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Wider Caribbean Region

Caracas, Venezuela, 28 January-1 February 1980

CARIBBEAN ENVIRONMENT PROGRAMME

ACTION PLAN

NATURAL DISASTERS

OVERVIEW

UNEP/CEPAL

1979

This document has been prepared as a contribution to the joint UNEP/CEPAL project on the environment of the Caribbean (FP-1000-77-01). The views expressed in it are not necessarily those of UNEP and CEPAL

Part I

GEOLOGICAL HAZARDS

1. Introduction

Of the various natural hazards which threaten the borders of the Caribbean, there are none which equal the range of destructive violence of the two geological phenomena of earthquake and volcanic eruption. Earthquakes such as the Jamaica event of 1692, the Caracas earthquake of 1812, and the Guadeloupe earthquake of 1843, demolished most masonry structures and killed about one third of the population; they caused major damage to buildings in zones several hundred kilometres long. There are few early-established cities in the Caribbean which have escaped devastation at least once during the last 300 years by major earthquake.

Volcanic effects are more localized both in the number of Caribbean islands in which they may occur and in the area devastated in a single event, but they can be even more intense in the damage they cause. In the 1902 eruption of Mt. Pelée in Martinique the entire city of St. Pierre and population of 28.000, except for one or two persons, were annihilated.

The objectives of this part of the overview are to describe the nature of these two kinds of geological hazard, the expected recurrence interval between damaging events, the prospects for future prediction of individual events and the various measures which can be taken to protect lives and property. Because there are substantial differences between the distribution, effects and predictability of earthquakes and volcanic eruptions, the two subjects will be treated under separate headings.

2. Earthquake distribution and magnitudes from instrumental records

The evaluation of seismic hazard for any region of the world will be limited by the quantity and quality of available observations. For the Caribbean region, the relevant data consist firstly of instrumental measurements, made with progressively increasing accuracy, over the last

/80 years;

80 years; secondly, they include historical reports of felt and damaging earthquakes which begin about 300 years ago and, like the instrumental readings, become more detailed and more reliable from the biginning to the end of the time interval in question.

The instrumental readings constitute the most important set of data, forming the basis of epicentre maps (figures 1 and 2) which show the geographic distribution of recent activity, and cross sections (figures 3 and 4) which illustrate focal depths and the subsurface orientation of active fault zones. Instrumental measurements also provide a basis for determining the dimensions of the rupture zone, the energy attenuation characteristics, and the effects of uncompacted near-surface layers at sites of particular interest.

The salient features of earthquakes distribution in the Caribbean are that for the 55-year period from 1898 through 1952 the earthquakes of Richter magnitude 5 or greater were more or less evenly distributed around the north, east and south borders of the Caribbean Sea, confirming the concept that the Caribbean sea-floor is an internally rigid slab of lithosphere with uniform long-term rates of displacement along its boundary with the encircling Atlantic-Americas plate.

In contrast with figure 1, the distribution of earthquakes for the shorter and more recent period from 1953-1976 (figure 2) shows several conspicuous seismicity gaps in the circum-Caribbean belt, including one with a length of 1,200 km, from the Cayman Islands through Haiti which has had a significant absence of larger earthquakes since 1953 and even less (no earthquake of magnitude greater than 5.4) since 1964. The deficit in earthquake energy release along this part of the seismic belt, calculated by reference to the mean energy release rate for the past 80 years around the entire Caribbean borders, amounts to a single earthquake of Richter scale 8 1/4. Two other smaller segments of the circum-Caribbean which have remained quiet since 1953 are the southern Lesser Antilles between 11.5° and 14°N, and northeast Venezuela between 64° and 67°W. All three of these areas which represent recent seismicity gaps showed normal activity in the preceding interval between 1898-1952 (figure 1), and it can therefore be

/Figure 1

CONTENTS

Figure 1

CARIBBEAN EARTHQUAKE EPICENTRES 1898-1952

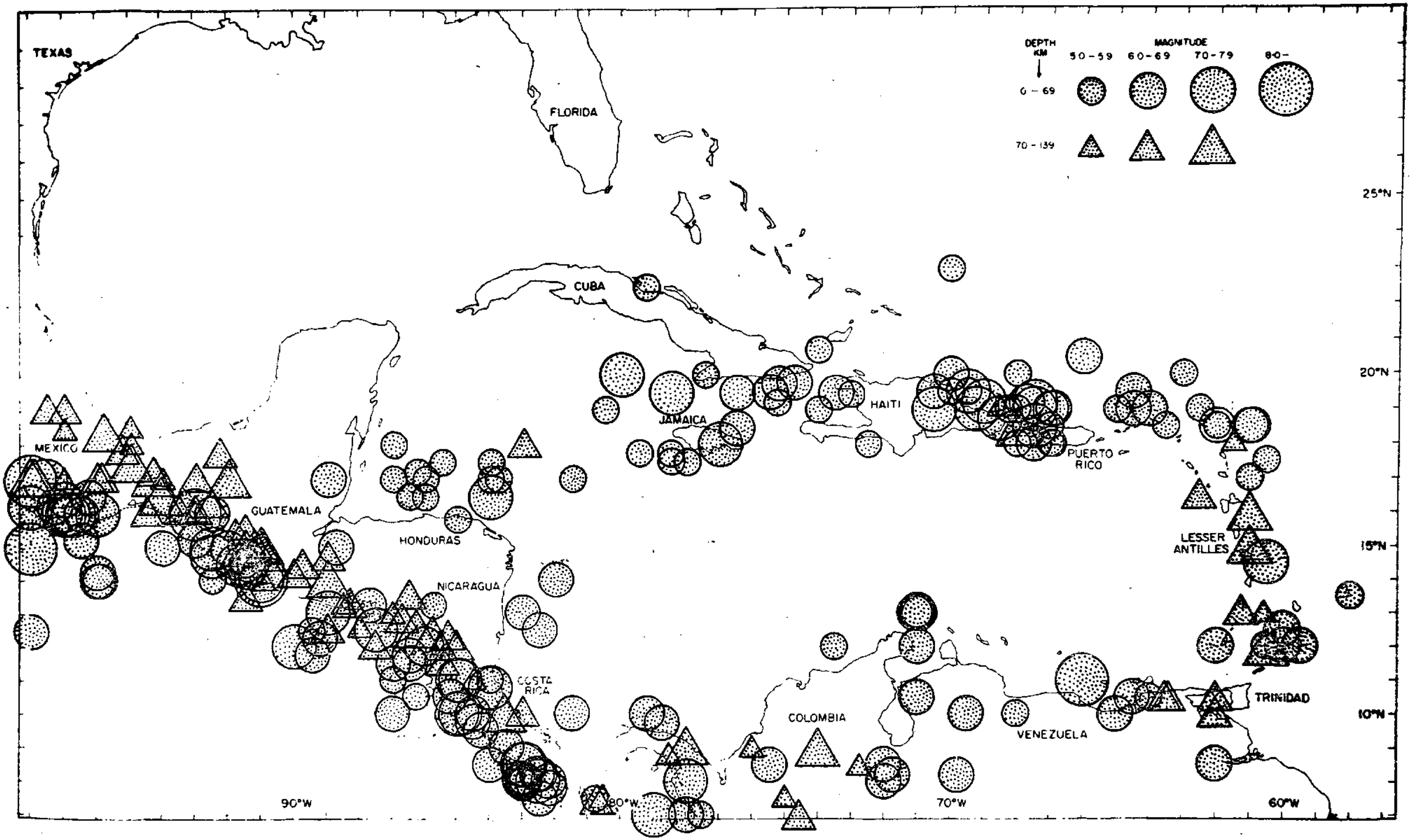
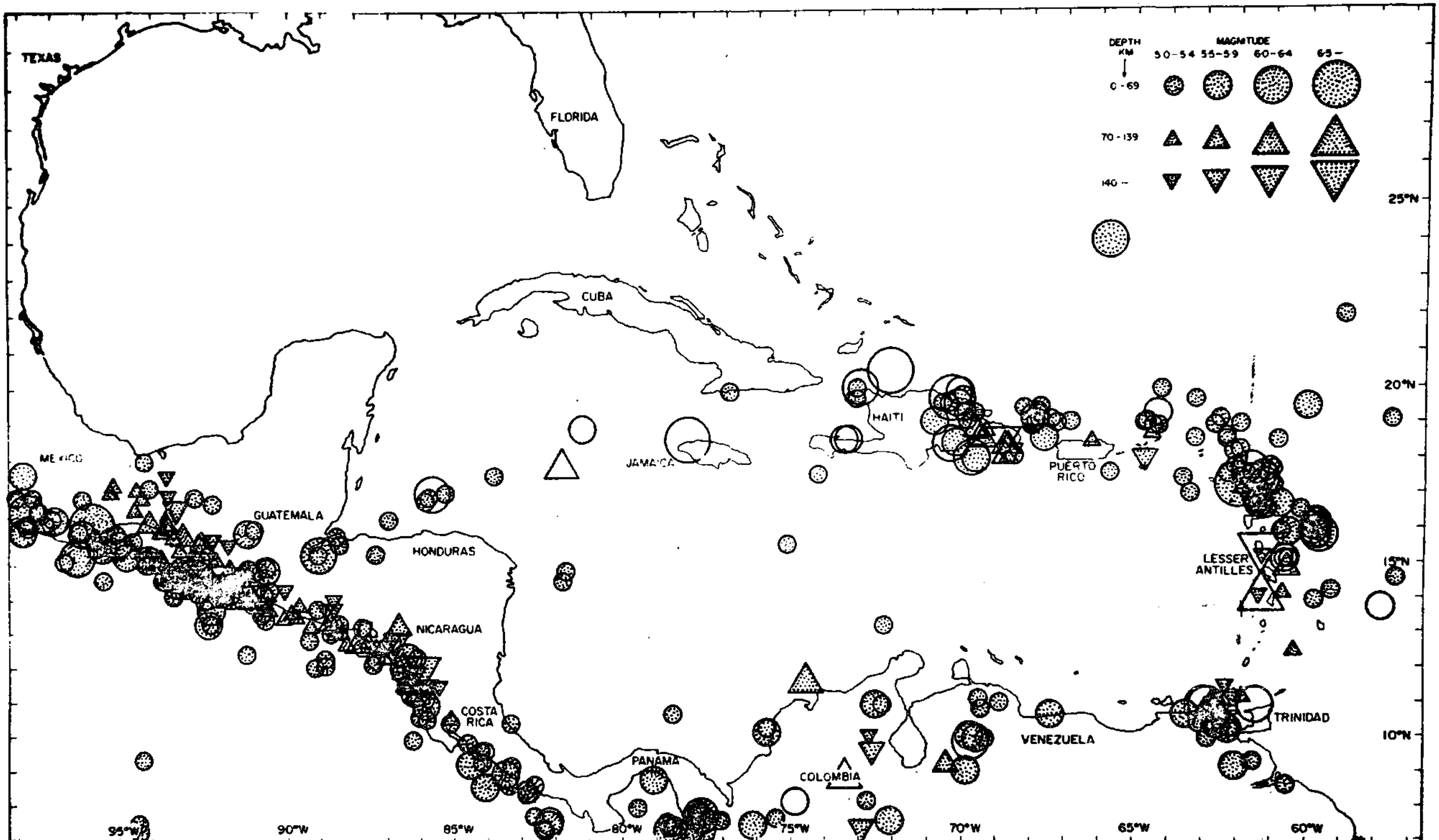


Figure 2

CARIBBEAN EARTQUAKES 1953-1963 (OPEN CIRCLES) AND 1964-1976 (DOTTED CIRCLES)



concluded that the present deficits in earthquake energy release are temporary and will ultimately be compensated by higher than normal activity. The longer the time interval and geographic segment of the seismic belt which remains anomalously quiet, the greater is the potential for a major earthquake (Kelleher et. al., 1973).

Comparisons of the rate of seismic energy release per unit length of the tectonic belt show that the mean rate for the circum-Caribbean is about one third of that for the Pacific coast of Central America, and two thirds that of the California coast.

3. Probabilistic estimates of hazard from instrumental data

In the absence of readily identifiable precursors to most large earthquakes, the best that can be done is to assess the hazard in probabilistic terms. For engineering and land use planning purposes, it is becoming common practice to express the hazard by a value such as the maximum bedrock acceleration with a 10% probability of exceedance in 50 years, and to draw maps showing iso-acceleration contours. To arrive at an estimate for this acceleration value, four basic steps are necessary, which are:

(a) to determine the recurrence intervals for each of a range of magnitude steps from about 5 upwards on the Richter scale. For this purpose, it is necessary to take average values over a segment of the seismic belt and time interval large enough to provide a statistically meaningful set of magnitude observations;

(b) to determine the dimensions and orientation of the local earthquake source zone(s). This involves the careful examination of maps and cross-profiles of earthquake hypocentres and geological structures such as major faults;

(c) to adopt a set of values representing the relations between (a) earthquake magnitude, (b) distance from the causative fault, and (c) bedrock acceleration, which are judged appropriate for the region in question. For the Caribbean, this involves the adoption of a series of empirical values obtained in one or more different parts of the world where the required measurements have been made. It assumes but does not establish, that seismic wave attenuation with distance is the same in the different areas.

/(d) to

(d) to calculate the sum of probabilities, for all magnitude levels considered, that a given acceleration will be exceeded during the chosen time interval at the point or along the zone of interest.

An example of the most elementary approach to the above calculation is given in table 1, which illustrates that for the mean magnitude-recurrence relations established for the circum-Caribbean as a whole for the interval 1898-1976, and using the magnitude-distance-acceleration curves of Schnabel and Seed (1973), the bedrock acceleration value with a 10% probability of exceedence in 50 years is 0.39 G for a location which lies directly within, i.e. at the surface outcrop of one of the principal seismic source zones. It is worth noting from table 1 that the largest magnitude (Richter 8 1/2) earthquake (with very low probability of occurrence within effective range of the target location) represents a slightly smaller contribution to the sum of probabilities than does an earthquake of Richter magnitude 7 for which the lower energy is more than compensated by the relatively high probability of occurrence within critically close range of the target location.

Various computer-based techniques have been developed (e.g. Cornell, 1968) for summing the effects of different source zones and for drawing iso-acceleration maps. It should, however, always be kept in mind that the reliability of the results of any such computations will depend almost entirely on the quality and quantity of the seismic and geological observations used as input, and that no amount of numerical manipulation will reduce the uncertainties inherent in measurements which are few in number, questionable in quality or in applicability to the region being considered.

4. Earthquake hazard assessment from historical damage records

Whereas instrumental measurements of earthquakes began only 80 years ago, and initially on a primitive basis, historical records of the surface effects of the strongest earthquakes are available for the Circum-Caribbean region since about 300 years ago (Robson, 1964; Tomblin and Robson, 1977). The obvious advantage of the historical damage record is that it extends

/Table 1

Table 1

PROBABILITY CALCULATION FOR BEDROCK ACCELERATION 0.1G IN CARIBBEAN EARTHQUAKES

M	Richter mag.	M_s	8½	8¼	8	7¾	7½	7¼	7	6¾	6½	6¼	6	5¾	5½	5¼
R	Radius ≥ 0.1G	km	110	103	96	88	80	71	62	53	44	40	37	33	29	11
A =	πR^2 = Area of ≥ 0.1G	$km^2 x10^3$	38	33	29	24	20	16	12	9	6	5	3.6	3.4	2.6	0.4
L	Rupture length	km	600	450	300	250	200	150	100	80	60	45	30	20	12	8
A_e	Extra area due to rupture	$km^2 x10^3$	120	90	58	44	32	21	12	8.4	5.3	3.6	2.2	1.3	0.7	0.2
A_t	Total area of ≥ 0.1G	$km^2 x10^3$	158	123	87	68	52	37	25	17	11	8.6	5.9	4.7	3.3	0.6
A_p	A_t as proportion of sector $200x10^3$ km^2		.79	.62	.44	.34	.26	.19	.12	.09	.06	.04	.03	.024	017	.003
D =	Depth factor for low magnitude deep events		1	1	1	1	1	1	.8	.66	.53	.45	.37	.31	.05	.11
N	No. of events in 50 yrs in sector $200x10^3$ km^2		.07	.10	.15	.23	.35	.52	.80	1.2	1.8	2.8	4.2	6.5	1[illegible]	15
A_pDN	No. of events ≥ 0.1G in area A per 50 yrs		.06	.06	.07	.08	.09	.10	.08	.06	.05	.05	.04	.05	.04	-
P_{50}	Probability of ≥ 0.1G in area A per 50 yrs		.06	.06	.07	.08	.09	.10	.08	.06	.05	.05	.04	.05	.04	-
$\sum P_{50}$	$=1-(1-P_{8½})(1-P_{8¼})$ etc.			.12				.31		.46					.56	. -

/over a

over a time interval corresponding to the return period of larger earthquakes, and in theory should help to test the significance of any shorter-period fluctuations in activity, such as gaps or strong concentrations of activity in particular segments of the belt, which were identified in the shorter, instrumental record.

The main disadvantages of the historical damage record are that it refers only to the locations and type of structures which existed in earlier times, and that the data do not form an adequate basis for estimating numerical values such as acceleration or for identifying seismic source zones. The historical records do, however, confirm that most of the early-established cities around the Caribbean margins have suffered at least one devastating earthquake, and also that several earthquakes have occurred which from the long length of the zone of destruction, e.g. 650 km from Merida to Caracas in 1812, probably had Richter magnitudes of 8 to 8 1/2.

The frequency of damaging earthquakes, based on the total historical record, range between 3 and 8 per century for different islands of the Lesser Antilles, to 14 for Port of Spain, Trinidad, and 17 in Kingston, Jamaica. The lower damage frequency for the Lesser Antilles compared with Trinidad and Jamaica, reflects the greater distance of most of the Lesser Antillean islands from the primary seismic source zone (compare figures 3 and 4).

5. Recent increases in exposure to earthquake hazard

The most disturbing single feature of the geological hazards in the Caribbean is that, especially in the case of earthquake, the level of exposure to them has increased so greatly in the last few decades. The prime reason for this is the general move to masonry (especially high-rise) buildings in place of traditional wood or tapia houses and the high level of investment in industrial complexes and comparable structures such as dams, pipelines, electric power transmission grids and harbour facilities, all of which are vulnerable to earthquakes. This means that an earthquake which migh have damaged 5% of total property and affected 5% of the gross national product 50 years ago in what was then a primarily agricultural community living in simple wooden or tapia houses, may now destroy 50% of all property and dislocate a similar proportion of industrial production for several years.

/Figure 3

Figure 3

CROSS-SECTIONS NORMAL TO THE AXIS OF THE LESSER ANTILLES, SHOWING EVENTS FOR THE INTERVAL 1964-1970 PROJECTED INTO PROFILES REPRESENTING THE NORTHERN (TOP SECTION) CENTRAL AND SOUTHERN (BOTTON SECTION) PARTS OF THE SUBDUCTION ZONE

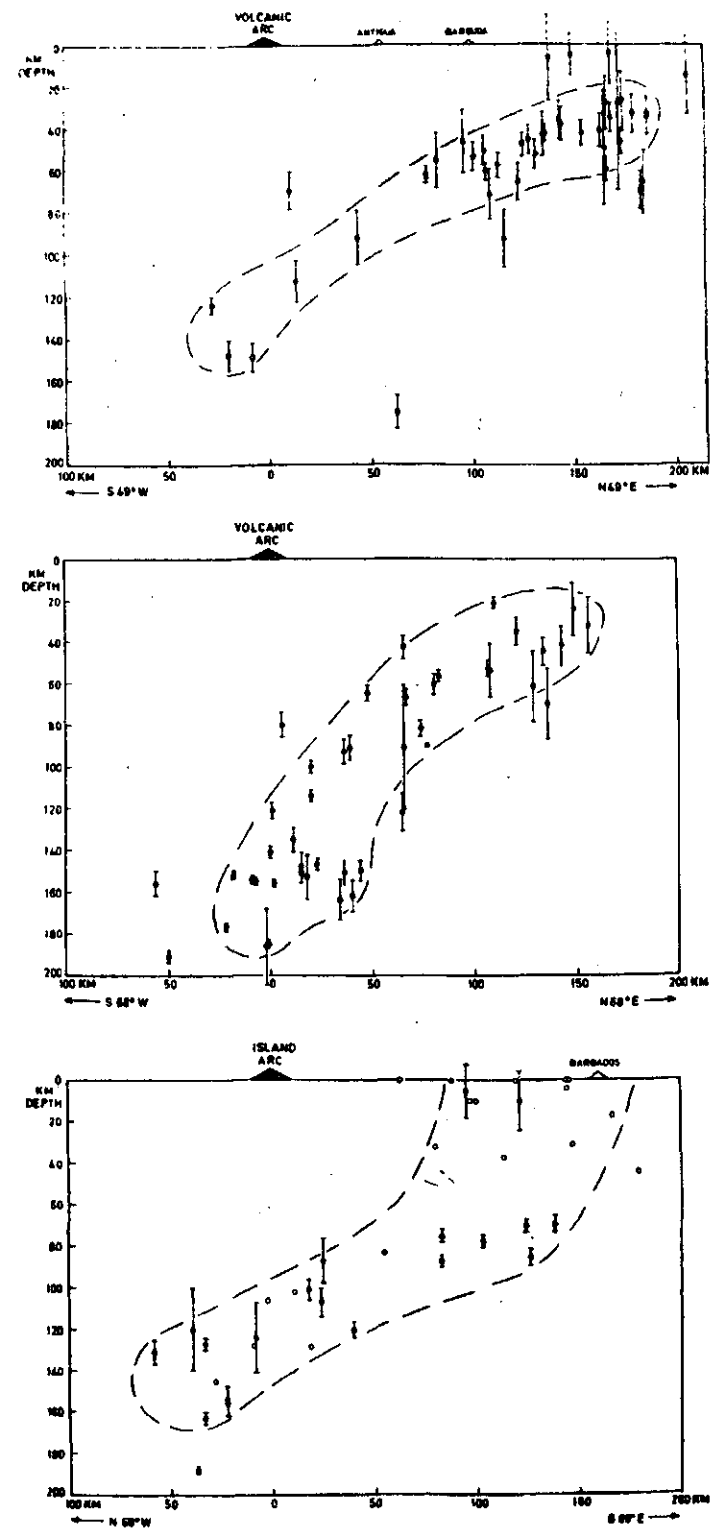
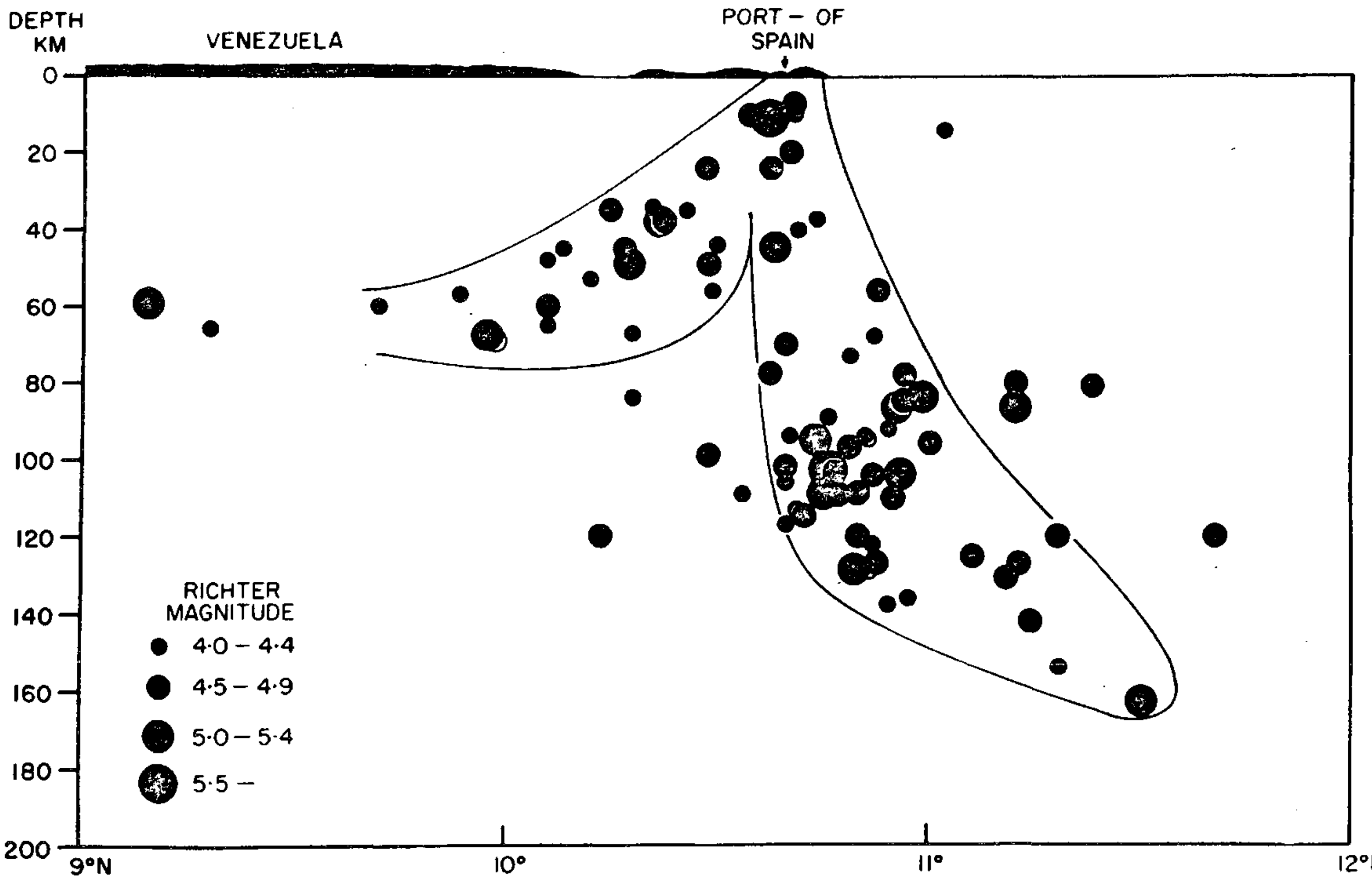


Figure 4

CROSS-SECTION SHOWING LARGER EARTHQUAKES NEAR TRINIDAD (BETWEEN 61° 63°W FOR YEARS 1964-1972) PROJECTED INTO A SINGLE NORTH-SOUTH PROFILE. THE LOBE TO THE RIGHT REPRESENTS THE EL PILAR FAULT ZONE WITH ACTIVITY TO A DEPTH OF 160 KM; TO THE LEFT IS THE ACTIVITY ON THE LOS BAJOS ZONE, MOSTLY LESS THAN 70 KM IN DEPTH



/It is

It is also true, although perhaps not generally realized, that whereas masonry houses by their large mass provide considerably better resistance to hurricane than lightweight, wooden structures, the opposite is true of masonry houses in earthquake. A similar shift in vulnerability also applies to shifts in the base of the gross national product: whereas in the past this depended mainly on agriculture, which was much more exposed to hurricane than to earthquake damage, the present shift to increasing industrial development means that the economic losses due to reduced agricultural output as a result of hurricane, become less significant. From the above it can be appreciated that the level of ground shaking which represented only a minor hazard 50 years ago in the Caribbean, has today become a much more significant hazard.

6. Volcanic hazards: geographical distribution and physical properties

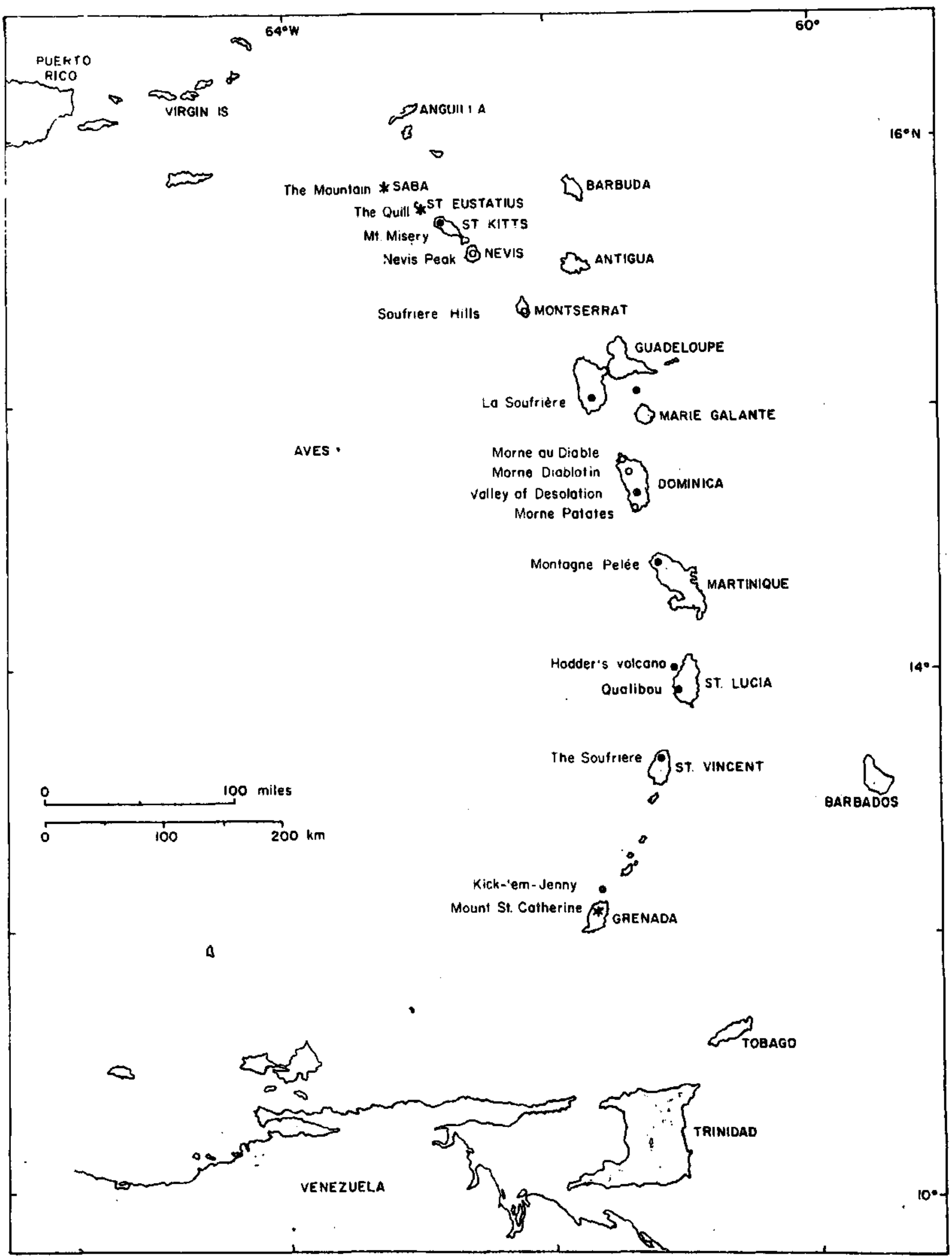
Volcanic hazards affect a much more restricted area than tectonic earthquakes. In the Caribbean, eruptions are likely to cause major damage mostly within about 10 km, and only exceptionally at greater distances, from the dorman volcanoes of the Windward and Leeward islands of the inner arc between Grenada and Saba (see figure 5).

