I. Background

1. The Mission

The OECS Mission was deployed on September 19th 2004. Mr. Timothy Antoine, Permanent Secretary in the Ministry of Finance was appointed as the focal point responsible for coordinating all logistical and technical support to the Mission Team. The Members of the Mission are identified below:

Dr. Len Ishmael	OECS, Director General
Dr. Estaban Perez	ECLAC, Regional Headquarters for the Caribbean (Technical Team Leader) Macro-Economist
Ms. Asha Kambon	ECLAC, Regional Headquarters for the Caribbean Social Scientist
Ms. Rosalyn Hazelle	OECS, Social Scientist
Dr. Vasantha Chase	OECS, Environmental Specialist
Mr. Francis Burnette	OECS, Public Health Specialist
Mr. George Alcee	OECS, Agricultural Specialist
Ms. Laurel Bain	ECCB, Macro-economist
Mr. Anthony Payne	USAID, Civil Engineer
Dr. David Smith	Smith Warner International, Coastal Engineer

Local counterparts provided continuous support to this effort. The full list of these colleagues is contained in Annex 1 of this Report.

2. Description of the Phenomenon and its Effects

The State of Grenada, which includes the islands of Carriacou and Petit Martinique, is located in the Caribbean Sea between latitudes 11°59′ and 12°20′ North and longitudes 61°36′ and 61°48′ West. Grenada is the largest and main island, being 18 km (11 miles) wide, 34 km (21 miles) long, and with a coastline of about 121 km (75 miles). It has an area of 312 km^2 (121 sq. miles) (Figure 1).

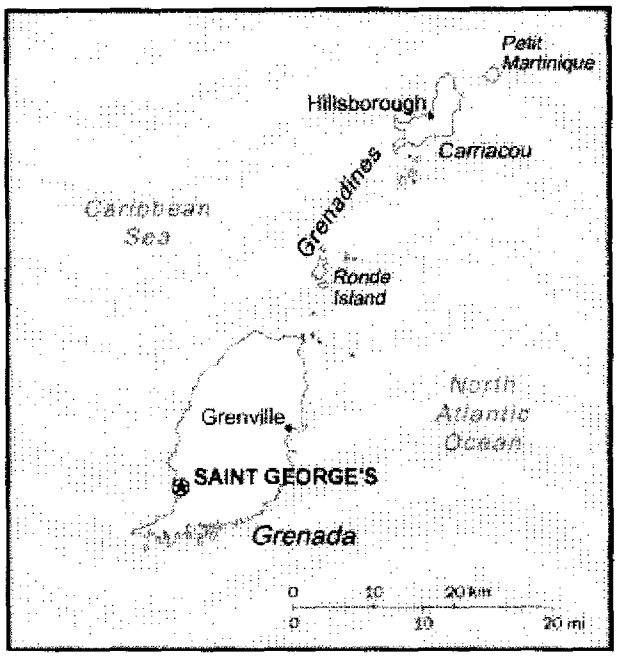

Figure 1 Map of Grenada

On Monday 6th September 2004, at 11:00AM, as Tropical Storm Ivan approached the Windward Islands from the Atlantic Ocean (Figure 2), tropical storm warnings for Grenada were upgraded to Hurricane warnings. As Hurricane Ivan came closer to Grenada, however, winds remained relatively light, less than 10 mph. At 1:00PM on the 7th, the eye of the storm was approximately 35 miles to the ESE of Grenada. Winds measured at the airport were gusting to 40 mph, while the maximum sustained wind speeds recorded by the National Hurricane Centre were of the order of 120 mph.

