Report On Mitigation Activities In the US Virgin Islands

FEMA-DR-1248-VI

Prepared by:
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PURPOSE

This report documents the intensity of Hurricanes Hugo, Marilyn and Bertha, the extent of damages caused by each hurricane, mitigation activities implemented to minimize damages from future hurricanes, and the effectiveness of mitigation measures in preventing major damage from Hurricane Georges in September 1998.

SUMMARY

In response to the catastrophic damage caused by Hurricanes Hugo, Marilyn and Bertha, a massive Federal/Territorial and private sector response and recovery effort was initiated. The major objective of the long-term recovery effort was to re-build the infrastructure, commercial and residential structures incorporating stronger mitigation measures to minimize the potential for damage from future hurricanes.

The Federal Emergency Management Agency (FEMA), the Government of the Virgin Islands, and the private sector began an immediate effort to identify measure to mitigate damage from future storms. They included projects to harden the power grid, adopt and implement upgraded building codes and practices, and public education programs to demonstrate to residents the value of mitigation measures.

With FEMA's support the Virgin Islands Government adopted and implemented stronger building codes designed to withstand sustained winds of 110 mph. The code requires anchoring systems, hurricane clips, shutters and other measures intended to hold buildings together and prevent flying debris during storms. The electrical distribution system was significantly strengthened by burying some of the major trunk lines, reducing the spacing between poles, locating transformers lower on the poles to reduce the wind shear and burying the poles deeper than normal specifications in order to reduce the recovery time following storms. Piers, water production and distribution facilities and oil storage facilities were strengthened. A massive effort to educate government officials, insurance underwriters and agents, homeowners, contractors, builders and the general public about proper building practices and other mitigation strategies was carried out.

Other mitigation plans and projects included upgrading communications systems, implementation of the National Flood Insurance Program (NFIP), and mitigation plans for the tourism and boating industry.

Hurricane Georges put these measures to the test and the results were excellent. Georges generated sustained winds of 110mph on St. Croix. Public and private efforts had retrofitted or rebuilt most of the structures on the island by September 1998. Damage from Hurricane Georges was limited to less than 2% of the private homes on the island. All hotels survived with minor or no damage. Power was interrupted to 15% of the island but was fully restored within 3 weeks. Schools and other public structures provided safe havens for residents.

Designing buildings to withstand a 110-mph or category 2 storm will not protect the island in the event of a higher level storm but it will prevent major damage in 87% of the

storms. Some day a major hurricane of more than 110-mph will hit the islands. But until that day, we can expect to have minimal damage in storms and even then, damage will be considerably less than it would be without the mitigation successes of the past decade.

HURRICANE GEORGES, September 21, 1998 (FEMA-1248-DR-VI)

Hurricane Georges, a strong category 2 storm, struck the US Virgin Islands on September 21, 1998. The path of the hurricane carried its eye over the east end of St. Croix and continued along the north coast with the center of the hurricane passing approximately 35 miles south of St. Thomas. An anemometer at the Port Facilities of Hess Oil on the south coast of St. Croix was recording sustained winds of 110 mph with gusts up to 120 mph. The maximum sustained winds were 95-100 mph with gust up to 110 mph recorded at Cyril E. King Airport on St. Thomas.

The hurricane generated 15-20 foot waves with periodic swells up to 25 feet, which pounded the eastern end and south coasts of St. John and St. Thomas. In Frederiksted, on the west coast of St. Croix, 15-foot waves were breaking approximately 100 yards off shore causing 6-8 foot waves along the shoreline. In Teague Bay on the northeast end of St. Croix there were 15-foot waves. A Presidential Disaster Declaration was signed on September 24,1998.

High winds generated by Hurricane Georges caused a partial collapse of this building.

FREQUENCY OF HURRICANES

The US Virgin Islands are extremely vulnerable to hurricanes. The breeding grounds for the Atlantic Hurricanes are the tropical waves moving off the Cape of Africa, from June through late October with the peak of hurricane activity from mid-August to late September.

