Mitigating the Impacts of Natural Hazards in the U.S. Virgin Islands

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The Virgin Islands Territorial Emergency Management Agency
(VITEMA)

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Mitigating the Impacts of Natural Hazards in the U.S. Virgin Islands

Section I: Natural Hazards in the U.S. Virgin Islands

1.1 Identification of Natural Hazards

1.1.1 Hurricanes

The U.S. Virgin Islands faces a serious threat from hurricanes and other coastal storms, and the resulting shoreline flooding and water surges. Hurricanes and coastal storms also bring extremely high winds which place unusual stresses on buildings and facilities.

Hurricane Hugo in 1989, (which concentrated its effects in St. Croix) produced losses of more than $1.5 billion. Hurricane Marilyn caused $2.3 billion damage (preliminary estimate Virgin Islands Bureau of Economic Research, 10/18/95), 80% of which occurred on St. Thomas.

1.1.2 Floods

Non-hurricane floods in the Virgin Islands have occasionally resulted in damages at the level of tens (or rarely hundreds) of millions of dollars. Three recent storms include:

- the floods of November, 1974, which resulted in severe flooding and damage to stores in both Charlotte Amalie and Christiansted;
- the floods of April 18, 1983, with reported 24-hour rains in the range of 18 to 23 inches, resulting in a federal disaster declaration;
- the eleven-inch rain storm caused by Tropical Storm Iris, approximately one week after Hurricane Hugo in 1989.

1.1.3 Seismic Events

Earthquakes are the hidden hazards of the West Indies, including the Virgin Islands. Although not frequent, they have resulted in major damage and loss of life in the region, and they tend to be severe when they do occur.

Seismic events—both earthquakes and tsunamis—have infrequently resulted in major damages in the past in the Virgin Islands. The most notorious seismic event in the Virgin Islands was the tsunami of 1867 which killed hundreds in St. Thomas. The Virgin Islands is classified as Zone Three in terms of earthquake hazard susceptibility—the same as most earthquake-prone areas of California.

Table 1.1.3 Earthquakes in the West Indies (Collymore, 1993)

Location	Date	Fatalities	Property Losses
Azua, Dominican Republic	1691	na	Town destroyed
Jamaica	1692	4,000	75% of housing destroyed
Haiti	1751	na	Port-au-Prince destroyed
Azua, Dominican Republic	1751	na	All housing destroyed
Santiago de Cuba	1766	na	City destroyed
Port-au-Prince	1770	250	City destroyed
Martinique	1839	387	4.7 million Francs
Cap Haitien	1842	5,000	Destroyed
Santiago	1842	300	Destroyed
Port de Paix, Haiti	1842	200	Destroyed
Pointe-a-Pitre	1843	5,000	na
Kingston	1907	600	2 million pounds
Puerto Rico	1918	100	$4 million
Dominican Republic	1946	75	$20 million

1.1.4 Global Climate Change

While still a controversial issue in the scientific community, there is general consensus that the world is entering a period of significant global climate change, as the result of global warming. Among the issues which need to be closely monitored for their significance to the Virgin Islands will be:

- sea level rise;
- increased frequency of large storms and hurricanes; and
- new climate change models which suggest diminished rainfall in the tropics.

Sea level rise has dramatic implications for natural hazards management. Based on projected temperature rises over the next century, the International Panel on Climate Change (IPCC) has estimated that global mean sea levels will rise 0.3-1.0 meters by the year 2100. Moreover, levels will continue to rise for several centuries even after greenhouse gas emissions are stabilized. (Collymore, 1992) The first and most obvious impact is the shoreline erosion and flooding which will occur as the normal level of the sea rises. While in the Virgin Islands this is not as serious a problem as it is the low lying coastal areas of the mainland United States (*e.g.*, Florida, Mississippi, Texas), there are still substantial amounts of property and development, in low harbor and shorefront locations. A second more indirect outcome of global and ocean warming is the likely increase in the frequency and severity of hurricane events which are fueled by latent ocean heat.

1.2 Likelihood of Natural Hazards in the U.S. Virgin Islands

1.2.1 Hurricanes

Historically, hurricanes have been the most likely hazard to impact the Virgin Islands, with an average interval of 12 to 15 years between hurricanes. From 1916 to 1989, however, there was an anomaly in the historical record which resulted in nearly three generations without a major hurricane. As this also coincided with the major spurt in tourism-fueled development in the Territory, there were many encroachments on zones of known risk.

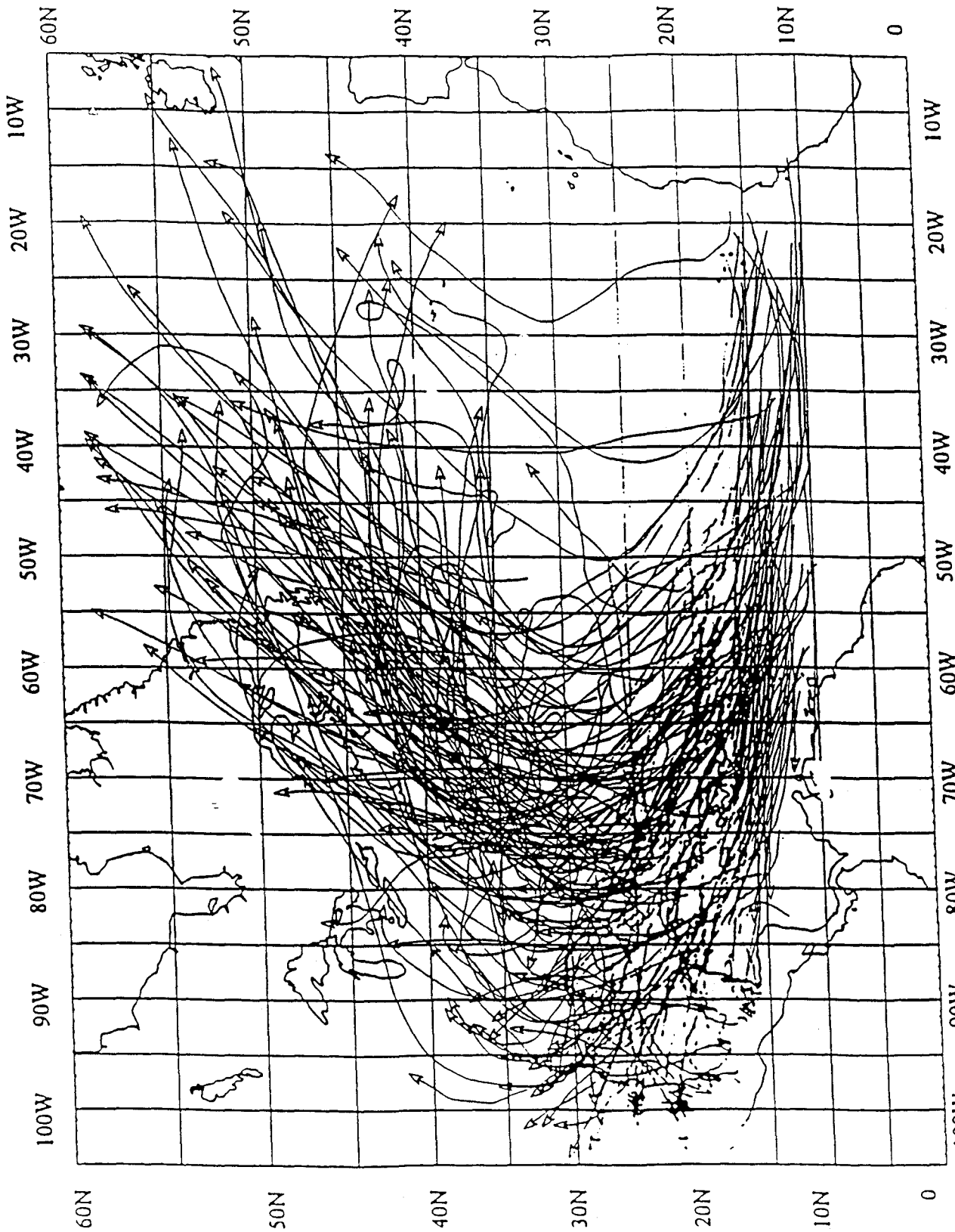
The Virgin Islands have a dramatic history of major hurricanes with particularly devastating storms hitting in 1867, 1871, 1916, 1989 and 1995. An historical analysis indicates that between 1867 and 1967 the

Virgin Islands experienced 48 tropical cyclones (including hurricanes, tropical storms, and tropical depressions), of which ten were hurricanes (Bowden, 1974; see also Island Resources Foundation, 1977). This history yields an annual probability of a tropical-storm of .42 and an annual probability of a hurricane of .10. These high historical probabilities are in contrast with the recent storm history of the islands. Until Hurricane Hugo in 1989, the last hurricane with winds of 120 mph or greater occurred in 1916—some 73 years (or three generations) before—suggesting that the islands had been long overdue for a major hurricane.

The occurrence of two damaging hurricanes (Hugo and Marilyn) within six years (5 years and 363 days) may represent either a return to historic patterns or an early foretaste of an even greater frequency of storms predicted in some forecasting models used by the International Panel on Climate Change.

