Part Two: Disaster and Response

E. Detection and Warning of the Storm

The Warning Network

The Republic of Salacca was widely reported to have one of the better meteorological departments in the region. It had an extensive network of traditional observation posts which reported surface and upper level observations round the clock throughout the year, using high frequency (HF) radio telephone. It also was able to draw upon geostationary meteorological satellite imagery for the region, and high resolution pictures from low orbit NOAA satellites, using terminals at its headquarters. The headquarters received colour digitised weather radar data by dedicated land-line from seven radar stations strategically located along the coastline and in the hinterland. The headquarters was linked into the Global Telecommunications System of the World Meteorological Organization's World Weather Watch, using both satellite and cables, and had additional telex links with the main regional forecast centre 2000 km to the Southwest. There were additional HF radio links to airports throughout the region.

Staff were well selected and well trained. Specialist training was provided through World Meteorological Organization programmes, with additional bilateral support in some specialties. However, an on-going problem for the department was the low level of civil service salaries. Almost all the staff were forced to supplement their income in some way, and many of the professional staff had interests in a range of small businesses (including office equipment, fish-farming, computer software, and cosmetics, to name just some). Inevitably, many of those at work found it difficult to concentrate full-time on their jobs, although the level of professional skill remained high.

Detection of the Storm, and Issue of Warnings

A low pressure circulation was detected about 330 km east of Salacca early in the morning of September 30th. Satellite pictures showed an unstructured cloud mass, and on the basis of this data the forecasters in the national Meteorological department estimated that the low pressure area would intensify and move to the west. Five hours later, at around midday, the forecasting unit issued a warning advice, predicting widespread rain and flash flooding in the central provinces. Early the following morning (October 1st), at 3.30 am. the national forecasting centre issued a second warning advice, repeated at 11 am. This said that the low pressure area had intensified into an active depression, and was moving West North West. It forecast heavy rain, flash floods, and very rough seas.

A fourth warning was issued on the same day (October 1st) at 6.00 pm. It gave a likely impact point for the storm, but no estimate of wind speeds. That evening, the position

of the depression shifted, and it started to move north at around 6 km/hr, intensifying over the next twenty hours.

The next warning was issued late in the afternoon of October 2nd. It reported that the depression had developed into a tropical storm moving northwest. Winds in the centre were reaching 70 km/hr. At this time it was about 230 km east of the coastline. The warning repeated that rough seas and flash floods could be expected, but gave no estimate of possible landfall. That evening, the storm was given the name *Zelda*, from the standard list issued by the Regional WMO committee.

The next warning was not issued by the Meteorological department for a further 18 hours, at around 11 am on the morning of October 3rd. It gave the storm's position, 180 km from the coastline, moving northwest at 9 km/hr. The warning stated that maximum winds at the centre were now about 110 km/hr, with 10 metre waves. Possible landfall was specified as somewhere on a stretch of coastline 220 km long. Heavy rain and flash floods were again forecast. At around midday, satellite photographs showed the development of an "eye" in the centre of the storm, and the meteorologists estimated that the maximum winds would increase over the next 24 hours to at least 130 km/hr within 40 km of the centre.

Early on October 3rd, the weather radar on the coast picked up the storm and tracked it continuously thereafter. The seventh warning was issued from the Meteorological Office at midday on 3rd October. It said that the storm had intensified into a Cyclone, and was moving West North West at 8 km/hr. Maximum winds of 135 km/hr were expected. However, the shipping forecast issued that afternoon still specified wind speeds in the Cyclone area at 30 to 50 km/hr.

The next warning was delayed. The reasons for this are still unclear. The warning was not issued until 5 am on the morning of 4th October, when the centre of the storm was only 40 km from the coastline near the town of Grenora. Landfall was expected at 8 am. The warning message stated that strong winds and heavy rain were expected within 60 km of the centre, and that trees, telephone lines and power lines were likely to be damaged. A sudden rise in sea level, and flash floods, were both mentioned, but no further details were given. The same morning, one hour later, the national TV weather bulletins, prepared by the Meteorological Department early that morning, were still forecasting 25 to 50 km/hr winds, and moderate to rough seas.