Although tropical storms and hurricanes are common in the Caribbean, hurricanes with maximum sustained winds over 110 mph are rare. From 1900 to 1996, there were 486 tropical storms and hurricanes in the Atlantic Ocean and Caribbean during August and September. Of these 158 were hurricanes that impacted the U.S. mainland with 94 (59%) being category 1 or 2, and 64 (41%) being category 3 or higher.

From 1515 to 1998, approximately 110 tropical storms and hurricanes have impacted the U.S. Virgin Islands and Puerto Rico. During the last century, 1898-1998, there were approximately 64 tropical storms and hurricanes that impacted the U.S. Virgin Islands and Puerto Rico. Thirty-seven of these or fifty eight percent (58 %) were tropical storms, 21 (33%) were category 1 or 2 hurricanes and 6 (9 %) were category 3 or higher

PAST DAMAGES

Housing

Hurricane Hugo's 130-mph winds damaged or destroyed 95% of the buildings, leaving thousands homeless. Although some individuals re-built using stronger mitigation measure, Hurricane Marilyn hit the islands at a time when very few changes had been made. Marilyn's 110-mph winds destroyed or damaged 40% or about 16,000 homes. Marilyn hit before many mitigation measures had been undertaken and had winds at the design speed of the current code requirements. Insured damages from these storms were reported by the insurance industry to be 39% of insured value and 27% respectively. Therefore, in an un-mitigated situation, we can expect 110mph winds to damage or destroy 40-50% of the housing stock and to cost about 27-30% of the value of insured property.

Public Buildings

After Hurricane Hugo, nearly every public building on the island including hospitals, schools, housing developments and shelters were destroyed or substantially damaged. Schools remained closed for many months with classes not resuming in those which could be re-opened for more than 5 weeks. In one case, the Central High School on St. Croix, the gymnasium was being used as a shelter. At one o'clock in the morning the building collapsed on approximately 200 people during the height of the storm.

Following Hurricane Hugo new codes were adopted for public buildings. Those buildings that had been repaired by the time Hurricane Marilyn hit faired relatively well. But others like the Airport on St. Thomas were not so lucky. The control tower was destroyed by the winds. Runway lights were inoperable and the airport could not be used for emergency work immediately after the storm.

Utilities

The high winds of Hurricane Hugo cause nearly total destruction of the power grid. On St. Croix, 100% of the power poles were down. Transformers, substations and switchgear were damaged or destroyed. Piers were destroyed or damaged interrupting

the supply of fuel to generation plants. Power was not restored to many parts of the islands for eight months.

Hurricane Hugo also severed all communications with the outside world as equipment was damaged and destroyed. During Hurricane Marilyn much of the same thing happened as satellite dishes, radio and television broadcasting towers and residential lines were damaged or destroyed.

Some improvements including better power pole placement were instituted by the time of Hurricane Marilyn but again the damage to the power grid was extensive. Power was not restored for nearly two months. Sewer and water systems required a similar time period to return them to service. Thus 45-60 days would seem to be the benchmark for public utilities in a category 2 storm.

MITIGATION ACTIVITIES

In response to the damage caused by Hurricanes Hugo, Marilyn and Bertha, a massive mitigation effort was undertaken to minimize the impact of future storms. Following are some examples of the types of projects developed and implemented by FEMA, the Government of the US Virgin Islands and the private sector to insure the security of the infrastructure and protect property. In all cases, improved storm resistance was demonstrated.

Power Distribution

The high winds accompanying Hurricane Hugo and Marilyn caused a total disruption of the power system. Wind loading caused electric pole shearing and downed power lines. In addition, falling roofs and structures caused a large volume of flying debris that caused further destruction of the transmission system components. Most plants and substations sustained major damage. Power poles in some areas had a 60% failure rate. Supplies of fuel to the generating plants were interrupted. In some areas, power was not restored for up to eight months following Hurricane Hugo.