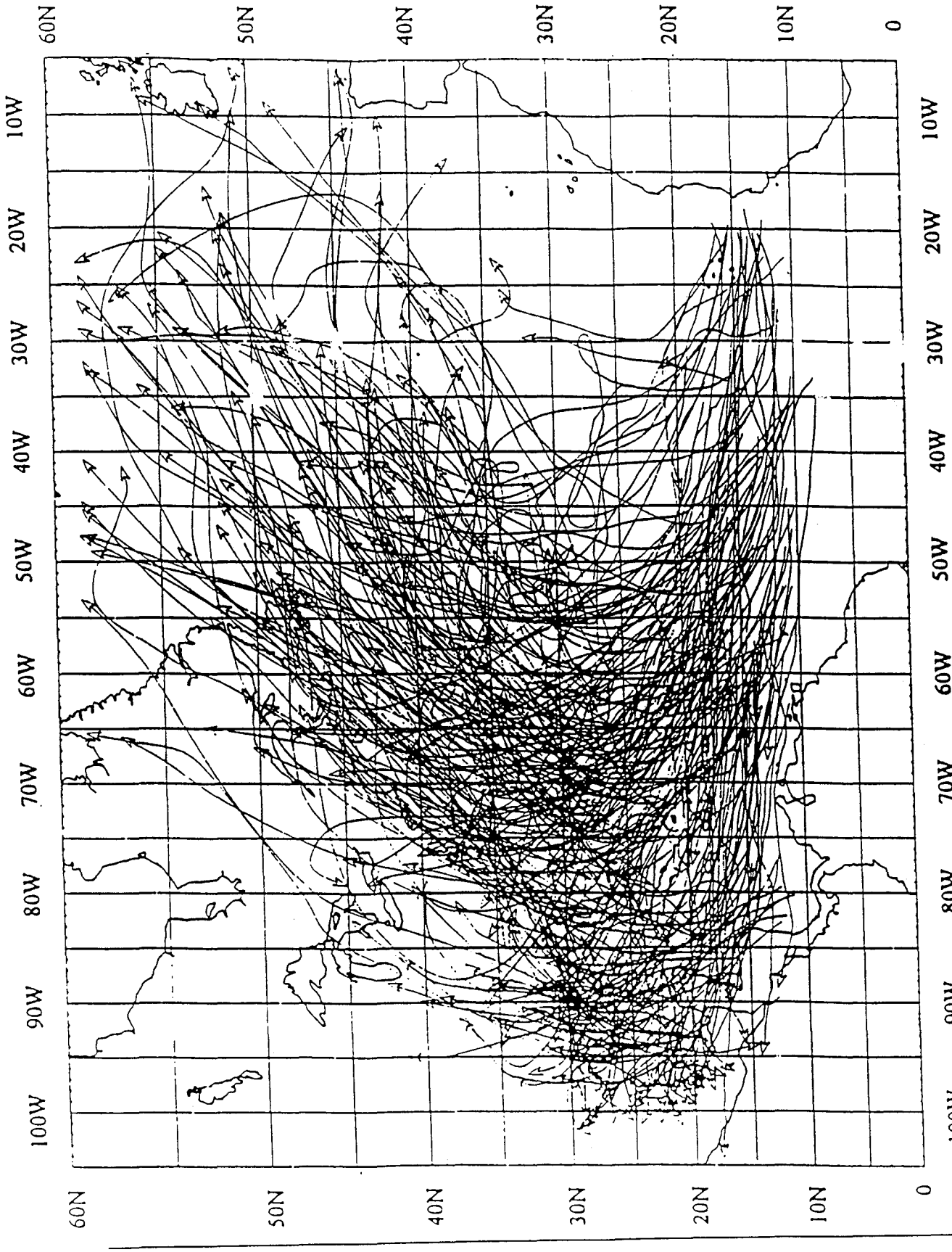
The following three pages illustrate long-term (1871-1986) hurricane tracks during the months of August and September, and the short-term history of tropical storm and hurricane tracks during 1995. The Virgin Islands are clearly at risk.

Figure 1.2.1a: Historic Hurricane Tracks for the month of August



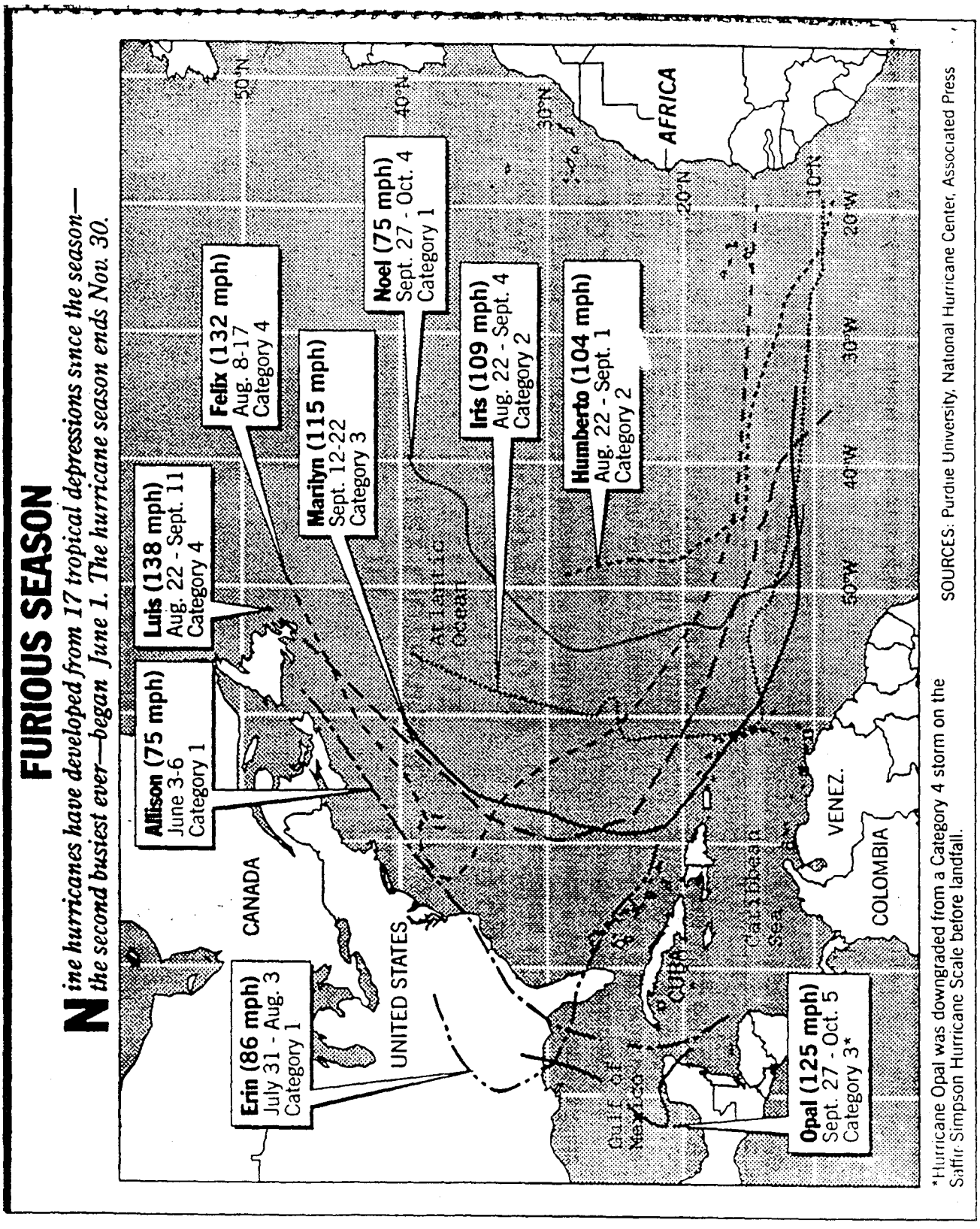
Tropical storms and hurricane paths for the month of August, for the 100-year period 1886 - 1986 (199 Storms)
(Neumann, et al. 1987).

Figure 1.2.1b: Historic Hurricane Tracks for the month of September



Tropical storms and hurricane paths for the month of September, for the 100-year period 1886 - 1986 (287 Storms) (Neumann, et al. 1987).

Figure 1.2.1c: Hurricane Tracks for 1995, through the month of September (Washington Post, 10/5/95)



1.2.2 Seismic Events

The Virgin Islands are located near the northeastern corner of the Caribbean Plate and as such are highly susceptible to earthquakes and seismic hazards. (For a full discussion of the geologic features of the regions with bearing on earthquake hazards see McCann, 1984; GeoScience Associates, 1984a). The first recorded earthquake activity in the Virgin Islands occurred in September of 1777. Strong shocks were recorded in 1843, 1867 and 1918.

A 1984 study prepared by GeoScience Associates, estimated the recurrence periods and future probability of earthquakes in the islands. The table below summarizes the conclusions of this aspect of the GeoScience study.

Table 1.2.2 Frequency of Major Earthquakes for the U.S. Virgin Islands

Island	**Earthquake Recurrence Period**	**Scale VIII Quake** 20-year probability	**Scale VIII Quake** 50-year probability
St. Croix	133-275 years	40-60%	55-75%
St. John	110-200 years	50-70%	60-80%
St. Thomas	110-200 years	50-70%	60-80%

Site-specific vulnerability to earthquake damages will depend upon localized construction practices and soil and geologic conditions. For example, recently filled areas will tend to be more subject to earthquake effects as these are areas where liquefaction and ground settling are likely to be greatest. Much of the waterfront areas of Charlotte Amalie, St. Thomas, and Christiansted, St. Croix, for example, pose potential liquefaction hazards as they are located on loose alluvial or manmade fill soils, similar to those reportedly found in the most heavily impacted areas of Kobe, Japan, in the 1994 quake which killed 5,000 people.

High-slope areas subject to rock or landslides may pose special hazards. The landslide potential is particularly great on St. Thomas and St. John; it is likely that substantial road damage will occur as a result of earthquake-induced landslides. Vulnerability from these conditions is exacerbated by the fact that most houses and many public buildings in the Virgin Islands are build on top of or close to large cisterns (local codes require 10 gallons of cistern capacity for each square foot of roof area) which are likely to rupture and cause additional damage in an extreme earthquake. Two particularly vulnerable cases-in-point for highway construction (identified by GeoScience's study) are the Centerline Road on St. John and the road to St. Thomas's west end. Both roads are likely to be impassable following an earthquake as a result of the land sliding that will occur.

The islands are also subject to another seismic hazard — tsunamis, or seismic-induced sea waves. Tsunamis were reported following the 1867 earthquake. GeoScience Associates has estimated-the height of tsunami surge in the harbors of Christiansted and Frederiksted, St. Croix, at approximately 10 to 15 feet, and some 10 feet at the Charlotte Amalie harbor (GeoScience Associates, 1984b). Coral Bay and Cruz Bay in St. John, and other harbors and anchorages in the Virgin Islands would also be subject to tsunamis.

1.2.3 Floods

Heavy rains are a common feature of the tropical Caribbean weather patterns, especially in hurricane season from late July to late October.