By far the most serious type of volcanic hazard is that arising from the eruption of glowing avalanches. These consist of hot, high-density clouds of lava fragments and fine dust suspended in rapidly expanding gas, with a temperature upon emission from the vent, of about 1,000°C. The bulk of this material is denser than the surrounding air and therefore remains close to the ground, flowing preferentially down river valleys and other topographic depressions. The flow will emerge mostly over the lowest part of the crater rim, although if the eruption is large enough, material will flow radially in all directions from the crater. The high gas content and pressure at emission from the crater, results in the rapid expansion of the glowing avalanche and a capacity for self-propulsion downhill at speeds which may exceed 100 kilometres per hour.

/Figure 5

Figure 5

DORMANT VOLCANOES OF THE LESSER ANTILLES. SOLID CIRCLES = VOLCANOES WITH RECORDED ERUPTIONS. OPEN CIRCILES = VOLCANOES EXHIBITING STEAM VENTING. BUT WITH NO HISTORIC ERUPTIONS. ASTERISKS = VOLCANOES WITH WELL-PRESERVED MORPHOLOGY, PROBABLY HAVING ERUPTED WITHIN THE LAST FEW THOUSAND YEARS



/The distance

The distance travelled by a glowing avalanche depends mainly on the volume emitted in one explosion. It is common for the larger glowing avalanches to travel 5 to 10 km from the crater. The maximum distance travelled from the crater by a historic glowing avalanche is 30 km, at Bezymianny in 1956 (Gorshkov, 1959): trees were snapped and set on fire at this distance. Prehistoric glowing avalanches at Crater Lake, Oregon, have been traced to straight-line distances of 55 km from their source (Williams, 1942). The thickness of deposits from a single flow is variable, but may locally exceed 20 m, especially in former valley floors.

The combination of high velocity and high density provides a pyroclast flow with tremendous kinetic energy. It is normal for all vegetation including forests to be razed, and sometimes even the tree stumps are removed and the land scoured of unconsolidated soil or ash layers. At the Pelée 1902 eruption, in the city of St. Pierre, massive buildings in stone were demolished, and ships in the harbour were totally stripped of their superstructure.

The physiological effects upon and animals are usually lethal; the principal cause of death appears to be asphyxiation from breathing a mixture of steam laden with hot dust. In addition to internal burns in the mouth and respiratory system, severe external burns may occur on parts of the body not protected by clothing. At St. Pierre in Martinique many people were dismembered by flying debris, but at other historic eruptions this was not reported to be common.

7. Other types of volcanic activity which constitute a hazard to human populations

Hot avalanches are by far the most dangerous feature of West Indian eruptions, but significant damage may also be caused by two other types of volcanic activity, namely Vulcanian eruptions and mudflows. Major catastrophes may also be caused indirectly by large submarine eruptions which produce tsunami.

Vulcanian eruptions consist of large vertical explosions in which pyroclasts are carried to heights of many thousand feet before falling back on and beyond the flanks of the volcano. Areas close to and especially down-wind of the active crater are most vulnerable. Pebble and larger

/fragments may

fragments may strike and kill people, whilst larger pyroclasts can puncture house roofs, and if hot enough may also cause fires. Thick deposits of fine ash, which are especially likely in the sector down-wind of the volcano, may also cause roofs to collapse. At the Japanese volcano Komagatake in 1929, (Kozu, 1934) house roofs as far as 11 km down-wind of the volcano collapsed under the weight of pyroclast fall deposits over one metre thick, in which the largest lumps measured up to 10 cm in diametre, whilst at 6.5 km distance, blocks of greater than 40 cm with red hot cores set many houses on fire. At the Soufrière of St. Vincent in 1902 (Anderson and Flett, 1903) blocks of up to 25 cm in diametre fell at a distance of 8 km from the crater, and up to 5 cm at a distance of 20 km from the crater.

Damage and danger to life may also result from mudflows, which are a special hazard at volcanoes with large crater lakes (e.g. the St. Vincent Soufrière in the West Indies). The water, mixed with ancient deposits from the lake floor plus new pyroclastic material, is likely to be blown out during the first strong explosions at the beginning of an eruption. Mudflows are a solid plus liquid mixture and travel down the major valleys of the volcano, especially those which head up to the lowest part of the crater rim. The distribution pattern of mudflows is therefore comparable with that of hot avalanches. "Secondary" mudflows develop when torrential rain falls on slopes covered by unconsolidated volcanic ash, and may be a hazard during periods of heavy rain both during and for several years after an eruption.

Tsunami or giant sea waves are produced by the sudden displacement of a large volume of sea water and one of the possible causes of this is a large volcanic eruption below or at the sea surface. The most dramatic and disastrous example in the historic record is the eruption of Krakatoa, off Java, in 1883 (Neumann van Padang, 1951). An eruption of this island volcano began on 20 May 1883, and reached its climax between 26 and 28 August in the same year, when massive quantities of fresh magma were erupted, after which two thirds of the pre-existing island (a volume of about 4 cubic miles) collapsed below sea level. A giant sea wave, which in some bays reached a height of 120 feet, swept the adjacent coasts of Java and Sumatra up to 200 km distant from the volcano, drowning 36,000 people. This is the largest recorded human disaster resulting from a volcanic eruption.

/In the

In the eastern Caribbean, four submarine volcanoes have been reported active in historic time, and there are probably numerous others in the region which have erupted in historic or recent prehistoric time, but which have not been identified. A very small sea wave was generated by a submarine explosion at Kick-'em Jenny volcano, north of Grenada island on 25 October 1965 (Robson and Tomblin, 1966). Although no large submarine eruption has occurred in the past 200 years in the West Indies, a future eruption of this type remains a possibility. Many people in the Lesser Antilles live and work at elevations not more than sixty feet above sea level, and a wave of this height could drown many thousands. If a submarine volcano were threatening to become violently active, it might be wise to move people and transportable property from low-lying coastal areas in adjacent islands.

8. Prediction and probability statistics for destructive volcanic eruptions

The essential problem of volcanic prediction is not the identification of the onset of an eruption, but the assessment of the level to which the activity will ultimately escalate, and the rate of escalation. There are no specific precursors to the emision of glowing avalanches, and it is therefore necessary to assess the situation on a probabilistic basis, utilizing:

(a) global statistics for the onset of glowing avalanche emission as a function of time elapsed after the beginning of the eruption;

(b) regional statistics on the ratio of eruptions which have included glowing avalanche emission to those which had no associated avalanches;

(c) a weighting factor to take into account the trend of activity, if increasing or decreasing, at the eruption in question.

From recent studies made at the Seismic Research Unit on the first two of the above items, the time interval has been determined, for each of the world's 43 best-described glowing avalanche eruptions, between the onset of eruption and the emission of the first glowing avalanche. From these intervals, an assessment can be made of the probability that the first glowing avalanche is yet to be erupted as a function of time elapsed since the eruption onset. Of the eruptions studies, 4 out of 43 (9%) escalated to nuées in less than 2 1/2 hours, and 19 out of 43 (44%) led to the first nuée within 2 days of the eruption onset. From the above it can be concluded, conversely, that if glowing avalanches are to be emitted at all during an eruption, at 2 days elapsed there is a 56% probability that the first glowing avalanche is yet to be emitted.

In order to assess the hazard of glowing avalanches as a function of any eruption onset, the data were collected from 11 volcanic regions with historical glowing avalanches, and it was found that the Lesser Antilles in which 4 (and possibly a fifth) out of 15 historic eruptions have led to glowing avalanches, have had a very much higher ratio of glowing avalanche to total eruptions than any other region of the world (compare Melanesia with 11 out of 106, Kamchatka with 7 out of 120, Indonesia with 28 out of 550, and Japan with 5 out of 229).

To obtain the probability as a function of time elapsed that any eruption will emit a glowing avalanche, the probability values for emission of the first nuée as a function of time elapsed are divided by the different regional factors for the ratio of glowing avalanche to total eruptions. The resulting curves are shown in figure 6. This illustrates that for the West Indies, there is about a 10% probability that any eruption, once started, will escalate to glowing avalanches sometime within the first day; that at the end of the first day there remains a 17% probability that a glowing avalanche will be emitted at some later time during the course of the eruption; that at the end of 10 days this probability is 11% and at the end of 100 days it is 5%. These statistics assume that the world-wide data for time intervals between eruption onset and first avalanche are applicable to the West Indies, and that there are no consistent differences between the individual volcanoes of the West Indies in the probability that an eruption onset will lead to glowing avalanches. Our present geological knowledge does not contradict these assumptions.

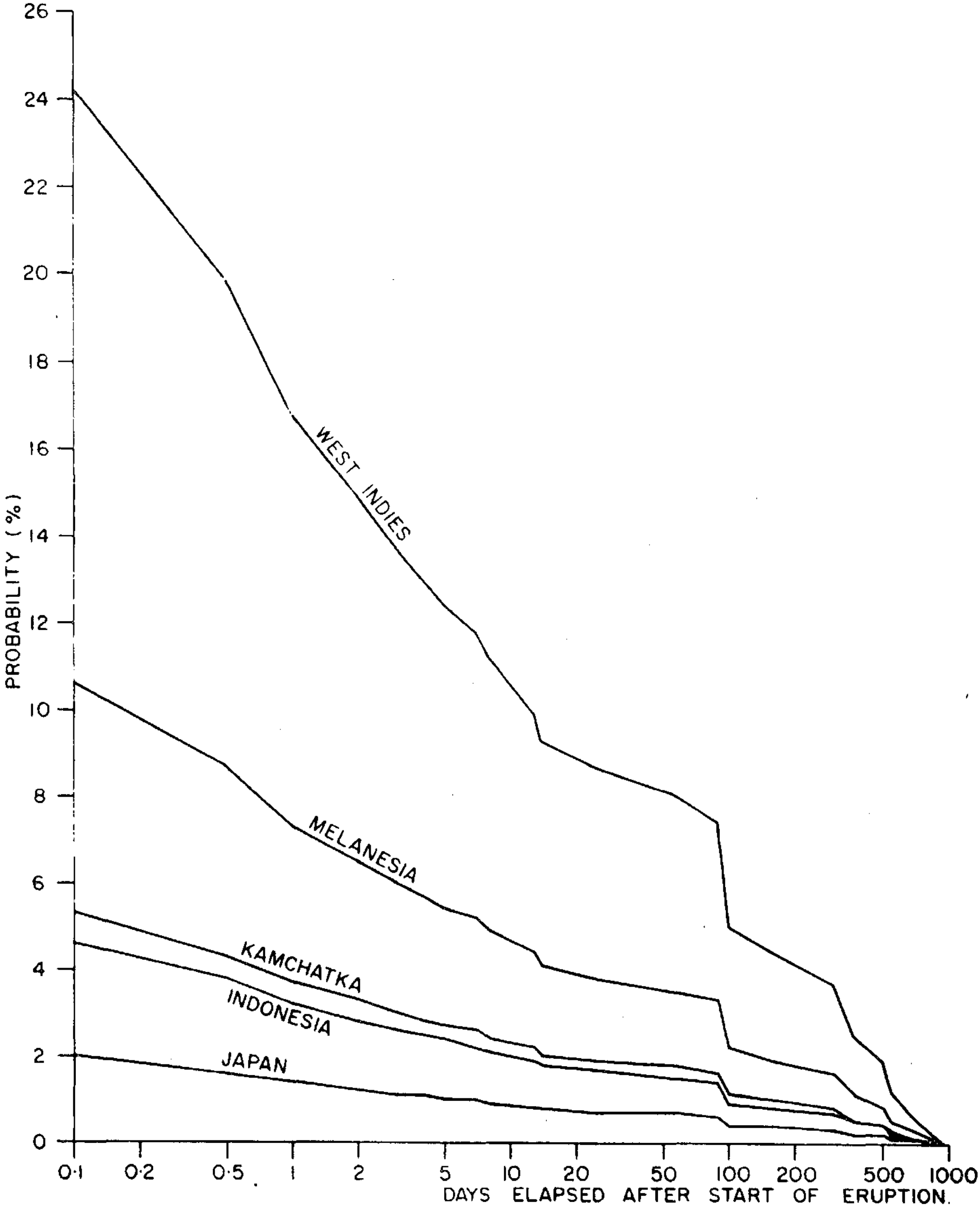
Finally, and most importantly, the above probability statistics will need to be weighted by a factor corresponding to the trend of current activity at the eruption in progress. No formula for quantifying the various observed parameters can be easily established, but the weighting factor should be based on the collective judgement of the observing and suitably experienced scientists.

/Figure 6

Figure 6

PROBABILITY THAT THE FIRST NUEE IS YET TO BE EMITTED

Based on 43 eruptions



9. Risk mitigation

Action required for the reduction of future losses from earthquake and volcanic hazards, falls into two main categories. These are firstly the collection by scientists of the best possible measurements on the nature, recurrence intervals and geographic extent of the hazards, plus the development of a capability for the reliable prediction of individual events. Secondly, on the part of civil authorities, there is a need for the assessment of what level of risk is acceptable in the light of the existing national economic and social conditions, and the establishment and implementation of the appropriate land use and earthquake-resistant building regulations. A general guide to the respective roles of scientists and civil authorities, and the sequence of actions required on each side and interactions between the two, is given for earthquake in table 2 and for volcanic emergency in table 3. It is worth noting that there are wide discrepancies between different Caribbean countries in the balance between the level of exposure to hazards and the level of scientific and or governmental interest in monitoring the hazards. Some of the more conspicuous deficiencies in scientific monitoring programmes have been identified in the paper by Tomblin (1977).

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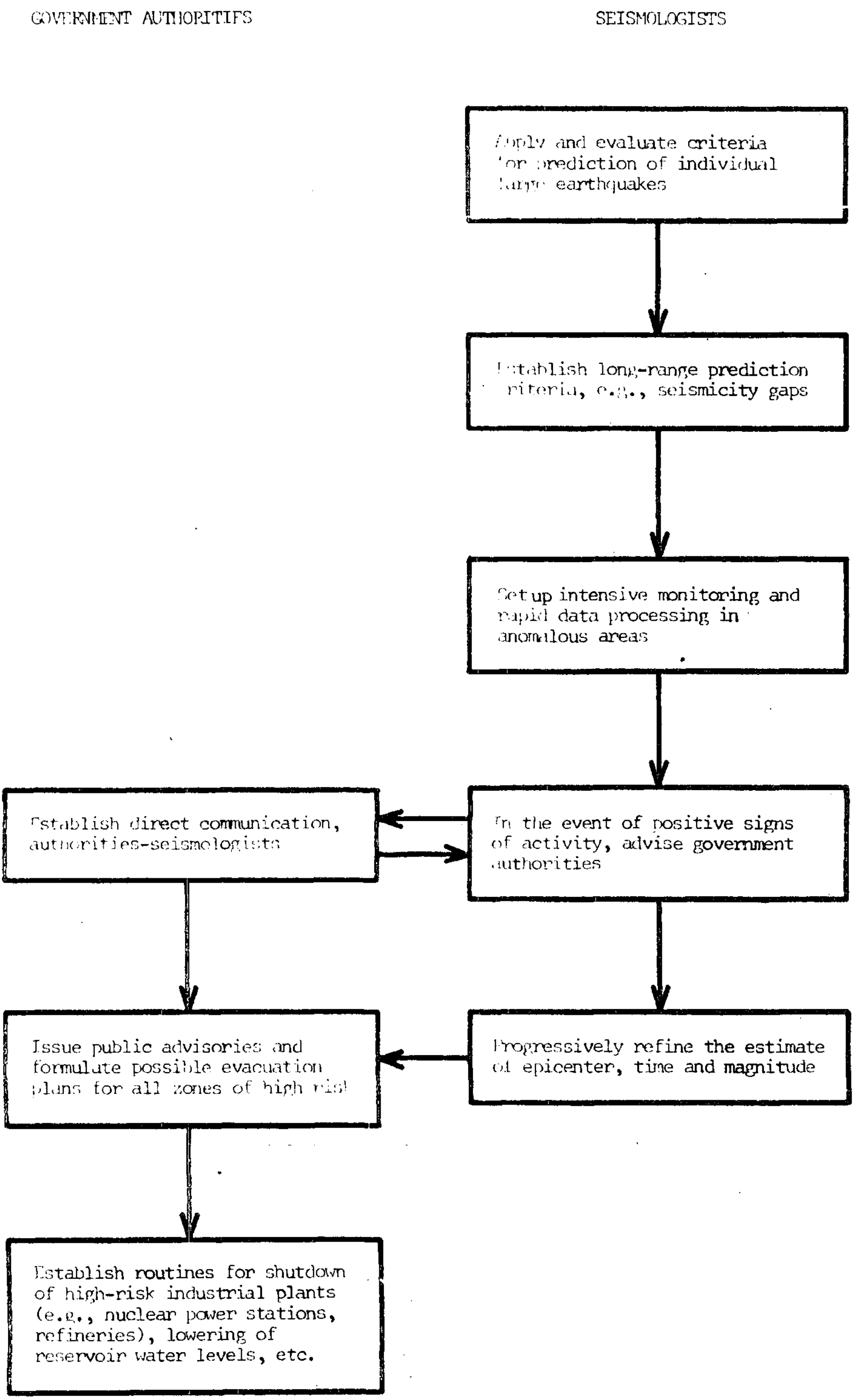
/Table 2

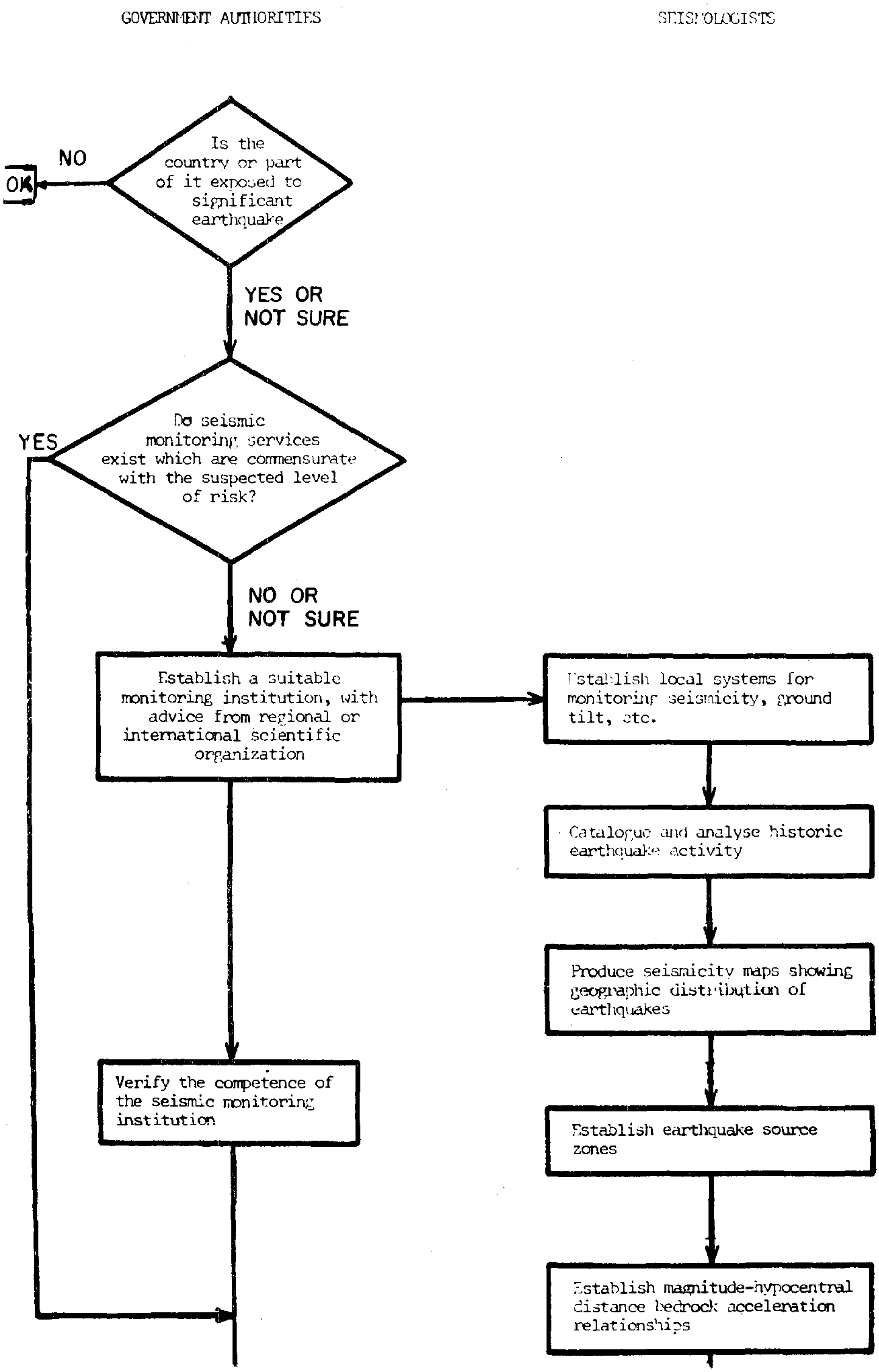
Table 2

A. PREDICTION OF SPECIFIC EVENTS



B. PLANNING FOR MITIGATION OF EARTHQUAKE DISASTERS

LONG RANGE PLANNING



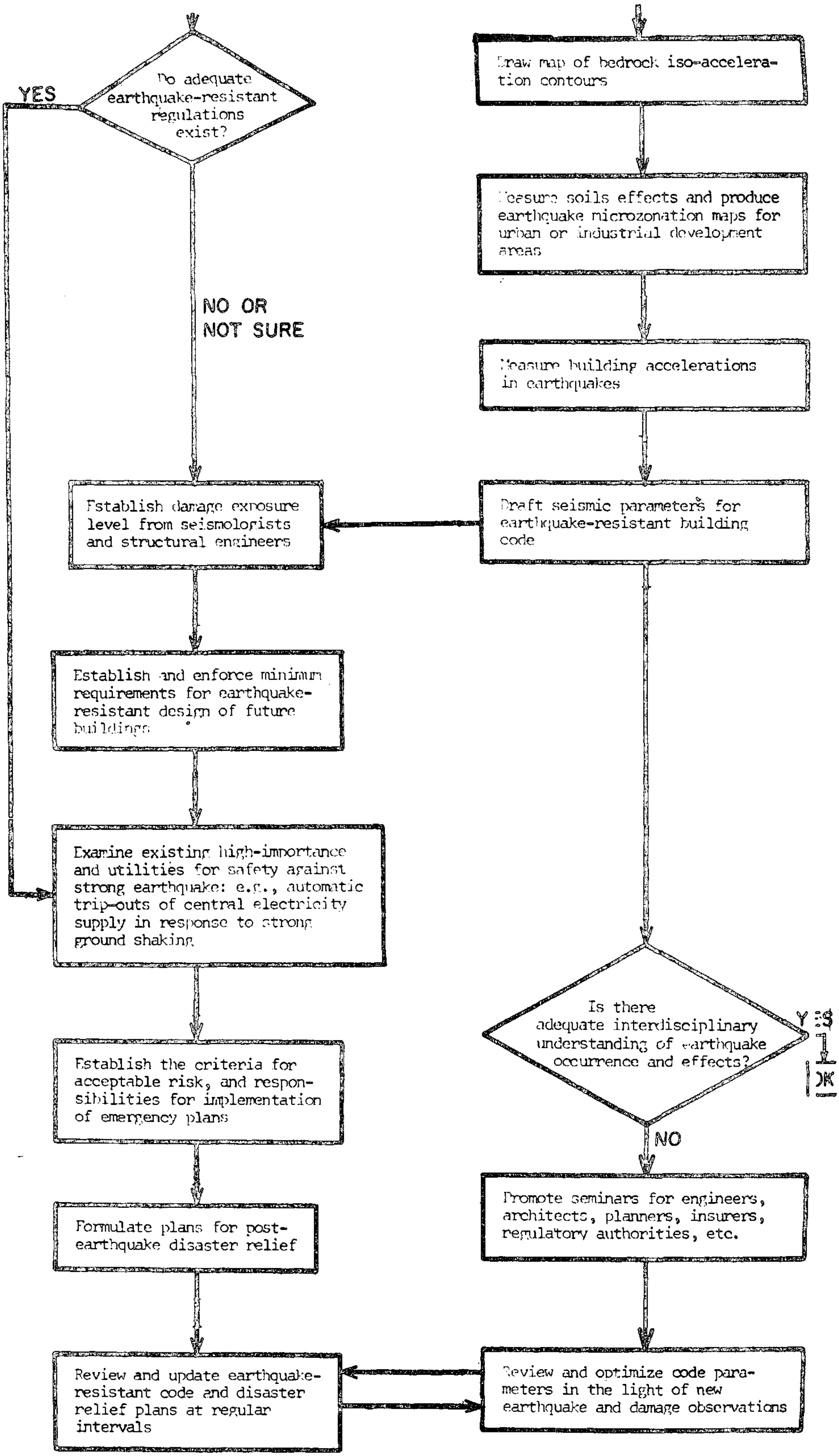
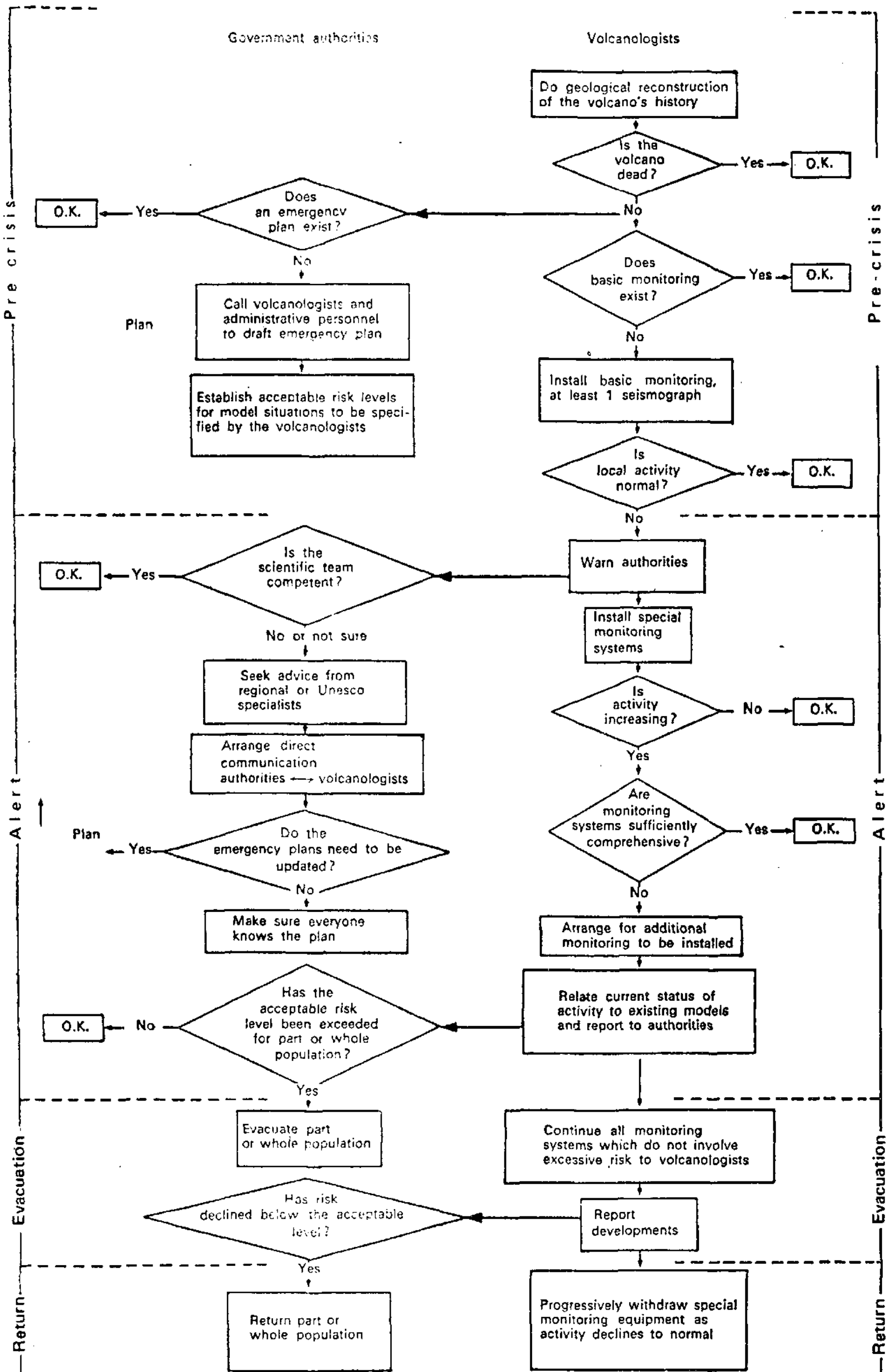

Do adequate earthquake-resistant regulations exist?
YES
NO OR NOT SURE
Draw map of bedrock iso-acceleration contours
Measure soils effects and produce earthquake microzonation maps for urban or industrial development areas
Measure building accelerations in earthquakes
Draft seismic parameters for earthquake-resistant building code
Establish damage exposure level from seismologists and structural engineers
Establish and enforce minimum requirements for earthquake-resistant design of future buildings
Examine existing high-importance and utilities for safety against strong earthquake: e.g., automatic trip-outs of central electricity supply in response to strong ground shaking
Is there adequate interdisciplinary understanding of earthquake occurrence and effects?
YES
OK
NO
Establish the criteria for acceptable risk, and responsibilities for implementation of emergency plans
Promote seminars for engineers, architects, planners, insurers, regulatory authorities, etc.
Formulate plans for post-earthquake disaster relief
Review and update earthquake-resistant code and disaster relief plans at regular intervals
Review and optimize code parameters in the light of new earthquake and damage observations

Table 3

VOLCANIC EMERGENCY PLANNING



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/Part II

Part II

HURRICANES AND TROPICAL STORMS

1. Scenario

In this section a brief description of some of the physical aspects of the hurricane and tropical storm problem in the Wider Caribbean Area is presented. This outline incorporates such features as: meteorological characteristics, frequency and intensity of occurrences; the major hazards arising from such incidences; and the geographically most vulnerable areas within the Region. It is neither intended to be used as an authoritative discussion of those characteristics, nor is it possible to address the phenomena in any detail with respect to individual territories. For such information, the wider literature should be consulted. This section merely attempts to present a general overall view.