After Hurricane Marilyn, the power distribution system was knocked out in St. Thomas. Approximately 30% of the poles surveyed were down. Of the downed poles, approximately one-half were broken with the remaining either leaning or down on the ground. The most damage to major feeder circuits and primary lines occurred in the downtown area of Charlotte Amalie. The pole failure rate in this area was approximately 50-60%. This was due to these poles supporting two power circuits, large joint communications cables, and larger power conductors and transformers, which significantly increased the transverse wind loading.

In the wake of these hurricanes a concerted planning effort was undertaken. The problems which led to failure were identified, including exposed generating plants and substations, a centralized system with little redundancy, and a high rate of power pole failure.

Using Public Assistance and Hazard Mitigation Grant Program funding, the Government of the Virgin Islands identified a series of major projects to remedy these problems:

- *To ensure reliable transmission* of power, procedures were instituted to ensure burial of poles to proper depths and to ensure that they would not be overloaded with multiple lines and other equipment. An undersea cable to St. John was constructed to ensure that power could be provided to that island. Power lines within major urban areas and to critical facilities were buried.

- *The power grid was decentralized* through the construction of new substations. Smaller areas could be re-energized and a failure in one area would no longer take down whole systems.

- *The production of power was secured* through the construction enclosed power generation and distribution facilities.

- *The supply of fuel to generation plants was secured* through construction of a new pier to accommodate oil barges in St. Croix, the construction of new oil storage tanks to provide redundant storage capacity.

After the passage of Hurricane Georges, power was interrupted to 15% of the island of St. Croix but was fully restored within 3 weeks. Very few poles were down. All of the substations and other projects built since Hurricane Hugo survived undamaged. In fact, most of the time taken to restore power was needed to inspect portions of the power grid before re-energizing the system. This remarkable achievement can be attributed to Hazard Mitigation Grant Program mitigation projects that were undertaken and completed after Hurricane Hugo and Marilyn. The Virgin Islands Water and Power and Power Authority (WAPA) decentralized their power generation system and diversified their fuel sources.

New fuel pier at Richmond Substation on St. Croix

Water Distribution

Both Hurricanes Hugo and Marilyn resulted in interruptions to the water distribution system. Damage to buildings in Hurricane Hugo was severe and the water plants were not an exception. Water supplies were not restored for several weeks in Hurricane Hugo and for several days after Hurricane Marilyn due to damage to the desalination plant and to two water storage tanks.

Ensuring an uninterrupted supply of fresh water became a priority. Following Hurricane Hugo two new desalinization plants were constructed using the new codes to protect them from wind damage. Two new water tanks were constructed and a damaged million-gallon tank was replaced with two .5 million-gallon tanks to provide redundancy in the system. All systems were built to withstand 140-mph winds.

These mitigation projects worked as planned. All plants and tanks were undamaged in Hurricane Georges and the supply of water was uninterrupted.

Building Codes

Although the Virgin Islands had enacted a building code in 1964, the devastation left by Hurricane Hugo proved it woefully inadequate. In the aftermath of Hurricane Hugo, a uniform code was adopted by Executive Order for all buildings owned, leased or occupied by the Virgin Islands government.

After Hurricane Marilyn devastated St. Thomas in September of 1995, it became obvious that building practices were still inadequate to withstand hurricanes. Only a month after the hurricane struck, the Legislature adopted a strengthened building code which incorporated the Uniform Building Code (UBC) for public structures and portions of the Council of American Buildings Officials (CABO) code for one and two family homes.

Proper building techniques used by residents.

EDUCATIONAL EFFORTS

A great deal of credit goes to the government of the Islands for recognizing that simply passing a new building code into law would not be sufficient. What was needed was to achieve widespread acceptance of the code by building owners, builders, and suppliers.

In the wake of Hurricane Marilyn, September 1995, the Government of the Virgin Islands cooperated with FEMA to launch an extensive, multi-faceted educational program. The three target areas of the efforts were; the general population of the islands, local builders and contractors, and local code administrators, primarily at the Department of Planning and Natural Resources (DPNR).

Professional Education

Because so much of the building stock of the islands was damaged in Hurricane Marilyn, there was a critical shortage of trained professionals. The Virgin Islands government received manpower and materials from FEMA needed to enhance and organize the permitting and inspection processes.

