Virgin Islands Territorial Emergency Management Agency (VITEMA)

United States Virgin Islands

Hazard Mitigation Plan

2019-Update

DOCUMENT VERSION CONTROL

TITLE	HAZARD MITIGATION PLAN 2019 – UPDATE
DESCRIPTION	The 2019 Hazard Mitigation Plan has been updated to incorporate the introduction to FEMA-Lifelines and USVI Hazard Mitigation Planning elements that addresses a wide-range of natural and human-caused hazards.
CREATED BY	The United States Virgin Islands Government (VIGOV) and the Virgin Islands Territorial Emergency Management Agency (VITEMA)
DATE CREATED	July 2019
MAINTAINED BY	VITEMA

VERSION NUMBER	Modified By	Modifications Made	Date Modified	Status
1.0	VITEMA	Mitigation Action Items	July 2019	Approved
1.1	CU, LLC	Hazard Mitigation Plan Development	February 2021	Approved
2.0	CU, LLC	Hazard Mitigation Planning elements	April 2021	Approved

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SECTION ONE: PLAN ADOPTION

This section describes the plan adoption process utilized in the Update of the US Virgin Islands Territorial Hazard Mitigation Plan.

CFR REQUIREMENTS FOR PLAN ADOPTION

DMA 2000 compliant Standard State Hazard Mitigation Plans must be formally adopted by the appropriate elected official(s). In the US Virgin Islands, the Governor has the authority to act on behalf of the Territory in this regard.

The CFR contains two specific requirements relative to the adoption of the Plan by the US Virgin Islands:

- **Requirement §201.4(c)(6):** *"The plan must be formally adopted by the State prior to submittal to (FEMA) for final review and approval."*

- **Requirement §201.4(c)(7):** *"The plan must include assurances that the State will comply with all applicable Federal statutes and regulations in effect with respect to the periods for which it receives grant funding, in compliance with 44 CFR 13.11(c). The State will amend its plan whenever necessary to reflect changes in State or Federal laws and statutes are required in in 44 CFR 13.11(d)."*

PLAN ADOPTION BY THE GOVERNOR OF THE US VIRGIN ISLANDS

Adoption of the Virgin Islands Territorial Hazard Mitigation Plan by the Governor of the US Virgin Islands affirms the commitment of the Territory to pursue the activities and actions identified in the Plan.

Following this page is a formal letter of adoption on behalf of the US Virgin Islands, signed by Governor Bryan on July 10, 2019, which incorporates and satisfies both **CFR requirements (§201.4(c)(6) and §201.4(c)(7)).**

U.S. Department of Homeland Security
Region II
Jacob K. Javits Federal Office Building
26 Federal Plaza, Room 1311
New York, New York 10278-0002

FEMA

July 3, 2019

The Honorable Governor Albert Bryan, Jr.
Governor of the U.S. Virgin Islands
Office of the Governor, Government House
21-22 Kogens Gade
Charlotte Amalie, USVI 00802

Reference: Approval of the 2019 U.S. Virgin Islands Territorial Hazard Mitigation Plan

Dear Governor Bryan:

The U.S. Department of Homeland Security, Federal Emergency Management Agency (FEMA) Region II Mitigation Division, Risk Analysis Branch has approved the 2019 U.S. Virgin Islands Territorial Hazard Mitigation Plan effective July 2, 2019 through July 1, 2024 in accordance with the planning requirements of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended, the National Flood Insurance Act of 1968, as amended, and Title 44 Code of Federal Regulations (CFR) Part 201.

A FEMA-approved state mitigation plan is a condition of receiving certain non-emergency Stafford Act assistance and FEMA mitigation grants from the following programs:

- Public Assistance Categories C–G (PA C–G)
- Fire Management Assistance Grants (FMAG)
- Hazard Mitigation Grant Program (HMGP)
- Pre-Disaster Mitigation (PDM)
- Flood Mitigation Assistance (FMA)

State mitigation plans must be updated and resubmitted to FEMA Region II Mitigation Division, Risk Analysis Branch for approval. If the plan is not updated by the date indicated on this FEMA approval letter, the plan is considered lapsed and FEMA will not obligate funds until the mitigation plan is approved by FEMA.

If at any time over the plan approval period FEMA determines that the state is not complying with all applicable Federal statutes and regulations in effect with respect to the periods for which it receives funding or is unable to fulfill mitigation commitments, FEMA may take action to correct the noncompliance (44 CFR § 201.3(b)(5) and 201.4(c)(7)).

In addition, FEMA will provide a reminder to the state, at a minimum, 12 months prior to the plan expiration date, of the consequences of not having a FEMA-approved mitigation plan with respect to eligibility for the FEMA assistance programs that require a FEMA-approved mitigation plan as a condition of eligibility. To maintain eligibility for PA C–G, FMAG,

USVI 2019 SHMP FINAL APPROVAL LETTER (CONTINUED)

HMGP, PDM, and FMA, the state must submit a draft of the next plan update prior to the end of the approval period, and allow sufficient time for the review and approval process, including any revisions, if needed, and for the formal adoption by the state following determination by FEMA that the plan has achieved a status of "Approvable Pending Adoption."

Finally, we look forward to working with you to discuss the status of the state mitigation program each year over the approval period. The written consultation agreement is attached to clarify expectations regarding the consultation progress, including details such as purpose and outcomes, points of contact, roles and responsibilities, and logistics.

If we can be of assistance, please contact Laura Forrest at 718-839-3314, or Laura.Forrest@fema.dhs.gov.

Sincerely,

Michael F. Moriarty
Director, Mitigation Division

Attachments:
1. State Mitigation Plan Review Tool
2. Mitigation Program Consultation Agreement

LETTER TO FEMA REGIONAL ADMINISTRATOR

THE UNITED STATES VIRGIN ISLANDS
OFFICE OF THE GOVERNOR
GOVERNMENT HOUSE
Charlotte Amalie, V.I. 00802
340-774-0001

July 1, 2019

Mr. Thomas Von Essen
Region II Administrator
Federal Emergency Management Agency
One World Trade Center
New York, N.Y. 10006

Re: Adoption of State Hazard Mitigation Plan

Dear Regional Administrator Von Essen:

Based on the recommendation of the Virgin Island Territorial Emergency Agency (VITEMA) and the Office of Disaster Recovery (ODR), I hereby approve the 2019 USVI Territorial Hazard Mitigation Plan and its adoption by the United States Virgin Islands. The Plan Update was prepared in response to the Standard State Hazard Mitigation Plan Update requirements of the Disaster Mitigation Act of 2000 (44 CFR 201.4). This updated plan will serve as the blueprint for future actions to reduce the devastating impacts of natural disasters on our residents, property owners and commercial enterprise.

The Plan Update follows our previous plan and outlines recommended actions ranging from programmatic measures that seek to incorporate mitigation practices within governmental agencies, to specific action that focus on implementing hazard mitigation projects for each island.

The Office of the Governor, Virgin Islands Territorial Emergency Management Agency and the Office of Disaster Recovery will comply with all applicable statues and regulations in effect with respect to the periods for which it received grant funding. We will also amend the plan as necessary to incorporate changes in state or federal laws and statutes as required in 44 CFR 1.11 (d). The Territory will execute, monitor and maintain the plan in keeping with the specific terms and actions contained therein.

Sincerely,

Albert Bryan Jr.
Governor

cc: Daryl D. Jaschen, VITEMA Director
Adrienne L. Williams, ODR Director

INTRODUCTION

EXECUTIVE SUMMARY

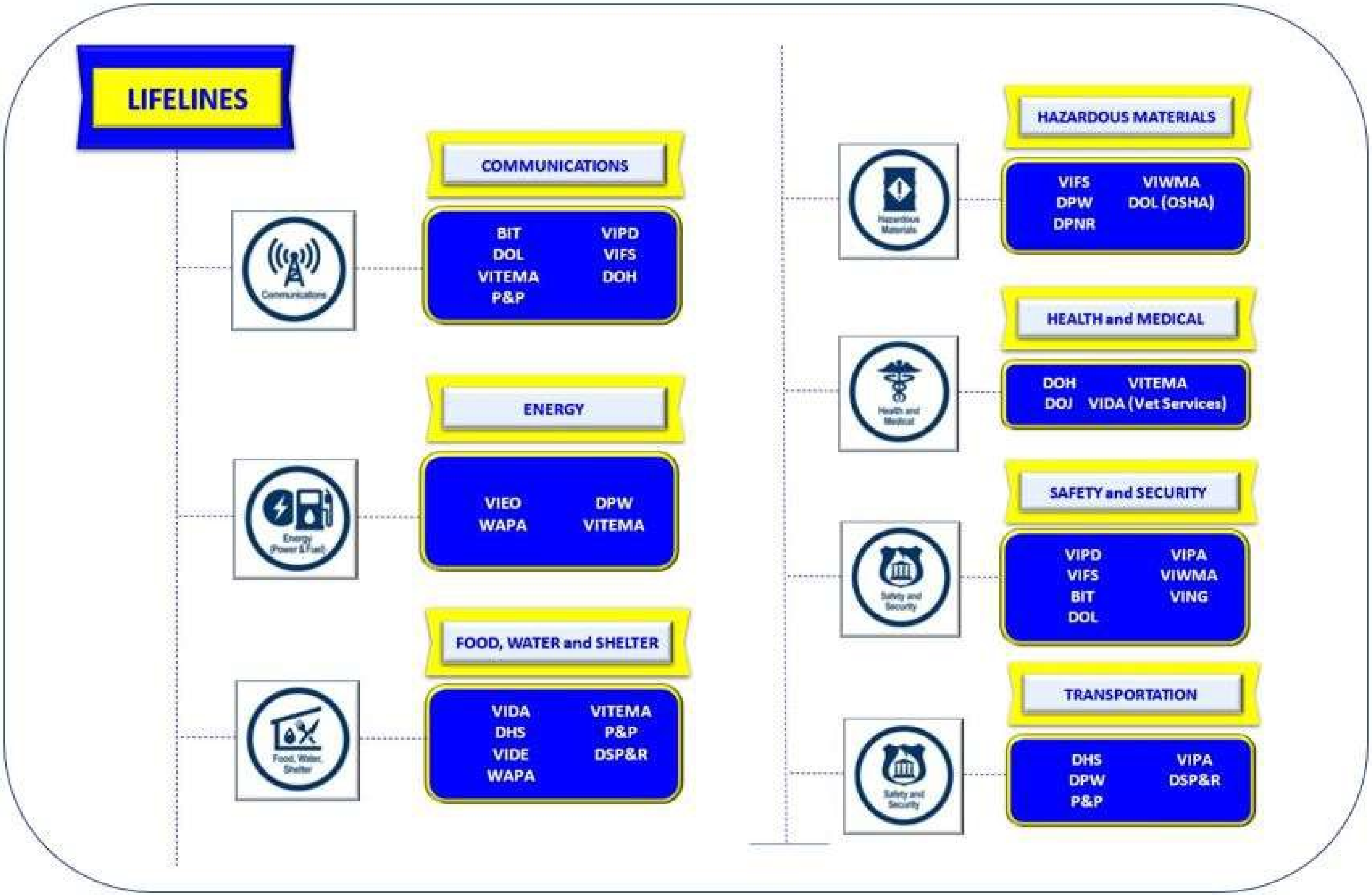
The Federal Emergency Management Agency (FEMA), in implementing the Disaster Mitigation Act of 2000, initiated far-reaching programs and policies that affected the approach to emergency management of every level of government. The legislation reinforces the importance of hazard mitigation planning and assigns specific responsibilities to state governments, which also apply to its territories such as the US Virgin Islands. As noted, the Disaster Mitigation Act of 2000 (DMA 2000) provides a strong incentive for the development of a Standard State Hazard Mitigation Plan.

Under the National Response Framework FEMA has constructed a system of Lifelines which provides indispensable service that would enable the continuous operation of critical business and government functions, and also critical to human health and safety or economic security. Lifelines were constructed to assist decision makers to rapidly determine the scope, complexity, and interdependent impacts of any hazard.

The planning process initially posts initial inception began in 2004 and led to the adoption of the Virgin Islands Territorial Hazard Mitigation Plan by the Governor and approved by the Federal Emergency Management Agency (FEMA) Region II on April 28th, 2005. The 2014 Plan update approval date was July 10th, 2014. The Territorial Hazard Mitigation Plan has been updated in 2011, 2014 and now the 2019 update, which confronts the possibility of natural and technological hazards that pose a risk to the health, welfare, and security of its citizens.

INTRODUCTION TO LIFELINES

FIGURE: 1.1 Lifelines Introduction



SECTION TWO: PLANNING PROCESS

This section is presented in the following four subsections:

- CFR Requirement for Planning Process,
- Plan Mission, Purpose, and Scope
- Description of the Planning Process,
- Coordination among Government Agencies, and
- Integration with other Planning Efforts

CODE OF FEDERAL REGULATIONS (CFR) REQUIREMENTS

CFR §201.4(b) states that "[a]n effective planning process is essential in developing and maintaining a good plan." The CFR continues to include three specific requirements for the process of developing Standard State Hazard Mitigation Plans:

- **Documentation of the Planning Process** per **Requirement §201.4(c)(1):** "[The State plan must include a] description of the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how other agencies participated."
- **Coordination Among Agencies** per **Requirement §201.4(b): "**The [State] mitigation planning process should include coordination with other State agencies, appropriate Federal agencies, interested groups."
- **Program Integration** per **Requirement §201.4(b): "**[The State mitigation planning process should be integrated to the extent possible with other ongoing State planning efforts as well as other FEMA mitigation programs and initiatives.

PLAN MISSION, PURPOSE AND SCOPE

The underlying purpose of the United States Virgin Islands Territorial Hazard Mitigation Plan is to identify strategies and actions that can be taken before a disaster strikes, and that can significantly reduce human suffering, damage to property, and the long- term economic impact of natural hazards. In September 2017, an unprecedented event occurred were two catastrophic Category 5 hurricanes tore through the US Virgin Islands within 14 days of each other. The storms crippled the Territory, destroying communications, power grid, and other infrastructures. Homes and businesses were demolished beyond repair. As the territory rebuilds, Hazard and Risk Assessments have been analyzed to determine the adequate Mitigative Efforts to prevent similar destruction from happening again with future storms. Capacity building and collaborative community efforts have also been incorporated into the plan update, which would create initiatives where the Territory would be able to be ultimately self-sustainable.

DESCRIPTION OF THE PLANNING PROCESS

The Plan Update was completed through an extensive planning process. The Virgin Islands Territorial Emergency Management Agency (VITEMA) was designated as the lead agency for the Plan Update. Various USVI departments and authorities actively participated in its development.

The Plan Update describes processes and methods that were utilized in the revise of each section of the Plan. Of primary importance, was interagency participation in the planning process along with public outreach efforts, which included meetings with external stakeholders. These efforts led to the Update of the hazard mitigation strategy that seeks to implement both programmatic as well as island specific actions for the US Virgin Islands.

Mitigation Planning regulation at 44 (FR.201.69d) (3) states: A local jurisdiction must review and revise its plan to reflect changes in development, progress, in local mitigation efforts and changes in priorities and resubmit for approval with five (5) years to continue to be eligible for mitigation grant funding. This information was taken from the Local Multi-Hazard Mitigation Planning Guidance which was updated on July 1, 2008.

This Update, like its predecessor, seeks to serve several purposes, including:

- Promote interagency coordination of programs, policies, and practices regarding hazard mitigation opportunities;
- Expansion of hazards to include the addition of Man-made hazards that would include Cybersecurity, Pandemic
- Enhance public awareness and understanding of hazards that affect communities and actions the public can take to make themselves safe;
- Identify, evaluate, and prioritize a range of mitigation actions that are specific to St. Thomas, St. Croix, and St. John;

- Comply with federal program requirements regarding eligibility for disaster recovery and mitigation grant funding;

- Assessment Findings will be incorporated post disasters which would identify capability deficiencies and risk assessments that were not identified prior to Hurricane Irma and Maria

- Expansion on Mitigation efforts which would be crucial in the implementation of mitigation efforts for the territory

This Update was prepared to meet all applicable state mitigation plan requirements as outlined in the Interim Final Rule for DMA 2000, published in the Federal Register on February 26, 2002, at 44 CFR Part 201 and 206. VITEMA gratefully acknowledges the efforts of the departmental representative for their participants as members of Internal Hazard Mitigation Committees, along with critical agencies and community representatives and Consultants who gave their time and support to this undertaking. A complete list of Committee member is included in Section 2 (Planning Process).

States and territories are required to prepare and submit a mitigation plan and then review and update the plan on a five-year planning cycle The Virgin Islands Territorial Emergency Management Agency (VITEMA) has established a Hazard Mitigation Steering Committee to provide oversight and assist in the Plan Update process.

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Table 2.1: Summary of Changes - 2019 HMP Plan Update

Plan Section	Summary of Changes
Front Material	▪ Added Executive Summary in place of introduction and revised language ▪ Added 2019 Territorial Approval Letter ▪ Added/Updated Mitigation Partners Section and acknowledges key contributors to the Plan Update.
Section One: **ADOPTION**	▪ An updated adoption letter has been included for the signature and adoption of the Plan Update by the Governor of the Virgin Islands. ▪ Includes July 2019 Adoption of State Hazard Mitigation Plan Letter to FEMA Reginal Administrator by the Governor of the Virgin Islands.
Section Two: **PLANNING PROCESS**	▪ Updated to reflect the planning process involved in this Plan Update ▪ Added summary of several meetings with the Hazard Mitigation Steering Committee, key stakeholders and Public.
Section Three: **CAPABILITY ASSESSMENT**	▪ Updated based on the findings of an assessment to evaluate USVI agency capabilities to implement the various hazard mitigation actions ▪ Added notations of collaborative efforts with nonprofit organizations such as the LRTG, TNC, Hurricane Recovery Task Force who play a major role in the community capacity building initiative. ▪ Updated References were included to new planning initiatives including the update of zoning and subdivision legislation. The limited capacity of VITEMA to implement the entire team of hazard mitigation actions in the 2014 Plan was discussed and recommendations made for a more realistic hazard mitigation strategy for the next five-year planning cycle that would also be incorporated into the Hazard Mitigation Resiliency Plan that will be developed fall of 2019.

Plan Section	Summary of Changes
Section Four: **RISK ASSESSMENT**	■ Updated to reflect changes in the Risk Assessment for the past three years as well as the data analyzed post disasters. Being that two Category 5 hurricanes have devastated the territory extremely assessment have been crucial to determine future and potential risk which can be navigated or defined by an assessment of assets in the territory which would include IT. ■ updated Mapping information across the territory and among agencies to lead to a centralized database where historical data will be established. ■ It outlines the hazard identification process which includes description of an evaluation process utilized to identify hazards for further study in this Plan update. This includes inventory information along with data maps that were developed in the hazard profile. ■ New profile information was added for coastal flooding, wind, which was integrated into the discussion on coastal flooding. New profiles and maps developed for drought, rain-induced landslides. This information was used to update the vulnerability assessment. Based on the published Mitigation Team Assessment that was conducted post disaster would be helpful with established information that was recorded. ■ Collaboratively working with UVI to gather information regarding the hazards that were affected post disaster and how those efforts can mitigate will also be a tool used to ensure with further potential risk those problems severity of damage can be limited.

Plan Section	Summary of Changes
Section Five: **MITIGATION STRATEGY**	■ Update was based on a detailed review of the goals, objectives and actions contained in the 2014 Plan update as well as incorporation of the goals Post disasters. The assessment of the mitigation strategy was based on the findings of the hazard identification and risk and capability assessment. ■ The mitigation strategy and associated mitigation actions reflected a greater emphasis on conducting planning and hydrologic and hydraulic studies to address areas throughout the islands where inadequate stormwater drainage leads to flooding issues for many neighborhoods. ■ Determining programmatic mitigation actions to emphasize reduction of loss properties throughout the USVI. Goals are also focused on mitigative efforts to build resilience by wind retrofits and further incorporation of safe rooms and shelters territory wide.
Section Six: **PLAN MAINTENANCE**	■ A detailed description of the maintenance process is contained in this section of the Plan Update. This includes information concerning the composition of the hazard mitigation committees and the responsibilities of each in the maintenance of this newly updated Plan. ■ Incorporation of the upcoming Hazard Resiliency all Hazards Plan will also be explained thoroughly where the goal would be to ensure accountability and accessibility will be extremely improved for future regarding the territories' sustainability.
Section Seven: **REFERENCES**	■ Updated to reflect new references that were utilized in the HMP-2019 Update. It provides an inventory of resources, materials and sources of relevant information utilized in this Plan update.

The plan update process began in November of 2018, with the initial internal review and assessment of changes within the Hazard Mitigation Division. The planning process included key stakeholder engagement through two meetings that officially begun in January of 2019. The draft plan review was completed in June 2020. In July 2019, the Plan was finalized and submitted to the Federal Emergency Management Agency (FEMA) Region II for review. During this update, the Plan was updated and improved to meet Standard State Hazard Mitigation requirements. State adoption was executed through a letter signed by the Governor, as shown in the Adoption Documentation section. This plan incorporates all changes associated with the implementation of federal and state hazard mitigation programs, including the applicable sections of the Disaster Mitigation Act of 2000. The Plan is updated at least every five years, or after each disaster declaration if needed, by members of the SHMT.

The law stipulates that the Plan will be updated and re-submitted to FEMA for re-approval every five (5) years as required by law. It is the understanding of the planning team, based on (44CFRPart201). In April of 2014, FEMA promulgated a Final Rule that changed the frequency of Mitigation Plan Updates (44CRR Part 201). The Final Rule extends the Plan Update requirement for States and Territories from 3 to 5 years. The work undertaken consisted of updating all sections of the 2019 Plan Update. This was done by using the best available data and methodologies for a target of July 2019 for FEMA's final approval. The process of planning and review of the Plan Update is detailed in this section. The method utilized includes the appraisal and expansion of the 2019 Plan. In accomplishing the objective of the Plan Update, several areas of importance were addressed. The following summary identifies the process used to revise and update each section of the plan.

The Plan Update represents the efforts and contributions of several governmental agencies and other stakeholders. The 2019 Plan Update was reviewed and analyzed, resulting in appropriate modifications. With the incorporation of information concerning climate change, which provides an overview of how susceptibility will increase or decrease, the territory's profile and understanding of natural hazards are more complete. Incorporation of Human-caused hazards were also included into this plan update. Normally the former Hazard Mitigation Plans only focused on Natural caused Hazards but the inclusion of man-made hazards were incorporated into this plan after initial adoption to comply with additional compliances that were required for the agency. Mitigation strategies were developed and prioritized to address present data concerns. The 2014 Plan, along with the recent data, formed the foundation for this Plan Update as well as published documentation post disasters that would speak to the Risk and Capabilities Assessments. The Hazard Mitigation Steering Committee has been newly formulated and has expressed a commitment to implementing an effective hazard mitigation program in the USVI, particularly those priority mitigation actions included in this Plan Update.

PLANNING TEAM

During the development of the 2019 Plan Update, VITEMA established an internal State Hazard Mitigation Working group/Team along with an External Steering Committee team who would be in charge of the Plan Update. This Committee is responsible for the implementation of actions identified in the Plan Update. FEMA, which played an advisory role on the Hazard Mitigation Steering Committee, emphasized the importance of monitoring and evaluation, and the importance of capturing historical information for the approval of hazard mitigation projects, especially flood drainage construction projects.

The Virgin Islands Territorial Hazard Mitigation Officer has organized the Hazard Mitigation Working Group and will chair the Working Group. The members of the Hazard Mitigation Working Group are noted in Table 2.1

Table 2.2: Hazard Mitigation Internal Working Group

Name	Department	Title
Graciela Rivera	**VITEMA**	Chairman
Ozzie Bradshaw	**VITEMA**	
Joanne White	**VITEMA**	
Malinda Vigilant-Messer	**VITEMA**	
Debra Henneman-Smith	**VITEMA**	
Collister Fahie	**VITEMA**	
Florecita Brunn	**VITEMA**	
Linda Williams	**VITEMA**	
Garry Green	**VITEMA**	
Regina Browne	**VITEMA**	
Emerito Torres* **	**VITEMA**	Former Chairman

VITEMA feels that the development of a capable state-level Hazard Mitigation Plan requires inclusion in the planning process of representatives from a wide range of public, private, and non-profit sectors. Clear lines of communication with the active participants and the general public are necessary.

The purpose of the Hazard Mitigation Working Group was too:

(1) to provide oversight to the VITEMA contractor during the Plan Update;
(2) to contribute to the development of a revised mitigation strategy; and
(3) To identify and prioritize mitigation actions that were specific to each island.
(4) Increase the Virgin Islands' disaster resiliency by developing and maintaining an effective statewide hazard mitigation program that is supported by all levels of government, non-governmental organizations, and the private sector.
(5) Promote hazard mitigation efforts to reduce loss of life and property by lessening the impact of disasters.
(6) Ensure the Virgin Islands' continued eligibility for federal disaster recovery dollars.
(7) Contribute expertise for development of the State Hazard Mitigation Plan, which serves as the foundation for enactment of a statewide mitigation program.

Integration of the state's Threat and Hazard Identification and Risk Assessment (THIRA) process also became a priority for the team. The team determined plan development required an analysis of core capabilities applicable to all five mission areas established by the National Preparedness Goal (NPG), Prevention, Protection, Mitigation, Response, and Recovery. These core capabilities include: Planning, Public Information and Warning, and Operational Coordination. Additionally, VITEMA considers Intelligence and Information Sharing as a core capability with applicability to all mission areas. The Internal Working Group/Team also directed analysis considers the mitigation core capabilities of: Community Resilience, Long-Term Vulnerability Reduction, Risk and Disaster Resilience Assessment, and Threat and Hazard identification.

The Team understood and valuated comments from FEMA staff regarding the 2019 plan and enacted several changes, including a Human-caused hazard section. Another goal going forward with any public outreach event would evolve into avenues which could create the platforms to ensure critical public feedback. The team has learned that public feedback can help contextualize the Territory's hazards and threats. During the future public outreach events the participants would be able to discuss how the hazards and threats impacted them personally and as a community; and shared their ideas for mitigating their impacts. An idea to include performing outreach to include participation from children between the years of junior high to high school will also be incorporated in a possible external committee.

MEETINGS

The Hazard Mitigation Working Group and the External Hazard Mitigation Committees met on two (2) separate occasions for the Plan Update.

HAZARD MITIGATION STEERING COMMITTEE MEETINGS

The Hazard Mitigation Working Group and Team collaborated on various dates to gather information while developing the 2019 Plan Update.

TABLE 2.3 Hazard Mitigation Steering Committee Meetings

Meeting Purpose/Outcome	Steering Committee Meetings Records			
	#	Date	Location	Attendance
Plan Organization	1	1/30/2019	**VITMA Headquarters**	VITEMA Mitigation Staff,
Hazard Resiliency Plan / General Information	2	2/6/2019		VITEMA Hazard Mitigation Plan/UVI Comprehensive Plan
To discuss possible Mitigation action items that can be added to the plan	3	3/13/2019		VITEMA Mitigation Staff, and Coral Reef Manager from FEMA
Technical Assistance with Plan Update	4	3/20/2019		VITEMA Planner, Jack Heide (FEMA Planner)
General Information	5	3/21/2019		VITEMA Mitigation Staff, Long Term Recovery Group Executive Directors

Sign-in sheets from the formal meetings are available in **Appendix A** of this Plan; others, where there was only general information shared, are not in the Appendix.

COORDINATION AMONG GOVERNMENT AGENCIES

For a State Hazard Mitigation Plan to become a useful tool in implementing hazard mitigation, it cannot remain the sole province of VITEMA. Coordination among government agencies that have a role in implementing hazard mitigation is essential. For this plan update, coordination with government agencies was very similar to the process utilized during the 2014 Plan development. There were some changes in this process during this Plan Update; these include;

- Different Participants from Government Agencies. There was a marked reduction of Federal and Territory agencies that played a role in this Plan Update. During this Plan Update, many participants that were included on committees were familiar with the Hazard mitigation planning process. However, some new members required more information to arrive at a basic understanding of emergency management and hazard mitigation. As these persons gain a better understanding of FEMA programs, processes, and terminology, the Plan Update process in the future will become more efficient along with the Sector-based groups that will be established with the upcoming Resiliency Plan.

- Identification of Key Stakeholders. Key stakeholders such as the Virgin Islands Territorial Emergency Management Agency (VITEMA), University of the Virgin Islands (UVI), Department of Planning and Natural Resources (DPNR), and Department of Public Works (DPW) were identified during the planning process. These agencies also made staff available for the Plan update, namely UVI, DPW, and DPNR.

FACILITATING INTERAGENCY COORDINATION

There were numerous ways in which VITEMA encouraged coordination among US Virgin Islands governmental departments, agencies, and authorities. The most crucial way that VITEMA encouraged coordination was to invite representatives of the relevant agencies to participate in the Hazard Mitigation Plan.

Public sector participants were encouraged to discuss the planning process with other staff in their respective departments. This brought their collective insight and enabled the identification of potential mitigation projects that could be brought back to subsequent Committee meetings. By interfacing with representatives of other VI departments within the setting of the Hazard Mitigation Committee meetings, participants gained an understanding of the respective roles of many agencies and departments. All the agencies that participated in the Hazard Mitigation Committees meetings had a stake and a vote in identifying and prioritizing new hazard mitigation actions at the Territorial-level as well as for each significant island.

PUBLIC SECTOR

- Virgin Islands Territorial Emergency Management Agency (VITEMA)
- Department of Planning and Natural Resources (DPNR)
- VI Housing Authority (VIHA)
- VI Port Authority (VIPA)
- VI Property and Procurement (VIP&P)
- VI Fire Service (VIFS)
- VI Police Department (VIPD)
- Emergency Management Services (EMS)
- VI Water and Power Authority (WAPA)

ORGANIZATIONS

- University of the Virgin Islands
- The American Red Cross
- Long Term Recovery Group
- Coral Bay Community Council
- St. Croix Community Foundation

STAKEHOLDERS

VITEMA has undertaken several steps to encourage the broadest range of stakeholder involvement from the onset of the Plan Update process. The Update of the US Virgin Islands Territorial Hazard Mitigation Plan was a collaborative effort resulting from dedicated efforts of several US Virgin Islands agencies, departments, and authorities, in addition to vital involvement of the public and private sectors.

1) Representatives of government agencies were identified as key stakeholders and were invited to be members of the Hazard Mitigation Steering Committees and/or to participate in feedback. The term" Stakeholders" as used in the rest of this Plan Update includes the following:

    - Virgin Islands Territorial Emergency Management Agency (VITEMA)
    - Department of Planning and Natural Resources (DPNR)
    - Department of Public Works (DPW)
    - VI Water and Power Authority (WAPA)
    - VI Waste Management (WMA)

INTEGRATION WITH OTHER PLANNING EFFORTS

All relevant and completed plans and/or on-going planning efforts were reviewed for this Plan Update. The 2014 Plan provides an excellent departure point to identify new opportunities where hazard mitigation can be better integrated into the US Virgin Islands' long-range planning initiatives. Those initiatives have led to the collaborative relationships between non-profit organizations such as the Long-Term Recovery Group. This group has been extremely instrumental in completing community assessment plans from each island, which details avenues that would ensure continued community capacity building. Incorporation and adaptation of their finding have been extremely beneficial for the 2019 Plan update.

OUTREACH STRATEGY

As part of the planning process, The US Virgin Islands plans to continuously communicate the planning process to the SHMT as well as collected feedback from larger stakeholder groups and the general public and incorporate it into this plan dynamically. An Outreach Strategy was created at the start of this planning process to document the various mechanisms of outreach to be applied throughout the plan update process while the HMRP is being completed.

PLANNING PROCESS CONCLUSIONS

The planning process is projected to be defined as “Whole Community” with a broad-based public-private partnership and high level of involvement by each member of the committee. Each hazard and threat profile contained a conclusion of the data that provided the foundation for developing the state’s mitigation strategy. As demonstrated with past updates to mitigation actions, the Steering Committee made adjustments to the actions to reflect changes in priorities.

Some improvements are recommended for the next plan update. They include revising the plan to provide both types of hazards to include both natural and human-caused which would also provide more specific direction for the SHMT. Unlike past plan updates, committee leads assumed more of a leadership role. Plan development occurred in a compressed time-period. For the next update, the collaboration with VITEMA and UVI will allow a longer time-period to discuss the hazard and threat profiles, capabilities, and mitigation actions. During this update, the SHMT accommodated quick turnarounds in a clear demonstration of their level of commitment to mitigation in the Virgin Islands.

SECTION THREE: CAPABILITY ASSESSMENT

The section is organized around the capability assessment process that includes the following five subsections:

- The CFR Requirements for Capability Assessments
- US Virgin Islands Policies, Programs, and Capabilities
- Funding
- Analysis and Evaluation of US Virgin Islands Departments, Agencies and Authorities
- Summary and Recommendations

THE CFR REQUIREMENT FOR CAPABILITY ASSESSMENTS

The Interim Final Rule (CFR) includes two specific requirements for conducting capability assessments as part of Standard State Hazard Mitigation Plans:

- State Capability Assessment per Requirement §201.4(c)(3)(ii): *"[The State mitigation strategy shall include a] discussion of the State's pre-and post-disaster hazard management policies, programs, and capabilities to mitigate the hazards in the area, including: an evaluation of State laws, regulations, policies, and programs related to hazard mitigation as well as to development in hazard-prone areas [and] a discussion of State funding capabilities for hazard mitigation projects."*
- Local Capability Assessment per Requirement §201.4(c)(3)(ii): *"[The State mitigation strategy shall include] a general description and analysis of the effectiveness of local mitigation policies, programs, and capabilities…"*

The Disaster Mitigation Act of 2000 (DMA 2000) requires that the territories of the United States, including the US Virgin Islands, meet the CFR requirements for States. However, the US Virgin Islands differ from the 50 States in one crucial way. Although the islands of St. Croix, St. John and St. Thomas could be considered as distinct *"communities"* in many regards, there are no incorporated units of local government. Since there are no incorporated counties, municipalities, or subunits below the Territorial government that can promulgate or enforce "local" policies, programs, or regulations, the requirement for a "Local Capability Assessment" does not apply and is not addressed in this Plan.

US VIRGIN ISLANDS POLICIES, PROGRAM AND CAPABILITIES

An essential purpose of this assessment is to identify the capabilities that need to be strengthened to assure the successful implementation of programs, and the rules and regulations intended to support the hazard mitigation related policies of the US Virgin Islands. The importance of the Capabilities in the territory has not been as crucial as it has been posted, Hurricane Irma and Maria. Being that this unprecedented event occurred two weeks within each other caused the crippling of already weakened capabilities to be affected even more severely. Although there were many adverse effects of these disasters, there were also opportunities that arose, which caused a chance to improve capabilities throughout the entire territory.

The remaining portions of this subsection of the Plan address:

- Policies
- Programs, Rules, and Regulations

KEYWORD DEFINITIONS

- The CFR does not provide definitions for keywords in its requirements, i.e., "policies, programs, and capabilities." For this assessment, the following definitions will be used:
- Policies – are statements included in the Territory's plans or enabling legislation that expresses the vision or intent of the US Virgin Islands government. In the specific context of this plan, policies are identified that already do, or feasibly can, support hazard mitigation in the US Virgin Islands.
- Programs – are related, coordinated activities by one or more agencies that have a distinct focus or purpose. Often, plans are developed as a direct response to policies and are enabled by the corresponding legislation or executive order. In the context of this assessment, relevant programs are often directly linked to rules and regulations.
- Capabilities – as used in this document, describe the past performance and future potential of agencies to carry out programs. As a simple example, if you want to build a house (the "program"), you need to assess your capability to do so. You should look at the materials and tools you have or need to buy; the skills you have or can hire (carpenters, electricians, plumbers, etc.); and whether the money you have saved for the project will be enough.
- Under this definition and for this particular planning exercise, capabilities refer to the strength and weaknesses of rules and regulations ("tools and materials"), the adequacy of human resources to carry out administrative procedures and enforcement activities (the "skills" to implement the program) and the funds available to maintain operations and provide capital improvements (the "project budget").

CAPABILITIES ASSESSMENT INTERVIEWS

For the Plan Update, in majority of capability assessment involved collaborating with representatives from VITEMA, DPNR, DPW, LTRG, UVI, and WAPA. The following list identifies the name, title, and affiliation of US Virgin Islands officials spoken to during the capability assessment:

DEPARTMENT OF PLANNING AND NATURAL RESOURCES

- Ellerton Maynard, DPNR, Floodplain Manager
- Amanda Jackson-Acosta, DPNR, Unit Chief, Building Permits

VIRGIN ISLANDS TERRITORIAL EMERGENCY MANAGEMENT AGENCY

- Daryl L. Jaschen Director
- Emerito Torres, Territorial Hazard Mitigation Officer (former)
- Graciela Rivera Deputy Hazard Mitigation Officer St Croix (current Territorial Hazard Mitigation Officer)
- Ozzie Bradshaw Deputy Hazard Mitigation Office St. Thomas-St. John (former)

VIRGIN ISLANDS WATER AND POWER AUTHORITY

- Vernon Alexander, Director of Special Projects

LONG TERM RECOVERY GROUP

- Jay Rollins, Executive Director, St. Croix
- Imani Daniels, Executive Director, St Thomas
- Hillary Bonner, Executive Director, St. John

UNIVERSITY OF THE VIRGIN ISLANDS

- Dr. Greg Guannel, Technical Lead for the Hazard Resiliency Plan

POLICIES

This section provides a summary of plans, policies, and legislation that layout specific goals, objectives, and policy statements that already do, or potentially could, support pre- and post-disaster hazard mitigation. The plans reviewed for the Plan Update include land use and environmental planning documents, specific hazard mitigation plans, and other emergency management plans. They are listed below:

LAND USE AND ENVIRONMENTAL PLANNING DOCUMENTS

- *Coastal Land and Water Use Plan* (see "Coastal Zone Management" under Section 2.3.1)
- *St. Croix East End Marine Park Management Plan*, VI Nature Conservancy and UVI for DPNR, Division of Coastal Zone Management (2002)
- *Coral Bay Watershed Management Plan: A Pilot Project for Watershed Planning in the USVI,* Center for Watershed Protection, (2008)
- *St. Croix East End Marine Watersheds Management Plan, USVI DPNR, NOAA, USDA NRCS (2011)*
- *USVI Zoning and Subdivision Code Update,* currently under development by Rutgers University and Duncan Associates, in conjunction with the Community Foundation of the Virgin Islands

Activities related to other areas or phases of emergency management were not evaluated for this Plan Update.

ALL HAZARD OR HAZARD SPECIFIC MITIGATION PLANS

- Natural Hazard Mitigation Plan for the US Virgin Islands, David Brower, Esq. and Timothy Beatley, Ph.D., for VITEMA (1988)
- Mitigating the Impacts of Natural Hazards in the US Virgin Islands, Island Resources Foundation, for VITEMA (1995)
- Mitigating the Impacts of Natural Hazards in the US Virgin Islands, Island Resources Foundation, for OMB (1999)
- Virgin Islands Flood Hazard Mitigation Plan, Island Resources Foundation for VITEMA, funded by FEMA FMA grant (2000)

EMERGENCY MANAGEMENT PLANS

- WAPA Emergency Operations Plan, WAPA (2018)
- Mitigation Assessment Team Report, FEMA (2016)
- Virgin Islands Territorial Emergency Management Agency Territorial Homeland Security Strategy 2011-2014
- The Virgin Islands Territorial Emergency Operations Plan (2016)

These plans provide a solid base for the maintenance, development, and pursuit of coordinated programs that can reduce the risk of damage and loss from natural disasters in the US Virgin Islands.

We have also chosen to adopt plans that were published post-disaster such as the CBCD-GR report, the Long-Term Recovery Groups for each island as well as the Hurricane Team's Report which provide additional data that could be incorporated into the opportunities of capacity building that has been given to the territory.

COMPREHENSIVE PLANNING

As highlighted in 2005, 2008, 2011 and 2014 Plans, the Comprehensive Land and Water Use Plan (CLWUP) adhered to goals and objectives laid out in the "Guidelines for the Development of a Long-Range Comprehensive Plan for the United States Virgin Islands" adopted by Executive Order No. 333-1991 on May 17, 1991. This plan will be further developed in the Comprehensive All hazards plan that will also be developed in 2021.

The Comprehensive Land and Water Use Plan (CLWUP) proposed to incorporate territorial-wide land and water use guidelines developed by the V.I. Department of Planning and Natural Resources (DPNR) into the Virgin Islands Code (V.I. Code). In 2005, a formal bill was proposed by Senator Richards (Bill No. 25-0209) which sought to amend title 29, chapter 3, Virgin Islands Code, to enact the "Virgin Islands Development Law of 2003". Bill No 25-0209, which sought to provide for a comprehensive land and water use plan for the U.S. Virgin Islands and also called for the revision of zoning districts on all islands of the US Virgin Islands.

The Legislature and stakeholders perceived the CLWUP as too restrictive to the economic development of the US Virgin Islands, and the draft bill was held in abeyance in a legislative committee. There are currently no long-range comprehensive or master plans in process for the US Virgin Islands. However, DPNR is in the process of developing zoning and subdivision code revisions, which will comply with all existing legislation, and will hopefully provide a basis for the eventual development and adoption of a comprehensive land-use plan, as required by Territorial law.

The zoning and subdivision code revisions are being developed with the assistance of Rutgers University. This project includes the following components:

- Comprehensive update and modernization of existing zoning and subdivision codes
- Organization, layout, ease-of-use/administration
- Internal/external consistency
- Administration/procedural clarity & efficiency
- Strategic amendments to address identified issues and opportunities
- Introduction of form-based floating zone
- Urban design plan for areas in Charlotte Amalie

These revisions are anticipated to support the process of moving towards the development of a comprehensive long-range plan. Several sections of the draft zoning and subdivision sections have been presented to a review committee and interested stakeholders. As of May 8, 2014, DPNR anticipates that the revisions will be finalized over the next several months, at which time they will be presented to both the Territorial Legislature and the public.

These code revisions will address significant, current issues related to hazard mitigation, including erosion control and management of stormwater runoff. The vital elements of the code revision are anticipated to encompass both technical standards and performance standards. It is expected that the code

Revisions will be complete and adopted in time for Plan Updates, and that more information regarding the specifics of the code revisions will be available at that time.

Other plans include policy-related statements that are more focused on specific hazard mitigation issues. Although outdated by the consolidation of hazard mitigation programs in the HMA Unified Guidance, the US Virgin Islands Flood Mitigation Plan, adopted in 2016, is still relevant today. The Plan will be updated in the upcoming year because there have been significant changes in the territory from 2016 to the time of this update. The goals and objectives highlighted in the 2016 plan were reflected in this Plan Update and support both pre- and post-disaster hazard mitigation activities for flooding, one of the critical hazards for the US Virgin Islands.

As such, the foundations of these plans continue to provide a solid base for the maintenance, development, and pursuit of coordinated programs that can reduce the risk of damage and loss from natural disasters in the US Virgin Islands. The extent to which the Territory has been fruitful in building on this base is discussed in the following subsections. After the descriptions of these programs, Section 3.5– Summary and Recommendations relates each plan's "policies," as well as the associated applications, rules, and regulations to the elements of the CFR requirements.

PROGRAMS, RULES, AND DEREGULATIONS

This subsection describes relevant programs, rules, and regulations of the US Virgin Islands. The discussion is organized by four main headings:

- Pre-disaster hazard mitigation;
- Post-disaster hazard mitigation;
- Other related programs; and
- Proposed programs.

PRE-DISASTER HAZARD MITIGATION

Programs, rules, and regulations that are focused primarily or substantially on pre-disaster hazard mitigation in the US Virgin Islands include:

- Floodplain Management;
- Coastal Zone Management; and
- Land Development Regulations (e.g., zoning; subdivision regulations; building codes)

FLOODPLAIN MANAGEMENT

Current pre-disaster floodplain management efforts in the US Virgin Islands are pursued through four interrelated programs:

- National Floodplain Insurance Program;
- US Virgin Islands Flood Map Modernization Program;
- US Virgin Islands Flood Hazard Mitigation Plan; and
- Flood Damage Prevention Rules.

NATIONAL FLOODPLAIN INSURANCE PROGRAM

Through the National Floodplain Insurance Program (NFIP), FEMA provides Federal insurance for structures and their contents located in participating communities. The NFIP was enacted by the Federal government in 1968 to help reduce flood damage by regulating new development in flood-prone areas and to provide flood insurance to the general public at reasonable rates to cover damages to buildings and their contents caused by flooding.

To participate and qualify their residents for flood insurance, communities must adopt minimum regulations governing floodplain development. For example, participating communities must prohibit new construction in designated floodways that raise flood levels. Also, the lowest floor of all new buildings in Special Flood Hazard Areas must be elevated to or above the height of the base flood elevation or “100-year flood”. A third significant requirement is that subdivisions must be designed to minimize exposure to flood hazards. Added standards are imposed on communities where the flood hazard is compounded by coastal wave action or “V” zones, as described in Section 4.2 – Hazard Identification and Profiles.

In June 2004, the National Flood Insurance Act (42 U.S.C. 4001 et seq.) was amended to introduce a mitigation plan required as a condition of receiving a reduced local cost-share for activities that mitigate severe repetitive loss properties under the Flood Mitigation Assistance (FMA) and Severe Repetitive Loss (SRL) grant programs. October 2007, Interim Final Rule established this requirement under 44 CFR §201.4(c) 93) (v) to allow a State to request the reduced cost-share under the FMA and SRL programs if it has an approved State Mitigation Plan that also included an approved Severe Repetitive Loss Strategy (contained in Appendix C).

The US Virgin Islands has been a member of the NFIP since 1980. The Territory adopted NFIP-compliant floodplain management provisions in 1993. See discussion under "Flood Damage Prevention Rules" below for a description and evaluation of the rules and regulations enacted by the US Virgin Islands that help satisfy the statutory requirements associated with their NFIP participation. The program is administered by DPNR, Division of Permits. The Director of Permits is the designated NFIP Coordinator for the US Virgin Islands.

EVALUATION/ASSESSMENT

The NFIP was an essential impetus for the enactment of the US Virgin Islands Flood Damage Prevention Rules. Also, the program has provided loss coverage for a significant number of properties.

The prioritization of mitigation activities to reduce the number of repetitive loss properties (through acquisition, elevation, etc.) is consistent with actions outlined in Section 5 of this Plan.

Also, in evaluating the impact of the current floodplain management program in the US Virgin Islands, three other issues are important to examine:

- NFIP policy coverage assessment – As of April 2017 data from the Flood Hazard Mitigation Plan, there were 1,677 policies with insurance coverage totaling $303,826,000 in the US Virgin Islands. This represents a decrease of approximately 858 policies since the 2016 FMA Plan. The 2016 FMA Plan also reported that the results of reviewing aerial photographs of the islands indicated that as much as 10 percent of the Territorial housing units are located in the Special Flood Hazard Area. Given that there are at least 50,500 housing units in the islands, 10 percent would yield approximately 5,050 units within the SFHA. If that is the case, NFIP policies cover roughly half of the total eligible properties. As of 8/25/2017 to 5/10/2019, there have been 321 approved NFIP claims and payout of $20,228,150 per FEMA Region II office.

- Insurance claims- As of August 25th, 2017, to present, there are 321 approved NFIP claims with a payout of $20,228,150.00 per FEMA Region 2 headquarters.

- Repetitive Loss Insurance claims – Since the inception of the Virgin Islands qualification for NFIP in 1980 through November 2010, two-hundred and twenty-five (225) properties have been identified and validated as repetitive flood loss properties. The total number of features identified and authenticated as severe repetitive losses is three (3), making it a minimal subset of the whole. The distribution of these properties is as follows:

  - **St. Croix:** **133 Repetitive Loss; 3 Severe Repetitive Loss**
  - **St. John:** **2 Repetitive Loss**
  - **St. Thomas:** **112 Repetitive Loss**

The figures above represent two hundred and fifty (250) total properties initially identified as repetitive loss or severe repetitive loss. Of these two hundred and fifty (250) identified properties, FEMA later validated two hundred and twenty-five (225). The twenty- five (25) that were removed from the list consisted primarily of duplicate entries, with others being mitigated properties or vacant lots.

These repetitive losses and severe repetitive loss properties have filed six hundred and seventy (670) claims in the previous thirty (30) years, and have received payments of

$33,417,083.88. This produces an average claim of $49,876.24 per property or an average of $1,662.54 per property each year for the previous thirty (30) years.

The relationship of the number of policies versus claims is overly simplistic, and likely does not accurately depict the flood risk to properties in the Territory. Although this was a problem initially, the hurricanes caused an extremely high percentage of rain and numerous flooding occurrences, which were able to provide the more accurate and current information as it pertains to the flood risk properties in the Territory. This allowed the influx of numerous claims to occur, which allowed more effort to be carefully developed and approved long-range comprehensive that would alleviate the amount of damage caused mitigative efforts could reduce that. Per the Story Map, there were not any significant changes when it comes to the new Advisory Mapping, only an additional 25 river miles of unmapped areas and small changes (~2.4 square miles added in floodplain extent. This is primarily because the active floodplains were typically more extensive than the new advisory floodplains due to the outdated terrain data used in the practical analysis. It is important to remember that although changes in floodplain extent were minimal, the variations in riverine surface elevation were more significant.

The Territory has a substantial opportunity to address and take decisive action relative to reducing the number of Repetitive Flood Loss properties. This Plan Update outlines specific steps (See Appendix G) to target these properties and the surrounding environment that perpetuates these losses.

Simple measures in the development review process have the potential to pay dividends in reducing future flood-related disaster damages. Care should also be taken to make sure that well-intentioned programs like the NFIP are focused on providing coverage for properties that are already at risk, not to support the development of new sources of risk and loss for the community.

FLOOD INSURANCE RATE MAPS (FIRMS)

The NFIP issues Flood Insurance Rate Maps (FIRMs), which delineate the Special Flood Hazard Areas (SFHA) as either A-zones (riverine flooding) or V-zones (coastal flood hazard areas) based on federal standards. The FIRMs, which have been utilized in the Virgin Islands since their initial issuance in August 1980, have served a useful purpose for establishing insurance rates.

- *The 2007 US Virgin Islands Digital Flood Insurance Rate Maps (DFIRMs) are consistent with the proposed five-year strategy for modernizing FEMA FIRMs and Flood Insurance Studies (FISs) in the Territory. The March 2004 strategy stated: "Because of the steep terrain on all three islands, there is also a need to update riverine studies in US Virgin Islands. Many of the riverine flood hazards are currently shown on the FIRM as approximate floodplains, which do not provide enough detail to mitigate risk and provide sound floodplain management properly. To better manage development in these areas, the US Virgin Islands requests that all the riverine flood hazards be studied in detail".*

- *Firm Maps have not been updated post-disaster and have allowed the occurrences that occurred after to be analyzed by various studies to indicate ways to alleviate potential hazards that would happen if the FIRMS were not updated. Before these disasters, the territory wasn't hit by a Hurricane of this statue, so because of that changed matters that may not have seen that much change in a decade was known severely affected, which prompted the switch to occur more rapidly. The advisory maps were updated and implemented in August of 2018.*

EVALUATION/ASSESSMENTS

- *Metadata accompanying the USVI DFIRM database indicates that: "The published effective FIRM and DFIRM maps are issued as the official designation of the SFHAs. As such, they are adopted by local communities and form the basis for the administration of the NFIP. For these purposes, they are authoritative..." (FEMA MSC, 2007). The data for the development of these maps is consistent with the "Guidelines and Specifications for Flood Hazard Mapping Partners" (FEMA, 2003). The DFIRMS is used as a reference and to obtain more detailed information in areas where Base Flood Elevations (BFEs) and/or floodways have been determined. Users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the FIS report (FEMA,2007).*

The DFIRM data has been provided to the US Virgin Islands in both hard copies and as a GIS-enabled product, which is consistent with FEMA's goals of distributing DFIRMs as GIS data online for the population of US Virgin Islands.

FLOOD HAZARD MITIGATION PLAN

In February 2016, the US Virgin Islands Territorial Emergency Management Agency (VITEMA) completed the US Virgin Islands Flood Hazard Mitigation Plan (FHMP), which was subsequently adopted in 2016. This plan was developed to preserve the eligibility of the US Virgin Islands for project grants from FEMA's Flood Mitigation Assistance (FMA) Program. Going forward the Territory will determine additional Flood Mitigation Projects and will also update the FHMP.