(a) Meteorological characteristics

The terms tropical depressions, tropical storms and hurricanes are meteorological terms applied to tropical cyclones having sustained surface wind speeds near to the centre of the system of, respectively, less than 18 ms^{-1}, 18 to 33 ms^{-1} or more than 33 ms^{-1}.

Typically a hurricane may have a diameter exceeding 450 km, a central eye of between 50 km and 80 km and a vertical circulation of up to 15 km.

The systems' energy is obtained from the heat and moisture absorbed from the warm tropical ocean surface. The air circulation pattern is inwards (towards the low pressure centre) and upwards, in a counterclockwise spiral. The zone of greatest precipitation (and highest energy release) is close to the outer "wall" of the central eye. The eye is an area of comparative calm and little rain.

Translational movement of a hurricane is comparatively slow, varying between 9 ms^{-1} during their formative period, to 25 ms^{-1} during their extra-tropical life.

Increased surface roughness of land together with the loss of the primary energy source (warm water) usually results in decreasing activity and eventual dissipation.

/(b) Frequency

(b) Frequency and intensity

The officially recognised hurricane season extends from the 1st of June through to the 30th November. On rare occasions however, hurricanes have occurred outside of this season (in May and December). Although some 100 "potential" hurricanes are observed during each year, only about 10% reach storm strength and fewer than 6% reach hurricane strength and of those not all, directly affect any territory.

Figure 7 is an indicative graph showing the monthly and cumulative distribution of tropical storms and hurricanes for the North Atlantic over the eighty-five year period 1886 to 1970. From the figure, it can be seen that the most intense period of hurricane activity occurs from August to October, with a peak in September. During those three months, 84% of all hurricanes have occurred. At the beginning and towards the end of the season, tropical storm activity is greater than hurricane activity. This is probably because physical conditions (particularly ocean surface temperatures do not favour the further development of a tropical storm into a hurricane.

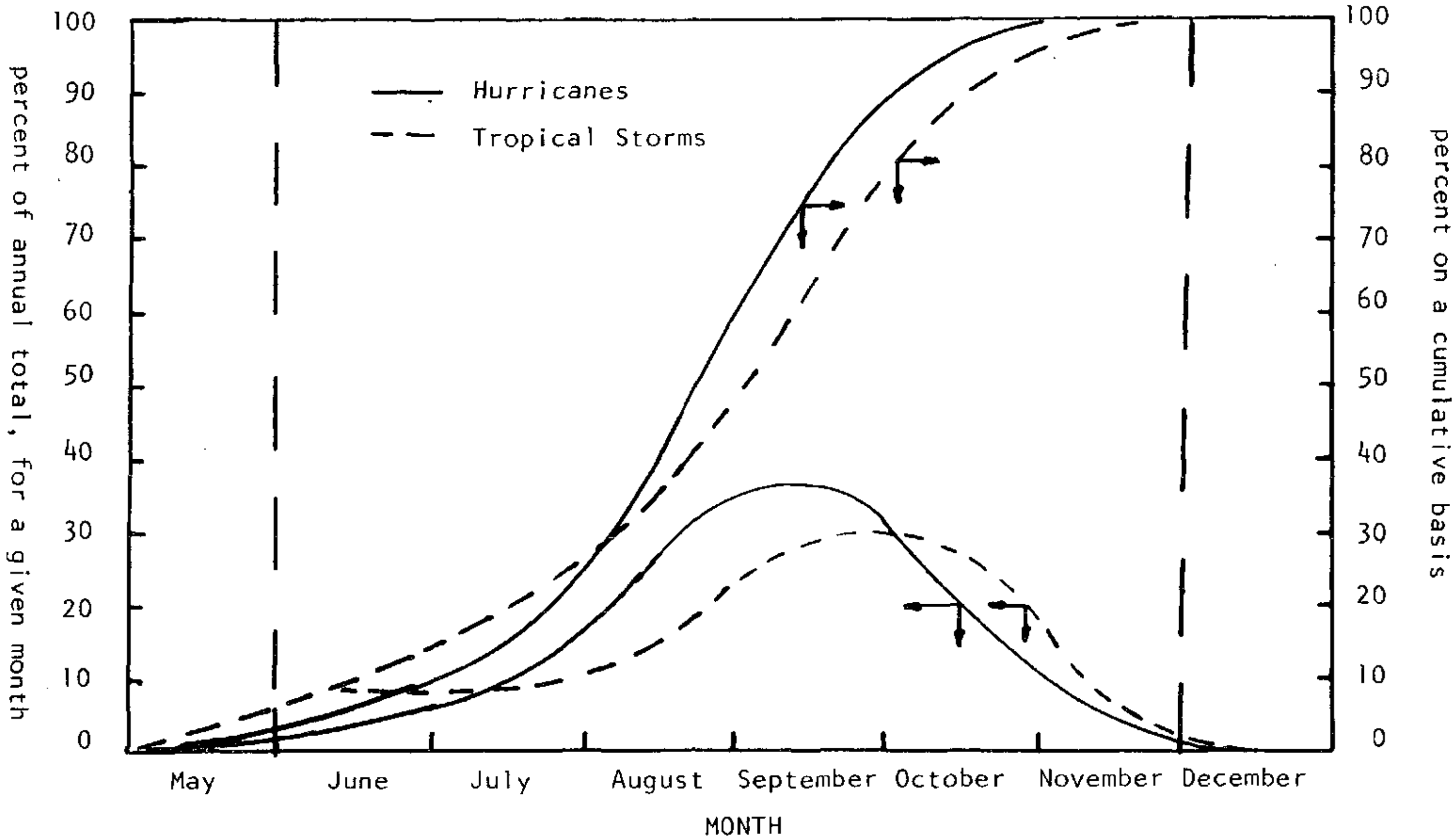
Studies of the frequency distribution of hurricanes and tropical storms over a ninety-two year period from 1886 to 1977 show that there are marked variations in the number of occurrences from year to year and that there are periods of relative inactivity followed by periods of high activity (see figure 8). However there does not appear to be any cyclical periodicity enabling rhe prediction of the possible level of activity which would occur in any given year. Nevertheless for planning purposes, it may be useful to note the average 85 year occurrences (up to 1970) of tropical storms and hurricanes in the North Atlantic. These figures, on a monthly basis, are given below in table 4.

/Figure 7

Figure 7

HURRICANE AND TROPICAL STORM OCCURRENCES BY MONTH AND ACCUMULATIVELY FOR NORTH ATLANTIC, MAY-DECEMBER 1886-1970

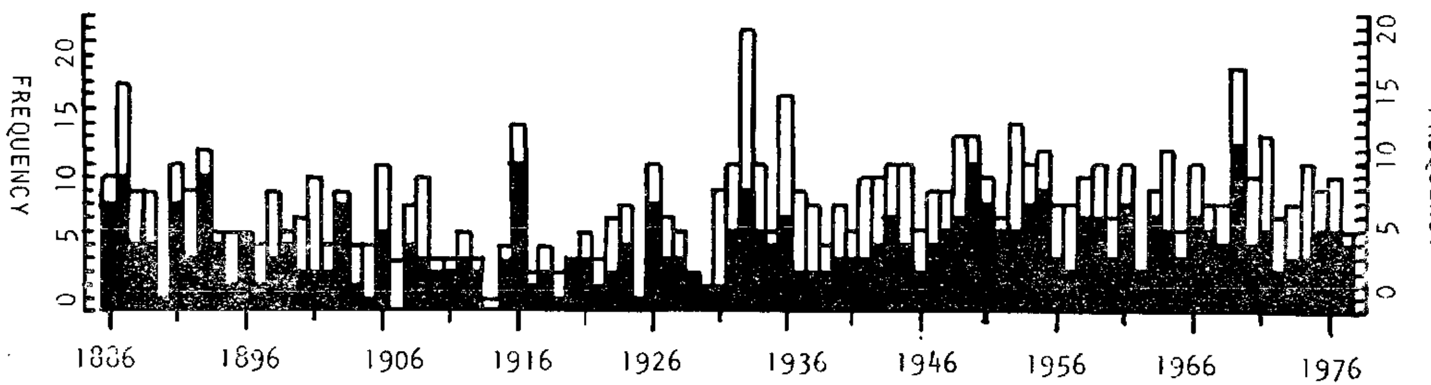
(Adapted from BRINKMANN, W.A.R. 1975)



/Figure 8

Figure 8

ANNUAL DISTRIBUTION OF THE 761 RECORDED ATLANTIC TROPICAL CYCLONES REACHING AT LEAST TROPICAL STORM STRENGTH (OPEN BAR) AND THE 448 REACHING HURRICANE STRENGTH (SOLID BAR), 1886 THROUGH 1977. THE AVERAGE NUMBER OF SUCH STORMS IS 8.3 AND 4.9 RESPECTIVELY



SOURCE: (NOAA. 1978)

/Table 4

Table 4

AVERAGE NUMBER OF TROPICAL STORMS AND HURRICANES BY MONTH, IN THE NORTH ATLANTIC
MAY-DECEMBER, 1886-1970

	May		June		July		August		September		October		Nov.		Dec.		Total	
	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%
Tropical Storms	0.09	3	0.31	9	0.27	8	0.48	14	1.01	30	0.94	28	0.20	6	0.02	1	3.33	100
Hurricanes	0.04	1	0.24	5	0.36	7	1.35	28	1.78	37	0.90	19	0.17	3	0.02	4	4.86	100
Total	0.13	2	0.55	7	0.63	8	1.83	22	2.79	34	1.84	23	0.37	5	0.04	4	8.19	100

Source: Adapted from Waltraud A.R. Brinkmann (1975).

/From figure

From figure 8, it appears that there was an increase in the number of storms and hurricanes during the period 1931 to 1977 compared to the period 1886 to 1930. The mean annual occurrences of these two phenomena over those two time periods were 4.8 and 5.6 (1931 to 1976) and 2.9 and 3.6 (1886 to 1930) respectively, compared with means for the total ninety-two year period of 3.4 and 4.9 respectively.

The reason for the apparent increase in occurrences has not been determined, but it is possible that there may not have been a real increase, rather, due to improved detection methods, more may have been detected. However, possible climatic changes should not be ruled out.

(c) Major hazards

The main destructive effects of a hurricane are caused by storm surge, wind, rain and tornadoes.

Storm surge is the rise of coastal waters above mean sea level. It is one of the most destructive effects of a hurricane and has been estimated to have accounted for about 90% of lives lost in coastal areas (American Meteorological Society, 1973). Storm surges of up to 7.5 m have been observed, and severe flooding can occur for more than 160 kilometres on either side of the eye and, depending on the elevation of the terrain, can affect the land for several kilometres inland. In bays and estuaries, the surge height can be increased as a result of the constriction.

Wind speeds approaching 90 ms^{-1} can occur at distances of 30 to 50 km from the eye of severe hurricanes and gusts can be in excess of 100 ms^{-1}. Wind speeds decrease rapidly away from the hurricane eye.

Rule of thumb relationships between wind speed and property damage are shown below (Brinkmann p. 9).

Wind Speed	Damage
22 to 35 ms^{-1}	Minor damage
36 to 45 ms^{-1}	Loss of windows and other intermediate damage
$\geq$45 ms^{-1}	Structural damage

In addition to direct wind-induced damage, severe property damage, death and human injuries can be caused by flying debris such as parts of building, uprooted trees and fallen power transmission lines.

/Rain. The

Rain. The rainfall associated with hurricanes is extremely variable and depends inter alia on factors such as: the forward speed of the hurricane and the topography of the terrain over which it is passing. Precipitation cannot be predicated from the wind speeds or minimum pressures within a hurricane system. Nevertheless, serious inland flooding caused by rainfall is often associated with the passage of a hurricane or tropical storm.

Tornadoes are often associated with the right front quadrant of a hurricane and usually form from about 6 to 12 hours prior to the arrival of hurricane force winds.

(d) Most vulnerable areas in the wider Caribbean

The United States National Climatic Center, in co-operation with the National Hurricane Center has published all the tracks of known hurricanes and tropical storms for the period 1871 to 1977 (NOAA 1978), by year. In agglomerated form, figure 9 shows that the only relatively unaffected parts of the Wider Caribbean Area are those countries in northern South America and Panama. However it is not possible to determine, from such a map, the most vulnerable territories, or those which are most likely to experience hurricanes and tropical storms most frequently.

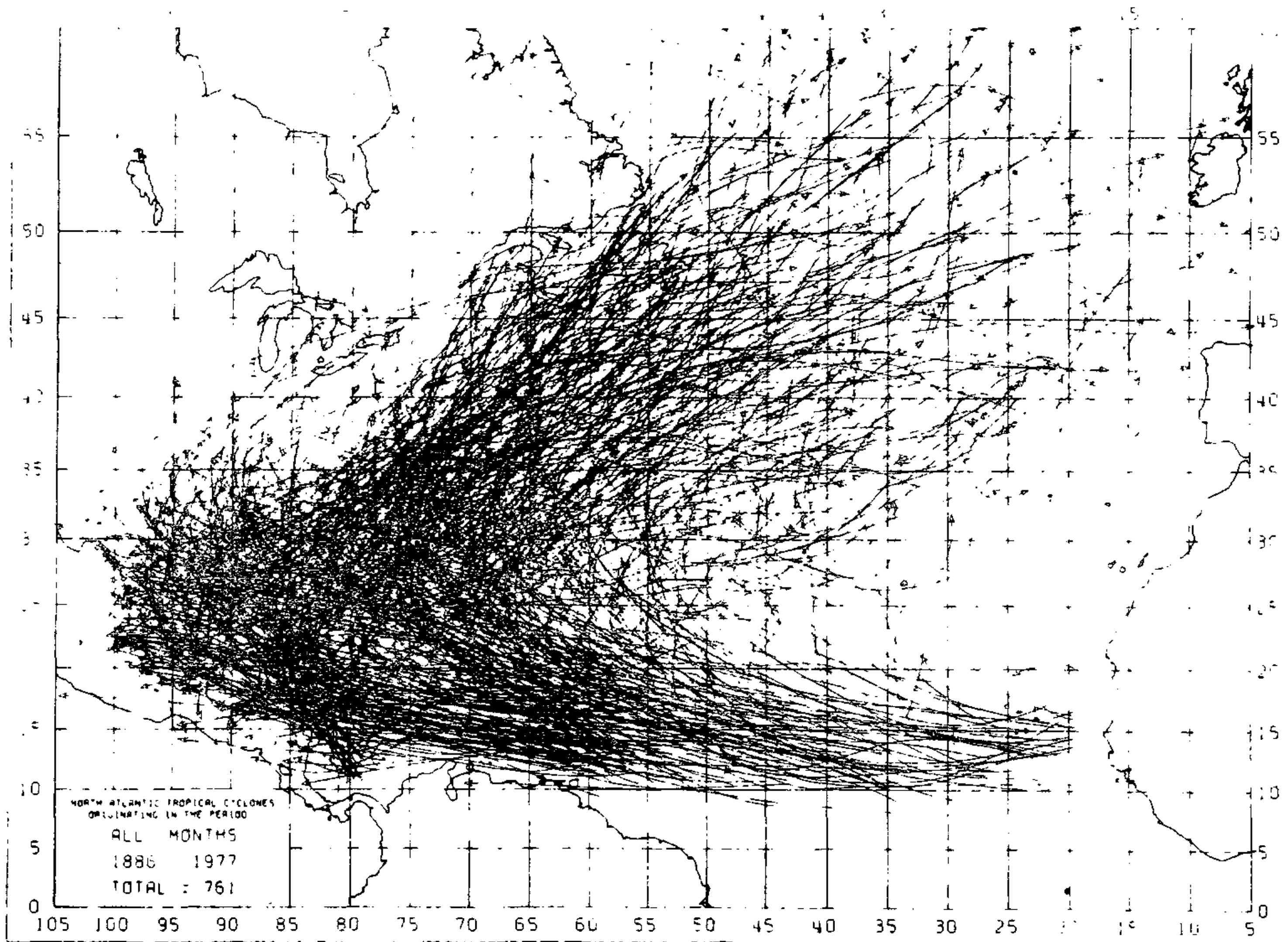
Using the annual charts published by NOAA (op.cit.), figure 10 has been prepared. This map clearly demonstrates that during the one hundred and seven year period (1871 to 1977) the territory which has experienced the largest number of hurricanes was the South Florida peninsular (55 - i.e. an average of one every two years). The other territories experiencing occurrences the most frequently were: Western Cuba (41 - two every five years); the windward islands of the Lesser Antilles (39 - 4 every 11 years); and northern Florida (32); the southern Bahamas (29); leeward islands of the Lesser Antilles (28); South West Texas (25) and the north Yucatan Peninsular (25) (i.e. frequencies ranging from three every ten years to four every seventeen years).

Of course, such gross, averaged statistics give no indication as to the severity of the hurricane, of lives lost or of damage to property. These aspects will be addressed in the next section. However, a map such as presented in figure 10 can be useful for regional and subregional contingency planning purposes.

/Figure 9

Figure 9

COMPUTER PLOT SHOWING THE TRACKS OF THE 761 KNOWN ATLANTIC TROPICAL CYCLONES REACHING AT LEAST TROPICAL STORM INTENSITY OVER THE 92-YEAR PERIOD 1886 THROUGH 1977

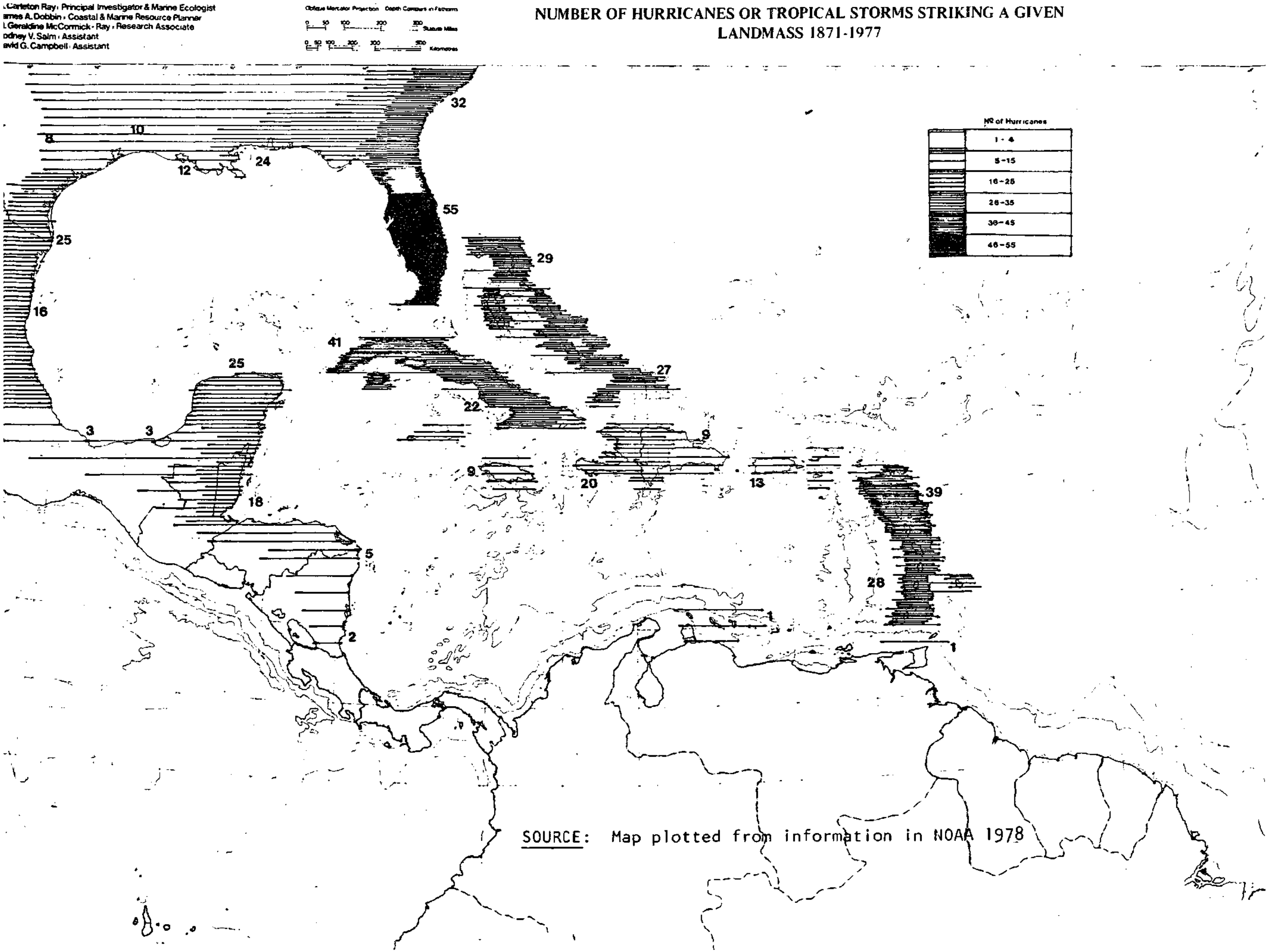


SOURCE: NOAA (1978)

/Figure 10

.Carleton Ray : Principal Investigator & Marine Ecologist
ames A. Dobbin : Coastal & Marine Resource Planner
. Geraldine McCormick-Ray : Research Associate
odney V. Salm : Assistant
avid G. Campbell : Assistant

NUMBER OF HURRICANES OR TROPICAL STORMS STRIKING A GIVEN LANDMASS 1871-1977



SOURCE: Map plotted from information in NOAA 1978

For planning purposes, the well established temporal and spatial variations of tropical cyclone formations are also important. Thus "early season tropical cyclones are almost exclusively confined to the western Caribbean and the Gulf of Mexico" (NOAA op.cit.). As the season progresses there is a continuous shift eastwards toward the Cape Verde Islands, coincident with a continuous increase in density. After mid-September, hurricane intensity decreases and their formative areas move back westward towards the western Caribbean and Gulf of Mexico.

2. Damage caused by hurricanes and tropical storms in the wider Caribbean

In an attempt to compile a catalogue of disasters caused by hurricanes and tropical storms in the Region, information was sought from each of the national meteorological institutions in the countries covered by this Overview.

Table 5 has been compiled based partially on the responses received. Comparatively few countries in the Region have compiled a catalogue of disasters caused by meteorological phenomena, nor would it appear that such an exercise has been undertaken by the subregional institutions. Even when catalogues have been prepared, it appears that very little quantitative data relating to infrastructural damage, damage to dwellings and agriculture or the cost of such damage had been evaluated. One notable exception is the United States of America for which a considerable amount of information is available.

The rest of this section, briefly discusses the damage caused by hurricanes and tropical storms in the Region from 1870 to 1978, based on the data shown in table 5.

(a) Deaths and Injuries

No comprehensive statistics are available on the number of persons killed or injured in the Region. Data obtained for the French and Netherland Antilles and the Bahamas show that the number of deaths in those territories totalled more than 1,300 during the past fifty years. Data from Tomblin (1979)1/

1/ Tomblin, J., - "Natural Disasters in the Caribbean: A Review of Hazards and Vulnerability", Natural Disaster Prevention and Preparedness Seminar, St. Lucia, June 10-20.

/Table 5

Table 5

HURRICANES AND TROPICAL STORMS AFFECTING THE INSULAR CARIBBEAN (1870-1978)

Year	Country	Name/intensity of hurricanes + storms a/	Deaths and (injuries)	Damage including cost
1870-1879				
1876	Netherland Antilles b/	-/-	-	Considerable
1876	Netherland Antilles c/	-/-	-	Minor
1877	Netherland Antilles c/	-/-	70	US$ 2 000 000
1880	Jamaica d/	-/-	30	-
1880-1889				
1886	Netherland Antilles c/	-/-	-	Considerable; many ships lost, buildings damaged
1887	Netherland Antilles c/	-/100 mph	-	-
1887	Netherland Antilles c/	-/ 60 mph	-	-
1888	Bahamas	-/ 50 mph	-	Little damage
1889	Netherland Antilles b/	-/ 60 mph	-	-
1889	Netherland Antilles b/	-/100 mph	-	-
1890-1899				
1891	Martinique	-/Violent	700(thousand)	Considerable damage/50 000 000 F
1891	Netherland Antilles b/	-/100 mph	-	-
		-/ 50 mph	-	-
		-/100 mph	-	-
1891	Bahamas	-/no record of high wind	-	No record of damage
1892	Netherland Antilles c/	-/100 mph	-	Ship lost
1893	Bahamas	-/ 37 mph	-	Little damage
1893	Netherland Antilles b/	-/120 mph	-	-
1894	Netherland Antilles b/	-/100 mph	-	-
1895	Bahamas	-/ 35 mph	-	Little damage
1895	Netherland Antilles c/	-/120 mph	-	-
1896	Bahamas	-/ 35 mph	-	Apparently no damage
1896	Netherland Antilles b/	-/120 mph	-	-
		-/120 mph	-	-
1897	Netherland Antilles c/	-/ 50 mph	-	-
1898	Netherland Antilles b/	-/100 mph	-	Considerable
		-/ 60 mph	-	Considerable
		-/ 60 mph	-	Considerable

/Table 5 (cont.1)

Table 5 (cont. 1)

Year	Country	Name/intensity of hurricanes + storms a/	Deaths and (injuries)	Damage including cost
1898	St. Vincent d/	-/ 74 mph	300	-
1899	Bahamas	-/174 mph	-	Old buildings and crop damaged, boats sunk
1899	Puerto Rico d/	-/-	3 000	Considerable
1899	Netherland Antilles b/	-/100 mph	1	Considerable: 50 houses destroyed
	b/	-/ 80 mph	0	-
	b/	-/120 mph	2	Considerable damage; over 100 houses
1900-1909				
1900	Netherland Antilles b/	-/ 50 mph	-	-
1901	Netherland Antilles c/	-/ 50 mph	-	-
	b/	-/ 35 mph	-	-
1903	Bahamas	-/ 90 mph	-	Flooding. Widespread damage
1903	Jamaica d/	-/-	65	£ 125 000
1903	Netherland Antilles b/	-/ 30 mph	-	-
1903	Martinique	-	31 (70)	-
1906	Netherland Antilles b/	-/100 mph	-	-
1908	Netherland Antilles b/	-/ 80 mph	-	-
	b/	-/ 60 mph	-	-
	b/	-/ 60 mph	-	-
1908	Bahamas	-/ 24 mph heavy swell	-	-
1908	Bahamas	-/ 80 mph	-	Widespread damage
1909	Bahamas	-/ 41 mph	-	Damage to trees
1909	Netherland Antilles b/	-/ 90 mph	-	-
	c/	-/ 40 mph	-	-
	b/	-/ 40 mph	-	-
1910-1919				
1910	Netherland Antilles b/	-/ 50 mph	-	-
	b/	-/ 90 mph	-	-
1912	Bahamas	-/ 15 mph	-	-
1912	Jamaica	-/-	142	Considerable
1915	Netherland Antilles b/	-/ 90 mph	-	-
1916	Netherland Antilles b/	-/ 40 mph	-	-
	b/	-/100 mph	-	-

/Table 5 (cont. 2)

Table 5 (cont. 2)