1.2.4 Inland Flooding

Perhaps the most significant natural hazard in the Territory in terms of frequency is the inland flooding which results from large amounts of rainfall occurring over short periods. Runoff from rainfall on the islands is collected in the narrow, steep drainage ditches called "guts". The runoff is exacerbated by the islands' steep topography, non-porous rock base, thin clayey soils (See CH2M Hill, 1979), and ever-increasing development of roads, parking lots, and other impermeable surfaces. As a result, percolation of rain water is limited, especially during storms generating 8-12 inches in a twenty- four hour period (considered heavy rains).

A series of studies conducted by CH2M Hill analyzes the nature of flooding problems. Two types of inland flooding problems are identified. One is the flooding which occurs in the islands' urban areas, and which often results from relatively small rains (e.g., one to three inches). This is largely the result of an increase in impermeable surfaces and the lack of an adequate stormwater drainage system.

On the other hand, these smaller rains have less impact outside of the heavily urbanized areas. Flooding problems occur in these non-urbanized areas during heavier rains largely as a result of a failure to recognize the importance of maintaining and respecting the natural guts and flood plains. These guts have been built upon, channelized, filled with debris and trash, and traversed by roads. Loss of natural vegetation may also contribute to increased runoff and flooding. A major culprit identified in the CH2M Hill study is the installation of **inadequate culverts** when roads cross guts. Undersized culverts reduce natural flow and cause overtopping of roads and gut banks causing flooding of adjacent properties (as the flood waters do not return to the natural gut) While larger culverts may be more costly in the short-run, in the long run they may save money since they will reduce flood damages and prevent the need to later replace undersized culverts. Other recommended design features include the use of guard rails instead of solid walls on top of road culverts, and using gutters and headwalls to divert flood overflows back into drainage channels (CH2M Hill 1979- see also CH2M Hill 1983). Guts are also modified through the construction of impoundments for water conservation. A key conclusion of the CH2M Hill study is that such modifications are made with little consideration of the larger hydraulic characteristics of the flood plain and may exacerbate an already dangerous condition.

The 1979 CH2M Hill study carefully examined the structural solutions available to correct the past mistakes of building on guts, installing undersized culverts, and so on. In the St. Croix basins studied, the estimated costs would be as high as $3.2 million (in 1979 dollars), and perhaps between $15 and 20 million to correct the twenty most serious drainage basins in the islands. *Correction of such past mistakes is expensive and emphasizes the need to prevent this type of hazardous development in the first place.*

1.2.5 Secondary Hazards

The following table illustrates the secondary effects anticipated from major triggering hazards:

Table 1.2.5 Primary and Secondary Hazards in the U.S. Virgin Islands

Primary Hazard: (Trigger)	Secondary Hazards (Natural and technological)														
	Land slip	Blast	Flash Flood	Storm Surge	Fire	Dam Fails	Ship Sink	Power Failure	Fuel Cut off	H2O Fails	Road Cutoff	Sea Level Rise	Haz Mat	Fone Fails	Nat Res
Natural Disasters															
Hurricane	•		•	•		•	•	•		•		•		•	•
Inland/Estuarine Floods	•		•			•					•			•	•
Earthquake	•				•	•		•		•	•	•	•	•	•
Landslide						•					•			•	
Tsunami			•			•	•		•	•	•	•	•	•	•
Marine Storms				•		•	•	•			•	•		•	•
Coastal Floods				•										•	•
Climate Change				•		•						•			•
Other Disasters															
Major Fire		•						•	•	•			•	•	•
Passenger Ship/Ferry Sink					•								•		•
Cargo Ship Accident		•			•			•	•				•		•
Aircraft Accident					•						•				•
Civil Disturbance		•			•			•			•			•	
Petro Spill		•			•						•		•		•

1.2.6 Systematic Risk Assessment

There is a need to incorporate comprehensive hazard or natural hazard risk in the Virgin Islands planning and development permitting systems. Further development of systematic risk assessment studies for the islands, especially in the wake of the severe disasters of the past few years, may provide an improved understanding of insurance costs and active mitigation efforts for future planning. Installation of a systematic risk assessment process should be a long-term goal of the Territorial Government. Because the Virgin Islands is such a small insurance market, and because there are few companies participating in the local insurance market, insurance rates do not provide a useful surrogate for risk assessment as they may in other jurisdictions. Risk in the Virgin Islands is a function of geography. It is important to any systematic assessment of risk in the Virgin Islands that the Government utilize and enhance serious geographic information systems capability. (See Section IV)

1.2.6.1 Assessment of Data Quality

Data resources, especially mapped resources and hazards (i.e., GIS) mustered for the recovery from Hurricane Marilyn by the FEMA GIS operators offer the potential for substantially increased data quantity and quality for mitigation planning, as well as disaster preparedness and recovery operations. At the present time data quality for mitigation faces difficulties in reliability, validity, spatial resolution, timeliness and relevance.

1.3 Vulnerability Assessment

The U.S. Virgin Islands are vulnerable to a number of major natural hazards with the potential for substantial loss of life and property damage. Indeed, the history of the Virgin Islands is replete with accounts of major natural disasters, including the Hurricane of 1772 documented by Alexander Hamilton who was then a youth in St. Croix. In this section of the plan a brief overview of these hazards is provided as well as a qualitative assessment of the extent of people and property currently at risk.

Current development trends suggest that the islands' population is increasingly vulnerable to the impacts of earthquakes. There has been a tremendous increase in the building of homes and other structures on hillsides and steep slopes, and involving the removal of stabilizing vegetation. Structures with walls of unreinforced masonry or clay tile are quite vulnerable and this has been a popular building style on the islands. Also quite vulnerable are structures with heavy roofs and elevated water tanks (GeoScience Associates, 1984b).

As part of their analysis of earthquake hazards, GeoScience Associates evaluated the vulnerability of approximately 200 buildings and facilities on the islands, rating them according to the likelihood that they would sustain damage from earthquakes. Many of these were found to be quite vulnerable (*i.e.*, likely to sustain major damage from an earthquake—see Appendix A, Vulnerability Classifications, GeoScience Associates, 1984b and Appendix A, Vulnerability Classifications, GeoScience Associates, 1985). *Some of the most vulnerable structures were found to be public schools and public housing projects.*

1.3.1 Population and Dwelling Units in the U.S. Virgin Islands

Table 1.3.1 Population and Dwelling Units in the U.S. Virgin Islands

Island	Area (square miles)	Population (1990)	Housing Units (1990)	Density (per sq mi)
St. Croix	81.93	50,139	18,937	612
St. Thomas	27.12	48,166	18,433	1,776
St. John	19.18	2,504	1,920	131

The special populations of the elderly, hospitalized and handicapped tend to be concentrated in the major population centers:

- Christiansted and Frederiksted, St. Croix,
- Cruz Bay and Coral Bay, St. John, and
- Charlotte Amalie and Estate Tutu in St. Thomas.

1.3.2 Property Values

There has been no comprehensive assessment of property values exposed to hazards in the Virgin Islands, but the experience of the past two major hurricanes is instructive. The value of damages from Hurricane Hugo (1989), concentrated on St. Croix, was in excess of $1.5 billion; preliminary estimates (October 18, 1995) of the value of damages from Hurricane Marilyn (1995) exceed $2.3 billion.

A preliminary and unofficial estimate of costs, issued early (10/25/95) in the aftermath of Hurricane Marilyn included:

Table 1.3.2 Estimated Damages for Hurricane Marilyn in the U. S. Virgin Islands

Category of Damage	Estimated Cost
Sewage Treatment Facilities	$1,000,000
Roads and Bridges	1,000,000
Damage to Manufacturing in STX	1,000,000
Agriculture	1,000,000
Water	3,000,000
Protective Measures	10,000,000
Debris Removal	18,000,000
Telephones	30,000,000
Electrical	70,000,000
Lost Employment	80,000,000
Public Buildings	210,000,000
Damage to Hotels	253,000,000
Lost Tourist Revenue	293,000,000
Private Housing	1,300,000,000
Total	$2,271,000,000

This estimate clearly illustrates that more than half of the total costs were incurred by private homeowners, which supports the high cost-effectiveness of building standards (and construction *practices)* in mitigating the total costs of hazards. Other high costs for lost employment and lost tourist revenues indicate the importance of rapid recovery, in order to resume economic activity.

1.3.3 Critical Facilities

Critical facilities in the Virgin Islands include:

- hospitals in St. Croix and St. Thomas, and 2 clinics and an ambulance boat maintained on St. John;
- power and desalinization facilities of the Virgin Islands Water and Power Authority (WAPA);
- sewerage systems maintained by the Department of Public Works and a large number of operators of private "package" sewage systems operated around all three islands;
- fire houses and police stations and their associated communications systems on all three islands;
- public shelters;
- air and sea ports maintained by the Virgin Islands Port Authority (VIPA);
- communications systems for both intra-island and critical long-distance systems by VITELCO, Telcom, and AT&T Caribbean long lines services;
- the St. Thomas cruise ship docks maintained by the West Indian Company and the Virgin Islands Port Authority (VIPA).
- Charlotte Amalie waterfront bulkhead.

In the extreme conditions of the two recent hurricanes, all of these critical facilities have suffered severe damages, often requiring months of outside support and reconstruction before they have been able to resume "normal" service to their respective communities. Special concern has been expressed for the failures of:

- hospital roofs, requiring the relocation of patients and curtailing services;
- sewerage distribution systems, leading to surface water and marine bay contamination; and
- the power and telephone distribution systems, requiring months of repairs and curtailed service.

1.3.4 Hazardous Facilities

Major hazardous facilities in the Virgin Islands include the Hess Oil Virgin Islands Corporation (HOVIC) refinery (one of the world's largest), on the south coast of St. Croix. This plant has many large tanks for crude oil and petroleum products, and is adjacent to a very large oil port which docks large tankers and lighters crude oil from VLCCs (Very Large Crude Carriers) and ULCCs (Ultra Large Crude Carriers) which anchor offshore. This port and refinery is adjacent to, and shares harbor approaches with a major bauxite refinery and port, now owned by ALCOA. This latter facility is not a hazardous facility itself, but it does increase risks associated with the refinery in a major disaster.

The major generating plants of the Virgin Islands Water and Power Authority at Richmond in St. Croix, and Krum Bay in St. Thomas are also hazardous facilities, located near sea level in bays subject to flooding and storm surge.