In November 1995, FEMA sponsored a series of California Association of Building Officials (CABO) courses in residential building codes. The California code was chosen because it contains strong seismic requirements (earthquake codes), and the US Virgin Islands are in a high-risk earthquake zone. These classes have been repeated on a regular basis until this day.

A series of NFIP (National Flood Insurance Program) courses was also launched to help inspectors and flood plain administrators learn the National Flood Insurance Program.

In November of 1995, FEMA held a two-day Universal Building Code (UBC) workshop, focusing on wind and earthquake resistant building techniques. Approximately 50 employees attended. This course was held again in early 1996, and repeated after Hurricane Bertha stuck in July of 1996. These subsequent courses were targeted to local builders, architects, and Virgin Island Department of Planning and Natural Resources (DPNR) employees.

A continuing education study course designed to help local inspectors become certified as One and Two Family Building Inspectors was offered to all inspectors. By the time Georges hit in 1998, nearly all inspectors had become certified.

Conducting this training ensured an informed construction and permitting community in the islands.

Community Education

Immediately after Hurricane Marilyn FEMA established mobile Recovery Information Centers staffed by Hazard Mitigation. These mobile centers took the message to those who needed it most, homeowners and builders. By parking at lumber yards, hardware stores and other locations frequented by tradesmen, we were able to distribute documents on the new building codes, and display models showing the use of hurricane straps and clips, as well as other new construction code techniques.

Another focus of the education effort was to take safe building practices into the schools. A mascot, Marvin the Mitigation Mongoose was created and children were involved in contests and poster development.

A wide variety of materials were produced, including a video Stronger, Safer and Smarter, a variety of brochures describing various mitigation measures, plus reproductions of the code and other engineering data of use to building professionals.

The Virgin Islands Territory Emergency Management Agency (VITEMA), FEMA and the boating and marine industry developed its own mitigation plan and produced an excellent educational book by Captain Fatty Goodlander entitled "How to Prepare Your Vessel to Survive a Hurricane in the US Virgin Islands".

A series of 10 weekly radio programs as well as regularly produced articles for newspapers helped to increase the acceptance of the code and its mitigation measures by the general public. A regular theme of the publicity, that the survival of your home depends on how your neighbor's home is built, went a long way toward creating positive peer pressure for code enforcement.

The end result of this effort was seen in the relatively mild damage inflicted by Hurricane Georges. Reports by FEMA inspection teams noted a high level of enforcement of the new code resulting in damage to less than 5% of the homes on the island. Public acceptance and use of the mitigation measures spelled out in the code is also very high. Thus a combination of legislative action, public education, and good technical mitigation measures has resulted in a dramatic lowering of damages in the Virgin Islands.

PUBLIC AND PRIVATE STRUCTURES

Home Protection Roofing Program

Hurricane Marilyn damaged more than 80% of the homes on St. Thomas, 60% on St. John and 40% on St. Croix. Many of the residences damaged by Hurricane Marilyn still had temporary roofing materials as their only source of protection when Hurricane Bertha arrived. The strong wind and rain destroyed many of these temporary protective coverings, creating a need for a full-scale roof protection effort.

Following Hurricanes Marilyn and Bertha, the Government of the US Virgin Islands initiated a comprehensive program to repair damaged roofs.organized an effort to expedite a solution to the unresolved roof problem. This effort is known as the Home Protection Roof Program (HPRP). The Home Protection Roofing Program (HPRP) is providing nearly 400 homeowners with roofs designed to stay on through a category 2 storm.

Immediately following Hurricane Georges, HPRP sites that were under construction and HPRP sites that had previously been completed on St. Thomas, St. Croix and St. John were inspected. Hurricane Georges did minimal damage to HPRP sites from the immediate external damage perspective. Some guttering was lost and some temporary protective measures taken by contractors to protect their construction sites were damaged but on the whole, the HPRP sites were visibly undamaged by the hurricane.

Homeowner stands in front of a newly constructed roof .