Year	Country	Name/intensity of hurricanes + storms a/	Deaths and (injuries)	Damage including cost
1916	Netherland Antilles b/	-/100 mph	-	-
	b/	-/ 75 mph	-	-
1917	Netherland Antilles b/	-/ 80 mph	-	-
1918	Netherland Antilles c/	-/ 50 mph	-	-
	c/	-/ 80 mph	-	-
1919	Bahamas	-/ 56 mph	-	Damage to trees, boats
1920-1929				
1922	Netherland Antilles b/	-/115 mph	-	-
1923	Bahamas	-/ 40 mph	-	-
1923	Netherland Antilles b/	-/ 50 mph	-	-
1924	Netherland Antilles b/	-/ 40 mph	-	-
	b/	-/100 mph	-	-
1924	Montserrat d/	-/-	30	£100 000
1926	Bahamas	-/120 mph	-	Widespread, damage
1926	Bahamas	-/120 mph	-	House damaged, boats sunk
1926	Bahamas	-/ 75 mph	-	-
1928	Guadeloupe	Violent	1 200	Centre of island devastated, 17 ships lost
1928	Bahamas	-/ 35 mph	-	-
1928	Bahamas	-/120 mph	-	Damage to buildings, boats
1928	Montserrat d/	-/-	42	£150 000
1928	Netherland Antilles b/	-/130 mph	-	-
1929	Bahamas	-/140 mph	Lives lost	Extensive damage to buildings and boats
1930-1939				
1930	Dominican Republic d/	-/-	2 000	Considerable
1930	Netherland Antilles b/	-/100 mph	-	-
1931	Netherland Antilles c/	-/ 40 mph	-	-
	b/	-/ 90 mph	-	-
1932	Netherland Antilles c/	-/100 mph	-	Not known
	b/	-/ 40 mph	-	-
	b/	-/120 mph	-	-
1933	Bahamas	-/ 20 mph	-	-
		-/ 30 mph	-	-
		-/ 35 mph	-	-

/Table 5 (cont. 3)

Table 5 (cont. 3)

Year	Country	Name/intensity of hurricanes + storms a/	Deaths and (injuries)	Damage including cost
1933	Netherland Antilles c/	-/100 mph	-	Not known
	c/	-/ 40 mph	-	-
	b/	-/ 50 mph	-	-
	b/	-/ 40 mph	-	-
	b/	-/ 50 mph	-	-
	b/	-/ 40 mph	-	-
1934	Netherland Antilles b/	-/ 50 mph	-	-
		-/ 50 mph	-	-
1935	Bahamas	-/ 25 mph	-	-
1937	Netherland Antilles b/	-/ 40 mph	-	-
1938	Netherland Antilles b/	-/ 65 mph	-	-
1939	Netherland Antilles b/	-/ 30 mph	-	-
		-/ 30 mph	-	-
1940-1949				
1940	Netherland Antilles b/	-/ 50 mph	-	-
1941	Bahamas	-/ 75 mph with	-	-
		gusts to 85 mph	-	Some damage to houses and boats
1941	Netherland Antilles c/	-/ 75 mph	-	-
1942	Netherland Antilles b/	-/ 30 mph	-	-
1943	Netherland Antilles b/	-/ 40 mph	-	-
1944	Jamaica	-/-	26	-
1945	Bahamas	-/ 35 mph; gusts to 60 mph	-	Some damage to houses
1945	Netherland Antilles b/	-/ 55 mph	-	-
		-/ 50 mph	-	-
1947	Bahamas	-/ 40 mph with gusts to 55 mph	-	Little damage
1947	Netherland Antilles b/	-/ 40 mph	-	-
1949	Bahamas	-/ 46 mph with gusts to 80 mph	-	Damage to buildings, boats
1949	Netherland Antilles b/	-/ 60 mph	-	-
		-/ 50 mph	-	-
1950-1959				
1950	Netherland Antilles b/	Baker/70 mph	-	-
		Dog/120 mph	-	US$ 70 000

/Table 5 (cont. 4)

Table 5 (cont. 4)

Year	Country	Names/intensity of hurricanes + storms a/	Deaths and (injuries)	Damage including cost
1951	Martinique	Dog/	5	95% banana crop destroyed 35 000 000 F
1951	Jamaica d/	Charlie/-	152	£10 000 000
1952	Bahamas	Fox/25 mph gusts to 48	-	-
1953	Netherland Antilles b/	Edna/ 40 mph	-	-
1954	Netherland Antilles b/	Enda/ 40 mph	-	-
	c/	Hazel/120 mph	-	US$ 350 000
1955	Netherland Antilles b/	Hilda/ 40 mph	-	Minor
	c/	Janet/ 80 mph	-	Minor
1956	Bahamas	Betsy/ 18 mph gusts to 29	-	-
1956	Netherland Antilles b/	Betsy/ 90 mph	-	-
1956	Guadeloupe	Betsy		1 200 houses destroyed 4 500 houses damaged damage to agriculture and equipment 40 000 000 F
1958	Netherland Antilles b/	Ella/ 40 mph	-	-
1959	Netherland Antilles b/	Edith/50 mph	-	-
1960-1969				
1960	Netherland Antilles b/	Donna/145 mph	-	Considerable
1960	Gustavia (Fr.)	Donna	-	80 000 000 F
1961	Netherland Antilles c/	Anna/70 mph	-	-
	b/	Frances/40 mph	-	-
	b/	Inga/30 mph	-	-
1962	Netherland Antilles b/	Daisy/40 mph	-	-
1963	Cuba + Haiti d/	Flora/	4 000	Considerable
1963	Netherland Antilles c/	Flora/110 mph	-	-
	b/	Helena/50 mph	-	-
1963	Martinique	Edith	10 (50)	Damage to agriculture and equipment: 300 000 000 F
1963	Guadeloupe	Helena	5 (14)	50% sugar cane 95% bananas destroyed
1964	Guadeloupe	Cleo	13 deaths many dozens injured	Bananas, sugar cane destroyed; 10 000 houses damaged

/Table 5 (concl.)

Table 5 (concl.)

Year	Country	Names/intensity of hurricanes + storms a/	Deaths and (injuries)	Damage including cost
1964	Netherland Antilles b/	Cleo/100 mph	-	-
1965	Bahamas	Betsy/80 mph gusts to 120	-	Extensive damage to buildings, trees, boats
1965	Netherland Antilles b/	Betsy/55 mph	-	-
1966	Bahamas	Inez/40 mph gusts to 63	-	Flooding and tornado
1966	Netherland Antilles b/	Faith/90 mph	-	-
		Inez/130 mph	-	-
1966	Guadeloupe	Inez	27/600	100 000 homeless 250 000 000 F
1967	Martinique	Beulah	14/2500	Destruction of public items; agriculture; industry; 71 000 000 F/ 450 persons homeless
1969	Netherland Antilles c/	Francelia/30	-	
1970-1978				
1970	Guadeloupe	Dorothy	44/4000	Destruction of public items, agriculture, industry - 170 000 000 F 700 homeless
1971	Netherland Antilles c/	Edith/70 mph	-	-
	c/	Irene/30 mph	-	-
	b/	Doria/30 mph	-	-
1973	Netherland Antilles b/	Christine/45 mph	-	-
1974	Netherland Antilles b/	Carmen/35 mph	-	-
1975	Netherland Antilles b/	Eloise/35 mph	-	Minor damage to roads
1978	Netherland Antilles b/	Cora/35 mph	-	-
	c/	Greta/45 mph	-	-

Note: Information for the Bahamas and the Netherland Antilles related to all hurricanes or storms passing within 100 miles of the territories. In the case of the Bahamas, the information is for Nassau only.

a/ For purposes of this table: <40 mph=depression; >40< 73 mph=tropical storm >73 mph=hurricane.

b/ Lesser Antilles, Eastern Caribbean.

c/ Aruba Bonaire/Curaçao.

d/ From Tomblin J., (1979) - St. Lucia Meeting op. cit.

/indicates that

indicates that more than 30,000 lives have been lost in the Insular Caribbean, as a direct consequence of hurricanes, during the past 250 years (more than 6,000 of these have occurred during the last 50 years). Data for the United States put the total number of deaths from hurricanes in that country from 1920 to 1969, at 5,500 (Brinkmann op. cit.).

In terms of loss of human life, the most catastrophic hurricane in recent times was Fifi, which in 1974 (16 to 20 September) resulted in the death of between 8,000 and 10,000 persons.2/

Such data as does exist, pertains only to deaths and injuries directly attributable to the particular event. That is to say, they do not include deaths, injuries or illness which may be occasioned by environmental factors due to disruption of public services (particularly water supply, waste disposal and lack of adequate shelter).

(b) Damage to infrastructure, dwellings and other buildings

In terms of impact on the population, damage to dwellings and infrastructure, is greatest. In the context of this overview infrastructural damage refers to damage resulting in the disruption of electricity and water supply, waste disposal and communications. The partial or complete immobilisation of these services at the time when they are most needed, naturally compounds the effects of the disaster for the entire population.

Disruption and/or contamination of water supplies, necessitates the boiling of that commodity before drinking; however disruption of road communications often results in the scarcity (among other things) of the fuel needed to boil the water.

Thus all the conditions for the outbreak of disease epidemics are magnified, resulting in the possibility of a much greater death rate than that occasioned by the hurricane/storm itself.

At the personal level, damage to dwellings can be very great. For example in 1966 100,000 persons (one third of the total population) suffered losses in Guadeloupe as a result of hurricane Inez.

2/ Republica de Honduras, Servicio Meteorología Nacional, Proyecto HON/72/006 Meteorología e Hidrología (1975). "Análisis Preliminar de la Precipitación Producida por el Huracan 'Fifi' a su paso por Honduras."

/Even less

Even less information regarding the cost of damage, is available. One would however anticipate that, the cost would increase with each successive strike, as a result of increasing development and population, unless such development were located in the more sheltered areas. Information for the United States (figure 11) confirms this hypothesis.

With respect to damage, storms and hurricanes are equally destructive. For example, hurricane Inez caused an estimated 250 million Francs damage in Guadeloupe in 1966 while Tropical Storm Dorothy resulted in 174 million Francs damage in Martinique in 1970.

(c) Damage to agriculture

Agriculture is perhaps the most vulnerable activity in so far as hurricane and storm strikes are concerned, particularly for the island territories. The economic impact can also be disastrous given many of the islands' dependence on one or two export crops for their foreign exchange earnings.

Tropical storm Helena, in 1963 destroyed 50% of the sugar cane and 95% of the banana crop in Guadeloupe. Total damage to agriculture in Martinique occasioned by Tropical Storms Beulah (1967) and Dorothy (1970) was estimated at 57.5 million Francs.

The quoted figures do not take account of lossess in subsequent years resulting from the disruption and/or saline condition of the soil resulting from inundation by storm surge.

For example it was estimated that banana production losses in Honduras due to hurricane Fifi (Sept. 1974) were 20% for 1974 and 50% for the following year (Honduras, Proyecto HON/72/006, 1975, op. cit.) resulting in a total foreign exchange loss of approximately 122 million dollars. Additionally some 60,000 head of cattle (valued at 12 million dollars) were lost.

3. Environmental considerations

The environmental effects of severe meteorological disturbances are intimately related to natural, physical and vegetative, features of the land, and to human use and modification of those features.

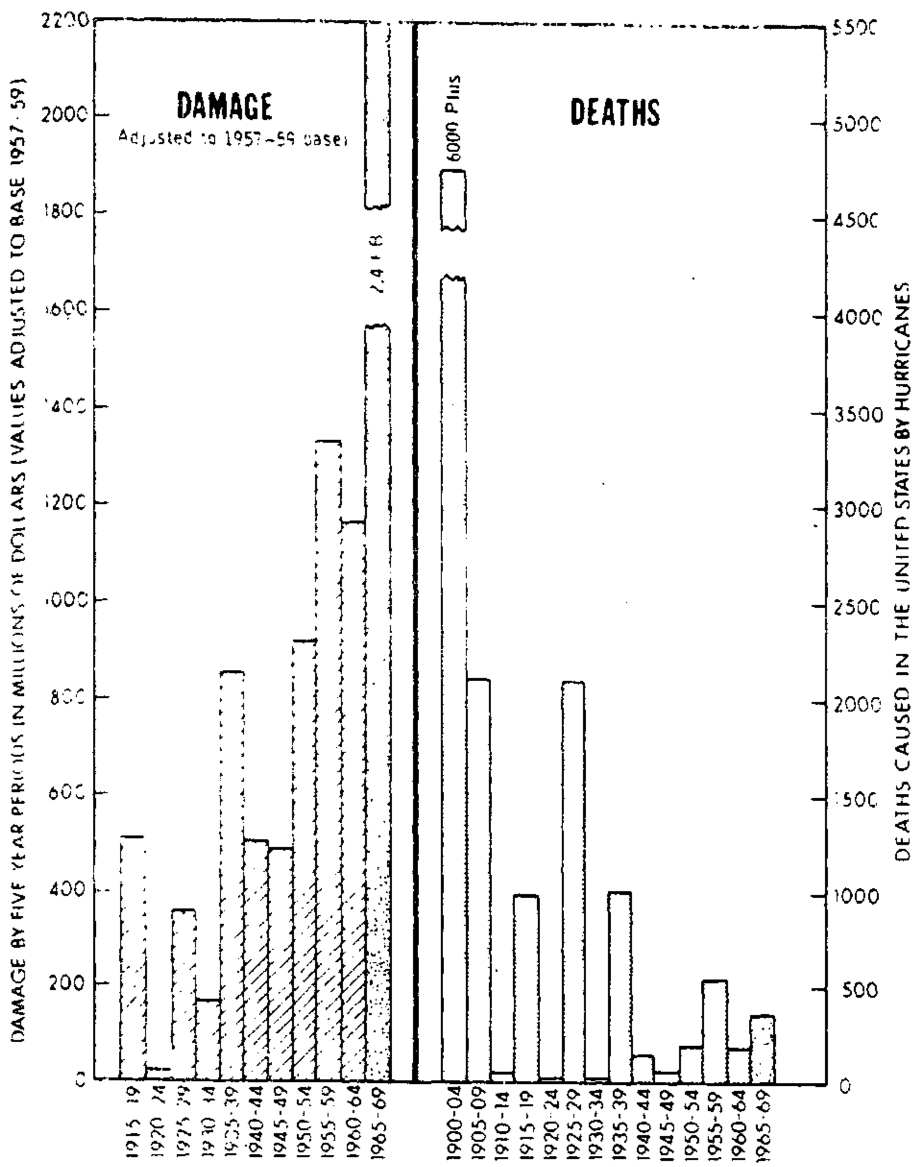
The ecosystems of the Region, that have developed over the millenia, have always been subjected to the ravages of hurricanes and storms and presumably coexisted in a form of dynamic equilibrium.

/Figure 11

Figure 11

DEATHS AND DAMAGES FROM HURRICANES IN THE UNITED STATES

(National Oceanic and Atmospheric Administration, 1972)



/For example,

For example, Brinkmann (1975) reported that "In a great hurricane of just half-a-day's duration, the re-configuration of the coastline may be such that the results of a century or more of ordinary wave action are cancelled."

At the same time, although some damage may be caused to coral reefs, they do help to dissipate the force of wave action.

Sand dunes and (coastal) mangrove forests also play a large role in the reduction of wave action. The removal of these natural barriers exposes the coastline to considerably higher risks from storm surges or necessitates their very costly replacement by man-made sea defences, which in any event may not be as effective as the natural system which they replace.

Because of their high fertility and eveness of topography, flood plains are usually occupied by farming communities and other human settlements. This practice of course exposes the population and property to considerable risk from storm surges and flooding caused by heavy precipitation.

The incidence and severity of flooding is also increased by activities such as the removal of vegetation (especially the deforestation of hillsides and mountains) and the covering of the land with impervious materials such as asphalt and concrete. Those actions by man increase the surface run-off of precipitation and induce the siltation of rivers and streams. The risk of landslides is also greatly increased

The removal of vegetative cover, particularly forests also exposes the built and natural environment to more severe wind-caused damage than would occur under completely natural conditions. For example, it has been found that far less wind-induced damage has occurred in Cuba in areas which were heavily forested than in those where the forest cover had been removed.

Tall buildings also modify the wind patterns leading to very high pressures on the windward side and low pressures on the leeward side, thereby accentuating the destructive power.

One other consideration which is often overlooked concerns the possible flooding of and/or structural damage to industrial installations. Apart from the obvious economic ramifications, such damage poses the threat of serious pollution of the environment through the accidental release of toxic materials into the water and air.

/In this

In this respect, the risk of major accidental oil spills during the hurricane season, either from tanker accidents or refinery damage must be very high. A considerable proportion (52%) of the Region's oil refinery capacity and all of the oil transshipment facilities are located in the island territories; and more of the latter are being contemplated.

Fortunately, in the Eastern Caribbean, the offshore oil production areas are located to the south of the hurricane prone areas where the risk of direct strikes are minimal. This, however, is not the case for the Gulf of Mexico, where there is considerable risk to the offshore production facilities.

4. Disaster preparedness and prevention in the region

In accordance with the terminology of the United Nations Disaster Relief Office (UNDRO), the following definitions have been adopted:

Disaster preparedness - action defined to minimize loss of life and damage, and to organize and facilitate timely and effective rescue, relief and rehabilitation in cases of disaster.

Preparedness is supported by the necessary legislation and means a readiness to cope with disaster situations or similar emergencies which cannot be avoided. Preparedness is concerned with forecasting and warning, the education and training of the population, organization for and management of disaster situations, including preparation of operationsl plans, training of relief groups, the stockpiling of supplies and the earmarking of the necessary funds.

Disaster prevention - measures designed to prevent natural phenomena from causing or resulting in disaster or other related emergency situations.

Prevention concerns the formulation and implementation of long-range policies and programmes to prevent or eliminate the occurrence of disasters. On the basis of vulnerability analyses of all risks, prevention includes legislation and regulatory measures, principally in the fields of physical and urban planning, public works and building.

(a) Disaster preparedness

Virtually without exception, every Caribbean territory has a national disaster preparedness plan. These plans generally have the following components: procedures dealing with advance warning of the threat; the composition and duties of standing governmental interdepartmental committees; protective and other action to be taken by individual householders; mechanisms for co-ordinating relief and other emergency activities after the event. Annex 1 is a typical example of the national plans in use within the Region.

At a recent seminar in St. Lucia (op.cit.) it was stressed that the key element of disaster preparedness was the development and maintenance of up-to-date national disaster plans.

This aspect is, of course, extremely important in the context of the rapidly changing patterns of development and human settlements as well as expanding populations and changing experience awareness levels of the general public. Nor should the private sector and non-governmental organizations be overlooked, since they have a key role to play in the implementation of any plan.

Public awareness/experience levels

Of critical importance for mitigating high incidences of deaths and injuries, is the awareness of the general public of the real dangers associated with severe meteorological phenomena. Persons who have never experienced a hurricane or tropical storm find it difficult to appreciate the full consequences of not taking appropriate action at the correct time. Even persons who have lived through such an event very quickly forget the full impact of the disaster. It has also been found, in studies in the United States that some people in fact feel more secure as a result of surviving a hurricane relatively unscathed.3/

An attempt has been made, in table 6 to determine the number of persons and the percentage of the total population of the island territories of the Region which was under ten years of age (or not born) when that

3/ Brinkmann (1975), op. cit. p. 45.

/Table 6

Table 6

INDICATORS OF HURRICANE EXPERIENCE OF POPULATION AT RISK IN THE INSULAR CARIBBEAN

COUNTRY	(1) No. of yrs. since last direct strike by hurricane.	(2) Present population which was more than 10 years old at time of last hurricane	(3) (2) as a % of total population
ANTIGUA	27	20 600	31.8
BAHAMAS	12	95 200	56.4
BARBADOS	22	117 500	47.5
CAYMAN IS.	22	5 000	47.4
CUBA	8	7 094 700	75.4
DOMINICA	21	36 000	48.0
DOMINICAN REPUBLIC	11	2 102 000	52.5
GRENADA	22	46 100	48.0
GUADELOUPE	11	179 100	57.3
HAITI	11	2 792 400	58.8
JAMAICA	26	587 900	32.4
MARTINIQUE	12	204 800	64.0
MONTSERRAT	27	4 400	38.6
NETHERLAND ANT.	16	111 200	50.9
PUERTO RICO	21	1 195 900	44.1
ST.KITTS/NEVIS/ANGUILLA	22	16 900	35.6
ST. LUCIA	10	64 000	64.1
ST. VINCENT	22	44 600*	48.0*
TRINIDAD AND TOBAGO	14	670 200	62.0
TURKS AND CAICOS IS.	14	2 900	52.9
VIRGIN IS. (U.K.)	24	5 500*	50.0*
VIRGIN IS. (U.S.)	24	28 900	46.3
TOTAL/AVERAGE	-	15 425 800	60.6

* Estimated by CEP.

Table 7

YEARS SINCE COUNTRY LAST STRUCK BY HURRICANE (CENTRAL AMERICA AND MEXICO) (AS OF 1977)

COUNTRY	Number of Years	COMMENTS
BELIZE	3	Hurricane Fifi
COSTA RICA	90	Storm: Country South of hurricane zone.
EL SALVADOR	66	Storm: country generally considered to be outside hurricane zone
GUATEMALA	8	Hurricane Francelia
HONDURAS	3	Hurricane Fifi traversed entire northern coastline causing widespread damage (8,000 to 10,000 deaths and 75 million dollars damage).
MEXICO	3	Carmen - Yucatan Peninsula
	11	Inez - Tampico area.
	0	Anita - North eastern coast.
NICARAGUA	66	Country relatively free from hurricanes except for extreme North east corner.

/The foregoing

country was last hit by a hurricane. This estimation could not be undertaken for the mainland territories of Central America since details of population at risk was not available for those countries, whereas for the islands it could be safely assumed that their total populations are at risk.

Table 6 shows that more than ten million persons (40% of the total population at risk) living in the Islands have no hurricane experience. This figure is approximately 40% of the total population. The country with the highest experience level is Cuba (75%),4/ whereas Jamaica's population's experience level is only 32%.

Although no detailed breakdown is available for any country, it has been estimated that the overwhelming majority of lives lost as a consequence of hurricanes, has been due to drowning. The Office for Emergency Preparedness U.S.A.,has estimated that for the United States "The greatest loss of life associated with hurricanes is from drowning, by a ratio of about nine to one" (OEP, 1972), and that these drownings are largely as a result of storm surge.

The potential disastrous consequences of storm surges puts those persons living along low-lying coastal areas and the adjacent plains at the greatest risks. Although no detailed breakdown of the coastal population distribution is available for the Region, it can be safely assumed that all of the island capital cities are at risk. The capital cities of most of the territories also contain fairly large proportions of the total populations (23 to 30%) and in general, due to urban migration, they are growing faster than the population as a whole.

In the United States is has been estimated that more than six million people are exposed to the storm surge hazard, with the majority living along the Gulf Coast (primarily in Louisiana). The total estimated population at risk from hurricane winds in the United States was almost 100 million in 1972.5/

4/ However, it should be noted that because of its larger size, the entire population is not directly affected by any one hurricane.

5/ Brinkmann, W.A.R. (1975), op. cit., pp. 11 and 13.(This figure is for the entire Atlantic and Gulf Coasts of the United States.)

/The foregoing

The foregoing serves to illustrate the need for keeping the population constantly aware of the dangers to which they are exposed in the face of a hurricane or tropical storm and completely familiar with their individual (and collective) responsibility and action which need to be taken to mitigate death and destruction. It also points to the need for constant review of national preparedness plans in the light of changing conditions within a country.

(b) Disaster prevention

Disaster prevention involves a wide range of long-term measures aimed at reducing the risks to the population and property occasioned by severe natural phenomena such as hurricanes and storms. Those measures include physical and urban planning, public works and buildings, policies and programmes.

The organizations necessary for preventive measures are very complex; require a multidisciplinary, multisectoral approach; and involves a substantial research effort.

It is not the intention that this overview should go into details regarding the steps and actions necessary to develop sound disaster prevention measures. These aspects are dealt with at length in "Guidelines for Disaster Prevention and Preparedness in Tropical Cyclone Areas".6/

The most important aspects to be covered by effective disaster prevention measures include:

(i) hazard risk analysis and the preparation of risk micro-zoning maps for all hazards;

(ii) land-use and zoning laws to restrict or prevent industrial and/or residential development in areas where the risk is high, e.g. flood plains and low-lying coastal areas subject to storm surges;

(iii) building codes setting out minimum safety standards in areas vulnerable to tropical cyclones;

(iv) soil and plant conservation measures to guard against erosion;

6/ Published jointly by ESCAP, WMO and the League of Red Cross, GENEVA/ BANGKOK 1977.

/(v) engineering

(v) engineering measures relating to the management and control of rivers, canals and other areas vulnerable to flooding or storm surge;

(vi) public health measures concerned with sanitation (air, water and waste disposal) and related matters.

It goes without saying that the above aspects must be embodied in appropriate legislation and must be in the context of the prevailing socio-economic conditions of the countries. Nor can such legislation be conceived in isolation form overall development and environmental objectives concerning human settlements, industrialization, water basin management, forestry, etc. In other words, disaster prevention must be made an integral part of the entire development process and must be within the context of the human, financial and technological capabilities of the nations concerned.

The first prerequisite for the development of a comprehensive plan is risk evaluation, that is an analysis of a country's vulnerability to disaster. At the macro level this involves the determination of the entire country's historical susceptibility to hurricane or tropical storm strikes, while at the micro-level the most vulnerable parts of the country must be ascertained. At the level of the latter, micro-zoning maps have proven to be very useful. Vulnerability at the micro-level includes exposure to and possible damage from winds and storm surge and the magnitue and extent of flooding which could be expected from heavy sustained precipitation (commonly as high as 250 mm in a 12 hour period).

Of all the studies and actions necessary for the development of a comprehensive plan, risk analysis is probably the cheapest and results in the greatest return on investment. Certainly, it is virtually impossible to carry out cost-benefit analyses with regard to the location of human activities without them. Such studies can be conducted fairly easily using long-term meteorological and hydrological records, and where found lacking they may even be supplemented by data from neighbouring countries, if it can be established that their climatological patterns and physio-geographic characteristics are similar.

From information sent by the national meteorological agencies, it would appear that few of the countries have carried out any micro-risk evaluations, nor does their physical planning incorporate disaster prevention in so far as land zoning is concerned.

On the macro level, it is necessary to analyse climatological records to determine the frequency of strikes of tropical cyclones of various intensities. Figure 12 is an example of a map which can be developed summarising the probability of a strike occuring in any given year. A similar exercise for the Bahamas using 2 1/2° squares resulted in the map presented as figure 13.

Regional Co-operation

With respect to the development and implementation of plans and programmes, Region IV of the WMO has a standing Hurricane Committee and a Working Group on Hydrology.

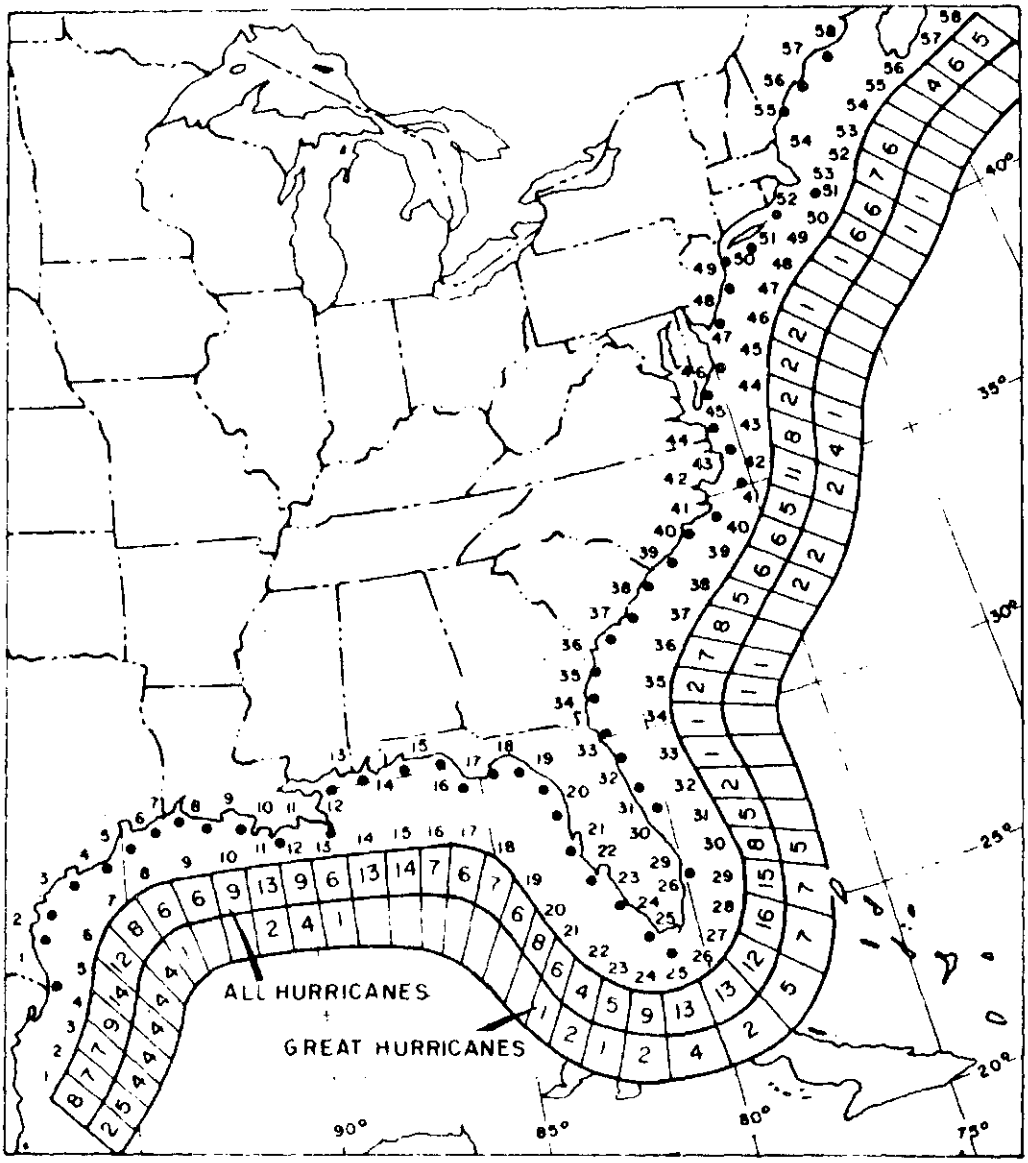
These groups are concerned with, inter alia: present national and regional hurricane forecast warning systems and activities connected with disaster prevention and preparedness; reviewing the effects of each hurricane season; the development and implementation of a regional hurricane operational plan; and the development of a technical plan and a programme for its implementation.