Secondary hazardous facilities include major public sewerage plants at the Cyril E. King Airport in St. Thomas, and at Anguilla in St. Croix. Associated with the sewage treatment plants is the sewerage distribution system which relies on a number of electrically powered lift stations.

Equally troublesome in a major coastal storm are the dozens of package sewage treatment plants maintained by private operators such as condominiums, sub-divisions, and resort hotels. These facilities may be abandoned for long periods of time after a disaster, while the housing facilities continue to discharge sewage, but directly to the sea.

Contamination of coastal waters after a disaster as a result of failure of the sewage treatment plants or the sewage lift stations is a major concern, especially since people may use the bays for bathing with no power or other means to readily get water from their cisterns.

Other than petroleum spills, there are few other instances of danger from exposure to hazardous materials after a natural disaster in the Virgin Islands. The HOVIC refinery mentioned previously handles significant quantities of hazardous materials, but these are generally well secured. Recently hospitals on St. Thomas and St. Croix have been found to contain leaking pesticide containers, but this is not a general or persistent problem.

Section II: Capability Analysis of Virgin Islands Mitigation Policies and Programs

2.0 Introduction

This section of the Hazard Mitigation Plan identifies and describes existing hazard mitigation capability in the U.S. Virgin Islands.

2.1 Virgin Islands Capability Assessment

In the Virgin Islands, a number of different agencies and offices conduct hazard mitigation as part of their organizational mission. The legal foundation for such hazard mitigation work is part of each agency's enabling legislation. Descriptions of each agency's hazard mitigation functions can be found in Appendix C.

On the Territorial level, Executive Order Number 304-1987, under Virgin Islands Code, Title 23, Chapter 12, Section 1126a, establishes the Emergency Management Council which sets the basic framework for the Territory's participation in the Federal Disaster Assistance Program.

The following table summarizes the hazard mitigation capabilities of Virgin Islands Government agencies and major utilities. These assessments are based on the responses to detailed questionnaires provided by each agency (Appendix C).

Table 2.1 Primary and Secondary Mitigation Responsibilities of Agencies in the U.S. Virgin Islands

Planning/Management Issues:	VITEMA	DPNR	DPW	Fire Service	Police	Tourism	OMB	P&P	Port Authority	WAPA	Ed	BIR	VI TELCO	Gov.	Lt. Gov.
Acquisition*		S					S	P							
Location of public buildings*		S													
Warning systems	P			P	P										
Flood/hazard insurance		P													S
Disaster loans and grants						S	S								
Education/public information	P	S				S		S						P	
Demarcation of hazard areas	S	P		S											
Building/health code revisions			P												
Inspection programs		P	P	S											
Flood plain easements		P	P					P							
Flood plain 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				P			
Hazard monitoring	P	P		S				S	P	P			P		
Flood proofing			P					P							
Preparedness planning	P	S	P	P		S	S			P	P		P		

* Most agencies have autonomous control over their own structures for purposes of acquisition, location and construction features or standards (*i.e.*, applying standards above legal minimums).

Structural Issues	VITEMA	DPNR	DPW	Fire Service	FEMA	Commerce	OMB		Port Authority	WAPA	Ed	BIR	VI TELCO	Gov.	Lt. Gov.
Flood proofing, gut maintenance	S	S	P										P		
Preparedness planning	P	P													
Stormwater systems			P												
Modify structures			P					P		P	P				
Breakwaters, bulkheads, *etc.*		S						S	P						
Shore protection measures		S						S	S						
On-site detention/dams		S	P					S							
Channel mods/culverts		S	P					S							

P — A primary responsibility of the agency
S — A secondary responsibility of the agency

2.1.1 Existing Programs of Virgin Islands Government Agencies

Many programs of agencies of the Government of the Virgin Islands have significant impacts on vulnerability reduction. This plan incorporates many of these plans, in order to foster cooperation and collaboration, to avoid duplication, and to promote active mitigation efforts throughout the Government.

The plans incorporated in this plan are:

- The Virgin Islands Section 6217 Coastal Nonpoint Pollution Program;
- The Virgin Islands Groundwater Protection Program;
- The Virgin Islands Coastal Zone Management Act, Title 12, Virgin Islands Code, Section 901 and following;
- Areas of Particular Concern; Designation of Legislature at Act 5986, (May 31, 1994);
- Protection of Indigenous Endangered and Threatened Fish, Wildlife and Plants, Title 12, Virgin Islands Code, Chapter 2;
- Development Permit Applications of Coastal Zone Management Act;
- Environmental Protection Program, Rules and Regulations, Virgin Islands Rules and Regulations, Section 531 and following;
- Solid and Hazardous Waste Management, Title 19 Virgin Islands Code Chapter 56;
- Oil Spill Prevention, Title 12 Virgin Islands Code Chapter 17, Sections 701-720;
- Navigation, Mooring and Anchoring of Vessels, Title 25, Virgin Islands Rules and Regulations, Chapter 16, Sections 401-412;
- Virgin Islands Hazardous Materials and Oil Spill Contingency Plan.

To conserve time, energy and space, these plans are not being distributed with this plan. Copies are available at the Department of Planning and Natural Resources.

2.2 Territorial Hazard Mitigation Actions Planned or in Process

In post Hurricane Hugo mitigation planning the Territory undertook a series of special initiatives, with special attention to power, water, sewerage and solid waste, communications and flood control activities. The following table provides a short description and assessment of the status of the hazard mitigation projects cited in the *1992 Implementation Annex Natural Hazard Mitigation Plan Update*:

Table 2.2 Hazard Mitigation Projects after Hurricane Hugo in the U.S. Virgin Islands

OMB Proj #	Title	Implementing Agency	Status	Completion Date
Hazard Mitigation Projects (FEMA §404) immediately after Hurricane Hugo				
1	STJ Alternate 34.5 KV submarine cable	WAPA	Complete	12/92
2	STT 34.5kV Substation	WAPA	Complete	12/95
3	STX Fuel P[illegible]	WAPA	Complete	12/92
4	STX Fuel Storage at Richmond Generating Plant	WAPA	Complete	6/95
6	STX .55 MGPD Desalinization Plant	WAPA	99%	na
7	STX Alternate South Shore Generating Plant	WAPA	Canceled	na
8	Government Records and Archive Center	DPNR	10%	na
9	Back-up Electric Power for Lifeline Facilities	WAPA	Withdrawn	12/94
12	STT Drainage Improvements on Harwood Hiway	DPW	95%	9/96
14	STT Drainage Improvements, Sugar Estate	DPW	80%	4/96
17	STJ Mongoose Junction Drainage	DPW	Designed	3/96
Other Hazard Mitigation Projects				
Power Projects under the auspices of WAPA				
22	STX Hess Oil Feeder Interconnection	WAPA	Withdrawn	6/94
26	STT 1.5 Million Gallon Fuel Storage Tank	WAPA	App'd /FEMA	na
	STJ Switchyard Modifications	WAPA	na	na
24	STT Krum Bay Hi Yard Modifications	WAPA	Low B/Cost	na
25	STX Switchyard Modifications	WAPA	Low B/Cost	na
23	STX Richmond Drainage Corrections	WAPA	Pending	na
39	STX Smithfield Switching Center	WAPA	FEMA Rev.	na
38	STT 35 MW Gas Turbine Generator	WAPA	FEMA Rev.	na
Water Projects under the auspices of WAPA				
	STJ Reverse Osmosis Plant in Coral Bay	WAPA	na	na
28	STJ 500,000 gallon water Storage Tank in Cruz Bay	WAPA	FEMA Rev.	na
	STJ Water distribution system for Cruz Bay	WAPA	na	na
29	STX Fredericksted Reverse Osmosis Desalinization	WAPA	FEMA Rev	na
Sewerage Projects under the auspices of WAPA				
	STX Emergency generators for sewerage pumping	DPW	EPA funded	na
	STJ Emergency generators for sewerage pumping	DPW	EPA funded	na
	STT Emergency generators for sewerage pumping	DPW	EPA funded	na
	Virgin Islands-wide Sewer Line Maintenance Program	DPW	STT started	na
	STX Flood Control at LBJ Sewerage Treatment Plant	DPW	partial	na
	STX Replacement of Sewage Pumps	DPW	EPA funded?	na
	STX Replace Coastal Interceptor	DPW	Proposed	na

Solid Waste and Landfill Operations				
	Comprehensive Groundwater Study	DPW	Proposed?	na
Communications				
	Engineering Survey of Emergency Comm System	VITEMA	Complete	2/93
Flood Control				
37	STX Estate Whim/Campo Rico	DPW	Const apprvd	na
30	STX Williams Delight	DPW	EA in train	na
	STX Mount Welcome	DPW	na	na
	STT Soto Town Drainage Basic	DPW	na	na
	STT Old Tutu, Turpentine Run	DPW	na	na
32	STT Sub Base Flood Control	DPW	EA in train	na
36	STT Smith Bay Flood Control	DPW	EA to start	na
	STX Tide Village	DPW	na	na
	STX Strawberry Hill/Sion Farm	DPW	na	na
33	STT Lindbergh Bay	DPW	EA in train	na
	STX La Grande Princess/Little Princess	DPW	na	na
	STX Contentment	DPW	na	na
Comprehensive Land Use Planning				
	Comprehensive Land Use Management Plan	DPNR	Expired	na
GIS				
	Virgin Islands Geographic Information System	DPNR	No Interior support	na
Archives				
35	Shelving for Records Center	DPNR	approved	na
Public **Education/Networking**				
	Video Conferencing Link	VITEMA	na	na
	Emergency Preparedness Training and Planning	Health	na	na
Retrofitting Emergency Housing Trailers				
	Tie-downs for Hurricane Hugo Trailers	HPR	na	na
	STX Frederiksted High Security Lighting	HPR	Withdrawn	na

Section III: Mitigation Goals and Objectives for the U.S. Virgin Islands

3.0 Introduction

It is important to establish the basic goals and objectives which this mitigation plan strives to achieve. What follows is a set of goals established to serve as a foundation for future actions and decisions. The U.S. Virgin Islands recognizes the following goals and objectives and will seek to advance them in both short-term and long-term actions:

3.1 To reduce loss of life and personal injury from natural hazards

The Government of the Virgin Islands' fundamental objective is to minimize the human loss and suffering resulting from natural hazards. This protection extends to both residents and visitors. Other governmental disaster planning functions, not strictly considered mitigation, have a substantial role to play in protecting health and safety, including warning, evacuation, and response functions. From a mitigation viewpoint, citizens have the right to live and work in *structures which will be structurally sound* in the event of hurricanes, earthquakes or other natural events. Moreover, they have the right to be out of harm's way, to the extent possible, during disaster events. This implies the need for public warning, shelter, and evacuation programs, and the regulation of construction. In addition, Government needs to encourage safe practices for developers for all Virgin Islanders and to limit development in high-hazard areas.