The plan is based on goals and objectives that were detailed earlier in Section 3.2. The plan also outlines an extensive series of recommended mitigation measures, some of which have been implemented. These include:

- Traditional property protection (e.g., the elevation of flood-prone structures, floodproofing, etc.);

- structural mitigation measures (e.g., retention basins, levees, or floodwalls, etc.) for specific areas of concern; and

- Recommendations to improve emergency response and recovery actions (see a more detailed discussion of this part of the plan under Section 2.3.2 – Post-Disaster Hazard Mitigation).

The US Virgin Islands Flood Hazard Mitigation Plan also recommended updating US Virgin Islands FIRMs, which have occurred post-disaster to reflect the changes that have been recorded. This action has finally been discussed, and the results are highlighted in the subsection above. Although the FIRMs have not been updated, the advisory maps were post-disaster.

EVALUATION/ASSESSMENTS

The *US Virgin Islands Flood Hazard Mitigation Plan* (2016) plan has not been updated at this time. Still, in coordination with the Hazard Resiliency plan, there will be a collaborative effort established to provide an updated plan to reflect data collected post-disaster, given FEMA's Unified Guidance for the Hazard Mitigation Assistance programs. By bringing all the major hazard mitigation grant programs (HMGP, PDM, and FMA) under one combined and simplified grant process, there is no need for a separate Flood Hazard Mitigation Plan. In essence, this update of USVI Territorial Hazard Mitigation Plan, and all future updates, integrates flood hazard mitigation as one crucial component of an all-hazard perspective. The 2016 FMA plan included recommendations in two essential areas.

Regulation and Permitting - recognizing that existing rules and regulations governing flood hazard mitigation are of little value without adequate enforcement, the plan identified six different recommendations under this heading including:

Adequately staff, train and equip regulatory agencies charged with issuing permits;

- Provide training and education for government officials, developers, and residents;
- Add flood hazard mitigation criteria to Coastal Zone Management (CZM) permitting (see discussion below regarding the CZM Program);

- Designate the SFHAs as an Area of Particular Concern (see CZM);
- Strengthen implementation and enforcement aspects of zoning and subdivision regulations (see discussion below under Land Development Regulations); and
- Ensure strict enforcement of the US Virgin Islands Building Code (see Land Development Regulations).
- Watershed Management Approach – recognizing that "the success of the Flood Hazard Mitigation Plan relies on its implementation" and building on an established principal

Strategy for controlling pollutant discharges in the US Virgin Islands under the §6217 Coastal Non-Point Pollution Control Program (see discussion below under Section 2.3.3 – Other Related Programs), the plan highlighted the benefits of implementation based on hydrologic units (watersheds or drainage basins). This approach would also be consistent with related efforts under the Unified Watershed Assessment and Restoration Priorities Program (see Section 2.3.3). It could increase the effectiveness and efficiency of all three programs.

The recommendations highlighted above are reflected in the programmatic actions of this Plan Update (see Section 5.3.2). Specific flood mitigation actions such as structural mitigation measures (e.g., retention basins, levees or floodwalls, etc.) for particular areas of concerns are highlighted in Sections 5.3.3; 5.3.4 and 5.3.5. Also addressed are several proposed actions to develop hydrological and hydraulic analyses and watershed-based studies to address repetitive losses.

COASTAL ZONE MANAGEMENT

The Federal Coastal Zone Management Act of 1972 included requirements for the States and Territories of the United States to develop a coastal zone management program. The US Virgin Islands Coastal Zone Management Act of 1978 became effective in 1979. The resulting US Virgin Islands Coastal Zone Management Program was prepared by the US Virgin Islands Planning Office (which hassince been reorganized as DPNR) and submitted by the Governor to the US Department of Commerce.

The Program, as articulated in Title 12 VIRR, Chapter 21, §901-14, is based on a fundamental desire to preserve a significant environmental resource that benefits the economy and quality of life for the Territory's residents. Included with the Program's "findings and goals" (§903) are statements that directly relate to hazard mitigation, including:

- "there has been uncontrolled and uncoordinated development of the shorelines…" [Title 12 VIRR, Chapter 21, §903 (a)(6)],and

- "improper development of the coastal zone and its resources has resulted in … erosion, sediment deposition, increased flooding, gut, and drainage fillings…" [Title 12 VIRR, Chapter 21, §903 (a)(6)]

Also, §906 identifies a wide range of policies "applicable to the first tier of the coastal zone" that specifically reference hazard mitigation issues including development policy:

- "to the extent feasible, discourage further growth and development in flood-prone areas and assure that development in these areas is so designed as to minimize risks to life and property;" [Title 12 VIRR, Chapter 21 §906 (a)(9)], and environmental policy:

- "to … assure that activities in or adjacent to [complexes of marine resource systems … including reefs, marine meadows, salt ponds, mangroves, and other natural systems] are designed and carried out to minimize adverse effects on … storm buffering capabilities," [Title 12 VIRR, Chapter 21, §906 (b)(2)].

DPNR is the central territorial agency for the administration of the Coastal Zone Management program in the US Virgin Islands. Other principal entities include the Office of the Governor, Legislature, the Department of Public Works, and the Board of Land Use Appeals. The Coastal Zone Management Act created a Coastal Zone Management Commission within DPNR. A Division of Coastal Zone Management was also produced within DPNR to assist the Commission and the Commissioner in administration and enforcement of the Act. There are three committees within the Commission, one for each significant island. Each committee has authority over the administration of the Program within its "jurisdiction" including:

- issuance of Coastal Zone Management (CZM) permits;
- compliance with requirements related to Areas of Particular Concern (APC); and
- compliance with conditions associated with the Coastal Barrier Resources Act (CBRA)

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COASTAL ZONE MANAGEMENT PERMITS

The Coastal Land and Water Use Plan was approved and implemented as part of Title 12 VIRR, Chapter 21, §910. The Plan provides comprehensive guidelines for the development of Tier 1 of the Coastal Zone.

Tier 1 is defined as the area extending from the outer limit of the territorial sea (including offshore islands) to distances inland, as indicated on a set of maps. The Tier 1 area does not necessarily correspond to consistent physiographic characteristics or other regulatory boundaries such as the SFHAs, DPNR regulatory buffers (to wetlands, guts, and salt ponds) Tier 2 includes all other interior portions of the three major islands.

- CZM permits are only required for development proposed in Tier 1. The appropriate committee of the Coastal Zone Management Commission or the Commissioner must find that *"the development as finally proposed incorporates to the maximum extent feasible mitigation measures to substantially lessen or eliminate all adverse environmental impacts of the development; otherwise, the permit application shall be denied."* [Title 12 VIRR, Chapter 21, §910 (a)(2)]. It is also worth noting an important exclusion from the requirements for a CZM permit for existing structures as "no coastal zone permit shall be required according to this chapter for activities related to the repair or maintenance of an object or facility located in the coastal zone, where such activities shall not result in addition to, or enlargement, or expansion of such object or facility." [Title 12 VIRR, Chapter 21§903 (b)(1)]

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Also, the Coastal Zone Management Act made provisions for two different levels of permits; major and minor, which are administered with slight differences for land and water-based projects. Major permits incorporate the requirements of the zoning use permit, the earth change permit, shoreline alteration, and submerged lands permit (see discussion of Land Development Requirements below). Also, Environmental Assessment Reports (EARs) are required for major and minor water projects and all major land projects in Tier 1. The EARs include requirements for submittal of information regarding:

- Climate and weather conditions including potential impacts resulting from wind, wave, and flooding;
- Landforms, geology, and soils;
- Drainage, flooding and erosion control;
- Oceanography;
- Marine resources;
- Terrestrial resources;
- Wetlands;
- Rare and endangered species; and
- Air quality.

In addition, a major permit is not required for subdivisions. For all these activities excluded from the major permit, a minor permit is needed, but the requirements for submittal and approval are correspondingly weaker. In particular, as noted above, EAR's are not necessary for minor permits. However, there is a provision in Title 12 VIRR, Chapter 21, §910 (c)(2)(E), that "*if the Commissioner, upon reviewing any minor permit application …, determines that the proposed activity is likely to have significant adverse environmental consequences. He shall, upon giving notice to the applicant, forward such application to the appropriate Committee of the Commission for review as a major coastal zone permit.*"

EVALUATION/ASSESSMENTS

The CZM permit can be an essential part of the process of protecting coastal resources and reducing the impacts of natural hazards on people and property. However, there are inherent weaknesses in the systems that need to be addressed to provide consistent and meaningful hazard mitigation results in the Territory, including:

The Virgin Island Coastal Zone Management program faces increasing pressure to make decisions regarding competing demands for tourist development, protection of existing threatened properties, and the rights of private property owners. The relatively small size of the islands, the essential connection between the coastal resources and the watersheds that lie above them, and the magnitude of the natural hazards that the islands are subjected to, all make a strong argument that the Coastal Zone and Coastal Zone permits should be extended. At a minimum, all development throughout the Territory should be reviewed at the same level of scrutiny as those permit applications in Tier 1. If the CZM permit system were consistently and aggressively administered, it could provide the appropriate information regarding the potential impacts of the proposed development on the built and natural elements of the islands and, in turn, the effects of natural hazards on the proposed development.

- Besides, excluding subdivision from review as a significant permit activity (bypassing the requirements for EARs) substantially weakens the system. By not requiring an environmental assessment and an accounting of the impacts of natural hazards on the proposed development, the potential for inappropriate development in the floodplain is significantly increased. By the time permit applications come along for construction of improvements to deeded lots, they only cover pieces of the overall land development project and may not, in and of themselves, be deniable. It is hoped that the revisions to the subdivision and zoning codes that are currently underway may serve to remedy this deficiency at least partially. However, that remains uncertain as of the development of this Plan Update. The hope would be as the Resiliency plan is further developed, there would be a clearer understanding of how the entire process is currently functioning and how improvements can be developed and implemented to assist with proper maintenance and strengthening.

- It is important to reiterate that the focus of the EAR is the impact of the proposed development on the site and adjacent features with only passing emphasis placed on the potential impact of the site and its conditions on the proposed development. To be most effective, the existing EAR requirements need to be revised to include specific references (and threshold criteria of benefits and costs) to assessing vulnerability and estimating potential losses to property from natural hazards as well as the cost of emergency response and recovery operations attributable to the proposed development. Before this Plan update is required for additional updates to remain in compliance, there will be an all-Hazards Resiliency Plan ultimately developed that will assess in the updates of the EAR as well, ensuring that the requirements are revised, and concretely appraised fur continued response and recovery efforts.

The NOAA Final 312 Evaluation Findings of the Virgin Islands Coastal Zone Management Program reiterated concerns about development and earth change in Tier 2 in which erosion and sedimentation are *"one of the major impacts to coastal water quality and the long-term health of the Territory's coral reefs" (NOAA, 2003). The report goes on to indicate that situation is a very complex issue to resolve, especially on St Thomas and St. John, where a majority of land occurs on slopes greater than 25%.*

One of the positive aspects of the VICZMP is that a mechanism already exists for initiating the changes to the CZM process. Title 12 VIRR, Chapter 21, §912 (b) identifies a requirement for "continued planning," which states: *"[t]o ensure that the provisions of this Chapter are regularly reviewed and the recommendations for revisions of, or amendments to, the Virgin Islands Coastal Zone Management Program will be … developed, …and to provide for continued territorial coastal planning and management, the Virgin Islands Planning Office [now DPNR] shall undertake on a continuing basis such activity and research as is necessary to maintain a continued involvement in the coastal zone management process…".* This provides DPNR with the ability to make recommendations for amendments that could accommodate the recommended changes in the requirements and process.

It is necessary to note that the VICZMP has initiated changes to rules and regulations in 2006. The 2006 revisions, which are currently under review, do not refine or expand the extent of the coastal zone and/or redefine permit review or CZM commission procedures. The 2006 revisions to the rules and regulations introduce changes to administrative processes and add new permit fees.

AREAS OF PARTICULAR CONCERNEVALUATION/ASSESSMENTS

The Coastal Zone Management Act Defined Areas of Particular Concern (APC) and established criteria for selection in 15 CFR Part 923. The process should include the development of a management plan for each designated area. In part, the management plans are intended to make provisions for acceptable levels of future land development that, in turn, can be used to revise the zoning designations in these areas. As a result, a formidable tool is available through the APC management plans to set the direction for development in these areas in advance of permit applications – i.e., taking a proactive versus reactive approach to land use and hazard mitigation. To date, eighteen regions have been designated as APCs in the US Virgin Islands. At this time of this Plan Update, draft management plans have been developed for numerous areas.

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EVALUATION/ASSESSMENTS

It also cited that the implementation of many of the goals relied on various territorial agencies and called for the development of a clear strategy that prioritizes APC plan development and seeks to identify partners within Territorial agencies for the implementation. This is another area that will be further developed and assessed where there will be clearer prioritizations of goals and objectives which would assist the territory in further implementation measures. There will be measures in place that would develop a future growth trend analysis which would incorporate historical trends which will detail existing vulnerabilities and strategically come up with a plan to alleviate those concerns.

COASTAL BARRIER RESOURCE SYSTEM

The Coastal Barrier Resources Act (16 U.S.C. 3509) (CBRA) was enacted in 1982 and established the Coastal Barrier Resources System (CBRS). The Act states that in the resulting designated areas along the Atlantic and Gulf of Mexico coastlines, *"most federal expenditures are no longer available to promote economic growth or development."* Thirty-five different coastal regions of the US Virgin Islands, covering a total of 130 miles of the coastline and hundreds of acres of sensitive landscapes, are included in the designations.

The protection of significant areas of the coastal system has been realized. However, development activity in some of the watersheds have contributed to (and will continue to do so if unchecked) degradation of the resources.

EVALUATION/ASSESSMENTS

Protection only extends to the actual coastal barrier resource in question and not to the watershed that can adversely affect the resource. This could be addressed through more aggressive implementation of a watershed approach to land use planning, and both the quality and quantity aspects of stormwater and floodplain management.

LAND DEVELOPMENT REGULATIONS

Land development regulations play an essential role in an integrated, coordinated program of hazard mitigation. By controlling where and how development occurs, significant problems can be lessened or avoided. Also, as properties are redeveloped or rebuilt, strong regulations can ensure that the replacement or repaired structures are better able to resist damage from future events.

The upcoming Hazard Resiliency Plan will utilize a more developed version which will encompass a land cover classification process which would be crucial for the baseline understanding which would ensure accuracy and future assessments which will be developed

In the US Virgin Islands, there are three main elements to the land development regulations, including:

- Zoning;
- Subdivision Regulations; Building Codes; and
- Building Permits.

ZONING

US Virgin Islands zoning law is based on VIC Title 29, Chapter 3, Subchapter 1. The code divides all the islands into various land and water-based districts as tabulated below:

TABLE 3.1 Zoning Designations

Zoning Category	Percentage of Total Area Per. Island		
	St. Thomas	St. John	St. Croix
Low-Density Residential	70	42	54
Agricultural	<5		25
Medium Density Residential		3	7
Industrial	<5	<1	5
Waterfront – Pleasure	4	2.5	2
Business / Commercial			1
Public and Other	15	52	6

EVALUATION/ASSESSMENTS

By prohibiting or regulating development and redevelopment in hazard-prone areas, zoning can be an effective means to eliminate or reduce the risk of loss of life and property damage. This is most relevant to hazards that have defined geographic extents such as flooding. Comparing the results of the hazard profiling and risk assessment from this study with the existing zoning map would help identify areas where potential development may be in harm's way. This could lead to revisions in the map that provide a better match between the suitability of the land for development and the type and intensity of the use proposed.

Creating and implementing a revised zoning map that includes substantial reductions in development capacities in hazard-prone areas will have immediate results in limiting future losses. Zoning can also be used to reduce density in existing developed areas. By down-zoning (i.e., reducing allowable development densities and intensities), non-conforming uses will be established. Like the current system, these uses will persist until such time as the property owners request permits for substantial changes to the property or the property is substantially improved or damaged (i.e., at a level higher than 50 percent of its value). In these cases, provisions can take effect that reduces hazard vulnerability and / or the property cannot be redeveloped.

DPNR is in the process of revising the US Virgin Islands' zoning regulations. The current revisions do not change the zoning map or zoning designations. Still, they will serve to bring the zoning code up to current standards and provide more flexibility in development review procedures by reducing the need for extensive use of variances. The revisions that were implemented in 2014, intended to create a more streamlined, enforceable zoning process. It is DPNR's intent, based on the recommendations of the Rutgers and Duncan Associates study (discussed earlier in this section), to draft and adopt new land use and zoning legislation that defines a set of prescriptive rules and regulations to support the existing land uses and to promote the desired future development patterns to maintain the health, safety, and welfare of the community over time.

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SUBDIVISION REGULATIONS

The main issues related to the subdivision regulations in the US Virgin Islands (as contained in Title 29, Chapter 3, Subchapter 231 of the VIC) are as follows:

Minor division of land (i.e., development proposals with less than four lots) is not considered a subdivision under the US Virgin Island Code. It is reviewed by the Chief Surveyor, working under the Lt. Governor's Office. While there are some requirements addressing flood prevention, there are no enforceable complimentary stormwater management provisions for these minor subdivisions. However, in the aggregate, all development on a relatively small and closed system like the US Virgin Islands will have some level of impact on stormwater runoff and, therefore, can detrimentally influence the effectiveness of programs intended to reduce non-point source pollution, protect coastal resources, and mitigate flooding.

Subdivisions with four lots and higher are reviewed by a representative of the DPNR, Division of Comprehensive and Coastal Zone Planning (CCZP). However, for developments in Tier 1, the applicant only needs to address the requirements for a minor CZM permit. The problems with this approach have been discussed previously under the CZM Program section. With no set review criteria, no substantial stormwater management regulations, and no formal process for bringing in environmental expertise from other relevant DPNR divisions, it is difficult to influence the way development is planned and implemented in the US Virgin Islands to reduce exposure and risk.

Basic engineering practices related to land development need to be better incorporated into the subdivision regulations. For example, under the current regulations, it is possible to build roads in the Special Flood Hazard Area with elevations up to two (2') feet below the regulatory flood elevation. In practice, what this can and does result in is the road becomes a conveyance for stormwater, promoting unsafe conditions and promoting damage to the roadway that must be repaired by the Territory after significant storm events.

DPNR can take more significant advantage of innovative subdivision design and siting techniques than currently allowed under the existing subdivision regulations or proposed revisions by requiring or providing better incentives for cluster development, open space preservation, density-bonuses, setbacks, overlay zoning techniques (described earlier), and special considerations for developments in coastal high hazard areas (for more information on these innovative techniques the interested reader is referred to the FEMA/APA Planning Advisory Service Report # 473 entitled, Subdivision Design in Flood Hazard Areas, 1997).

It is necessary to note that DPNR and the Division of Environmental Protection have implemented a regulation requiring all applicants submitting documents and plans for construction or earth change permits, for developments one acre or higher, to provide a stormwater prevention plan. The stormwater prevention plan must consider pre-existing hydrology as well as postulate on post-construction run-off. The stormwater prevention plan must also clearly indicate how mitigation measures will be introduced in the site design. This action has the potential to be an effective strategy to ensure that surface run-off does not exceed pre-existing conditions and may assure that future development does not exacerbate flooding in downstream areas.

At the time of this Plan Update, the subdivision regulations were in the same revision process as the zoning codes. These revisions should also be completed by mid-2019 and are also expected to produce subdivision regulations that are easier to understand, interpret and enforce, that incorporate new technology and new ways of thinking about subdivision zoning, and that creates a path for the development of a comprehensive land-use plan, which does not currently exist in the US Virgin Islands.

BUILDING CODES

An effectively administered and enforced building code can save lives. For current use, the US Virgin Islands has adopted and enacted the International Construction Standards. These include:

- International Building Code (IBC) - Pertains to the construction of commercial and multi-dwelling buildings.
- International Residential Code (IRC) – Regulates the construction of single and two-family dwellings.
- International Mechanical Code (IMC) – Establishes standards for electrical, plumbing, and air quality systems.
- International Energy Conservation Code (IECC) – Pertains to the standards for energy-efficient structure construction

These codes established by the International Code Council contain specific references to hazard mitigation. Consistent enforcement of these construction codes should result in a significant reduction of property loss, especially from the hazards of windstorms, earthquakes, and fire. The building code was updated post-disaster and implemented in 2018 and has been provided to the public to prepare and build resilience for any potential risk that could occur.

EVALUATION/ASSESSMENTS

The implementation of the IBC, while a good step for the Territory, has met mixed results. In the evaluation for the Plan Update, DPNR has indicated that the local developers and architects have adopted and followed the IBC guidelines well. IBC Standards were forced to be changed and implemented post-disaster, being there was such a high level of damage recorded since the last disaster incident. The changes notated below were implemented in April of 2018, where guidance to the community was provided as to how they would be able to safely mitigate their repairs in the event of another potential hazard. DPNR stated these options are based on the latest model building code requirements, which included the US Virgin Islands essential wind speed of 165 miles per hour, as stated in the 2018 International Residential Building Code. The scope of the International Building Code includes all buildings except detached one- and two-family dwellings and townhouses up to three stories.'

The 2018 IBC contains many significant changes, such as:

- Accessory storage spaces of any sizes are now permitted to be classified as part of the occupancy to which they are accessory
- New code sections have been introduced addressing medical gas systems and higher education laboratories
- Use of Firewalls to create separate buildings is now limited to only the determinization of permissible types of construction based on allowable building area and height
- Live loads on decks and balconies increase the live deck load to one and one-half times the vital capacity of the area served.
- The minimum lateral load that firewalls are required to resist is five pounds per square foot.
- Wind Speeds maps updated Terminology describing wind speeds has changed again with ultimate design wind speeds now called necessary design wind speeds.
- Five-foot tall wood trusses requiring permanent bracing must have a periodic special inspection to verify that the necessary bracings have been installed.
- A new alternative fastener schedule for the construction of mechanically laminated decking is added, giving equivalent power-driven fasteners for the 20-penny nail.

Being able to work collaboratively with DPNR and FEMA to ensure the Building Code was adopted, territory-wide was a significant accomplishment for DPNR to achieve. Throughout the implementation process, VITEMA will extend technical support to DPNR. At the same time, they perform their capacity building opportunities that would, in turn, allow the entire territory to be strengthened through these updated building codes, which will build a more resilient community.

There will also be efforts during the development of the Resiliency plan, which will also allow processes to be defined and allow more straightforward techniques for the implementation procedures that would enable the information to be readily available to everyone.

BUILDING PERMITS

A measure of the enforcement of building codes is the number and type of building permits issued. The following tables illustrate the amount and type of building permits issued and inspections performed throughout the USVI from FY2008 – FY2019, as well as the estimated value of new construction resulting from these permits and inspections.

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TABLE 3.2 Building Permit, Inspection, and New Construction Data - FY2008

Permit Applications	Received Applications by District				Approved Applications by District		
	St. Thomas	St. John	St. Croix	Total	STT/STJ	STX	Total
Flood Plain	1	0	35	36	1	40	41
Plan Review	299	105	528	932	262	315	577
Demolition	8	1	22	31	5	23	28
Building	475	84	410	969	226	312	538
Plumbing	211	63	300	574	206	285	491
Electrical	422	68	487	977	422	445	867
Use and Occupancy	156	69	252	477	263	237	500
Sign	2	0	0	2	1	0	1

Site Inspections	Requested Inspections by District				Approved Inspections by District		
	St. Thomas	St. John	St. Croix	Total	STT/STJ	STX	Total
Flood Plain	1	0	26	27	1	14	15
Plan Review	106	41	55	202	108	59	167
Building	1035	558	1105	2698	1496	1089	2585
Plumbing	339	237	712	1288	519	749	1268
Electrical	615	243	830	1688	858	1125	1983
Violation	84	2	46	132	82	46	128
Site Visit	1003	84	73	1160	1182	113	1295

Estimated Construction Cost	St. Thomas	St. John	St. Croix	Total
New Construction	$137,567,534.00	$18,460,796.00	$92,301,398.00	$248,329,728.00

TABLE 3.3 Building Permit, Inspection, and New Construction Data - FY2009

Permit Applications	St. Thomas			St. John			St. Croix		
	Received	Approved	Issued	Received	Approved	Issued	Received	Approved	Issued
Flood Plain	0	0	0	0	0	0	27	33	26
Plan Review	158	118	91	55	40	38	509	432	388
Demolition	11	6	5	0	0	0	29	28	24
Building	418	256	180	75	22	18	485	457	391
Plumbing	215	167	220	50	29	20	335	225	221
Electrical	401	317	171	56	43	29	409	424	411
Use and Occupancy	153	147	135	46	39	39	247	210	188
Restoration (Hurricane)	0	0	0	0	0	0	10	10	0
Total	**1356**	**1011**	**802**	**282**	**173**	**144**	**2051**	**1819**	**1649**

Inspections	St. Thomas		St. John		St. Croix	
	Received	Approved	Received	Approved	Received	Approved
Flood Plain	0	0	0	0	3	0
Plan Review	119	131	45	32	39	39
Building	842	1112	445	419	1099	782
Plumbing	313	280	220	229	676	695
Electrical	545	746	316	299	970	1411
Violation	153	172	8	7	22	80
Site Visit	1213	1507	31	40	44	44
Restoration	0	0	0	0	21	20
Total	**3185**	**3948**	**1065**	**1026**	**2874**	**3071**

Estimated Construction Cost	St. Thomas	St. John	St. Croix	Total
New Construction	**$63,989,406**	**$6,358,632**	**$124,472,981**	**$194,821,018**

TABLE 3.4 Building Permit, Inspection, and New Construction Data - FY2010

Permit Applications	St. Thomas			St. John			St. Croix		
	Received	Approved	Issued	Received	Approved	Issued	Received	Approved	Issued
Flood Plain	0	0	0	0	0	0	11	16	15
Demolition	14	5	4	3	3	3	35	39	33
Building	355	251	213	54	44	30	469	432	418
Plumbing	152	158	93	23	22	12	262	256	240
Electrical	315	275	181	54	46	31	490	449	437
Use and Occupancy	148	151	142	30	34	32	273	262	226
Total	**984**	**840**	**633**	**164**	**149**	**108**	**1540**	**1454**	**1369**

Inspections	St. Thomas		St. John		St. Croix	
	Received	Performed	Received	Performed	Received	Performed
Flood Plain	0	0	0	0	0	0
Building	807	883	633	587	1175	996
Plumbing	307	315	192	181	667	632
Electrical	601	599	202	202	987	1204
Violation	77	77	16	16	20	19
Site Visit	693	693	55	55	39	39
Total	**2485**	**2567**	**1098**	**1041**	**2888**	**2890**

Estimated Construction Cost	St. Thomas	St. John	St. Croix	Total
New Construction	$63,328,779	$8,426,109	$92,917,843	$164,672,730

TABLE 3.5 Building Permit, Inspection, and New Construction Data - FY2011

Permit Applications	Received			
	St. Thomas	St. John	St. Croix	Total
Flood Plain	0	0	16	**16**
Demolition	6	0	21	**27**
Building	350	0	383	**733**
Plumbing	107	0	148	**255**
Electrical	602	0	418	**1,020**
Use and Occupancy	145	0	133	**278**
Site Inspections	**Requested**			
	St. Thomas	St. John	St. Croix	Total
Building				562
Plumbing				192
Electrical				485
Net Metering				162
Total Site Visits				**1401**

Estimated Construction Cost	St. Thomas	St. John	St. Croix	Total
New Construction	102,710,395.30		58,880,542.20	161,590,931.00

TABLE 3.6 Building Permit, Inspection, and New Construction Data - FY2012

Permit Applications	Received			
	St. Thomas	St. John	St. Croix	Total
Flood Plain	0	0	10	**10**
Demolition	5	0	15	**20**
Building	328	0	351	**679**
Plumbing	114	0	220	**334**
Electrical	550	0	362	**912**
Use and Occupancy	60	0	157	**217**
Site Inspections	**Requested**			
	St. Thomas	St. John	St. Croix	Total
Building				603
Electrical				610
Net Metering				135
Total Site Visits				**1348**

Estimated Construction Cost	St. Thomas	St. John	St. Croix	Total
New Construction	88,716,777.20		45,710,424.00	134,427,201.20

TABLE 3.7 Building Permit, Inspection, and New Construction Data - FY2013

Permit Applications	Received			
	St. Thomas	St. John	St. Croix	Total
Flood Plain	0	0	7	**7**
Demolition	8	0	15	**23**
Building	261	0	333	**594**
Plumbing	82	0	131	**213**
Electrical	264	0	356	**620**
Use and Occupancy	36	0	178	**214**
Site Inspections	**Requested**			
	St. Thomas	**St. John**	**St. Croix**	**Total**
Building				572
Plumbing				310
Electrical				626
Net Metering				64
Total Site Visits				**1572**

Estimated Construction Cost	St. Thomas	St. John	St. Croix	Total
New Construction	88,716,777.20		45,710,424.00	134,427,201.20

TABLE 3.8 Building Permit, Inspection, and New Construction Data - FY2014

Permit Applications	Received			
	St. Thomas	St. John	St. Croix	Total
Flood Plain	2	0	5	**7**
Demolition	13	0	20	**33**
Building	146	0	315	**461**
Plumbing	10	0	148	**158**
Electrical	78	0	262	**340**
Use and Occupancy	15	0	96	**111**
Site Inspections	**Requested**			
	St. Thomas	**St. John**	**St. Croix**	**Total**
Building				451
Plumbing				220
Electrical				399
Net Metering				26
Total Site Visits				**1096**

Estimated Construction Cost	St. Thomas	St. John	St. Croix	Total
New Construction			82,271,744.00	0.00

TABLE 3.9 Building Permit, Inspection, and New Construction Data - FY2016

Permit Applications	Received			
	St. Thomas	St. John	St. Croix	Total
Flood Plain	0	0	9	**9**
Demolition	25	0	34	**59**
Building	1590	0	1886	**3,476**
Plumbing	101	0	118	**219**
Electrical	298	0	359	**657**
Use and Occupancy	64	0	61	**125**
Site Inspections	**Requested**			
	St. Thomas	St. John	St. Croix	Total
Building				
Plumbing				109
Electrical				0
Net Metering				3
Total Site Visits				**112**

Estimated Construction Cost	St. Thomas	St. John	St. Croix	Total
New Construction				

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TABLE 3.10 Flood Mitigation Assistance and Pre-Disaster Mitigation Grant Projects in the USVI

Flood Mitigation Assistance and Pre-Disaster Mitigation Grant Projects in the US Virgin Islands						
FY	**Grant No.**	**Grantee/ Sub-Grantee**	**Project Title & General Summary of Project Goal**	**Federal**	**Non-Federal**	**Total Project**
Flood Mitigation Assistance Program						
2014	PDMC-PJ-02-VI-2014-002	VITEMA/VIWMA	St. Croix Coastal Interceptor Location Project: The project consists of the easement and land acquisition to clean and inspect sewer lines with close circuits camera, clean sewage lines, install two lateral connections, and install new force main piping with air release valves.	**$1,845,374.00**	**$615,150.00**	**$2,460,524.00**
2014	PDMC-MC-02-VI-2014-003	VITEMA/WAPA	VITEMA Headquarters St. Thomas Electrical Underground Mitigation Project Installation efforts of placing all electrical switch that would terminate existing electrical abilities while installing new system which would allow stronger capabilities for the headquarters.	**$249,899.99**	**$83,300.01**	**$3,073.093.87**
2015	PDMC-PJ-02-VI-2015-002	VITEMA/JFL	Juan F. Luis Hospital Mitigation Project This project is to seek support for the purchase of one emergency backup generator and installation fees.	**$234,375.00**	**$78,125.00**	**$234,375.00**
2017	PDMC-PL-02-VI-2017-006	VITEMA	USVI Standard State Hazard Mitigation Plan Update VITEMA will be updating its existing multi hazard mitigation plan to comply with Federal regulations to remain in eligibility.	**$150,000.00**	**$50,000.00**	**$200,000.000**

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TABLE 3.11 Hazard Mitigation Grant Program Projects in the US Virgin Islands

Flood Mitigation Assistance and Pre-Disaster Mitigation Grant Projects in the US Virgin Islands					
Disaster Number	Applicant/Project Name	Total Estimated Cost	Total Approved Net Cost	Federal Share	Non-Federal
1503	**Virgin Islands Department of Education/** Upgrade Existing stormwater system to Pearl B. Larsen School in St Croix, VI.	**$38,220**	**$38,220**	**$37,700**	**$0.00**
1567	**Virgin Islands Department of Education/** Installation of Shutters at the Oliver Benjamin School Shutters in St Thomas. Acquisition and Installation of RE-60 roll-up shutters to protect the Benjamin School Cafeteria and Library Storefront.	**$113,870**	**$113,870**	**$113,870**	**$0.00**
1807	**Department of Property and Procurement/** Hurricane High Impact Windows (STT)	**$466,667**	**$466,667**	**350,000.25**	**$116,666.75**
1807	**Department of Public works/** Hurricane High Impact Windows (STT)	**$146,667**	**$146,667**	**$110.000.25**	**$36,666.75**
1807	**Department of Human Services/** Hurricane High Impact Windows (STT)	**$192,414**	**$192,414**	**$144,310.50**	**$48,103.50**
1807	**Department of Education/** Hurricane High Impact Windows (STT)	**$32,467**	**$32,467**	**$24,350.35**	**$8,1116.75**
1807	**American Red Cross/** Storm Shutters (STX)	**$64,509.33**	**$64,509.33**	**$48,382.00**	**$16,127.33**
1807	**Virgin Islands Fire Service (Emilie Henderson)/** Storm Shutters (STX)	**$18,467.00**	**$18,467.00**	**$13,850.25**	**$4,616.75**

Flood Mitigation Assistance and Pre-Disaster Mitigation Grant Projects in the US Virgin Islands					
Disaster Number	Applicant/Project Name	Total Estimated Cost	Total Approved Net Cost	Federal Share	Non-Federal
1807	**Virgin Islands Fire Service (Renceliar Gibbs)/** Roll-up Doors (STX)	**$22,916.00**	**$22,916.00**	**$17,187.00**	**$5,729.00**
1807	**Virgin Islands Port Authority/ Henry E. Rohlsen/** Fabric Shutter System (STX)	**$236,044.00**	**$236,044.00**	**$177,033.00**	**$59,011.00**
1807	**Department of Health (DeCastro Clinic)/** Storm Shutters (STJ)	**$21,305.33**	**$21,305.33**	**$15,979.00**	**$5,326.33**
1939	**Water and Power Authority (WAPA)/** Wind Retrofitting of the Pad Mounted Transformers on St Croix (Replacing large pole mounted transformers banks with pad mounted transformers at local elementary schools in STX.	**$315,000**	**$315,000**	**$236,250**	**$78,750**
1939	**VI Fire Service/** Roll Up Doors at Emile Henderson Fire Station	**$43,509**	**$43,509**	**$32,632**	**$10,877**
1948	**Water and Power Authority (WAPA)/** Wind retrofitting of Pad Mounted Transformers	**$307,052**	**$307,052**	**$230,289**	**$76,763**
1949	**Water and Power Authority (WAPA)/** Replacement of three phase trans closures with pad mounted transformers, St. Croix	**$499,255**	**$499,255**	**$374,441**	**$124,814**

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FIGURE: 3.1 Primary and Secondary Mitigation Responsibilities of Agencies in the US Virgin Islands

MITIGATION TASK	VITEMA	DPNR	DPW	VIFS	VIPD	DOT	OMB	P&P	VIPA	DOJ	DSP&R	VIEO	VIDA	DOH	VING	DOL	BIT	DHS	VIDE	VIWMA	WAPA
Planning / Management Issues																					
Acquisition		S					S	P													
Location of Public Buildings		S																			
Warning Systems	P			P	P																
Flood / Hazard Insurance		P																			
Disaster Loans and Grants						S	S														
Education / Public Information	P	S				S		S													
Demarcation of Hazard Areas	S	P		S																	
Building / Health Code Revisions			P																		
Inspection Programs		P	P	S																	
Floodplain Easements		P	P					P													
Floodplain Regulation		P																			
Hazard Risk Assessment	S			S				P													
Development Restrictions		P																			
Hazard Disclosure Regulation		S		P				S													
Zoning Regulations		P																			
Wetland Regulations		P																			
Acquisition of Development Rights		P					S	P													
Areas of Particular Concern		P																			
Open Space Planning		P																			
Relocation			P																		
Special Fees and Taxes		S					S	S													
Hazard Monitoring	P	S	P	P				S	P												P
Preparedness Planning	P	S	P	P		S	S														P
Flood Proofing			P					P													
Structural Issues																					
Flood Proofing, Gut Maintenance																					
Preparedness Planning	P	P																			
Stormwater Systems			P																		
Modify Structures			P					P													P
Breakwaters, Bulkheads, etc.		S						S	P												
Shore Protection Measures		S						S	S												
On-Site Detention / Dams		S	P					S													
Channel Modifications / Culverts		S	P					S													

Legend: Mitigation Responsibilities	
P	Perceived Primary responsibility
S	Perceived Secondary responsibility

It may not always be clear which agency is responsible for taking the lead role, and which department exists under, or works closely with, which agency. The following shows the relationship between Departments and Agencies:

US Virgin Islands Departments and Agencies

- Virgin Islands Territorial Emergency Management Agency (VITEMA)
- Department of Planning and Natural Resources (DPNR), including the Divisions of Permits (DOP)and Subdivisions; Coastal Zone Management; Environmental Protection; and Fish and Wildlife.
- Department of Agriculture
- Department of Education
- Department of Public Works
- Office of Management and Budget

US Virgin Islands Committees

- Hazard Mitigation Committees
- Coastal Zone Management Commission Committees
- Non-Point Source Pollution Steering Committee

University of the Virgin Islands (UVI) Departments

- UVI Cooperative Extension Service
- UVI Center for Marine and Environmental Studies
- Virgin Islands Conservation Data Center of the Eastern Caribbean Center of UVI
- Water Resources Research Institute

As a result, several departments, agencies, and authorities in the US Virgin Islands continue to have existing and potential roles in the implementation of the updated 2019 Virgin Islands Territorial Hazard Mitigation Plan.

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STAFFING

As previously stated, VITEMA, DPNR, and DPW are the key governmental agencies that have the primary responsibility for the development and implementation of Hazard Mitigation in the Territory. This is particularly true for Floodplain Management, Environmental Planning and Permitting, Building Code Enforcement, Coastal Zone Management, and Capital Improvement Projects.

While each of these agencies is tasked with the success of territorial hazard mitigation, each agency presently is overwhelmed with the implementation of its core program or department mandates. Faced with the budgetary constraints of the central government and the uncertainty future general revenues, each of these agencies needs for additional staffing to be fully able to address the concerns of Hazard Mitigation. Each agency has numerous unfilled positions making full compliance with the program mandates almost untenable. The lack of essential personnel and insufficient experience exacerbates both compliance and enforcement. The problem is most critical in DPNR, which oversees the divisions of Coastal Zone Management, Permits and Subdivisions, Fish and Wildlife, and Environmental Protection.

This situation is likely to persist throughout the life of this revision period. Even though each agency is insufficiently staffed, each agency, as well as the administration of the central government, have the dedication to, and the concern for, the mandates of the Virgin Islands Territorial Hazard Mitigation Plan and will actively pursue its implementation.

For VITEMA, the Hazard Mitigation team has grown tremendously with consideration of the Disaster Recovery funds; the team has established positions that would assist in the planning capabilities. The Mitigation Planning structure has improved since the 2014 Plan update, which has allowed an enhanced organizational structure that would allow better management of hazard mitigation planning and project needs of the Territory.

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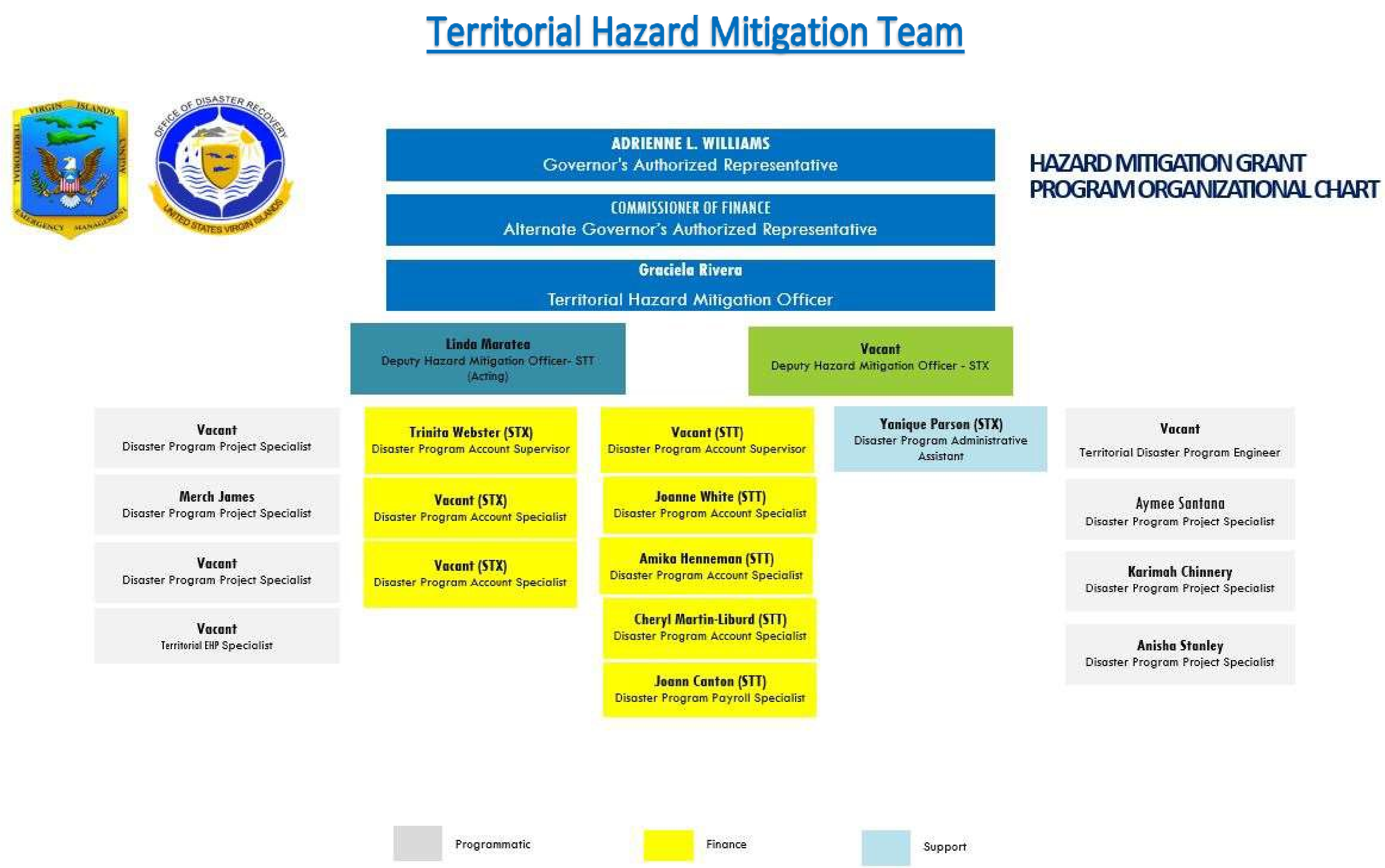
FIGURE: 3.2 Personnel within Territorial Hazard Mitigation Department



For DPNR, a severe need for qualified GIS staff exists, which will allow for a more thorough and more effective permitting process. Since 2011, all inspectors will be certified by the International Code Council and will be required to maintain that certification through the completion of CEUs. This is expected to result in a better, trained, better-qualified workforce. Serious consideration is also being given to increasing the number of Certified Floodplain Managers (CFMs) in the DPNR, as this will also result in better floodplain management throughout the Territory. Also, through the Hazard Mitigation Grant Program, DPNR has been allowed to hire adequate and highly trained employees who would be able to assist in the building of their workforce capacity. Also, as mentioned before, the Resiliency plan will help tremendously with specified training that would enhance individuals in the community to be able to be qualified for these positions, which in terms of longevity will assist DPNR.

TECHNICAL CAPACITY

The evaluation for the 2014 Plan Update highlighted the urgent need for data collection and management of hazard information. Currently, there are still minimal technical capabilities in the Territory, although staffing capabilities have improved drastically post-disaster, sustainability is a high priority for the territory.

VITEMA has limited technical data management capabilities. Most critical is the need for archiving and managing data related to hazards and/or hazard mitigation programs. VITEMA presently does have a dedicated staff which will allow a better system to be established for the collection and archiving hazard plans or studies (i.e., hurricane plans, earthquake plans, riverine and coastal flood plans). The collection of such information would facilitate a more thorough assessment of the hazards such as the location of events, previous occurrences within the Territory, and promote a better prediction of the probability of future events. This would also facilitate a more comprehensive assessment of hazards and risks.

The technical capabilities for the implementation of hazard mitigation programs and plans also remain weak. While VITEMA has maintained its capabilities for the implementation of hazard mitigation programs and plans since the 2014 Plan; most of the staff are relatively new and have limited experience in hazard mitigation but are actively participating in capacity building training where the ability to further their understanding of hazard mitigation will be expanded.

For many, the most recent disaster declaration is their first real exposure to hazard mitigation issues, programs, and plans. VITEMA staff, therefore, must continue to require extensive training in hazard mitigation concepts (i.e., floodplain management, benefit-cost analysis, etc.) as well as hazard mitigation grant support (i.e., grant writing, project and application development and review, accounting, and financial reporting, etc.) which have already been initiated.

SUMMARY AND RECOMMENDATIONS

This section points the way to specific recommendations to be included in the mitigation strategy: The first table relates Territorial plans/programs/regulations to the relevant CFR requirements and assesses effectiveness in supporting hazard mitigation. The second table provides a summary of significant "gaps" in the Territory's capabilities and recommendations to address the gaps.

REGULATORY COMPLIANCE WITH DMA 2000

Section 3 identified the basic requirements of the CFR for Capability Assessments. Key components of those requirements ask to what extent the Territory's policies, programs, and capabilities support:

- Pre-disaster hazard mitigation; and
- Post-disaster hazard mitigation; and
- Regulation of development in hazard-prone areas

The findings of the evaluation for this Plan Update illustrate that the US Virgin Islands' capabilities to address hazard mitigation have changed tremendously since the development of the 2014 Plan. Many of the requisite tools are currently in place. They are continuing to evolve with efforts such as the development of the Resiliency Plan, which will assist with the territory's capacity-building efforts.

Therefore, the Virgin Islands has not reached its full potential to support hazard mitigation. Still, significant improvements have been notated that will begin to be further developed prior to the upcoming Plan update. Both disasters have shed light on the severity of not being adequately prepared for a disaster can do the community and the economy. Building resilience and mitigative efforts are imperative to limit the damage of any potential hazard that could occur, the territory along with VITEMA understands the importance by developing a Hazard Mitigation Team along with nurturing the relationships between federal partners to ensure the territory is prepared at all times.

TABLE 3.12 Regulatory Compliance with DMA 2000

Description	Pre-Disaster Hazard Mitigation	Post-Disaster Hazard Mitigation	Regulation Development
General Plans and Policies			
Coastal Zone Management Plan	1	1	1
Comprehensive Land Use Planning	1	1	1
Pre-Disaster Hazard Mitigation Plans, Rules and Regulations			
National Floodplain Insurance Program	1	0	1
Multi-Hazard Flood Map Modernization Program	1	0	1
US Virgin Islands Flood Mitigation Plan	1	1	1
Flood Damage Prevention Rules	1	0	1
Coastal Zone Management Permitting	1	0	1
Areas of Particular Concern	1	0	1
Coastal Barrier Protection System	1	1	1
Zoning	1	0	1
Subdivision Regulations	1	0	1
Building Codes	1	1	0
Post-Disaster Hazard Mitigation Plans, Rules and Regulations			
Emergency Management Council	1	2	0
US Virgin Islands Flood Mitigation Plan	1	1	1
Hazard Mitigation Grant Administrative Plan	1	1	2
Emergency Operations Plan	0	1	0
Hurricane Evacuation Plan(s)	1	2	0
Other Related Programs			
Unified Watershed Assessment and Restoration Priorities Program	1	1	1
Non-Point Pollution Control Program	1	1	1
Sediment Reduction Program	1	1	1
Protection of Endangered Species	1	1	1

Legend

0	No potential relationship
1	Potential exists to support activity but is not fully realized
2	Supports activity to full potential of the plan, program, or policy

SPECIFIC RECOMMENDATIONS

Table 3.13 was included in the 2014 Plan and has been updated, where appropriate. It summarizes the recommendations (organized according to the major categories) that can help continue the process of making hazard mitigation more integrated into the day-to-day operations and long-range planning efforts of the US Virgin Islands government.

TABLE 3.13 Recommendation

Description	Recommendations for Addressing Issues Identified in Capability Assessment	Implemented in the Previous Plan Update Cycle
General Plans and Policies, including: ✓ **Coastal Zone Management Plan** ✓ **Completion and adoption of Subdivision and Zoning Code Revisions**	✓ Incorporate hazard mitigation directly into existing and proposed general-purpose plansin the US Virgin Islands to increase the "profile" of hazard mitigation and ensure incorporation of hazard mitigation in the resulting and related rules and regulations ✓ Institutionalize hazard mitigation into Territorial public investments	✓ **Revision of Subdivision and Zoning Code Revisions underway, with help from technical experts**
Pre-Disaster Hazard Mitigation Plans, Rules and Regulations, including: ✓ **National Floodplain Insurance Program** ✓ **Flood Damage Prevention Rule** ✓ **Coastal Zone Management** ✓ **Permitting** ✓ **Areas of Particular Concern** ✓ **Coastal Barrier Protection System** ✓ **Zoning** ✓ **Subdivision Regulations** ✓ **Building Codes**	✓ Decrease numbers of repetitive loss properties ✓ Continue to increase participation in the NFIP ✓ Avoid development in hazard prone areas ✓ Increase freeboard requirements for development that is approved in flood prone areas ✓ Require buildable areas in lots outside of Special Flood Hazard Areas ✓ Extend CZM permit requirements to all the islands ✓ Require major permit application procedures for subdivision (island wide), i.e., remove Tier 1 and Tier 2 distinctions to the extent possible ✓ If tiered system remains, revise Tier 1 boundaries to included regulated natural features such as floodplains, wetlands, salt ponds, mean high tide, and associated buffers. ✓ Increase hazard assessment aspects of EAR process ✓ Continue APC management planning ✓ Assess development suitability in terms of hazard vulnerability as a first step in revising zoning designations to better reflect risk and exposure ✓ Strengthen planning and enforcement	✓ **All building inspectors are now required to be certified by ICC, and are required to maintain that certification**

Description	Recommendations for Addressing Issues Identified in Capability Assessment	Implemented in Previous Plan Update Cycle
	Capabilities through increased staffing and training: ✓ Strengthen data collection and management capabilities, to create database and sources for use in project development and justification	
Post-Disaster Hazard Mitigation Plans, Rules and Regulations, including: ▪ **Emergency Management Council** ▪ **Hazard Mitigation Grant Administrative Plan** ▪ **Emergency Operations Plan** ▪ **Hurricane Evacuation Plan(s)**	✓ Improved management of federal grants ✓ Increase funding for matching federal grants ✓ Integrate hazard mitigation and sustainability considerations into post- disaster recovery process	✓ **HMGP sub-grants have been made available in the aftermath of 3 Presidential declarations in 2017**
Other Related Programs, including: ▪ **Unified Watershed Assessment & Restoration Priorities** ▪ **Non-Point Pollution Control Program** ▪ **Sediment Reduction Program** ▪ **Protection of Endangered Species**	✓ Extend the watershed approach from relatedprograms to hazard mitigation and development review process.	

The capability assessment evaluated both the "written word" on mitigation (i.e., the adopted or proposed legislation, regulations, plans, and policies in the US Virgin Islands) and the administrative capabilities of US Virgin Islands agencies, departments, and authorities.

In summary, many of the necessary policies, regulations, and programs are already in place. Likewise, the Government of the Virgin Islands can draw upon the existing expertise in several key departments charged with implementing many of the mitigations recommended in this Plan.

To provide support for Hazard mitigation planning the US Virgin Islands Government should try to augment existing resources and agency operating budgets to make a significant impact over the next five years in creating a more sustainable future for the Territory.