The above-mentioned activities, in themselves constitute an action plan in so far as hurricanes and storms are concerned. As such, the two plans drawn up by the RA IV Hurricane Committee are appended to this overview. (Annexes II and III.)

/Figure 12

Figure 12

PROBABILITY (PERCENTAGE) THAT A HURRICANE (WINDS EXCEEDING 33 m s^{-1}) OR GREAT HURRICANE (WINDS IN EXCESS OF 56 m s^{-1}) WILL OCCUR IN ANY ONE YEAR IN A SEGMENT OF THE COASTLINE (AFTER SIMPSON AND LAWRENCE, 1971)



Note: each segment is approximately 80 km. in length

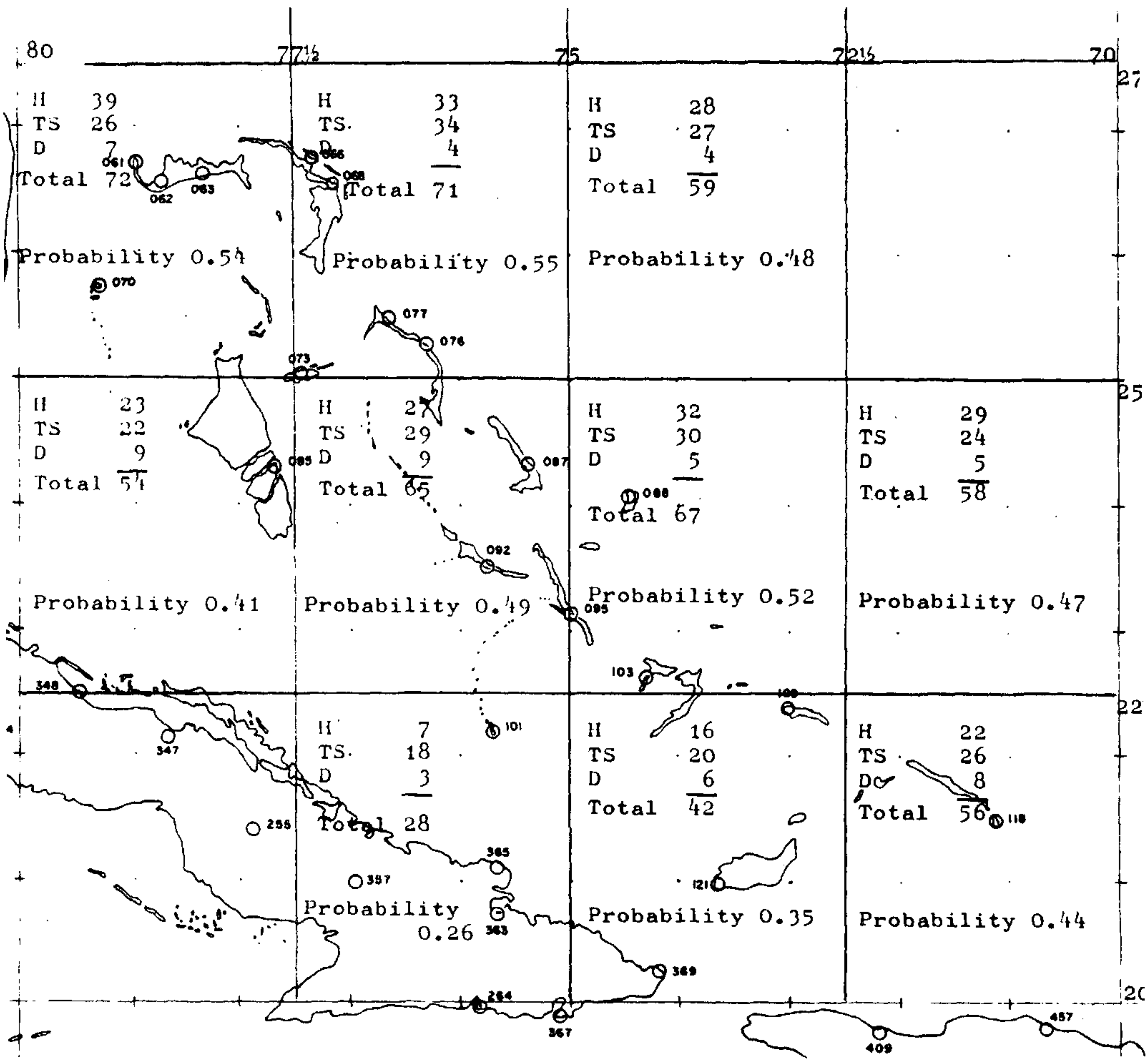
Source: ESCAP et al (1977).

Figure 13

NUMBERS OF STORMS PASSING TRHOUGH EACH 2½ DEGREE SQUARE DURING THE 84 YEAR PERIOD 1886 TO 1969

The figures against H, TS and D give the numbers of these storms which were Hurricanes, Tropical Storms or Depressions respectively on entering these 2½ degree squares. The probability figure is the probability of at least one hurricane or tropical storm passing through the 2½ degree square in one year.

Based upon data in NOAA Technical Memorandum SR-55.



Part III

RECOMMENDATIONS FOR NATURAL DISASTER PREVENTION AND PREPAREDNESS

The borders of the Caribbean are exposed to three of the most violent kinds of natural disaster: earthquakes, volcanoes and hurricanes and tropical storms. The worst examples of all these kinds of disasters in the region have caused loss of life running into tens of thousands, and property losses amounting to many hundreds of millions of dollars. Almost every capital city around the Caribbean has been devastated at least once during the last 300 years by major earthquakes, whilst destructive eruptions causing large scale loss of life have occurred at volcanoes in the Lesser Antilles and in Central America. Hurricanes and tropical storms cause, annually, massive destruction to agriculture, loss of life and property damage.

Although there is no means of preventing the occurrence of these events, it is now possible through careful monitoring and planning to reduce, considerably, the scale of these disasters, and especially the loss of human lives. In many parts of the wider Caribbean region, relatively little progress has been made towards carrying out monitoring particularly of seismological phenomena, along modern lines, or where basic monitoring exists, towards analysing the data thus obtained for prompt and detailed risk evaluation. The purpose of these recommendations will be to review those aspects of hazard assessment and mitigation which are judged to be capable of reducing environmental risks of seismic, volcanic and meteorological origin in the region.

The essential stages are (a) the making of good quality field observations; (b) the prompt processing and interpretation of the data for risk assessment, and (c) the establishment of the necessary response mechanisms by civil authorities to ensure the full utilization of scientific results. Specific projects are identified which, in the writers' judgement, represent the directions in which significant progress can be made in the Caribbean region

/towards the

towards the mitigation of disasters. The first two of these projects represent feasibility studies which will provide the necessary guidelines for future implementation. The remaining projects are suitable for immediate implementation.

1. Natural disaster prevention

In section 4.(b) a summary of the guidelines necessary for adequate precautionary measures to be incorporated into a country's development planning in order to reduce the risk to human life and property arising from severe natural disturbances.

Implicit in those guidelines are that natural disaster prevention measures for all types of disasters must be developed in an integrated manner. This is particularly important for the development of appropriate building codes since hurricane resistant structures are not necessarily earthquake resistant and vice-versa.

In line with the recommendations of a recently concluded Disaster Planning and Preparedness Seminar (St. Lucia 1979, op. cit.) the following recommendations are reproduced.

(a) General Policy

Each country should review and evaluate its disaster responsibilities and establish policies and programmes for disaster prevention mitigation, preparedness and emergency action. Advance disaster planning should include provisions for legislation, funding, education, organization, logistics, supplies, communications, co-ordination of resources agencies, and relations with regional, bilateral and international organizations.

(b) Planning Information and Acceptable Risk

Governments should clearly identify, and where necessary develop, the official groups which will provide scientific advice and the sources to which information should be comunicated. Information from event scientists should be as comprehensive as possible. Governments should determine and establish the levels of risk that are acceptable to their countries.

/(c) Development

(c) Development of National Earthquake Monitoring Networks

One of the first preparedness essentials is to collect scientific data on which to base predictions and make risk assessments. The nucleus of a data collection system is a national or subregional seismograph network, and it is recommended that those countries which do not possess such a network take steps to develop one.

As a first step to the implementation of the above recommendations, every effort should be made to internalize (nationally) the recommendations of the WMO Region IV Hurricane Committee.

Additionally, it is recommended that a permanent "Wider Caribbean" committee for natural disaster prevention and preparedness be established. Such a committee should consist of members drawn from bodies such as RAIV, subregional meteorological institutions such as the Caribbean Meteorological Institute and those national bodies responsible for overall disaster planning. This committee could function in a manner similar to the RAIV Hurricane Committee.

2. Natural Disaster Preparedness

Although most countries of the Region do have Disaster Preparedness Plans, it is not clear as to whether or not they are subject to continual revision in the light of constantly changing settlement patterns, general development and new information about disaster-causing phenomena.

As a result of the generally perceived unsatisfactory situation, the following recommendations made at the St. Lucia (1979 op. cit.) meeting are reproduced below.

/(a) Administrative

(a) Administrative Structure for Disaster Planning and Relief

The national agency for disaster planning and relief operations should be under the direct authority of the head of government, who can delegate this responsibility to a minister, based on specific legislation defining the role of each sector and the interministerial committee responsible for co-ordination of relief and reconstruction operations.

(b) Requirements and Alternatives in Pre-Disaster Planning

A model pre-disaster and post disaster preparedness plan should be developed for the Caribbean region. Individual countries should formulate their own national plan or modify the existing one based on a regional model.

Government interest and commitment in pre-disaster planning could be stimulated by reference to recent disasters in neighbouring countries, the adverse economic, social and political effects of disasters, the availability of international assistance and the possibility of being able to assist other countries which may be victims of a disaster.

(c) Disaster Threat Awareness

Current levels of awareness of disaster threats and mitigation methods should be improved and extended to (1) decision makers, (2) opinion makers, and (3) the general public. Media, audiovisual and printed materials should be designed for this purpose.

(d) Communications

Each government should establish a communications policy and a reliable disaster/emergency communications system. Country and regional level communications planning teams should be formed to survey existing communications systems and prepare disaster communications schemes.

(e) News Media Role

Every disaster plan should include a section on the role of the media in the pre, intra and post disaster periods. Governments should provide a quick, accurate flow of uncensored information to media outlets. The social responsibility of the media and the media's educational role in preparedness and training should be recognized by government. Media should refrain from publishing unsubstantiated information which may alarm the public.

/Two major

Two major areas of priority need to be addressed immediately. These are:

(a) evaluation of evacuation routes; their use, capacity and adequacy; to determine minimum warning times necessary to avoid loss of life. Simultaneously the location of safe refuges needs to be constantly reviewed; and

(b) the preparation of audio-visual material aimed at improving the level of public awareness to the disaster potential of earthquakes, volcanoes, hurricanes and tropical storms.

It is recommended that Regional collaboration and international assistance be maximised by the development of common methodologies, and the sharing of experiences and film material. Audio-visual material could be prepared at subregional centres such as the Caribbean Meteorological Institute and the University of the West Indies Seismology Unit, for the English-speaking Caribbean.

International funding agencies should be approached with a view to financing such projects.

3. Project proposals

Specifically with respect to earthquake and volcanic eruption risk mitigation, the following five project proposals are presented.

Project 1: Analysis of needs for data collection in those parts of the region where no specific monitoring programme has been implemented or planned: the Dominican Republic, Haiti, Cuba, Cayman Islands and Netherlands Antilles.

The above countries of the region still lack, to the best of the writer's knowledge, a plan for the installation and operation of modern equipment for determining earthquake locations and energy. Two consultants will visit these countries in order to (1) establish the needs in equipment, personnel training and logistical support for the establishment of national seismograph network; (2) recommend specific sites for field stations, provide detailed assessments of the most appropriate type of equipment, give an estimated installation schedule, outline suitable techniques for data processing, and suitable training programmes for permanent national staff who will operate and maintain the network, together with complete cost estimates.

The consultants will be siesmologists, including preferably one with experience of instrumentation and field installations, and one with specialization in network administration and data processing. They will spend approximately three weeks in the field plus one week to review findings and write detailed recommendations. Total work time will be 8 man-weeks. The report will represent a complete manual giving guidance to national scientific and/or funding authorities, or to foreign funding sources, as to the human and financial resources required to initiate and maintain the monitoring programme.

Project 2: Establishment of a task force for volcanic emergencies in Central America and the Lesser Antilles.

The objective of this project will be to carry out a feasibility study for the creation of a specialized "Commando Unit" of scientists and equipment which can be mobilized rapidly to investigate abnormal activity at any volcano of the region.

Three consultants will be required, with combined experience in instrumentation and techniques for volcano monitoring, in the management of field operations on active volcanoes, and in liaison with civil authorities for risk assessment.

The consultants will prepare a report identifying the potentially dangerous volcanoes of the region and reviewing the particular risks involved. They will describe and assess the various methods for volcano monitoring and give specific recommendations, with costs, for the establishment of a pool of portable monitoring equipment and the formation of an international (preferably regional) panel of specialists who will be on call to participate at short notice in emergency operations. The three consultants will need to spend six weeks in the field plus two weeks reviewing their findings and preparing their report.

Project 3: Analysis of existing earthquake data for medium and short-range prediction in the Caribbean region.

This project is not a feasibility study, but is intended for immediate implementation. It will entail the analysis of recent earthquake location, time and energy parameters for the purpose of identifying areas of anomalous

/activity, e.g.

activity, e.g. seismicity gaps, for longer-range prediction. For short-range prediction, searches will be initiated for distinctive activity patterns prior to recent major earthquakes, and computer-based techniques will be developed for characterizing such foreshock sequences and for recognizing comparable future recurrences.

The consultants should include preferably one seismologist with specialization in data processing, who can be contracted for a period of not less than three months. Support for at least one month from a specialist in computer systems analysis would be desirable. Provision should be made for continued support of this project if it has produced positive results and if further prospects are favourable.

The product of the first four man-months will be a detailed report describing all attempts at data analysis and indicating which have been successful and what techniques should be used for applying these in real time to future data.

Project 4: Analysis of the resistance of typical regional housing and commercial building designs to strong earthquakes.

The objective of this study will be to show how the design of private dwelling houses and larger buildings can be optimized without additional cost for resistance to earthquake damage. The use of two consultants is proposed, with joint experience in earthquake engineering, regional seismicity and earthquake damage analysis, to work for eight weeks on the collection and analysis of data for the more popular types of construction in the region.

The report will compare the performance of each type of building in theory and also so far as possible, in practice. It will discuss the respective merits and disadvantages of each type of construction in terms which will be readily understood by local planning authorities, architects and small builders.

Project 5: Analysis of dam hazards.

The main purpose of this project will be to examine the risk of earthquake damage to existing and planned dams in the region, including not only the expected performance of the dam but also the extent of the human and property losses which could be expected if the structure were to fail unexpectedly.

/The project

The project will entail 6 weeks of field study by two consultants, one with specialization in earthquake engineering and one with knowledge of regional seismotectonics. Two further weeks will be required to complete the report and recommendations, which will be intended for use by public works engineers and emergency planning authorities.

/Annex I

Annex 1

HURRICANE PREPAREDNESS PLAN FOR COUNTRY

Part I - National Hurricane Warning Plan

A. Meteorological

If a tropical cyclone can give storm conditions in some parts of the country within 60 hours, a Hurricane Alert is issued 3 or 4 times per day stating the areas which might be affected.

If a tropical cyclone can produce storm or hurricane conditions in the country within 36 hours, a Hurricane Watch is added at the beginning of the Alert giving the areas threatened and precautionary measures to be taken.

If a tropical cyclone can produce hurricane conditions within 24 hours in the country, a Hurricane Warning is prefixed to the Alert giving the areas threatened and precautions to be taken.

When the threat is past, this is stated in the Alert along with any further precautions necessary.

B. Administrative and Operational

1. Communications

Alerts are disseminated as follows:

1. by broadcast over the local radio station on receipt and, in the case of Warnings, at frequent intervals after;
2. by marine broadcast to shipping;
3. by recording on Weather-by-Phone which can take up to 10 calls at any given time;
4. by the Telecommunications Corporation to all the islands of the archipelago through internal arrangements;
5. by Police Radio Telephone if other means of communication fail.

/Part II

Part II - Hurricane Precautions

Seasonal Precautions

Early in June each householder should:

(a) Check the house, secure loose shingles or tiles. Repair window shutters as necessary. Keep a supply of boards for boarding up unshuttered windows.

(b) Check the surrounds: trim or remove dead or dying trees. Trim trees in proximity to overhead power lines to keep branches clear of the lines. If you are in doubt whether it is safe to do this, call the power company. Anchor removable objects such as trash cans and lumber. Remove any debris.

(c) Keep on hand flashlights and spare batteries, candles, matches, a battery operated radio, a reserve supply of food and containers for drinking water.

(d) Keep the petrol tank of your car reasonably full. Do not wait until it is empty before refilling.

Precautions when a Hurricane Alert is issued

When a Hurricate Alert is issued each person should:

(a) Check the 'seasonal precautions' listed above.

(b) Do NOT telephone the Meteorological Office or Radio NAME for information. Your inquiry will interfere with their work. The latest information is broadcasted on Radio NAME and can be heard in certain locations on 'Weather by Phone' (dial XXX).

(c) If you will be away from your house, turn off the main electricity switch and cut off gas supply.

Precautions when a Hurricane Watch is notified

If the Hurricane Alert message gives a Hurricane Watch for your area, you should:

(a) Fix hurricane shutters to upper floors of multifloored buildings and ensure that shutters for ground floor windows are immediately available.

(b) Move boats to a safe harbour.

(c) See that garbage cans, garden furniture, lumber etc., are well secured.

/(d) Take

(d) Take down T.V. and radio antennae.

(e) Clean and fill bath tubs and spare containers with drinking water.

(f) Check that you have adequate food supplies.

(g) Listen for future Hurricane Alert messages on Radio NAME and follow any advice given in them.

Precautions when a Hurricane Warning is issued

When a Hurricane Warning is issued for your area, you should:

(a) Check that all precautions mentioned above have been taken.

(b) Fix hurricane shutters to all remaining windows; do not delay this, as high winds may make it impossible later.

(c) Listen to all Hurricane Warnings on Radio NAME and follow any advice in them. These will advise whether to abandon low lying areas and seek refuge in shelters, or advise whether to stay in your house.

(d) People going to shelters should take food, water, and a blanket with them.

(e) Do not listen to rumours. Rely on the advice in the Hurricane Warnings or from responsible public officials.

(f) Keep calm. Your ability to meet emergencies will help others.

(g) Do not relax precautions if there is a lull in the storm. This lull may be because the eye of the storm is passing over you, and will be followed by hurricane force winds from the opposite direction. The broadcast warning will advise you when it is safe to leave shelter.

Post Hurricane Precautions

After the passage of a hurricane, all persons should take the following precautions:

(a) Remain in shelter until advised by broadcast message or responsible officials to go out.

(b) Seek medical care at a Red Cross First Aid Post for any person injured in the storm.

(c) Avoid loose or dangling wires, and report them to the electricity company.

(d) Report broken water mains to the Water Authority.

(e) Check the food in your refrigerator. It may be spoiled if the power has been cut for some time.

/(f) Stay

(f) Stay away from disaster areas unless you are particularly qualified to render assistance.

(g) Do not drive unless you must; roads should be kept clear for emergency vehicles. In any event, drive with great care; there is likely to be debris on the roads and probable washaways.

(h) Take down your shutters and save any lumber for the future.

(i) There is a risk that water might be contaminated, so it should be boiled.

Part III - Precautionary Planning

A Permanent Hurricane Committee has been set up comprising:

Secretary to the Cabinet (Chairman)
Permanent Secretary, Ministry of Works and Utilities
Permanent Secretary, Ministry of Labour and Home Affairs
Commissioner of Police
Permanent Secretary, Ministry of Education and Culture
Permanent Secretary, Ministry of Health and National Insurance
Director of Civil Aviation
Director of Agriculture and Fisheries
Director of Local Government
Director of Meteorological Department
General Manager, Radio Station
Director of Red Cross
Commodore, Emergency Relief Agency
General Manager, Electricity Corporation
General Manager, Telephone Co.

whose functions are:

(1) to direct a programme to educate the public on hazards of hurricanes and the protective measures required;

(2) to initiate and co-ordinate plans of major Ministries and Civil Organizations for action required in the event of a hurricane threat.

Each Ministry and Department should issue its own hurricane precaution instructions. Copies of these instructions should be submitted to the Secretary to the Cabinet for information of the Prime Minister and for the

Hurricane Committee to ensure co-ordination. The Director of Local Government is responsible for the issue of instructions for all NAME Island Areas including CITY.

Shuttering of Government Buildings

The Secretary to the Cabinet, acting on the instructions of the Prime Minister, is responsible for conveying authority for the shuttering of Government buildings in New Providence to the Director of Public Works and for dealing with emergency matters not covered in the plans.

The Director, Meteorological Department is responsible for keeping the Director of Public Works informed of hurricane threats to REGION, bearing in mind that 36 hours notice is required, so that the latter may request authority from the Secretary to the Cabinet to shutter public buildings in good time. The Director, Meteorological Department will also inform the Secretary to the Cabinet of any hurricane watch or warning issued.

The Ministry of Works, in co-operation with the tenant Ministeries or Departments concerned is responsible for the shuttering of all government buildings in New Providence and Red Cross Headquarters, except those of the Police, Telecommunications Corporations, Electricity Corporation, Ministry of Health Buildings, the Department of Lands and Surveys and Airport Buildings. The Department of Local Government is responsible for checking that shuttering is available for Government Buildings on Family Islands and that there are suitable shelters.

Each tenant Ministry or Department is responsible for checking with the Ministry of Works the plans for dealing with buildings within its responsibility, and that manpower for shuttering will be available. Where proper shutters are available and especially in buildings which have jalousie shutters operated from within the building, the tenant Ministry or Department concerned should arrange for their own staff to fix or close them. In any case, each Ministry or Department should maintain a senior officer on duty until shuttering is completed, either to supervise their own shuttering teams or to assist and give access to the Ministry of Works teams.

Each Ministry or Department which rents office space from or leases space to a private firm should examine the terms of its lease to determine whether shuttering of buildings is the responsibility of the tenant or landlord. If responsibility lies within the Ministry or Department, the Ministry of Works should be informed for necessary action.

Each Ministry or Department should check on its shuttering arrangements in June of each year and report any defective parts to the Ministry of Works in cases where that Ministry is responsible for the buildings.

Radio Communication

The Police are responsible for maintaining an emergency radio telephone network (Channel 3) for use if the telephone system fails, connecting the following points:

1. Police Control Room - Address
2. Government House - Lounge, Government House
3. Prime Minister's Residence - Prime Minister's Study
4. Cabinet Office - Secretary to the Cabinet's Office
5. Telco. - General Manager's Office
6. Meteorological Office - Forecast Office International Airport
7. Radio NAME - News Room
8. Chief Medical Officer - Doctors' Library
9. Ministry of Works - Permanent Secretary's Office
10. Prison - The Superintendent of Prison's Office
11. NAME Power Station - Deputy General Manager's Office
12. Red Cross Headquarters - Assistant Director's Office
13. Central Bank Building - Governor's Office (Dressing Room)
14. Governor's Residence, ADDRESS - Lounge
15. NAME - The Administrator's Office
16. Electricity Co. - The Deputy General Manager's Office

These sets will be activated and manned at each post when Hurricane Watch is announced for CERTAIN LOCATIONS. Radio NAME will provide a separate emergency radio communication link between Z.N.S. and the Cabinet Office.

Shelters

The Ministry of Education and Culture is responsible for providing the following schools, which have been equipped with shutters, as shelters:

The Headteacher of each school will be in charge of the shelter, and a Deputy will be designated in case of his absence. Their names and addresses will be supplied to the Police. Shelters will be open when a Hurricane Watch is announced for LOCATION.

Red Cross First Aid Shelter Posts will be set up at the following points:

Additional posts will be considered if volunteers are available.

A list should be made of persons entering and leaving Red Cross and school shelters so that they may be traced later.

Part IV - Post Hurricane operations

The Prime Minister will take charge of all post hurricane operations, will direct what action should be taken and will appoint such Committees of Ministers or Officials as may be required.

The Hurricane Committee will meet on the first opportunity after the Hurricane has passed to assess the situation, report to the Prime Minister and co-ordinate such remedial action as may be necessary.

Post Hurricane reconnaissance teams may be appointed at the direction of the Prime Minister. They would as far as possible include an Administrative Officer, a Member of the Ministry of Works, a Medical Officer of Health, a Member of the Red Cross Committee, an Electricity Co. Officer and a Telecommunications Officer. Permanent Secretaries should keep lists of the names, addresses and telephone numbers of Officers who could be called upon when necessary.

The Department of Local Government, in conjunction with the Ministry of Labour and Home Affairs and the Red Cross, subject to the direction of the Prime Minister, will be responsible for obtaining and shipping relief supplies.

/Annex II

Annex II

NATURAL DISASTERS OVERVIEW

Appendix II

Draft

RA IV HURRICANE OPERATIONAL PLAN

CHAPTER I

1.1 Introduction

The purpose of this plan is to enhance the co-operative efforts of Members within WMO Region IV in carrying out their roles in preparing for and issuing forecasts and warnings of all tropical cyclones affecting the area. Responsibilities of Members are defined. Tropical cyclone releases issued by the Regional Meteorological Centre (RMC) Miami are explained and examples provided. Observational platforms including land-based radar, satellites and aircraft reconnaissance are discussed. Communication procedures are outlined with special emphasis on headings required to assure proper computer-processing and distribution of messages. The lists of hurricane names for the Caribbean Sea, Gulf of Mexico and the North Atlantic Ocean and the eastern North Pacific are included.

1.2 Standard terminology in RA IV

Advisory: A formal message from a Hurricane Warning Office giving warning information along with details on tropical cyclone location, intensity and movement and precautions that should be taken. Where possible, the RMC Miami advisory will contain a resumê of all warnings in effect.

Bulletin: A public release from a weather office issued in the event of the occurrence or forecast occurrence of severe weather, including the developing stage of a tropical cyclone or after formal advisories on a hurricane or tropical cyclone have been discontinued. Bulletins emphasize features which are significant for the safety of the public and summarize all warnings in effect.

/Gale warning

Gale warning: A warning of average winds within the range 63 to 117 km/h (39 to 73 miles per hour) (34 to 63 knots).

Tropical storm warning: A warning of average winds in the range of 89 to 117 km/h (55 to 73 miles per hour) (48 to 63 knots) inclusive.

Hurricane/typhoon: A warm core tropical cyclone in which maximum average surface wind (1 minute mean) is 119 km/h (74 miles per hour) (64 knots) or greater.

Hurricane centre, or eye: The relatively calm area near the centre of the storm. In this area winds are light and the sky often is only partly covered by clouds.

Hurricane "season": The portion of the year having a relatively high incidence of hurricanes. In the Atlantic, Caribbean and Gulf of Mexico it is isually regarded as the period from June to November, and in the East Pacific June to November 15, and in the Central Pacific it is usually regarded as the period from June to October.

Hurricane warning: A warning that one or both of the following dangerous effects of a hurricane are expected in a specified coastal area in 24 hours or less: (a) Average winds 119 km/h (74 miles per hour) (64 knots) or higher; (b) Dangerously high water or a combination of dangerously high water and exceptionally high waves, even though winds expected may be less than hurricane force.

Hurricane watch: An announcement for specific areas that a hurricane or an incipient hurricane condition poses a threat to coastal and inland communities. All people in the indicated areas should take stock of their preparadness requirements, keep abreast of the latest advisories and bulletins and be ready for quick action in case a warning is issued for their areas.

Local action statement: A public release prepared by a Weather Service Office in or near a threatened area giving specific details for its area of country responsibility on: (a) weather conditions; (b) section that should be evacuated; and (c) other precautions necessary to protect life and property.

Tropical cyclone: A non-frontal cyclone of synoptic scale, developing over tropical or subtropical waters and having a definite organized circulation.

/Tropical disturbance:

<u>Tropical disturbance</u>: A discrete system of apparently organized convection originating in the tropics or subtropics, having a non-frontal migratory character and having maintained its identity for 24 hours or more. It may or may not be associated with a detectable perturbation in the wind field. As such, it is the basic generic designation which, in successive stages of intensification, may be subsequently classified as a tropical wave, depression, storm or hurricane.

<u>Tropical wave</u>: A trough or cyclonic curvature maximum in the trade wind easterlies. The wave may reach maximum amplitude in the lower middle troposphere, or may be the reflection of an upper-troposphere cold low or equatorward extension of a middle latitude trough.

<u>Tropical depression</u>: A tropical cyclone in which the maximum average surface wind (1 minute mean) is 61 km/h (38 miles per hour) (33 knots) or less.

<u>Tropical storm</u>: A well-organized warm core tropical cyclone in which the maximum average surface wind (1 minute mean) is in the range 63 to 117 km/h (39 to 73 miles per hour) (34-63 knots) inclusive.

<u>Meaning of other terms used</u>

<u>Centre Fix</u>. The location of the centre of a tropical cyclone obtained by means other than reconnaissance aircraft penetration, i.e., surface observations, satellite, ships, land-based radar.

<u>Vortex Fix</u>. The location of the centre of a tropical cyclone obtained by reconnaissance aircraft penetration.