F. Characteristics of the Threatened Area:

The Provinces of Akutan and Kylinia have a combined population of 4.9 million people. The economy is based on petrochemical products (centred on the city of Sotorino), textiles, agricultural products (particularly tree crops), fishing, and tourism. A major new industrial complex is under construction at Freeport, 30 km North of Sotorino, which also has a new deep-water container port, a natural gas terminal, and a refining complex.

Topographically, the area consists of a narrow coastal alluvial plain, backed by steep hills sloping up to mountains. The coastline is mainly sand and mudflats. Numerous small rivers cross the plain. The main route south to Sotorino crosses three major road bridges, and twenty smaller ones. The rail route is poorly developed, running about twenty km further inland.

There are many small fishing villages on the coast, most connected to the main highway by metalled roads. Inland, in the rural areas, a variety of different tree crops are grown. Large estates intermix with smallholdings. Farms on higher ground mostly produce either livestock or grain.

The main provincial centres are Sotorino and Morenia.

G. Actions at the Provincial and Local Level in Response to Warning

In reality, very little action was taken at the Provincial and local level in response to the warnings. Some efforts were made to activate the Provincial emergency operating centres in the main towns along the coastline. Hospitals and clinics were placed on alert by a member of the Ministry of Health emergencies team who had watched TV weather broadcasts and taken the initiative to call in at the Meteorology office forecasting centre. Staff at hospitals and clinics had been instructed to move essential equipment to protected areas, and to check radio equipment, generators, and fuel stocks. Informally, hospital administrators began restricting admissions to emergency cases only.

The Armed Forces, alerted by Air Force meteorologists, began redeploying fighter and transport aircraft from two bases in Akutan Province to a base in the North. Two Army helicopter units were alerted and put on standby, and three special forces communications teams were moved with their equipment to a base about 100 km outside the expected impact zone. Following an agreed plan, three Air Force helicopters were tasked to transport joint government/UN-Disaster Management Team (DMT)/Red Cross damage assessment teams, formed after the last detailed review of emergency preparedness. A further two commercial helicopters were chartered for the use of a joint WHO/Ministry of Health assessment and surveillance team.

There were no detailed plans setting out a clear policy for actions to be taken during the various stages of the warning period. In the absence of these, Provincial Governors faced a number of decisions, all involving substantial disruption, and most likely to incur expenditures far higher than their statutory discretionary powers. From their perspective, these decisions included:

The content and timing of public warnings. There were no standing instructions on the content of warning messages which could be broadcast on local radio stations. There was also particular concern in some areas that tourism would be severely disrupted unnecessarily.

Decisions on evacuation. Uncertainty about where (if at all) the storm would cross the coast made any consideration of evacuation highly difficult. The population in the forecast possible impact area (over 300 km of coastline, and at least sixty miles inland) was over four million people. There were no detailed evacuation plans. Some Governors felt that a population caught on the roads might be more at risk than those at home.

Decisions on whom to give priority for evacuation. In particular few government staff had any knowledge of the risks of storm surge.

Decisions on where to evacuate people to. The main choice was to move people to schools, and churches. However, few of these had been surveyed and designated, and their were no plans to receive evacuees.

Decisions on protection of government facilities. Movement of records and strengthening of buildings would involve substantial extra expenditure, and would lead to considerable disruption of normal activity. Without authorization from central government, there were no allocated funds to cover the purchase of timber and plastic sheeting, hire workers, or purchase additional generators and supplies of fuel.

Decisions on mobilizing local government staff. Only a proportion of staff in local offices reported operationally to the Governor. Politically, his position to order a major redeployment of staff and resources without reference to central government was not strong.