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SECTION FOUR: RISK ASSESSMENT

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

- Introduction and Methodology
- CFR Requirements for Risk Assessment
- Hazard Identification
- Hazard Profile
- Inventory of Assets
- Vulnerability Assessment
- Loss Estimates
- Loss Estimation Summary and Hazard Ranking

INTRODUCTION AND METHODOLOGY

The risk assessment methodology utilized in this Plan Update is the same as was utilized in the 2014 Plan, but the incorporation of post disasters data and risk will be adopted. 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 4.0 shows the four significant steps that comprise the risk assessment process: Hazard Identification, Hazard Profiling, Vulnerability Assessment, and Loss Estimation.

Many natural and technological hazards and adversarial threats have the potential to affect the Virgin Islands. An additional incorporation was also added to the plan which allowed the ability to analyze man made hazards as well although to include the following additions:

- Cyber/Hazardous Material Release,
- Infectious Disease (Pandemic),
- Transportation incidents; and additional potential hazards will also be included.

FIGURE: 4.0 Risk Assessment process

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, UVI, LTRG, and the general public.

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

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 seriousness. Each hazard type has unique characteristics that can impact the Territory in different ways. At the hazard identification phase, several significant 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 this Plan Update. They are listed in the order that they will be discussed in the Plan Update:

Natural Hazards

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

Human-caused Hazards

- Cyberattack
- Hazardous Material Release
- Infectious Disease (Pandemic)
- Transportation

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 historical 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 2014 plan update, and mitigation actions were included in the 2019 Plan to collect information concerning the location, frequency, and history of these events in the Territory. There has data has been compiled for use in this Plan Update and that data gap will limit the ability to profile these hazards fully – I.e., catalog of events from which to ascertain their frequency of occurrence and/or estimate the magnitude of historical facts, let alone to estimate vulnerability and losses (i.e., future impacts) accurately

It is also necessary to note that some hazard models or maps have been developed for the 2019 Plan update, with information assessed during the post-disaster period. The potential impact of climate variability on natural hazards identified in the plan has been discussed qualitatively in the description of the hazards as well as the deficiencies in addressing the impacts of climate change in a more quantitative manner. As such, actions have been added to the Mitigation Strategy (Section 5) of this Plan Update.

STEP 3 – INVENTORY OF ASSETS

The inventory of assets quantifies what can be lost when a hazard occurs. Precisely, 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, the value of buildings, and the population in the Territory.
- Determine the proportion of buildings, the value of buildings, and the population located in hazard-prone areas, and
- Calculate the proportion of assets located in hazard areas.

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

POPULATION

2010 U.S. Census information was updated using projected annual population growth rates for the Territory. 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.

CRITICAL FACILITIES AND INFRASTRUCTURE

A detailed list of critical facilities and infrastructure was developed by VITEMA with input from the Hazard Mitigation Steering Committee. The list was based on critical facilities included in the 2014 Plan, the Critical Facility Infrastructure Plan, and from information collected from the Department of Property and Procurement. Detailed procedures used to update exposure values of critical facilities (replacement and content values) are provided below:

VITEMA constructed the current listing of critical facilities and infrastructure. The listing was the same as the listing used in the 2014 Plan with the exception of the recent addition of ViNGN by Governor Map on May 31, 2018. Site visits were necessary as the general structural characteristics and general conditions of each critical facility did change significantly since the previous update due to the two disasters that impacted the territory in 2017.

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. The damage post-disaster was also incorporated to indicate the amount of vulnerability that was compromised during the disaster period and recovery phase.

Replacement and content values for facilities for the 2014 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 updated post- disaster.

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 for this plan update.

The incorporation of the updated International Building codes also had an impact on pricing and inflation.

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 the characteristics of hazards (i.e., wind, speed, flood depth, etc.) 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 (deficient, 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. Information made available by the information provided by UVI and the Mitigation Assessment Team assisted with defining the vulnerabilities and how mitigative efforts can be improved.

STEP 4—LOSS ESTIMATION

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 economic loss potential. In its purest 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 HAZUSMH for hurricane wind, earthquake and flooding, various published reports, expert opinion, and other propriety information. Data availability post-disaster did allow for the development of damage functions or the newly identified hazards. Still, hazards such as drought, rain-induced landslide, and wildfire could not clearly be defined as data limitations. 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 specific hazard intensity level (i.e., hurricane wind speed).

2) Exposure to a specific hazard (i.e., the number of buildings, % percentage of entire buildings, and value) was determined for identified buildings (general building stock and critical facilities).

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.

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).

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 is 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.

It is important to note that loss estimates in this risk assessment used the best available data and methodologies but should still be considered approximates. 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.

Difficulties also result from approximations and simplifications that are necessary for a comprehensive analysis (e.g., incomplete, or outdated inventory, demographic, or economic parameter data).

CFR REQUIREMENTS FOR RISK ASSESSMENT

CFR REQUIREMENTS FOR HAZARD IDENTIFICATION AND PROFILES

201.4(c)(2) of the CFR 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 statewideoverview.

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 specific local risk and vulnerability assessments.

The CFR 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.

CFR REQUIREMENTS FOR VULNERABILITY ASSESSMENT AND LOSS

The CFR 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 operated buildings, infrastructure, and critical facilities located in the identified hazard areas. ‖

US Virgin Islands local risk assessments were somewhat available as well as assessment reports that were able to assist in the adaptation of this plan update. In order to provide risk comparisons among the islands, the Hazard Mitigation Team performed, for each island, local risk assessments that meet the CFR Requirement §201.6(c)(2) for local mitigation plans. These local risk assessments, while not required by the State CFR guidelines, provide information valuable to the mitigation process.

HAZARD IDENTIFICATION

Since the completion of the 2014 Plan, there have been two Presidential Declarations in the US Virgin Islands in 2017, an unprecedented event no one could have imagined would occur. As a result, the Territory suffered a significant loss of property from the two hurricanes. Since 1995, the US Virgin Islands has received thirteen presidential disaster declarations. Yet, none have been as vital as the two Category 5 Hurricanes that made an impact in a two-week time span. As shown in Table 4.1, the primary sources of damages in recent years have been hurricanes and flooding.

Table 4.1 USVI Presidential Disaster Declarations

Presidential Disaster Declarations in the US Virgin Islands, 1994 – 2018			
Year	**Disaster #**	**Date**	Declaration / Disaster Type
1995	**1067**	**16-Sep**	Major Disaster / Hurricane (Marilyn)
1996	**1126**	**10-Jul**	Major Disaster / Hurricane (Bertha)
1998	**1248**	**24-Sep**	Major Disaster / Hurricane (Georges)
1999	**1309**	**23-Nov**	Major Disaster / Hurricane (Lenny)
1999	**1309**	**18-Nov**	Emergency / Hurricane (Lenny)
2003	**1503**	**9-Dec**	Major Disaster / Flooding
2004	**1567**	**7-Oct**	Major Disaster / Tropical Storm (Jeanne)
2008	**1807**	**29-Jan**	Major Disaster / Hurricane (Omar)
2010	**1949**	**24-Nov**	Severe Storms, Flooding, Rockslides, and Mudslides associated with Tropical Storm Tomas
2010	**1948**	**5-Nov**	Severe Storms, Flooding, Mudslides, and Landslides associated with Tropical Storm Otto
2010	**1939**	**28-Sep**	Major Disaster / Hurricane (Earl)
2017	**4335**	**7-Sep**	Major Disaster / Hurricane (Irma)
2017	**4340**	**20-Sep**	Major Disaster / Hurricane (Maria)

These hazards have challenged the US Virgin Islands to develop ways to reduce future damages and understand the gravity of aggressive mitigative efforts and preparations. 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 2014 Plan as well as new hazards that were identified post-disaster. There were further additions; it is essential to note that the Tsunami section in this Plan Update was updated due to new hazard mapping data. There were also updates to the rain, wind, flooding recorded after Hurricane Maria and Irma. The list of hazards addressed in this Plan Update include:

- Drought,
- Earthquake,
- Riverine Flooding,
- Coastal Flooding and Erosion,
- Hurricane Winds,
- Rain-Induced Landslide,
- Tsunami, and
- Wildfire
- Man Made Hazards Tablet Needed
- Cybersecurity
- Hazardous Material release
- Infectious Diseases (Pandemic)
- Criminal Terrorist Nation Attack

Each natural hazard was discussed in detail during the External Taskforce meeting, as well as the internal VITEMA Hazard Mitigation Team meetings, in addition to summarizing the hazards evaluated and the risk assessment process was discussed collaboratively with UVI's Dr. Guannel. He provided his expertise and knowledge with changes that were assessed and analyzed post-disaster.

The feedback that was offered from Citizens on St. John expressed concerns about hurricanes, earthquakes, landslides. At the same time, residents on St. Thomas and St. Croix spoke about hurricanes, earthquakes and had a more significant concern about riverine flooding.

Hazard identification was conducted during a series of an interagency meeting where feedback was provided as to how Hazard Mitigation Grant Funding can assist with the potential risk for hazard, there was discussing of concerns among critical agencies and how VITEMA would be able to provide technical assistance.

The result of this input and pursuant discussion with VITEMA allow for an evaluation of each of the hazards with criteria that were outlined in the 2019 Plan Update. The evaluation criteria included the following five significant 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 the informational meetings contributed through a lively discussion of both the reasons for inclusion and, conversely, the reasons for the exclusion of hazards that should be addressed in this Plan Update. The decision for the integration of the following hazards was made by the Hazard Mitigation Steering Committee. This was indicated to the Hazard Mitigation team that all hazards included in the 2014 Plan are still valid and are of concern to VITEMA with the additional updates that were recorded post disasters. Although some of the updated are noted in this 2019 plan update, not all hazards were affected by the 2017 disasters.

Based on the results, the consensus was to endeavor to assess all of the identified hazards. The Hazard Mitigation Steering Committee and felt that the several critical hazards posed the highest threat to the Territory and demanded attention specifically with the changes that occurred post-disaster. These hazards are Hurricane, Earthquake, and Flooding

The discussion focused on the fact that there was not sufficient, credible, and historical data for drought and wildfire hazards to address these hazards thoroughly during the last Plan Update. In this regard, the Territory included specific actions to collect more reliable information for those and other hazards specifically to those updated post disasters.

VITEMA believes the Territory's position is justified as per key language included in the CFR, specifically the *CFR 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 hazardevents."* 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 islands. Some mitigation work will also be done on Water Island.

[1] **Rating:**

1 –**low ability**

2- moderate ability

3 –high ability

4–very high ability

THREAT AND HAZARD PROFILES

The Risk Assessment consists of individual profiles that evaluate the risks from each hazard and threat to the state. A stand-alone hazard and threat profile allows for the comprehensive analysis from many different aspects. Each profile contains the description of the hazard or threat containing information from specific hazard or threat experts. The profiles also each contain a section on previous occurrences, compiled from a wide variety of databases and sources. Location and extent where spatial differences exist, allows for analyses by geographic location and magnitude of events. Some hazards and threats, such as riverine flooding, can have varying levels of risk based on location (i.e., proximity to a river) and severity of event. Other hazards and threats, such as winter storms or drought, cover larger geographic areas and the delineation of areas is not typically available or useful. The Consequence Analysis researched and detailed the various impacts of each hazard and threat on individual community sectors, including the public, state operations, the environment, responders, economic condition, public confidence, facilities/infrastructure, and property.

CONCLUSIONS AND RISK FACTOR ASSESSMENT

At the end of the Risk Assessment, the Summary / Conclusion brings together data from each of the jurisdictional ratings were brought together to show the areas of the state that are most vulnerable to all hazards and threats. The prioritization of hazards and threats into high, moderate, and low categories is based on the classification by the individual jurisdictions which was then reviewed and adjusted by the state planning team. The summary also describes the final results of the risk factor assessment.

A risk factor assessment was conducted to determine the overall risk of each hazard and threat, using the state risk assessment, previous occurrences, location and extent, and any additional resources documented in the hazard or threat profile. Table 3.3-6 shows the risk factor assessment approach, including the risk factor category, degree of risk, and weight value. Due to the inherent data limitations present in any risk assessment, the results of this risk assessment should only be used for planning purposes and in developing projects to mitigate potential losses.

ASSESSMENT OF FUTURE CONDITIONS

The assessment on development in identified hazard areas is based on an analysis of development trends with consideration of those jurisdictions that had moderate-high and high vulnerability to the hazard or threat based on the State's risk assessment. Also considered are the mechanisms currently in place to limit or regulate development in hazardous areas. Some hazards or threats can be mitigated during development, others cannot.

The impacts were assessed through a narrative on how new and future development could be impacted by the hazard or threat given population growth. Additionally, an analysis was conducted on climate change and its impacts on the frequency, duration, extent, and location of hazards.

DATA LIMITATIONS

Many unknown variables limit the ability to quantitatively assess all aspects of a hazard with high accuracy. Therefore, data limitations provide a framework for identifying the missing or variable information.

These limitations were determined by hazard and threat through the risk assessment process. In some cases, the limitations may be resolved through research or data collection. If a limitation can be reasonably resolved through a mitigation project, the resolution is included in the mitigation strategy initiatives. Other key documents, as well as other data resources and state agencies, are listed since many other plans and studies provide important pieces of information regarding a particular hazard or threat and often contain more data than is needed or useful in a multi-hazard plan

HAZARD PROFILE 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 time-period, usually a season or more in length.

Droughts can be classified as meteorological, hydrologic, agricultural, and socioeconomic. Table 4.2 below presents definitions for these types of droughts.

TABLE 4.2 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 wellbeing and economic security of the islands. Water resources or access to them are already limited and subject to competing demands (i.e., growing population and 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 groundwater 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.

Any reductions in the amount or type of precipitation will only increase those costs.

http://www.usgcrp.gov/usgcrp/nacc/education/islands/islands-edu-3.htm

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

Figures 4.1, 4.2, and 4.3 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 of 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 drought is very limited for the US Virgin Islands. There are scant references to drought 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 1920s to '30s, St Croix experienced a period of drought. During this time, the US Government assisted with the construction of Creque Dam (1923) to capture rainwater. This program was expanded throughout the islands. Several reservoirs and catchment areas were constructed near the towns to collect in rainwater. Ponds were created for the maintenance of livestock. Windmills were converted to cisterns, and wells were sunk in former cane fields to fill water troughs.

The first Federal declaration in the US Virgin Islands for drought was on June 8, 1964. Although the effects of this event 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 the East End of St Croix was suffering a localized severe drought. According to local famers 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 on 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. According to the National Climate Data Center, there have been no new drought events reported in the Territory since 2002.

Typically, the dry season lasts from January to April with a smaller dry season in June and Jul. Rainfall patterns vary significantly from year to year. USVI can experience above-average precipitation and flooding one year and drought or near-drought conditions the following year. The cause of this annual variability is still unclear as some already known factors, and severely obscurely known processes drive both rainfall patterns.

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FIGURE: 4.1 Drought Hazard Map, St. Thomas

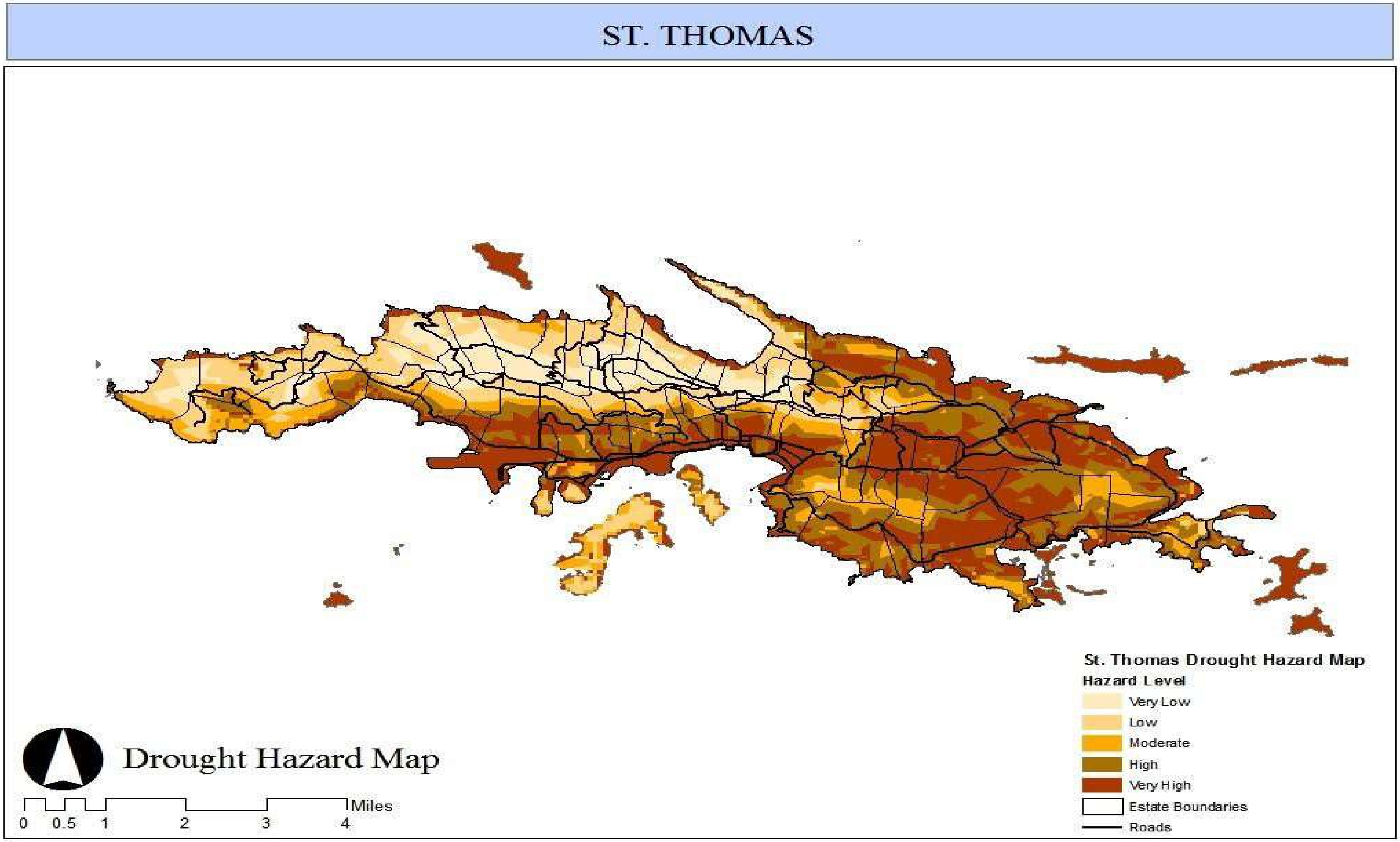


FIGURE: 4.2 Drought Hazard Map, St. John

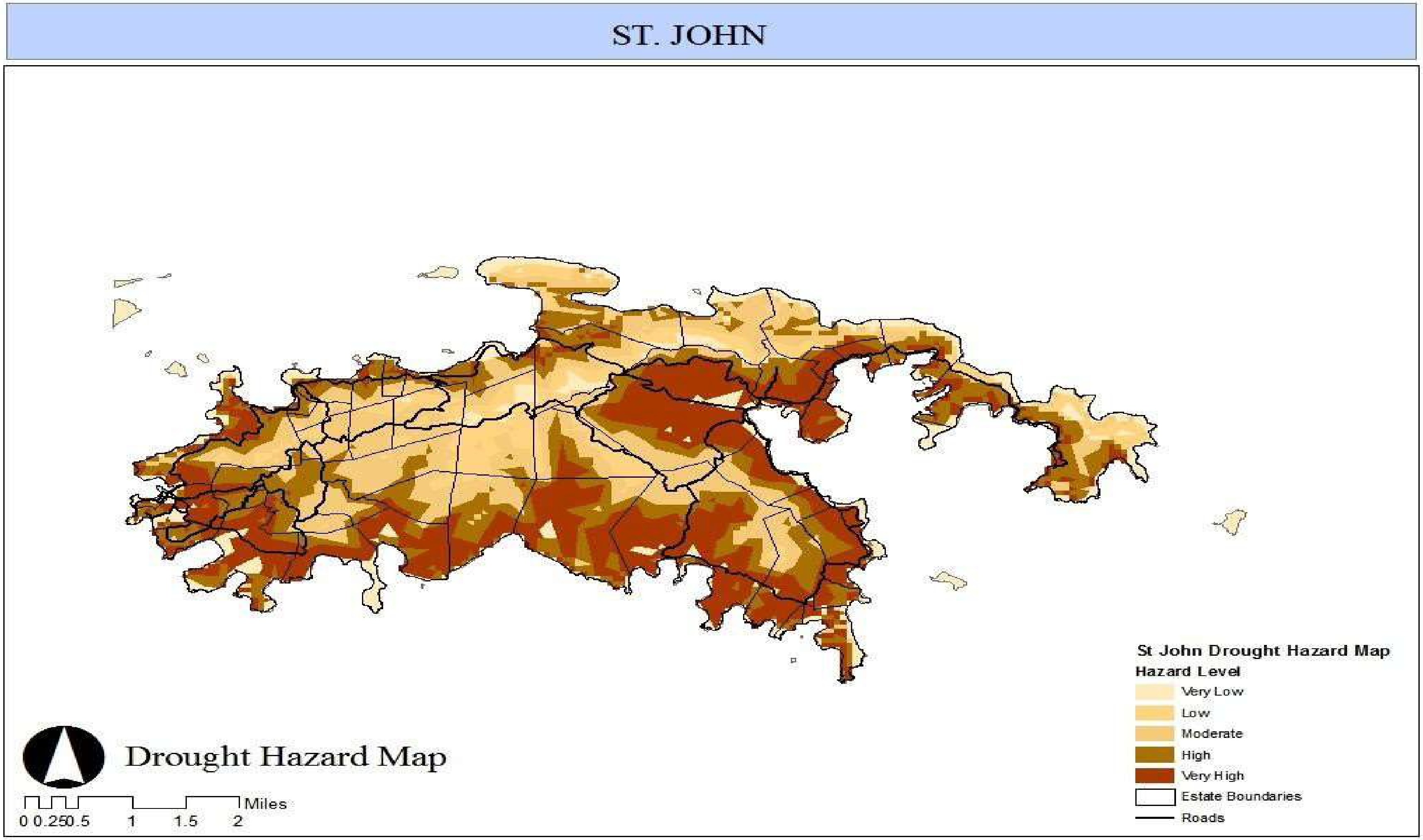
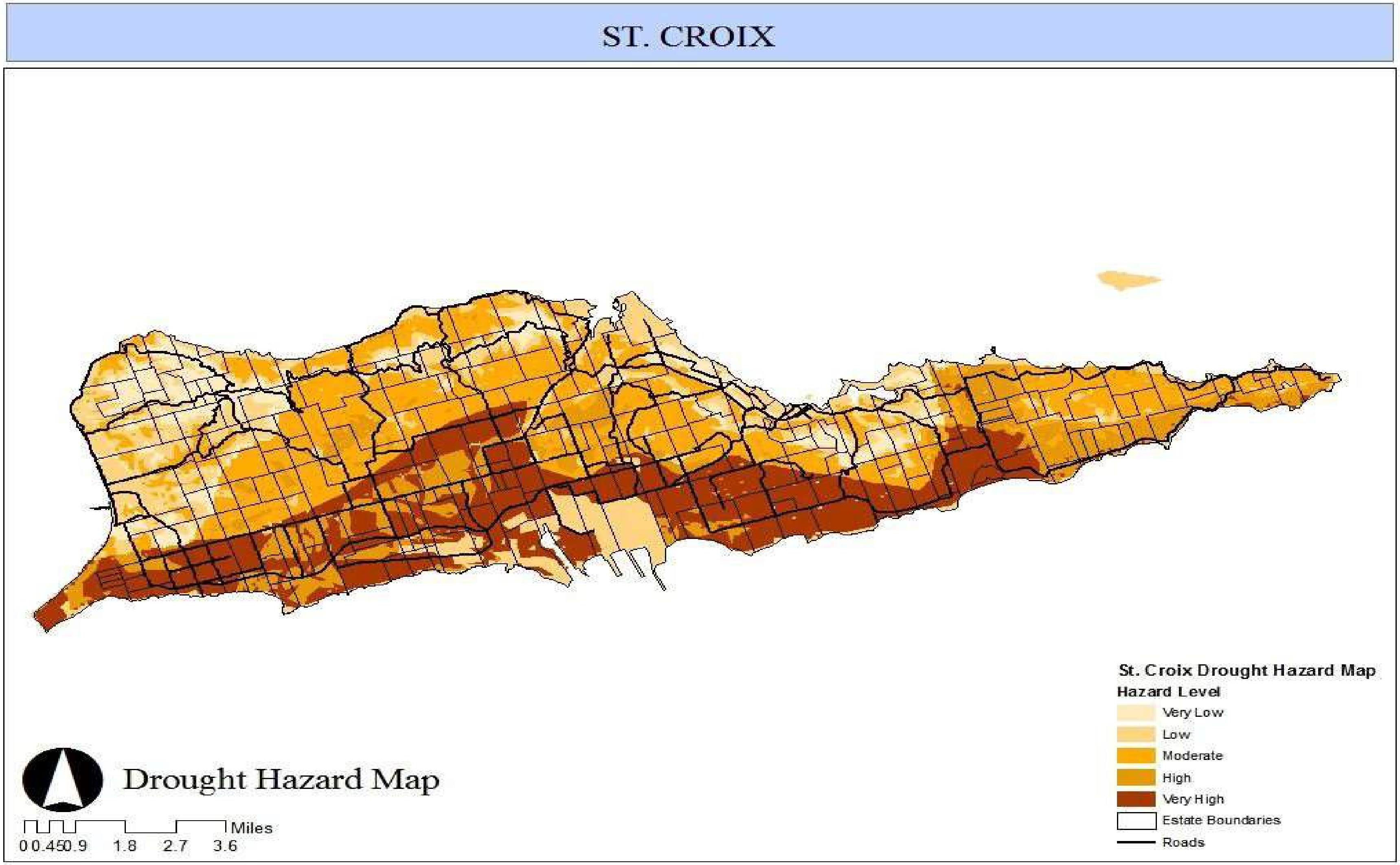


FIGURE: 4.3 Drought Hazard Map, St. Croix



CLIMATE VARIABILITY, HAZARD FREQUENCY AND MAGNITUDE

There is a general lack of understanding of 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 due to climate variability.

Taking into consideration climate change data, the McGill University furthers that climate change models indicate that temperatures are very likely to rise (90-99% probability) and that there is expected to be a decrease in annual precipitation in the region of 5 to 15% with the most significant change during June to August.

Such data provides a clear indication that the occurrence of drought events will increase in the future, which in turn means that there is likely to be a decrease in the reported incidence of periods defined as having no drought.

Therefore, drought probability, which is tied to annual average precipitation, for the Caribbean region, which includes a region which includes the US Virgin Islands, is estimated to be% below average.

Beginning on June 6, 2019, the US Virgin Islands was officially added to the US Drought Monitor by the National Oceanic and Atmosphere Administration (NOAA). This would provide us ongoing data to better monitor the occurrence of drought and identify areas where possible drought mitigation may be a necessity.

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 serve 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
- Drought and Precipitation Monitoring for Enhanced Integrated Water Resources Management in the Caribbean (2008)
- (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.
- US National Assessment of the Potential Consequences of Climate Variability and Change Educational Resources Regional Paper: US-Affiliated Islands of the Pacific and Caribbean, http://www.usgcrp.gov/usgcrp/nacc/education/islands/islands-edu-3.htm

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

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 the proportion of assets located in areas that are susceptible to drought.

SOCIAL IMPACTS

Table 4.3 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 4.3 Social Impacts (Drought)

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	**54,229**	8,876	16%	2,187	4%
St. Croix	**56,404**	8,271	15%	2,037	4%
St. John	**4,447**	925	21%	228	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 11,215 residential structures exposed to this hazard on St. Thomas and 787 commercial structures. On St. Croix, there are 9,458 residential structures and 192 commercial structures exposed to this hazard, while on St. John, the total number of residential properties exposed is 1371and 11 commercial structures.

- On St. Thomas, approximately 48% percent of the residential building stock and 36% of the commercial building stock is considered to be vulnerable to drought. Of this percentage, approximately 26% of the residential building stock is of high vulnerability, and the remaining 22% is of very high susceptibility 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 a 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 a high or very high vulnerability rating to a drought event.

The tables 4.4 through 4.6 below show potential dollar exposure to drought hazard on St. Thomas, St. Croix, and St. John.

TABLE 4.4 Estimated Drought Exposure and Vulnerability (St. Thomas)

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	48%	13%	23%	16%	26%	22%
No. of Residential	11,215	1,404	5,262	3,836	6,148	5,193
Value of Residential	**$3,085,163,402**	**$386,351,477**	**$694,754,849**	**$506,474,402**	**$811,865,287**	**$685,717,387**
Commercial Buildings						
% of Commercial	**36%**	36%	64%	0%	0%	0%
No. of Commercial	**787**	284	503	0	0	0
Value of Commercial	**$655,447,244**	**$236,689,283**	**$418,757,961**	**$0.00**	**$0.00**	**$0.00**

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TABLE 4.5 Estimated Drought Exposure and Vulnerability (St. Croix)

OCCUPANCY CLASS		**Number, Percentage, and Value of Buildings by Vulnerability Rating**				
Total Number of Buildings/ Percentage		**Very Low**	**Low**	**Moderate**	**High**	**Very high**
Residential Buildings						
% of Residential	**43%**	9%	14%	34%	15%	28%
No. of Residential	**9458**	822	117	39	6	2
Value of Residential	**$2,492,165,251**	**216,673,928**	**30,756,222**	**10,393,800**	**1,583,133**	**444,630**
Commercial Buildings						
% of Commercial	**23%**	41%	61%	0%	0%	0%
No. of Commercial	**192**	79	48	0	0	0
Value of Commercial	**$331,528,001**	**135,625,091**	**82,554,403**	**$0.00**	**$0.00**	**$0.00**

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TABLE 4.6 Estimated Drought Exposure and Vulnerability (St. John)

OCCUPANCY CLASS		Number, Percentage, and Value of Buildings by Vulnerability Rating				
Total Number of Buildings/ Percentage		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	61%	2%	12%	26%	28%	33%
No. of Residential	1371	24	164	352	385	446
Value of Residential	$500,995,060	8,631,645	59,792,124	128,575,545	140,893,622	163,102,125
Commercial Buildings						
% of Commercial	14%	14%	86%	0%	0%	0%
No. of Commercial	11	2	10	0	0	0
Value of Commercial	$47,540,397	6,791,485	40,748,912	$0.00	$0.00	$0.00

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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 and St. Croix.

TABLE 4.7 Estimated Drought Exposure and Vulnerability, Critical Facilities, and Infrastructure (St. Thomas)

Facility		Vulnerability Rating					Total Exposure
	# of Facilities in Class	Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	5	2			2	1	12,727,552
Fire Stations	5	3	2				7,792,547
Emergency Response	1					1	6,472,875
Hospital, Clinics, and special needs	5	4		1			95,838,253
Government Buildings	11	9		9	9		118,417,923
Shelters / /Special Needs	5	2	1		1	1	123,556,219
Transportation Infrastructure							
Marine Ports	4	4					26,038,712
Airport	1	1					22,475,260
Utilities							
Electrical Power Generating Plants	1	1					51,172,046
Sewage Treatment Plant	1			1			61,792,356
Water Treatment Plant	1		1				
WAPA Tanks	1			1			
Pumping Station	1	1					

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

TABLE 4.8 Estimated Drought Exposure and Vulnerability, Critical Facilities, and Infrastructure (St. Croix)

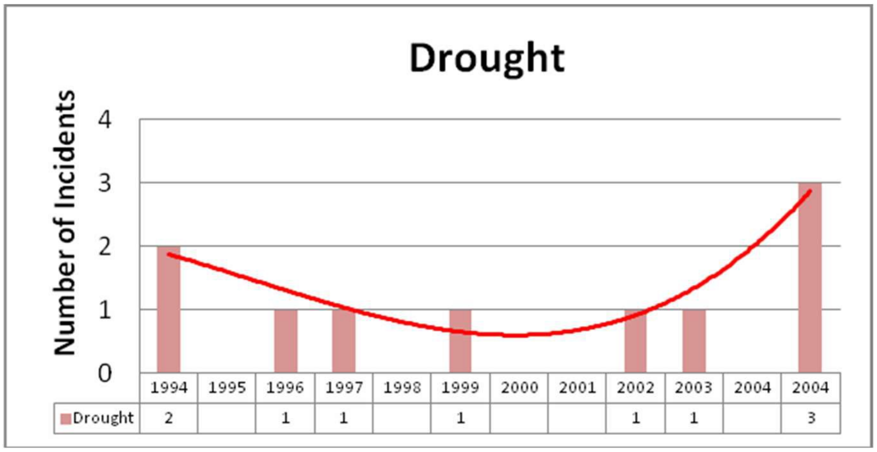
Facility		Vulnerability Rating					Total Exposure
	# of Facilities in Class	Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	**6**	3	2		1		**63,719,946**
Fire Stations	**5**	3		2			**9,269,808**
Emergency Response	**N/A**						**-**
Hospital, Clinics, and special needs	**3**	3					**135,990,389**
Government Buildings	**12**	6			2	4	**121,046,648**
Shelters / /Special Needs	**11**	3			5	3	**173,286,506**
Transportation Infrastructure							
Marine Ports	**5**	5					**9,922,078**
Airport	**1**	1					**57,686,500**
Utilities							
Electrical Power Generating Plants	**1**	1					**51,917,850**
Sewage Pumps	**14**	9				5	
Sewage Treatment Plant	**1**	1					
Water Treatment Plant	**1**	1					
WAPA Tanks	**8**	1	4	3			**110,067,300**
Pumping Station							

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility This subsection of the risk assessment presents the —estimate of losses for drought hazard.

Estimated Losses Facilities

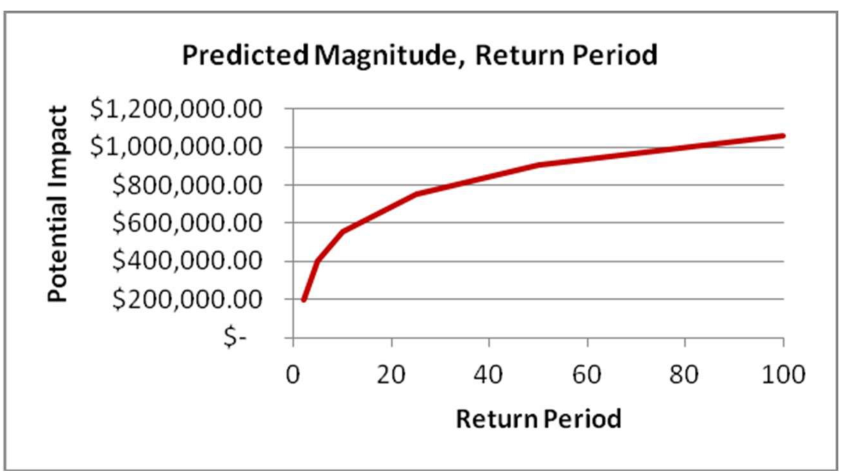
Estimated losses for drought were aggregated for primary economic impacts that could impact the US Virgin Islands through regional economic loss. The primary economic impact was assumed to be increased costs associated with feeding cattle.

FIGURE: 4.4 Historical Droughts in the US Virgin Islands, 2003-2007



This figure was based on regional historic drought data for Puerto Rico and the US Virgin Islands. Based on the available data and the assumptions provided above, the predicted impact of a drought with a 50% probability of occurrence is $200,000.

FIGURE 4.5 Historical Droughts in the US Virgin Islands, 2003-2007



The expected impact of a drought for a 100-year return period is approximately 1.058M. Damage parameters from only two (2) historical events in the US Virgin Islands were used to develop this estimate.

EARTHQUAKES

HAZARD PROFILE

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 rockslides 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 the 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 depend upon such specifics as to the distance from the epicenter and depth of the epicenter

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TABLE 4.9 Earthquake Magnitude / Intensity Comparison

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**	Felt only by a few persons at rest, especially on upper floors of buildings. 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**	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. 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**	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. 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**	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. 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**	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly. . 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.			

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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 between 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.

Generalized seismic maps were developed by USGS to guide construction in 2010. The Figure below provides a depiction of the hazard intensity to provide guidance to building design and construction professionals. The seismic design categories for Puerto Rico and the Virgin Islands have been developed for low rise occupancy Category I and II structures located on sites with average alluvial soil conditions.

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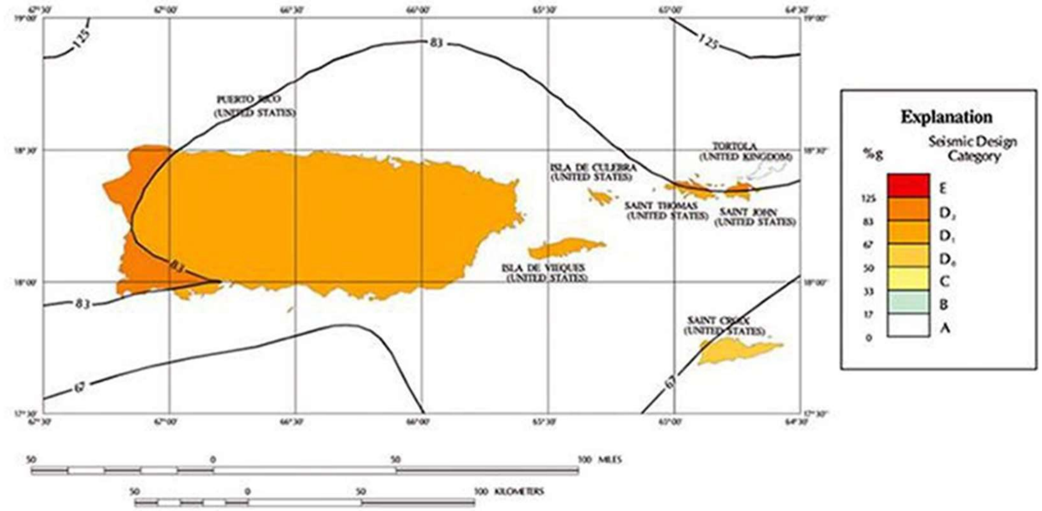
FIGURE: 4.6 Seismic Design Map for Puerto Rico and the Virgin Islands



source: http://www.fema.gov/earthquake/earthquake-hazard-maps

The colors in the maps denote ―seismic design categories‖ (SDCs), which reflect the likelihood of experiencing earthquake shaking of various intensities. (Building design and construction professionals use SDCs specified in building codes to determine the level of seismic resistance required for new buildings.)

The following table describes the hazard level associated with each SDC and the associated levels of shaking. Although stronger shaking is possible in each SDC, it is less probable than the shaking described.

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TABLE 4.10: Seismic Design Categories

SDC	Map Color	Earthquake Hazard	Potential Effects of Shaking*
A	White	Very small probability of experiencing damaging earthquake effects.	
B	Gray	Could experience shaking of moderate intensity.	Moderate shaking—Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
C	Yellow	Could experience strong shaking.	Strong shaking—Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built structures.
D0	Light brown	Could experience very strong shaking (the darker the color, the stronger the shaking).	Very strong shaking—Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures.
D1	Darker brown		
D2	Darkest brown		
SDC	Map Color	Earthquake Hazard	Potential Effects of Shaking*
E	Red	Near major active faults capable of producing the most intense shaking.	Strongest shaking—Damage considerable in specially designed structures; frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations. Shaking intense enough to destroy buildings.
* Abbreviated descriptions from The Modified Mercalli Intensity Scale.; source: http://www.fema.gov/earthquake/earthquake-hazard-maps			

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 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 Louise and Water Island formations are highly weathered, jointed, and fractured (Geoscience Associates 1984). From a geologic standpoint, the islands are necessarily the same landmass, separated by a garden, Pillsbury Sound.

As illustrated in the maps (Figure 4.7, 4.8, and 4.9), 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 to 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 landfill. The performance of such materials is notoriously poor.

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FIGURE: 4.7 Earthquake Hazard Map, St. Thomas

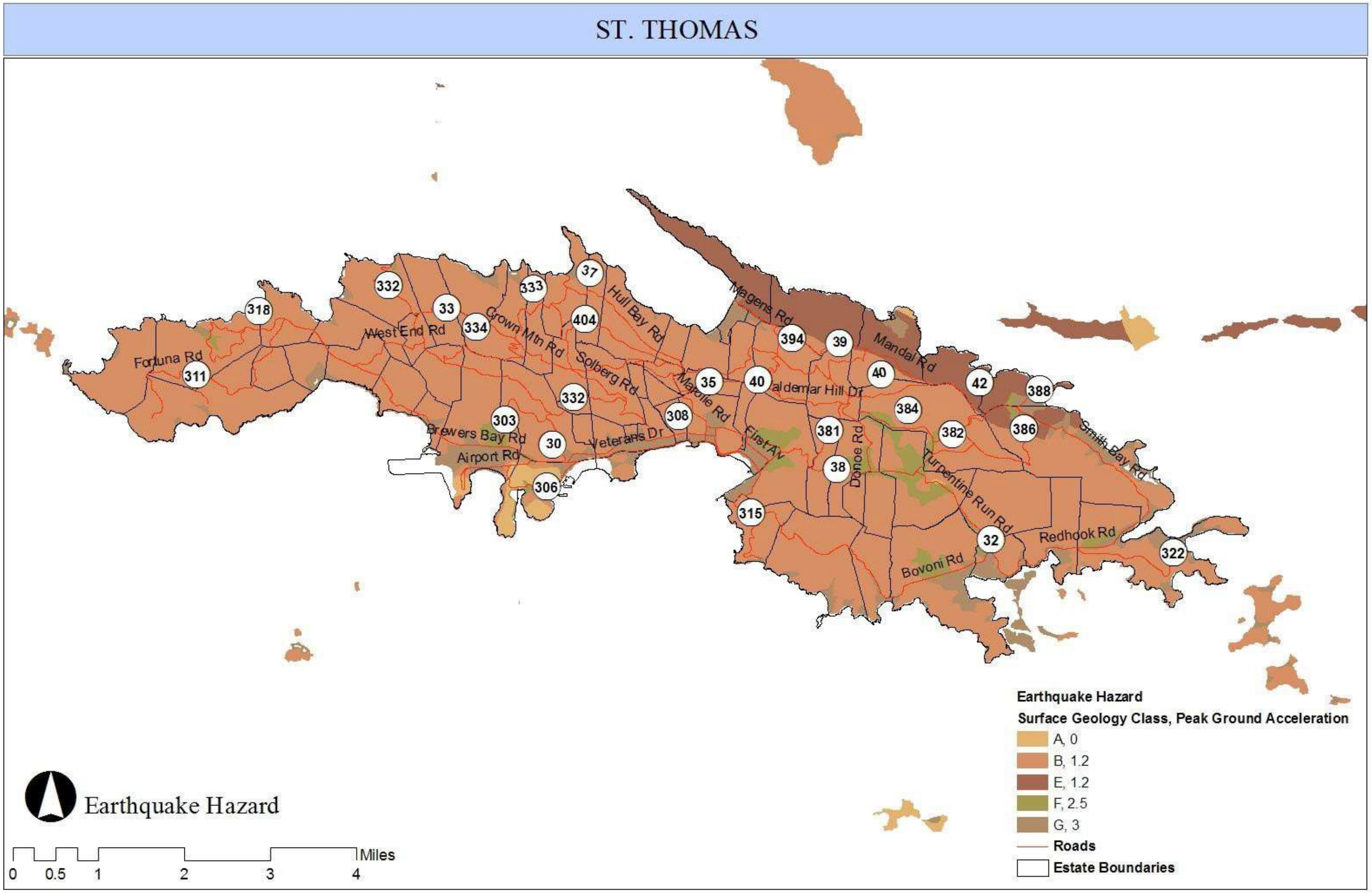


FIGURE: 4.8 Earthquake Hazard Map, St. Croix

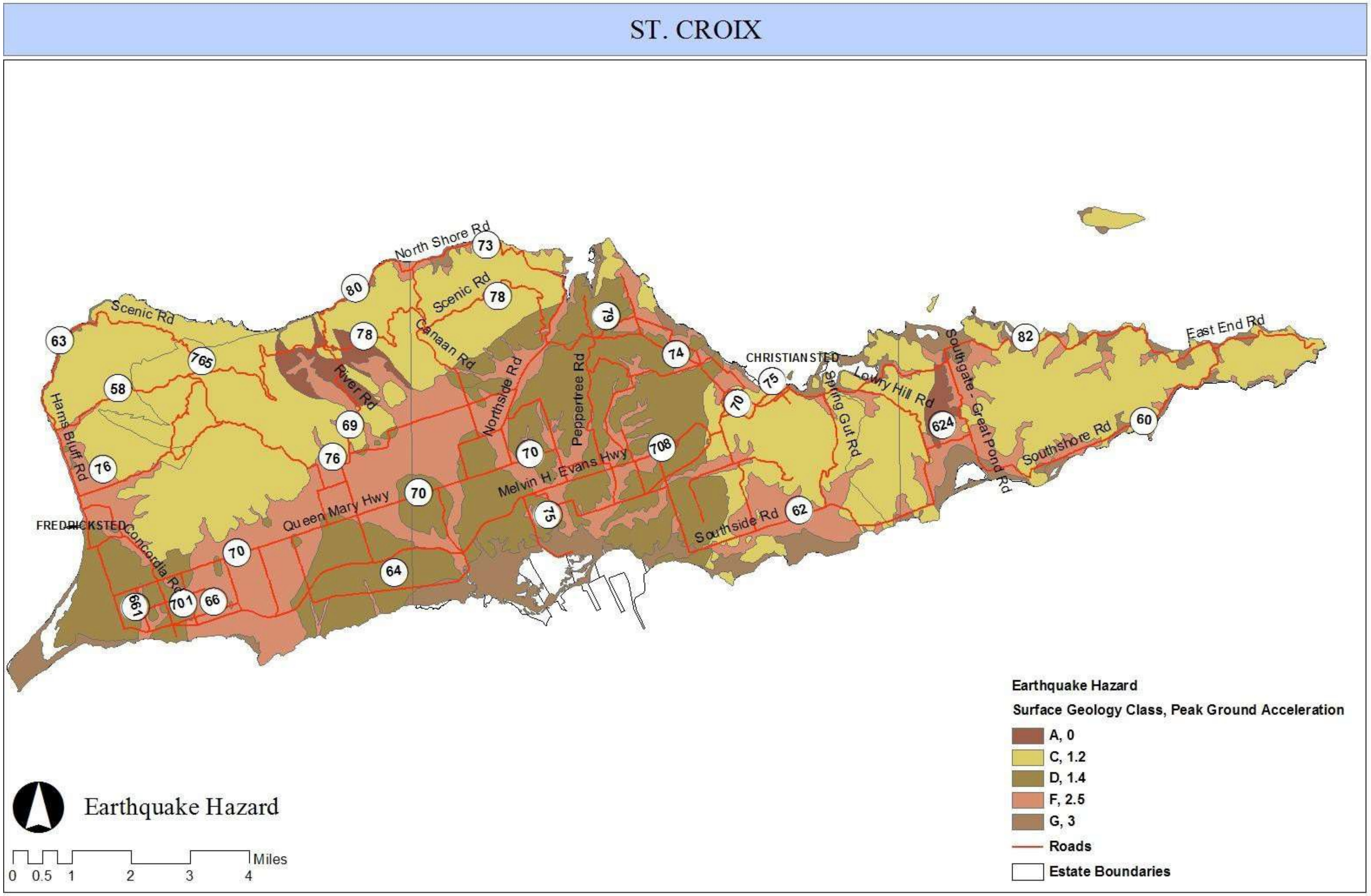
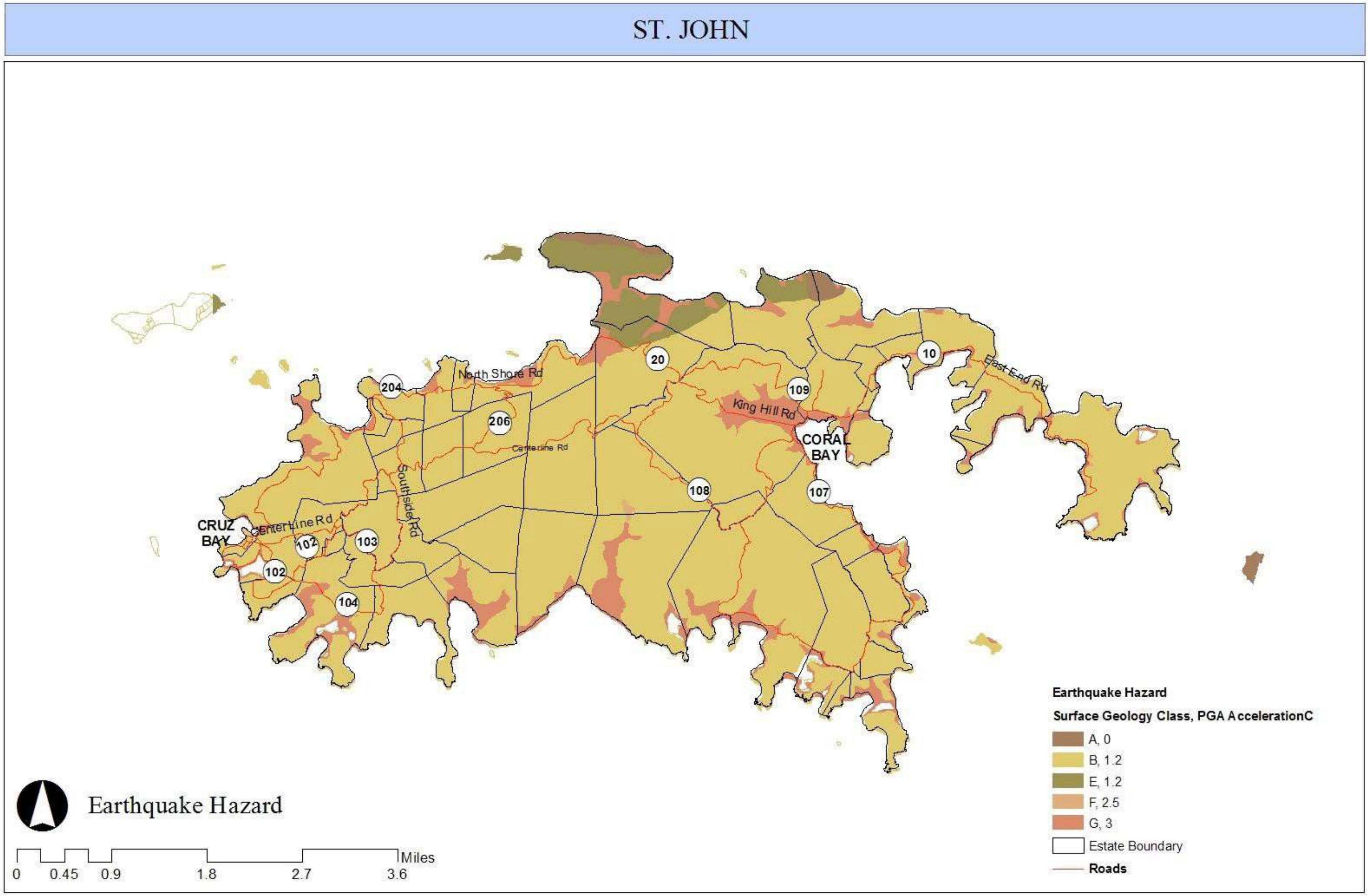


FIGURE: 4.9 Earthquake Hazard Map, St. John



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 intrusive. The rock formations are tilted up to near-vertical orientation. The rock formations include Caledonia, Allandale, Cane Valley, and Judith Fancy formations, all of the late Cretaceous age (Geoscience Associates 1984).

Much of Christiansted and Frederiksted waterfronts mimic the performance of the waterfront areas on St. Thomas. Much of the town of Frederiksted 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 landfills, 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 valid 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). Still, 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 significant 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 April 2011 to April 2014, there have been 65 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 6.4 on the Richter Scale and occurred in Puerto Rico on January 13, 2013.

The event that stands in our minds is the event in Haiti in January 2010. The 2010 Haiti earthquake was a catastrophic magnitude 7.0 Mw earthquake, with an epicenter 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

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.

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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.

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 (□) 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.