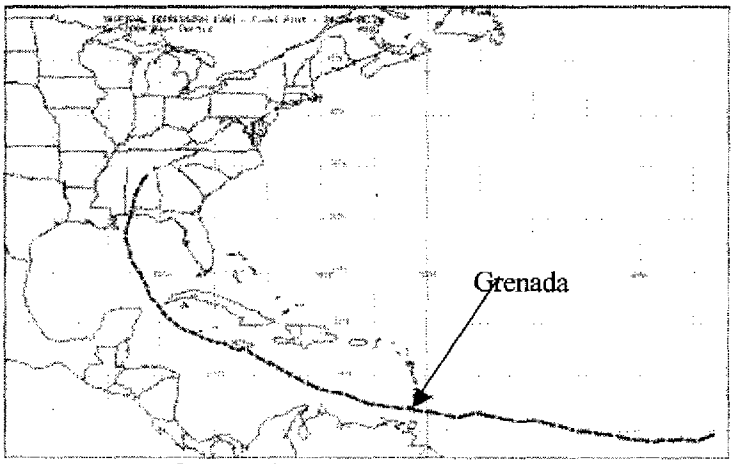

Figure 2 Track of Hurricane Ivan

Conditions in Grenada depreciated rapidly after this, with measured central pressures dropping from 998 mb at 1:00PM down to 955 mb at 4:30PM. Concurrently, wind speeds increased to over 120 mph at the Point Salines Airport, with gusts of over 145 mph occurring between 4:05PM and

4:10PM. By midnight of the 7th, recorded atmospheric pressures had risen to 1000 mb, and winds had dropped to between 40 and 60 mph. Over the following day, wind speeds slowly decreased and atmospheric pressures climbed to 1010 mb.

A satellite image of Hurricane Ivan is presented in Figure 3. This image was taken as the eye of the hurricane was almost directly over Grenada.

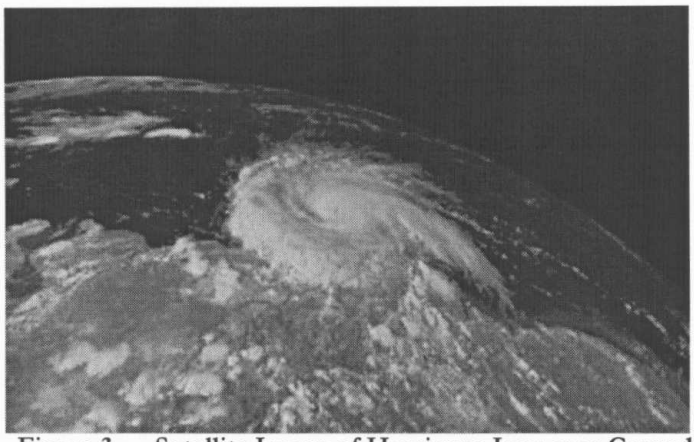

Figure 3 Satellite Image of Hurricane Ivan over Grenada

Damage caused by the storm was extensive, with the worst observed being in the parishes of St. George's, St. David's, St. John's and St. Andrew's. Significant damage to the housing stock was recorded, in the form of wooden houses being totally destroyed, roofing being blown off houses (both concrete and wood), and with concrete walls being knocked down. In addition, electrical poles were downed in many areas of the country, thereby affecting power distribution and telecommunications. Reservoirs and intake structures were adversely affected (fallen trees, silt and general debris). In addition, distribution lines were damaged. This resulted in island-wide disruption of water supply services.

Photo 1 Damaged Housing in St. Georges

As a result of electric poles coming down, telecommunications island-wide were disrupted. This also extended to the cellular network, where antennae were moved out of alignment.

Damage to housing infrastructure was also accompanied by widespread deforestation throughout the island (Photo 2). Anecdotal reports indicate that during the hurricane's passage over Grenada, several small but powerful whirlwinds were noted. These had the effect of exacerbating significantly, the damage that occurred.

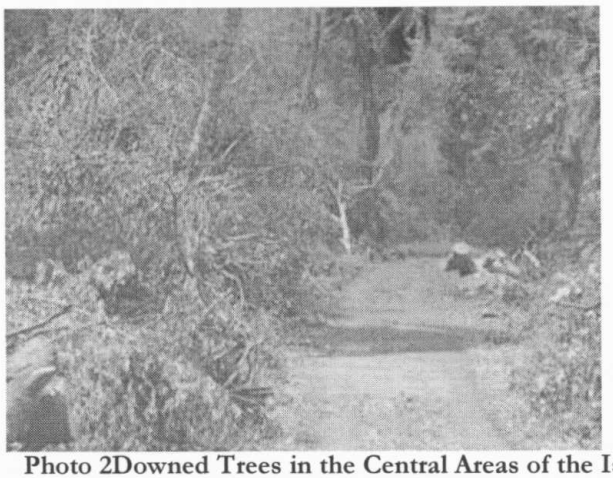

Photo 2Downed Trees in the Central Areas of the Island

Hurricane advisory data taken from the National Hurricane Center (NHC) database, gave information on central pressures during the storm's approach to Grenada. Using this data, along with observed forward speed and maximum wind data, a very preliminary estimate was done of the waves that would have been generated by Hurricane Ivan. This procedure[3] gave waves in deep water approximately 14m in height, with directions to the NW. Once the hurricane passed west of Grenada, wave directions would have shifted to the north. Even though these large waves were generated offshore, they would have been reduced as they traveled inshore, as a result of the large offshore bank that trends in a NE-SW direction off the south and east coasts of Grenada. These banks would have resulted in a significant amount of wave energy loss occurring before the arrival of the storm waves onshore, therefore reducing the amount of damage caused by this phenomenon. This was evidenced by the fact that only limited areas were seriously affected by wave action.