Failures in the Warning Process

The immediate pre-disaster period was characterised by a general failure of the warning process. Broadcast warning bulletins simply did not reach a majority of the population in the area which was potentially at risk. Many did not listen anyway. Those that did were generally unable to interpret the messages. These failed on three accounts:

First, they did not, in general, describe the likely impact in terms listeners could understand (for example, that most roofs would be at least partially blown off; that winds would make it impossible to move around outside well before the height of the storm; that storm surges could reach two metres or more, last for hours, and carry fast-flowing debris as large as trees; that flood waters could reach three metres or more in places, and persist for three or four days; that wind-driven horizontal rain would penetrate almost any unprotected building; that trees, roofing sheets, and other debris would become flying missiles; and so on).

Second, they did not relate terms such as "alert", "watch" and "warning" to actions people should take.

Third, they did not specify useful measures people could take. Examples included evacuating named low-lying coastal areas, and other areas susceptible to deep flooding; avoiding moving to steep hillsides in certain areas; at home, securing loose items;

stowing away glass items; boarding windows; reinforcing roofs; preparing extra food and water (many will need sufficient food and water for five days spent on a roof); wrapping warm clothes and other personal items in polythene sheeting; and preparing mats or other coverings to crouch under during the storm.

It was suggested later by one international economist that the inadequacy of warning messages led directly or indirectly to at least 200 million US dollars worth of avoidable damage to personal property. Both the Meteorological Department and the broadcasting networks immediately challenged this assertion.

The need for improvised preparations also highlighted widespread prior failures in mitigation. Several hundred thousand people inhabited low lying areas near the coast. Many thousands, in fact, lived in houses built on piles beyond the coastal low-water mark. Housing construction was in general lamentably inappropriate for high-wind resistance, and no effective building codes were enforced in the area. Most of the public buildings in the risk area were highly cyclone-prone, and many evacuees would (it later transpired) also be at substantial risk in schools or churches.

Overall, one of the worst aspects of the warning failure, in human terms, was the inadequacy of warning for fishermen and other seafarers. Although the widespread use of small, hand-held Citizen Band radios by small boat owners had (when combined with rebroadcasting from larger vessels) increased the coverage of direct warning messages, the system as a whole was still dependent on the accuracy and reliability of the meteorological department's warnings. In this case, the text of the messages issued by that department failed to convey the urgency of the situation effectively to the broadcast control centre run for fishermen and coastal seafarers by the Ministry of Trade and Industry. This, combined with the inadequacy of the general weather forecast which was broadcast (often after further editing) by the commercial stations, meant that most fishermen expected a storm they could ride out at sea in traditional sheltered bays and headlands.

H. Primary Impact

Even before landfall, the Cyclone had killed most of those who died - more than three thousand people. Its winds and high waves destroyed hundreds of fishing boats, many of them small, three or four person vessels, which were sheltering in the lee of islands, or had been beached on low shores. Bodies of fishermen continued to be washed ashore for several weeks, and most were never properly identified.

Cyclone Zelda slammed ashore into the town of Grenora at 8.30 on the morning of 4th October. Winds of 30 to 50 km per hour had been building up since the previous evening, and there had been continuous heavy rain for the past 24 hours. But no one expected the force of the impact. Most of the population were in their houses. The next ten hours were a shrieking, soaking, battering confusion of flying debris, falling trees, driving rain, disintegrating houses, breaking glass, and rising flood, as people clutched their children, crouched under carpets, fled across spaces ripped by flying iron

sheeting, and clawed their way into neighbouring houses in search of respite. Half way through the afternoon the passage of the eye of the storm brought a still, humid, awesome quiet. Some people, believing themselves safe, carried injured relatives into the streets, searched for the missing, or tried to salvage possessions. Half an hour later the opposite wall of the eye rolled across the town, whipping up the debris of a thousand broken houses and cutting down those still outside. Only at dusk did the wind falter, and then darkness covered streets awash with floodwater, carrying tile, metal, and dented up-turned cars, wooden beams, branches, and paper everywhere.

The Cyclone moved on, inland, deroofing most houses, destroying many buildings completely, and flooding some areas to a depth of three metres or more. Most structures on a path one hundred kilometres wide were rendered uninhabitable. Almost all roads in the area were blocked by flooding and fallen trees. All towns in the area lost power - a population of three million people was without light that evening.