A recent study published in August 2018 "Caribbean Tsunami and Earthquake Hazard Studies – Models (*Overview cited from the USGS website)* states "The Puerto Rico trench exhibits great water depth, shallow gravity anomaly, and a tilted carbonate platform between (reconstructed) elevations of =+1300 m and -4000 m, we suggest that these features are large vertical movements of a segment of the Puerto Rico Trench, is forearc, and the island of Puerto Rico that took place 3.3 m years ago overtime period as short as 14-40 kyr. These vertical movements are explained by a sudden increase in the slab's descent angle that caused the trench to subside and the island to rise. The increased dip could have been caused by shearing or even by a complete tear of the descending North American slab although the exact nature of this deformation si unknown. The rapid 14-40 kyr and uniform tilt along a 250-km-long section of the trench is compatible with scales of mantle flow and plate bending. The proposed shear zone or zone of tear is inferred from seismic, morphological and gravity observations to start at the trench at 64.5 W and trend southwestward toward eastern Puerto Rico" Image below is a representation included in the overview cited above. Link to the information is directly below.

https://www.usgs.gov/centers/whcmsc/science/caribbean-tsunami-and-earthquake-hazards-studies-models?qt-science_center_objects=0#qt-science_center_objects

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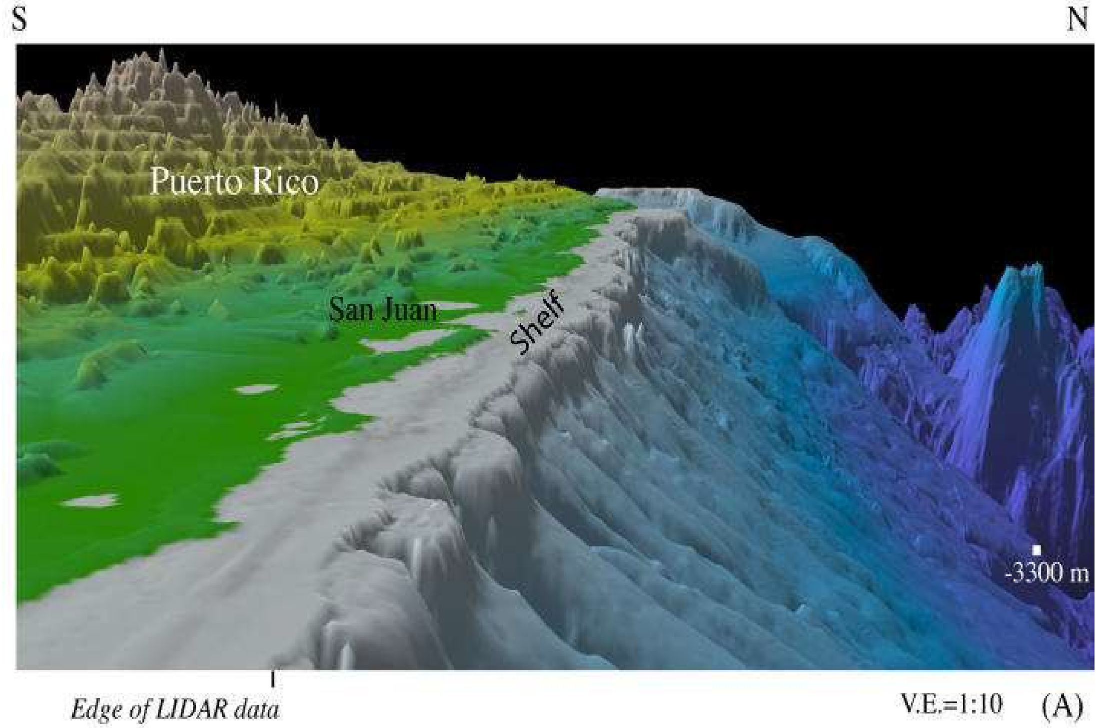
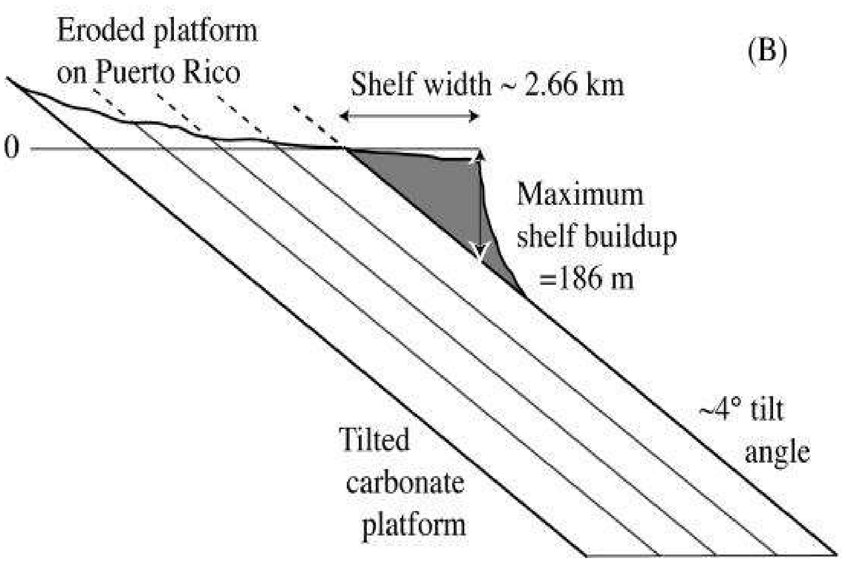
FIGURE 4.10 & 4.11 Earthquake Hazard Study Model





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EARTHQUAKE HAZARD ASSESSMENT AND DETERMINATION

HAZARD FREQUENCY AND MAGNITUDE

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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 (□) 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.

DATA SOURCES, MODELS AND METHODOLOGIES

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

Base Data (Earthquake)

A 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.

- 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)
- Charles Mueller, Arthur Frankel, Mark Petersen, and Edgar Leyendecker (2010) New Seismic Hazard Maps for Puerto Rico and the U.S. Virgin Islands. Earthquake Spectra: February 2010, Vol. 26, No. 1, pp. 169-185.

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 () 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

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

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 the proportion of assets located in earthquake hazard areas.

SOCIAL IMPACTS

Table 4.11 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 (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	**54,229**	5,965	11%	1,627	3%
St. Croix	**56,404**	8,461	15%	1,692	3%
St. John	**4,447**	623	14%	178	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 558 residential properties exposed to this hazard on St. Thomas. On St. Croix, there was an increase of 405 residential properties exposed to this hazard, while on St. John, the total number of residential properties exposed increased by 41. On St. Thomas, there were 55 additional commercial properties exposed to this hazard. In St. Croix, there was an increase of 18 commercial properties exposed to this hazard. On St. John, there were two less commercial properties exposed to this hazard.

- On St. Thomas, approximately 91% percent of the residential building stock and 96% of the commercial building stock are considered to be vulnerable to an earthquake event. Of this percentage, approximately 42% of the residential building stock is of high vulnerability, and the remaining 58% is of very high vulnerability to an earthquake event. About 20% of the commercial building inventory is of high vulnerability to an earthquake, and the remaining 80% 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 are 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 84% of the commercial building inventory is of medium vulnerability, none has a 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 steeply 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.

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

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	91%	0.00	0.00	0.00	42%	58%
No. of Residential	21,262	0	0	0	9,807	13,558
Value of Residential	$5,848,955,616	$0	$0	$0	$2,697,864,850	$3,729,558,904
Commercial Buildings						
% of Commercial	96%	0.00	0.00	0.00	20%	80%
No. of Commercial	2,098	0	0	0	435	1,750
Value of Commercial	$1,747,859,317	0	0	0	$362,197,527	$1,458,489,262

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

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	70%	0%	0%	75%	5%	20%
No. of Residential	15,398	0	0	16,497	1,100	4,399
Value of Residential	4,057,013,200	0	0	3,042,759,900	202,850,660	811,402,640
Commercial Buildings						
% of Commercial	84%	0%	0%	73%	0%	27%
No. of Commercial	701	0	0	512	0	189
Value of Commercial	1,210,797,916	0	0	883,882,479	0	326,915,437

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

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	71%	0	0	71%	11%	19%
No. of Residential	1,595	0	0	1,133	175	303
Value of Residential	583,125,398	0	0	414,019,033	64,143,794	110,793,826
Commercial Buildings						
% of Commercial	85%	0	0	32%	20%	48%
No. of Commercial	69	0	0	22	14	33
Value of Commercial	288,638,126	0	0	92,364,200	57,727,625	138,546,300

CRITICAL FACILITIES

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

TABLE 4.15 Estimated Earthquake Exposure and Vulnerability, Critical Facilities, and Infrastructure (St. Thomas)

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	5	1			1	3	12,727,552
Fire Stations	5	1		1	1	2	7,792,547
Emergency Response				1			6,472,875
Hospital, Clinics, and special needs	5				4	1	95,838,253
Government Buildings	11			3		8	118,417,923
Shelters	5	1		1		3	123,556,219
Transportation Infrastructure							
Marine Ports	4	1		1		2	26,038,712
Airport	1	1					22,475,260
Utilities							
Electrical Power Generating Plants						1	51,172,046
Sewage Treatment Plant	1				1		61,792,356
Water Treatment Plant	1				1		
WAPA Tanks	1					1	
Pumping Station	1				1		

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility

TABLE 4.16 Estimated Earthquake Exposure and Vulnerability, Critical Facilities and Infrastructure (St. Croix)

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	6	1		3	1	1	63,719,946
Fire Stations	5	1			1	3	9,269,808
Emergency Response	1			1			-
Hospital, Clinics, and special needs	3			2		1	135,990,389
Government Buildings	12			6	2	4	121,046,648
Shelters / Special Needs	11		1	3	1	6	173,286,506
Transportation Infrastructure							
Marine Ports	5	5					9,922,078
Airport	1			1			57,686,500
Utilities							
Electrical Power Generating Plants	1				1		51,917,850
Sewage Treatment Plant	14	3	3	6	2		110,067,300
Water Treatment Plant	1				1		
WAPA Tanks	1	1					
Pumping Station	8			4	2	2	

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility

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

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	2		1		1		4,321,296
Fire Stations	2			1		1	4,845,666
Emergency Response	1			1			5,142,339
Hospital/ Medical Clinic	2	1				1	17,590,586
Government Buildings	3		1			2	13,159,486
Shelters/Special Needs	5			1	1	3	52,473,202
Transportation Infrastructure							
Marine Ports	1	1					2,884,325
Airport	N/A						--
Utilities							
Electrical Power Plant	1				1		15,575,355
WAPA Desalinization Plant	1			1			33,518,154
WAPA Water Tank	1				1		
Sewage Treatment Plant	1				1		
Potable Water Tank	1				1		

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

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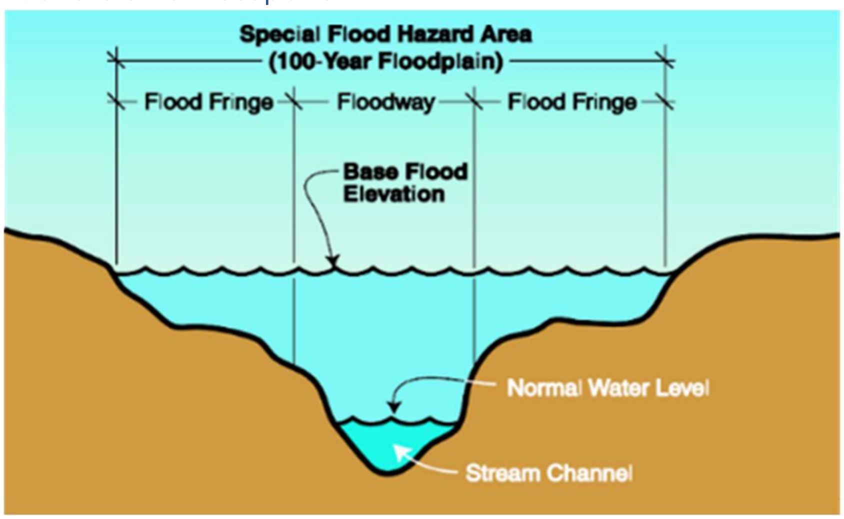
RIVERINE FLOODING

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 4.12 below).

FIGURE 4.12 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 a 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. Advisory Maps have been updated and implemented in August of 2018.

Historically, floods often exceed the mapped floodplains in the Virgin Islands. The 2007 Flood Insurance Study for the US Virgin Islands indicates that the principal causes of flooding are associated with stormwater 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 a new development) and where guts in many areas are filled with debris (e.g., accretion, erosion, sedimentation, etc.)

Nature of the Hazard Physical

Heavy floods are a common feature of the 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 several large-scale devastating flooding events through time. Historically, most of these massive events have had the most significant 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. However, it is less damaging on an event-by-event basis.

The islands' mostly hilly to rugged and mountainous terrain, especially on St. Thomas and St. John, 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; Subbase 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 Dorothea in St. Thomas or Gallows Bay in St. Croix;
- A failure to upgrade stormwater management facilities to meet the needs of on-going development (i.e., Enighed Pond St. John),
- Lack of consistent maintenance of other stormwater 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

Figures 4.13, 4.14, 4.15 and 4.16 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's 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 stormwater drainage systems both in the highland areas and lowland environs. The former disregard intensifies the problems of the latter.

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 stormwater drainage infrastructure on Centerline and Bordeaux Mt. Roads; need to improve stormwater 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 a 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 stormwater drainage system in Frydenhoj (next to and across from the 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 the Bolongo Bay 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 back up and flood a rather sizeable surrounding area. The historic business district is prone to shallow flooding that is caused by a lack of adequate 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 stormwater drainage infrastructure systems on the highway from Pueblo to Addelita Cancryn School (Subbase) and from Pueblo (Subbase) to Crown Bay Port Facility continue to flood and cause traffic disruption, mainly when cruise ships are in port. Inadequate stormwater 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 the accumulation of floodwaters 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 roadways 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; Frederiksted Lagoon Area; on Prince Street (Christiansted); on King Cross Street (Christiansted); Fort Frederik Beach; East Golden Rock on Rt. 75 (North Shore Road) and the La Grange Gut and associated drainage systems.

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FIGURE: 4.13 Riverine Flooding Hazard, St. Thomas

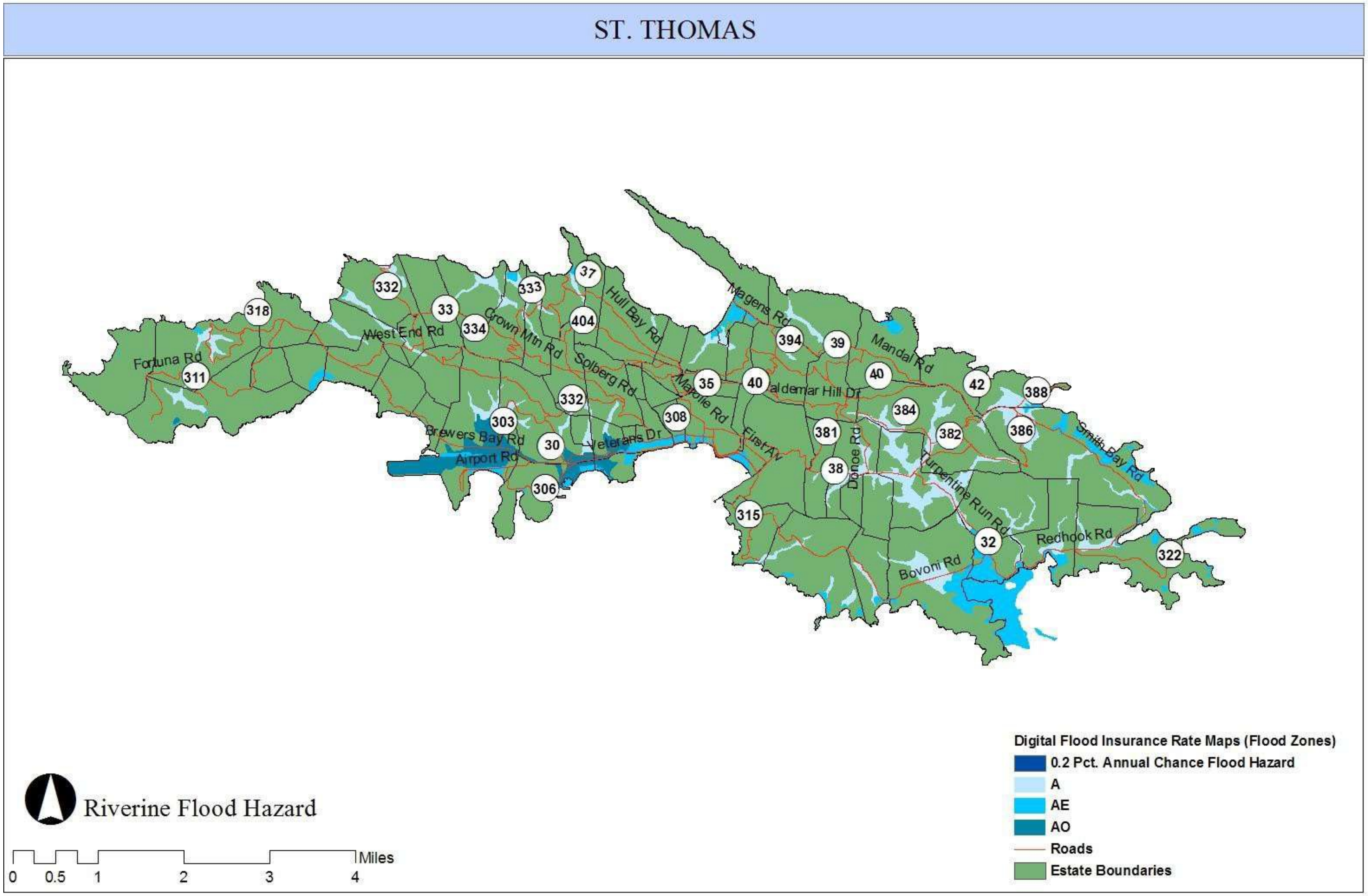


FIGURE: 4.14 Riverine Flooding Hazard, St. Croix

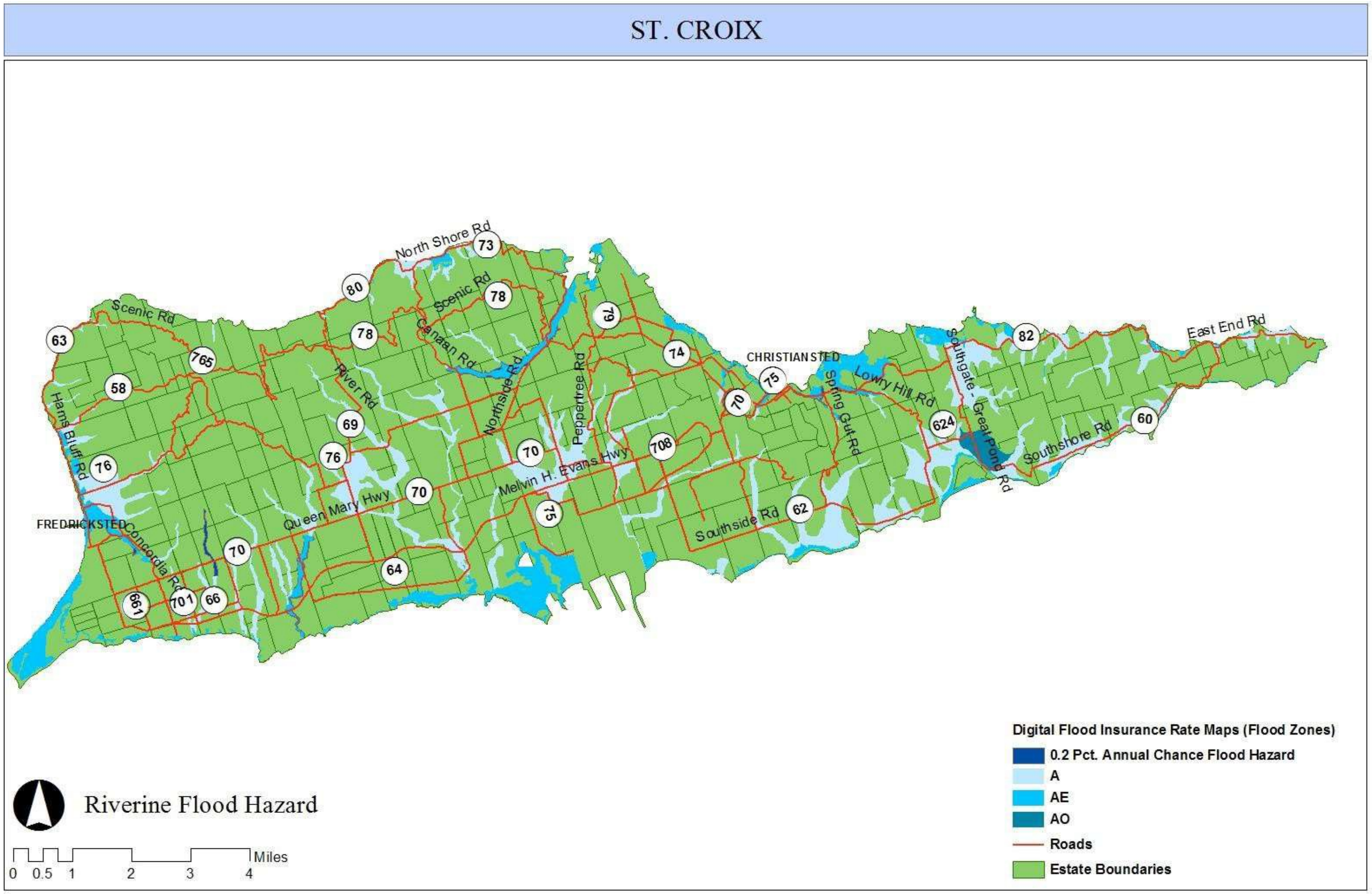


FIGURE 4.15 Riverine Flooding Hazard, St. John

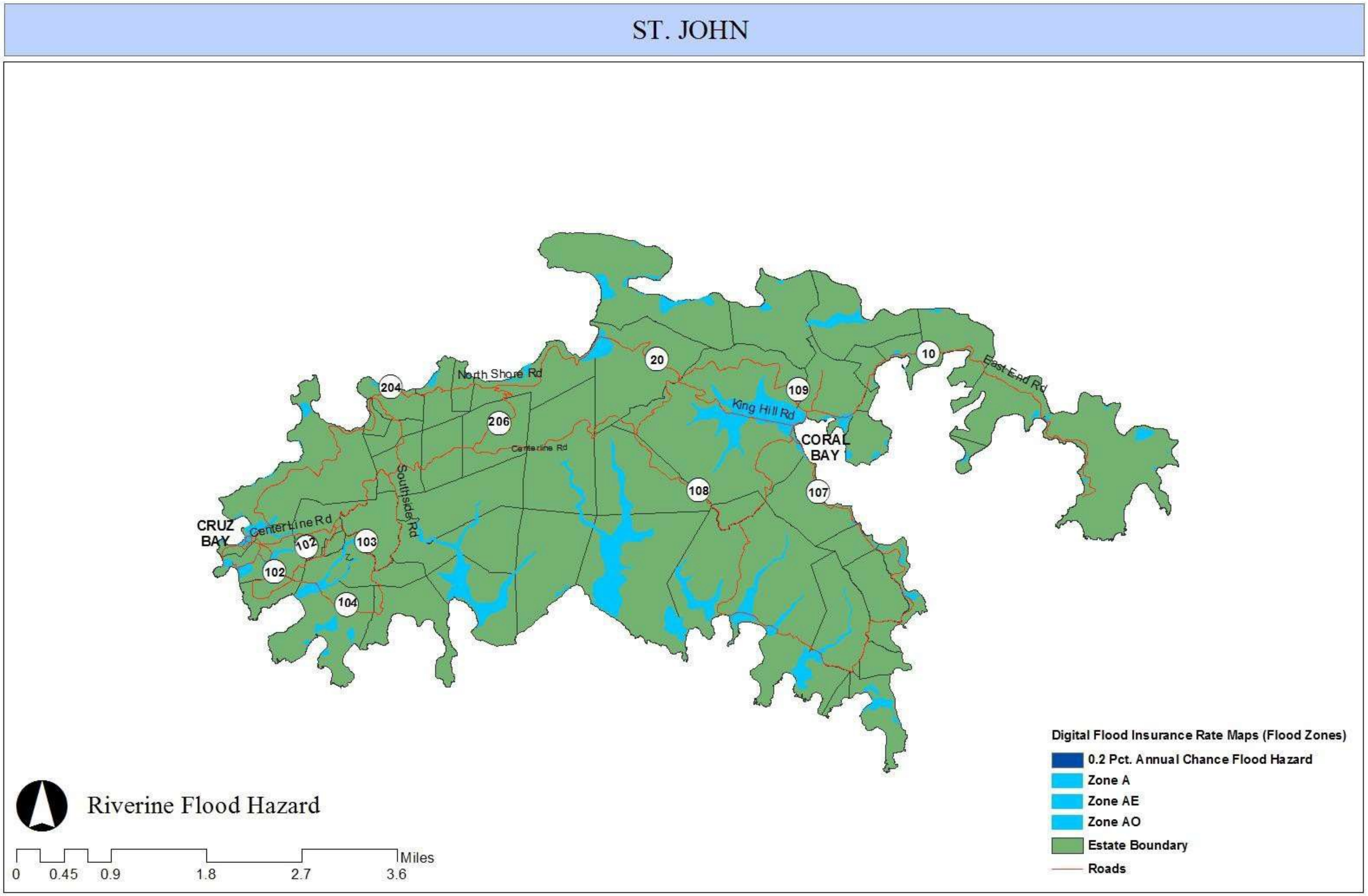
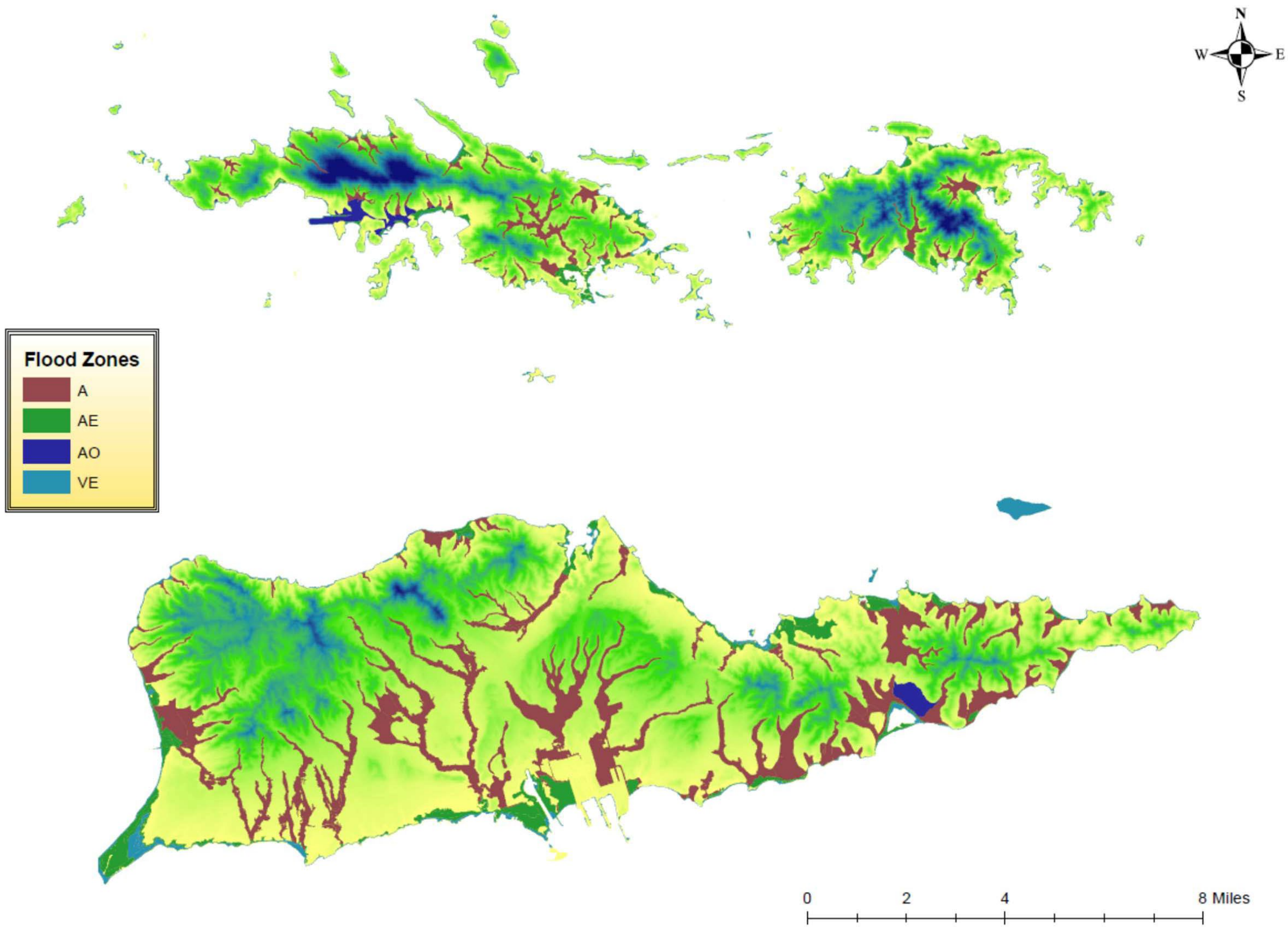


FIGURE 4.16 Riverine Flooding Hazard, USVI



DISASTER HISTORY

Since 2010, there have been 5 Federal disaster declarations, of which two 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 average rainfall events with probable flood events, but the results are not conclusive. 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 extensive 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 widespread 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 areas 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 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 by 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 the temporary closure of that road.

The passing of these systems presented major challenges to the Public Works crews. 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 severe in the area of Enighed Pond. Sewers were overwhelmed in several locations, and manhole covers were carried away as dirty water flowed down the streets.

On St Croix, roadways flooded, water pooled in several urban areas in Christiansted and Frederiksted, in places where motorists had not seen water standing before, causing some to stall out in the torrential downpours. The runoff from the rains collapsed a section of roadway that spans Gut#5 within Enfield Green, cutting the Westside of that neighborhood off to vehicular traffic and leaving no exit. 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 within 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, Frederikshaab, Wheel of Fortune, Little Princess Hill, St. John, Grange Hill, Brookshill, Turner Hole, New Works, Bethlehem, and Monbijou.

Rainfall in the USVI averages around 39 inches per year with significant variations within the geography of each island and on the different islands. The wettest months are from September to November. However, rainfall patterns vary significantly from year to year: USVI can experience above-average precipitation one year and drought or near-drought conditions the following year. The causes of this annual variability are still unclear, as some already known factors and several obscurely known processed drive both rainfall patterns.

CLIMATE VARIABILITY, 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 likelihood of event 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 several 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.

TABLE 4.18 Flood Probability Terms

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%

While the FEMA flood maps that were utilized for this assessment, they do not incorporate the impacts of climate change, it will become an increasingly important parameter for predicting flood hazard and mapping the extent of flood hazards.

To incorporate climate change into flood models, FEMA flood mapping experts must work to incorporate projected data for future climatic conditions into hydrological and hydraulic models, which can be used to delineate the extent of flooding for specific return periods.

Since climate models indicate that there is a likely to be a potential increase in extreme rainfall events, it will be essential to monitor such data to understand changes in susceptibility to flooding due to climate change throughout the territory. Higher frequency of extreme rainfall events will translate into larger (more profound and more widespread) floods occurring in the Territory more often. Table 4.18 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, 4.17, 4.18 and 4.19), 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.

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

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 the proportion of assets located in riverine flooding hazard areas.

SOCIAL IMPACTS

Table 4.19 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 4.19 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	54,229	3,796	7%	1,085	2%
St. Croix	56,404	4,512	8%	1,128	2%
St. John	4,447	267	6%	44	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 141 residential properties exposed to this hazard on St. Thomas. On St. Croix, there was an increase of 70 residential properties exposed to this hazard, while on St. John, the total number of residential properties exposed to this hazard increased by 14. On St. Thomas, there were 21 more commercial properties exposed to this hazard. On St. Croix, there were two more commercial properties exposed to this hazard. On St. John, there were not any additional 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 47% of the residential building stock is of medium vulnerability, and the remaining 53% is of high susceptibility to river flooding. About 36% of the commercial building inventory has a low vulnerability to river flooding, and the remaining 79% 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 4.20 Estimated Riverine Flooding Exposure and Vulnerability (St. Thomas)

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	23%	0.00	0.00	0.47	0.53	0.00
No. of Residential	5,374	0	0	2,519	2,855	0
Value of Residential	$1,478,307,463	$0.00	$0.00	$692,844,520	$785,462,943	$0.00
Commercial Buildings						
% of Commercial	36%	0.00	0.00	20	79	0.00
No. of Commercial	787	0	0	156	630	0
Value of Commercial	$655,447,244	$0	$0	$130,391,110	$525,056,134	0

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TABLE 4.21 Estimated Riverine Flooding Exposure and Vulnerability (St. Croix)

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		**Very Low**	**Low**	**Moderate**	**High**	**Very high**
Residential Buildings						
% of Residential	**12%**	**0%**	**0%**	**68%**	**32%**	**0%**
No. of Residential	**2,640**	**0**	**0**	**1,795**	**845**	**0**
Value of Residential	**695,487,977**	**0**	**0**	**472,931,824**	**222,556,153**	**0**
Commercial Buildings						
% of Commercial	**10%**	**0%**	**0%**	**51%**	**49%**	**0%**
No. of Commercial	**83**	**0**	**0**	**43**	**41**	**0**
Value of Commercial	**144,142,609**	**0**	**0**	**73,512,731**	**70,629,878**	**0**

TABLE 4.22 Estimated Riverine Flooding Exposure and Vulnerability (St. John)

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		**Very Low**	**Low**	**Moderate**	**High**	**Very high**
Residential Buildings						
% of Residential	**24%**	**0%**	**0%**	**81%**	**19%**	**0%**
No. of Residential	**539**	**0**	**0**	**437**	**102**	**0**
Value of Residential	**197,112,811**	**0**	**0**	**159,661,377**	**37,451,434**	**0**
Commercial Buildings						
% of Commercial	**15%**	**0%**	**0%**	**44%**	**48%**	**0%**
No. of Commercial	**12**	**0**	**0**	**5**	**6**	**0**
Value of Commercial	**50,936,140**	**0**	**0**	**22,411,902**	**24,449,347**	**0**

It may be overly simplistic to determine flood vulnerability as a yes or no 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 were 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 was subtracted from the 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 of the building stock estimated to be vulnerable to flooding was within the defined 100-year floodplain.

The flood hazard information in this Plan Update was used to integrate a Severe Repetitive Loss Strategy in the Mitigation Strategy. As in the 2014 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. The 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. Findings 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.

TABLE 4.23 Estimated Riverine Flooding Exposure and Vulnerability, Critical Facilities, and Infrastructure (St. Thomas)

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	**5**	2			1	2	**12,727,552**
Fire Stations	**5**	2		1		2	**7,792,547**
Emergency Response	**1**	1					**6,472,875**
Hospital, Clinics, and special needs	**5**	3	1			1	**95,838,253**
Government Buildings	**11**	3		1	2	5	**118,417,923**
Shelters	**5**	3		1	1		**123,556,219**
Transportation Infrastructure							
Marine Ports	**4**	3		1			**26,038,712**
Airport	**1**	1					**22,475,260**
Utilities							
Electrical Power Generating Plants							**51,172,046**
Sewage Treatment Plant	**1**				1		**61,792,356**
Water Treatment Plant	**1**				1		
WAPA Tanks	**1**	1					
Pumping Station	**1**	1					

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

TABLE 4.24 Estimated Riverine Flooding Exposure and Vulnerability, Critical Facilities, and Infrastructure (St. Croix)

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	**6**	6					**63,719,946**
Fire Stations	**5**	5					**9,269,808**
Emergency Response	**1**	1					**-**
Hospital, Clinics, and special needs	**3**	3					**135,990,389**
Government Buildings	**12**	9		1	1		**121,046,648**
Shelters	**11**	11				1	**173,286,506**
Transportation Infrastructure							
Marine Ports	**5**	5					**9,922,078**
Airport	**1**	1					**57,686,500**
Utilities							
Electrical Power Generating Plants	**1**		1				**51,917,850**
Sewage Treatment Plant	**14**	12	2				**110,067,300**
Water Treatment Plant	**1**	1					
WAPA Tanks	**1**		1				
Pumping Station	**8**	6	1	1			

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility

TABLE 4.25 Estimated Riverine Flooding Exposure and Vulnerability, Critical Facilities, and Infrastructure (St. John)

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	2	1			1		4,321,296
Fire Stations	2	2					4,845,666
Emergency Response	1	1					5,142,339
Hospital, Clinics, and special needs	2	2					17,590,586
Government Buildings	3	2			1		13,159,486
Shelters	5	3				2	52,473,202
Transportation Infrastructure							
Marine Ports	1						2,884,325
Airport	N/A						--
Utilities							
Electrical Power Generating Plants	1	1					15,575,355
Sewage Treatment Plant	1	1					
Water Treatment Plant	1	1					
WAPA Tanks	1				1		
Pumping Station	1	1					33,518,154

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

COASTAL FLOODING AND 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 several 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 the "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 4.26

TABLE 4.26 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.

The IPCC Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5) indicates that the frequency of the most intense storms and associated storm surges or coastal floods is more likely than not to increase by more than +10% (IPCC 2013, AR5), while the annual frequency of tropical cyclones and associated storm surges or coastal floods are projected to decrease or remain relatively unchanged for the North Atlantic.

This suggests no major change in the frequency of hurricanes and associated storm surges or coastal floods in the North Atlantic region comprising the US Virgin Islands. The model, however, that sea-level rise is projected to increase by a small magnitude of 0.35 m over the projected for the 2040s relative to the 1960- 1990 baseline. These projections have implications for the USACE's SLOSH (Sea, Lake, and Overland Surges from Hurricanes) computer model (developed by the National Weather Service) that was utilized for this study and could increase the expected surge levels in Table 4.7 above.

Such parameters can be used by the USACE and NWS to understand the potential impact of climate change on coastal inundation levels and magnitude (Table 4.41)

As indicated in the 2014 plan, 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 wearing away or eroding 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 may, over the long-term, 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 because erosion rates are not uniform and vary overtime at any single location.

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 NATURE OF THE HAZARD

Hazard Location, Extent and Distribution

Figures 4.17 through 4.22 illustrate the geographic coverage of coastal flooding on the three major islands. The high winds 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 of 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 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 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.

FIGURE: 4.17 Coastal Flooding Hazard Map, St. Thomas (a)

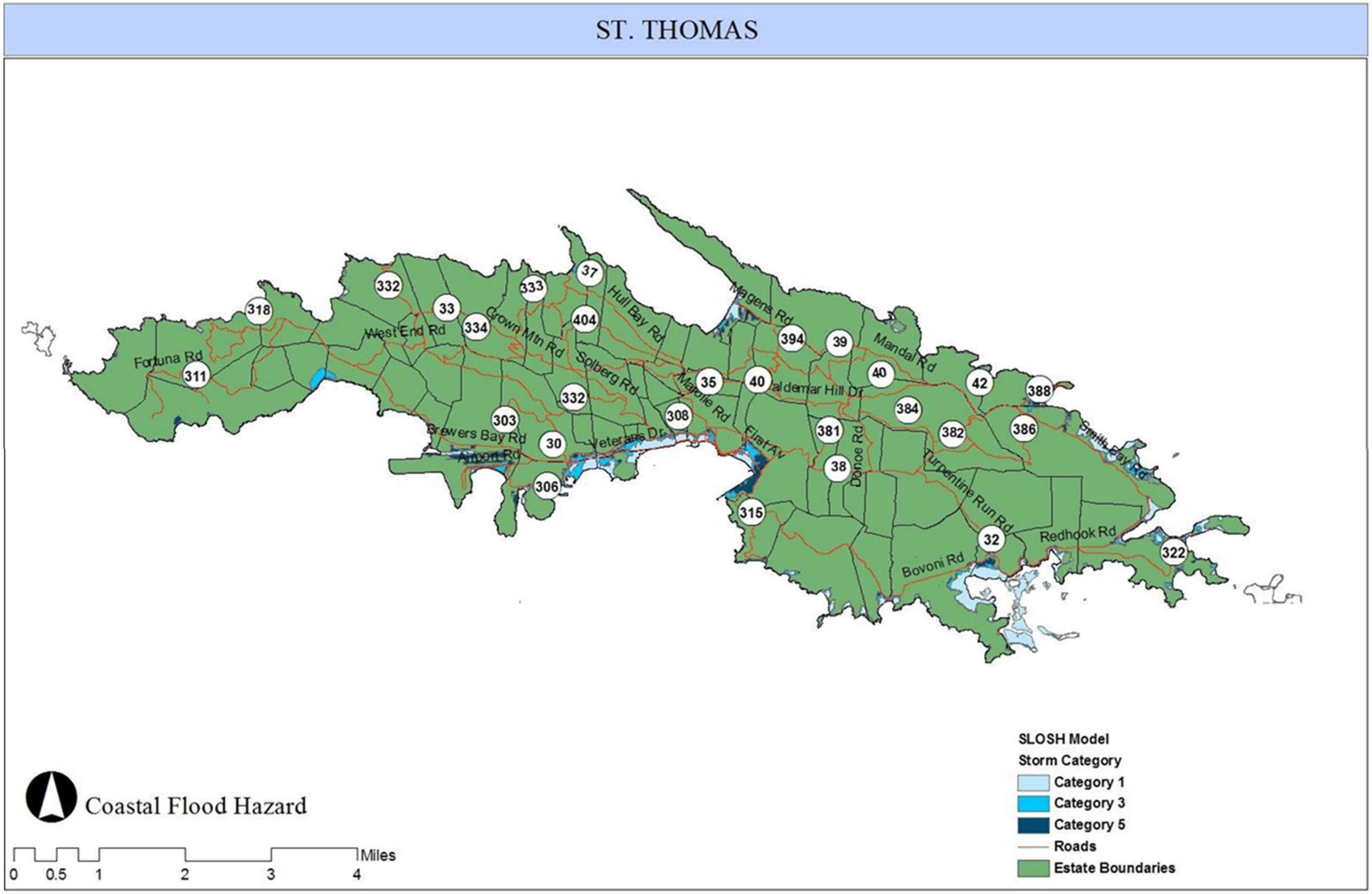


FIGURE 4.18 Coastal Flooding Hazard Map, St. Thomas (b)

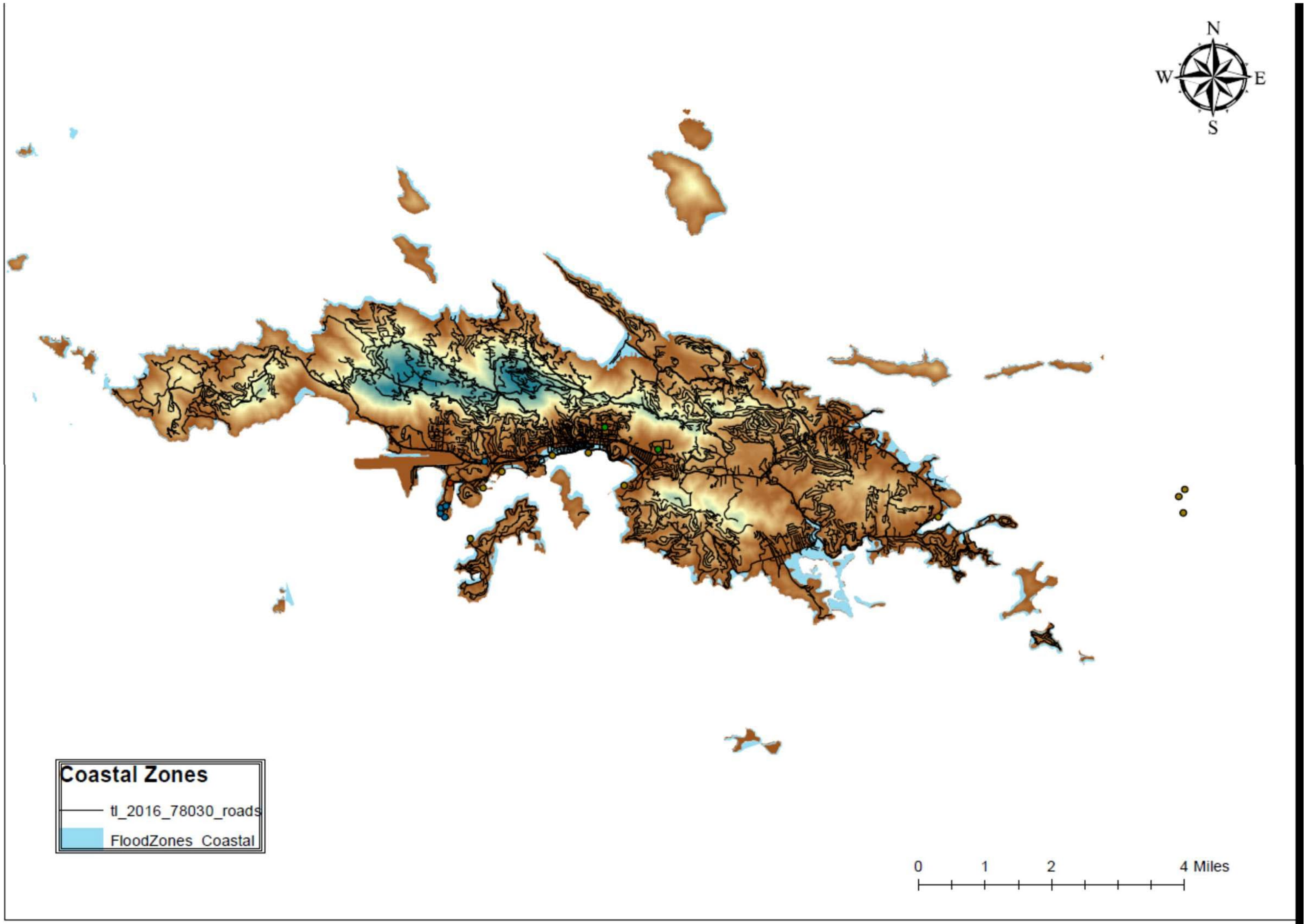


FIGURE 4.19 Coastal Flooding Hazard Map, St. Croix (a)

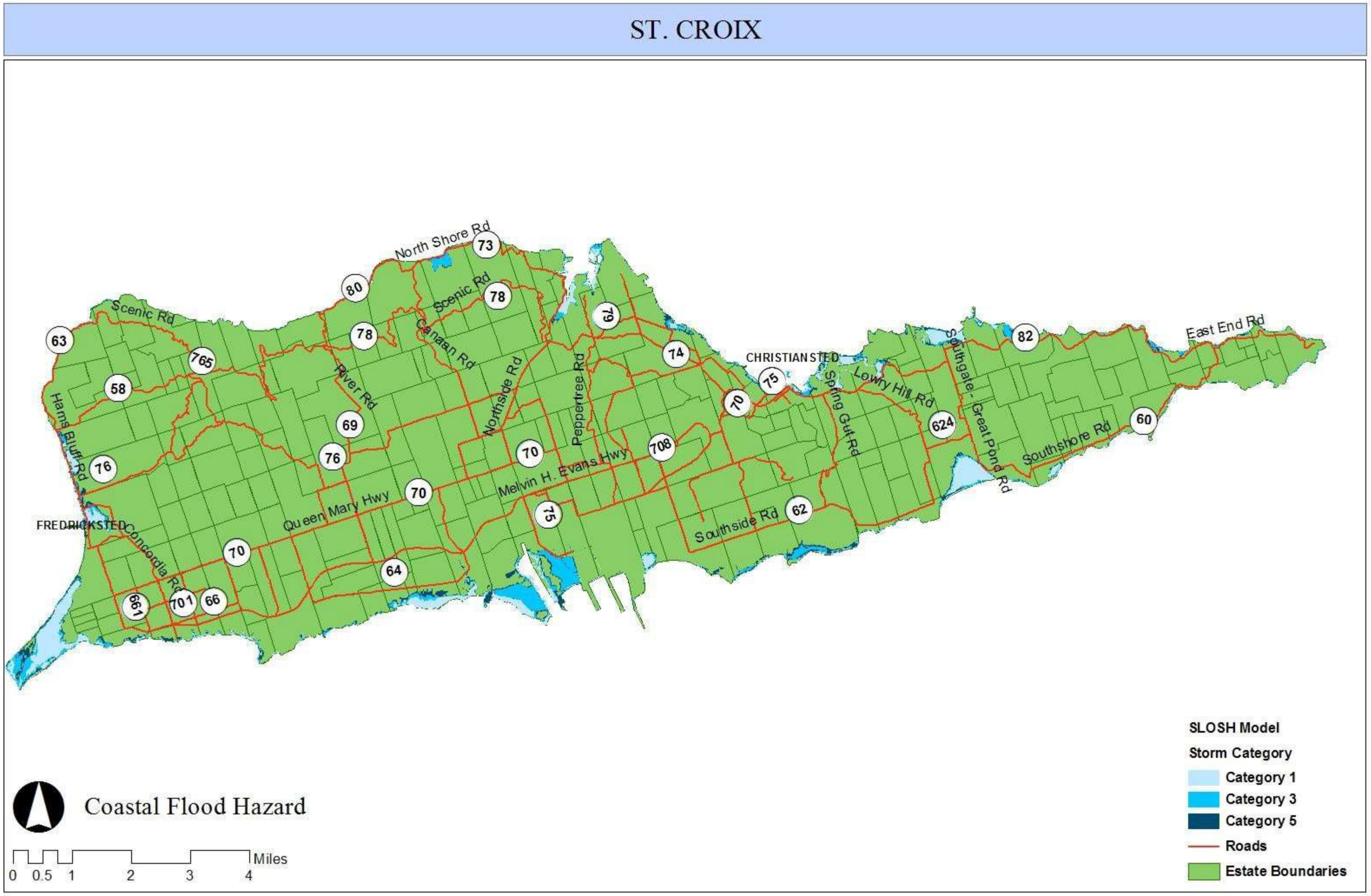


FIGURE 4.20 Coastal Flooding Hazard Map, St. Croix (b)

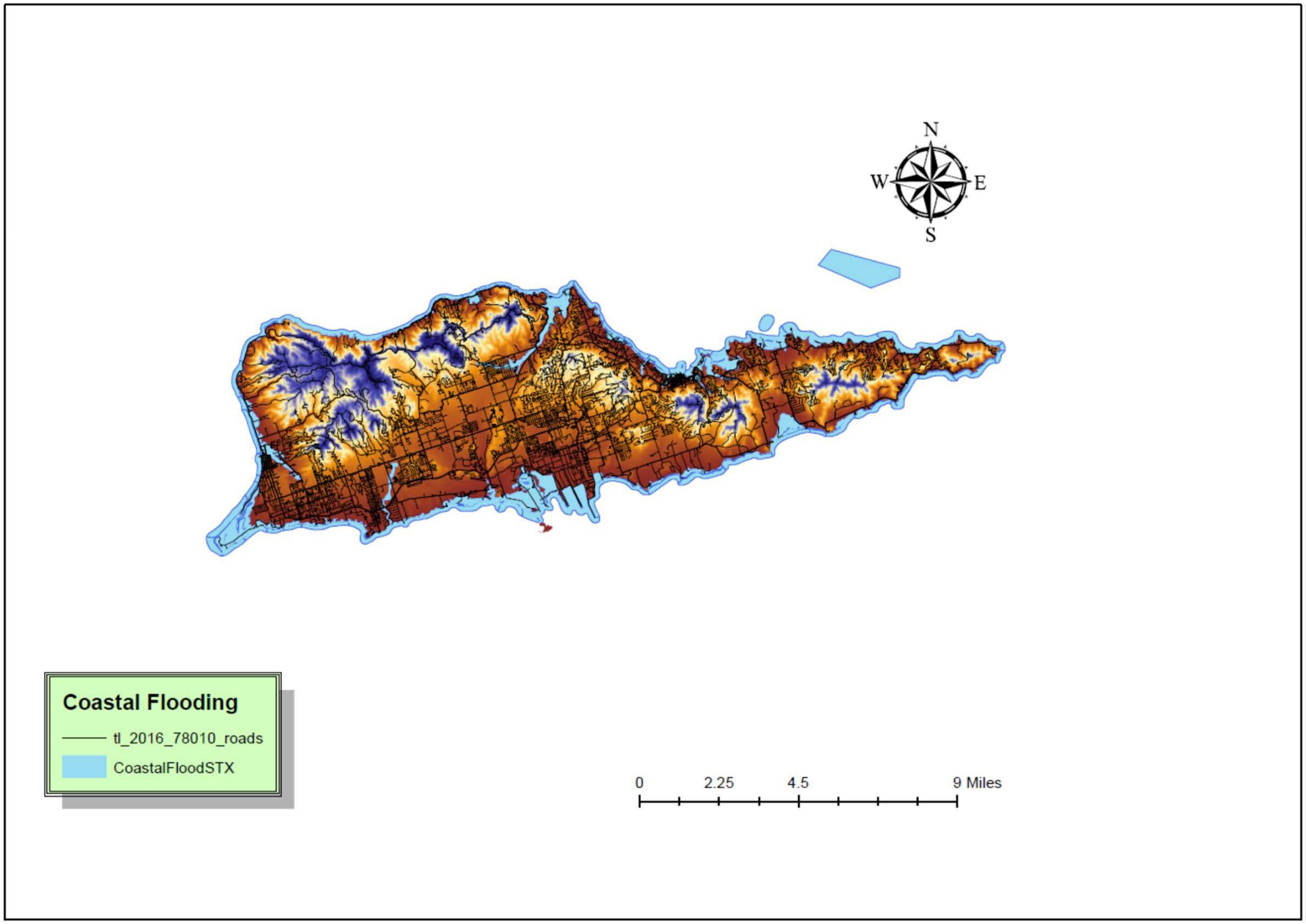


FIGURE 4.21 Coastal Flooding Hazard Map, St. John (a)