<u>Subtropical cyclones</u>. Non-frontal, low pressure systems comprising initially baroclinic circulations developing over subtropical waters. There are two types: (1) A cold low with circulation extending to the surface layer and maximum sustained winds generally occuring at a radious of about 160 km (100 miles) or more from the pressure centre. These cyclones sometimes undergo a metamorphosis and become tropical storms or hurricanes. (2) A mesoscale cyclone originating in or near a frontolyzing zone of horizontal wind shear, with radious of maximum sustained winds generally less than 48 km (30 miles). The entire circulation sometimes encompasses an area initially no more than 160 km (100 miles) in diameter. These marine cyclones may change in structure from cold to warm core. While generally short-lived, they may ultimately evolve into major hurricanes or into extra-tropical wave cyclones.

/Subtropical cyclones

Subtropical cyclones are classed according to intensity as follows:

(1) Subtropical depression. A subtropical cyclone in which the maximum sustained surface winds (1-minute mean) is 61 km/h (33 knots) (38 miles per hour) or less.

(2) Subtropical storm. A subtropical cyclone in which the maximum sustained surface wind (1-minute mean) is 63 km/h (34 knots)(39 miles per hour) or greater.

Storm surge. The difference between the actual tide as influenced by a meteorological disturbance (i.e., storm tide) and the tide which would have occurred in the absence of the meteorological disturbance (i.e., astronomical tide). Storm surge results from the combined effects of low barometric pressure and water moved shoreward by wind stress.

Wind stress. The dominant factor in storm surge.

Storm tide. The actual water level as influenced by a meteorological disturbance. The storm tide consists of the normal astronomical tide and the storm surge.

Equivalent terms

English	French	Spanish
Advisory	Bulletin météorologique	Advertencia
Hurricane season	Période des cyclones (in France 15 July through 15 October)	"Temporade" de huracanes
Hurricane warning	Alerte cyclone - consignes ORSEC N° 2	Aviso de huracân
Hurricane watch	Prê-alerte cyclone - Consignes ORSEC N° 1	Alerta de huracân

Relationship between hurricane intensity and potential flooding in coastal areas

A scale* from one to five based on the hurricane's present intensity which gives an estimate of the potential property damage and flooding along the coast from a hurricane is as follows:

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* This scale was developed by Saffir and Simpson and is commonly known as the Saffir/Simpson Hurricane Scale (SSH).

/One. Winds

<u>One.</u> <u>Winds 119-153 km/h (74-95 mph) or storm surge 1.2-1.5 m (4-5 feet) above normal.</u> No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery, and trees. Also some coastal road flooding and minor pier damage.

<u>Two.</u> <u>Winds 155-177 km/h (96-110 mph) or storm surge 1.8-2.4 m (6-8 feet) above normal.</u> Some roofing material, door, and window damage to buildings. Considerable damage to vegetation, exposed mobile homes, and piers. Coastal and low-lying escape routes flood 2-4 hours before arrival of centre. Small craft in unprotected anchorages break moorings.

<u>Three.</u> <u>Winds 179-193 km/h (111-130 mph) or storm surge 2.7-3.7 m (9-12 feet) above normal.</u> Some structural damage to small residences and utility buildings with a minor amount of curtainwall failures. Mobile homes are destroyed. Flooding near the coast destroys smaller structures and larger structures damaged by floating debris. Terrain continuously lower than 1.5 m (5 feet) may be flooded inland 13 km (8 miles) or more.

<u>Four.</u> <u>Winds 195-233 km/h (131-155 mph) or storm surge 4-5.5 m (13-18 feet) above normal.</u> More extensive curtainwall failures with some complete roof structure failure on small residences. Major erosion of beach areas. Major damage to lower floors of structures near the shore. Terrain flooded inland as far as 9.7 m (5 miles).

<u>Five.</u> <u>Winds Greater than 233 km/h (155 mph) or storm surge greater than 5.5 m (18 feet) above normal.</u> Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. Major damage to lower floors of all structures located less than 4.6 m (15 feet) above sea level and within 460 m (500 yards) of the shoreline.

CHAPTER II

Responsibilities of Members

2.1 Forecasts and warnings for the general population

In Region IV the responsibility for preparing and issuing warnings is as follows:

Antigua	- The islands and coastal waters of Antigua, Anguilla, Barbuda, British Virgin Islands, Montserrat, Nevis, St. Kitts.
Bahamas	- The islands and coastal waters of the Bahamas, Turks and Caicos Islands.
Barbados	- The islands and coastal water of Barbados, Dominica, St. Lucia, St. Vincent.
Belize	- The coastal waters and inland area of Belize.
Canada	- The coastal waters and inland areas of Canada.
Colombia	- The islands, coastal waters and inland areas of Colombia.
Costa Rica	- The coastal waters and inland areas of Costa Rica.
Cuba	- The islands, coastal waters and inland areas of Cuba.
Dominican Republic	- The coastal waters and inland areas of the Dominican Republic.
El Salvador	- The coastal waters and inland areas of El Salvador.
Guatemala	- The coastal waters and inland areas of Guatemala.
Honduras	- The coastal waters and inland areas of Honduras.
Jamaica	- The coastal waters and islands of Jamaica and the Cayman Islands.
France	- The coastal waters and islands of Martinique, Guadeloupe (Grande Terre and Basse Terre), Marie-Galante, Desirade and Les Saintes.
Mexico	- The coastal waters and inland areas of Mexico.
Nicaragua	- The coastal waters and inland areas of Nicaragua.
Panama	- The coastal waters and inland areas of Panama.
Trinidad & Tobago	- The islands and coastal waters of Trinidad, Tobago, Grenada and the Grenadines.

United States of America - The coastal waters and inland areas of the United States, including Puerto Rico and the US Virgin Islands. In addition, the United States (through Puerto Rico) has agreed to issue warnings for Haiti, Netherlands Antilles (Aruba, Bonaire, Curaçao, Saba, St. Eustatius, St. Maarten), France (St. Barthelemy, Sr. Martin), and their coastal waters. The United States provides Bermuda with information on threatening tropical storms and hurricanes. Forecasts issued by the United States are discussed in Chapter III.

The dissemination of these warnings within each country or territory is the responsibility of that country or territory.

2.2 Forescasts and warnings for the open sea

The United States of America is responsible for preparing marine tropical cyclone forecasts and warnings for the Caribbean Sea, Gulf of Mexico and the North Atlantic Ocean.

2.3 Observations

(1) Radar. Antigua, the Caribbean Meteorological Institute, Barbados, Belize, Cuba, France (Martinique and Guadeloupe), Jamaica, Netherlands Antilles (Curaçao), Trinidad and Tobago, and the United States will take and distribure radar observations whenever a tropical cyclone is within radar range. Frequency and times of observations will be in accordance with US or WMO radar reporting procedures.

(2) Reconnaissance. The United States will make available all operational reconnaissance observations obtained in connexion with tropical disturbances.

(3) Satellite. Near-polar orbiting and geostationary satellite products are made available to countries having the necessary receiving equipment (see WMO Publication No. 411).

(4) Surface. In addition to routine observations, additional observations will be taken by Members upon request of the RMC Miami.

(5) Upper-air. Beside routine observations, additional six hourly rawinsonde observations will ba taken by Members upon request of the RMC Miami.

/2.4 Communications

2.4 Communications

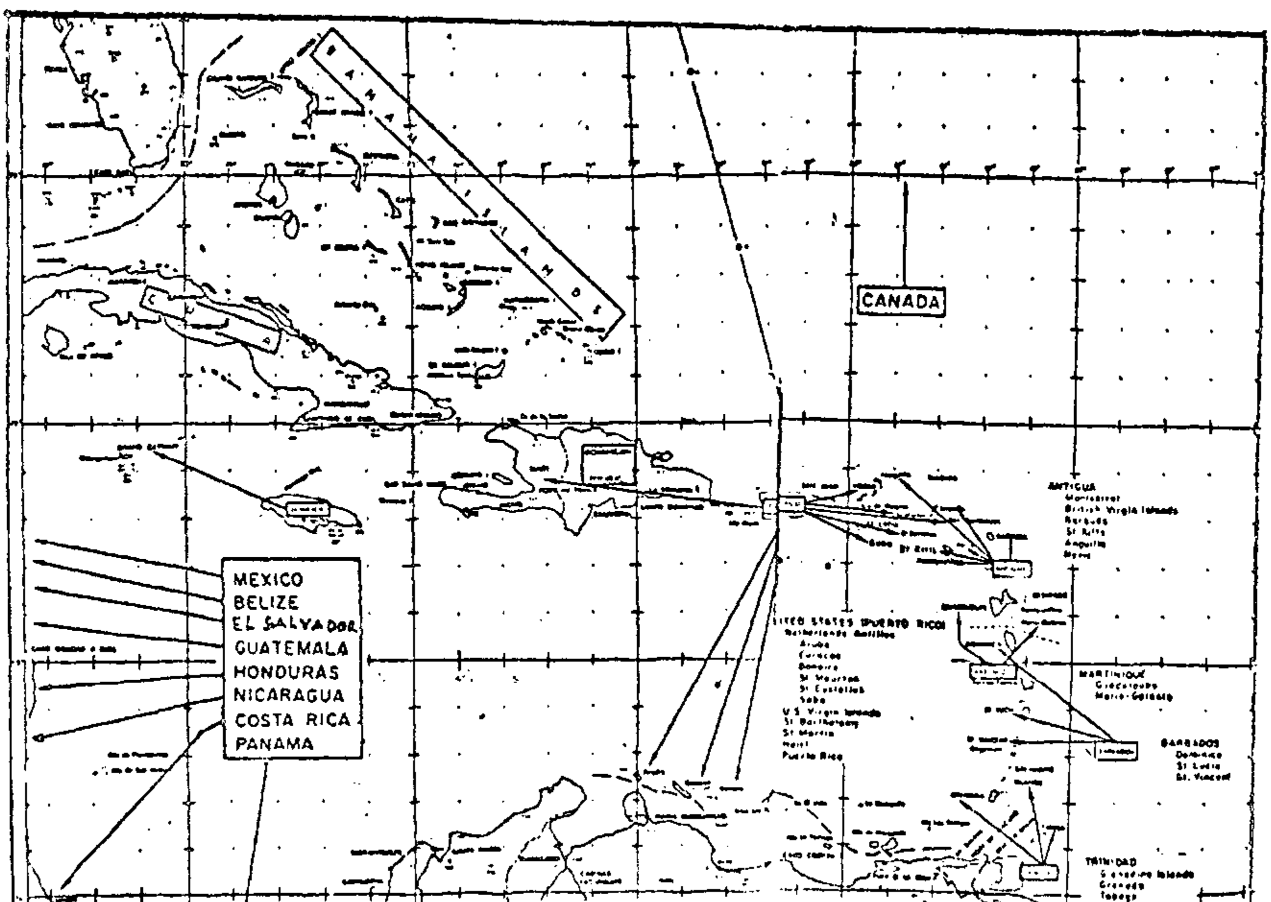
Members will disseminate forecasts, warnings, and observations in accordance with established communications headings presented in this plan and the WMO-WWW Manual on the Global Telecommunication System (WMO - No. 386).

2.5 Information

RMC Miami also serves as a regional information centre on tropical cyclones. This function is performed both during active tropical cyclone periods, and as a source for information on past tropical cyclone activity.

/ATTACHMENT 1

TROPICAL CYCLONE WARNING RESPONSIBILITY OF WMO RA IV COUNTRIES



ATTACHMENT 1

CHAPTER III

TROPICAL CYCLONE ISSUANCES BY THE UNITED STATES

3.1 Tropical Weather Outlook

The Tropical Weather Outlook is prepared by RMC Miami from 1 June through November 30. The Outlook is transmitted at 0530, 1130, and 1730 Eastern local time. Normally the Outlook covers only the tropical and subtropical Atlantic, the Caribbean, and the Gulf of Mexico. The Outlook discusses which areas are expected to remain stable and which disturbed or suspicious areas are becoming favorable for tropical development during the next day or two.

The Outlook is also used for tropical depressions, tropical storms, and hurricanes which are not expected to threaten land areas around the Gulf of Mexico, Caribbean, or Western North Atlantic. In these cases, the Outlook will include in brief form the location, size, movement, and intensity. Map co-ordinates will not be used in giving the location. Whenever advisories are being issued on a tropical cyclone west of 35W, the Tropical Outlook may include areas under threat and/or not expected to be under threat.

Monthly summaries of tropical weather will also be included as part of the Outlook to describe briefly past tropical cyclone activity or lack of it and if possible, to determine how general atmospheric circulation patterns influenced these events.

Example:

ABCA KMIA 091530

TROPICAL WEATHER OUTLOOK FOR THE ATLANTIC...THE CARIBBEAN SEA AND THE GULF OF MEXICO

NATIONAL WEATHER SERVICE MIAMI FL

1130 AM EDT WEDNESDAY JUNE 9, 1976

SATELLITE PICTURES THIS MORNING INDICATE THAT SHOWER ACTIVITY OVER THE NORTHWESTERN CARIBBEAN SEA AND ADJACENT LAND AREAS HAS INCREASED SIGNIFICANTLY SINCE TUESDAY. THERE IS NO EVIDENCE THAT A LOW PRESSURE CENTRE IS DEVELOPING AT THE PRESENT TIME...HOWEVER LOCALLY HEAVY

/RAINS MAY

RAINS MAY OCCUR OVER ISLANDS OF THE NORTHWESTERN CARIBBEAN SEA AND PORTIONS OF BELIZE...HONDURAS...AND NICARAGUA.

TROPICAL STORM FORMATION IS NOT EXPECTED THROUGH THURSDAY.

3.2 Public Advisories

The primary tropical cyclone forecasts issued by the United States to the public are advisories. In the Atlantic, Gulf of Mexico, and Caribbean, an initial public advisory will be issued for all tropical cyclones. Public advisories will continue to be issued for all tropical cyclones threatening or expected to threaten land areas in the Gulf of Mexico, Caribbean, and western North Atlantic. Otherwise, tropical cyclone forecasts will be part of the Tropical Weather Outlook. In the Pacific, public advisories will be issued for tropical storms or hurricanes which are expected to affect United States territory within 48 hours. Public advisories normally will cease when tropical cyclones are below storm strength.

3.2.1 Tropical Depression Advisories

Public tropical depression advisories are issued only for the Atlantic, Caribbean, and Gulf of Mexico. The initial advisory will be issued at the time the depression becomes a threat to land. Subsequent issuances normally will be distributed at the same scheduled times as tropical storm and hurricane advisories. However, the time and frequency of issue may be varied depending on the situation.

The advisory will give the depression location in general terms rather than as map co-ordinates. Both the present and 24 hour forecast movement will be given. Also included will be a description of the depression in terms of size, wind strength, tidal effects, rainfall potential, and tornado potential.

Public tropical depression advisories, with one exception, will not be numbered nor will the depressions be numbered or named. Public tropical depression advisories will only be numbered when a named tropical cyclone reverts to a tropical depression. The numbering will continue as long as advisories are issued. The last statement in each advisory will tell the time of the next advisory and the office responsible for issuing it. This will be followed by the forecaster's last name. The information in the advisory will be in descending order of importance.

/Example:

Example:

BULLETIN

TROPICAL DEPRESSION ADVISORY

NATIONAL WEATHER SERVICE MIAMI, FL

500AM CDT MON OCT 11 1976

THE NATIONAL HURRICANE CENTER ADVISES AT 5 AM CDT THAT THE TROPICAL DEPRESSION IN THE NORTHWESTERN CARIBBEAN SEA WAS CENTERED 350 MILES SOUTH OF GRAN CAYMAN. IT WAS MOVING NORTH NORTHWEST AT 10 MPH AND SHOULD CONTINUE TO DO SO THROUGH TUESDAY MORNING. WINDS OF 30 TO 35 MPH EXTEND 300 MILES NORTH AND EAST OF ITS PRESENT LOCATION. THESE WINDS WILL START AFFECTING WESTERN JAMAICA THIS AFTERNOON AND THE CAYMAN ISLANDS TONIGHT. THE DEPRESSION SHOULD REMAIN AT THIS STRENGTH INTO TUESDAY. OPERATORS OF SMALL CRAFT AROUND JAMAICA AND THE CAYMAN ISLANDS SHOULD NOT GO FAR FROM PORT.

RAINFALL FROM THE DEPRESSION SHOULD START OVER WESTERN JAMAICA TODAY AND OVER THE CAYMAN ISLANDS TONIGHT. ALL INTERESTS AROUND THE WESTERN CARIBBEAN SEA SHOULD CONTINUE TO KEEP INFORMED ABOUT THIS DEPRESSION.

THE NEXT ADVISORY WILL BE RELEASED BY THE NATIONAL HURRICANE CENTER AT 11 AM CDT TODAY.

PELISSIER

3.2.2 Hurricane and Tropical Storm Advisories

Only the United States will issue tropical storm and hurricane advisories on a regional basis. The initial tropical storm advisory will be issued when either the wind speed in a tropical cyclone reaches or is expected to shortly reach, tropical storm strength or the central pressure falls or is expected to soon fall to 1005 millibars or less. After the initial advisory, advisories will continue to be issued as long as the tropical storm or hurricane threatens or is expected to threaten land areas in the Gulf of Mexico, Caribbean, or western North Atlantic. Otherwise, tropical storm and hurricane forecasts will be part of the Tropical Weather Outlook. Tropical cyclones will be given a name in the initial advisory, and this name will continue to be used until the last advisory is issued. The initial and scheduled advisories in the Atlantic, Caribbean, and Gulf will be numbered consecutively beginning with each new storm named. Once numbering begins, it will be continued as long as advisories are being issued, even if the storm decreases to tropical depression strength. In the eastern North Pacific initial public advisories will be given the same number as the marine advisory with which they are issued.

a. Issuance times. In the Atlantic, Caribbean, and Gulf of Mexico scheduled advisories will be issued at 0400, 1000, 1600, and 2200 Greenwich Mean Time (GMT). When no coastal warnings are included, the 0400 GMT advisory may be issued at 0230 GMT. In the eastern North Pacific schedule times are 0300, 0900, 1500 and 2100 GMT for position times of 0000, 0600, 1200 and 1800 GMT, respectively. Actual transmission of the advisories will be 30 minutes before issue time. Unnumbered advisories called intermediate advisories will be prepared at 2 or 3 hour intervals between scheduled advisories whenever a warning is in effect for land areas.

b. Special Advisories. Scheduled or intermediate advisories will be updated whenever the following criteria are met.

(1) Conditions require a hurricane watch or warning to be imposed.

(2) A tropical storm changes to a hurricane or vice versa.

(3) Conditions require change or cancellation of an existing coastal warning.

(4) A tornado threat develops.

(5) Any other significant change occurs based on the judgement. of the forecaster.

These special advisories will be numbered in sequence with the scheduled advisories.

c. Format and Content. All advisories will begin with a "headline" statement which highlights the contents. This headline will be separated from the rest of the advisory. The information in the remainder of the advisory will be presented in descending order of importance or urgency. At the end of the advisory the storm position will be repeated, and the time and office responsible for the next advisory will be given. Following this, the forecaster's name will be included.

Advisories will summarize all coastal warnings and watches that are in effect and should include those areas where operators of small craft should take precautions. The first advisory in which a hurricane watch or warning is mentioned will give the time it becomes effective.

All advisories will include the tropical cyclone location both as distance and direction from a well-known point and as latitude and longitude of the centre. The present movement will be given to 16 points of the compass, if possible. A 24-hour forecast of movement and speed will be included in terms of a continuation or departure from the current movement and speed. This may be reduced to a 12 hour forecast if conditions do not permit a sufficiently high verification probability of the longer period forecast. Uncertainties in either storm location or movement will be explained in the advisory.

Although movement forecasts apply to the storm center, center landfall forecasts will be made with caution to avoid giving the public any false sense of security. It will be stressed that the effects of the hurricane will not be confined to a small area.

Other parameters used to describe the storm will include wind, pressure, storm tide and rainfall. The radius of both hurricane and gale force winds will be given along with the speed of the maximum sustained winds. Specific gust values may be given when the maximum sustained winds are greater than 90 MPH. Otherwise phrases such as "briefly stronger gusts", "winds stronger in squalls", etc., will be used. Central pressure will be included only if a recent reliable value is available. Observed storm tide heights along the coast will be given for specific locations when available.

Wind forecasts will be made in all advisories and, when appropriate, forecasts of flooding induced by storm tide or heavy rain, and any tornado threat. Intensity forecasts will be for 12 hours only and stated as an increase, decrease, or no change from the present intensity. The storm may also be compared to some memorable hurricane, or referred to in terms of a relative intensity scale. The wind forecasts will indicate the approximate times of gale, and hurricane force winds along the mainland coasts or island chain. Storm tide forecasts will give the time of significant heights at areas along the coast and include wave information, if possible.

Examples:

BULLETIN
TROPICAL STORM ANNA...ADVISORY NUMBER 4
NATIONAL WEATHER SERVICE MIAMI, FLORIDA
600 AM EDT MON AUGUST 21 1978
---ANNA MOVING WESTWARD...NO IMMEDIATE THREAT TO LAND---
THE NATIONAL HURRICANE CENTER ADVISES AT 6 AM EDT...1000Z...THAT TROPICAL STORM ANNA WAS CENTERED NEAR LATITUDE 14.5 NORTH LONGITUDE 76.5 WEST OR ABOUT 240 MILES SOUTH OF KINGSTON, JAMAICA. THE STORM WAS MOVING TOWARD THE WEST AT 10 MPH AND SHOULD CONTINUE TO DO SO THROUGH TUESDAY MORNING.
THE LOWEST PRESSURE IN THE STORM WAS ESTIMATED TO BE 29.50 INCHES OR 999 MILLIBARS. ANNA IS EXPECTED TO INCREASE IN INTENSITY BY TONIGHT. MAXIMUM SUSTAINED WINDS AT 6 AM WERE 60 MPH NEAR THE CENTER WITH GALES EXTENDING OUT 75 MILES NORTH AND 50 MILES SOUTH OF THE CENTER.
INTERESTS IN NICARAGUA, HONDURAS, GUATEMALA, BELIZE, AND THE YUCATAN PENINSULA OF MEXICO SHOULD KEEP IN CLOSE TOUCH WITH FUTURE ADVICES ON THIS STORM.
REPEATING THE 6 AM EDT LOCATION...14.5N 76.5W.
THE NEXT ADVISORY ON TROPICAL STORM ANNA WILL BE ISSUED BY THE NATIONAL HURRICANE CENTER IN MIAMI AT NOON EDT.
LAWRENCE

BULLETIN
HURRICANE LADY ADVISORY NUMBER 7
NATIONAL WEATHER SERVICE SAN JUAN PUERTO RICO
6 PM AST WED SEPT 14 1978
...LADY EXTREMELY DANGEROUS...CONTINUES TOWARD LEEWARDS...BASED ON

/RECONNAISSANCE AIRCRAFT

RECONNAISSANCE AIRCRAFT REPORTS AND SATELLITE PHOTOGRAPHS THE CENTER OF DANGEROUS HURRICANE LADY WAS ESTIMATED AT 6 PM AST...2200Z... TO BE LOCATED NEAR LATITUDE 12.0 NORTH...LONGITUDE 51.2 WEST OR ABOUT 560 MILES EAST OF BARBADOS. IT IS MOVING TOWARD THE WEST ABOUT 15 MPH AND IS EXPECTED TO MAINTAIN THAT COURSE AND SPEED TONIGHT. HIGHEST SUSTAINED WINDS NEAR THE CENTER ARE ABOUT 140 MPH AND HURRICANE FORCE WINDS EXTEND OUTWARD 50 MILES IN ALL DIRECTIONS. GALE FORCE WINDS EXTEND 150 MILES IN THE NORTHERN AND 100 MILES IN THE SOUTHERN SEMICIRCLE. THE LOWEST PRESSURE IS 27.75 INCHES OR ABOUT 940 MILLIBARS. GRADUAL STRENGTHENING IS EXPECTED DURING THE NEXT 24 HOURS.

ALL INTERESTS AROUND THE LEEWARD AND WINDWARD ISLANDS...THE VIRGIN ISLANDS AND PUERTO RICO SHOULD KEEP IN CLOSE TOUCH WITH FUTURE ADVICES AS THIS DANGEROUS HURRICANE CONTINUES TO APPROACH.

SMALLER CRAFT AROUND THE LESSER ANTILLES FROM GRENADA NORTHWARD SHOULD REMAIN IN PORT. SHIPS IN THE PATH OF THE HURRICANE SHOULD EXERCISE EXTREME CAUTION.

REPEATING THE 6 PM AST POSITION...12.0N...51.2W...

THE NEXT ADVISOTY WILL BE ISSUED BY THE SAN JUAN WEATHER SERVICE OFFICE AT 9 PM AST.

COLON

BULLETIN

HURRICANE LADY ADVISORY NUMBER 9

NATIONAL WEATHER SERVICE SAN JUAN PUERTO RICO

6AM AST THU SEP 15 1978

...HURRICANE THREATENS PORTIONS OF LEEWARD AND WINDWARD ISLANDS...

AT 6AM AST THE WEATHER SERVICE OF BARBADOS ISSUED HURRICANE WARNINGS FOR THE ISLANDS OF BARBADOS...ST VINCENT...ST LUCIA...AND DOMINICA. THE WEATHER SERVICE OF MARTINIQUE AT 6AM AST ALSO ISSUED HURRICANE WARNINGS FOR MARTINIQUE. HURRICANE WARNINGS THEREFORE EXTEND FROM ST VINCENT NORTHWARD THROUGH DOMINICA. GALE WARNINGS AND A HURRICANE WATCH CONTINUE OVER GRENADA AND THE GRENADINES AND FROM NORTH OF DOMINICA THROUGH ANTIGUA. AT 6AM AST...1000Z...THE CENTER OF HURRICANE

LADY WAS ESTIMATED FROM RECONNAISSANCE AIRCRAFT REPORTS TO BE NEAR LATITUDE 12.5 NORTH LONGITUDE...55.0 WEST OR ABOUT 300 MILES EAST OF BARBADOS. IT IS MOVING TOWARD THE WEST NORTHWEST ABOUT 15MPH AND IS EXPECTED TO CONTINUE THIS COURSE AND SPEED TODAY.

HIGHEST SUSTAINED WINDS NEAR THE CENTER ARE 150MPH WITH GUSTS UP TO 180MPH. HURRICANE FORCE WINDS EXTEND 50 MILES IN ALL DIRECTIONS. GALE FORCE WINDS EXTEND 150 MILES IN THE NORTHERN AND 100 MILES IN THE SOURTHERN SEMICIRCLE. THE LOWEST PRESSURE IS 930 MILLIBARS... 27.46 INCHES. SOME FURTHER STRENGTHENING IS LIKELY DURING THE DAY.

GALE FORCE WINDS WILL REACH BARBADOS THIS AFTERNOON AND INCREASE TO HURRICANE FORCE EARLY TONIGHT. ELSEWHERE IN THE HURRICANE WARNING AREA GALE FORCE WINDS WILL BEGIN TONIGHT AND HURRICANE FORCE WINDS WILL BEGIN BY FRIDAY MORNING. GALE FORCE WINDS OR HIGHER ARE LIKELY FROM GRENADA THROUGH ANTIGUA BY FRIDAY MORNING.

TIDES ARE BEGINNING TO INCREASE AND ARE EXPECTED TO REACH 5 FEET ABOVE NORMAL IN THE HURRICANE WARNING AREA TONIGHT AND 10 TO 15 FEET ABOVE NORMAL AROUND BARBADOS AS THE CENTER OF THE HURRICANE NEARS THE ISLAND FRIDAY MORNING.

INTERESTS IN THE REMAINDER OF THE LEEWARD ISLANDS AND THE VIRGIN ISLANDS SHOULD KEEP IN CLOSE TOUCH WITH FUTURE ADVICES. SMALL CRAFT FROM TRINIDAD TO PUERTO RICO SHOULD REMAIN IN PORT. REPEATING THE 6AM AST POSITION 12.5N...55.0W.

THE NEXT ADVISORY WILL BE ISSUED BY THE SAN JUAN WEATHER SERVICE OFFICE AT 8AM AST.

COLON

Statements in the advisories and bulletins issued by the RMC Miami (US) concerning Members will also, where possible, be co-ordinated with the National Meteorological Services concerned.

3.2.3 Marine Advisories

Marine tropical cyclone advisories are prepared only by the US hurricane centers. They are prepated for all tropical depressions, tropical storms, or hurricanes within a center's area of responsibility. Advisories will cease when tropical cyclones drop below depression stage or have gone inland and winds over the water have dropped below gale force.

/a. Time

a. Time of Issuance

In the Atlantic, Caribbean, and Gulf of Mexico these advisories should be distributed 30 minutes prior to their valid times of 0400, 1000, 1600 and 2200 GMT. In the Eastern North Pacific the advisories are scheduled for 0300, 0900, 1500 and 2100 GMT for position times of 0000, 0600, 1200 and 1800 GMT, respectively. Eastern North Pacific advisories will be transmitted 15 minutes prior to the valid time.

b. Special Advisories

Special advisories will be issued for important changes in tropical cyclones such as changes in direction, intensity, etc. In addition, special marine advisories will be issued whenever public special advisories are issued.

c. Naming and Numbering Cyclones and Advisories

Tropical depressions will be numbered consecutively each season beginning with one. If a tropical depression becomes a tropical storm or hurricane, it will be named and the number dropped. Later, if the named storm reverts to a tropical depression, it will again have the same number as before it was named.

In the Atlantic, Caribbean, and Gulf of Mexico advisories will be numbered consecutively begining with each new depression. When the depression becomes a storm or hurricane, the advisory numbering will revert to one and start all over again. Special advisories will also be numbered.

In the Eastern North Pacific advisories will be numbered consecutively beginning with each new depression and continued consecutively if the depression becomes a storm or hurricane. Special advisories will be numbered in sequence with scheduled advisories. Eastern North Pacific advisories will not be numbered sequentially with NHC advisories on storms crossing Central America into the Pacific.

All marine advisories on tropical storms and hurricanes will contain 12- and 24-hour forecast periods only.

d. Content of Advisories

Marine/Aviation advisories will contain the following information:

(1) Time of issue.