The *death toll* on land by the evening of the 4th October was approximately three hundred. One hundred and eighty of these had been caught in the storm surge in two villages close to the town of Grenora, as houses built over the beachfront collapsed, and as a group of workers fled across a sand-bar. Another forty were killed in the town of Grenora itself, mainly by the collapse of roofs into public buildings, by flying metal roof-sheeting, by drowning, and falling trees. The rest died in house collapses, flash flooding, landslips, automobiles and buses, and in attempts to wade to higher ground.

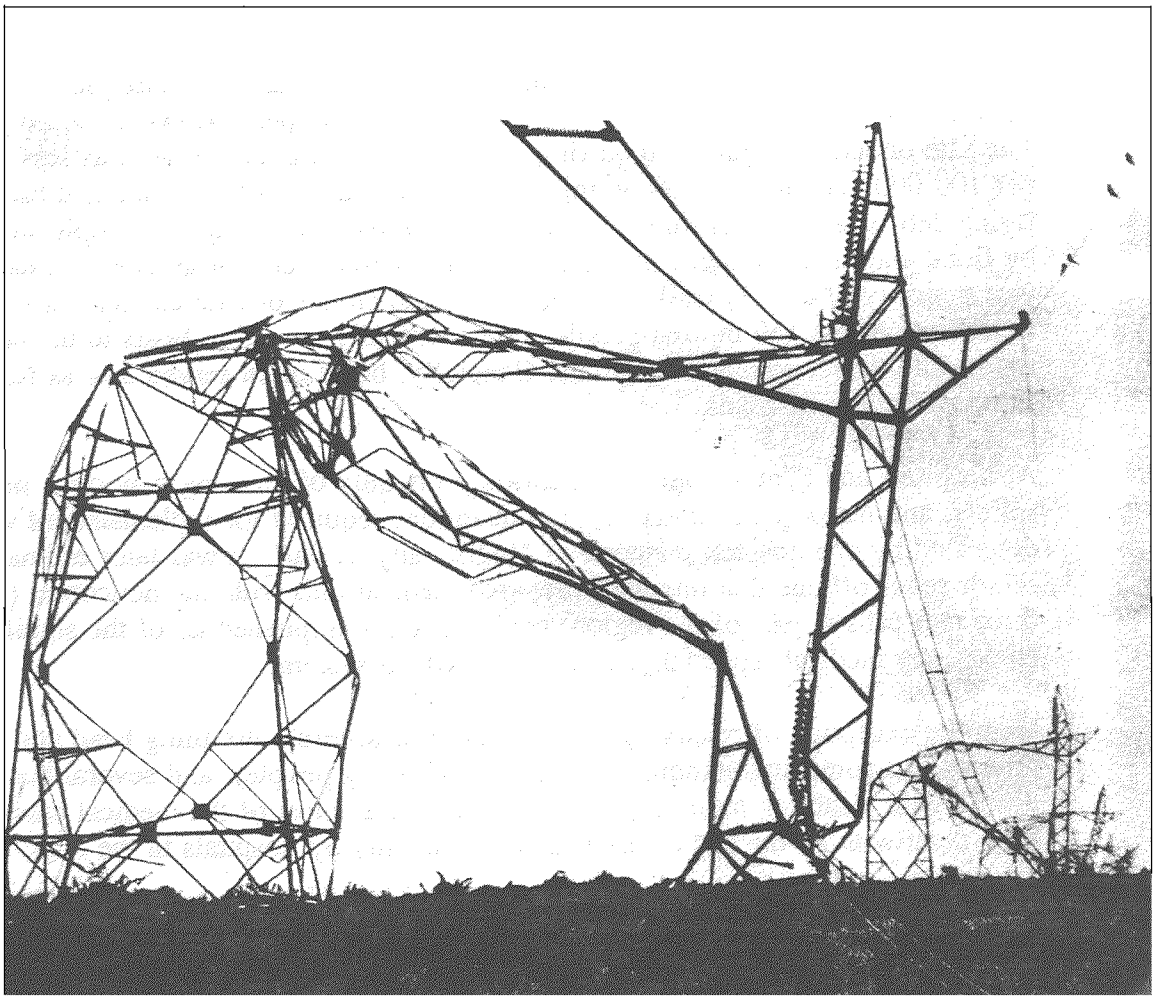
By dawn next morning the extent of flooding, and the damage to buildings was obvious, both from the air and from the ground. *Damage to housing* was almost universal. There was widespread loss of corrugated metal sheeting, loss of asphalt shingles, loss of the roof structure, blown out windows and doors, and collapsed timber and concrete blockwall buildings. Specific aspects of local domestic building practice contributed to additional damage, including the method of fixing wooden rafters in concrete lintels, and the increasing tendency to build low-pitched roofs with overhanging gables. Many of the weaker buildings had simply collapsed into a pile of wooden sticks and broken sheeting.