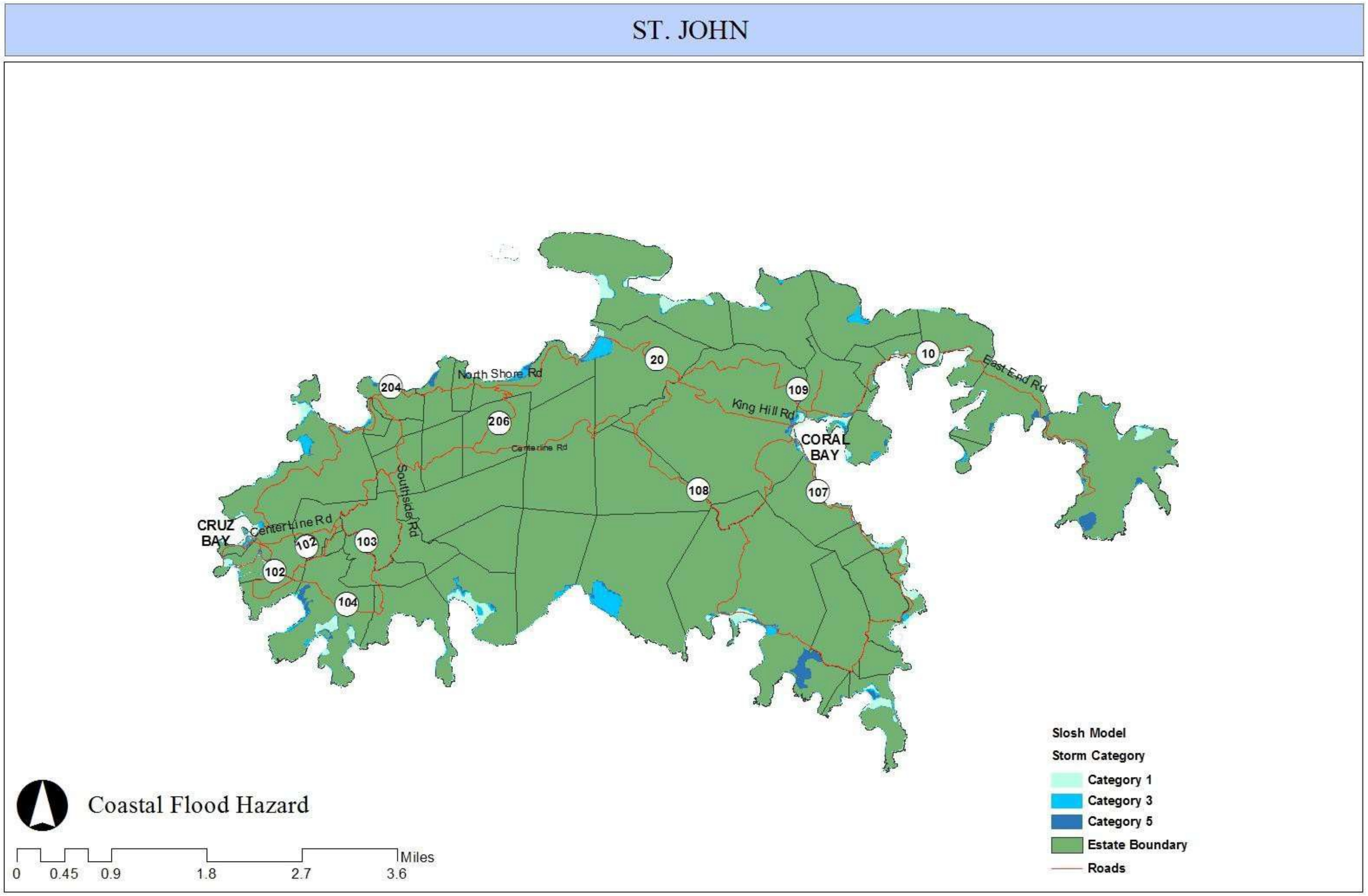
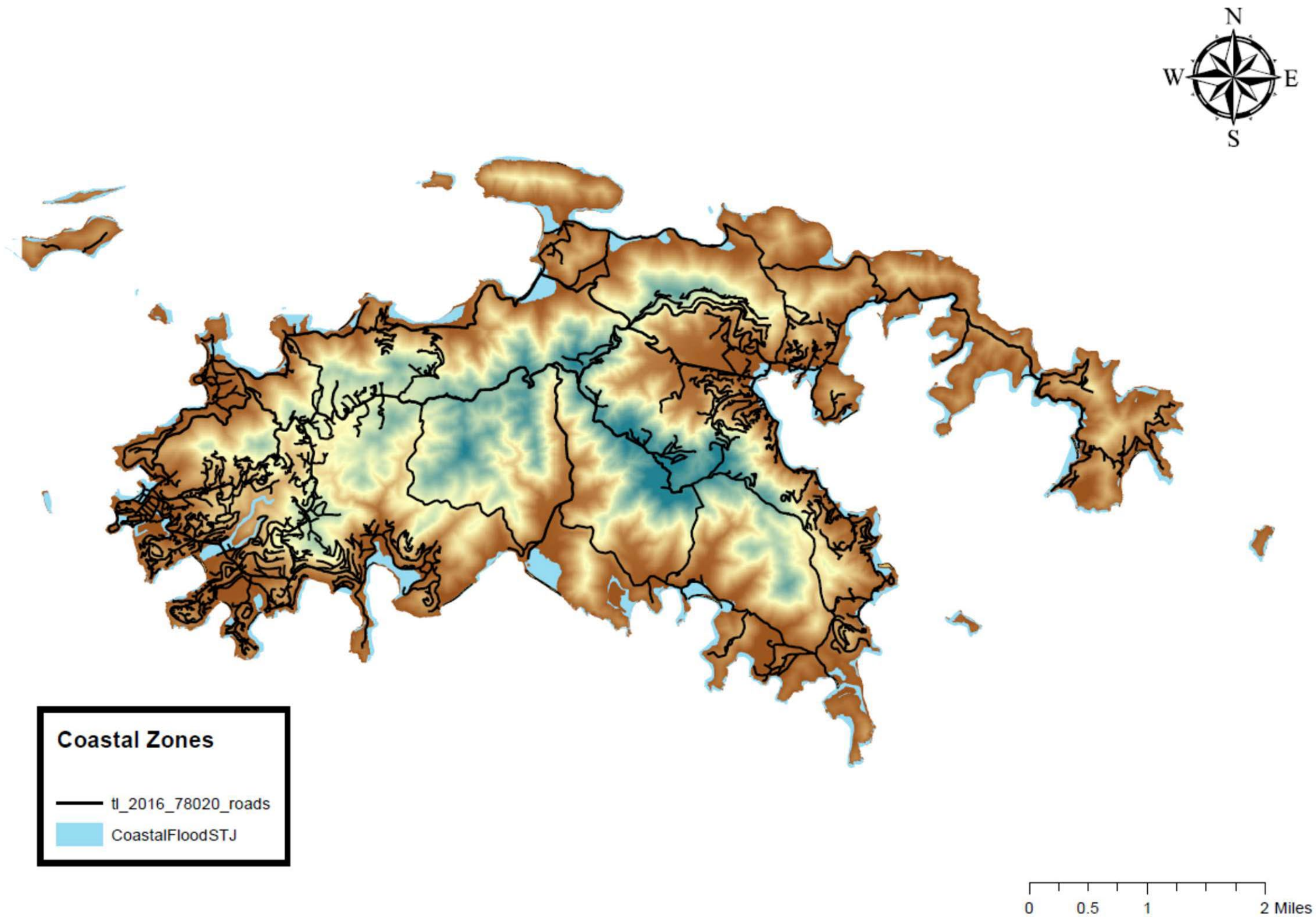


FIGURE 4.22 Coastal Flooding Hazard Map, St. John (b)



DISASTER HISTORY

Since the last Plan Update (2019), there have not been any major coastal flooding Federal disaster declarations that have caused damage to residential and/or commercial buildings. During the last planning period (2014-2019), Hurricane Irma and Maria were the strongest storms to past the islands; these storms did have an impact on the shorelines such as washing several boats ashore, roads being washed away as well as dunes being compromised.

There is limited available information from the US Virgin Islands that isolates coastal flooding from other hazard impacts. This is an instance where the Hazard Mitigation Resiliency plan would be able to assist. The focus will be given to coastal factors and how planning and preparation can assist with this hazard and how utilizing agencies who are instrumental would be an assist with mitigation goals that can be implemented and assessed. One undocumented source list 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 equal damage.

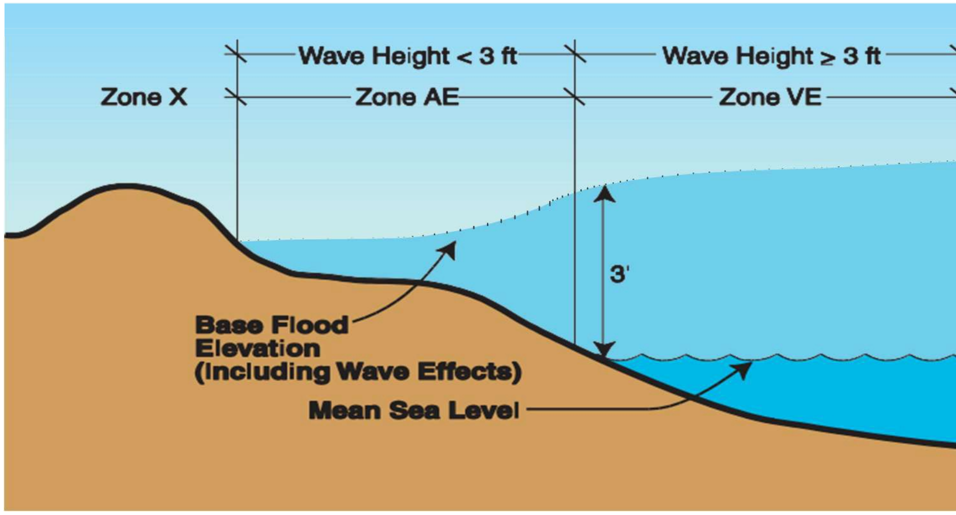
During Hurricane Irma and Maria, tremendous storm surge and wave action affected structures well inland of the coastal high hazard zone (Zone VE), as shown on the FIRMs. The beach and dune systems in the coastal impact areas were destroyed, causing increased storm surge inundation levels and wave action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

Climate Variability, 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 4.23 Definition Sketch for Coastal Floodplains



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, 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 floodwaters 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.

In low-lying coastal areas, such as estuaries, wetlands, and mangroves, storm surge can cause problematic saltwater intrusion into freshwater systems. As rising water levels submerge low-lying portions of the lands, it has the potential disrupt sensitive ecosystems and potential diminish critical habitat for larval fish, natural sinks for sediments and pollutants, natural storage for floodwaters, and cherished aesthetic quality of coastal regions (Incorporating Sea Level Change Scenarios at the Local Level, NOAA 2012).

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 was 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.
- NOAA Coastal Service Center, Incorporating Sea Level Change Scenarios at the Local Level, NOAA 2012

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

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 the proportion of assets located in coastal flood hazard areas.

SOCIAL IMPACTS

Table 4.27 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 4.27 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					
St. Croix					
St. John					

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 43 residential properties exposed to this hazard on St. Thomas. On St. Croix, there was an increase of 29 residential properties, while on St. John, the total number of residential properties exposed increased by 6. On St. Thomas the total number of commercial properties increased by

- On St. Croix, there was one more commercial property exposed to this hazard, and on St. John, there was no change. 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 2% of the residential building stock is of medium vulnerability, 45% of the residential building stock is of high vulnerability, and the remaining 53% is of very high vulnerability to coastal flooding. About 1% of the commercial building inventory is of medium vulnerability to coastal flooding, 19% of the stock is of high vulnerability, and the remaining 80% 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 23% 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 4.28 Estimated Coastal Flooding Exposure and Vulnerability (St. Thomas)

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	7%	0.00	0.00	0.02	0.45	0.53
No. of Residential	1,636	0	0	29	738	869
Value of Residential	449,919,663	0	0	7,936,939	202,928,784	239,053,939
Commercial Buildings						
% of Commercial	4%	0.00	0.00	0.01	0.19	0.80
No. of Commercial	87	0	0	1	16	70
Value of Commercial	72,827,472	$0	$0	929,427	13,558,474	58,339,570

TABLE 4.29 Estimated Coastal Flooding Exposure and Vulnerability (St. Croix)

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	5%	0%	0%	1%	76%	24%
No. of Residential	1,100	0	0	11	836	264
Value of Residential	289,786,657	0	0	2,897,867	220,237,859	69,548,798
Commercial Buildings						
% of Commercial	2%	0	0	4%	67%	29%
No. of Commercial	17	0	0	3	54	23
Value of Commercial	28,828,522	0	0	57,657,044	965,755,481	418,013,566

TABLE 4.30 Estimated Coastal Flooding Exposure and Vulnerability (St. John)

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	10%	0%	0%	1%	76%	23%
No. of Residential	225	0	0	2	171	52
Value of Residential	82,130,338	0	0	821,303	62,419,057	18,889,978
Commercial Buildings						
% of Commercial	10%	0	0	4%	47%	49%
No. of Commercial	8	0	0	0	4	4
Value of Commercial	33,957,427	0	0	1,358,297	15,959,990	16,639,139

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.

TABLE 4.31 Estimated Coastal Flooding Exposure and Vulnerability, Critical Facilities, and Infrastructure (St. Thomas)

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	**5**	5					**12,727,552**
Fire Stations	**5**	5					**7,792,547**
Emergency Response	**1**	1					**6,472,875**
Hospital, Clinics, and special needs	**5**	5					**95,838,253**
Government Buildings	**11**	11					**118,417,923**
Shelters / Special Needs	**5**	5					**123,556,219**
Transportation Infrastructure							
Marine Ports	**4**	4					**26,038,712**
Airport	**1**	1					**22,475,260**
Utilities							
Electrical Power Generating Plants	**1**	1					**51,172,046**
Sewage Treatment Plant	**1**	1					**61,792,356**
Water Treatment Plant	**1**	1					
WAPA Tanks	**1**	1					
Pumping Station	**1**	1					

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

TABLE 4.32 Estimated Coastal Flooding Exposure and Vulnerability, Critical Facilities, and Infrastructure (St. Croix)

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	**6**	6					**63,719,946**
Fire Stations	**5**	5					**9,269,808**
Emergency Response	**1**	1					**-**
Hospital, Clinics, and special needs	**3**	3					**135,990,389**
Government Buildings	**12**	11				1	**121,046,648**
Shelters / Special Needs	**11**	11					**173,286,506**
Transportation Infrastructure							
Marine Ports	**5**	5					**9,922,078**
Airport	**1**	1					**57,686,500**
Utilities							
Electrical Power Generating Plants	**1**	1					**51,917,850**
Sewage Treatment Plant	**14**	14					**110,067,300**
Water Treatment Plant	**1**	1					
WAPA Tanks	**1**	1					
Pumping Station	**8**	8					

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility

TABLE 4.33 Estimated Coastal Flooding Exposure and Vulnerability, Critical Facilities, and Infrastructure (St. John)

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	2	2					4,321,296
Fire Stations	2	2					4,845,666
Emergency Response	1	1					5,142,339
Hospital, Clinics, and special needs	2	2					17,590,586
Government Buildings	3	2				1	13,159,486
Shelters / Special Needs	5	5					52,473,202
Transportation Infrastructure							
Marine Ports	1	1					2,884,325
Airport	N/A						--
Utilities							
Electrical Power Generating Plants	1					1	15,575,355
Sewage Treatment Plant	1	1					
Water Treatment Plant	1					1	
WAPA Tanks	1					1	33,518,154
Pumping Station	1	1					

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

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 – Riverine and Coastal Flooding, respectively.

Hurricane magnitude is measured on the Saffir-Simpson hurricane scale, shown in Table 4.34, which categorizes hurricane magnitude by wind speeds and storm surge above normal sea levels.

TABLE 4.34 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). The peak of activity occurs in September, with half of the number of average annual storms occurring in that month.

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.In 2017 the US Virgin Island was impacted by two major Category 5 hurricanes. On September 6, Hurricane Irma struck the US Virgin Islands, predominantly the islands of St. Croix, St. Thomas, and Water Island.

FIGURE 4.24: St. Thomas after being impacted by two major Category 5 hurricanes (Irma and Maria)

ST. THOMAS

Less than two weeks later, on September 19, 2017, Hurricane Maria also struck the US Virgin Islands, predominately the island of St Croix. Both hurricanes left significant devastation behind, power distribution was severely damage, communication was severely limited, potable water and wastewater treatments were inoperable, and there were many buildings, both residential and commercial, significantly damaged or destroyed.

FIGURE 4.25: St. Croix after being impacted by two major Category 5 hurricanes (Irma and Maria)

ST. CROIX

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Figure 4.26: St. John, after being impacted by two major Category 5 hurricanes (Irma and Maria)

ST. JOHN	
	

Pictures are a combination of pictures shared and pictures obtained via an internet search. The intent of pictures is strictly to capture instances of the damages caused by Hurricane Irma and Maria in the various islands within the Territory as part of this plan. No copyright infringement is intended.

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.

Necessarily there are no areas of the US Virgin Islands that are free from hurricane-force winds. The coastal and low-lying regions experience the first effects of damaging winds. Still, 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 code 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 two federal disaster declaration in the US Virgin Islands. Disaster # 4335 Hurricane Irma and Disaster # 4340, Hurricane Maria. Two category 5 Hurricanes made landfall on the territory within two weeks -a time span of each other. Devastating damage was sustained on all three islands. Disaster Recovery is still ongoing two years later

Of the 22 deadliest, costliest, and most intense hurricanes to strike outlying US territories and the State of Hawaii over the past 100 years, 9 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
- Marilyn (1995). US Virgin Islands and P.R. Damages estimated at 1$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.
- Irma (2017) US Virgin Islands, PR, FL, GA, and SC. Damages estimated at $45 billion
- Maria (2017) US Virgin Islands and PR. Damages estimated at $102 billion.

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 Frederiksted 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 impacted St. Croix. As a result, St. Croix suffered damages of catastrophic proportions. 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*** (September 1995). This time, St. Thomas bore the brunt of this massive 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 ten 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 its coastline. Lenny's maximum winds reached 150 mph as it approached the US Virgin Islands.

- **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 southern of the US Virgin Islands, which received 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 four hurricane, with maximum winds of around 135 mph while it was moving away from the Virgin Islands.

- **Hurricane Irma and Maria** (September 2017). Hurricanes Irma and Maria, both Category 5 storms with wind gusts of up to 178 MPH at their centers, impacted the USVI within two weeks of each other on September 6 and September 20, 2017. Hurricane Irma most affected the St. Thomas-St. John district and damaged St. Croix as well; Hurricane Maria most affected St. Croix, which by then had become the staging ground for recovery operations for areas damaged by Irma, and further damaged what was already damaged on St. Thomas and St. John. The hurricanes caused five direct deaths in the Territory.

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

It is important to note that before Hurricane Irma and Maria, the last hurricane with winds of Category 3 or greater occurred was Hurricane Hugo, which occurred in 1989. During the period from 1989 to 2018, dozens of milder tropical storms and hurricanes came in close proximity or made landfall, but none caused the damages associated with Irma and Maria.

Climate Variability, Hazard Frequency, and Magnitude

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 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 structure and areal extent of the wind field in tropical cyclones are mainly independent of intense storms and play an essential role in potential impacts. With the use of satellite imagery and other instruments, intensity measurements have become more accurate. As a result, the recorded intensities of windstorms in the Atlantic have been increasing.

However, the IPCC Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5, 2013) indicates that the frequency of the most intense storms is more likely than not to increase by more than +10% (IPCC 2013, AR5), while the annual frequency of tropical cyclones is projected to decrease or remain relatively unchanged for the North Atlantic. This suggests no major change in the frequency of hurricanes in the North Atlantic region comprising USVI and that wind speeds are expected to decrease by a minimal magnitude of 0.25 m/s (0.559 mph) over the projected for the 2040s relative to the 1960-1990 baseline.

The design wind speed for the USVI in ASCE 7-05 is 145 mph (3-second peak gust) may decline marginally due to climate change projects if it were indeed related to a return interval. 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.)
- IPCC AR4, 2007, The IPCC Fourth Assessment Report of the Intergovernmental Panel on Climate Change
- IPCC AR5, 2014, IPCC Fifth Assessment Report of the Intergovernmental Panel on Climate Change

Hurricane Hazard Assessment and Determination

The American Society of Civil Engineers (ASCE) 7-05 Design Wind Speed maps where the primary data input for the wind hazard model as probabilistic data were not readily available. The ASCE Design Wind Speeds considers historical events such as hurricanes and tropical storms. http://www.aoml.noaa.gov/hrd/tcfaq/G11.html

The design wind speed in **ASCE 7-05**[10] 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
- University of the Virgin Islands

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

There was significant wind speed that was produced by Hurricane Irma and Maria, which were utilized in the hurricane tracks that were developed for FEMA in 2017. When the maps were produced, they were combined with the topographic models and developed further.

Consequently, when topography is considered, some locations have maximum wind speeds that are less than those which would have been estimated assuming flat open terrain over the entire island. A comparison of the two sets of maps shows the very significant effect topography has on both reducing and increasing the gust wind speeds compared to the open terrain cases. The maximum and minimum wind speeds with and without the effects of topography are summarized in Table 4.57

Table 4.35 Modeled maximum and minimum gust wind speeds on the three main islands of the USVI caused by Hurricane Irma, showing the effect of topography.

Table 4.35 Modeled maximum and minimum gust wind speeds in USVI caused by Hurricane Irma

ISLANDS	Flat Open Terrain		Open Terrain with Topography	
	Minimum (mph)	**Maximum (mph)**	**Minimum (mph)**	**Maximum (mph)**
St. John	145.7	174.1	59	266
St. Thomas	127	156.8	53	231.2
St. Croix	56.3	75.3	24.7	112

Table 4.36 Modeled maximum and minimum gust wind speeds on the three main islands of the USVI caused by Hurricane Maria, showing the effect of topography.

Table 4.36 Modeled maximum and minimum gust wind speeds in USVI caused by Hurricane Maria

ISLANDS	Flat Open Terrain		Open Terrain with Topography	
	Minimum (mph)	**Maximum (mph)**	**Minimum (mph)**	**Maximum (mph)**
St. John	83.4	93.9	33.6	145.3
St. Thomas	90.2	102.7	36.3	150.3
St. Croix	105	151.9	49.9	201.6

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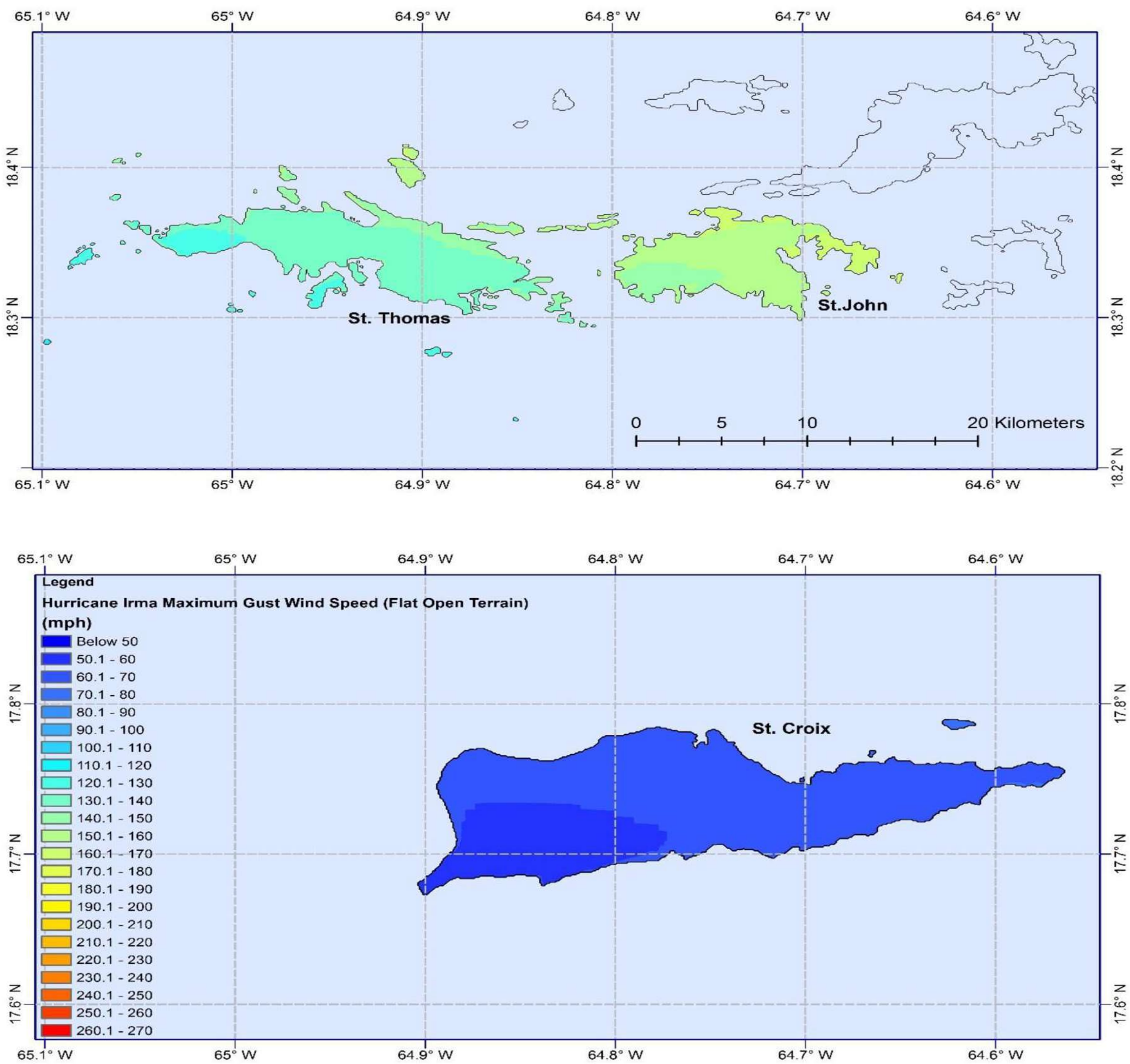
Figure 4.27 Illustration of Maximum Gust Winds from Hurricane Irma



This section discussed the population and the proportion and value of buildings located in areas affected by a Hurricane Winds hazard. It also provides an estimate of the proportion of assets located in Hurricane Winds hazard areas. Although there no areas of the US Virgin Islands that are free from hurricane-force winds, the vulnerability of each island-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 individual models building types that found throughout each island, e.g., single-family wood-frame buildings, may experience various types of damage to the hurricane wind hazard (ranging from Very Low, Low, Moderate, High, to Very High).

SOCIAL IMPACTS

Table 4.37 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 4.37 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	**54,229**	11,388	21%	2,711	5%
St. Croix	**56,404**	14,101	25%	2,820	5%
St. John	**4,447**	1,067	24%	267	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 an increase of 331 residential properties exposed to this hazard on St. Thomas. On St. Croix, there were 9239 residential properties presented to the hazard, which represented an increase of 243 properties. On St. John, there were 786 residential properties, which represented an increase of 2 structures that are exposed to high winds. On St. Thomas, there were 41 more commercial properties exposed to this hazard. While in St. Croix, there were 31 more commercial properties and no increase in commercial properties on St. John.

- 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 1% of the commercial building inventory has a low vulnerability to hurricane-force winds, and the remaining 99% 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 susceptibility to such winds.

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

TABLE 4.38 Estimated Hurricane Exposure and Vulnerability (St. Thomas)

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	54%	0%	1%	94%	5%	0%
No. of Residential	12,617	0	126	11860	631	0
Value of Residential	$3,470,808,827	$0	$34,708,088	$3,262,560,297	$173,540,441	$0
Commercial Buildings						
% of Commercial	70%	0%	1%	99%	0%	0%
No. of Commercial	1530	0	28	2157	0	0
Value of Commercial	$1,274,480,752	$0	$23,235,666	$1,797,451,122	$0	$0

TABLE 4.39 Estimated Hurricane Exposure and Vulnerability (St. Croix)

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	42%	0%	83%	12%	5%	0%
No. of Residential	9,239	0	7,668	1,109	462	0
Value of Residential	2,434,207,920	0	2,020,392,573	292,104,950	121,710,396	0
Commercial Buildings						
% of Commercial	58%	0%	69%	31%	0%	0%
No. of Commercial	484	0	334	150	0	0
Value of Commercial	1,441,426,090	0	994,584,002	446,842,088	0	0

TABLE 4.40 Estimated Hurricane Exposure and Vulnerability (St. John)

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	35%	0	0.86	0.09	0.05	0
No. of Residential	786	0	676	71	39	0
Value of Residential	287,456,182	0	247,212,317	25,871,056	14,372,809	0
Commercial Buildings						
% of Commercial	35%	0	0.73	0.27	0	0
No. of Commercial	28	0	21	8	0	0
Value of Commercial	118,850,993	0	86,761,225	32,089,768	0	0

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 4.41 Estimated Hurricane Exposure and Vulnerability, Critical Facilities, and Infrastructure (St. Thomas)

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	**5**			3	1		**12,727,552**
Fire Stations	**5**		1	2	2		**7,792,547**
Emergency Response	**1**		1				**6,472,875**
Hospital, Clinics, and special needs	**5**		1	2	2		**95,838,253**
Government Buildings	**11**		2	1	6	2	**118,417,923**
Shelters	**5**			1	4		**123,556,219**
Transportation Infrastructure							
Marine Ports	**4**	1	1	1	1		**26,038,712**
Airport	**1**		1				**22,475,260**
Utilities							
Electrical Power Generating Plants	**1**		1				**51,172,046**
Sewage Treatment Plant	**1**		1				**61,792,356**
Water Treatment Plant	**1**		1				
WAPA Tanks	**1**		1				
Pumping Station	**1**		1				

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

TABLE 4.42 Estimated Hurricane Exposure and Vulnerability, Critical Facilities, and Infrastructure (St. Croix)

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	6		4	2			63,719,946
Fire Stations	5	1			1	3	9,269,808
Emergency Response	1		1				-
Hospital, Clinics, and special needs	3			2		1	135,990,389
Government Buildings	12			6	2	4	121,046,648
Shelters	11		1	3	1	6	173,286,506
Transportation Infrastructure							
Marine Ports	5	4	1				9,922,078
Airport	1			1			57,686,500
Utilities							
Electrical Power Plants	1		1				51,917,850
Sewage Pumps	14	3	2	3	4	2	110,067,300
Wastewater Treatment Plant	1		1				
Water Treatment Plant	1		1				
WAPA Pumps	8		8				
WAPA Tanks	12	2	3	3	4		

Appendix E provides detailed Vulnerability and Loss Estimate calculations for each facility

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

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	2		1		1		4,321,296
Fire Stations	2		1		1		4,845,666
Emergency Response	1		1				5,142,339
Hospital, Clinics, and special needs	2		1			1	17,590,586
Government Buildings	3		2		1		13,159,486
Shelters	5			2	3		52,473,202
Transportation Infrastructure							
Marine Ports	1		1				2,884,325
Airport	N/A						
Utilities							
Electrical Power Plant	1		1				15,575,355
WAPA Desalinization Plant	1		1				33,518,154
WAPA Water Tank	1		1				
Sewage Treatment Plant	1		1				
Potable Water Tank	1	1					

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

RAIN INDUCED LANDSLIDES

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 movements, such as rockfalls, profound 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 rockslides, slumps, mudslides, and earth flows. 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 dues 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 the spatial extent of landslides is hard to determine, human impacts have a substantial effect 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

Figures 4.67, 4.68, and 4.69 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 blockeda major road.

- St. Thomas. The mountain areas, mainly 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 massive 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 CrownMountain 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 Islands[11].

A reconnaissance of landslide potential on St. Thomas (Brabb, 1984) indicates that earth flows, 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

- The most massive 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 of rain in 14 hours. In addition to extensive flooding, this storm event produced a number of landslides. Two earth flows 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 Bayand 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

FIGURE 4.28 Landslide Hazard Map, St. Thomas

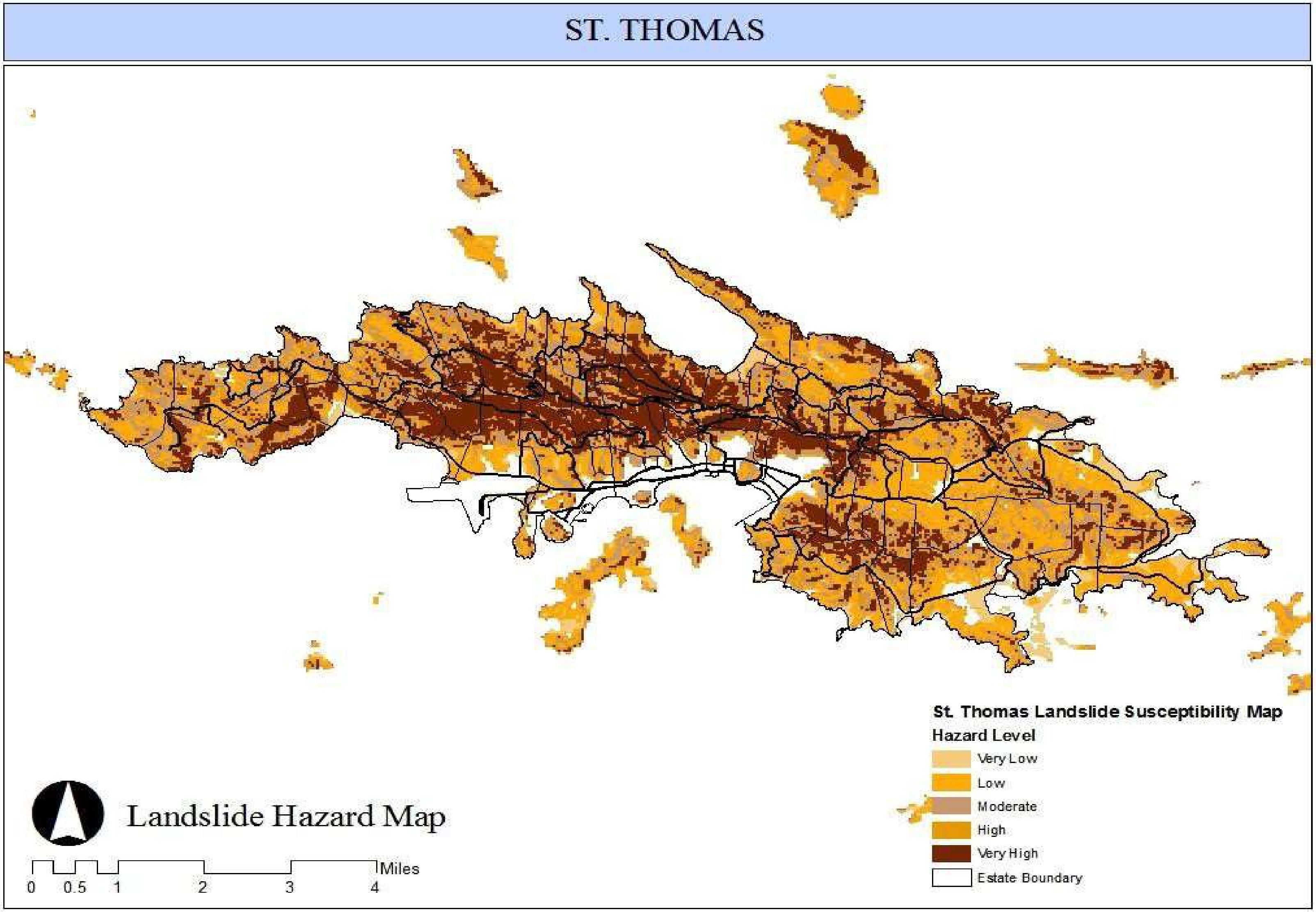


FIGURE 4.29 Landslide Hazard Map, St. Croix

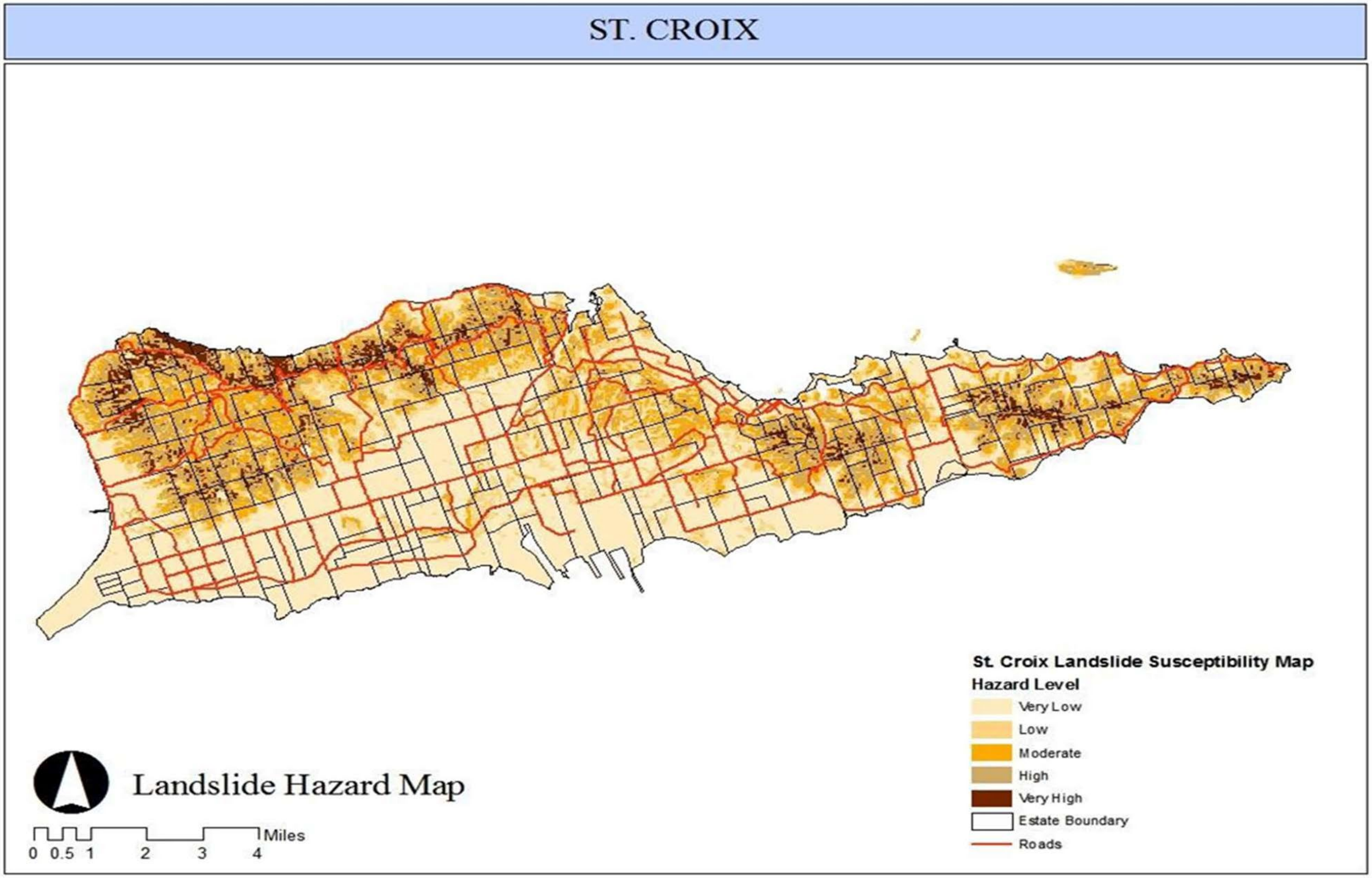
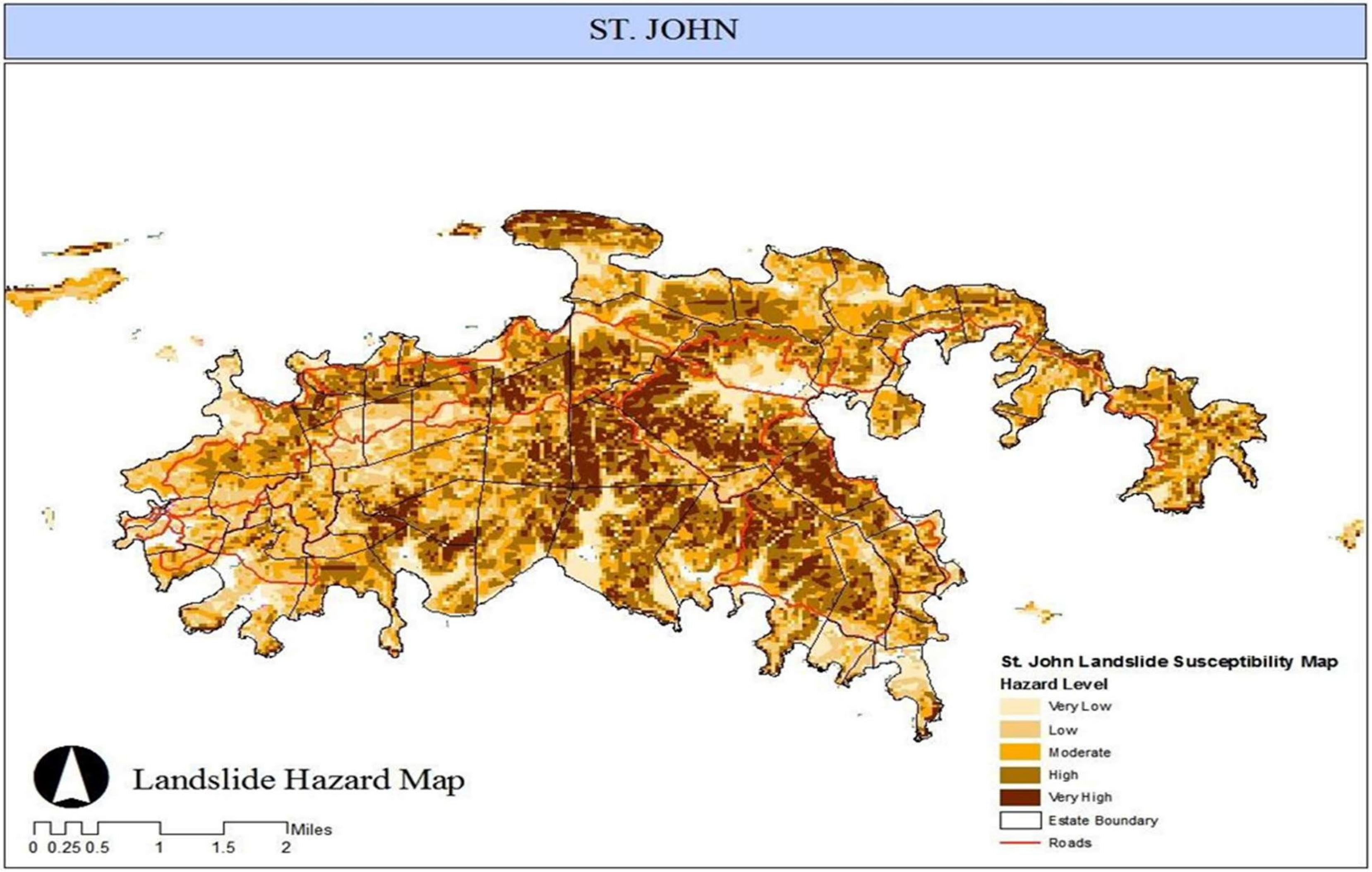


FIGURE 4.30 Landslide Hazard Map, St. John



Climate Variability, 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 massive 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.

The implications of climate variability on the landslide hazard are tied to the intensity of past climate data to facilitate an understanding of whether data derived from regional climate models will increase the potential for landslide events in the study area. The hazard model that was used took into consideration precipitation, which indicates that landslide events are triggered by intense precipitation. Therefore, based on the IPCC projections, which predict an increase in intense precipitation events, the impact of climate change will increase the possibility of experiencing landslides will increase.

To incorporate climate change into future landslide hazard models will necessitate making use of detailed historical records.

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

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

SOCIAL IMPACTS

Table 4.44 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 4.44 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	**54,229**	9,246	17%	2,278	4%
St. Croix	**56,404**	3,462	6%	853	2%
St. John	**4,447**	1,516	34%	146	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 11,682 residential structures and 830 commercial structures exposed to this hazard on St. Thomas. On St. Croix, there are 3,959 residential structures and 150 commercial structures exposed to this hazard on St. Thomas. On St. John, there are 876 residential structures and 30 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 susceptibility to rain-induced landslide events. Commercial structures are considered to be less vulnerable to rain-induced landslide, with the majority of structures falling into the shallow 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 the 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 hazards on St. Thomas, St. Croix, and St. John.

TABLE 4.45 Estimated Rain-Induced Landslide Exposure and Vulnerability (St. Thomas)

Total Number of Buildings/ Percentage		**Number, Percentage, and Value of Buildings by Vulnerability Rating**				
OCCUPANCY CLASS		**Very Low**	**Low**	**Moderate**	**High**	**Very high**
Residential Buildings						
% of Residential	**50%**	**5%**	**33%**	**22%**	**13%**	**27%**
No. of Residential	**11,682**	**629**	**3,834**	**2,546**	**1,463**	**3,211**
Value of Residential	**$3,213,711,877**	**$173,052,574**	**$1,054,598,986**	**$700,405,281**	**$402,405,769**	**$883,249,267**
Commercial Buildings						
% of Commercial	**38%**	**13%**	**87%**	**0**	**0**	**0**
No. of Commercial	**830**	**109**	**721**	**0**	**0**	**0**
Value of Commercial	**$691,860,980**	**$91,034,339**	**$600,826,640**	**$0**	**$0**	**$0**

TABLE 4.46 Estimated Rain-Induced Landslide Exposure and Vulnerability (St. Croix)

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
of Residential	18%	46%	20%	17%	13%	5%
No. of Residential	3959	1,805	790	654	504	207
Value of Residential	$1,043,231,966	475,623,664	208,168,636	172,259,816	132,684,653	54,495,197
Commercial Buildings						
% of Commercial	18%	70%	30%	0	0	0
No. of Commercial	150	105	46	0	0	0
Value of Commercial	259,456,696	180,833,455	78,623,241	0	0	0

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

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	39%	15%	22%	24%	27%	12%
No. of Residential	876	130	197	206	236	107
Value of Residential	$320,308,317	47,473,212	71,913,125	75,445,644	86,187,058	39,289,278
Commercial Buildings						
% of Commercial	37%	41%	59%			
No. of Commercial	30	12	18	0	0	0
Value of Commercial	125,642,478	50,936,140	74,706,338	0	0	0

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

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	**5**	3	2				**12,727,552**
Fire Stations	**5**	3	2				**7,792,547**
Emergency Response	**1**	1					**6,472,875**
Hospital, Clinics, and special needs	**5**	4	1				**95,838,253**
Government Buildings	**11**	10	1				**118,417,923**
Shelters	**5**	2	1	1	1		**123,556,219**
Transportation Infrastructure							
Marine Ports	**4**	4					**26,038,712**
Airport	**1**	1					**22,475,260**
Utilities							
Electrical Power Generating Plants	**1**	1					**26,038,712**
Sewage Treatment Plant	**1**		1				**22,475,260**
Water Treatment Plant	**1**		1				
WAPA Tanks	**1**	1					
Pumping Station	**1**		1				

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

TABLE 4.49 Estimated Rain-Induced Landslide Exposure and Vulnerability, Critical Facilities, and Infrastructure (St. Croix)

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	**6**	6					**63,719,946**
Fire Stations	**5**	5					**9,269,808**
Emergency Response	**N/A**						**-**
Hospital, Clinics, and special needs	**3**	3					**135,990,389**
Government Buildings	**12**	11	1				**121,046,648**
Shelters	**11**	11					**173,286,506**
Transportation Infrastructure							
Marine Ports	**5**	5					**9,922,078**
Airport	**1**	1					**57,686,500**
Utilities							
Electrical Power Generating Plants	**1**	1					**51,917,850**
Sewage Pumps	**14**	14					**110,067,300**
Wastewater Treatment Plant	**1**	1					
Water Treatment Plant	**1**	1					
Water Pumps	**8**	5	3				

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

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

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	2	1	1				4,321,296
Fire Stations	2	1	1				4,845,666
Emergency Response	1	1					5,142,339
Hospital, Clinics, and special needs	2	1	1				17,590,586
Government Buildings	3	2	1				13,159,486
Shelters	5	3	2				52,473,202
Transportation Infrastructure							
Marine Ports	1	1					2,884,325
Airport	N/A						--
Utilities							
Electrical Power Generating Plants	1	1					15,575,355
WAPA Desalinization Plant	1	1					
WAPA Water Tank	1	1					
Sewage Treatment Plant	1	1					
Potable Water Tank	1	1					33,518,154

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

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 rate diminishes, its wavelength decreases, and its height increases significantly. 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 proximity to a landmass to be catastrophic.

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 landmass, 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 the 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 historical 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 concise. Therefore, the types of strategies that will be a 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 US 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 proximity of the Puerto Rican Trench and the Anegada Fault, a devastating tsunami could occur before a 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 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 run-up at Charlotte Amalie and a maximum of 75 meters of landward inundation. Frederiksted, in St. Croix was also stuck by two tsunami waves, that same day, although of lesser magnitude, estimated at 7.6 meters high.