(2) Heading, advisory number, corrected, or relocated, type cyclone and name or number, and hour and day.

(3) Warnings in effect.

(4) Position, in degrees and tenths.

(5) Time of position in GMT.

(6) Accuracy of position.

(7) Present movement.

(8) Present winds:

(a) Maximum sustained winds and gusts.

(b) Maximum sustained winds and gusts more than 16 km/h (10 miles) inland from the coast (Atlantic, Gulf of Mexico and Caribbean only).

(c) Radius of 119-93, and 63 km/h (64-, 50-,and 34-knot) sustained winds (Atlantic, Gulf of Mexico and Caribbean only).

(d) Radius of 161-93, and 63 km/h (100-, 50-, and 34-knot) sustained winds (Eastern Pacific only).

(9) Radius of seas 4.6 m (15 feet) or higher (Atlantic, Gulf of Mexico and Caribbean only).

(10) Repeat center location and time.

(11) Forecasts:

(a) The 12-hour forecast position:

(1) Maximum sustained winds and gusts in 12 hours.

(2) Maximum sustained winds and gusts over inland areas (Atlantic only).

(3) Radius of 93 km/h (50-knot) sustained winds in 12 hours.

(b) The 24-hour forecast position:

(1) Maximum sustained winds and gusts in 24 hours.

(2) Maximum sustained winds and gusts over inland areas (Atlantic only).

(3) Radius of 93 km/h (50-knot) sustained winds in 24 hours.

/(12) Storm-tide

(12) Storm-tide forecast.

(13) Heavy precipitation forecast.

Examples:

TROPICAL DEPRESSION THREE MARINE ADVISORY NUMBER 4
NATIONAL WEATHER SERVICE MIAMI FL
1000Z JUL 3 1976
DEPRESSION CENTER LOCATED NEAR 15.2 NORTH 82.4 WEST AT 031000Z.
POSITION GOOD BASED ON NOAA RECONNAISSANCE TIME OF FIX 030819Z.
PRESENT MOVEMENT NORTH NORTHWEST OR 340 DEGREES AT 9 KT.
MAX SUSTAINED WINDS OF 30 KT EXTENDING 200 NM NORTH AND EAST OF THE CENTER.
24 HOUR FORECAST VALID 041000Z 19.0N 82.7W.
MAX SUSTAINED WINDS OF 30 KT EXTENDING 200 NM NORTH AND EAST OF THE CENTER.
NEXT ADVISORY AT 031600Z.

TROPICAL STORM BONNY MARINE ADVISORY NUMBER 2
NATIONAL WEATHER SERVICE SAN FRANCISCO CA
0900A AUG 4 1976
TROPICAL STORM CENTER LOCATED NEAR 19.0 NORTH 109.0 WEST AT 040600Z.
POSITION ACCURATE WITHIN 60 MILES BASED ON SATELLITE.
PRESENT MOVEMENT WEST NORTHWEST OR 300 DEGREES AT 12 KT.
DIAMETER OF EYE 10 NM.
MAX SUSTAINED WINDS 40 KT WITH GUSTS TO 65 KT.
RAD OF 34 KT WINDS 50 NM.
REPEAT CENTER LOCATED 19.0N 109.0W AT 040600Z.
FCST VALID 041800Z 19.5N 113.0W.
MAX SUSTAINED WINDS OF 60 KT WITH GUSTS TO 75 KT.
RADIUS OF 50 KT WINDS 25 NM.
FCST VALID 050600Z 23.0N 115.0W
MAX SUSTAINED WINDS OF 60 KT WITH GUSTS TO 75 KT.
RADIUS OF 50 KT WINDS 25 NM.
NEXT ADVISORY AT 041500Z

/HURRICANE LADY

HURRICANE LADY MARINE ADVISORY NUMBER 9
NATIONAL WEATHER SERVICE MIAMI FL
1000Z SEP 15 1978
HURRICANE WARNINGS ARE IN EFFECT FOR BARBADOS...ST VINCENT...
ST LUCIA...DOMINICA AND MARTINIQUE. GALE WARNINGS AND A HURRICANE
WATCH ARE IN EFFECT FOR GRENADA AND THE GRENADINES AND FROM
NORTH OF DOMINICA THROUGH ANTIGUA.
HURRICANE CENTER LOCATED NEAR 12.5 NORTH...55.0 WEST AT 15/1000Z.
POSITION GOOD BASED DOD RECONNAISSANCE TIME OF FIX 150830Z
SATELLITE AND SHIP REPORT.
PRESENT MOVEMENT WEST NORTHWEST OR 285 DEGREES AT 12 KT.
MAX SUSTAINED WINDS 130 KT WITH GUSTS TO 160 KT.
RADIUS OF 64 KT WINDS 50NE 25SE 25SW 50NW.
RADIUS OF 50 KT WINDS 75NE 50SE 50SW 75NW.
RADIUS OF 34 KT WINDS 150NE 100SE 100SW 150NW.
RADIUS OF SEAS 15 FT OR HIGHER 150NE 100SE 100SW 150NW.
REPEAT CENTER LOCATED 12.5N 55.0W AT 15/1000Z.
FORECAST VALID 15/1800Z 13.0N 56.5W.
MAX SUSTAINED WINDS OF 140 KT WITH GUSTS TO 170 KT.
RADIUS OF 50 KT WINDS 100NE 75SE 75SW 100NW.
FORECAST VALID 16/0600Z 13.3N 59.0W.
MAX SUSTAINED WINDS OF 140 KT WITH GUSTS TO 170 KT.
RADIUS OF 50 KT WINDS 100NE 75SE 75SW 100NW.
STORM TIDE UP TO 5 FEET ABOVE NORMAL IN THE HURRICANE WARNING
AREA TONIGHT INCREASING TO 10-15 FEET AROUND BARBADOS BY 16/1200Z.
NEXT ADVISORY AT 15/1600Z.

/CHAPTER IV

CHAPTER IV

GROUND RADAR OBSERVATIONS

4.1 Discussion

Radar reports during tropical cyclones are among the most important and useful observations available to the hurricane forecaster and to those whose responsibility it is to issue warnings. It is essential that continuous radar observations be taken whenever a tropical cyclone is under surveillance by a particular radar, and that all responsible officials co-operate to insure that the observations are distributed to hurricane centers and other concerned meteorological offices.

United States radar stations will encode their observations in the formats specified in the Federal Meteorological Handbook No. 7.

Weather Radar Observations

Adherence to the following procedures when radar operators observe a tropical cyclone will enhance their value to users.

4.1.1 Scheduled Observations

Transmit complete observations at the regularly scheduled times. These observations will include data on the eye when it is observed.

Special Observations

Any observation containing an eye or center position will be designated a special observation. Include the latitude and longitude of the eye or center and any other appropriate remarks.

4.1.2 Definition of the Eye or Center

Derive the eye position from a continuous and logical sequence of observations. Ideally, the radar observed eye is readily apparent as a circular echo free area surrounded by the wall cloud. Report the geometric center of this echo free area as the eye location. If the wall cloud is not completely closed it is still usually possible to derive an eye location by sketching the smallest circle or oval that can be superimposed inside the observed part of the wall cloud. When circulation is identifiable but no wall cloud is observed, the center of circulation should be reported as a center.

/4.1.3 Terminology

4.1.3 Terminology

When the central region of a storm is defined by an identifiable wall cloud, report central region as an "EYE". If the center of circulation is recognizable, but not well defined by a wall cloud, report the center as a "CNTR". If an eye or center is only occasionally recognizable, or if there is reason to suspect the central organization, the fix should be reported as a "PSBL EYE" or "PSBL CNTR".

Include a remark with eye fixes to indicate the degree of confidence in the fix. When the wall cloud is closed or nearly closed and the eye is symmetrical, the remark "GOOD FIX" will usually be used. When the wall cloud is poorly formed or the eye asymmetrical, use the remark "POOR FIX". Use the remark "FAIR FIX" to express an intermediate level of confidence.

4.1.4 Use of Spiral Band Overlays

Spiral band overlays may be used to estimate the location of the eye when the center of a hurricane or tropical storm is over water. Normally, at least 90° and preferably 180° of arc of the spiral band should be observed when using spiral band overlays. Standard overlays are available with 10°, 15°, and 20° crossing angles. Since the crossing angle of a given spiral band may increase from near 0° at the eye to more than 20° at distances over 160 km (100 miles) from the center, the best results can be expected by using the spiral band overlay which best fits the intermediate portion of the band (usually 45-140 kilometers (25-75 nautical miles) from the eye). The radar control settings should be adjusted to enhance the definition of the spiral band when using spiral band overlays. When spiral band overlays are used, include a remark specifying which crossing angle was used.

4.2 Coastal radars are operated by US National Weather Service at the following sites:

	IDENTIFICATION	RADAR	LATITUDE	LONGITUDE
Apalachicola, FL	AQQ	WSR-57	29°44'N.	84°59'W.
Atlantic City, NJ	ACY	WSR-57	39°27'N.	74°35'W.
Baton Rouge, LA	BTR	WR-100-5	30°32'N.	91°09'W.
Brownsville, TX	BRO	WSR-57	25°54'N.	97°26'W.
Brunswick, ME	NHZ	WSR-57	43°54'N.	69°56'W.
Cape Hatteras, NC	HAT	WSR-57	35°16'N.	75°33'W.
Charleston, SC	CHS	WSR-57	32°54'N.	80°02'W.
Chatham, MA	CHH	WSR-57	41°39'N.	69°54'W.
Daytona Beach, FL	DAB	WSR-57	29°11'N.	81°03'W.
Galveston, TX	GLS	WSR-57	29°18'N.	94°48'W.
Jackson, MS	JAN	WSR-57	32°19'N.	90°05'W.
Key West, FL	EYW	WSR-57	24°33'N	81°45'W.
Lake Charles, LA	LCH	WSR-57	30°07'N.	93°13'W.
Miami, FL	MIA	WSR-57	25°43'N.	80°17'W.
New York, NY	NYC	WSR-57	40°46'N.	73°59'W.
Patuxent, MD	NHK	WSR-57	38°17'N.	76°25'W.
Pensacola, FL	NPA	WSR-57	30°21'N.	87°19'W.
San Juan, PR	MJSJ	FPS-67*	18°16'N.	65°46'W.
Slidell, LA	SIL	WSR-57	30°17'N.	89°46'W.
Tampa, FL	TBW	WSR-57	27°42'N.	82°24'W.
Victoria, TX	VCT	WR-100-5	28°51'N.	96°55'W.
Volens, VA	7VH	WSR-74S	36°57'N.	79°00'W.
Waycross, GA	AYS	WSR-57	31°15'N.	82°24'W.
Wilmington, NC	ILM	WSR-57	34°16'N.	77°55'W.

4.3 Panama Radar

Howard FFB Canal Zone*	MBHO	FPS-77	08°77'N	79°36'W

* Operated by the U.S.

/4.4 Canadian

4.4 Canadian radar

Halifax Intl. Airport, N.S.	CYHX		44°53'	63°31'

4.5 Radars of the Caribbean Meteorological Organization Network:

	IDENTIFICATION	RADAR	LATITUDE	LONGITUDE
Belize International Airport, Belize	MZBZ	MITSUBISHI RC-32B	17°32'	88°18'
Kingston, Jamaica	MKJP	"	18°04'	76°51'
Coolidge Airport, Antigua	MKPA	"	17°07'	61°47'
Crown Point Airport, Tobago	MKPT	"	11°09'	60°50'
Bridgetown, Barbados	MKPB	"	13°09'	59°37'
Timehri Airport, Georgetown, Guyana	MLTM	"	6°30'	58°15'

4.6 Cuban Radars: (Collective heading, SDCU MUHV)

Havana	78325		23°10'	82°21'
Camaguey	78255		21°25'	77°51'
LaBajada	78311		21°55'	80°28'
Punta del Este	78324		21°34'	82°33'
Gran Piedra	78366		20°00'	75°38'

4.7 French radars

Fort-de-France, Martinique	MFFD	OMERA RP 41		
Lamentin, Martinique	MFFF	OMERA QRP 330	14°36'	61°00'
Le Raizet, Guadeloupe	MFFR	OMERA RP 41	16°16'	61°32'
Rochambeau, French Guiana	MOOO	OMERA RP 41	4°50'	52°22'

4.8 Netherlands Antilles Radars

Dr. A. Plesman Airport Curaçao, Neth. Antilles	MACC	TEXAS INSTR. 10cm/90 mi	12°11'	68°58'
Willemstad Curaçao, Neth. Antilles *	MACC	WSR-74S 10cm/250 mi	12°00'	68°58'

4.9 Surinam Radar

Zanderij Airport, Surinam	MEZY		5°27'	55°12'

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* To be implementated January 1979

/CHAPTER V

CHAPTER V

SATELLITE SURVEILLANCE OF TROPICAL AND SUBTROPICAL CYCLONES

5.1 Meteorological Satellites Operated by the United States

(a) Geostationary Operational Environment Satellite (GOES)

The GOES system consists of three satellites, two operational and one standby. The principal GOES products are 1/2 hourly pictures with implanted grids automatically applied to all sectors. During the daylight hours 0.8 km, 1.6 km and 3.2 km (1/2 mile, 1 mile and 2 miles) resolution visible fixed standard sectors are produced, and during the night equivalent 1.6 and 3.2 km (1 mile and 2 miles) IR (infrared) standard sectors are produced. Additionally, certain IR pictures will be enhanced at specified times to emphasize various features, and floating sectors at 0.8 km, 1.6 km and 3.2 km (1/2, 1 and 2 miles) resolution may be produced as desired to augment standard sector coverage. Full disc infrared (IR) pictures of 6.4 km (4 miles) resolution are produced every 30 minutes 24 hours per day. All products are delivered in near-real-time to Satellite Field Service Stations (SFSSs), to the National Environmental Satellite Service (NESS) Analysis and Evacuation Branch, and to Weather service Forecast Offices.

(b) NOAA Polar-Orbiting Satellites

The NOAA (National Oceanic and Atmospheric Administration) polar-orbiting satellites provide global visible and IR pictures with 0.8 km (1/2 mile) resolution twice a day which are centrally received, processed and disseminated. In addition, any nation with automatic picture transmission (APT) receiving capability can obtain these pictures.

5.2 Satellite Field Service Stations

a. Support Concept. Under the NESS SFSS support concept, GOES imagery in support of the hurricane warning services is distributed by the Central Data Distribution Facility at Marlow Heights, Maryland, to the SFSS's in Miami, San Francisco, Honolulu and Washington. These SFSS's are co-located with National Weather Service (NWS) hurricane forecasting units and are responsible for providing support to them.

/b. Station

b. Station Contact. SFSS satellite meteorologist can be contacted as follows:

(1) Miami - between 0630-1630 EDT and 2000-0400 EDT at (305) 350-4310.

(2) San Francisco - 24 hours a day 415-470-9122/9123.

5.3 NESS Analysis and Evaluation Branch (AEB). The AEB operates 24 hours a day to provide GOES and NOAA satellite data support to the National Meteorological Center (NMC).

Table 1, Appendix A, summarizes data available from various United States satellites.

/Table 1

Table 1

SATELLITES AND SATELLITE DATA AVAILABILITY FOR 1978 HURRICANE SEASON

Satellite	Type of Data	Local Time	
GOES-1 (East 75.0°W SMS-2/GOES (West) 135.0°W SMS-1/GOES (Standby) 105.0°W	VISSR	#Every 30 minutes (24 hrs/day) (Limited scan for short interval viewing available.)	1. 1/2, 1 and 2 mi. resolution visible Standard Sectors covering Western U.S., Mid-West and Eastern U.S. (daylight hours). 2. 1 and 2 mi. equivalent IR Standard Sectors for the entire U.S. (nighttime hours). 3. Equivalent IR enhanced imagery. 4. Floating sectors at 1/2, 1 and 2 mi. resolution (visible and equivalent IR). 5. Full disc IR (day and night). 6. Movie Loops. 7. Wind Analysis.
ITOS (NOAA series)	SR (stored) APT (direct) VTPR VHRR	0900/2100	1. Mapped digitized SR (cloud cover Imagery) 2. Sea-surface Temperature Analysis 3. Moisture Analysis 4 Soundings

Except for scheduled interrupts for preventive maintenance (PM), i.e., 2 1/2-hour period for each satellite on alternating days: GOES-1 PM 0450 through 0720 GMT and SMS-2 PM, 0505 through 0735 GMT. Full disc IR will be provided during these periods.

VTPR - Vertical Temperature Profile Radiometer.
APT - Automatic Picture Transmission
SR - Scanning Radiometer
VHRR - Very High Resolution Radiometer
VISSR - Visible-Infrared Spin Scan Radiometer
VHR - Very High Resolution (Visual Scanning Radiometer 1/2nm)
HR - High Resolution (Visual Scanning Radiometer 2nm)
WHR - Very High Resolution (Infrared Scanning Radiometer 1/2nm)
MI - High Resolution (Infrared Scanning Radiometer 2nm)
ITOS - Improved TIROS Operational Satellite
SMS - Synchronous Meteorological Satellite
GOES - Geostationary Operational Environmental Satellite
IR - Infrared

CHAPTER VI

AIRCRAFT RECONNAISSANCE

6.1 The tropical cyclone reconnaissance system of the United States normally will be prepared to generate up to five reconnaissance aircraft sorties per day in the Atlantic and eastern North Pacific areas. Notification of requirements generally must be levied by the RMC Miami early enough to allow 16 hours plus en route flying time to insure that the aircraft will reach the area on time.

6.2 Aircraft Reconnaissance Data:

6.2.1 Parameter Requirements. Data needs in order of priority are:

(1) Geographical position of vortex center (surface center if known).

(2) Central sea level pressure (by dropsonde or extrapolation from within 1500' of sea surface).

(3) Minimum 700 millibar (mb) height (if available).

(4) Wind profile data (surface and flight level).

(5) Temperature (flight level).

(6) Sea Surface temperature.

(7) Dewpoint temperature (flight level).

(8) Height of Eye Wall.

6.2.2 Meteorological Instrument Capabilities. Required aircraft reconnaissance data instrument capabilities are as follows:

(1) Data positions - within 18.5 km (10 nm).

(2) Sea level pressures - ±2 millibars.

(3) Pressure heights - ±10 meters.

(4) Temperatures (including dewpoint and sea surface temperatures (SST)) - ±0.5 degrees C.

(5) Winds - speed ± 9 km/h (±5 knots); direction ±10 degrees.

6.3 Mission Identifier

Each reconnaissance report will include the mission identifier as the opening text of the message.

Regular weather and hurricane reconnaissance messages will include the 5 digit agency/aircraft indicator followed by the assigned mission-system indicator. Elements of the mission identifier are:

/Agency - Aircraft

Agency - Aircraft Indicator - Mission System Indicator

Agency - Aircraft Number	# of missions this system	TD# or XX if not a	Storm Name or words
AF Plus last 3 digits of tail number	(2 digits)	TD or greater (2 digits)	CYCLONE or DISTURB
NOAA Plus last digit of registration number			

Examples:

AF985 01XX DISTURB (1st mission on a disturbance)

AF987 0503 CYCLONE (5th mission on depression #3, tropical or subtropical)

NOAA2 0701 AGNES (7th mission on TD #1 which has acquired the name Agnes)

6.4 Observation Numbering and Content

(1) The first weather observation will have appended as remarks the ICAO four letter departure station identifier, time of departure and estimated time of arrival (ETA) at the co-ordinates or storm. It will be transmitted as soon as possible after take-off.

Example:

AF966 0308 EMMY OB 1

97779 TEXT TEXT...DPTD KBIX AT 102100Z ETA

31.5N 75.0W AT 110015Z

(2) All observations on tropical cyclone missions requested by Hurricane Centers will be numbered sequentially from the first to the last.

6.5 Aerial Reconnaissance Weather Encoding and Reporting

6.5.1 Horizontal and Vertical. Horizontal meteorological observations and vertical observations will be coded and transmitted in RECCO code and TEMP DROP Code, respectively. En route RECCO observations will be taken and transmitted at least hourly until the aircraft is within 370 km (200 nm) of the center of the storm at which time observation frequency will become at least every 30 minutes.

6.5.2 Vortex Data. All observed vortex fix information will be included in the Detailed Vortex Data Message (Form 1, Appendix A) prepared and

/transmitted for

transmitted for all scheduled fixes and in all Detailed Vortex Data Messages prepared and transmitted on an "as required" basis for intermediate non-scheduled fixes. An Abbreviated Vortex Data Message (Form 1, Appendix A, Items A-H) may be sent in lieu of the detailed message for intermediate fixes. These messages should be transmitted as soon as possible.

6.5.3 Supplementary Vortex Data. Penetration and collection of supplementary vortex data on operational flight patterns will normally start at 700 millibars at a redius of 148 km (80 nm) (nautical miles) from the center as determined by the flight meteorologist. The supplementary vortex data requires are as shown in form 2 of Appendix.

6.5.4 Aerial Reconnaissance Weather Encoding and Reporting. Other than vortex data and supplementary vortex data messages, teletype aerial reconnaissance observation messages will have the following format:

9xxx9 GGggi_d YQ$L_aL_aL_a$ $L_oL_oL_o$Bf_c $h_ah_ah_ad_td_a$ ddfff TTT_dT_dw m_wjHHH 4ddff and

9$V_iT_wT_wT_w$ 95559 GGggi_d YQ$L_aL_aL_a$ $L_oL_oL_o$Bf_c ddfff TTT_dT_dw m_wjHHH 4ddff plus

9$V_iT_wT_wT_w$. The weather monitor will append coded latitude and longitude groups, flight level wind group and/or surface wind group following the last group of the RECCO report.

Symbol Identification

9xxx9	- RECCO indicator group specifying type of observation.
xxx = 222	- Basic observation without radar data.
555	- Intermediate observation.
777	- Basic observation with radar data.
GGgg	- Time of observation (hours and minutes -GMT).
i_d	- Humidity indicator (0-no humidity; 4-°C Dewpoint).
Y	- Day of week (Sun-1).
Q	- Octant of the globe (0- 0° - 90°W N.H.) (1-90° -180°W N.H.)
$L_aL_aL_a$	- Latitude degrees and tenths.
$L_oL_oL_o$	- Longitude degrees and tenths.
B	- Turbulence (range 0 - none to 9 - frequent, severe).
fc	- Cloud amount (range 0 - less than 1/8 to 9 - in clouds all the time).

/$h_ah_ah_a$ -

$h_a h_a h_a$ - Absolute altitude of aircraft (decameters).

d_t - Type of wind (range 0 - spot wind to 9 averaged over more than 740 km (400 nm)).

d_a - reliability of wind (range 0-90% to 100% reliable to 7 - no reliability, and 8 - no wind).

dd - Wind direction at flight level (tens of degrees true).

fff - Wind speed at flight level (knots).

TT - Temperature (whole degrees C); (50 added to temperature for negative temperatures).

$T_d T_d$ - Dewpoint temperature (whole degrees C), (when // with i_d = 4 indicates relative humidity less than 10%).

w - Present weather (0 - clear, 4 - thick dust or haze, 5 - drizzle, 6 - rain, 8 - showers, 9 - thunderstorms).

m_w - Remarks on weather (range 0 - light intermittent to 5 - heavy continuous, and 6 - with rain).

j - Index to level (0 - sea level pressure in whole millibars (mb), thousands omitted; 1 - 1000 mb surface height in geopotential meters, 500 added HHH if negative; 2-850 mb and 3 - 700 mb height in gpm, thousands omitted; 4 - 500 mb, 5 - 400 mb and 6 - 300 mb height in geopotential decameters; 7 - 250 mb height in geopotential decameters tens of thousands omitted; 8 - D - value in geopotential decameters, 500 added to HHH if negative; 9 - no absolute altitude available).

4 - Group indicator for surface wind direction and speed.

V_i - Inflight visibility (1 - 0 to 1.8 km (0 to 1 nm); 2 - greater than 1.8 km (1 nm), but not exceeding 5.5 km (3 nm); 3 - greater than 5.5 km (3 nm)).

$T_w T_w T_w$ - Sea surface temperature (degrees and tenths C).

/APPENDIX A, Form 1

APPENDIX A

Form 1

DATE	SCHEDULED FIX FIVE	AIRCRAFT NUMBER	ARWO
MANOP HEADING (PRECEDENCE IMMEDIATE)			
MISSION IDENTIFIER AND OBSERVATION NUMBER			
(ABBREVIATED) (DETAILED) VORTEX DATA MESSAGE			

A	Z	DATE AND TIME OF FIX
B	DEG MIN N S	LATITUDE OF VORTEX FIX
	DEG MIN E W	LONGITUDE OF VORTEX FIX
C	MB M	MINIMUM HEIGHT AT STANDARD LEVEL
D	KT	ESTIMATE OF MAXIMUM SURFACE WIND OBSERVED
E	DEG NM	BEARING AND RANGE FROM CENTER OF MAXIMUM SURFACE WIND
F	DEG KT	MAXIMUM FLIGHT LEVEL AND WIND NEAR CENTER
G	DEG NM	BEARING AND RANGE FROM CENTER OF MAXIMUM FLIGHT LEVEL WIND
H	MB	MINIMUM SEA LEVEL PRESSURE COMPUTED FROM DROPSONDE OR EXTRAPOLATED FROM WITHIN 1,500 FT OF SEA SURFACE
I	C/ M	MAXIMUM FLIGHT LEVEL TEMP. PRESSURE ALTITUDE OUTSIDE EYE
J	C/ M	MAXIMUM FLIGHT LEVEL TEMP. PRESSURE ALTITUDE INSIDE EYE
K	C/ C	DEWPOINT TEMP. SEA SURFACE TEMP. INSIDE EYE
L		EYE CHARACTER: CLOSED WALL, POORLY DEFINED, OPEN SW, etc.
M		EYE SHAPE ORIENTATION DIAMETER. Code eye shape as C=Circular; CO=Concentric; E=Elliptical transmit orientation of major axis in tens of degrees I.E. 01-010 to 190, 17-170 to 350. Transmit diameter in nautical miles. Example CB=Circular eye 8 miles diameter. E09/15.5=Elliptical eye major axis 090-270, length of major axis 15 NM, length of minor axis 5 NM, C06-14=Concentric eye, diameter inner eye 8 NM, outer eye 14 NM.
N	DEG MIN N S	CONFIRMATION OF FIX: Coordinators and time
	DEG MIN E W	
	Z	
O	/	FIX DETERMINED BY/FIX LEVEL FIX DETERMINED BY: 1 - Penetration, 2 - Radar, 3 - Wind, 4 - Pressure, 5 - Temperature. FIX LEVEL (Indicate surface center if visible; indicate both surface and flight level centers only when same) 0 - Surface, 1 - 1,500 FT, 8 - 850 mb, 7 - 700 mb, 5 - 500 mb, 4 - 400 mb, 3 - 300 mb, 2 - 200 mb, 9 - other.
P	/ NM	NAVIGATION FIX ACCURACY/METEOROLOGICAL ACCURACY
Q		REMARKS

INSTRUCTIONS: Items A through G (and H when extrapolated) are transmited from the aircraft immediately following the fix. The remainder of the message is transmitted as soon as available for scheduled fixes and at the ARWO's discretion for unscheduled (intermediate) fixes.
*CHECK SUM REQUIRED IN WESTPAC.

/APPENDIX A Form 2

APPENDIX A

Form 2

DATE	AIRCRAFT NUMBER	ARWO

MANOP HEADING (PRECEDENCE IMMEDIATE)

MISSION IDENTIFIER AND OBSERVATION NUMBER

SUPPLEMENTARY VORTEX DATA MESSAGE

1 AZIMUTH	2 ddDEG DEG	3 FLZZZ FL					
4 LEFT RIGHT	5 FRONT REAR	6 QUAD					
7 DjHHH 8	8 DTTQQ 8	9 DjHHH 4	10 DTTQQ 4	11 DjHHH 3	12 DTTQQ 3	13 DjHHH 1	14 DTTQQ 1
15 DjHHH 0	16 DTTQQ 0	17 64RRR 64	18 50RRR 50	19 34RRR 34	20 MXFFF MX	21 BBBRR	22 hhhhh
23 LEFT RIGHT	24 FRONT REAR	25 QUAD					
26 DjHHH 8	27 DTTQQ 8	28 DjHHH 4	29 DTTQQ 4	30 DjHHH 3	31 DTTQQ 3	32 DjHHH 1	33 DTTQQ 1
34 DjHHH 0	35 DTTQQ 0	36 64RRR 64	37 50RRR 50	38 34RRR 34	39 MXFFF MX	40 BBBRR	41 hhhhh
42 LEFT RIGHT	43 FRONT REAR	44 QUAD					
45 DjHHH 8	46 DTTQQ 8	47 DjHHH 4	48 DTTQQ 4	49 DjHHH 3	50 DTTQQ 3	51 DjHHH 1	52 DTTQQ 1
53 DjHHH 0	54 DTTQQ 0	55 64RRR 64	56 50RRR 50	57 34RRR 34	58 MXFFF MX	59 BBBRR	60 hhhhh
61 LEFT RIGHT	62 FRONT REAR	63 QUAD					
64 DjHHH 8	65 DTTQQ 8	66 DjHHH 4	67 DTTQQ 4	68 DjHHH 3	69 DTTQQ 3	70 DjHHH 1	71 DTTQQ 1
72 DjHHH 0	73 DTTQQ 0	74 64RRR 64	75 50RRR 50	76 34RRR 34	77 MXFFF MX	78 BBBRR	79 hhhhh

Remarks

CODE FIGURES		
dd	–	True direction in tens of degrees (pattern orientation based on direction of storm motion
zzz	–	Flight level in hundreds of feet (absolute altitude below 5500 feet)
D	–	Group indicator designating the distance from the center in nautical miles (8–80, 4–45, 3–30, 1–15, 0–center)
hhhhh	–	Height of the eyewall in feet
jHHH	–	Pressure height data in RECCO format
TTQQ	–	Temperature/dewpoint in degrees Celsius. Add 50 for negative values
FFF	–	Maximum observed wind speed in knots
BBBRR	–	Bearing and range from the center of MXFFF
RRR	–	Radii of extent of 64 kt, 50 kt, and 34 kt winds from the center in nautical miles
//	–	Data are unknown or unobtainable

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CHAPTER VII

CHAPTER VII

SURFACE AND UPPER-AIR OBSERVATIONS

7.1 In addition to regulary scheduled surface and upper-air observations, additional observations are required at key locations when a tropical cyclone is an imminent threat to Members. These additional observation requests are normally initiated by the RMC Miami. The frequency of special observations depends on the individual tropical cyclone situation. Additional observations may require 24-hour staffing of a station.