Damage to government buildings was also extensive. Again, roof structures commonly failed. There was also serious damage to interiors, caused by driving rain and flooding. Government offices in the main towns of Morenia and Galenna were largely unusable.

Damage to public utilities had significant knock-on effects immediately. A key element was the interdependence of these systems. Power needs communications, water needs power, hospitals need water, restoring utilities needs an open road network, and so on. Most of the communications towers and masts failed (microwave, HF, and VHF). These were uniformly under-engineered for high winds, poorly anchored, and on inadequate foundations. Corrosion of unprotected steel structures further contributed to structural failures. The power and electronic equipment associated with microwave towers was severely damaged first by horizontally driving rain, and often also by loss of windows and roofs and the impact of flying debris. Telephone exchanges in the area were severely damaged by water and flying debris. Some were flooded. Rain damage to switchgear for alternative power supplies (together with inadequate maintenance in

Roofing blown off of most housing

UNDRO NEWS 3/4.84



Main power lines were badly damaged

UNDRO NEWS 3/4 85

some cases) prevented rapid recovery of the less damaged facilities. The entire trunk telephone network was inoperative throughout the region.

Overground lines of both telephone and electricity transmission systems failed at numerous points. A major contributory factor was the failure of wooden poles weakened by rot and insect damage. Electricity transmission was especially vulnerable where long spans crossed deep valleys.

Most of the *main hospitals* experienced failure of roof fixing bolts, hooks, and washers. Flat, metal sheeted roof contributed to vulnerability, with tearing of thin sheet at fixings. Large glass panels blew in. Poor maintenance, resulting in corroded fittings, meant that the cladding of several buildings ripped off, causing debris-damage, a number of injuries, and problems moving vehicles up to the buildings.

Many *school buildings* were badly damaged. Their shape and design contributed to this. They were narrow and long, with flat pitch roofs and gable ends. Some metal-frame schools suffered corrosion of the frame and roof elements and this greatly increased the chance of roof collapse.

Casualties and their Treatment

Injuries were closely related to building failure in many areas. Subsequent analysis showed that the rate of injuries overall was about 4700 per 100,000 exposed people. The rate of serious injuries, requiring immediate hospital attention, was less than 400 per 100,000. The most common injuries were lacerations of the arms and back from flying debris, and cuts from broken glass on the feet. Most injured people were isolated by flood waters, and unable to reach any site for treatment for at least two days. The vast majority of injured walked by themselves to clinics or first aid centres to seek treatment. About 150 injured people were eventually moved in boats to the nearest roads, and thence to major hospitals. Generally, boats often served best as ferries on flooded sections of roads.

At hospitals and clinics, there were shortages mainly of dressing materials, orthopaedic splints, and major pain-killers, but the quantities required for replenishment were described by one hospital manager as "logistically trivial". It was later estimated by a senior relief official that one well-prepared medical unit with one helicopter (or indeed, three taxi-cabs in part of the region) could have accomplished all of the significant emergency medical replenishment for the medical system.

With the exception of relatively small number of severely disabling head and spinal injuries and some amputations (a total of about forty people), and several hundred people with disabling injuries to joints and muscles, most of the medical caseload had been dealt with by the end of the first week, mainly by hospitals in the area.