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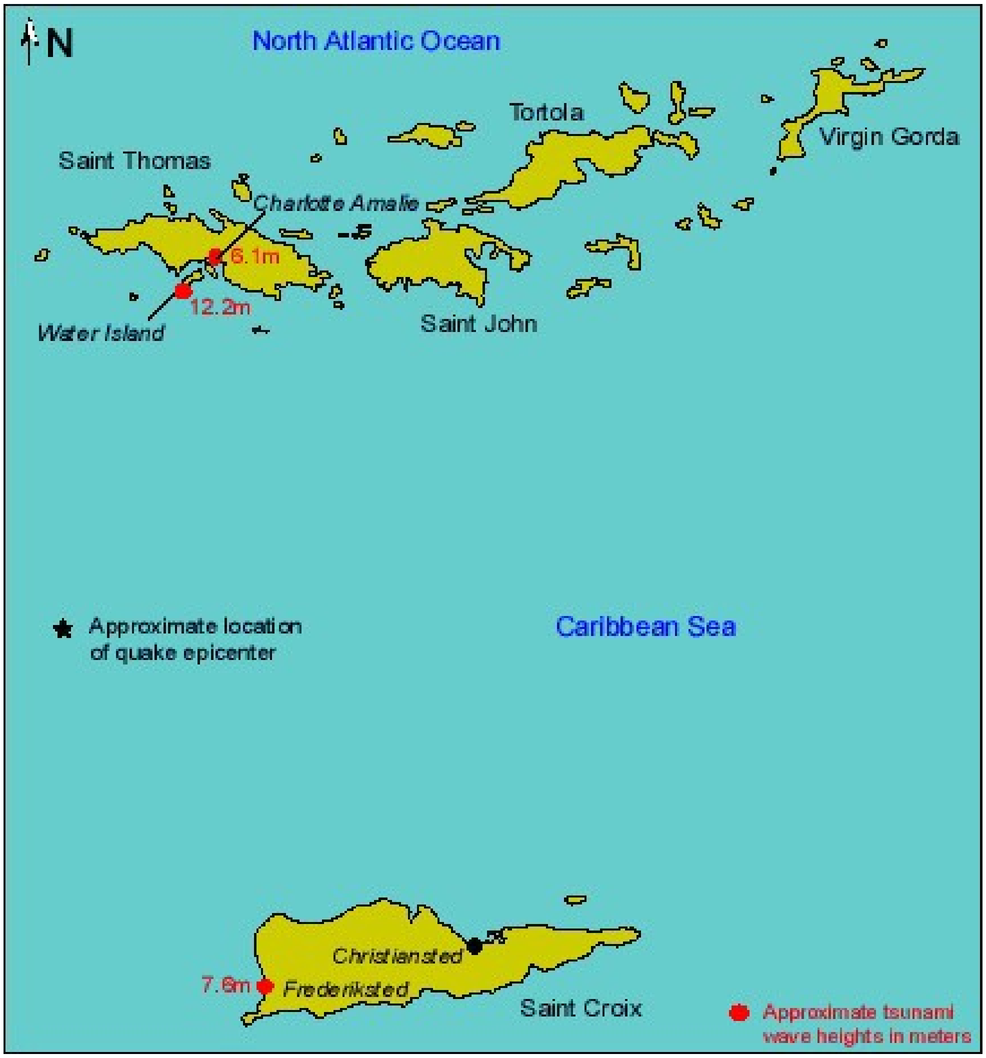
Figure 4.31 illustrates the projected epicenter of the 1867 earthquake in relation to St. Thomas and St. Croix



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Hazard Location, Extent and Distribution

Tsunami hazard areas are all low lying, relatively flat coastal areas. Tsunami hazard areas in the US Virgin Islands are depicted in Figures 4.32, 4.33, and 4.34. Tsunami impacts will vary in the Virgin Islands. The Tsunami hazard maps have been updated for this Plan Update to be more conservative. They have been developed in accordance with national tsunami evacuation planning mapping documentation. The maps have been developed to define an evacuation zone for the US Virgin Island using an 82-foot elevation profile and an inundation of 2 miles from the coast. This evacuation criterion was based on historical events, tsunami modeling results from Puerto Rico and the BVI, and the US National Tsunami Hazard Mitigation Program guidelines. This conservative estimate, however, did not consider offshore and nearshore 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 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, Dr. Roy A. Watlington of the University of the Virgin Islands, indicated that on the third 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 hazards. The town of Frederiksted suffered significant 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.

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FIGURE 4.32 Tsunami Hazard Map, St. Thomas

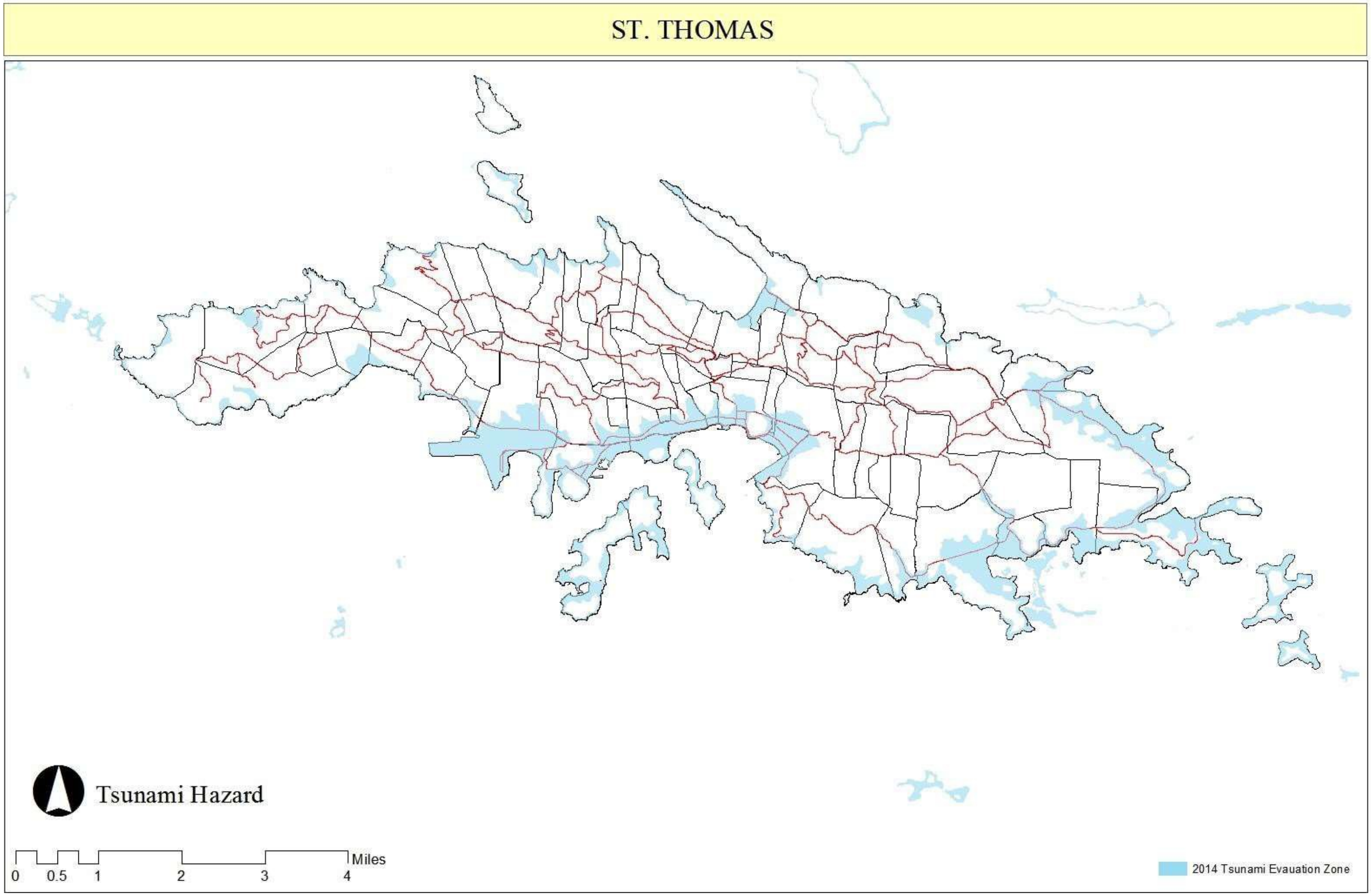


FIGURE 4.33 Tsunami Hazard Map, St. Croix

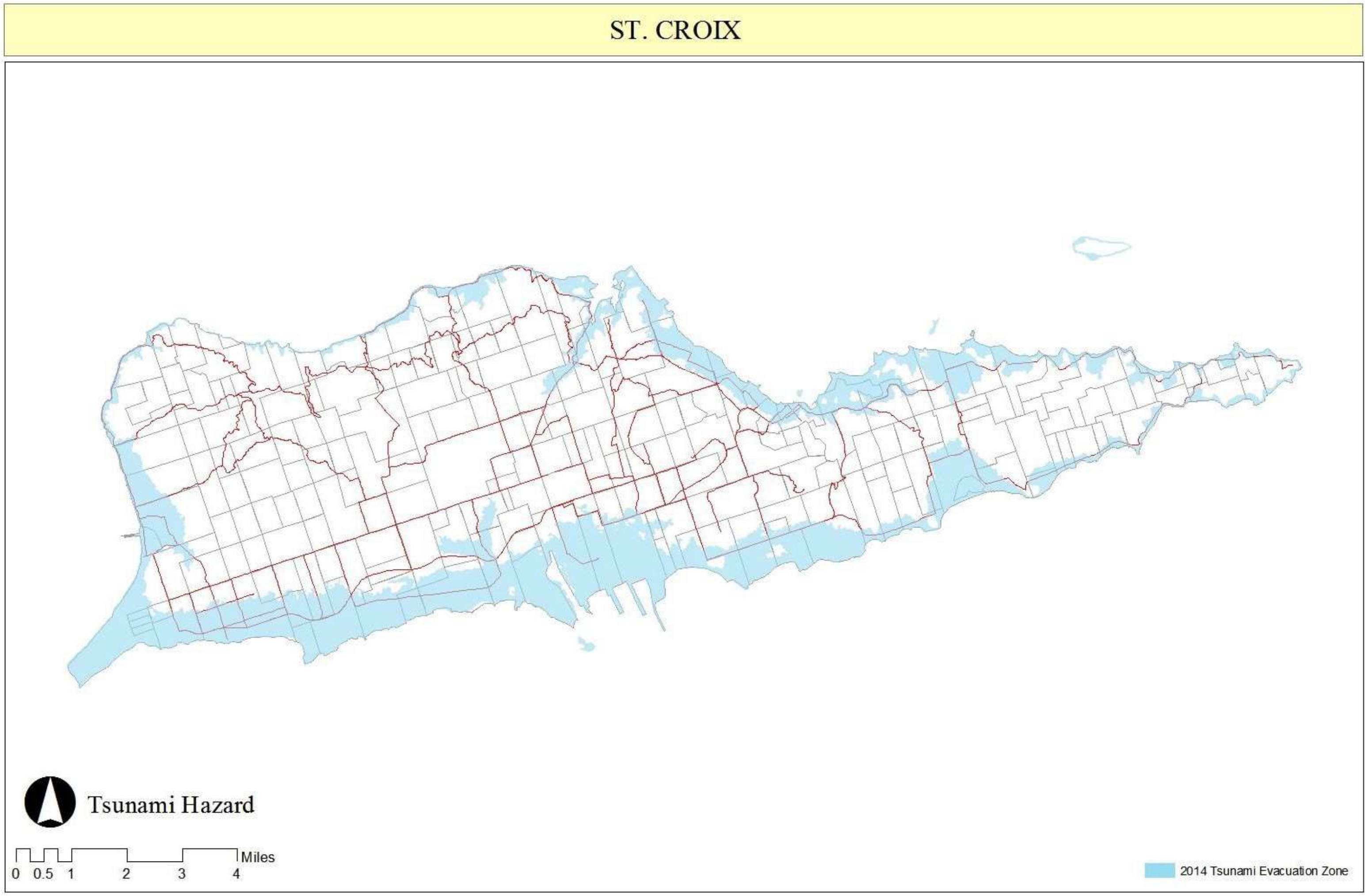
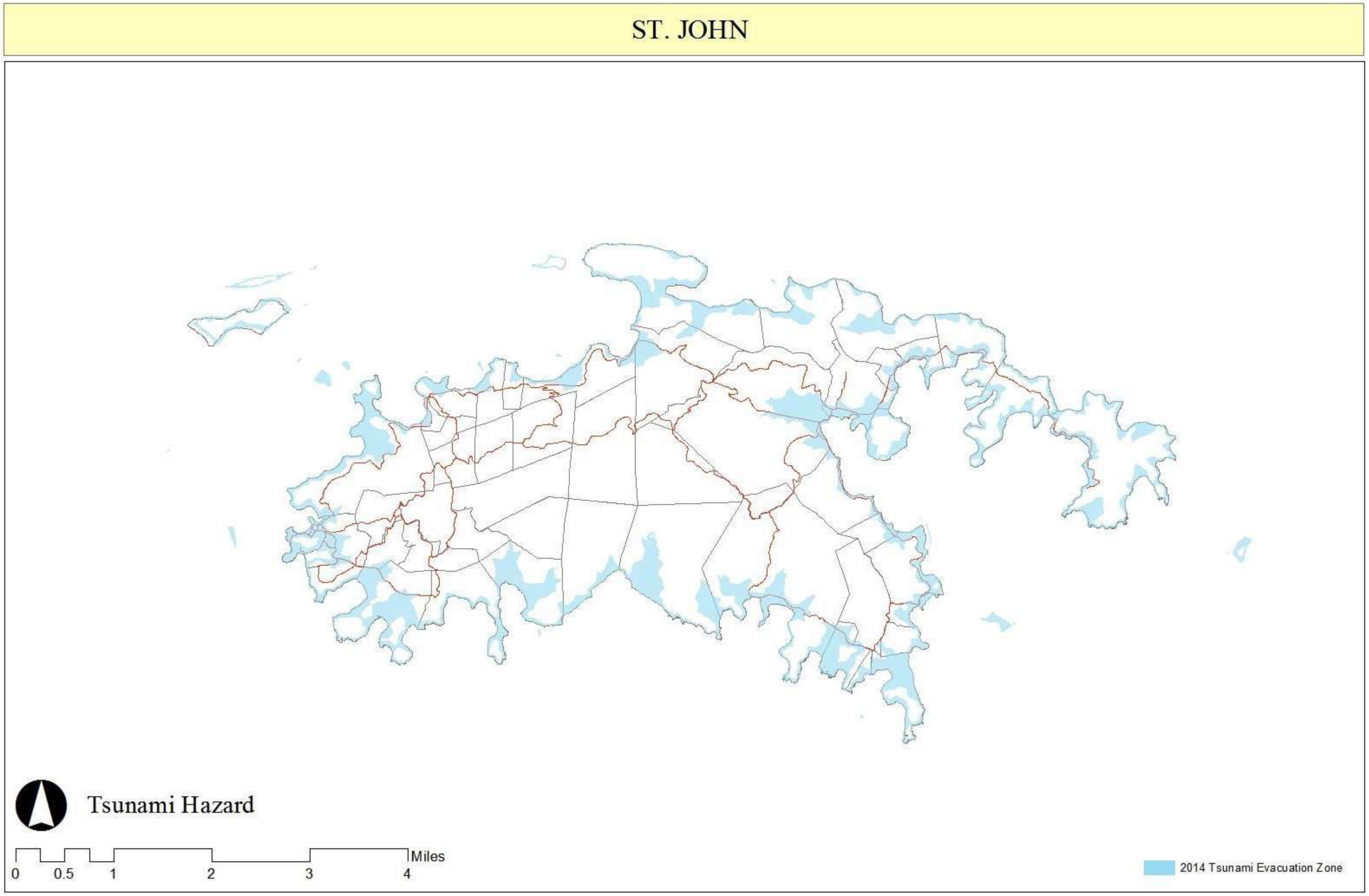


FIGURE 4.34 Tsunami Hazard Map, St. John



DISASTER HISTORY

Tom Parsons and Eric Geist[12] identify 116 individual observations of tsunami run-ups over 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). Thirty 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. A tsunami hit St. John. The 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 five 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 runs 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

- 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
- Guidelines and Best Practices to Establish Areas of Tsunami Inundation for Non-modeled or Low-hazard Regions II

(see; http://nthmp.tsunami.gov/modeling_guidelines.html).

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

- Preparing Your Community for Tsunamis – A Guidebook for Local Advocates, Version 2.1, February 1, 2008, Laura Dwelley Samant, L. Thomas Tobin, Brian Tucker (http://www.preventionweb.net/files/3984_PreparingYourCommunityforTsunamisV21.pdf).

Tsunami Hazard Assessment and Determination

- 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 historical tsunami scenarios 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.
- The database of Caribbean Tsunami observations is 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

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 the proportion of assets located in tsunami hazard areas.

SOCIAL IMPACTS

Table 4.51 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 4.51 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	54,229	2,440	5%	813	2%
St. Croix	56,404	2,758	5%	919	2%
St. John	4,447	141	3%	71	2%

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 1,476 residential properties exposed to this hazard on St. Thomas. For St. Croix, there were 1011 fewer residential properties exposed to this hazard, while on St. John, the total number of residential properties exposed decreased by 111. On St. Thomas, there were 253 more commercial properties exposed to this hazard. On St. Croix, there were 17 more commercial properties, while on St. John, there was an increase 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 susceptibility 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 Frederiksted.

- Tsunamis have the potential to have an enormous impact on the tourist industry. Cruise ships and their passengers are particularly exposed to this hazard, especially while in the harbor.

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

TABLE 4.52 Estimated Tsunami Exposure and Vulnerability (St. Thomas)

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	18%	0	0	0	40%	60%
No. of Residential	4,206	0	0	0	1,682	2,523
Value of Residential	$1,156,936,276	$0	$0	$0	$462,774,510	$694,161,765
Commercial Buildings						
% of Commercial	33%	0	0	0	20%	80%
No. of Commercial	721	0	0	0	144	577
Value of Commercial	$600,826,640	$0	$0	$0	$120,165,328	$480,661,312

TABLE 4.53 Estimated Tsunami Exposure and Vulnerability (St. Croix)

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	11%	0	0	0	40%	60%
No. of Residential	2,510	0	0	0	1,004	1,506
Value of Residential	661,293,152	0	0	0	264,517,261	396,775,891
Commercial Buildings						
% of Commercial	5%	0	0	0	20%	80%
No. of Commercial	41	0	0	0	8	33
Value of Commercial	70,485,736	0	0	0	14,097,147	56,388,589

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

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	13%	0	0	0	40%	60%
No. of Residential	286	0	0	0	114	171
Value of Residential	104,469,790	0	0	0	41,787,916	62,681,874
Commercial Buildings						
% of Commercial	13%	0	0	0	20%	80%
No. of Commercial	10	0	0	0	2	8
Value of Commercial	43,193,847	0	0	0	8,638,769	34,555,077

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CRITICAL FACILITIES

Tables 4.55 through 4.57 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 4.55 Estimated Tsunami Exposure and Vulnerability, Critical Facilities, and Infrastructure (St. Thomas)

<table>
<tr><th colspan="2">Facility</th><th colspan="5">Vulnerability Rating</th><th rowspan="2">Total Exposure</th></tr>
<tr><th colspan="2"># of Facilities in Class</th><th>Very Low</th><th>Low</th><th>Moderate</th><th>High</th><th>Very high</th></tr>
<tr><td colspan="8">Critical Facilities</td></tr>
<tr><td>Police Stations</td><td>5</td><td>4</td><td></td><td></td><td></td><td>1</td><td>12,727,552</td></tr>
<tr><td>Fire Stations</td><td>5</td><td>3</td><td></td><td></td><td></td><td>2</td><td>7,792,547</td></tr>
<tr><td>Emergency Response</td><td>1</td><td>1</td><td></td><td></td><td></td><td></td><td>6,472,875</td></tr>
<tr><td>Hospital, Clinics, and special needs</td><td>5</td><td>4</td><td></td><td></td><td></td><td>1</td><td>95,838,253</td></tr>
<tr><td>Government Buildings</td><td>11</td><td>4</td><td></td><td></td><td></td><td>7</td><td>118,417,923</td></tr>
<tr><td>Shelters</td><td>5</td><td>5</td><td></td><td></td><td></td><td></td><td>123,556,219</td></tr>
<tr><td colspan="8">Transportation Infrastructure</td></tr>
<tr><td>Marine Ports</td><td>4</td><td>1</td><td></td><td></td><td></td><td>3</td><td>26,038,712</td></tr>
<tr><td>Airport</td><td>1</td><td>1</td><td></td><td></td><td></td><td></td><td>22,475,260</td></tr>
<tr><td colspan="8">Utilities</td></tr>
<tr><td>Electrical Power Plant</td><td>1</td><td></td><td></td><td></td><td></td><td>1</td><td>51,172,046</td></tr>
<tr><td>Sewage Treatment Plant</td><td>1</td><td></td><td>1</td><td></td><td></td><td></td><td rowspan="4">61,792,356</td></tr>
<tr><td>Water Treatment Plant</td><td>1</td><td></td><td>1</td><td></td><td></td><td></td></tr>
<tr><td>WAPA Tanks</td><td>1</td><td></td><td>1</td><td></td><td></td><td></td></tr>
<tr><td>Pumping Station</td><td>1</td><td></td><td>1</td><td></td><td></td><td></td></tr>
</table>

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

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

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	**6**	6					**63,719,946**
Fire Stations	**5**	5					**9,269,808**
Emergency Response	**1**	1					**-**
Hospital, Clinics, and special needs	**3**	2				1	**135,990,389**
Government Buildings	**12**	11				1	**121,046,648**
Shelters	**11**	11					**173,286,506**
Transportation Infrastructure							
Marine Ports	**5**	1				4	**9,922,078**
Airport	**1**					1	**57,686,500**
Utilities							
Electrical Power Plant	**1**	1					**51,917,850**
Sewage Pumps	**14**	14					**110,067,300**
Wastewater Treatment Plant	**1**					1	
Water Treatment Plant	**1**	1					
Water Pumps	**8**	7					

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

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

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	2	1				1	4,321,296
Fire Stations	2	1				1	4,845,666
Emergency Response	1	1					5,142,339
Hospital, Clinics, and special needs	2	2					17,590,586
Government Buildings	3	3					13,159,486
Shelters	5	1				1	52,473,202
Transportation Infrastructure							
Marine Ports	1					1	2,884,325
Airport	N/A						
Utilities							
Electrical Power Plant	1					1	15,575,355
WAPA Desalinization Plant	1					1	33,518,154
WAPA Water Tank	1					1	
Sewage Treatment Plant	1	1					
Potable Water Tank	1	1					

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

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, new 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 each 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 rated 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 the natural litter, duff, roots, or sometimes even highly organic soils. Once started, they are challenging to control, and some ground fires may even rekindle after being extinguished.

- Surface fires burn in grasses and low shrubs (up to 4' tall) or 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 wild land/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 4.35, 4.36, and 4.37).

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.

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FIGURE 4.35 Wildfire Hazard Map, St. Thomas

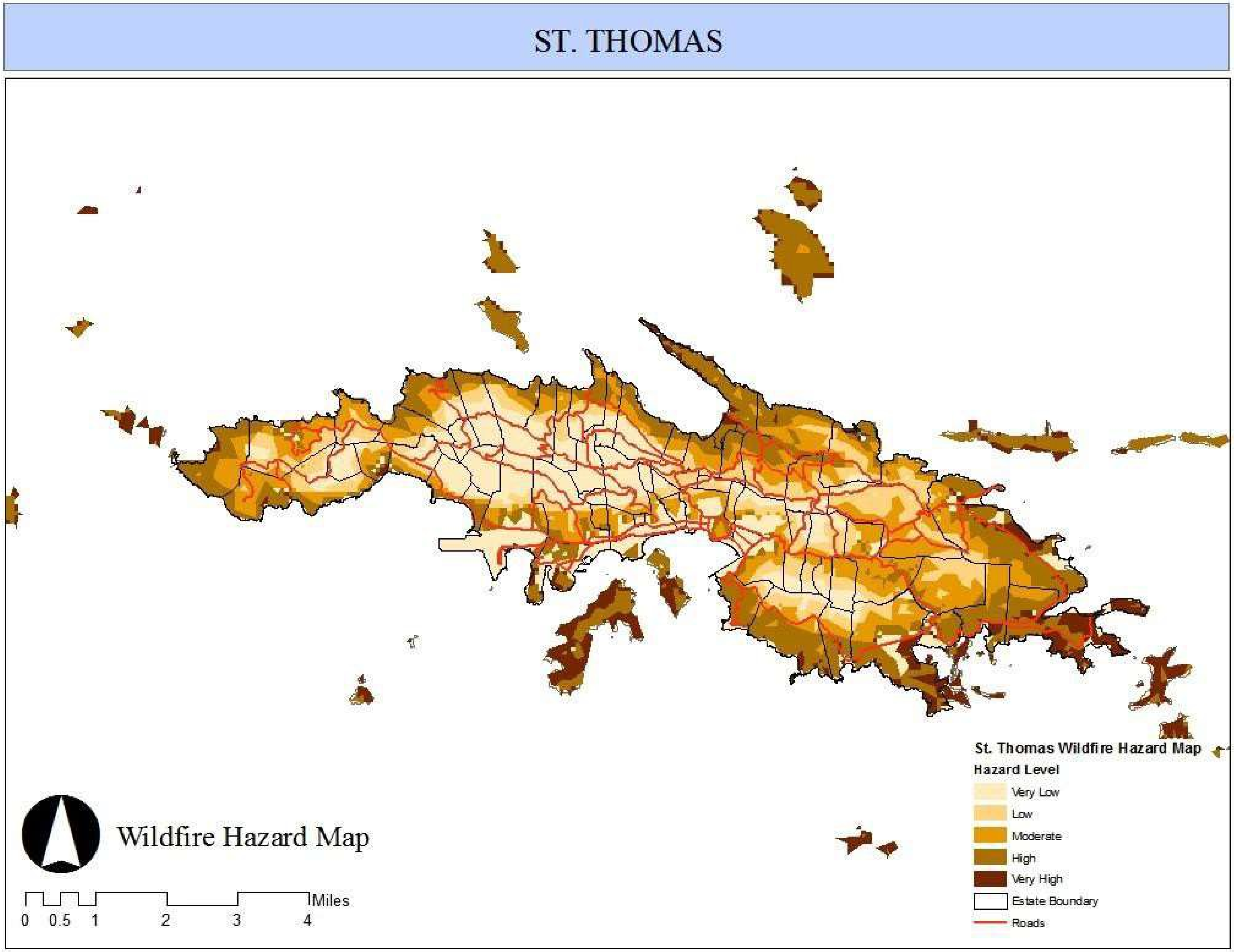


FIGURE 4.36 Wildfire Hazard Map, St. Croix

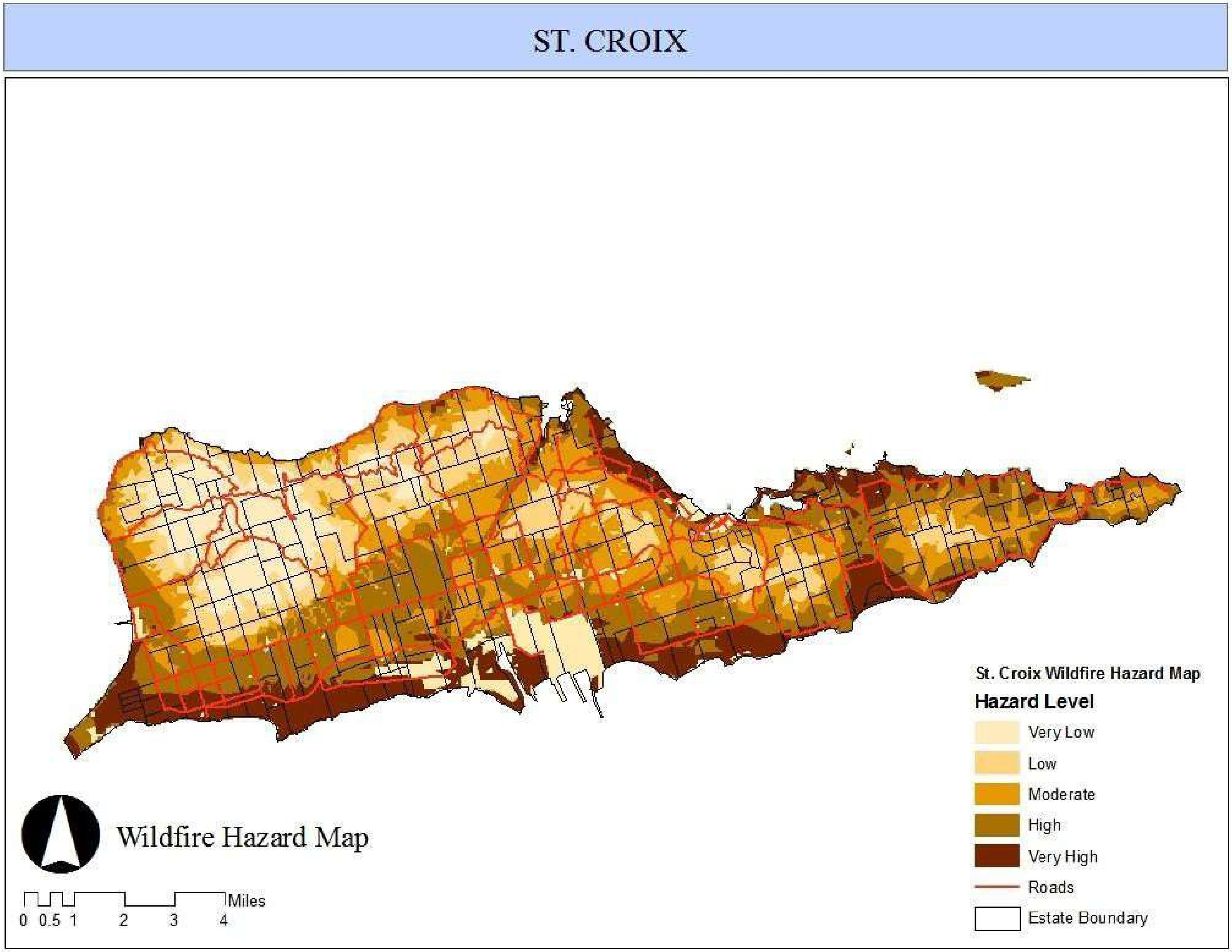
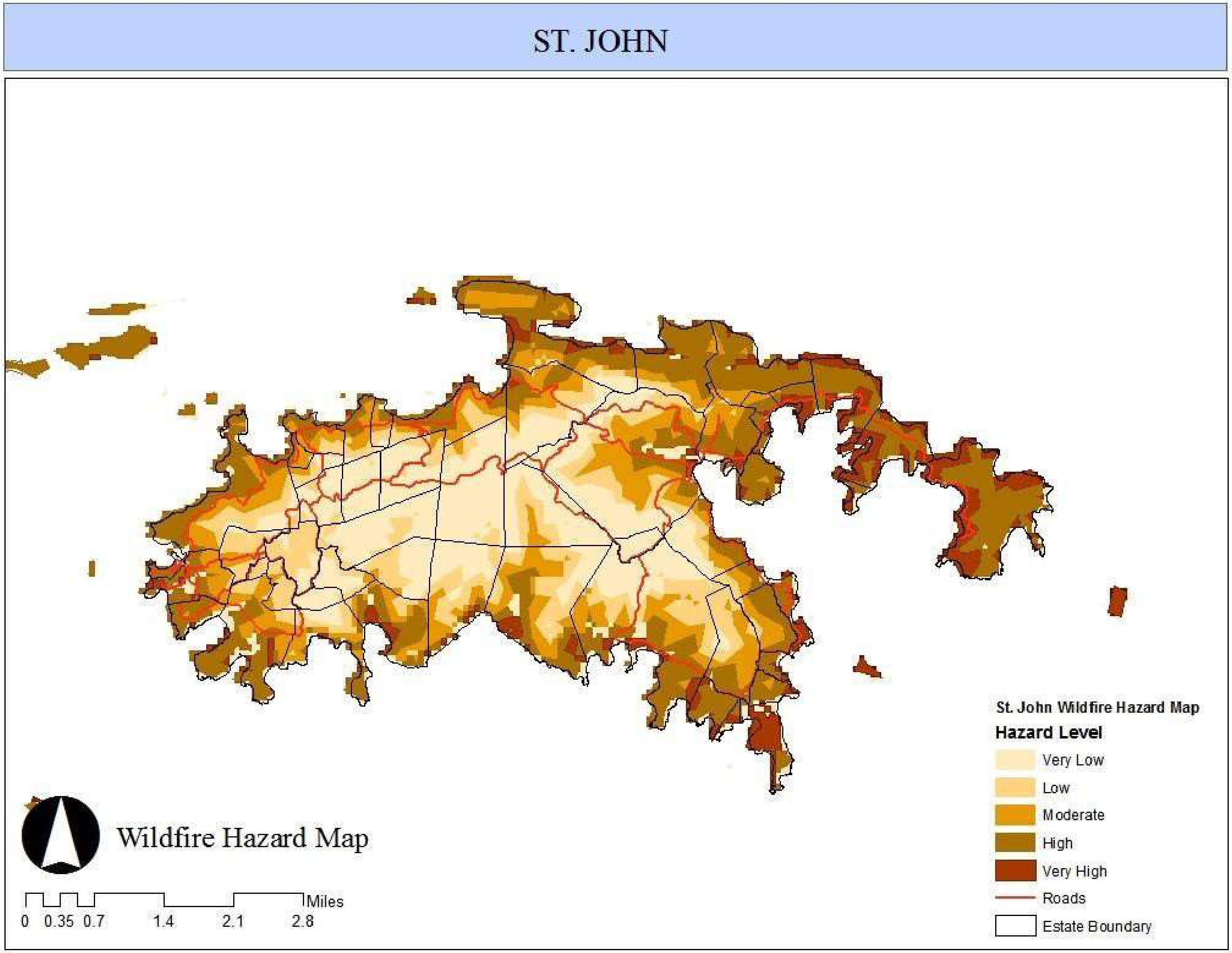


FIGURE 4.37 Wildfire Hazard Map, St. John



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 Calqouhoun 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 the 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 Kingshill 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, structures or affected any people. The cause of these fires 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 Shore Cafe in Estate Petronelli. Several utility poles were damaged.

9. March 8, 2005. More than 15 acres of the brush were 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 hundreds 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. More 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 Ha'Penny 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 was consumed.

Climate Variability, 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, the 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, a thorough understanding of the magnitude of wildfire events is very limited.

It is important to note that IPPC and PRECIS climate change models predict that temperatures will increase. Taylor et al. (2007) on the basis of the first round of PRECIS simulations driven by the HadAM3P GCM have shown that the Caribbean is 1°- 5°C warmer in the annual mean by the2080s (a 30-yr period from 2071 to 2100), and one also characterized by greater warming in the northwest (Jamaica, Cuba, Hispaniola, and Belize) in comparison to the eastern Caribbean islands, which includes the Virgin Islands. They also predict greater warming in the summer months than in the drier early months of the year (Taylor, M. A., and Coauthors, 2007).

This, combined with the expected incidence of drought, provides a clear indication that the occurrence of wildfire events is likely to increase in the future due to climate change.

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

SOCIAL IMPACTS

Table 4.58 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 4.58 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	54,229	7,767	14%	1,913	3.53%
St. Croix	56,404	7,111	13%	1,752	3.11%
St. John	4,447	421	9%	104	2.33%

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.

- 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 hazards on St. Thomas, St. Croix, and St. John.

TABLE 4.59 Estimated Wildfire Exposure and Vulnerability (St. Thomas)

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	42%	18%	17%	22%	32%	11%
No. of Residential	9813	1781	1694	2178	3099	1061
Value of Residential	$2,699,517,976	$489,938,678	$466,103,823	$599,108,197	$852,463,874	$291,903,404
Commercial Buildings						
% of Commercial	35%	51%	49%	0	0	0
No. of Commercial	774	398	376	0	0	0
Value of Commercial	$644,801,763	$331,612,335	$313,189,428	$0	$0	$0

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

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	47%	10%	17%	26%	30%	16%
No. of Residential	10067	1,051	176	46	14	2
Value of Residential	$2,723,994,577	284,286,019	47,720,282	12,397,796	3,762,452	618,913
Commercial Buildings						
% of Commercial	27%	37%	63%	0	0	0
No. of Commercial	590	219	138	0	0	0
Value of Commercial	$389,185,044	144,142,609	90,756,458	0	0	0

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

Total Number of Buildings/ Percentage		Number, Percentage, and Value of Buildings by Vulnerability Rating				
OCCUPANCY CLASS		Very Low	Low	Moderate	High	Very high
Residential Buildings						
% of Residential	38%	26%	18%	18%	30%	8%
No. of Residential	854	223	154	153	259	65
Value of Residential	$312,095,283	81,626,575	56,353,525	55,923,345	94,585,735	23,606,104
Commercial Buildings						
% of Commercial	44%	59%	41%	0	0	0
No. of Commercial	36	21	15	0	0	0
Value of Commercial	$150,128,802	88,712,474	61,416,328	0	0	0

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 4.62 Estimated Wildfire Exposure and Vulnerability, Critical Facilities, and Infrastructure (St. Thomas)

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	**5**	**1**			**4**		**12,727,552**
Fire Stations	**5**	**1**		**2**	**4**		**7,792,547**
Emergency Response	**1**	**1**					**6,472,875**
Hospital, Clinics, and special needs	**5**	**4**	**1**		**1**		**95,838,253**
Government Buildings	**11**	**1**		**1**	**10**		**118,417,923**
Shelters	**5**	**4**		**3**	**1**		**123,556,219**
Transportation Infrastructure							
Marine Ports	**4**				4		**26,038,712**
Airport	**1**				1		**22,475,260**
Utilities							
Electrical Power Plant	**1**	1					**51,172,046**
Sewage Treatment Plant	**1**		1				**61,792,356**
Water Treatment Plant	**1**		1				
WAPA Tanks	**1**	1					
Pumping Station	**1**		1				

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

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

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	6	3		2	1		63,719,946
Fire Stations	5	1				4	9,269,808
Emergency Response	N/A						-
Hospital, Clinics, and special needs	3	2		1		1	135,990,389
Government Buildings	12	7				5	121,046,648
Shelters	11	11		3	8		173,286,506
Transportation Infrastructure							
Marine Ports	5	5					9,922,078
Airport	1	1					57,686,500
Utilities							
Electrical Power Generating Plants	1	1					51,917,850
Sewage Pumps	14	9		3	2	3	110,067,300
Wastewater Treatment Plant	1	1				1	
Water Treatment Plant	1	1					
Water Pumps	8	3		3	2	3	

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

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

Facility		Vulnerability Rating					Total Exposure
# of Facilities in Class		Very Low	Low	Moderate	High	Very high	
Critical Facilities							
Police Stations	2				2		4,321,296
Fire Stations	2	1			1		4,845,666
Emergency Response	1	1					5,142,339
Hospital, Clinics, and special needs	2	1					17,590,586
Government Buildings	3				3		13,159,486
Shelters	5	3			2		52,473,202
Transportation Infrastructure							
Marine Ports	1	1					2,884,325
Airport	N/A						
Utilities							
Electrical Power Generating Plants	1					1	15,575,355
WAPA Desalinization Plant	1					1	33,518,154
WAPA Water Tank	1					1	
Sewage Treatment Plant	1					1	
Potable Water Tank	1					1	

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

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 2011 Plan. It includes:

- Estimate or count the total number of buildings, the value of buildings, and the 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.

Inventory of 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 fiscal cadastral (tax values) derived from the Lieutenant Governor's Tax Assessors Office. 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 actual prices for commercial and residential structures, which were derived from the Office of the Lieutenant Governor's Tax Assessors Office. Update of critical facility information was derived from 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 a tax lot information and could be used to identify the use of parcel and/or building.

Since the 2014 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 2014 Update was utilized to categorize the built environment.

The OLG database, however, had certain limitations related to structure classification and only classified buildings by general usage. Field surveys were eliminated from the budget and not conducted during this Plan Update. The field investigations that were conducted during the 2014 and 2019 Plan Updates 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 the information that would be useful to determine general loss estimates, structural categories remained the same as in the 2014 Plan Update. The ten (10) model building types remain consistent with field investigations conducted during this Plan Update; 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. It is necessary to note, however, that based on a rapid inspection of buildings that steel frame buildings a becoming more prevalent for larger institutional buildings.

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 INFRASTRUCTURES

A major change that occurred since the 2014 Plan was when the past Governor added VINGN to the list of the critical facility which was signed into law by the Order and Proclamation. The listing of critical facilities provided by VITEMA was crossed checked with the listing of facilities included in the 2014 plan and other adjustments that were made. 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.

The following three-part definition of critical facilities and infrastructure shall apply:

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 aging.

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

- Marine Facilities, and
- Airports.

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.
- VINGN

This list of facilities was provided by VITEMA for this Plan Update. No new data was provided by the Department of Property and Procurement for this plan Update, despite several requests being made by the contractor and VITEMA. Therefore, it was determined that a detailed site inspection was not required during this plan update. Instead, information gathered from VITEMA was used to update inventory information.

The 2019 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 2014 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 2014 Plan Update, facility values were updated utilizing a compounded inflation factor for the five-year period.

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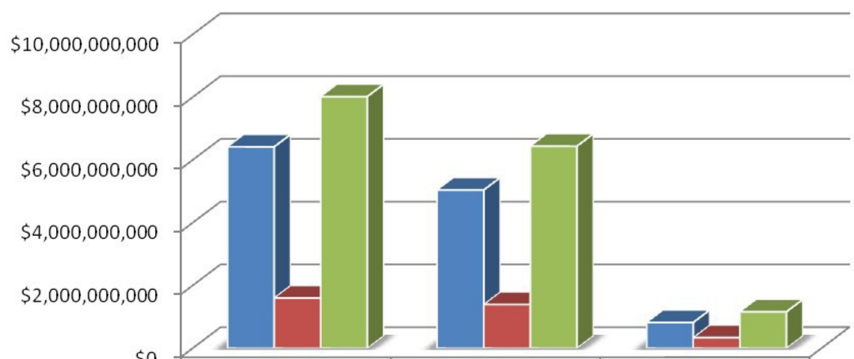
VALUES

Exposure, as applied in this section of the Plan Update, means the total amount of property value that is 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 4.38 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 $16 billion, which represents an increase of approximately $2 billion dollars since 2011.

FIGURE 4.38 Building Stock Values by Occupancy Class for US Virgin Islands



	St. Thomas	St. Croix	St. John
Residential	$6,417,782,618	$5,042,503,925	$821,303,378
Commercial	$1,601,294,031	$1,394,636,244	$339,574,266
Total	$8,019,076,649	6,437,140,168	$1,160,877,643

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

For this Plan Update (2019), an in-depth analysis of building stock was not undertaken, but it is a fair assessment that the US Virgin Islands has been affected by the same housing downturn that has affected the US mainland. Values, as reflected by inflation multipliers, have remained stable in the Territory with St. John receiving the newest construction activity of all three islands. St Croix has experienced only a modest increase in the value of residential and commercial structures as opposed to the 15% increase in the value of residential and commercial structure increase-experienced on St. Thomas and St. John.

TERRITORIAL FACILITIES AND INFRASTRUCTURE UTILITIES AND INFRASTRUCTURE

Table below 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 e valuation of these facilities for this Update was based on the estimated area of the structures and an inflation factor.

13 Single-family dwellings are a subset of the total residential occupancy class. Total values include the sum of residential and commercial occupancy classes for the s. for the three-year period. This inflation factor was developed through data supplied by the **U.S. Department of Commerce, Bureau of Economic Analysis**

LOSS ESTIMATES OVERVIEW OF PLAN UPDATE

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.

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

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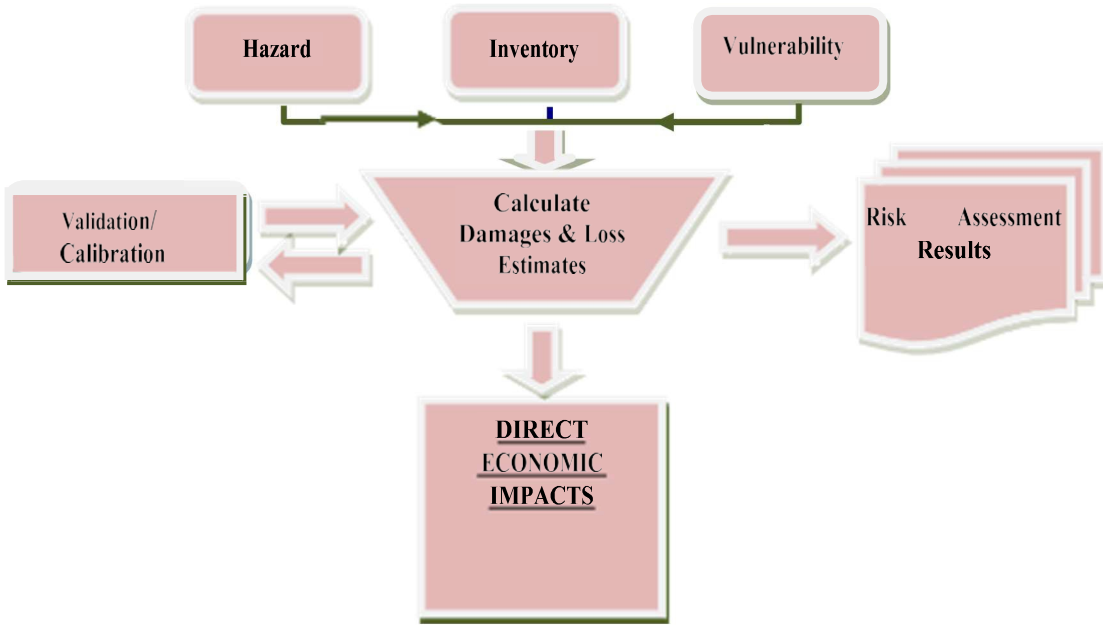
FIGURE 4.39 Conceptual Model of Risk Assessment Methodology



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

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

EARTHQUAKES

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 $6 billion for St. Thomas, $4.3 billion for St. Croix, and $463 million for St. John. This represents a $419 billion increase in estimated losses for St. Thomas since the 2011 Plan. Estimated losses for St. Croix have increased by 11M and 9.7 M on St. John.

TABLE 4.65 Estimated Losses: General Building Stock for Earthquake Hazard

Occupancy	No. of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	21,679	$ 4,641,269,145	72%
Commercial	981	$ 1,384,710,463	86%
Total	22,660	$ 6,025,979,608	
St. Croix			
Residential	18,082	$ 3,645,930,917	56%
Commercial	670	$ 746,489,600	53%
Total	18,753	$ 4,392,420,517	
St. John			
Residential	1,431	$ 386,386,207	54%
Commercial	70	$ 76,830,370	65%
Total	1,501	$ 463,216,578	

Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix and St. John are highlighted in Table 4.66.

TABLE 4.66 Estimated Losses: Critical Facilities and Infrastructure for Earthquake Hazard

Facility	St. Thomas	St. Croix	St. John
Critical Facilities			
Police Stations	**$13,804,002**	**$42,949,130**	**$2,373,142**
Fire Stations	**$32,370,825**	**$7,431,814**	**$3,321,795**
Emergency Response	**$6,331,171**	**$2,476,394**	**$3,367,056**
Hospital, Clinics, and special needs	**$71,272,393**	**$106,217,486**	**$9,393,598**
Government Buildings	**$103,612,740**	**$109,157,907**	**$8,777,514**
Shelters/Special Needs	**$123,062,681**	**$128,181,063**	**$54,803,795**
Transportation Infrastructure			
Marine Ports	**$6,844,012**	**$364,105**	**$33,953**
Airport	**$26,632**	**$30,627,988**	**$0**
Utilities			
Electrical Power Generating Plants	**$30,892,492**	**$43,768,184**	**$14,094,331**
Water Treatment Plants	**$44,509,147**	**$15,989,798**	**$2,096,480**
Wastewater Treatment Plants	**$910,804**	**$16,707,348**	**$20,768,378**
Pumps	**$295,361**	**$16,476,882**	**--**
Tanks	**$8,080,947**	**$8,451,850**	**$1,090,889**

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

RIVERINE FLOODING O V E R V I E W O F P L A N U P D A T E

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 4.67 by occupancy class. The total expected loss for a 100-year MRP is approximately $1B million for St. Thomas, $768 million for St. Croix, and $17million for St. John. This represents a significant increase for the Territory.

TABLE 4.67 Estimated Losses: General Building Stock for Riverine Flooding Hazard

Occupancy	No of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	11,390	$ 752,430,862	12%
Commercial	742	$ 292,639,745	18%
Total	12,133	$ 1,045,070,607	
St. Croix			
Residential	4,648	$ 618,081,641	9%
Commercial	349	$ 150,076,139	11%
Total	4,996	$ 768,157,780	
St. John			
Residential	309	$ 15,718,980	2%
Commercial	9	$ 1,570,220	1%
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.

Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix and St. John are highlighted in Table 4.68.

TABLE 4.68 Estimated Losses: Critical Facilities and Infrastructure for Riverine Flooding Hazard

Facility	St. Thomas	St. Croix	St. John
Critical Facilities			
Police Stations	$2,208,247	$846,102	$2,450,885
Fire Stations	$32,635,564	$0	$0
Emergency Response	$0	$0	$0
Hospital, Clinics, and special needs	$4,495,220	$0	$0
Government Buildings	$81,303,611	$41,134,403	$6,613,182
Shelters/Special Needs	$55,258,961	$8,146,920	$24,107,203
Transportation Infrastructure			
Marine Ports	$2,143,620	$0	$34,183
Airport	$0	$0	$0
Utilities			
Electrical Power Generating Plants	$0	$0	$2,768,783
Water Treatment Plants	$44,437,250	$9,229,275	$0
Wastewater Treatment Plants	$937,800	$0	$22,218,625
Pumps	$0	$1,525,473	--
Tanks	$0	$517,334	$0

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

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 are $171 million for St. Thomas, $78.5 million for St. Croix, and $26.6 million for St. John. Table 4.69 presents these results by occupancy class. This represents a $439 million increase in estimated losses for the Territory since the 2011 Plan.

TABLE 4.69 Estimated Losses: General Building Stock for Coastal Flooding Hazard

Occupancy	No of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	**1,511**	**$ 115,105,946**	**2%**
Commercial	**236**	**$ 56,606,106**	**4%**
Total	**1,747**	**$ 171,712,053**	
St. Croix			
Residential	**3,425**	**$ 52,319,194**	**1%**
Commercial	**334**	**$ 26,256,719**	**2%**
Total	**3,760**	**$ 78,575,913**	
St. John			
Residential	**386**	**$ 22,500,497**	**3%**
Commercial	**3**	**$ 4,123,048**	**3%**
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 geographic distribution of structures by occupancy class across estate boundaries.

Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix and St. John are highlighted in Table 4.70.

TABLE 4.70 Estimated Losses: Critical Facilities and Infrastructure for Coastal Flooding Hazard

Facility	St. Thomas	St. Croix	St. John
Critical Facilities			
Police Stations	**$133,178**	**$0**	**$0**
Fire Stations	**$13,900,517**	**$0**	**$0**
Emergency Response	**$0**	**$0**	**$0**
Hospital, Clinics, and special needs	**$3,196,231**	**$0**	**$0**
Government Buildings	**$6,455,387**	**$3,987,047**	**$9,113,250**
Shelters/Special Needs	**$0**	**$0**	**$0**
Transportation Infrastructure			
Marine Ports	**$2,774,553**	**$2,871,330**	**$102,548**
Airport	**$0**	**$0**	**$0**
Utilities			
Electrical Power Generating Plants	**$13,317,856**	**$0**	**$14,766,840**
Water Treatment Plants	**$0**	**$9,844,560**	**$0**
Wastewater Treatment Plants	**$17,091,250**	**$0**	**$29,055,125**
Pumps	**$0**	**$379,623**	**--**
Tanks	**$0**	**$162,591**	**$1,296,013**

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

HURRICANE WINDS

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 4.71 by occupancy class. The total expected for a loss for a hurricane event with a 50-year MRP is approximately $3.6 billion for St. Thomas, $1.8 billion for St. Croix, and $190 million for St. John. This represents an increase of $2.3 billion in the Territory since the 2011 Plan.

TABLE 4.71 Estimated Losses: General Building Stock for Hurricane Wind Hazard

Occupancy	No of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	**14,184**	**$ 3,097,521,815**	**48%**
Commercial	**856**	**$ 571,109,732**	**36%**
Total	**15,041**	**$ 3,668,631,547**	
St. Croix			
Residential	**12,986**	**$ 1,508,195,711**	**23%**
Commercial	**555**	**$ 307,082,553**	**22%**
Total	**13,542**	**$ 1,815,278,264**	
St. John			
Residential	**745**	**$ 163,596,725**	**23%**
Commercial	**32**	**$ 26,457,092**	**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 destruction; the total dollar damage estimates the overall impact on 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.

Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix, and St. John are highlighted in Table 4.72.