Hurricane Marilyn has demonstrated that mariners assume special vital risks in hurricanes which need to be addressed in future mitigation activities.

3.2 To reduce damages to existing development from natural hazards

It is the goal of the Territory to the extent possible to reduce threats to existing development. Such a goal suggests the possibility of a range of public actions, including, in extreme cases, relocation of structures out of high hazard zones and into less hazardous areas, retrofitting of structures to better withstand earthquakes and other hazards, and undertaking certain structural improvements such as additional drainage channels to help alleviate existing flooding problems, among others.

3.3. To reduce damages to future development from natural hazards

Future growth and development in the islands is to be managed in ways which do not place people and property at risk. Developers of all new development must be provided with greatly improved information on the risks and opportunities in new development areas in order to fully evaluate natural hazards. While it is typically quite difficult to correct past mistakes, cost-effective opportunities exist to guide new development in ways which make it less vulnerable to natural hazards.

3.4 To reduce damages to present and future development financed by public funds

Just as private development is subject to damage and destruction from natural hazards, so also are public investments. Many public investments are vulnerable to natural hazards, including schools, government buildings, roads and streets, airports, among many others. These investments can be located and designed in ways which minimize their vulnerability. Public roads, for instance, can be located outside of flood plains, or can be elevated above predicted flood levels. Efforts can also be made to correct for past mistakes, for instance by retrofitting critical public buildings so that they will better withstand hurricanes, earthquakes, and other hazards.

3.5 To reduce public expense for response and recovery services following disasters

There is a direct correlation between hazardous development patterns and the post-disaster emergency response and recovery expense that must be assumed by the public. If buildings and infrastructure had not been located in hazardous areas, for example, there would be little or no need to expend public monies to rebuild and restore them.

3.6 To protect and advance the long term economic prosperity of the Virgin Islands

A critical goal upon which most agree is the need to protect and enhance the conditions under which the islands will develop and prosper economically. Tourism is a key element of the local economy and hazard mitigation figures into this in several important ways. First, because a healthy tourist economy cannot thrive and grow unless prospective tourists perceive the islands as a safe place to visit and vacation. A hurricane or earthquake with tremendous damage, destruction or loss of life may create a long lasting image that the Virgin Islands are a dangerous and risky vacation setting.

Second, the continued viability of the tourist economy depends on the ability of the Virgin Islands to preserve the beauty and natural features that attract people in the first place. Obvious elements of this attraction include clean beaches, green vegetated hills, thriving, colorful reefs, and clear blue waters, among many others. Many of the hazard mitigation policies identified in Section IV also protect these aesthetic and natural features. For example, an increased shoreline setback, in addition to reducing the risks of hurricane and shoreline flooding will protect the incredible beauty of the islands' beaches and shoreline upon which much of the Territory's tourism is founded. Mitigating the impacts of natural hazards will also reduce or eliminate the loss of business activity and income that necessarily results while the commercial sector rebuilds following a disaster. Even a short period of recovery can translate into a substantial loss of commercial revenue.

Involvement of the private sector, and the public-at-large, in the hazard mitigation planning process is a directly linked to the need to protect short and long-term economic interests. Conversely, failure to openly debate hazard mitigation planning activities is likely to result in ineffective or unrealistic plans.

3.7 To protect the natural environment of the Virgin Islands

An important goal is the protection of the natural environment of the Virgin Islands. Many elements of the natural environment, such as wetlands and mangroves, serve to naturally mitigate the impact of natural hazards. The Territory should guard against development impacts on the environment such as:

- direct alteration of critical habitat by destroying reefs, filling mangrove swamps, and dredging marinas out of salt ponds;
- injection of pollutants into the environment such as fertilizers, pesticides and herbicides;
- over-exploiting natural resources such as using sand for construction, or over-fishing the reef fisheries.

The islands' natural resource base is crucial to the future of the area's economy and should be carefully considered in any mitigation program or policy. Given the long and active history of NGO involvement in environmental affairs in the U.S. Virgin Islands, private environmental groups are especially well suited for active involvement in planning for or assessing the effects of natural hazards on the natural environment.

Section IV: Mitigation Strategies, Policies, Programs and Priorities

4.1 Reduce Vulnerability of Existing Development

Existing development is obviously vulnerable to the impacts of natural hazards. It is estimated that new construction adds only one percent to the total stock of buildings in the Virgin Islands per year. Therefore, if the vulnerability of the U.S. Virgin Islands is to be decreased, means to *decrease the vulnerability* of existing structures will have to be devised. .

4.1.1 Gather Information on Building Failure

Reliable information that explains why existing buildings fail in natural hazards is vital to this process. Studies that will provide this vital information will be encouraged.

4.1.2 Retrofit Existing Structures

Retrofitting of existing structures so that they will be better able to withstand the impacts of natural hazards will be encouraged.

4.1.3 Remove Buildings in Highly Hazardous Areas

Some existing structures are located in highly hazardous areas. Acquisition, amortization or relocation of these structures will be encouraged.

4.1.4 Building Code

When existing structures are repaired or enlarged they should be built to better withstand the impacts of natural hazards. The new building code will be reviewed and amended periodically to ensure that the standards in it are adequate to achieve this purpose. The building code will be effectively and professionally enforced.

4.2 Reduce Vulnerability of New Development

Future development will increase the vulnerability of the U.S. Virgin Islands to natural hazards simply because there will be more buildings and probably more people in the Territory to be vulnerable to the impacts of natural hazards. The Territory will, however, make every effort to ensure that future development will increase vulnerability as little as possible.

4.2.1 Plan Virgin Islands Land Use

The Government of the U.S. Virgin Islands will prepare a Comprehensive Land Use Plan that will guide the future development of the Territory. Mitigating the impacts of natural hazards will be one of the primary goals of the plan.

4.2.2 Adopt Growth Management Tools

Appropriate land use controls and other growth management tools and techniques will be adopted to implement the Comprehensive Land Use Plan. Among these will be a revised zoning law, a revised subdivision control law, a flood damage control law, *etc*.

4.2.3 Implement Building Codes

It is vital that all new structures be built to withstand the impacts of natural hazards. To achieve this end, the Government of the Virgin Islands must have:

- an adequate building code that is regularly updated;
- professional enforcement of that code;
- training programs for the building industry; and
- educational programs for consumers.

4.2.4 Limit Siting of New Structures in Hazard-Prone Areas

It is also vital that all new structures be located in areas that are the least hazardous and that development in hazardous areas be undertaken very cautiously to limit the number of lives and the amount of the built environment that are vulnerable to natural hazards as much as possible.

4.3 Land Ownership to Mitigate Hazards

Land ownership is the most powerful tool any public agency has to manage growth and development. The Territory will develop a program to use land ownership creatively to mitigate the impact of natural hazards.

4.3.1 Mitigate Vulnerability of Publicly-Owned Lands

Land that is already owned in fee simple or less than fee simple by the Territory will be managed carefully to mitigate the impact of natural hazards and to ensure that it is not developed in ways that will unduly increase the vulnerability of the Territory to the impacts of natural hazards. Public trust areas and areas owned by other Federal agencies (*e.g.*, the U.S. Department of Defense and the Department of Interior) should be included in this management program.

4.3.2 Acquire Vulnerable Property

When feasible land and buildings that are especially vulnerable to natural hazards should be acquired and removed from the development stream. Land that can be used for public purposes in addition to mitigation (e.g., park sites) will be given special consideration. Buildings that have suffered repetitive losses under the National Flood Insurance Program will also be given special consideration.

4.4 Public Buildings to Mitigate Hazards

Public buildings are of special importance in that they represent investments of all the public. It is vital that many of them be operational during the hazardous event and immediately thereafter. Some of these buildings serve as shelters and all of them are examples to the rest of the community.

4.4.1 Build to High Standards

Public buildings will be built to the highest standard in the building code, and whenever feasible to an even greater standard, creating a safe haven complete with redundant infrastructure and in independent communication system.

4.4.2 Build Safe Havens within Public Buildings

When it is not feasible or practicable to build the entire building to higher-than-code standards serious consideration will be given to building a section of the structure as a safe haven.

4.4.3 Site Public Buildings in Safe Areas

Public structures will not be located in hazardous areas. Public structures in hazardous areas will be amortized and removed from service as quickly as possible.

4.5 Schools and Hazard Mitigation

All of the school buildings used for instructional purposes will be built to the highest standard of the building code. All, or a significant portion of each building will be built as a **safe haven**.

Engineering studies of school facilities will identify options for "differential hardening" of schools to protect essential services and shelter facilities, while applying less stringent and costly standards to non-critical areas such as walkways.

4.6 Flood Insurance and Hazard Mitigation

Territorial implementation of the **National Flood Insurance Program** will be evaluated in terms of its present and potential value for mitigation purposes. The provisions of the Flood Insurance Reform Act will also be carefully studied to determine how these programs should be administered in the Virgin Islands to best mitigate flood hazards.

4.7 Administration of Hazard Mitigation

For mitigation to achieve its full potential in the U.S. Virgin Islands there should be a person who is responsible for:

- mitigation planning,
- implementing the plan including the generation of mitigation projects [*e.g.*, Section 404 projects, the Flood Mitigation Assistance Program (FMAP), *etc.*],
- monitoring and evaluation.

VITEMA will create such a position but will continue to work with the Governor's Authorized Representative and the [VI] Office of Management and Budget in carrying out such projects. This position will also be the Point of Contact (POC) for the Flood Mitigation Assistance Program authorized by the National Flood Insurance Reform Act of 1994.