7.1.1 Surface Observations

Additional surface observations at one, three, or six hourly intervals may be requested from those stations listed in Appendix A.

7.1.2 Additional upper-air observations at six hourly intervals may be requested from those stations listed in Appendix B.

7.1.3 Request format

Examples of forms used to request additional surface and/or upper-air observations via teletype message are shown below:

MKCGYM
ATTN MR. ROULSTONE
REQUEST ADDITIONAL ONE/THREE/SIX HOURLY SURFACE OBSERVATIONS AND SIX HOURLY RAOBS BEGINNING ___/_____Z UNTIL FURTHER NOTICE.
BEST REGARDS.

FRANK

MHTGYM
WOULD APPRECIATE ADDITIONAL OBSERVATIONS AT ONE/THREE/SIX HOURLY INTERVALS BEGINNING AT ___/_____Z FROM 701 706 708 711.
BEST REGARDS.

FRANK

CHAPTER VII

APPENDIX A

Stations from which special surface observations may be requested during tropical cyclones:

	STATION NAME	BLOCK AND STATION N°	INT. LOCATION INDICATORS FOR ADDRESSED MESSAGES
Antigua	Coolidge Field (Aux.AFB)	78861	MKPA
	Coolidge Airport	78862	MKPA
Bahamas	West End, Grand Bahama	78061	MYGW
	Freeport, Grand Bahama	78062	MYGF
	Green Turtle Cay, Abaco	78066	
	Alice Town, Bimini	78070	MYBS
	Nassau, New Providence	78073	MYNN
	Dunmore Town, Harbour Island, Eleuthera	78077	MYER
	Mangrove Cay, Andros	78085	
	The Bight, Cat Island	78087	
	Cockburn Town, San Salvador	78088	MYSM
	George Town, Exuma	78092	MYEG
	Clarence Town, Long Island	78095	
	Duncan Town, Ragged Island	78101	
	Albert Town, Long Cay, Crooked Island	78103	
	Abraham Bay, Mayaguana	78109	MYMM
	Matthew Town, Inagua	78121	MYIG
Barbados	Grantley Adams	78954	MKPB
Belize	Belize International Airport	78583	MZBZ
Canada	Sable Island, N.S.	71600	CYSA
	Shearwater, N.S.	71601	CYAW
	Yarmouth, N.S.	71603	CYQI

/Eddy Point,

	Eddy Point, N.S.	71604	CWOQ
	Gagetown, N.B.	71701	CYCX
	Sydney, N.S.	71707	CYQY
	Cape Race, Nfld.	71800	CWRA
	St. John's/Torbay, Nfld.	71801	CYYT
	St. Lawrence, Nfld.	71802	CWDS
	Argentia, Nfld.	71807	CYAR
	Stephenville, Nfld.	71815	CYJT
Cayman Islands	Grand Cayman	78384	MKCG
Colombia	San Andres (Isla)	80001	MCSP
	Providencia (Isla)	80002	
Costa Rica	San José/Juan Santamaría	78762	MROC
	Puerto Limón	78767	MRLM
Cuba	Nueva Gerona	78221	MUNG
	Havana/José Martí	78224	MUHA
	Varadero	78229	MUVR
	Cienfuegos	78244	MUCF
	Camagüey	78255	MUCM
	Manzanillo (ARPT)	78256	MUMZ
	Santiago de Cuba	78264	MUCU
	Guantánamo	78267	MUGT
	Baracoa	78268	MUBA
	Cabo San Antonio	78310	
	Matahambre	78312	MUMH
	Isabel Rubio	78313	
	Pinar Del Rio	78315	MUPR
	Paso Real de San Diego	78317	
	Guira de Melena	78320	
	La Fe	78321	
	Casa Blanca	78325	
	Cayo Guano de Este	78340	
	Cienfuegos	78344	
	Caibarien	78348	MUCB
	Nuevitas	78353	

/Cabo Cruz

	Cabo Cruz	78360	
	Santiago de Cuba	78364	MUCU
	Puenta Lucrecia	78365	
	Punta de Maisi	78369	MUMA
Domînica	Melville Hall	78905	MKPD
	Roseau	78907	MKPR
Dominican Republic	Montecristi	78451	
	Puerto Plata	78457	MOPP
	Santiago	78460	MOST
	Arroyo Barril	78466	
	Sabana de la Mar	78467	
	San Juan de la Maguana	78470	
	Bayaguana	78473	
	Cabo Engano	78478	
	Jianiani	78480	
	Barahona	78482	MDPH
	Caucedo	78485	MDSD
	Santo Domingo	78486	
Grenada	Pearls Airport	78956	MKPE
Guadeloupe	Le Raizet	78897	MFFR
Guatemala	Flores	78615	MGFL
	Huehuetenango	78627	MGHG
	Puerto Barrios	78637	MGPB
	Guatemala	78641	MGGT
	San Josê	78647	MGSJ
Haitî	Cap Haitien	78409	
	Port-au-Prince	78439	MTPP
	Cayes	78447	MTCH
Honduras	Islas del Cisne	78501	MHIC
	Guanaja	78701	MHNJ
	La Ceiba/Golosôn	78705	MHLC
	Tela	78706	MHTE
	La Mesa/San Pedro Sula	78708	MHLM

/Puerta Lempira

	Puerta Lempira	78711	MHPL
	Catacamas	78714	MHCA
	Santa Rosa de Copân	78717	MHSR
	Tegucigalpa	78720	MHTG
	Choluteca	78724	MHCH
Jamaica	Montego Bay	78388	MKJS
	Kingston	78397	MKJP
	Morant Point	78399	
Martinique	Le Lamentin	78925	MFFF
Mexico	Isla Guadalupe, B.C.*	76151	
	Fraccionamiento Libertad,* Empalme, Son.	76256	
	Aerop. Internacional Monterrey, N.L.	76394	
	La Paz, B.C.*	76405	
	Colonia Juan Carrasco Mazstlan, Sin.*	76458	
	Isla Pêrez, Yuc.	76490	
	Tampico	76548	
	Isla Lobos	76570	
	Arenas, Yuc.	76580	
	Felipe Carrillo, Puerto Isla Mujeres, Q. Roo.	76599	
	Tuxpan, Ver.	76640	
	Aerop. Int. Mérida, Yuc.	76644	
	Cozumel	76648	
	Manzanillo, Col. *	76654	
	Aerop. Int. Mêxico, D.F.	76679	
	Hacienda Ylang Ylang, Veracruz, Ver.	76692	
	Campeche, Camp.	76695	
	Isla Socorro, Col.*	76723	
	Coatzacoalcos, Ver.	76741	
	Chetumal, Q. Roo.	76750	

* Stations on the Pacific coast.

/Acapulco, Gro.*

	Acapulco, Gro.*	76805	
	Salina Cruz, Oax.*	76833	
	Tapachula, Chis.*	76904	
Neth.Antilles	Juliana, St. Maarten	78866	MACM
	Oranjestad St. Eustatius	78873	MACE
	Prinses Beatrix Airport Aruba	78982	MACA
	Dr. A. Plesman Airport Curaçao	78988	MACC
	Kralendijk, Bonaire	78990	MACB
Nicaragua	Puerto Cabezas	78730	MNPC
	Bluefields	78745	
Panama	Tocumen	78792	MPTO
	David	78793	MPDA
	Howard AFB	78806	MBHO
St. Kitts	Basseterre	78857	
St. Lucia	Castries	78946	
	Vigie	78947	MKPC
	Hewanorra Intern. Airport	78948	MKPL
St. Vincent	Arnos Vale	78951	MKSV
Trinidad and Tobago	Scarborough/Crown Point Airport	78962	MKPT
	Piarco	78970	MKPP
Turks and Caicos Islands	Grand Turk, Auxiliary AFB	78118	MKJT
	Grand Turks	78119	
Puerto Rico	San Juan	78526	MJSJ

Mainland coastal stations will take additional observations on requests. Requests will normally be made to the relevant NMC but may also be made directly to the station.

---

* Stations on the Pacific coast.

/CHAPTER VII

CHAPTER VII

APPENDIX B

Stations from which special upper-air observations may be requested during tropical cyclones:

	STATION NAME	BLOCK AND STATION Nº	INT. LOCATION INDICATORS FOR ADDRESSED MESSAGES
Antigua	Coolidge Field (Aux-AFB)	78861	MKPA
Bahamas	Nassau	78073	MYNN
Barbados	Grantley Adams	78954	MKPB
Canada	Sable Island, N.S.	71600	CYSA
	Gagetown, N.B.	71701	CYCX
	St. John's/Tarbay, Nfld.	71801	CYYT
	Stephenville, Nfld.	71815	CYST
	Shelbourne, N.S.	71399	CWOS
Cayman Islands	Georgetown, Grand Cayman	78384	MKCG
Colombia	San Andrés (Isla)	80001	MCSP
Costa Rica	San José/Juan Santamaría	78762	MROC
Cuba	Camagüey	78255	MUCM
	Havana	78325	MUHA
	Guantánamo	78367	MUGM
Dominican Republic	Santo Domingo	78486	MDSD
France (St. Barthélémy)	Gustavia	78894	
France (Guadeloupe)	Le Raizet	78897	MFFR
France (Martinique)	Le Lamentin	78925	MFFF
Guatemala	Guatemala City	78641	MGGT

/Haití

Haitî	Port-au-Prince	78439	MTPP
Honduras	Islas del Cisne	78501	MHIC
	Tegucigalpa	78720	MHTG
Jamaica	Kingston	78397	MKJP
Mexico	Isla Guadalupe, B.C.*	76151	
	Empalme, Son.*	76256	
	Monterrey, N.L.	76394	
	Mazatlân, Sin.*	76458	
	Mérida, Yuc.	76644	
	Manzanillo, Col.*	76654	
	Mêxico City, D.F.	76679	MMMX
	Veracruz, Ver.	76692	
	Isla Socorro, Col.*	76723	
Neth.Antilles	Dr. A. Plesman Airport Curaçao	78988	MACC
	Juliana Airport, St. Maarten	78866	MACM
Nicaragua	Puerto Cabezas **	78730	MNPC
	Managua	78741	MNMG
Panama	Howard AFB	78806	MBHO
Trinidad and Tobago	Port of Spain	78970	MKPP
Turks and Caicos	Turks Island	78118	MKJT
U.S.A.	Rawinsonde stations within 300 miles of the coast.		

* Stations on the Pacific coast.

** Pilot balloon only.

/CHAPTER VIII

CHAPTER VIII

COMMUNICATIONS

8.1 General

The basic communication circuits for the interchange of forecasts, warnings, and observations among Members will be the Central American Meteorological Circuit (CEMET), the Antilles Meteorological Circuit (AMNET), and the WBR Miami CARMET and synoptic broadcasts. However, initial transmission of messages from several countries may be relayed through other circuits.

8.2 WMO Communications headings, stations location identifiers, and international block and station index numbers will be used to send surface upper-air observations.

8.3 Tropical cyclone warning headings to be used by Members are listed in Appendix A.

8.4 Radar report headings to be used by Members are listed in Appendix B.

CHAPTER VIII

APPENDIX A

HEADING

	TROPICAL DEPRESSION HEADING	TROPICAL STORM OR HURRICANE HEADING
Antigua	WOCA31 MKPA	WHCA31 MKPA
Bahamas	WOBA31 MYNN	WHBA31 MYNN
Barbados	WOCA31 MKPB	WHCA31 MKPB
Belize	WOCA31 MZBZ	WHCA31 MZBZ
Canada	WONT31 CYTO	WHNT31 CYTO
	NIL	WBCN1 CWHX
		WBCN1 CWQX
Costa Rica	WOCA31 MRSJ	WHCA31 MRSJ
Cuba	WOCA31 MUHV	WHCA31 MUHV
Dominican Republic	WOCA31 MDSD	WHCA31 MDSD
France (Martinique)	WOCA31 MFFF	WHCA31 MFFF
France (Guadeloupe)	WOCA31 MFFR	WHCA31 MFFR
Guatemala	WOCA31 MGGT	WHCA31 MGGT
Honduras	WOCA31 MHTG	MHCA31 MHTG
Jamaica	WOCA31 MKJP	WHCA31 MKJP
Mexico	WOMX1 MMMX WOMX2 MMMX	WHMX1 MMMX WHMX2 MMMX
Nicaragua	WOCA31 MNMG	WHCA31 MNMG
Trinidad	WOCA31 MKPP	WHCA31 MKPP
United States:		
Miami, Fl.	WOCA31-35 KMIA	WHCA31-35 KMIA
Washington, D.C.	WONT31-35 KDCA	WHNT31-35 KOCA
Boston, Mas.	WONT31-35 KBOS	WHNT31-35 KBOS
San Juan, PR.	WOCA31-35 MJSJ	WHCA31-35 MJSJ
San Francisco, CA.	WOPN31-35 KSFO	WHPN31-35 KSFO
Hololulu, HI.	WOPN31-35 PHNL	WHPN31-35 PHNL

CHAPTER VIII

APPENDIX B

	Heading	
Antigua	SDCA	MKPA
Barbados	SDCA1	MKPB
Belize	SDCA	MZBZ
Cuba	SDCA	MUHV
Jamaica	SDCA	MKJP
France (Guadeloupe)	SDCA1	MFFR
France (Martinique)	SDCA1	MFFD
Netherlands Antilles (Curaçao)	SDCA1	MACC
Trinidad and Tobago	SDCA1	MKPT
United States *	SDUS1 SDUS1	RWRB RWRA

* Individual station identifiers can be found in Chapter 4.

UNITED STATES HEADINGS FOR TROPICAL CYCLONE RELEASES

	PUBLIC		MARINE		PUBLIC
	TROPICAL DEPRESSION	TROPICAL STORM OR HURRICANE	TROPICAL DEPRESSION	TROPICAL STORM OR HURRICANE	SUSPICIOUS AREA
Miami, Fl.	WOCA31-35 KMIA	WHCA31-35 KMIA	WOCA21-25 KMIA	WHCA21-25 KMIA	WOCA41 KMIA
Washington, D.C.	WONT31-35 KDCA	WHNT31-35 KDCA			WONT41 KDCA
Boston, MA.	WONT31-35 KBOS	WHNT31-35 KBOS			WONT41 KBOS
San Juan, PR.	WOCA31-35 MJSJ	WHCA31-35 MJSJ			WOCA41 MJSJ
San Francisco, CA.	WOPN31-35 KSFO	WHPN31-35 KSFO	WOPN21-25 KSFO	WHPN21-25 KSFO	WOPN41 KSFO
Honolulu, HI.	WOPN31-35 PHNL	WHPN31-35 PHNL	WOPN21-25 PHNL	WHPN21-25 PHNL	WOPN41 PHNL

Note: United States advisory headings range from 1 to 5 and are re-cycled with the 6th, 11th, 16th numbered depression or named storm.

CHAPTER IX

HURRICANE NAMES

9.1 The lists in Appendices A and B contain the names for the Caribbean Sea, Gulf of Mexico and the North Atlantic ocean named tropical cyclones, 1979-1983, and for the eastern North Pacific, 1978-1981.

/APPENDIX A

APPENDIX A

Atlantic Names

1979	1980	1981	1982	1983
Ana	Allen	Arlene	Alberto	Alicia
Bob	Bonnie	Bret	Beryl	Barry
Claudette	Charley	Carla	Chris	Chantal
David	Danielle	Dennis	Debby	Dean
Elena	Earl	Emily	Ernesto	Erin
Frederic	Frances	Floyd	Florence	Felix
Gloria	Georges	Gert	Gilbert	Gabrielle
Henri	Hermine	Harvey	Helene	Hugo
Isabel	Ivan	Irene	Isaac	Iris
Juan	Jeanne	Jose	Joan	Jerry
Kate	Karl	Katrina	Keith	Karen
Larry	Lisa	Lenny	Leslie	Luis
Mindy	Mitch	Maria	Michael	Marilyn
Nicolas	Nicole	Nate	Nadine	Noel
Odette	Otto	Ophelia	Oscar	Opal
Peter	Paula	Philippe	Patty	Pablo
Rose	Richard	Rita	Rafael	Roxanne
Sam	Shary	Stan	Sandy	Sebastien
Teresa	Tomas	Tammy	Tony	Tanya
Victor	Virginie	Vince	Valerie	Van
Wanda	Walter	Wilma	William	Wendy

/APPENDIX B

APPENDIX B

Eastern Pacific Names

1978	1979	1980	1981
Aletta	Andres	Agatha	Adrian
Bud	Blanca	Blas	Beatriz
Carlotta	Carlos	Celia	Calvin
Daniel	Dolores	Darby	Dora
Emilia	Enrique	Estelle	Eugene
Fico	Fefa	Frank	Fernanda
Gilma	Guillermo	Georgette	Greg
Hector	Hilda	Howard	Hilary
Iva	Ignacio	Isis	Irwin
John	Jimena	Javier	Jova
Kristy	Kevin	Kay	Knut
Lane	Linda	Lester	Lidia
Miriam	Marty	Madeline	Max
Norman	Nora	Newton	Norma
Olivia	Olaf	Orlene	Otis
Paul	Pauline	Paine	Pilar
Rosa	Rick	Roslyn	Ramon
Sergio	Sandra	Seymour	Selma
Tara	Terry	Tina	Todd
Vicente	Vivian	Virgil	Veronica
Willa	Waldo	Winifred	Wiley

/Annex III

Annex III

NATURAL DISASTERS OVERVIEW

Annex to Recommendation 2 (RA IV/HC-I)

RA IV HURRICANE COMMITTEE'S TECHNICAL PLAN AND IMPLEMENTATION PROGRAMME

Meteorological Component

The meteorological component of this technical plan is based on the following principles:

(1) That National Meteorological Services in the area shold be properly developed and provided with adequate staff and equipment to meet their responsibilities;

(2) That the observing, telecommunication and data-processing systems of the World Weather Watch (WWW) will be fully implemented by all Members in the hurricane area.

1. Development of the meteorological observing system

1.1 Manned surface stations

1.1.1 Members to give the highest priority to the removal of deficiencies in the synoptic observation programmes at 0000 and 0600 GMT at stations of the RA IV regional basic synoptic network lying in the area between latitudes 5°N and 35°N, and between longitudes 50°W and 140°W.*

1.1.2 Members with large land masses to investigate the possibilities of establishing simple stations which may be operated by volunteers and would supply hourly observations of direction and approximate speed of wind, and atmospheric pressure only during (hours) periods that a hurricane is within about 200 km of the station. Such stations could suitable be placed where stations of the WWW network are more than 200 km apart.

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* Items with an asterisk constitute the implementation programme for 1978-1979.

/1.1.3 Members

1.1.3 Members to introduce the practice of requesting stations along the shore to provide observations additional to those in the regular programme during hurricane periods, in particular when required by the RA IV Hurricane Operational Plan.*

1.2 Upper-air stations

1.2.1 Members concerned to establish the following upper-air stations:*

76548	Tampico, Tamps.	Radiowind and radiosonde
76612	Guadalajara, Jal.	Radiowind and radiosonde
76805	Acapulco, Gro.	Radiowind
76833	Salina Cruz, Oax.	Radiowind
76840	Arriaga, Chis.	Radiowind
76904	Tapachula, Chis.	Radiowind
78311	La Bajada, Pinar del Rio	Radiowind and radiosonde
78583	Belize Intl. Airport	Radiowind and radiosonde
78741	Managua	Radiowind

1.2.2 That Colombia be invited to consider the establishment of a radiowind and radiosonde station on its north coast, if possible, at Barranquilla and take the necessary action for its inclusion in the regional basic synoptic network of RA III.*

1.2.3 Members concerned to implement two radiowind observations per day at all radiowind stations throughout the hurricane season.*

1.2.4 Until the requirements of paragraph 1.2.3 can be accomplished, Members to make two radiowind observations per day whenever a named hurricane is within 1000 km of the station.*

1.2.5 Members concerned to implement the upper-air observations required at 0000 GMT under the World Weather Watch plan to enable a sufficient coverage during night hours.

1.3 Ships' weather reports

1.3.1 Members of the Region to continue their efforts to recruit ships to participate in the WMO Voluntary Observing Ship Scheme, in particular by:

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* Items with an asterisk constitute the implementation programme for 1978-1979.

/(i) recruiting

(i) recruiting selected and supplementary ships plying the tropics;*

(ii) designating Port Meteorological Officers.*

1.3.2 Members operating Coastal Radio Stations to improve liaison between Meteorological Services and the Coastal Radio Stations and arrange for specific requests for ships' reports from any area of current hurricane activity even if such reports have to be transmitted in plain language.*

1.4 Automatic weather stations

1.4.1 Members concerned to explore the possibility of installing automatic reporting devices at stations with insufficient staff for operation throughout the 24 hours; such stations might then be operated during daylight hours as manned stations and during night time as unattended automatic stations, possibly with a reduced observing programme.

1.4.2 Members concerned to explore the possibility of installing automatic weather stations at locations which may be considered critical for the hurricane warning system for operation at least during the hurricane season.

1.5 Radar stations

1.5.1 All Members to promote the establishment and operation of a subregional network of 10 cm/5.6 cm wavelength radar stations.*

1.5.2 Members concerned to establish and operate 10 cm/5.6 cm wavelength radar stations at the following locations or nearby:

(a) areas of Veracruz and Merida* on the Mexican coast of the Gulf of Mexico and at about 97°W longitude on the Mexican Pacific Coast;

(b) in El Salvador;

(c) on the Central American coast of the Gulf of Mexico (within longitudes 83° and 84°W and latitudes 14° and 16°N) either in Honduras or Nicaragua;

(d) the North Coast of the Dominican Republic;*

(e) the North Coast of Colombia latitudes 73° and 75° longitude W.

1.5.3 Members operating 10 cm/5.6 cm radar stations to ensure that radar information, and particularly eye-fixes are made speedily available to all other countries in the hurricane area in accordance with the Hurricane Operational Plan for Region IV.*

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* Items with an asterisk constitute the implementation programme for 1978-1979.

/1.6 Air

1.6 Air reconnaissance flights

The Committee accepted the offer of the United States to undertake aircraft reconnaissance when required in accordance with the Hurricane Operational Plan for Region IV and to disseminate the information obtained to all concerned.*

1.7 Meteorological satellite systems

1.7.1 Members to establish at their NMC, either a ground WEFAX receiving station or to modify their existing APT stations to enable the regular reception of WEFAX broadcasts from the WMC, Washington, on 1691 MHz.*

1.7.2 Members to ensure that their APT stations are properly maintained and in operation for the reception of cloud pictures from near-polar orbiting satellites, including any modified or new equipment necessary for the reception of information from the TIROS-N series of satellites.*

1.8 Storm surges

1.8.1 Members are encouraged to establish a network of tide gauge stations in coastal areas where storm surges are likely to occur.*

1.8.2 Members are invited to co-operate fully in the studies to be undertaken on storm surges as a subproject of the WMO Tropical Cyclone Project in the Hurricane Committee area.*

1.9 Meteorological Telecommunications

1.9.1 National telecommunication networks

1.9.1.1 Members to take urgent action to ensure the provision of suitable telecommunication facilities for the collection at NMCs of all observational data from stations in the regional basic synoptic network in accordance with the requirements of WWW (i.e. 95% of reports to reach the collecting center within 15 minutes of the observating station's filing time).*

1.9.1.2 Members to consider implementing, where necessary, bilateral communication links to enable direct contact between warning centers at least during the hurricane season.*

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* Items with an asterisk constitute the implementation programme for 1978-1979.

/1.9.2 Regional

1.9.2 Regional telecommunication network

1.9.2.1 Members concerned to do their utmost to fully implement the Regional Meteorological Telecommunications Plan, as adopted by RA IV in the Caribbean and Central American areas.*

2. Hydrological component

This component of the plan is to be prepared by the RA IV Working Group on Hydrology and will be included in the plan in due course.

3. Disaster prevention and preparedness

3.1 Disaster prevention

3.1.1 Members not having long-range policies and programmes to prevent or eliminate the occurrence of disasters to take steps to formulate and implement such policies and programmes as a co-ordinated activity involving all appropriate authorities and agencies as soon as possible.*

3.1.2 Members having or developing such policies and programmes to take steps to ensure that these are based on appropriate vulnerability analyses of disaster threats.*

3.1.3 Members to draw attention of national authorities to the need for carrying out vulnerability analyses, taking account of meteorological and hydrological factors, in order to formulate and apply legislative and regulatory measures, principally in the fields of physical and urban planning, land use zoning, public works and building codes, to mitigate the effects of hurricanes and the resulting storm surges and floods.

3.1.4 Members to ensure periodic review of such policies programme and measures to reflect changes made necessary by such factors as long-range national development plans, new major public works and further advances in the meteorological, hydrological and other components.

3.1.5 Members to recognize the potential impact of disaster prevention policies, programmes and measures upon other Members, as appropriate, and to consult with such other Members to ensure a co-ordinated approach to disaster prevention.

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* Items with an asterisk constitute the implementation programme for 1978-1979.

/3.1.6 The

3.1.6 The purpose of disaster prevention planning to be brought to the notice of the public, together with information on natural disasters and the policies, programmes and measures introduced to eliminate or mitigate their effects.*

3.1.7 Members to ensure that planners and policy-makers in key fields of concern (urban and regional planning, civil engineering and building, etc.) are provided with supplementary training in disaster prevention techniques.

3.2 Disaster preparedness

3.2.1 Members not having national procedures for action designed to minimize loss of life and damage in cases of disaster, and to organize and facilitate timely, effective rescue, relief and rehabilitation in such cases, to prepare such procedures as a co-ordinated activity involving all appropriate authorities and agencies, as soon as possible.*

3.2.2 Members having national procedures for disaster preparedness to take steps to formalize these procedures by the production of detailed national disaster plans, supported by appropriate executive and administrative arrangements and by such legislation as should prove necessary, allocating roles to all involved authorities and agencies, both government and voluntary, and co-ordinating their activities in both planning and operations, so that each may produce its own plans within a co-ordinated framework.

3.2.3 Members to arrange the early transmission of forecasts of hurricanes and flooding to the central co-ordinating agency responsible for the organization of protective and relief measures, and to similar co-ordinating agencies at regional level, to allow the timely dissemination of warnings by such agencies.*

3.2.4 Members to ensure that the responsibility for planning and operational co-ordination at each level of administration and for each phase of counter-disaster response is clearly allocated to a designated and appropriate authority or agency, whose lead role in such circumstances is known to and accepted by other counter-disaster authorities and agencies.*

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* Items with an asterisk constitute the implementation programme for 1978-1979.

/3.2.5 Members

3.2.5 Members to arrange suitable programmes of public education and information to ensure that the public is advised of the nature of disaster threats and of preparedness plans to meet such threats, and in addition, is informed of appropriate individual and community counter-disaster actions to be taken before, during and after the onset of a disaster event.*

3.2.6 Members to prosecute actively the provision of safe refuges in disaster-prone areas and the planning of evacuation and shelter procedures in such areas.*

3.2.7 Members to stock pile food, clothing, supplies and construction materials, as appropriate, to support counter-disaster plans and to expedite the relief of victims of disaster, and to earmark funds to establish and maintain such stockpiles.

3.2.8 Members to include in their disaster preparedness plans at all levels provisions for the rapid survey and evaluation of damage and needs following disasters.

3.2.9 Members to make provisions for the planned logistic support of counter-disaster operations.

3.2.10 Members to ensure that official advisory statements concerning forecasts, warnings, precautionary actions or relief measures to be made only by authorized persons and to be disseminated without alteration.

3.2.11 Members to establish training programmes to support preparedness programmes, to include disaster administrators, disaster control executives and rescue/relief groups and workers in all counter-disaster authorities and agencies.

3.2.12 Members to develop a suitable search and rescue code and organization.

3.3 Reviews and test exercises

3.3.1 Members to organize periodic reviews of both disaster prevention and disaster preparedness plans to ensure that they are active and up-to-date.*

3.3.2 Members to conduct periodic staff checks and test exercises to test the adequacy of disaster preparedness plans, preferably on a progressive

* Items with an asterisk constitute the implementation programme for 1978-1979.

/annual basis

annual basis prior to the expected seasonal onset of natural disaster threats but also, in respect of plans to meet sudden-impact disasters, on an occasional no-warning basis.

4. Training

4.1 Members to assess current and expected future needs for the training of specialized staff to man their warning systems at all levels under the following headings, and to take appropriate steps to organize such training programmes.*

(i) Those capable of being met through training facilities already available in Member countries,* and

(ii) those for which assistance from external sources is needed.*

4.2 Seminars or workshops to be arranged on specific topics of particular interest for hurricane prediction and warning purposes, priority being given in the first instance to techniques for the interpretation of satellite data and storm surge prediction.*

5. Research

5.1 Members to ensure that information on research activities carried out in their own countries is readily available to other members of the Committee; the WMO Secretariat when requested to facilitate the exchange of information on these activities, as well as on sources of data available for research.*

5.2 Proposals to be drawn up for consideration by the Committee for joint research activities to avoid duplication of effort and to make the best use of available resources and skills.

5.3 Members to arrange for exchange visits of staff between national research centers.

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* Items with an asterisk constitute the implementation programme for 1978-1979.