TABLE 4.72: Estimated Losses: Critical Facilities and Infrastructure for Hurricane Wind Hazard

Facility	St. Thomas	St. Croix	St. John
Critical Facilities			
Police Stations	**$8,455,970**	**$28,488,869**	**$1,783,516**
Fire Stations	**$30,035,180**	**$6,495,932**	**$2,481,830**
Emergency Response	**$3,402,979**	**$1,462,893**	**$1,899,208**
Hospital, Clinics, and special needs	**$50,949,906**	**$94,355,181**	**$8,595,732**
Government Buildings	**$84,600,149**	**$80,955,418**	**$5,960,850**
Shelters/Special Needs	**$83,389,427**	**$102,857,136**	**$41,504,841**
Transportation Infrastructure			
Marine Ports	**$10,007,260**	**$750,907**	**$90,909**
Airport	**$9,924,923**	**$28,222,427**	**n/a**
Utilities			
Electrical Power Generating Plants	**$10,839,286**	**$23,936,125**	**$5,266,686**
Water Treatment Plants	**$19,565,950**	**$23,936,125**	**$1,287,957**
Wastewater Treatment Plants	**$364,269**	**$9,267,130**	**$9,494,825**
Pumps	**$110,851**	**$6,865,235**	**--**
Tanks	**$2,998,359**	**$2,084,234**	**$591,014**

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

RAIN INDUCED LANDSLIDES

A deterministic approach was used to address the rain-induced landslide hazard based on a worse- 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, the estimated impact of a rain-induced landslide is approximately $500,000. Damage parameters from historical 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 the rain-induced landslide is summarized in Table 4.73. Estimated property damages and losses for the landslide hazard were aggregated across occupancy classes and are estimated to be $76 million for St. Thomas, $20 million for St. Croix, and $21 million for St. John.

TABLE 4.73 Estimated Losses: General Building Stock for Rain-Induced landslide Hazard

Occupancy	No of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	**4,169**	**76,647,667**	**1%**
Commercial	**0**	**$ -**	**0%**
Total	**4,169**	**$ 76,647,667**	
St. Croix			
Residential	**1,209**	**$ 20,892,953**	**4%**
Commercial	**0**	**$ -**	**0%**
Total	**1,328**	**$ 20,892,953**	
St. John			
Residential	**455**	**$ 21,247,859**	**3%**
Commercial	**0**	**$ -**	**0%**
Total	**535**	**$ 21,247,859**	

Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix and St. John are highlighted in Table 4.74.

TABLE 4.74 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, Clinics, and special needs	**$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**

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 to the Tsunami hazard. The physical damage that could occur as a result of the Tsunami is summarized in Table 4.75. Estimated property damages and losses for the tsunami hazard were aggregated across occupancy classes and are estimated to be $1.2 billion for St. Thomas, $786 million for St. Croix and $114 million for St. John. This represents a $234 million increase in estimated losses for on the Territory since the 2011 Plan.

TABLE 4.75 Estimated Losses: General Building Stock for Tsunami Hazard

Occupancy	No of Affected Buildings	Expected Losses	% Value
St. Thomas			
Residential	**4,417**	**$ 808,769,974**	**19%**
Commercial	**376**	**$ 402,633,004**	**38%**
Total	**4,793**	**$ 1,211,402,978**	
St. Croix			
Residential	**2,961**	**$ 524,598,730**	**13%**
Commercial	**258**	**$ 261,998,197**	**30%**
Total	**3,218**	**$ 786,596,927**	
St. John			
Residential	**833**	**$ 96,449,264**	**19%**
Commercial	**35**	**$ 18,284,842**	**21%**
Total	**868**	**$ 114,734,106**	

Estimated Losses: Critical Facilities and Infrastructure

Critical facilities and infrastructure losses for St. Thomas, St. Croix, and St. John are highlighted in Table 4.76.

TABLE 4.76 Estimated Losses: Critical Facilities and Infrastructure for Tsunami Hazard

Facility	St. Thomas	St. Croix	St. John
Critical Facilities			
Police Stations	$532,714	$0	$1,036,413
Fire Stations	$54,003,910	$0	$1,171,972
Emergency Response	$0	$0	$0
Hospital, Clinics, and special needs	$11,762,331	$26,441,762	$0
Government Buildings	$98,704,238	$4,208,549	$15,003,849
Shelters/Special Needs	$0	$0	$13,348,261
Transportation Infrastructure			
Marine Ports	$11,098,214	$8,251,656	$290,551
Airport	$0	$61,528,500	$0
Utilities			
Electrical Power Generating Plants	$49,720,000	$50,850,000	$18,458,550
Water Treatment Plants	$68,365,000	$18,458,550	$3,586,232
Wastewater Treatment Plants	$1,442,768	$27,346,000	$0
Pumps	$0	$663,030	--
Tanks	$0	$258,667	$1,472,742

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

WILDFIRE

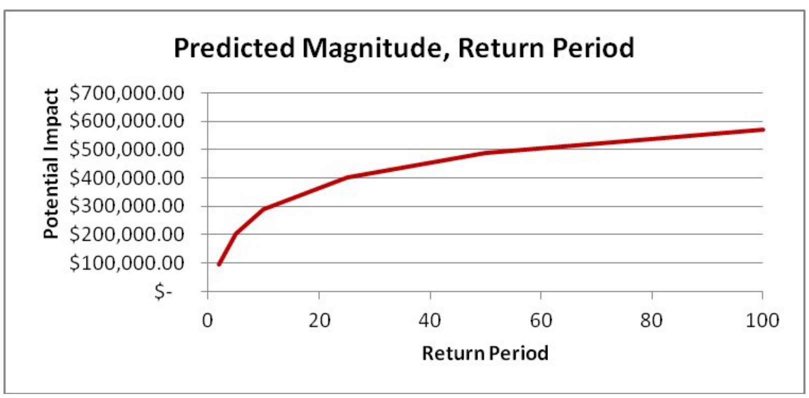
This subsection of the risk assessment presents the ―estimate of losses for wildfires. Estimated losses for wildfires were aggregated for primary economic impacts that could impact the US Virgin Islands through economic loss.

Estimated Losses: 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.

This figure was based on regional historic drought data for the US Virgin Islands. Based on the available data and the assumptions provided above, the predicted impact of a drought with a 50% probability of occurrence is $93,500,000 and a 1% occurrence of experiencing a wildfire event of $570,000.00.

FIGURE 4.40 Historical Wildfire in the US Virgin Islands, 2000-2010



The expected impact of a drought for a 100-year return period is approximately 570,000.00. Damage parameters from seventeen (17) events historical events in the US Virgin Islands were used to develop this estimate.

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 2014 Plan. This section is used to evaluate the risk of 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. Tables 4.77 through 4.79 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 4.77 Hazard-by-Hazard Summary of Loss Estimates for St. Thomas

Hazard	Return Period (Years)	Critical Facility Losses	Residential Losses	Commercial Losses	Total Loss	Loss/Year
Drought	**100**	**N/A**	**N/A**	**N/A**	**$1,058,989.77**	**$10,590**
Earthquake	**1000**	**$442,013,206**	**$ 4,641,269,145**	**$1,384,710,463**	**$6,467,992,814**	**$6,467,993**
Riverine Flooding	**100**	**$223,420,272**	**$752,430,862**	**$292,639,745**	**$1,268,490,879**	**$12,684,909**
Coastal Flooding	**120**	**$56,868,971**	**$115,105,946**	**$56,606,106**	**$228,581,024**	**$1,904,842**
Hurricane	**50**	**$314,644,509**	**$ 3,097,521,815**	**$571,109,732**	**$3,983,276,056**	**$79,665,521**
Rain-Induced Landslide	**50**	**$23,153,076**	**$76,647,667**	**$ -**	**$99,800,743**	**$1,996,015**
Tsunami	**500**	**$295,629,176**	**$808,769,974**	**$402,633,004**	**$1,507,032,154**	**$3,014,064**
Wildfire	**10**				**$571,815**	**$57,181**

TABLE 4.78 Hazard-by-Hazard Summary of Loss Estimates for St. Croix

Hazard	Return Period (Years)	Critical Facility Losses	Residential Losses	Commercial Losses	Total Loss	Loss/Year
Drought	**100**	**N/A**	**N/A**	**N/A**	**$1,058,989.77**	**$10,590**
Earthquake	**1000**	**$528,799,950**	**$ 3,645,930,917**	**$746,489,600**	**$4,921,220,467**	**$4,921,220**
Riverine Flooding	**100**	**$61,399,508**	**$618,081,641**	**$150,076,139**	**$829,557,287**	**$8,295,573**
Coastal Flooding	**120**	**$17,245,151**	**$52,319,194**	**$26,256,719**	**$95,821,063**	**$798,509**
Hurricane	**50**	**$409,677,613**	**$ 1,508,195,711**	**$307,082,553**	**$2,224,955,877**	**$44,499,118**
Rain-Induced Landslide	**50**	**$ -**	**$20,892,953**	**$ -**	**$20,892,953**	**$417,859**
Tsunami	**500**	**$198,006,714**	**$524,598,730**	**$261,998,197**	**$984,603,641**	**$1,969,207**
Wildfire	**10**				**$571,815**	**$57,181**

TABLE 4.79 Hazard-by-Hazard Summary of Loss Estimates for St. John

Hazard	Return Period (Years)	Critical Facility Losses	**Residential** Losses	**Commercial** Losses	**Total** Loss	Loss/Year
Drought	**100**	**N/A**	**N/A**	**N/A**	**$1,058,989.77**	**$10,590**
Earthquake	**1000**	**$120,120,930**	**$444,103,045**	**$88,306,986**	**$652,530,961**	**$652,531**
Riverine Flooding	**100**	**$58,192,860**	**$18,067,019**	**$1,804,774**	**$78,064,652**	**$780,647**
Coastal Flooding	**120**	**$54,333,776**	**$25,861,531**	**$4,738,932**	**$84,934,239**	**$707,785**
Hurricane	**50**	**$78,957,369**	**$188,034,154**	**$30,409,148**	**$297,400,671**	**$5,948,013**
Rain-Induced Landslide	**50**	**$ -**	**$21,247,859**	**$ -**	**$21,247,859**	**$424,957**
Tsunami	**500**	**$54,368,571**	**$96,449,264**	**$18,284,842**	**$169,102,677**	**$338,205**
Wildfire	**10**				**$571,815**	**$57,181**

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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 Return Period can allow each jurisdiction individually to prioritize their hazards on an individual basis and 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 lack 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 4.80. which shows that the dollar loss for the Territory is greatest for hurricanes and wildfires.

TABLE 4.80 Summary of Hazard Rankings for USVI

Hazard	St. Thomas	St. Croix	St. John
Drought	8	8	8
Earthquake	3	3	4
Riverine Flooding	2	2	2
Coastal Flooding	5	5	3
Hurricane	1	1	1
Rain-Induced Landslide	6	6	5
Tsunami	4	4	6
Wildfire	7	7	7

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HUMAN-CAUSED HAZARDS

In this section of the Plan Update the 2020 hazard and threat identification process produced a list of probable hazard and threat groups to be profiled. Tables in each hazard indicates the hazards and threats, and how and why they were identified. The level of detail for each hazard and threat correlates to the relative risk of each and is limited by the amount of data available. As new hazards and threats are identified, they will be added to the list, profiled, and mitigated. As the incorporation of human-caused hazards are expanded upon additional hazard lists will be incorporated and explanations will be formulated as to why some threats and hazards were excluded and the reasoning. The process to identify new hazards and threats in future plan updates should include:

- Evaluation of the identified hazards and threats by stakeholders;
- Review of other state plans and programs for other hazards and threats identified and/or managed;
- Review of other mitigation projects and plans for other hazards and threats identified; and
- Review of recent disaster history for new hazards and threats.

Human-caused hazards in this section will include;

- Cyberattack
- Hazardous Material Release
- Infectious Disease (Pandemic)
- Transportation

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CYBERATTACK

A cyberattack is the attack or hijack of information technology infrastructure critical to the functions controlled by computer networks such as: operating, financial, communications, and trade systems. Any cyberattack that creates unrest, instability, or negatively impacts confidence of citizens/consumers can be considered cyber terrorism. Computer security incidents are an ongoing threat and require due diligence to address accordingly to mitigate any potential disruption to critical infrastructure. There are seven common types of cyberattacks that governments, businesses, and people; are at risk to, as described below (Crime Statistics Online [CSO], 2017).

1. Socially engineered malware: A normally trusted site is compromised, and the attackers embed malware into the site. Users of the site are tricked into downloading malware onto their computers through a Trojan Horse.
2. Password phishing attacks: Emails are designed to look like they are from trusted vendors and users are prompted to enter their passwords to access the content from the email. The site the user is taken to saves the password the user provides, which attackers can use to access the real site and the user's information.
3. Unpatched software: Cyber attackers can access software on users' computers if the software patches are not up to date.
4. Social media threats: Friend or application install requests are designed to mask malware or phishing attempts. Users who accept these requests are tricked into providing their email, downloading malware, or otherwise giving cyber attackers access to their computer and data.
5. Advanced persistent threats: Cyber attackers gain access to an organization's data using phishing or Trojan Horse attacks. These attacks typically target multiple employees to trick at least one into providing their password or downloading the malware.
6. Distributed Denial of Service: An attack in which multiple compromised computer systems attack a target, such as a server, website or other network resource and cause a denial of service for users of the targeted resource.
7. Doxing: Discovering and releasing of personally identifiable information.

To ensure a quick and proper response to cyberattacks, systems vulnerable to cyber terrorism should have an incident response plan to minimize negative impacts.

Previous Occurrences

One of the largest cyberattacks occurred within the past five years that directly impacted Virgin Islands which was through the Bureau of Information Technology (BIT). In 2017, the BIT network was hit with a cyberattack that shut down its email abilities. This type of attack compromises several computer systems to target a network source and flood it with connection requests, malformed packet, or incoming messages to slow down or crash the system.

Location and Extent

A cyberattack could occur or impact any location in the territory. The impacts from a cyberattack are not limited to the location of the targeted system and could have far-reaching impacts. Additionally, a cyberattack that occurs outside of the Virgin Islands may still impact people, business, and institutions.

Table 4.81: describes the spatial extent of impacts from a cyberattack in the Virgin Islands.

Resources	Extent of Impacts
People	**Local**
Property	**Local**
Infrastructure	**Local**
Government Operations	**Local**
Environment / Natural Resources	**Local**
Cultural Resources	**Local**

Consequence Analysis

As part of a holistic risk and vulnerability assessment, it is important to evaluate the resulting consequences posed to individual sectors of a community from a hazard event stemming from a cyberattack incident. Effects on the environment and economic conditions would be the least impacted, although these sectors may still experience a moderate impact. The full results of the consequence analysis can be found in the table below.

Table 4.82 Cyberattack Consequence Analysis

Cyberattack Impacts	
Public	Often the public is unaware that an attack has occurred; many times, they are made aware only when it affects them personally (i.e., loss of personal identifying information [PII], financial issues due to exposure of personal financial information). Spread of misinformation related to the cyber incident may also affect the public.
Responders	In cyberattack incidents, responders span from law enforcement and the private sector. Law enforcement tends to focus on the forensics of the attack (i.e., tactics, techniques, and procedures [TTPs], where the threat originated, and who may be responsible for the attack. Law enforcement also pursues prosecution of cyber attackers when they are identified.
COOP	Continuity of operations could be greatly impacted by a cyberattack, which could lead to catastrophic consequences. Technological systems are relied upon in nearly all industries, including government, education, banking and financial institutions, utilities, health and medical organizations, public works and engineering, and a host of other sectors. Any incident that affects the functioning of these systems may negatively impact continuity of operations.
Delivery of Services	Delivery of services may be greatly impacted by a cyberattack due to the same factors that would negatively affect continuity of operations. In today's world, the delivery of goods and services is heavily reliant on technology for the facilitation of transactions. A cyber incident could significantly disrupt the delivery of goods and services to the extent upon which businesses and entities rely on technology for the delivery of their materials.
Property, Facilities, and Infrastructure	Property, facilities, and infrastructure are often the target locations for cyber attackers, and many times are damaged and/ or destroyed during an incident. These damages and potential destruction may have far-reaching consequences, including loss of power and electricity during severe winter or summer weather, or the malfunctioning or shutting down of critical utilities and facilities that operate systems including traffic control, police and fire dispatch, and response systems.
Environment	Cyberattacks have little impact on the environment unless the attack is specifically targeted at facilities or infrastructure where physical controls are affected, and release of potentially harmful chemicals or other agents is successful. For example, a cyberattack targeting a pipeline may contribute to the release of harmful chemicals into the environment.
State Economy	Increased, un-forecasted public and private costs due to response and recovery requirements, especially if the cyberattack targets personal financial information; loss of productivity and economic loss due to interrupted and/or delayed lawful activities. Tourism and travel industries may be affected. Additionally, attacks on the national informational or financial infrastructure could lead to significant declines in the national economy. Given the complexity of many cyberattacks the full economic impacts may never be known. Entities affected by cyberattacks may experience varying levels of economic impact. These impacts may include loss of production and/or services, repair, or replacement of equipment (i.e., servers, electrical grids, fiber lines), and loss of stakeholders.

Cyberattack Impacts	
Public Confidence in the State's Governance	Social values and public confidence can be affected by any sort of homeland security incident, particularly one that occurs locally. Community members may not feel safe and may have lasting emotional impacts, especially if personal information is released or obtained by an attacker. Regardless of the level of response, it is likely that the public will display both positive and negative confidence in their government leaders. The focus of the government should be on public safety and ending a cyber-incident as quickly as possible. Often if a private sector entity is affected the government is unaware of the attack and do not have a role in protecting, responding, or assisting the entity.

State Risk Assessment

Cyber attackers are persistent in targeting their intended victims, but there are also countermeasures for each type of cyberattack. For the most common types of cyberattacks, educating personnel and the public about the dangers of providing secure information online, ensuring all software patches are up-to-date, installing anti-malware programs, and having enhanced authentication systems (i.e., smartcards, biometrics) can help to reduce the probability of cyberattacks.

However, employing countermeasures does not guarantee the protection against all cyberattacks. Impacts of cyberattacks range from theft of personal or business information to loss of functionality for communications and information systems to impacts on the physical world through cyberattack vectors causing damage to infrastructure, systems, or people. Due to the prevalence and ever-changing tactics of cyberattacks, the probability of attacks occurring in the future is high.

Vulnerability Assessment

The three branches in the government, businesses, and other organizations and institutions are vulnerable to the impacts of cyberattacks. Increased awareness of these threats, preventative education about avoiding attacks, and enhanced counter-measures can protect all organizations from cyberattacks, but if a cyber-attacker is able to gain access to an organization's data or systems, then the organization is at a great risk of loss of functionality or services, or an impact on infrastructure, systems, or people.

State Assets and/or Critical Facilities at Risk

The 2019 THIRA identified critical infrastructure sectors within the Virgin Islands. Ongoing work continues with sector partners to identify and prioritize critical facilities, assets, systems, and networks that need to be protected. Identifying critical facilities to ensure considerations are made to reduce risk pre- and post-disaster remains a capability gap.

Securing information technology resources, state assets, and critical facilities requires collaboration among stakeholders. In accordance with the Incident Prevention/Response/Notification Standard, each organization should designate an agency contact known as a security officer. Security officers become part of a proactive group that communicates and corrects security incidents and vulnerabilities. This improved efficiency increases the vulnerability of critical facilities and state assets to a cyberattack.

There are current limitations to sharing levels of threat information outside the government sector, between agencies and levels of government, and within the private sector to those outside their organizations. The current operating environment and regulatory limitations present obstacles to sharing optimal levels of information.

Changes in Development

Successful mitigation of cyberattacks requires an understanding of the current risk posed by the hazard, combined with information relating to how that risk is expected to change in the future. It is also important to consider both the direct and indirect impacts from other hazards and how those may also influence future risk to cyberattacks.

To develop and maintain resilient cybersecurity capabilities, there must be cooperation between federal, state, local, tribal, non-governmental organizations, and private sector partners. Multi-sector discussions and outreach efforts increase emphasis on whole community participation in planning which are being currently developed in the Hazard Mitigation & Resiliency Plan. Detecting highly structured malicious activity (via all threat vectors) directed against all critical infrastructure, key resources, and networks must be a priority. Law enforcement and intelligence assets should be leveraged to identify, investigate, and prosecute malicious actors.

Planning documents with processes for achieving these targets are complete but require updates and testing through exercises or real-world events.

Summary / Conclusion

Following this plan's risk assessment adversarial hazards such as cyberattacks have been understood in the context of the following definitions:

Future probability: If probability cannot be calculated numerically, probability is indicated as either highly likely, likely, or possible.

Highly likely probability: generally, indicates judgments based on high-quality information and/or the nature of the issue makes it possible to conclude a solid judgment.

Likely probability: generally, means there are various ways to interpret the information, we have alternative views, or the information is credible and plausible but not corroborated sufficiently.

Possible probability: generally, means the information is scant, questionable, or very fragmented which makes it difficult to make solid analytic inferences.

The probability of a cyberattack in any given year in the Virgin Islands is therefore considered to be possible. The impact of a cyberattack may range from limited to critical. Limited impact may include minor injuries, limited property damage (10% of the area or less), and the shutdown of critical facilities or infrastructure for more than one day; critical impact may include multiple deaths and/or injuries, property damage or destruction in 25% or more of the affected area, and the complete shutdown of critical facilities and infrastructure for more than one week.

Data Limitations / References

BIT has cybersecurity and cyberattack plans in place for state government systems but are currently working on a territorial plan as well as exercises to determine the gaps with the assistance of CISA. Some key documents exist to inform this profile including but not limited to the following:

- 2020 Virgin Islands THIRA

HAZARDOUS MATERIAL RELEASE

Description

Hazardous materials (hazmat) are substances posing an unreasonable risk to safety and health, the environment, and the property of Virgin Islands citizens. The term hazardous materials encompass a vast array of products, from the relatively innocuous types, such as creosote, to highly toxic or poisonous types, such as anhydrous ammonia. The severity of potential hazards caused by these materials varies, but the primary reason for the designation is their risks to public safety.

The Federal Motor Carrier Safety Administration (FMCSA) designates nine categories of hazardous materials as follows:

- Explosives (Class 1)
- Gases (Class 2)
- Flammable and combustible liquids (Class 3)
- Flammable solids, spontaneously combustible, and dangerous when wet (Class 4)
- Oxidizing substances and organic peroxides (Class 5)
- Toxic/poisonous substances and poison inhalation (Class 6)
- Radioactive materials (Class 7)
- Corrosive substances (Class 8)
- Miscellaneous hazardous materials/products, substances, or organisms (Class 9)

Hazardous material incidents are categorized as uncontrolled releases occurring during transportation (truck or pipeline) or at a fixed source such as a manufacturing or storage facility. Accidental releases may be due to equipment failure, human error, or a natural or human-caused hazard event. This profile's goal is to analyze both transportation and fixed facility releases of chemical and radiological hazardous materials. Although the listed hazardous materials are classified essentially the same in both transportation and fixed facility incidents, the USDOT determines and regulates hazardous materials associated with transportation, including pipelines. The EPA determines and regulates which materials are considered hazardous in fixed facility releases.

Hazardous material releases occur as a result of multiple causes but are often initiated by a transportation accident. Almost any hazard that destroys infrastructure can lead to a hazardous material release. For example, floods can wash out bridges or roadways causing transportation accidents as well as infiltrate storage areas causing a hazardous material release at a fixed facility. As periodically occurs in flooding, propane and other chemical tanks can become dislodged and float downstream. Strong winds, poor visibilities, or slippery roadways may also instigate a transportation accident. Hazardous material releases during any hazard event will most certainly compound the complexity of the event.

Oil and Natural Gas Industry

Previous Occurrences

This section may be incorporated within the Territories Hazard Mitigation and Resilience Plan for 2022.

Location and Extent

Hazardous material incidents can happen anywhere, but the most likely locations are associated with the oil and natural gas industry development, at fixed facilities producing, housing, or using hazardous materials or along the refinery, roads, and pipeline infrastructure. The table below provides an overview of the spatial extent that hazardous material releases can impact different resources.

Table 4.83: Spatial Extent of Hazardous Material Release Impacts

Resources:	Extent of Impacts
People	**Local**
Property	**Local**
Infrastructure	**Local**
Government Operations	**Local**
Environment / Natural Resources	**Regional**
Cultural Resources	**Local**

Consequence Analysis

As part of a holistic risk and vulnerability assessment, it is important to evaluate the resulting consequences posed to individual sectors of a community from a hazard event. Tables below summarizes the primary and secondary impacts a hazardous material release incident may have on a community.

Table 4.84 Hazardous Material Release Consequence Analysis

Hazardous Material Release Impacts	
Public	The impacts to people are often greater than the structural impacts as a result of a hazardous material incident. Hazardous material release can cause significant impacts on health, such as cancer, genetic mutations and birth defects, physical abnormalities, among others (EPA, Date Unknown). Depending on the material, the health impacts to humans can be long and short term. A hazardous material incident could have a greater impact on those areas with higher population concentrations such as cities, special needs facilities, and businesses. In a hazardous material release, those in the immediate isolation area would have little to no warning, whereas the population further away in the dispersion path may have time to evacuate, depending on the weather conditions, material released, and public notification. Additionally, a release near a special needs' facility may present unique evacuation challenges.
Responders	Hazardous material release can be impactful to responders if the release or event obstructs access to communities. Additionally, responders would be at risk responding to emergencies in communities (the level of risk would be dependent on the type of event), which would inhibit their ability to respond, particularly if they did not have the proper resources to address the hazardous material release event.
COOP	Continuity of operations would experience less impact than other community sectors but could still be affected if the event is severe. Continuity of operations could be more heavily impacted and limited if operations were directed towards evacuation and response. Additionally, employee absenteeism related to the event and/or fear of the event would impact the continuity of operations.
Delivery of Services	Delivery of services could be impacted locally and federally depending on the size and scale of a hazardous material release event. Transportation routes may be closed to reduce public exposure to dangerous chemicals, therefore limiting the ability for services to be delivered and preventing employees from getting to work. Businesses and places of commerce may close due to hazardous material release events in the vicinity of the workplace, which could lead to disruption of goods and services.
Property, Facilities, and Infrastructure	A hazardous material release event could severely impact properties, facilities, and infrastructure. The infrastructure containing or transporting the hazardous material, as well as those in close proximity, would be at high risk of damage. Furthermore, any delay in response may cause the event to exacerbate damage at facilities or spread to other facilities.
Environment	Significant losses can occur to the environment and other ecological values. Clean-up efforts may mitigate the effects, but some losses may occur. Sensitive habitats could be damaged or air and water quality reduced. Wildlife and vegetation can be killed or experience reproductive failure which can subsequently disrupt the health and viability of ecosystems (EPA, Date Unknown). In water habitats, wildlife health and populations can decline, which can also pose a threat to human consumption (NOAA, 2018). Chronic exposure to toxic elements is known as chronic toxicity and can impact both animals and humans (EPA, Date Unknown).

State Assets and/or Critical Facilities at Risk

Since hazardous material releases can occur virtually anywhere, all government-owned buildings and property are at risk. Fortunately, unless an explosion is present with the release, structures surrounding the incident location are typically not damaged in a hazardous materials release. However, if a government-owned building becomes contaminated from a hazmat release, the building may be uninhabitable for some time. Therefore, the risk to government-owned buildings and property is low; however, those facilities in close proximity to a fixed facility containing hazardous materials, are at an enhanced risk. Much of the vulnerability depends on specifically where a release occurs in proximity to the critical facilities and infrastructure. Should a hazardous material release affect one of the critical facilities, the level of emergency services available to a community could be reduced, including emergency medical services and firefighting.

It is difficult to determine specific state assets at risk due to the variability of hazardous material release events, and subsequently presents a challenge in estimating costs.

Loss Estimates

Sufficient data is not available at this time to make estimates of potential losses by jurisdiction for all types of hazardous material release incidents. However, the following assumptions have been made that begin the process of estimating these actual losses:

- Most hazmat events are localized and affect only the immediate area.
- Most events are small in nature and are quickly contained and cleaned.
- Most hazmat events involve an immediate response and an expedited cleanup with relatively fixed costs. Depending on the size and location of a release, the associated costs can range from a few thousand dollars to hundreds of thousands of dollars.
- Losses could include limited loss of life, injuries, and sickness for the general population and for the first responders.
- There could be significant loss of reputation or confidence in associated organizations.
- There could be short-term impacts to the local economy due to a major event.

Future Conditions

Successful mitigation of hazardous material releases requires an understanding of the current risk posed by the hazard, combined with information relating to how that risk is expected to change in the future. Two of the largest factors influencing future risk relate to how and where population growth (or withdraw) and development occurs, in addition to the effects of our changing climate on a hazard. It is also important to consider both the direct and indirect impacts from other hazards and how those may also influence future hazardous material release risk.

Climate Change

Although hazardous material releases are largely human-caused, climate change indirectly impacts this hazard. The effects of climate change on other natural hazards, such as wildfire and flood, may increase the frequency of hazardous material releases. Floods can cause hazardous material releases, particularly at fixed facilities. It is unknown how future conditions will impact the extent/intensity and duration of hazardous material events.

Changes in Development

Structures located near fixed facilities, highways, and other high traffic roadways are most at risk to a hazmat event. Any development that takes place in these areas will place more people and structures in the risk area for hazmat events; however, currently most hazardous material spills are associated with the oil and natural gas growth industry.

Summary / Conclusion

Hazardous materials are constantly present in the Virgin Islands, and with the refinery locally, they will be persistent in the future. Hazardous material releases can cause public health and safety concerns such as explosions and exposure to harmful chemicals. It has a high impact on the public due to health concerns, and even the potential of airborne risks.

Additionally, a hazardous material release can contaminate the surrounding environment, requiring costly clean-up efforts. This not only severely impacts the environment, but it also the economy. Property, infrastructure, and facilities are also at high risk depending on the proximity to the hazardous release event, and whether these structures contain or transport hazardous material. Hazardous material release is a moderate risk event due to localized nature. However, these events occur with no warning, and clean-up, removal, and remediation can endure for long periods of time. The need to reduce the risk to hazardous material releases is becoming more apparent as the growth in the industry, as well as event probability, grows.

Data Limitations / References

Understanding when, where, and what substances are mostly likely to be released in a hazardous materials incident is the greatest limitation in analyzing this hazard. A study of the number and types of hazardous materials using the highways in the territory would improve this profile, as would GIS mapping of the pipelines traversing the state.

INFECTIOUS DISEASES

Description

For the purposes of this plan, infectious diseases include human pandemics. Each species has its own natural immune system to ward off most diseases. The causes and significance of diseases vary. Of consequence in the emergency management realm are infectious diseases and with the potential for high infection rates in humans. Such diseases and infestations can directly or indirectly impact human populations and the economy.

Disease transmission may occur naturally or intentionally, as in the case of bioterrorism, and infect populations rapidly with little notice. New diseases regularly emerge or mutate. Known diseases, such as influenza, can be particularly severe in any given season. Pests have the potential to effect crops, health, food supplies, and vegetation. Furthermore, our increasingly global society results in a continual movement of people and products capable of disseminating diseases rapidly.

Other disasters, such as those resulting in the loss or contamination of water supplies, may result in an increased probability of disease. In fact, following most major disasters, disease is a primary concern due to the lack of sanitation. More specifically, long-term power outages can lead to household food contamination, and flooded properties often develop mold or mildew toxins. Standing water frequently contains hazardous bacteria and chemicals.

Some infectious disease agents relative to the VI are listed below and described further in this plan.

Human

- Influenza
- Emerging or Foreign Diseases
- Foodborne illness

Previous Occurrences

Prior to 2020 the Virgin Islands had not experienced any devastating human disease outbreaks within its population in recent years, but the outbreak of the COVID-19 virus changed that significantly.

In recent years there have been numerous emerging and foreign diseases that have impacted the United States, either directly or indirectly. The territory was fortunate enough to not have had these diseases affect the territory significantly other than Zika and COVID 19. Examples of recent emerging diseases and outbreaks include, but are not limited to:

- COVID-19 Pandemic which affected the entire United States and world.
- The Ebola hemorrhagic fever outbreaks in Africa and the outbreak in 2014-2015;

- Zika virus in South, Central and North America starting in 2016;
- Measles outbreaks in several states among pockets of unvaccinated people;
- Emerging coronaviruses causing severe respiratory infections including severe acute respiratory syndrome (SARS) in 2003 and middle east respiratory syndrome (MERS) in 2012, while no cases of SARS have been reported since 2004, MERS transmission continues;
- The current hepatitis A outbreaks occurring among the homeless in several states in the United States;
- The increasing emergence of antibiotic resistant bacteria in the world, including the United States;
- Increasing numbers of nation-wide outbreaks caused by foodborne pathogens with and an ever-expanding variety of food vehicles and other products that are associated with these outbreaks; and
- The emergence of fungal infections associated with steroid injections or other health care.

In addition to these emerging diseases, there is also a concern regarding the expansion of disease vectors such as mosquitoes and ticks. Among these concerns are:

- Identifying the Asian longhorn tick in several eastern states in 2018, which can spread several diseases that can infect people and animals, including livestock;
- The expansion of the Asian tiger mosquito which can transmit yellow fever, dengue fever, Chikungunya fever and Usutu virus to people.

Emerging and foreign diseases require public health departments to remain diligent in disease surveillance activities and prepared for the detection and to the response to these diseases. Efforts to educate health care providers about the emergence and threat of diseases as they are detected must be maintained. Providing technical assistance regarding clinical presentation, laboratory diagnosis and patient management is also a key element to the detection of and response to these emerging threats. Increasing capacity to conduct vector surveillance will be beneficial in more rapidly identifying disease transmission potential.

Location and Extent

The magnitude of an infectious disease outbreak varies from everyday disease occurrences to widespread infection. The pandemic that has affected the territory this past year and the world has indicated the significance and how things can truly occur to change the level of normalcy. The events and lives lost throughout this pandemic has shown how the entire world can react to a severe magnitude event.

A highly contagious, incapacitating disease that entered the Virgin Islands population has the potential to overwhelm local health resources. The magnitude of an infectious disease outbreak is related to the ability of the public health and medical communities to stop the spread of the disease. For example, local health jurisdictions have specific pandemic influenza response plans, and mass prophylaxis plans, but most jurisdictions have only a few staff members. This recent pandemic was able to show this and proved the gaps that were there.

Consequence Analysis

As part of a holistic risk and vulnerability assessment, it is important to evaluate the resulting consequences posed to individual sectors of a community from a hazard event as demonstrated in the Table below:

Table 4.85: Infectious Disease Consequence Analysis

Infectious Disease Impacts	
Public	Human epidemics may lead to quarantines, large-scale use of the medical care system, and mass fatalities. Typically, the elderly, young children, and those with suppressed immune systems are at greatest risk from infectious diseases.
Responders	Responders would be impacted due to limited resources and staffing should the magnitude of the event increase, particularly since responders and other health care officials could be exposed to the infectious diseases early on. Additionally, social distancing measures and illness may cause further reductions in staff, making it difficult to continue with emergency response procedures.
COOP	The continuity of operations could be heavily impacted should the spread of disease limit personnel availability due to illness or social distancing measures. The lack of staff and the infectious disease event could also have subsequent impacts on the mental health of government staff. Additionally, there is a need for financial support for diagnostic labs and robust surveillance purposes which could further strain government operations. The spatial extent of a rapidly spreading infectious disease could quickly impact government operations statewide.
Delivery of Services	Infectious diseases would greatly impact the delivery of services, particularly in health care. The capacity of the health care system is limited. For example, local health jurisdictions have specific pandemic influenza response plans, and mass prophylaxis plans, but most jurisdictions have only a few staff members. Many local health jurisdictions would need to rely on volunteers, pre-scripted messages and procedures, and the cooperation of the public to respond effectively to a large-scale pandemic.

Infectious Disease Impacts	
Property, Facilities, and Infrastructure	There is little to no impact on physical property and infrastructure. However, infectious disease could highly impact critical facilities. Disease spread that impacts staff availability, also due to social distancing measures, could affect the maintenance of facilities and infrastructure. Moreover, due to the lack of personnel, facilities could experience shutdowns of 30 days or more. Workers who become ill, need to care for loved ones, or are fearful of contracting the disease may not show up for work. The impact to critical industries and services could be severe.

State Risk Assessment

Quantifying the probability of a human disease affecting the Virgin Islands would have presented challenges due to a limited history of outbreaks but the recent outbreak has allowed more quantifiable data to be available. Four human influenza pandemics have occurred over the past 100 years with one, the 1918 pandemic, severely affecting the United States with the COVID pandemic being the fifth.

Vaccination rates have been rising slowly since 2007 and continued to rise since the COVID 19 vaccine has become available. Although higher than United States rates for this indicator, the coverage rate is below the target of 90%, as designated by the CDC.

Vulnerability Assessment

The entire territory was vulnerable to a major disease outbreak. Health professional shortage areas and hospitals are more susceptible to having limited medical capabilities, and by extension, are more susceptible to the possibility of being overwhelmed because of a large surge of patients seeking care. The territory is not able to sustain a mass casualty event and the availability of isolation rooms at the hospital were very limited being that the territory only has one island per territory.

State Assets and/or Critical Facilities at Risk

All government-owned buildings and human-occupied critical facilities are assumed to be at risk of contamination from a communicable disease. If facilities supporting emergency response lost their functionality because of contamination, delays in emergency services could result. Additionally, with a significant human disease outbreak, resources such as the ambulance services, hospitals, and medical clinics could quickly become overwhelmed.

In most cases, critical infrastructure would not be affected by communicable disease. Scenarios that would affect infrastructure include the contamination of the water supplies and diseases that require special provisions in the treatment of wastewater. Should an epidemic necessitate quarantine or incapacitate a significant portion of the population, support of and physical repairs to infrastructure may be delayed, and services may be disrupted for a time due to limitations in getting affected employees to work.

Loss Estimates

There is data currently available on the economic impact of previous influenza pandemic illness in the Virgin Islands tracked by the Epidemiology team. Using the pandemic COVID-19 as the worst-case scenario for estimating potential losses, the VIDOH's Pandemic Planning Taskforce has developed the following vulnerability estimate. The COVID-19 Pandemic has indicated the Territory has tested over 70 thousand individuals and had over 2500 positive cases. The 7-day positivity rating documented by the EPI team is tracked at 1.78% from March 5, 2020 until now. The number of deaths to date as of April 1, 2021 is 26. The pandemic has taught the VIDOH to consistently remain prepared and to use this pandemic as a learning tool to mitigate and be prepared for all health hazards. The most common risk factors territorial wide would-be community, close contact, and travel.

Future Conditions

Successful mitigation of infectious diseases and infestation requires an understanding of the current risk posed by the hazard, combined with information relating to how that risk is expected to change in the future. Two of the largest factors influencing future risk relate to how and where population growth (or withdraw) and development occurs, in addition to the effects of our changing climate on a hazard. It is also important to consider both the direct and indirect impacts from other hazards and how those may also influence future infectious disease risk.

Climate Change

The following 04.86 presents the best available data relating to climate changes impacts to infectious disease in the VI. The important summary of these changes is that the state should expect an increased risk to infectious disease in the future.

Table 4.86: Expected Changes to Infectious Disease Future Condition

Impact	Projected Change
Location	Climate change will influence vector-borne disease prevalence, but the direction of the effects (increased or decreased incidence) will be location and disease specific. Animal and plant diseases may spread to more northern regions as average temperatures increase.
Extent/Intensity	Intensity of human disease is projected to increase. Disadvantaged populations are expected to bear a greater burden from climate change because of their current reduced access to medical care and limited resources for adaptation strategies. Extent of certain human diseases is expected to increase. Additionally, the extent of animal and plant diseases are projected to increase with climate change. Climate change may increase the prevalence of parasites and diseases that affect livestock and crops (i.e., the earlier onset of spring and warmer winters could allow some parasites and pathogens to survive more easily).
Frequency	Additional research is needed to determine the effects of climate change on the frequency of infectious disease.
Duration	Additional research is needed to determine the effects of climate change on the duration of human disease. Under warmer winter temperatures, some existing agricultural pests can persist year-round.

Summary and Conclusion

Factors including probability, impact, spatial extent, warning time, and duration were evaluated for each hazard, including infectious disease. Infectious diseases have the greatest impact on the natural environment (including wildlife), public health, and the state economy through decreased agricultural production. Vulnerable populations, particularly those under the age of 5 and over the age of 65, are most at risk of contracting an infectious disease.

In summary, an infectious disease could have major impacts in the territory including overwhelming medical centers, deaths, and economic damage to the agriculture industry. As described in the 2019 THIRA, in the event of a human pandemic, there are a lot of moving pieces to reduce the impact. Planning and ensuring the Virgin Islands has the necessary capabilities to respond to an event is an integral part of reducing the impact. These measures include emphasizing public information and education, vaccinations, preventive treatment, therapeutic treatment, supportive therapy, behavioral changes, and enforcement.

Data Limitations and References

Diseases are spread in a variety of ways, and without emergency action plans which include accurate, up-to-date descriptions of resources, as well as current response capabilities, the analysis of potential loss estimates suffers. If these documents were available, combined with specific disease transmission modes and infection rates, a more accurate estimate of potential losses could be derived. Additional analysis could provide specific information on the number of ill that could be treated at any one time or any one location using existing supplies and personnel resources.

Other key documents related to infectious diseases include the VIDOH Pandemic Influenza Plan, ESF-8 Public Health All-Hazards Plan. Information, data, and other resources were obtained from the following organization VI DOH.

TRANSPORTATION

A transportation incident, for the purposes of this plan, is any large-scale vehicular, aircraft, or watercraft accident involving mass casualties. Mass casualties can be defined as an incident resulting in a large number of deaths and/or injuries that reaches a magnitude that overtaxes the ability of local resources to adequately respond. In most disasters, death and injury represent one of the effects of the hazard, while in transportation accidents, mass casualties are often the primary impact and focus of the event. Long-duration and/or severe weather events such as winter storms and extremely high winds can also contribute to transportation incidents and may necessitate emergency medical, rescue, and sheltering operations.

Probably the most significant and common hazard associated with transportation incidents is the release of hazardous materials. Many hazardous material releases occur as a result of a transportation incident. Any transportation accident involving the release of hazardous materials significantly increases the complexity and potential damages from such an accident. Additionally, many times, weather hazards lead to transportation accidents. Another example is flood damage to the infrastructure of transportation networks. Almost any hazard can cause or aggravate a mass casualty transportation incident.

Successful mitigation of transportation accidents requires an understanding of the current risk posed by the hazard, combined with information relating to how that risk is expected to change in the future. Two of the largest factors influencing future risk relate to how and where population growth and development occurs, in addition to the effects of our changing climate on a hazard. It is also important to consider both the direct and indirect impacts from other hazards and how those may also influence future transportation accident risk.

This section may be incorporated further within the Territorial Hazard Mitigation and Resiliency Plan for 2022.

SECTION FIVE: MITIGATION STRATEGY

Section Five is divided into the following seven subsections:

- CFR Requirement for Mitigation Strategy
- Introduction to Mitigation Strategies
- Goals and Objectives
- Identifications of Mitigation Actions
- Evaluation and Prioritization of Mitigation Actions
- Implementation of Actions
- Summary of the Risk and Capability Assessment

CFR REQUIREMENT FOR MITIGATION STRATEGY

Section §201.4(c)(3) of the CFR states that — [to be effective, the plan must include] the State 's blueprint for reducing the losses identified in the risk assessment.

The CFR includes three specific requirements that relate to the development of a Mitigation Strategy for the US Virgin Islands:

- **Hazard Mitigation Goals** per Requirement §201.4(c)(3)(i): — [The State shall include a] description of State goals to guide the selection of activities to mitigate and reduce potential losses.

- **Mitigation Actions** per Requirement §201.4(c)(3)(iii): "[State plans shall include an] identification, evaluation, and prioritization of cost-effective, environmentally sound, and technically feasible mitigation actions and activities the State is considering and an explanation of how each activity contributes to the overall mitigation strategy.

- **Funding Sources** per Requirement §201.4(c)(3)(iv): "[The State mitigation strategy shall include an] identification of current and potential sources of Federal, State, local, or private funding to implement mitigation activities. ‖

INTRODUCTION TO MITIGATION STRATEGIES

REVIEW OF MITIGATION ACTIONS

The programmatic mitigation actions from the 2014 Plan were reviewed and then discussed at the June 28, 2019; meeting held on St. Croix with the respective Hazard Mitigation, Monitoring, and Evaluation Committees.

As noted in Sections 5.3.1 and 5.2.2 above, the mitigation strategy reflects a realistic assessment by VITEMA, and the Hazard Mitigation Committees limited technical and financial capacity as well as the findings of the risk assessment.

VITEMA presented a prioritized listing of mitigation actions to the Hazard Mitigation Committees via email correspondence on June 27, 2019, so that representatives of the committee could concur on the priority of hazard mitigation action items. Committee members were asked to prioritize each mitigation action on the basis of the action 's potential for loss reduction and to consider all the evaluation criteria included in the STAPLEE criteria. These considerations include:

- **S** - for socially acceptable
- **T** - for technically feasible
- **A** - for administrative (having the capability and capacity to undertake the action)
- **P** - for politically acceptable
- **L** - for legal (having the legal authority to implement the action)
- **E** - for economic (stressing adequate funding to implement the action)
- **E** - for the environment (understanding positive and adverse impacts of the action

It is important to note that there has been some, albeit limited, progress in the implementation of past plan actions. Having public sector representation in all three Island Hazard Mitigation Committees was vital in determining which of the mitigation actions from the 2014 Plan had been fully or partially implemented. Many of the pending projects listed in 2014 have been addressed or are being addressed as part of the Disaster Recovery effort post-Hurricane Irma and Maria. The major successes to report include:

- For a further discussion as to specific actions that were completed, deleted, or deferred, please refer to the Plan Update and to Appendix D. Which presents a matrix that provides an overview of all mitigation actions included in the 2014 Plan that were either completed, removed, or remain valid.

GOALS AND OBJECTIVES

The Mitigation Strategy includes a series of proposed mitigation actions based on goals and objectives established as part of an overarching hazard mitigation framework for the US Virgin Islands. As used in this Plan, these key terms are defined as follows:

- **Goals**: Broad policy statements to be achieved through the implementation of specific objectives. They served as the framework for obtaining the desired results over the long-term planning horizon.

- **Objectives**: Specific steps to support, correspond, and define a path on how to attain the desired goals and lead to their implementation.

- **Actions**: Efforts that seek to reduce or eliminate risk (see Appendix F). Actions can be grouped into two broad categories:

    - Programmatic or ―soft‖ mitigation actions implemented through legislation, regulations, or programs that operate on a Territory-wide level. One good example of programmatic actions is strengthening engineering specifications that address hazard risk reduction in the design and construction of public and private roads.

    - Projects that are designed and constructed to eliminate or reduce future disaster damages. Projects can include personal property and natural resource protection.

IDENTIFICATION OF GOALS AND OBJECTIVES

The Strategy for the Plan Update has not fundamentally changed since the 2014 Plan. The goal was moving forward and with the continued development of the Hazard Mitigation, Resiliency Plan would be to mitigate across all hazards while always trying to regain function ability after any dysfunction. VITEMA identified six (6) overarching goals and several related objectives based on the risk assessment and capability assessment. Both the findings of the risk assessment and capability assessment have not changed significantly in the past five years.

VITEMA has changed the structure in comparison to the 2014 Plan to state goals as broad statements that will be achieved by a listing of previous goals now identified as objectives and action items.

USVI MITIGATION GOALS

- **Goal 1** - Identity and actively participate in sustained action that eliminates or reduces long-term risk to people and property from different hazards. Reduce threats to the community's public health and public safety, reduce or eliminate damage caused by disasters wherever possible and reduce the burden placed on local, state, and federal preparedness, response, and recovery activities.

- **Goal 2** - Strengthen and mitigate the Territory key structures and infrastructures to reduce damage by any hazards.

- **Goal 3** - Improve Territory's communication to ensure any detrimental impacts to Governmental agencies, departments and to the community is minimized much as possible.

- **Goal 4** - Address all identified gaps and challenges within the Territory's Flood Ordinance and ensure continued participation in the NFIP

- **Goal 5** -Improve sheltering capabilities throughout the entire Territory

- **Goal 6** - Increased protection from all disasters to cultural, historical, and natural resources. Continue to identify additional opportunities to use natural resources to mitigate against a variety of hazards.

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ACTION ITEM 1: INTEGRATED COMPREHENSIVE PLANNING

USVI MITIGATION GOAL 1 ACTIVITY

Background

Over the past years, the territory has struggled with the ability to have a conducive planning initiative and team effort where the needs of the territory are met, and there are planning efforts implemented to maintain the plans that will be developed in the future. As part of the Territorial Hazard Mitigation and Resiliency Plan (HMRP) currently in process, the territory will use all relevant impact and damage assessments available to update and incorporate information into the planning process and documents. The HMRP is possible due to the award of an HMGP approved grant. There would be a formation of engagement of all sectors of the Virgin Islands, which would assess the planning and the capacity needs of all agencies, which would allow technical assistance to be provided to agencies as well.

While developing the HMRP, there will be a formation of a Unified Comprehensive Plan Taskforce and steering committee and technical advisory committee to assist in ensuring the territories needs are met continuously, and mitigative efforts are continuing to be fostered to ensure the territory's needs collaboratively are always addressed. This initiative would act as form, creating a standardized process that would allow engagement of all sectors in the planning processes and procedures that would attribute to the capacity needs of the territorial agencies. This project is currently an Active HMGP project, which will be submitted in the fall of 2021.

THE HMRP is the driving activity to Goal 1 of the USVI Mitigation Goals. This plan will provide key information to identify the various areas where mitigation can be utilized to harden the community structures, to protect cultural and historical resources, to identify activities using the Territory's natural resources as a means for mitigation of a variety of hazards. The HMRP will specifically incorporate activities to increase resilience, sustainability, and climate adaptation into the current and future development of the Territories.

The HMRP will include the input and cooperation of stakeholders that will account for key areas of interest that are essential in the mitigation of all hazards. These areas of interest include climate adaptation and its impact, economic development, transportation, agriculture, housing, health and human services, utilities, telecommunication, storm-water management, the environment, parks and recreation, arts and culture, and all relevant sectors of the community.

ACTION ITEM 2: STRENGTHEN THE USVI BUILDING CODES AND THE ABILITY TO ENFORCE THEM

USVI MITIGATION GOAL 2 ACTIVITY

Background

After every hazard that occurs, and the damage is assessed by the Territory, usually there would be a need to strengthen the USVI Building codes and the processes in how they can be enforced. After the Presidential Declaration was instated, there was a Mitigation Assessment Team which was able to perform fieldwork to assess select strategic building science-related damages of significance through subject matter expert (SME) technical support, develop Recovery Advisories, Fact Sheets to help with recovery operations, provide training, develop a final report, and provide related SME technical support for disaster recovery operations. Coordination efforts have been initiated with the University of Virgin Islands, non-profits, other Federal, Territory, and local agencies, the private sector, trade, or other organizations, as is appropriate, will support this effort.

VITEMA would be in the capacity to provide technical assistance with the support of FEMA to DPNR in reviewing, inspecting, and enforcing adopted building codes. Department of Planning and Natural Resources (DPNR) submitted an application under HMGP that was approved on March 6, 2018, which is allowed the agency to receive funding and sufficient support to initiate and implement the latest hazard resistant building codes and to develop a permitting and enforcement system that will aid compliance. VITEMA will continue to provide technical assistance to DPNR in the overall improvement of their capabilities to enforce the updated building codes for the USVI.

DPNR will correlate new code provisions (new design wind speed maps, consensus with flood standard, etc.) with the older local ordinances and proceed with the amendments necessary for the updated USVI building code.

ACTION ITEM 3: STRENGTHEN THE USVI POWER DISTRIBUTION SYSTEM

USVI MITIGATION GOAL 2 ACTIVITY

Background

The strengthening of the USVI, power distribution system, has been a reoccurring problem affecting the territory's immediate ability to regenerate power to the territory following a hazard such as both hurricanes that devasted the entire territory. By utilizing the information developed, obtained, and disseminated by FEMA, the United States Corp of Engineers (USACE), Department of Energy (DOE) and the Virgin Islands Water and Power Authority (VIWAPA) distribution system assessed the damage and impacts of the Hurricanes. In addition, assessments were conducted to determine the impact of the hurricanes on past mitigation projects (i.e., Underground distribution) funded and implemented in the USVI to determine the success of those projects. Review industry exemptions for wind design on structures less than 60 feet in height.

It is utilizing these assessments of the damage, identification of the risks and vulnerabilities to the VIWAPA Distributions System, and identification of the potential mitigation opportunities to strengthen the overall system to prevent future impacts from natural hazards. Utilization efforts would be key in defining the expertise in VIWAPA, USACE, FEMA, and DOE to develop potential actions and, in addition, utilizing past mitigation projects that were successful and unsuccessful in supporting these action items. Maximization of the use of FEMA's 406 Mitigation program to strengthen and mitigate the USVI power distribution system that was damaged by the storm, where 406 mitigation is not eligible to utilize 404 HMGP to fill gaps. In addition, utilization of the RSFLG is ongoing to identify other resources to support this effort to strengthen the VIWAPA power systems either through technical assistance, funding resources, innovative system ideas, etc.