Public Schools

Many of the public school buildings were damaged or destroyed by Hurricane Marilyn. Major damage was sustained at schools on St. Thomas including school libraries, classrooms, administrative offices, and cafeterias. The severity of the damage sustained at some schools resulted in school closures requiring modular units to serve as temporary classrooms.

On St. Croix, Central High School suffered serious damage as the hurricane's 150-mph winds destroyed the gymnasium and several classrooms. The gymnasium was serving as a hurricane shelter and residents had to be evacuated during the storm as the building collapsed.

After Hurricane Marilyn the Virgin Islands Department of Education instituted a significant number of mitigation measures. The majority of the mitigation measures undertaken were based on the recommendations contained in the Uniform Building Code as well as proposals made by FEMA. However, a number of the steps taken to mitigate disasters resulted from the Virgin Islands Department of Education's own experience and subsequent study of the damage resulting from Hurricane Marilyn.

Since the storms all buildings and other structures within the Virgin Islands Department of Education are designed as well as constructed to sustain hurricane winds and resist earthquakes. After Hurricane Georges, the schools were reopened within 5 days.

Insurance Incentives

The Virgin Islands licensed property and casualty insurance agencies recognized the value of building structures to withstand storm damage by offering discounts to policyholders. Discounts are available when the construction complies with the USVI building codes and incorporates features such as hurricane shutters, adequate steel reinforcement and roof straps, and elimination or reduction in the length of roof overhangs.

Reductions in insurance premiums are also offered and range from a 5% reduction for no claims filed for a one-year period up to 12.5% reduction for 4 years.

After Hurricane Marilyn, in 1995 more than 10,000 residents filed claims and insurance provider paid out approximately $750 million dollars in damages. Insurance loses after Hurricane Hugo in 1989 were 39% of the total value of the insured properties, after Hurricane Marilyn in 1995 insurance losses were 27% of the total value of the insured properties while after Hurricane George losses are expected to be less than 3%.

HAZARD MITIGATION GRANT PROGRAM

The goal of this report is to describe the mitigation accomplishments undertaken in the US Virgin Islands to reduce future property loss due to hurricanes, and the subsequent economic loss to both the public and private sectors. The objectives of a long-range mitigation efforts are to identify structures damaged, to identify measures that will reduce vulnerability to damage from such events, to provide guidance for the implementation of mitigation measures, and to provide partial funding for eligible activities through the Hazard Mitigation Grant Program

Following is a list of Hazard Mitigation Grant Program projects as a result of Hurricanes Hugo and Marilyn:

Undersea Cable to St. John

Construction of an underwater electrical cable from St Thomas to St. John to integrate the system with the St. John transmission and distribution system.

East End Power Substation

Constructions of an electric substation, including switchgears, underground utilities and transformers on St. Thomas too effectively manage power to St. John.

St. Croix Fuel Pier

Construction of new pier facility to permit the safe delivery of fuel oil to the St Croix Power Generation Plant.

St Croix 1.5 MB Fuel Storage Tank

Construction of an additional 1.5 million-gallon fuel tank adjacent to the two existing tanks and new fuel transfer system to provide additional capacity for fuel storage.

St. Croix Desalinization Plant

Erection of desalinization plant on the Island of St. Croix, and controls necessary to integrate the new plant into the existing system.

Richmond Switch-Gear

Replace the existing open substation at the Richmond Power Plant with an enclosed substation.

Cruz Bay Water Storage Tank

Site preparation and installation of a 500,000-gallon storage tank on the island of St. John.

CONCLUSION

The actual costs of recovering from Hurricane Georges will be a small fraction of what they were after Hurricane Hugo and Marilyn. FEMA spent $321 million to aid in recovery from Hurricane Hugo, the recovery from Hurricane Georges will cost less than $6 million, a savings of $315 million.

The amazing success of the Virgin Islands mitigation activities in minimizing the potential damage from a strong category 2 hurricane is documented in this report. Inspection of the damages caused by the three hurricanes is visual proof that a

community can greatly minimize the potential for loss of life, damage to the infrastructure, and commercial and residential structures from a strong category 2 hurricane.

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