To put the intensity of hurricane generated waves into perspective, the estimated wave heights from Hurricane Ivan can be compared with a wave analysis carried out recently for Grenada[4]. That analysis also involved the use of parametric wave models to derive a data series of wave heights from hurricanes (HURWave). The NOAA database of hurricane records, which dates back to 1900, was used. All hurricanes passing within a 400 km radius of Grenada were selected from the larger database, and wave heights in deep water (greater than 150m deep) computed for those selected occurrences. A statistical analysis was carried out on the data series of wave heights. The following plot (••••••••••• • ▪ • •4) shows the fit of the distribution used to the data series of wave heights.

[3] Young, I.R. 1988. "Parametric Hurricane Wave Prediction Model"

[4] Smith Warner International Ltd. 2004. "Marine Component of EIA for Prickly Bay, Grenada"

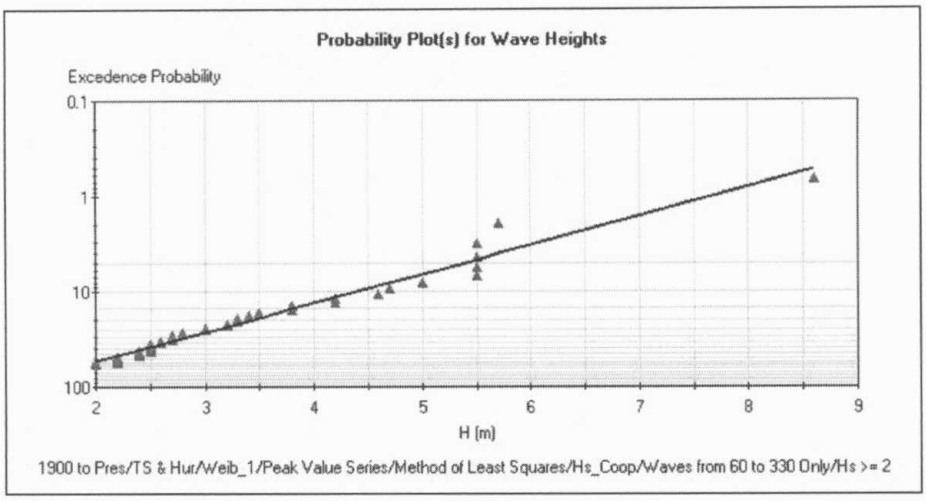

Figure 4 Hurricane Wave Extremal Analysis

Coming out of this analysis, a number of return period events were identified. The results of this hurricane analysis are shown below in Table 1. The probability that a particular wave height would be exceeded within the next 50 years, is also shown in the table below.

Weibull Distribution, k =	1.0		
Correlation Coefficient =	0.971		
Return Period (years)	**Significant Wave Height H_s (m)**	**Wave Period, T_p (s)**	**Exceedance Probability (%) for 50 yrs**
2	1.74	4.68	100.0
5	3.04	6.65	100.0
10	4.02	7.93	99.5
20	5.01	9.10	92.3
25	5.32	9.46	87.0
50	6.30	10.53	63.6
100	7.29	11.53	39.5

Table 1 Results of Statistical Hurricane Analysis

The comparison of the estimate of wave heights, generated under Hurricane Ivan, with those previously obtained for the larger database, indicates that Ivan may have been a more than 100 year event.

Three areas in particular suffered damage form storm surge and wave action. These were the areas of Soubise to Marquis, Rive Antoine and Waltham. At Soubise for example, local eyewitness accounts indicate that the storm surge and wave run-up was in excess of +3.0m above Mean Sea Level. The result of this was that the sea pushed all of the houses along that strip of roadway from the seaward side of the road over to the landward side. Residents subsequently relocated their homes back to their original places after the storm.