Use of the post-disaster assessments and the resulting identification of risks and vulnerabilities to the VI WAPA distribution system supplemented by the awareness of the ongoing recovery activities will identify potential future mitigation opportunities to continue to strengthen the overall system to minimize or prevent future impacts from hazards.

ACTION ITEM 4: STRENGTHEN THE USVI EMERGENCY COMMUNICATION SYSTEMS

USVI MITIGATION GOAL 3 ACTIVITY

Background

Many of the programmatic actions in this Plan Update focus on developing capabilities of VITEMA. The identified actions focus on developing capabilities to gather data and implement management systems, as they relate to increasing the territories' ability to communicate effectively during the onset of any hazard that could occur. During the two Hurricanes, the territory was unable to communicate with each other, which in turn affected communication among the essential agencies that are a part of the critical infrastructure.

Information developed, obtained, and disseminated by FEMA, ESF-2, the United States Corp of Engineers (USACE), Department of Energy (DOE), BIT, etc. assessed the damage and impacts of the Hurricanes to the VI's communications systems. Utilizing these assessments and information, identified the risks and vulnerabilities to the VIWAPA land and radio systems, the other public communications systems (landline, internet, VOIP, etc.) and private communication systems, including cellular. Identification opportunities to strengthen the overall systems to prevent future impacts from Hurricanes were determined to be implemented at that moment, utilizing the expertise in BIT, ESF-2, FEMA MERS, USACE, FEMA HM, and DOE to develop potential actions. Funding has been identified where the use of FEMA's 406 Mitigation funding will be used to strengthen and mitigate the public communication systems that were damaged by the storm, where 406 mitigation is not eligible to utilize 404 HMGP to fill gaps.

A project for improvement and hardening of the Government and Public Safety LMR (Land Mobile Radio) systems for critical and emergency communications is funding via PA. Potential funding to increase reliability and resiliency via an additional HMGP project is possible.

VITEMA is currently working with BIT on various communication opportunities. An example is the incorporation of satellite phones that are being provided to each agency as well as educational training on the importance of HAM radios and their effectiveness during a disaster.

ACTION ITEM 5: STRENGTHEN THE USVI WASTE MANAGEMENT SYSTEM

USVI MITIGATION GOAL 2 ACTIVITY

Background

As mentioned in the capabilities section Waste Management System this agency shares similar gaps in their capacity and their ability to function at a high level. The information developed, obtained, and disseminated by FEMA, the United States Corp of Engineers (USACE), and Department of Energy (DOE), assessed the damage and impacts of the Hurricanes to the VI's waste management systems. By utilizing these assessments and information, identification of the risks and vulnerabilities, the Territory was able to identify opportunities to strengthen the overall systems to prevent future impacts from Hurricanes. The expertise in ESF-3, ESF-10, FEMA PA, and FEMA HM is being used and will continue to be utilized to develop potential actions.

There continues to be ongoing identification of a variety of funding that would be able to strengthen and mitigate the waste management system. PA funding has been identified that will be used to repair the waste management system that was damaged by the storms. Collaborative Efforts and initiatives would be developed to incorporate the private sector in the development of potential opportunities.

VITEMA will continue to provide technical assistance where the territory will be responsible for ensuring that WMA would be able to operate at a high level of productivity while strengthening the system.

A developed metric system will be established as well as during the development of the Resiliency plan to determine where the faults and gaps are and mitigate how different agencies can work collaboratively in strengthening the system since the other critical agencies are intertwined at some point.

ACTION ITEM 6: FLOOD RISK REDUCTION

USVI MITIGATION GOAL 4 ACTIVITY

Background

Collaborative initiatives to reduce flood risk in the territory have included VITEMA, FEMA, and DPNR to indicate measures that would mitigate the amount of damage that would occur after any hazard. Some of the tools that would be utilized would be Advisory Base Flood Elevation (ABFE) guidance to mitigate future flood risk and strengthen building codes during the recovery phase of the operation. By FEMA supporting the USVI in utilizing the Hazard Mitigation Grant Program to provide longer-term support to the DPNR in enforcing the floodplain damage prevention ordinance, floodplain management plan, storm-water management, and building codes during the recovery effort. This includes readiness packages of future assistance through mutual aid or EMAC agreements.

The use of 404 and 406 hazard mitigation grants to reduce or eliminate flood risk to structures through acquisition, elevation, drainage systems, flood-proofing, and other flood-control measures. Post-Hurricane Irma and Maria, FEMA has provided and continues to provide a variety of courses in building science, construction, and floodplain management to all territory agencies and other stakeholders as needed. Creation of new maps that better demonstrate risk have taken place are being as additional tools be used in the Advisory capacity.

A flood plain management application was submitted under HMGP and approved on August 20, 2018. This grant funding has allowed DPNR to begin the process of strengthening their internal capacity to utilize mitigative initiative with the full support of VITEMA. This grant will improve and provide support to DPNR capabilities in adopting an updated flood plain damage prevention ordinance and also allow them to develop the readiness, tools, and community and parcel data in a comprehensive that allows for faster recovery in future flood events. The project will also provide technical assistance and training for DPNR to enforce the updated ordinance and floodplain management plan. DPNR now has new mapping products to better identify areas of risk. The identification of these risk areas will assist in the identification of potential future Hazard Mitigation projects for VITEMA to address severely flood-prone structures and infrastructures.

The ongoing Ridge to Reef overarching project is also a crucial part of the development of this goal. Two critical agencies DPNR and DPW, will work very carefully to ensure that when the H&H study is conducted will concretely determine additional flood risk that might not have been indicated previously.

ACTION ITEM 7: INCREASED FLOOD INSURANCE COVERAGE AND NFIP SUPPORT

USVI MITIGATION GOAL 4 ACTIVITY

Background

Being complainant with the guidelines of the Flood Insurance Coverage and NFIP has been an issue the territory has faced throughout the years as to how the capacities can be strengthened to allow the territory to become NFIP compliant. Evaluation and updates of the current Flood Insurance Rate Maps territory-wide, which would allow the USVI to be enrolled in the NFIP Community Rating System territory-wide.

The ability to provide technical support and training to local officials WILL increase their abilities to assist residents with the NFIP program. The outreach would allow local officials to be trained on the flood-resistant provisions of the International Codes and ASCE 24. There would be additional outreach conducted to better educate the population on the NFIP, which has already been initiated, and FEMA provided NFIP Insurance Agent Training for insurance agents stressing the importance of NFIP awareness. There would be initiatives conducted to provide information and handouts on the NFIP to homeowners, renters, and business owners through local improvements and events.

This initiative continues to be developed as part of the HMGP funding for the approval DPNR Flood Plain Management project. It will continue to assist with identifying the gaps as well as the challenges the territory faces. As the project is continued to be further developed, the targeted goal would be to regain good standing with the NFIP regulations and guidelines.

Additional action items that would provide support for the broader action item include improvement and support to the Office of the Lt. Governor Division of Banks, Insurance, and Financial Regulation to track, enforce and provide education and outreach on NFIP. Part of the end goal of this item, along with the increased public outreach cited above, will increase the amount of insurance policies throughout the territory.

To assist with the outreach and improved awareness, FEMA has done multiple NFIP training and will continue to do so with key agencies beyond DPNR to include DWP (Department of Public Works) and WAPA to ensure they are updated with the changes that are occurring with this initiative.

ACTION ITEM 8: IMPROVE RESPONSE CAPABILITIES AT USVI PORTS OF ENTRY

USVI MITIGATION GOAL 2 ACTIVITY

Background

During both disasters' response capabilities at the ports of entry were not highly functional being that there was no process or software in a place where inventory could be tracked and monitored to then be able to distribute to locations. Some potential measures that could be used would be to Acquire Automated Commercial Environment (ACE), which would allow a single-window computer software program that allows for the streamlining of import-export operations.

There would be a need to identify and prioritize the necessary infrastructure and components needed to support the implementation of ACE software. Training will be conducted to Port Authority employees and the private sector on the use and implementation of ACE software.

Collaborative efforts have been initiated where VITEMA's director Daryl Jaschen and the Office of Disaster Recovery will work for hand in hand to ensure before any potential hazard that the territory is equipped with this software so that the same problems occurred post-disaster would not occur again and create a high percentage of errors. Improvement of the process will have a positive impact on the supply chain of various resources and commodities prior to and during response and recovery operations based on pre- and post-disaster operations.

This improvement of this infrastructure will address the shortcomings identified post-Hurricane Irma and Maria with the prompt distribution of goods due to the lack of inability to know where the cargo was readily located.

Additional benefits tied to the overall improvement of the various ports of entry the ability to improve and support the capabilities of business and agencies in the Territory to streamline the import of commodities to the USVI at the ports of entry to increase efficiency, supply, and ease of importing emergency commodities during disaster response and recovery operations.

CBDG-DR Funding will be providing approximately $40,000,000.00 in ports and airports enhancements.

ACTION ITEM 9: IMPROVE THE CAPABILITY IN THE TERRITORY TO SHELTER POPULATION THREATENED BY NATURAL HAZARDS INTRODUCTION AND METHODOLOGY

USVI MITIGATION GOAL 5 ACTIVITY

Background

Sheltering has become a critical aspect of ensuring that the sheltering population capabilities are always at a high functioning level and ability. The capacities and deliverables that will ensure the improvement of shelter measures such as a Sheltering Plan that has been developed to speak to the capacities to mitigate responsive measures. The development of the initial Sheltering plan has provided Identification of the current capabilities of the island to shelter the threatened population through identifying the number of accredited safe rooms and post-events, recovery shelters, and their current functioning capabilities. There will be several individuals on the islands that would potentially need to be sheltered during the storm.

Ensuring the availability of the existing shelters and identifying additional locations that meet or can be improved to meet the applicable mitigative measures required by FEMA safe room program criteria is critical to provide shelter to the USVI community. There is a defined ongoing identification of shelters on all four islands. Various HMGP and CDBG-DR projects are currently in progress or being developed to provide these much-needed shelters that meet the FEMA P-361 and ICC 500 requirements for a safe room.

The importance of shelters has gained tremendous attention, and as stated above, multiple projects are currently ongoing. As the lead coordinating agency, VITEMA will continue to ensure that the safety of the residents of the territory in coordination with the leading agency Department of Human Services. Beyond the currently active projects, the additional ongoing development of project applications for additional potential safe rooms on the various islands within the Territory continues.

Post-storm, the displacement of members of the USVI community due to significant damage or loss of residential structures, environmental contamination, or other factor is an area of grave concern. The VI, Housing Finance Authority, is working on an Emergency Housing Plan to provide safe, sanitary, and functional temporary housing options for displaced residents as part of the long-term community recovery.

ACTION ITEM 10: IMPROVE THE HEALTH CARE CAPABILITY IN THE TERRITORY TO BE ABLE TO SURVIVE AND RESPOND TO A NATURAL DISASTER

USVI MITIGATION GOAL 2 ACTIVITY

Background

Post-disaster, there were many negative impacts on the territory where health care was low functioning due to the lack of inability to be able to respond to the severity of the natural disaster. There needs to be a developed system of metrics that would dictate a capacity that the health care facilities would be able to become high functioning, and patients would not be forced to leave the island after any natural disaster. Measures that can be followed would be to assess damages and impacts to the hospitals from an infrastructure and building performance standpoint. Being able to utilize the damage assessments, identify the risks and vulnerabilities would assist in improving the overall system.

Identification of potential funding opportunities under the FEMA 406 Public Assistance Mitigation Program would maximize the programs for reconstruction and restoration recommendations to be able to strengthen the overall system. Utilization of Assessments and updates provided from the disaster response plan and the identification of opportunities to mitigate communications, power distribution and medical inventory and supply challenges which would prevent future impacts from hurricanes and all other potential hazards as it pertains to health care capability

Currently, the various hospitals and clinics are receiving assistance from Public Assistance as it pertains to repairs and strengthening of the different facilities throughout the Territory. Due to the extensive damage received by the Juan F. Luis Hospital on St Croix, a full rebuilt has been approved by FEMA.

ACTION ITEM 11: STRENGTHEN THE USVI EDUCATION BUILDINGS TRODUCTION AND METHODOLOGY

USVI MITIGATION GOAL 2 ACTIVITY

Background

Post-disaster, the strength of the educational buildings in the Territory were extremely weakened and caused education to be on somewhat of a hold, which in turn affected the community and the ability to regain normalcy. While rebuilding to standard functional capabilities, there needs to mitigative measures that would ensure that the buildings are strengthened and retrofitted to avoid any severe impact that was already felt post-Irma and Maria.

Various funding has been identified as the address of the repairs and hardening of the schools that have been deemed to be reparable. Due to the fact that schools were severely damaged post-disaster, and several were used as long-term shelters, current safe room projects have been geared toward the identification of safe room not located within schools.

This would allow posting the necessary strengthening of the school and post any potential future disaster an earlier return to school for students in the community. This return to some degree to normalcy for the younger members of our community is essential to address any possible psychological impact as a result of exposure to a disaster.

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ACTION ITEM 12: INCREASE RESPONSE AND RECOVERY CAPABILITIES OF VITEMA

USVI MITIGATION GOAL 2 ACTIVITY

Background

As previously mentioned in the Capabilities section, VITEMA's resources have not been filled; therefore, there were strains on the abilities to try to function on a high-level capacity. Their assessments conducted to determine the needs and requirements of VITEMA's capabilities and infrastructure to identify the gaps and challenges which would increase response and recovery operations capabilities. By being able to prioritize the critical infrastructure, component, and administrative needs needed to complete response and recovery operations effectively would benefit the entire territory tremendously. FEMA will offer and provide emergency management courses to enhance professional development and technical expertise, which would be able to build the capacity of everyone employed at VITEMA.

In one capacity VITEMA in partnership with BIT has developed an ongoing project to strengthen the capabilities of VITEMA, relying heavily on the resources and capacities that BIT can offer. Through HMGP funding, those sources will be funded, further developed, and implemented.

VITEMA has an approved HGMP project that will allow for the repairs and retrofit of the previous location at Estate Hermon Hill on St Croix. This location will house VITEMA, the Emergency Operations Center (EOC), 911 Calling Center, and BIT (Bureau of Information Technologies). The improvements in this location will provide additional support for addressing preparing, responding, and recover operations.

The new facility would consist of capacity for the following staff and operations within two buildings:

Building #1

- VITEMA Staff for the day today
- 911 Emergency Call Center
- Homeland Security Office (HLS)
- Emergency Operation Center (EOC)
- Male and Female dorms – Capacity 70 people
- Climate Control Room for emergency commodities storage
- Secure underground parking for VITEMA emergency response vehicles
- Kitchen and cafeteria
- Four (4) large conference rooms for training and meetings

Building #1 (continued…)

- Communications room with retractable antenna
- Server Room
- Solar system to power all lights
- Possible garage area
- Helipad
- Laundromat
- Fitness facilities

Building #2

- BIT staff
- Storage for BIT equipment
- VIPD substation
- Indoor two-lane range
- Secure firearm locker room

Additional action items within this goal to develop the capabilities of VITEMA are:

- Improve and support the capability of VITEMA to respond and recover from emergency and disaster events through the improvement of the agency's critical infrastructure, components, and administration.

- Continuation of ongoing training to increase VITEMA's capabilities to provide technical and professional expertise in response and recovery operations within the Territory.

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ACTION ITEM 13: PROTECT AND MITIGATE CULTURE HERITAGE INSTITUTIONS AND COLLECTIONS

USVI MITIGATION GOAL 6 ACTIVITY

Background

Protecting cultural heritage institutions is a factor that has been overlooked in the past. Still, with this plan update and the Comprehensive plan, there will be measures that would define mitigative efforts to protect these areas. Identification and assessments of the needs and requirements of cultural institutions across the islands would assist with the help of the mitigation actions and activities. There would be the inclusion of the local cultural institutions in the EHP, which would unify the federal review process, which would ensure protection and potential mitigation for important cultural institution sites and collections.

Partnerships will be established with the Virgin Islands Council for the Arts to provide education and planning assistance to create strategic plans for the future of the arts and culture sector of the USVI. Additional technical assistance would be provided through the Heritage Emergency and Response Training (HEART) through the HENTF.

Action items tied to this goal include:

- Provide education and training to cultural institutions to increase the incorporation of cultural and historic resources into disaster planning and hazard mitigation efforts at all levels of government.
- Provide technical assistance, guidance, and resources to cultural institutions to address disasters-related impacts to cultural and historical resources to better respond, recovery, and mitigate against future disasters.

ACTION ITEM 14: PROMOTE NATURAL SOLUTIONS TO HAZARD MITIGATION AND CLIMATE ADAPTATION

USVI MITIGATION GOAL 6 ACTIVITY

Background

The importance of Climate Adaption has not been as prevalent as it has currently become in recent years, which is essential for the Territory to prioritize in the incorporation of Hazard mitigative efforts for natural solutions. Identification and assessments of the opportunities to employ natural and restorative solutions for natural infrastructure and to assist with the mitigation of hardened infrastructure. Engagement with other federal agencies and non-profits will be done to determine training and educational opportunities for local agencies and non-profits.

Currently, projects are an ongoing process, a variety of projects involving the use of mitigation by addressing and enhancing the recovery of coral reefs and mangroves have either been approved or have been submitted pending approvals. Studies of existing watersheds and additional hydrology studies are also current HMGP active projects or projects in development.

Additional action items include:

- To provide education and training to territorial agencies to increase the incorporation of natural solutions for hazard mitigation planning, project, and programs.
- To provide technical assistance, guidance, and resources to cultural institutions to address natural solutions to hazard mitigation
- Create an Environmental Resource Inventory for the territory
- To provide training and workshops on natural solutions to hazard mitigation

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IDENTIFICATION, EVALUATION AND PRIORITIZATION OF MITIGATION ACTIONS

IDENTIFICATION OF MITIGATION ACTIONS

The mitigation action focuses on actions that VITEMA may take to reduce the impacts of natural hazards in the Territory. The challenges in the past implementation of 2014 were the lack of technical and financial resources within VITEMA to manage and coordinate the implementation of specific actions/projects – soft projects (education, training, etc. and hard-construction projects (flood drainage, structural retrofit, etc. with a variety of government agencies.

An evaluation of the cost-effectiveness of many of the mitigation actions identified in the Plan Update is challenging to demonstrate. It may not be practical for such a strategic plan. The quantification of costs associated with soft actions and/or projects normally require the calculation of utilization of internal resources, either human and/or budgetary, while the quantification of benefits is more elusive. The identified hard-actions or projects, on the other hand, specify locations for structural projects (i.e., flood drainage improvements in St John) and may be quantified; however, the quantification of costs and benefits may require an in-depth engineering assessment to be performed. A formal Benefit-Cost Analysis, including the calculation of a benefit/cost ratio, would be performed at a future date for any projects sent forward for funding consideration under Federal programs.

In the following pages, the Programmatic and Island specific mitigation actions are presented along with a current status update of each activity as available during this disaster recovery:

Programmatic mitigation actions applicable for the entire USVI Territory (numbered as USVI-#);

1. **Prioritized mitigation actions for St. Croix (numbered as STX-#);**
2. **Prioritized mitigation actions for St. Thomas (numbered as STT-#);**
3. **Prioritized mitigation actions for St. John (numbered as STJ-#).**

EVALUATION AND PRIORITZATION OF MITIGATION ACTIONS

Following the identification of each proposed programmatic and island-specific mitigation action, VITEMA Steering Committee prepared a preliminary list of mitigation actions for the Hazard Mitigation Committees. The programmatic committees were reviewed, evaluated, and prioritized via email communication that was sent out on June 14, 2019. Each proposed mitigation action was reviewed and, where necessary, amended, deleted from consideration, and in several instances, alternative mitigation actions were developed by Committee members.

Each action was reviewed based on the examination of the available resources versus the potential benefits of each action on reducing risks to the residents and property in the Territory. A simple ranking criterion was utilized for evaluating the potential for loss reduction.

Potential for Loss Reduction

- H - which represents the highest relative potential for loss reduction;
- M - which represents the moderate relative potential for loss reduction; and
- L - representing the lowest relative potential for loss reduction.

The programmatic and island-specific actions were then prioritized using a simple voting technique. Each member of the respective Committees voted on the priority of actions that should be included in the plan. The Voting procedure was based on consensus, which differed from the voting technique utilized in the 2008 Plan Update. The tables below reflect the evaluation of loss reduction potential as well as the prioritization of island-specific hazard mitigation actions:

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IDENTIFICATION, EVALUATION AND PRIORITIZATION OF PROGRAMMATIC MITIGATION ACTIONS

Following the evaluation and prioritization of island-specific mitigation actions, the VITEMA Hazard Mitigation Steering Committee reviewed, evaluated, and prioritized the programmatic mitigation actions for the entire Territory. The finalized list of programmatic actions was then discussed with the Hazard Mitigation Committee via a teleconference meeting that was held on June 17, 2018. Tables 5.1, 5.2 and 5.3 below highlight the results of the Hazard Mitigation Committee evaluation and prioritization.

The importance of the implications of climate change variability on hazard mitigation planning for the USVI was noted previously in the Mitigation Strategy. Several of the programmatic actions identified below acknowledge this need and the lack of empirical data to address those implications more effectively. Most important is USVI-4, which proposes to strengthen the USVI Emergency Communications System. Another programmatic mitigation action (USVI-2) would be to Strengthen the USVI Waste Management System. All these hazards will be affected by climate change variability in the future, and a complete database is necessary.

Some of the assumptions of climate change implications that merit further investigation include future increases in the intensity of rainfall events;

- Extended periods of drought on the islands and potential impacts on wildfires and availability of potable water supplies;
- Sea level rise and increase in storm surge levels, particularly significant for St. Croix;
- Potential changes to Special Flood Hazard Areas (SFHA), if climate variability data is integrated into models used in the development of FEMA flood maps.

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Table 5.1 St. Thomas Mitigation Actions

Action	Description	Goal	Potential for Loss Reduction	Existing (E) or New (N)	Priority	Status	Funding Source
STT-1	Construct drainage improvements on Turpentine Run (Brookman Road) to alleviate localized flooding	Goal 2	H	E	5	Currently a project being reviewed	ACOE
STT-2	Construct drainage improvements to improve the capacity of the drainage system by Yvonne Bowsky Elementary School (Peace Corp) to alleviate localized	Goal 2	M	E	14	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STT-3	Construct drainage improvements to improve the capacity, and clean, the storm water drainage system in Frydenhoj (next to and across from ball field) to alleviate localized flooding and damage of private property	Goal 2	H	E	26	Project currently in development	HMGP
STT-4	Construct drainage improvements on Rt. 30 adjacent to Bolongo Bay to alleviate flooding to residential areas and beach	Goal 2	H	E	27	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STT-5	Construct drainage improvements for major drainage channel that conveys flood waters from the surrounding Altona and Anna's Fancy areas to resolve recurrent flooding after heavy rainfall events	Goal 4	H	E	1	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STT-6	Construct Lindberg Estates, Phase IV Drainage Project north through Kirwin Terrace Public Housing Units	Goal 2	H	E	16	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STT-7	Improve drainage infrastructure along Rt. 30 Estate Hope / Fortuna to eliminate flooding of nearby residences in Fortuna 3C Subdivisions	Goal 2	H	E	19	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STT-8	Expand and reinforce communication infrastructure that is being implemented by BIT to mitigate damages from hurricanes to ensure rapid recovery and return to normal service	Goal 3	H	E	13	Current active project (Communication Towers), PA Project - land mobile radio	PA
STT-9	Replace and improve drainage infrastructure at Food Center to resolve flooding issues of roads and business, also addressing potential impact to wetlands	Goal 4	H	E	15	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA

Action	Description	Goal	Potential for Loss Reduction	Existing (E) or New (N)	Priority	Status	Funding Source
STT-10	Conduct hydrologic study of the Smith Bay basin and implement drainage improvements to resolve the flooding problems at Coki Point and Smith Bay Roads, and, improvements to open channels draining through the resort complex into Water Bay to resolve localized flooding problems that periodically close roads, create traffic hazards, prevent emergency vehicle and public access, and cause damage to adjacent businesses and road pavement	Goal 4	H	E	3	Project currently in development	HMGP
STT-11	Construct drainage improvements to secondary road that provides access to Caret Bay West. Improvements could include paving and/or providing proper roadside drainage and properly sized culverts where appropriate to carry stormwater across the road to minimize erosion of the road surface	Goal 2	M	E	18	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STT-12	Complete installation of Hurricane Shutters at main police station in Charlotte Amalie	Goal 2	M	E	20		
STT-13	Improve drainage infrastructure along Hospital Gade from Antonio Jarvis School to the Police Station on Veteran's Drive, paying particular attention to the intersection of Hospital and Kongens Gade (Moravian Church and Zoras)	Goal 2		E	21	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STT-15	Resolve flooding problems at Subbase Entrance. Pursue Phase II drainage improvements which include the installation of properly sized culverts near Bellows across Veteran's Drive to connect to Phase 1 drainage improvement	Goal 4	H	E	8	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STT-16	Enlarge box culverts, storm drains, and improvements to open channels from Veterans Drive to the Bay along the east edge of Frenchtown in southwest Charlotte Amalie (Frenchtown Drainage East), in order to resolve flooding, traffic access and business interruption	Goal 2	H	E	10	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA

Action	Description	Goal	Potential for Loss Reduction	Existing (E) or New (N)	Priority	Status	Funding Source
STT-17	Harden WAPA Substations. Design and construction of hardened switchgear buildings at the East End and Tutu substations	Goal 2	H	E	25	Various Projects currently under development	PA/406
STT-18	Water Island Ferry Dock at ―Philips Landing‖ experiences periodic flooding in the main turn around area. Periodic flooding caused by inadequate drainage at this facility impedes ferry traffic and emergency vehicles	Goal 2	M	N	8	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STT-19	Honeymoon Beach at Druid Bay, western end of Water Island; flooding caused from inadequate drainage blocks vehicular passage and covers road with as much as 3 feet on the beach road and then takes as much as 3 weeks to drain. Economic impacts by blocking access to two commercial establishments & public health issue from mosquito breeding		H	N	10	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STT-20	Evelyn Williams School hurricane-strength wind mitigation retrofit of structural roof system and replacement	Goal 2	H	N	6		
STT-21	Resolve flooding problems at Abattoir Estate Nadir (racetrack) due to inadequate drainage	Goal 4	M	N	23		
STT-22	Address inadequate drainage at Tutu Fire Station	Goal 2	M	N	12		
STT-24	Structural retrofit of following critical facilities used for sheltering (Lockhart School, Bertha Bochulte Middle School and Human Services Head Start buildings).	Goal 2	H	N	4		
STT-25	Four WAPA power line projects to place feeder lines underground to eliminate damage from hurricane strength winds. They include feeder lines 9A, 8E, 13 and 7E	Goal 2	H	N	9		
STT-27	Rehabilitation of Water Storage Tank at Sara Hill to include seismic & wind retrofit. Complete rehabilitation & upgrade of the 105 MG Water Storage Tank. Work includes structural repairs and new wind girders and seismic joints	Goal 2	H	N	7		

Table 5.2 St. Croix Mitigation Actions

Action	Description	Goal	Potential for Loss Reduction	Existing (E) or New (N)	Priority	Status	Funding Source
STX-1	Resolve flooding problems and improve storm water drainage infrastructure in the Grove at La Reine	Goal 4	H	E	24	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STX-2	Conduct a hydrological study of the St. Croix watersheds with particular attention given to the La Grange, Prosperity, Bethlehem, and Salt River watershed basins. Attention should focus on upgrading inadequate drainage systems focused on reducing the impact of flooding (see USVI -4 Mitigation Action	Goal 6	H	E	1	Application has been submitted and is pending review under Advance Assistance (DPNR)	HMGP
STX-3	Perform Assessment of flooding problems within La Grande Princess Estate. Approximately 50 of 250 NFIP-insured losses in St. Croix (one in five repetitive losses) occur in La Grande Princess. Eighty-two properties were identified as being in the 100-year flood plain and the potential for acquisition, structural solutions, and nonstructural control measures to reduce repetitive losses to residences should be assessed (see USVI -2 Mitigation Action)	Goal 4					
STX-4	Improve drainage system to along Melvin H. Evans Highway in the area west of Williams Delight stop light and Carlton. Extend drainage system to connect with drainage improvements in Williams Delight Community	Goal 2	M	E	10	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STX-5	Conduct a hydrological study of the Christiansted watershed or catchment area with particular attention given to the sub-watersheds of Spring Gut and Water Gut to determine technically feasible and cost-effective structural solutions to address the flooding problem in cost effective structural solutions to address the flooding problems in Christiansted	Goal 4	H	E	12	Application has been submitted and is pending review under Advance Assistance (DPNR)	Application has been submitted and is pending review under Advance Assistance (DPNR)
STX-6	Resolve flooding problems and improve stormwater drainage infrastructure for Spring Gut all the way to Gallows Bay	Goal 4	H	E	13	Approved HMGP Project (STX foundation/VI Trail Alliance)	HMGP

Action	Description	Goal	Potential for Loss Reduction	Existing (E) or New (N)	Priority	Status	Funding Source
STX-7	Resolve flooding problems and improve stormwater drainage infrastructure for Tide Village by implementing a low water crossing to divert surface run-off into the natural gut	Goal 4	H	E	14	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STX-8	Pursue Christiansted Gut USACE Section 205 Project. Preliminary feasibility phase currently underway by the Corps to determine whether technically feasible and cost-effective solutions exist to reduce flood damages in residential and business areas adjacent to King Cross Street	Goal 2	H	E	17		
STX-9	Construct a retention pond at the property line of White Bay and the National Park Service reserve within the localized depression	Goal 6	H	E	18	Submitted project under DPW	HMGP
STX-10	Perform assessment of adjacent drainage basins that flow into Estate Williams Delight to identify alternate routing of surface runoff. Evaluate creation of stormwater detention pond below Blue Mountain	Goal 2	H	E	21	Currently under development	PA 406
STX-11	Implement and improve storm water drainage infrastructure to relieve flooding at the Alfredo Andrews School and adjacent low-lying areas	Goal 2	H	N	5	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STX-12	Construct drainage improvements at the Ricardo Richards Elementary School at Estate Barren Spot near Melvin H. Evans Highway (Route 66)	Goal 2	H	E	19	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STX-14	Implement and provide emergency power generator units for all wastewater pumping stations on St Croix	Goal 2	M	E	11	Application under development under WMA	PA 406
STX-15	Pursue equipment anchoring program for the Richmond Electrical Generating Plant. Anchor critical equipment in the Plant to mitigate damages caused by earthquake, hurricane-strength winds, tsunami, and storm surge	Goal 2	H	E	15		

Action	Description	Goal	Potential for Loss Reduction	Existing (E) or New (N)	Priority	Status	Funding Source
STX-16	Improve Various Water Storage Tanks throughout the island. Install flexible connectors at multiple water storage tanks to permit pipe flexibility during earthquake events and ensure rapid recovery and to permit pipe flexibility during earthquake events and ensure rapid recovery and normal service	Goal 2	M	E	16		
STX-17	Lew Muckle School shutter project	Goal 1	H	N	23		
STX-18	The 30 Coastal Interceptor transports sewage from the La Grande Princess area to the LBJ Pump Station in Christiansted. Shoreline erosion from coastal storms has left the interceptor submerged in the sea approximately 50'from the shore. The mitigation action would reroute the pipeline inland, replacing approx. 1900'of pipe, construct new lift station and associated improvements	Goal 2	H	N	4	Ongoing Project	PDM
STX-19	FEMA Community Rating System (CRS). Initiate a planning project to have STX become a CRS Community by developing a strategy and action plan for improving the flood management program on the Island. The planning study would include an outreach strategy and series of community meetings on the NFIP Program, first living floor and base flood elevation determinations, LOMARS, and other flood insurance questions and concerns	Goal 4	M	N	3		
STX-20	LBJ Pump Station flood and storm surge protection. The pump station is located 215' (feet) south of an existing gut and 125' (feet) from the shoreline. Mitigation action involves improving conveyance from existing gut, regarding and rising existing roadway to site, fabrication of flood prevention brackets to provide protection from floodwaters and storm surge	Goal 2	H	N	7	Potential project for complete replacement. Minimally the project will receive 406 improvements	PA/406/428
STX-21	Structural retrofits of Claude O. Markoe School and St. Croix Educational Complex critical facilities used for sheltering	Goal 2	H	N	8		

Action	Description	Goal	Potential for Loss Reduction	Existing (E) or New (N)	Priority	Status	Funding Source
STX-22	Structural retrofits of Juan Luis Hospital for enhanced protection from hurricane-strength winds and earthquake hazards for enhanced protection from hurricane -strength winds and earthquake hazards	Goal 2	H	N	22	Complete Replacement	428
STX-23	Place Queen Street power lines in Christiansted underground to eliminate damage from hurricane-strength winds	Goal 2	H	N	6		
STX-24	Storm flows from Tropical Storm Otto collapsed a culvert and road crossing of Gut 5 in Enfield Green that connects the east and west sides of the Estate. Mitigation action involves replacing culvert with a larger diameter and implementing drainage improvements on Gut 5	Goal 2	M	N	20	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA

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Table 5.3 St. John Mitigation Actions

Action	Description	Goal	Potential for Loss Reduction	Existing (E) or New (N)	Priority	Status	Funding Source
STJ-1	Conduct a hydrological study of Coral Bay watershed to propose technically feasible and cost-effective solutions to flooding problems due to storm drain locations, undersized drainage, and lack of consideration of natural drainage guts	Goal 4	M	E	2	Application has been submitted and is pending review under Advance Assistance (DPNR)	HMGP
STJ-2	Evaluate and construct drainage improvements to eliminate localized flooding at the lower end of ―Carolina Gut‖ at Little Plantation where natural storm flows in the catchment area have been altered by construction and improper siting of structures	Goal 4	H	E	6	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
ST-3	Construct drainage improvements to eliminate localized flooding at Pond Mouth at intersection of Rt. 102 and Rt. 105	Goal 4	H	E	7	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STJ-4	Implementing a slope stabilization program to reduce damage and blockage of roads during windstorm and flooding events. A program establishment of more stable and cut and fill slopes, removal of material that may be subject to landslide and rock fall events, re-vegetation of disturbed slopes, etc.	Goal 2	H	E	8	Slope Stabilization Ironwood in Coral Bay	HMGP
STJ-5	Evaluate and construct drainage improvements to eliminate localized flooding along Route 20 southbound in Coral Bay (Estate Carolina)	Goal 2	H	E	11	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STJ-6	Increase fuel capacity of the Myra Keating Health Clinic Emergency power and generator unit	Goal 2	H	E	5	Ongoing project under review	PA
STJ-7	Provide an alternate power generation substation for Coral Bay to ensure that there is adequate power source for all public services and critical facilities on the east end of the island	Goal 2	H	E	4		
STJ-8	Construct underground feeders from the St. John substation to various termination points within Cruz Bay to mitigate damages to hurricane winds and ensure rapid recovery and return to normal service	Goal 2	H	E	9	Submarine cable from Cruz Bay to Coral Bay	

Action	Description	Goal	Potential for Loss Reduction	Existing (E) or New (N)	Priority	Status	Funding Source
STJ-9	Improve drainage infrastructure (Box Culverts) at WAPA building and treatment plant, while addressing potential secondary impacts to wetlands	Goal 2	H	E	10	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STJ-10	Coordinate with the National Park Service for the construction of appropriate drainage system improvements to eliminate localized flooding along Route 20 in Maho Bay	Goal 2	H	E	12	Potentially part of Ridge to Reef	PA, HMGP &/or FHWA
STJ-11	Resolve flooding concerns from inadequate drainage at Cruz Bay Fire Station	Goal 4	M	N	3	Potential drainage solution. Coordination ongoing with DPW to identify additional potential funding streams	HMGP
STJ-12	Functional replacement and relocation of the Fire Station in Coral Bay due to multiple coastal hazards and structural issues of this critical facility resulting from subsidence	Goal 2	H	N	1		

Key points of awareness:

- Extensive work continues as part of the Ridge to Reef project that will impact many of the gut and road drainage issues identified in the four mitigation tables covering the Territory and the individual islands. As the additional determination of projects is determined and proceed in the varying funding sources, the information will be updated in this update in preparation for the HMRP.

- Project continues to be developed, and this process will continue until the end of the application period for the different grant opportunities. That information will also be updated as part of the preparation for the development of the HMRP.

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IMPLEMENTATION OF ACTIONS

The Hazard Mitigation Steering Committee considered the cost-effectiveness of all islands specific and programmatic actions. The Hazard Mitigation Steering Committee further evaluated each of the identified mitigation actions by utilizing the STAPLEE criteria during meetings held on June 17, 2019.

The Hazard Mitigation Steering Committee was introduced to the STAPLEE process for evaluating both programmatic and island-specific mitigation actions as recommended by FEMA guidance. The Hazard Mitigation Steering Committee agreed to use this method to further evaluate prioritized mitigation actions. The STAPLEE method provided the Hazard Mitigation Steering Committee with a systematic way of evaluating the opportunities and constraints of implementing particular mitigation actions that were rated for their loss reduction potential and prioritized through a simple voting technique.

The STAPLEE is an acronym for evaluating each action in terms of Social, Technical, Administrative, Political, Legal, Economic, and Environmental (STAPLEE) factors:

- **S** - for Social; the mitigation strategy must be socially acceptable.
- **T** - for Technical; the proposed action must be technically feasible.
- **A** - for Administrative; the community must have the capability to implement the action (for example, the logical lead agency must be capable of carrying out oversight of the project).
- **P** - for Political; mitigation actions must be politically acceptable.
- **L** - for Legal; the community currently must have the authority to implement the proposed measure.
- **E** - for Economic; economic considerations must include the present economic base, projected growth, and opportunity costs.
- **E** - for Environmental; the impact on the environment must be considered because of statutory considerations and the public 's desire for sustainable and environmentally healthy communities.

A separate matrix is provided for each programmatic or island-specific action that includes the following information:

- Description of the mitigation action,
- Potential for Loss Reduction Rating,
- Priority ranking,
- The goal and objective that the action is intended to achieve,
- The specific hazard the action is intended to achieve (or all-hazard),
- Responsible agency, department, or division,
- Projected timeframe - Short Term (1-2 years), Medium Term (3-5 years), and LongTerm (5-10 years),
- Projected resources,
- Comments on the rationale for action, contribution to goal, or another comment, and
- STAPLEE criteria evaluation, by individual criterion and total score.

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SUMMARY OF THE RISK AND CAPABILITY ASSESSMENT INTRODUCTION

SUMMARY OF RISK ASSESSMENT

The overall risk assessment methodology utilized in this Plan Update was similar to the one that was utilized in the 2014 Plan, but there were incorporation's made post-disaster due to the new data that was assessed as well as the incorporation of manmade hazards to comply with EMAP standards. 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 Hazard and Estimating Losses (FEMA 2001) and utilizes a risk assessment methodology similar to HAZUS _MH.

The results of the hazard identification process and discussions with VITEMA, which held a meeting with the Hazard Mitigation Committees prior to the consultant team being contracted to develop the plan, indicated that there were not necessarily new natural hazards that needed to be considered in this Plan Update but rather the incorporation of manmade hazards. Therefore, regarding the natural hazards addressed in the 2019 plan Update are the same that were addressed in the 2014 Plan with the inclusion of new data post-disaster. It should be noted that data sets for conducting vulnerability assessments for all of the hazards were not readily available (frequency of occurrence; magnitude and damages associated with historical events) so that the losses were estimated in a deterministic manner to arrive at the worst-case scenario loss estimates for wildfire, landslide, and drought. Also, both disasters caused significant damage to occur, which also caused pertinent and existing data to be lost, which was also a factor in the information not being as readily accessible by the critical agencies.

Like the 2014 plan, the lack of accurate historical data prevented VITEMA from conducting a detailed and verifiable assessment for these hazards and necessitated using different estimation techniques. Hazard overlays were performed to identify the number of buildings in hazard susceptibility zones identified on newly created maps for these hazards. Hence, the vulnerability assessments for the new hazards provide only a rough estimate of the built environment that is exposed to these hazards. VITEMA relied heavily on the ability of assessments that were conducted by agencies who collaborated effectively with the agency to provide post-disaster information that related to some of the hazards so historical data can be initiated.

The hope is that with the development of the Comprehensive Plan, there would be a historical database constructed to assist with remedying this problem from reoccurring so that data can be accurately tracked and monitored.

A summary of the finding of the Risk Assessment for the 2019 Plan Update was presented to VITEMA at a meeting on June 13, 2019. The risk assessment served as a foundation for the deliberation of the Committees in formulating a mitigation strategy for this Plan Update. Additionally, the incorporation of manmade hazards will be shared with the Steering Committee for expansion with the new update being developed by the HMRP. The goal going forward incorporate the information to provide data that would speak to mitigative efforts regarding both natural and manmade hazards.

As a result of variation in values of Real Property over the past five years, the Estimated Losses that would occur as a result of natural hazard events also fluctuated. To illustrate the impact that the reevaluation of the property values has upon the Loss Estimates, the following matrix is proving. Table 5.4 "Hazard by Hazard Comparison of Loss Estimates of the 2014 Plan and 2019 Plan Update" demonstrates the differences in the Loss Estimates between the 2014 Plan and the 2019 Plan Update. A summary is provided for each major island in the Territory. The values presented in this Matrix are painted in broad strokes with the intent to furnish a synopsis only of the changes in estimated losses include in this Plan Update.

TABLE 5.4 Hazard-by-Hazard Comparison of Loss Estimates of the 2014 Plan and 2019 Plan Update

Hazard	2014 Plan Update	2019 Plan Update	Difference (+ / -)
St. Thomas			
Drought	N/A	1.058M	1.058M
Earthquake	5.7B	6.4B	.7B
Riverine Flooding	1.1B	1.2B	419.1M
Coastal Flooding	203M	228M	25M
Hurricane	3.5B	3.9B	.4B
Rain-Induced Landslide	1.3B	1.9M	-1.2B
Tsunami	1.3B	1.5B	.2B

SECTION SIX: PLAN MAINTENANCE

DESCRIPTION OF EFFORTS

To ensure the plan updates will be maintained, there is a clear understanding that this interim plan would be further developed with the Resiliency Plan in collaboration with the University of the Virgin Islands. The Virgin Islands Territorial Emergency Management Agency (VITEMA) is updating and greatly expanding the U.S. Virgin Islands (USVI) Territorial Hazard Mitigation Plan (HMP). 2017 Pre-disaster Mitigation (PDM) funds are being used to provide a concise and limited update of the current 2014 Territorial Hazard Mitigation Plan, and this update will be coordinated with the broader Comprehensive Plan scope of work.

Although this plan is currently an interim plan that will be developed with the Resiliency Plan the agency is currently trying to attain EMAP accreditation which required the expansion of manmade hazards and not be limited to natural hazards solely. The Agency met the compliance requirements of two-thirds of the EMAP standard 4.2.1; however, our agency did not include in our mitigation plan. During the application process it was determined the plan lacked compliance of the following:

- Is based on the natural and human-caused hazards identified in Standard 4.1.1 and the risk and consequences of those hazards

The updated HMP will be the result of a multi-sectoral planning effort that integrates principles and elements of resilience, sustainability, and climate adaptation, and that will also lead to the creation of a series of associate plans that support the ultimate development of mitigation strategies. Therefore, the HMP resulting from this planning effort will be named the Hazard Mitigation and Resilience Plan for the Virgin Islands (HMRP). The University of the Virgin Islands (UVI) will lead this multi-year planning effort and work hand-in-hand with VITEMA. UVI is uniquely positioned to lead the creation of the plan, manage the data resulting from this planning effort, and help build the capacities required for the implementation of mitigation and plan maintenance activities.

The results of the HMRP effort will be made available exclusively online so agencies leaders, stakeholders, and the public can readily access the plan and its components. An online plan increases the transparency of processes, and allow stakeholders, which include the public, to readily access information to educate themselves, and take ownership of a plan focused on building a more sustainable and resilient Virgin Islands.

GUIDING PRINCIPLES

The HMRP will be guided by the five overarching principles of resilience, sustainability, climate adaptation, socio-cultural awareness, and capacity building:

- **Resilience** is "the ability to prepare for and adapt to changing conditions and to withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents"1, and the first trait of a resilient society is a society where "every individual and community in the nation has access to the risk and vulnerability information they need."

- **Sustainability, or sustainable development**, is "*a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations*."

- **Climate adaptation** seeks to reduce the risk posed by the consequences of climate change.

- **Socio-Cultural Awareness** means awareness and integration of the differences and singularities of the different socio-cultural groups in the USVI into the development and implementation of activities.

- **Capacity building** is "*the process by which people, organizations, and society systematically stimulate and develop their capability over time to achieve social and economic goals, including through improvement of knowledge, skills, systems, and institutions – within a wider social and cultural enabling environment*".

Throughout the planning effort, UVI will emphasize capacity building and will integrate resilience, sustainability, and climate adaptation goals into all its efforts. Through a participatory approach, the plan will also reflect and align with the values and culture of the islands and be sensitive to the various mitigation strategies that different socio-cultural groups have already adopted. As stated above, embedded in these guiding principles is the need to develop the Territory's capacity to implement the mitigation strategies developed and proposed. UVI will pay attention to how it can provide support to government agencies and the community to build capacity through education, research, and professional development. Specifically, the opportunity to integrate UVI faculty and students into the HMRP process will accelerate the development of skilled professionals. They can address any deficit of expertise and management needed to implement mitigation strategies and actions.

COORDINATION WITH VITEMA

UVI will work closely with VITEMA during the update of the Territory's Hazard Mitigation planning efforts. While the UVI planning efforts are more comprehensive and wide-ranging, UVI understands the importance of VITEMA's Pre-Disaster Mitigation (PDM) planning effort, and as such, will work closely with, and to the extent possible participate in, the VITEMA PDM planning effort. To reduce duplicative actions and help streamline UVI's overall planning efforts, it will be important for UVI to follow and understand PDM outputs, particularly the results of hazard mapping and risk assessments, and the mitigation strategies that will be developed.

STAKEHOLDER COLLABORATION AND COORDINATION

The quality, effectiveness, and implementation of mitigation strategies depend on their relevance and acceptance by USVI constituents. Throughout the process, UVI will rely on a Steering Committee to guide its efforts, and it will gather input and receive feedback from government agencies, communities, and other stakeholders by relying extensively on sector-based working groups and public workshops.

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Figure 6.1: VITEMA Strategic Planning Process

Figure 6.2: Emergency Management Accreditation program (EMAP) Task Checklist

EMERGENCY MANAGEMENT ACCREDITATION PROGRAM (EMAP) TASK AND OBJECTIVE
1. Begin tracking communications associated with the plan update.
2. Review existing plan and crosswalk and identify needed updates.
3. Identify who will be responsible for updating the plan (i.e. agency personnel, contractors) and the timeframe for completing the update.
4. Secure any necessary funding sources.
5. If necessary, develop a request for proposals, evaluate proposals, and award contract(s).
6. Begin tracking significant plan changes.
7. Evaluate and update the planning process.
8. Review the stakeholder contact list, make necessary changes, and identify new stakeholders.
9. Initiate plan outreach and discussion, including a stakeholder meeting.
10. Consider the addition, removal, or modification of hazards identified in the plan.
11. Update and revise membership of the mitigation planning committees.
12. Evaluate risk assessment methodologies and data sources.
13. Evaluate and update state inventory information.
14. Evaluate and update the hazard profiles, including interaction with the mitigation planning committees.
15. Evaluate and update the risk assessment summary.
16. Evaluate and update the mitigation strategy, including interaction with the mitigation planning committees.
17. Evaluate and update the mitigation implementation system, including interaction with relevant state agencies.
18. Evaluate and update the plan maintenance.
19. Develop the necessary annual mitigation reports.
21. Integrate new and updated related state plans.
22. Evaluate and update other plans sections (i.e. table of contents, adoption documentation, introduction, appendices).
23. Identify and add any additional sections or information needed per EMAP and FEMA standards.
24. Review updated plan in its entirety.
25. Conduct updated plan outreach, including public information, comment period, and stakeholder meeting.
26. Integrate additional comments received.
27. Finalize plan document.
28. Complete crosswalk and submit final plan to FEMA for review and approval.
29. If necessary, make additional modifications as required.
30. Obtain signed letter from the Governor adopting the plan.

STEERING COMMITTEE

UVI will establish and lead an HMRP Steering Committee, which will generate a vision statement, develop strategies, and set goals. The Steering Committee will meet regularly during the development of this planning effort and is anticipated to be composed of a small group of key stakeholders, chosen in close consultation with VITEMA.

SECTOR-BASED WORKING GROUPS

To maximize the input and feedback from a wide-reaching group of stakeholders, UVI will develop sector-based working groups, which is consistent with the National Disaster Recovery Framework. Representation should include, but not be limited to, emergency managers, long-term recovery groups, territorial government, private and non-profit sectors. High-level stakeholders, preferably with decision-making responsibilities from the following sectors, would be a part of this working group:

- Emergency Management
- Emergency Response (First Responders)
- Economic Development
- Tourism
- Agriculture and Fisheries
- Public Works
- Health and Human Services
- Planning and Natural Resources
- Education

Understanding that the HMRP (Hazard Mitigation Resiliency Plan would be developed during a shorter time period than the mandated five (5) year from this update, the Resiliency Plan would become the plan that would be used to analyze all hazards and create a live plan where changes would automatically be updated. The process allows this plan update to be a guide and innately cause meetings to occur within the agencies who would be considered a part of the critical infrastructure to determine capacities that can be further developed and maintained going forward. This update would act as a guide or tool of where the gaps are and where improvements can be made and how mitigative initiatives can ensure a reduction of risk and loss.

LIST OF ABBREVIATIONS

This section provides the definitions of all acronyms and abbreviations used in the plan.

Abbreviation	Meaning
ARC	American Red Cross
BCA	Benefit Cost Area
BCR	Benefit Cost Ratio
BEA	Bureau of Economic Analysis
BFE	Base Flood Elevation
CAD	Caribbean Area Division
CDBG	Community Development Block Grant
CFR	Code of Federal Regulations
CLWUP	Comprehensive Land and Water Use Plan
CRBA	Coastal Resource Barrier Act
DOA	Department of Agriculture
DMA 2000	Disaster Mitigation Act of 2000
DPW	Department of Public Works
DHS	Department of Homeland Security
DOH	Department of Health
DOT	Department of Tourism
DPNR	Department of Planning and Natural Resources
DSP&R	Department of Sports, Parks & Recreation
EMAP	Emergency Management Accreditation Program
FEMA	Federal Emergency Management Agency
FHBM	Flood Hazard Boundary Map
DFIRM	Digital Flood Insurance Rate Map
FAC.	Facilities
FIS	Flood Insurance Study
FMA	Flood Mitigation Assistance Program
FMV	Fair Market Value
GAR	Governor's Authorized Representative for Hazard Mitigation
GIS GDP	Geographic Information System Gross Domestic Product
HAZUS	Hazards United States
HMGP	Hazard Mitigation Grant Program
HUD	Housing and Urban Development
HPR	Department of Housing, Parks and Recreation
HMTAP	Hazard Mitigation Technical Assistance Program
HMC	Hazard Mitigation Committee
JFLH	Juan F. Luis Hospital
LTRG	Long Term Recovery Group

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MITIG.	Mitigation
NEPA	National Environmental Policy Act
NFIA	National Flood Insurance Act
NOAA	National Oceanic and Atmospheric Administration
OMB	Office of Management and Budget
PDM	Pre-Disaster Mitigation Program
P&P	Department of Property & Procurement
SRMC	Schneider Regional Medical Center
SLOSH	Sea, Lake and Overland Surges from Hurricanes
STAPLEE	Social, Technical, Administrative, Political, Legal, Economic and Environmental review criteria
UVI	University of the Virgin Islands
VIDA	Virgin Islands Department of Agriculture
VIDE	Virgin Islands Department of Education
VIEO	Virgin Islands Energy Office
VIFD	Virgin Islands Fire Department
VIPA	Virgin Islands Port Authority
VIPD	Virgin Islands Police Department
VITEMA	Virgin Islands Territorial Emergency Management Agency
VIWMA	Virgin Islands Waste Management Authority
WAPA	VI Water and Power Authority

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