4.8 Hazard Mitigation by Building Code

The building code has already been mentioned in several other policies which demonstrates its importance. The building code and its enforcement are absolutely critical to the process of building a total building stock which is less vulnerable to natural hazards. There are several essential factors:

4.8.1 Update Building Code

The new building code must be kept up to date. The Universal Building Code is amended periodically and these **revisions** should be added to the Virgin Islands Code as they become available.

4.8.2 Adapt Code to VI Conditions

Special factors for the Virgin Islands should be considered for inclusion in the Code, such as:

- standards for **cisterns**, including a requirement for hand pumps or gravity feeds;
- the location and construction of **septic systems**;
- **hurricane shutters** and other structural mitigation features.

4.9 Comprehensive Strategic Mitigation Action Plan

The purpose of this plan is to guide development and redevelopment following Hurricane Marilyn. This plan will be replaced as soon as possible by a **Comprehensive Strategic Mitigation Action Plan** which will be both more comprehensive and more detailed. That Action Plan will be prepared to satisfy the requirements of Section 409 of the Stafford Act, the planning requirements of the Flood Insurance Reform Act and it will also take into consideration Section 309 of the Coastal Zone Management, the Community Rating System of the National Flood Insurance Program, and other relevant programs.

The Comprehensive Action Plan will be formulated with the full participation of relevant Virgin Islands and Federal agencies and relevant non-governmental agencies and the public—with a degree of dialogue that is currently impossible to implement, given the continuing problems with the Territory's telephone and power systems. The plan will be a multi-hazard and multi-objective plan.

The purpose of the Comprehensive Strategic Mitigation Action Plan will be to guide development and redevelopment to mitigate the impacts of natural hazards during the day-to-day operations of the entire Virgin Islands Government, in addition to providing guidance for post disaster recovery operations.

4.10 Energy Efficiency for Hazard Mitigation

A number of **energy efficient steps** need to be implemented to **reduce dependence on the public power system** in future disasters. Among the new options which need to be encouraged, promoted or specified for new construction are:

- — Requiring manual water pumps (pitcher pumps or yacht-type pumps could be used) in kitchens and bathrooms for easier access to cistern water;
- — Incentives for shutters;
- — Incentives for back-up or passive solar systems for water heating and possibly low level lighting or fan applications;
- — Solar panels for cellular phones and newer personal communications devices;

— Research other incentives for other feasible alternative energy systems.

Codes or regulations need to be researched to ensure that such features, perhaps uniquely cost-effective in the Virgin Islands, are **eligible for FEMA replacement** in future disasters.

4.11 Insurance

Adequate insurance programs are essential to maintaining the confidence of residents and especially new investors. Sound mitigation strategies will reduce vulnerability for structures in the Virgin Islands, and thus enhance the insurability of property.

4.12 Water Quality

The **Non Point Source Pollution and Protection Programs** of the Department of Planning and Natural Resources identifies measures for hazard mitigation relating to surface and groundwater resources of the Virgin Islands.

4.13 Tax Incentives

A study will be conducted of new **real estate tax** schedules and other non-regulatory incentives which might be used to promote hazard mitigation.

4.14 Hazards Mapping

Cumulative hazards mapping is a concern. VITEMA will build a system for cumulative mapping of the various natural hazards present on the islands, based on the mapping resources of the ECC Digital Mapping Center. These cumulative hazard maps would include issues ranging from geologic studies for landslide potential, land use/sedimentation rates such as those studies undertaken by the Water Resources Center of UVI, to long-term impacts on coasts resulting from the deterioration of fringing reefs.

4.15 Retrofitting WAPA and DPW Facilities

Mitigation retrofitting programs of the **Virgin Islands Department of Public Works** and the **Water and Power Authority** were designed in the wake of Hurricane Hugo (Section 2.2). These will be continued, and added resources may be directed to address many of the most acute infrastructural problems leading to flood damages in the Virgin Islands. Priorities include:

— rebuilding public structures and facilities above the new construction standards to meet the policy of using public facilities to reduce vulnerability,

— adding facilities to existing public structures such as baths and first aid rooms for improved secure shelter facilities.

— building redundant critical facilities, such as police stations and communications systems,

— hardening utility and communications facilities.

— equipping facilities with back-up power and water systems.

*One specific retrofitting priority for the **Department of Public Works** is building back-up power systems, including study of the feasibility of **alternative power sources for sewage treatment and distribution** to keep these critical facilities operating in the face of prolonged power losses and flooding.*

4.16 Alternative Technologies

Processes should be designed to encourage the application of feasible low-energy solutions which will significantly enhance the ability to survive and prosper in the aftermath of a disaster. These measures include:

- Manual water pumps for access to cistern water;
- Shutters;
- Back-up or passive solar systems for water heating and possibly low level lighting or fan applications;
- Solar panels for cellular phones and newer personal communications devices;
- Research on other feasible alternative energy systems.

Codes or regulations need to be researched to ensure that such features, perhaps uniquely cost-effective in the Virgin Islands, are **eligible for FEMA replacement** in future disasters.

4.17 Research of Construction Practices

New retrofitting projects, especially addressing hurricane wind hazards are yet to be designed, but it is notable that some new public structures, such as the new gym at the Ivanna Eudora Kean High School at Red Hook on St. Thomas, lost their roofs. Identifiable cases such as these should be closely studied to determine why the roof failed so that it will not happen again.

4.18 Protection of Hospitals

Protection of Virgin Islands **hospitals** is a special concern given extensive damages which have occurred to the hospitals in recent disasters. Steps will be taken to ensure the protection of hospital residents, to guarantee the availability of medical services in future disasters, and to assure the safety and strength of the buildings themselves.

4.19 Mitigation for Boating and Marina Interests

Given the loss of life, the high volume of uninsured losses, the environmental impacts of groundings and recovery activities, and the high cost of losses to the Virgin Islands economy, it is important to study **mooring systems** and hurricane warning **systems for boats** and marinas to determine basic hazard mitigation steps to be taken for this sector.

4.20 Mitigation in National Historic Districts

Mitigation priorities should include priorities for protecting and upgrading protection of public and private structures in **National Register Historic Districts**, while incorporating **design** features which extend and enhance the appearance of the Historic District.

4.21 Mitigation for Sewerage Systems

The **Department of Public Works** will assess the current flood status of the sewage treatment plants and lift stations, and will prepare a plan to upgrade these facilities beyond the post-Hugo mitigation projects (See Section 2.2). This study will include benefit/cost calculations for the use of alternative energy systems

as well as the feasibility of consolidating multiple small sewerage systems, such as the five surrounding Mangrove Lagoon in St. Thomas, into one centralized system.

4.22 Telephone Service

New technologies and configurations will be studied to ensure more reliable **telephone service** in the event of a disaster are a major priority. Options in this area are more feasible because of recent advances in fiber optic cable and other communications technologies.

4.23 Government-wide Facilities Planning

Section 2.1, Virgin Islands Capability Assessment, reveals there is currently no **government-wide facilities planning** function within the Government of the Virgin Islands. Coordinated facilities planning creates the possibility for much more effective hazard mitigation than the individual, uncoordinated actions of a dozen or more departments and agencies on three islands. A high priority is accorded to building a government-wide facilities planning capability.

4.24 Research for Empowerment

A major focus of the Virgin Islands hazard mitigation should be based on empowering individuals to take more responsibility for their own safety by providing them with improved and more accessible information about hazards and hazard mitigation in the Virgin Islands.

There are a variety of natural hazard issues which need to be developed and translated into information products or educational tools which can be applied to hazard mitigation by individuals in the Virgin Islands, such as:

"Best and Worst Construction Practices" need to be actively publicized, with specific examples drawn from recent hurricane failures and survival. The point of this exercise should be that the purchaser can actively exercise control over the hazard mitigation capabilities of his own property, regardless of the formal capabilities defined by the building code.

There is a need for a study to examine the use of NOAA's **SLOSH** model for storm surge prediction, and other newer storm surge models such as the new **TAOS** model developed by the Department of Regional Development and the Environment of the Organization of American States.

4.25 Protection of Archives

Protection of libraries and government archives is of special importance for the Virgin Islands because it has a unique history, culture and natural environment, and a unique political structure and organization. In the past, and including response activities for Hurricane Marilyn, disaster response and recovery activities have been retarded because of the inability to locate essential public records, reports or studies. This problem has been especially acute with the destruction of many key Government Offices such as the Office of the Lieutenant Governor with its responsibilities for land records, insurance companies and corporate registrations, and for the Department of Planning and Natural Resources, with its wide range of planning, permitting, monitoring and environmental enforcement activities. A high priority should be placed on **building and protecting repositories** of public records, including those backup and ancillary collections maintained by non-governmental organizations.

4.26 Computer Mapping Resources

There is a need to develop **digital property maps** based on the Army Corps of Engineers digital ortho rectified aerial photos (1:2400 scale). This is essential for **improved hazard mapping and development planning** by government and private developers. The lack of geo-referenced cadastral information is also a major problem in immediate post disaster recovery operations. Generating the geo-referenced property maps should also be relatively inexpensive, given the new digital aerial photos from the Corps of Engineers. These maps should become the new standard for the Virgin Islands.

Digital elevation maps should be developed by the new GIS facilities of the **Department of Planning and Natural Resources** , based on the Army Corps of Engineers digital ortho quarter quads (1:2400 scale). **Land cover mapping** should also be considered to provide improved **analysis of runoff** conditions, possibly as part of the researches of the Water Resources Research Institute located at the University of the Virgin Islands.

4.27 Areas of Particular Concern

Special **environmental monitoring** should be conducted for the 18 **Areas of Particular Concern**, established under the Coastal Zone Program, plus the 37 sites surveyed after Hurricane Hugo ("Development Of A Post Hurricane Hugo Environmental Recovery Strategy, Including Planning For A Territorial Park System"). These studies will help to assess both storm effects and the interaction of environmental stress from anthropogenic sources and long-term damages to terrestrial and marine environmental resources which are known to mitigate disaster effects.

4.28 Geographic Information Systems

The Virgin Islands has an unhappy experience of not being able to establish a viable center for geographic information. The lack of such information was a handicap in early stages of recovery and is a major on-going problem in planning mitigation strategies.

The **Eastern Caribbean Center (ECC)** of the University of the Virgin Islands should expand its Conservation Data Center to serve as the Digital Map Center for the Virgin Islands. The Digital Map Center for the Virgin Islands would be custodian and archiving center for **all** (marine *and* terrestrial) **digital mapping and GIS products** for the Territory, including all special purpose coverages generated by FEMA for Hurricane Marilyn.

Among the known products which should be available through the Digital Map Center include census data and the Tiger geographic files, the WAPA detailed mapping of roads and shorelines, the USGS 1:24,000 digital maps, the Landview II coverages, and the new Army Corps of Engineers 1:2400 ortho rectified photos as well as post-Marilyn digital products.

4.29 Global Climate Change

The Government of the Virgin Islands will increase its commitment to monitoring and planning for natural hazards based on **global climate change**, including working with the Global Environment Facility-supported OAS/CARICOM project on planning for adaptation to global climate change which will provide new information on developing effects in the Caribbean region. These hazards include sea level rise, storm frequency, drought, and changed patterns of fisheries resources.

4.30 Financing

VITEMA and the **Office of Management and Budget** will commission a joint study to examine **new financing alternatives** for the on-going costs of the Virgin Islands Hazard Mitigation Program as it will be defined under the Comprehensive Hazard Mitigation Action Plan (Section 4.9, above) , including database management, mapping and administrative functions.

A second significant constraint on mitigation management in the aftermath of natural hazards is the inability to estimate **economic and Government fiscal effects** resulting from the loss of Territorial economic resources and tourist markets. Economic and fiscal forecasting models available to the Bureau of Economic Research of the Department of Tourism should be fully developed for such revenue forecasting functions.

Section V: Monitoring and Evaluation

Monitoring the progress being made toward the achievement of any plan is essential to its overall accomplishment. VITEMA will develop a monitoring process that will measure the progress being made by the Territory to mitigate the impacts of natural hazards. Monitoring and evaluation are functions especially well suited to the private (profit and non-profit) sector role and comment on the needs for and feasibility of mitigation activities.

A system of indicators and benchmarks will be used to monitor progress yearly.

Section VI: Conclusions

The U.S. Virgin Islands are confronted with a variety of serious natural hazards. They are also confronted with growth and development pressures which, if not carefully managed could result in even greater numbers of people and properties being vulnerable to natural hazards. In addition, in order to further promote and develop its tourism-based economy, the Virgin Islands need to maintain an attractive and safe environment for visitors.

This mitigation plan is an important step in addressing in a comprehensive manner the natural hazards problem. The Government of the Virgin Islands is committed to fulfilling the goals and objectives set forth in Section III, as well as moving forward in considering and examining the more detailed tactical alternatives identified in Section IV. These developments will be carefully coordinated among the multiple government agencies, private voluntary organizations, commercial and industrial interests which should be continuously involved in hazard mitigation planning.

Hazard mitigation planning is a continuous and ongoing process. Consequently this plan will be reviewed yearly and updated accordingly with involvement by all elements of the wider Virgin Islands community. New programs and policies may need to be added and mitigation priorities may change. As a result of such changes, long term mitigation measures may rise in importance and may be reclassified as short term priority actions. The reverse may also occur. The Comprehensive Strategic Mitigation Action Plan will provide an opportunity for intermediate term corrections and refinements, and will also clarity the need for changes in the longer term mitigation plan.

At each yearly review, a status or progress assessment will be prepared for each identified policy or program. Where a short term priority measure has not been achieved the reasons for such will be identified and proposals formulated to overcome these difficulties. VITEMA will have the primary responsibility for the yearly evaluation. It is important that Virgin Islands agencies become acquainted with this mitigation plan and work to incorporate its elements into their day-to-day decision making. These agencies should also be intimately involved in the annual update and progress report.

Appendix A

This is an extended bibliography of sources relevant to hazard mitigation in small tropical islands and the United States Virgin Islands

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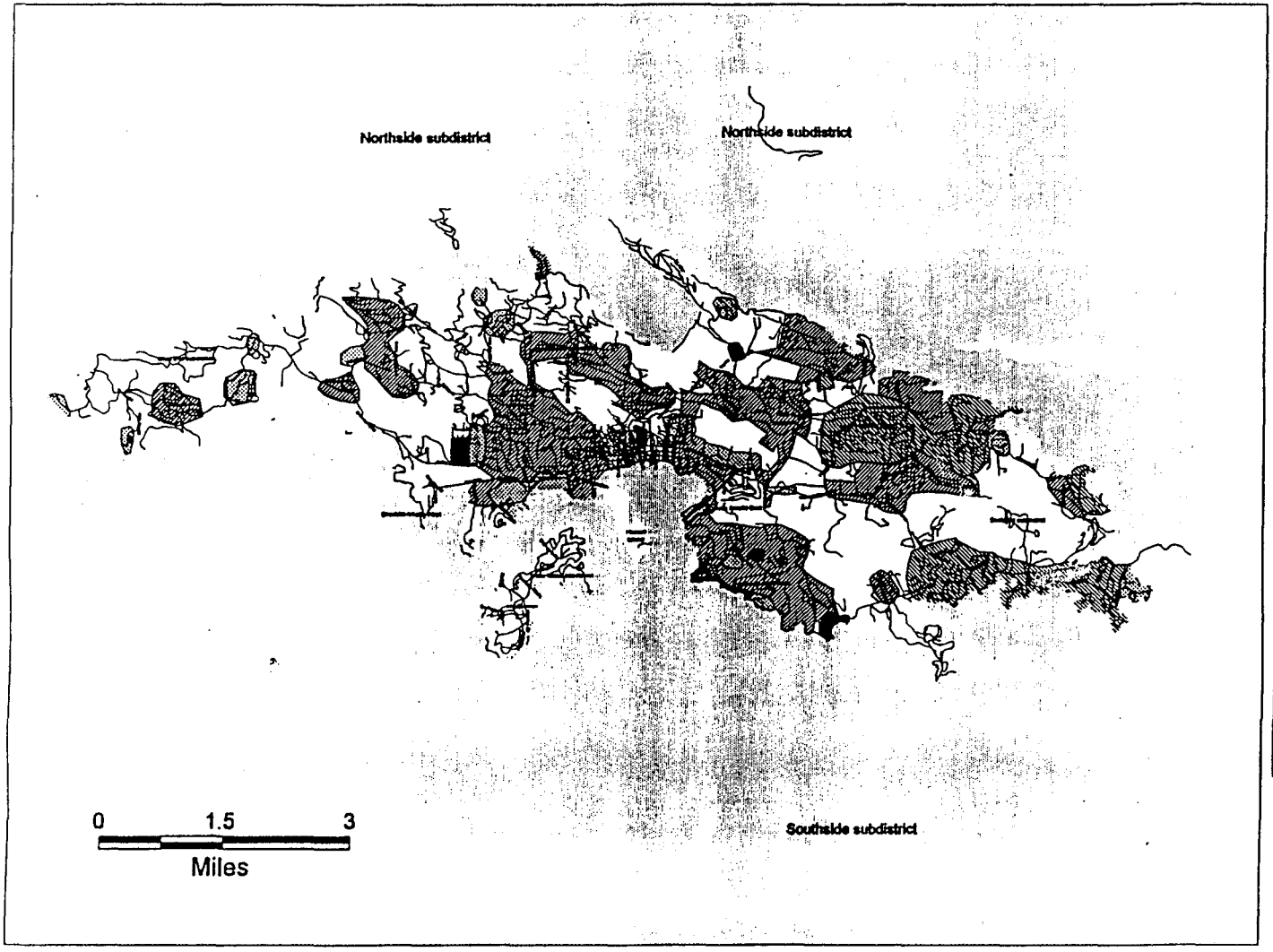
Appendix B

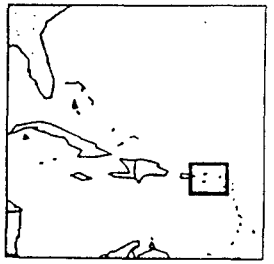
The United States Virgin Islands

Remote Sensing Damage Levels

October 9, 1995

US Virgin Islands - St Thomas
Remote Sensing Damage Levels





LEVEL 1: No real damage. Isolated buildings and homes may have minor damage to roofing material. No structural damage

LEVEL 2: Moderate damage. Some or all residences and buildings suffering exterior damage to roofs. There may be a limited amount of debris scattered in the area. No structural damage.

LEVEL 3: Heavy damage. Widespread damage to roofs, some with exposed roof beams and some with complete roof failure. Isolated homes and buildings structurally damaged or destroyed. There is a significant amount of debris scattered in the area

LEVEL 4: Devastation. Complete roof failure on most residences and buildings. Some or most residences and buildings suffering complete structural failure. The area is covered with debris.

Remote Sensing Damage Levels

- Level 1
- Level 2
- Level 3
- Level 4

	Population	Housing Units
1990 Census Totals	48,166	18,433
Damage Estimates		
Level 1	1,408	433
Level 2	5,037	2,115
Level 3	18,397	7,210
Level 4	10,665	3,627
Total Damages	35,504	13,385

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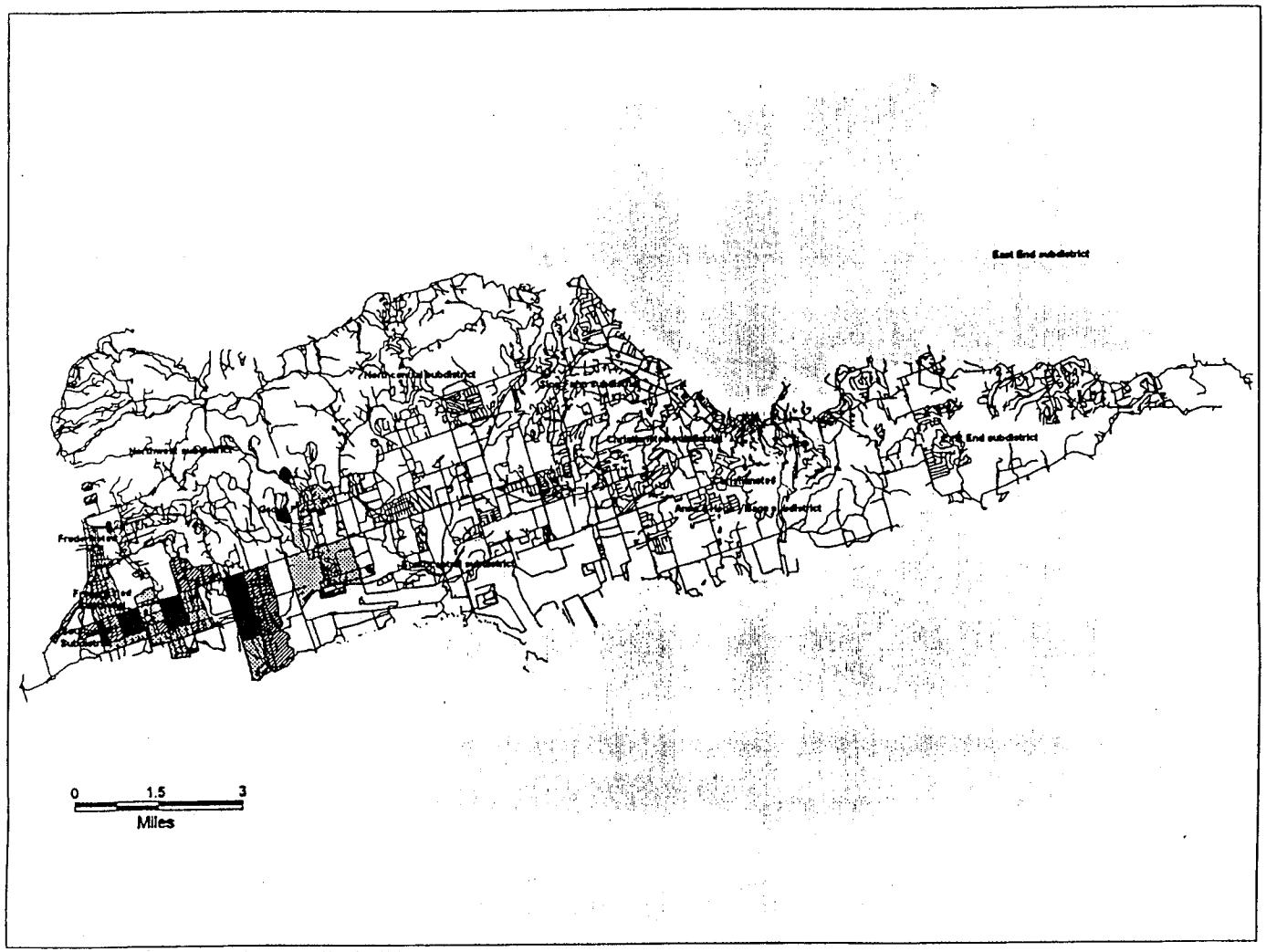
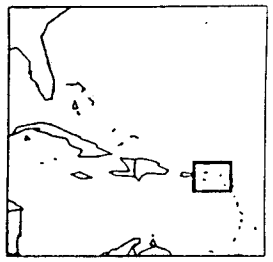
US Virgin Islands - St Croix
Remote Sensing Damage Levels





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Remote Sensing Damage Levels

- Level 1
- Level 2
- Level 3
- Level 4

	Population	Housing Units
1990 Census Totals	50,139	18,937
Damage Estimates		
Level 1	2,137	818
Level 2	7,673	2,636
Level 3	4,363	1,258
Level 4	341	395
Total Damages	14,514	5,107

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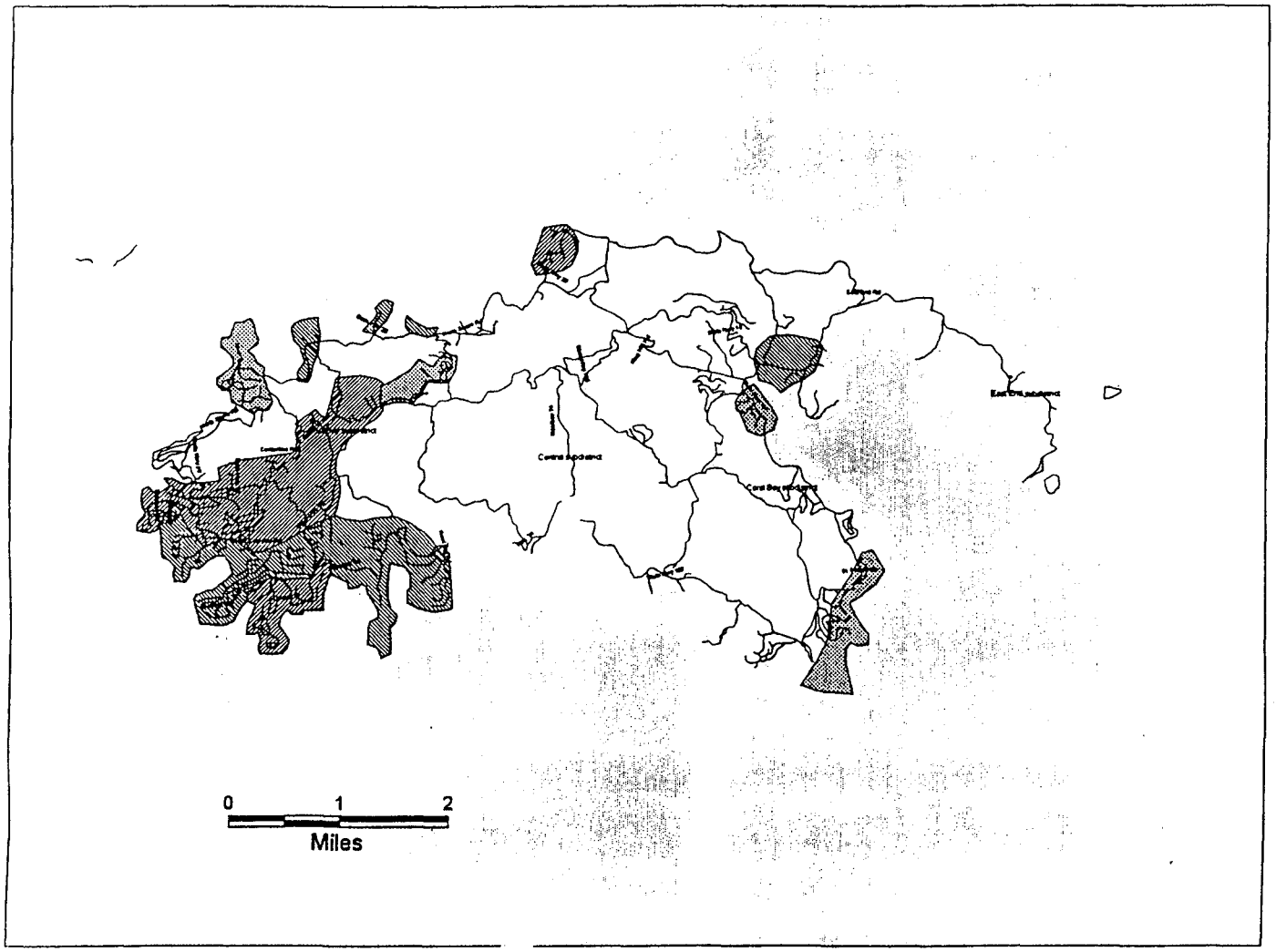
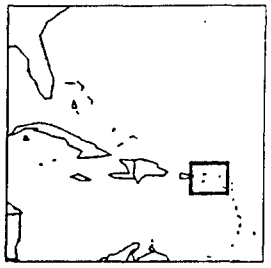
US Virgin Islands - St John
Remote Sensing Damage Levels





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Remote Sensing Damage Levels

- Level 1
- Level 2
- Level 3
- Level 4

	Population	Housing Units
1990 Census Totals	2,504	1,920
Damage Estimates		
Level 1	0	0
Level 2	26	17
Level 3	1,754	872
Level 4	835	554
Total Damages	2,615	1,443

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Appendix C

Capability Assessment by Agency and Major Mitigation Activity

[These forms are the product of interviews with the designated Virgin Island agency mitigation representative, or his or her designee during the post-Marilyn recovery operations. We are extremely grateful to those who took the time to respond to our queries. Because of constraints of time and space, we have occasionally interpreted responses we received rather than quoting them verbatim. If this has resulted in unintentional misquotes, we apologize.]

Summary of Hazard Mitigation Capabilities

Planning/Management Issues:	VITEMA	DPNR	DPW	Fire Service	Police	Tourism	OMB	P&P	Port Authority	WAPA	Ed	BIR	VI TELCO	Gov
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						P
Demarcation of hazard areas	S	P		S										
Building/health code revisions			P											
Inspection programs		P	P	S										
Flood plain easements		P	P					P						
Flood plain regulation		P												
Hazard risk assessment	S			S				P						
Development restrictions		P												
Hazard disclosure regulation		S		P				S						
Zoning regulations		P												
Wetland regulations		P												

* Most agencies have autonomous control over their own structures for purposes of acquisition, location and construction features or standards (above legal minimums.

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				P		
Hazard monitoring	P	P		S				S	P	P			P	
Flood proofing			P					P						
Preparedness planning	P	S	P	P		S	S			P	P		P	
Structural Issues	VITEMA	DPNR	DPW	Fire Service	FEMA	Commerce	OMB		Port Authority	WAPA	WICO	Health	VI TELCO	Gov
Flood proofing, gut maintenance	S	S	P										P	
Preparedness Planning	P	P												
Stormwater Systems			P											
Modify Structures			P					P		P	P			
Breakwaters, bulkheads, etc.		S						S	P					
Shore protection measures		S						S	S					
On-site Detention/dams		S	P					S						
Channel mods/culverts		S	P					S						

Hazard Types:

Landslide	Wind Damage	Isolation/Road Cutoff
Tsunami	Ship Accident	Toxics/Oil/Haz Mat Release
Blast	Plane Accident	Communications Failure
Flash Flood	Power Failure	Nat Resource Destruction
Storm Surge	Fuel Shortage	Radiation Release
Fire	Water System Failure	