HONG KONG RAINFALL AND LANDSLIDES IN 1988

GEO REPORT No. 5

J. Premchitt

GEOTECHNICAL ENGINEERING OFFICE
CIVIL ENGINEERING DEPARTMENT
HONG KONG

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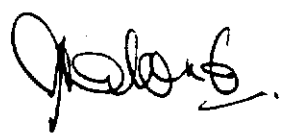
PREFACE

In keeping with our policy of releasing information of general technical interest, we make available some of our internal reports in a series of publications termed the GEO Report series. The reports in this series, of which this is one, are selected from a wide range of reports produced by the staff of the Office and our consultants.

Copies of GEO Reports have previously been made available free of charge in limited numbers. The demand for the reports in this series has increased greatly, necessitating new arrangements for supply. In future a charge will be made to cover the cost of printing.

The Geotechnical Engineering Office also publishes guidance documents and presents the results of research work of general interest in GEO Publications. These publications and the GEO Reports are disseminated through the Government's Information Services Department. Information on how to purchase them is given on the last page of this report.



A. W. Malone
Principal Government Geotechnical Engineer
April 1995

FOREWORD

This report presents a general review of rainfall and landslides in Hong Kong in 1988. Geotechnical Engineers of GCO District Divisions provided details of the notable landslides. Supplementary landslide data were provided by the Agriculture and Fisheries Department, Architectural Services Department, Civil Engineering Office, Fire Services Department, Highways Department, Housing Department and Water Supplies Department. The Royal Observatory provided rainfall information. All contributions are gratefully acknowledged.

(A. J. Cooper)
Chief Geotechnical Engineer/Special Projects

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1. INTRODUCTION

This report reviews rainfall and landslide occurrence in Hong Kong throughout 1988. Rainfall information has been obtained from the Geotechnical Control Office (GCO) automatic raingauge system and from the Royal Observatory (RO). Most of the landslide data have been taken from the records of incidents reported to the GCO during the year. Supplementary data have been obtained from other Government departments.

In this report, a landslide is defined as the collapse of a soil or rock mass, and includes the failure of fill slopes, cut slopes, retaining structures, natural slopes and rock or boulder falls. A major landslide is defined as a failure in which the volume of the collapsed mass exceeded 50 cu m.

The GCO received a total of 157 incident reports in 1988. Of these, 131 were classified as genuine landslides and five of them were major. The remaining incidents were minor ground or structural movements. It is notable that 41 incidents out of the whole year's total occurred during a severe rainstorm on 19-20th July. This report will emphasize the cases of landslides reported to the GCO, since these were inspected by the GCO's Geotechnical Engineers and detailed information is available.

The arrangement of this report is similar to the previous rainstorm and rainfall - landslides reports (GCO, 1982a, 1982b; Choot, 1984 and Premchitt, 1985-1988). The report reviews rainfall and landslide occurrence throughout the whole one-year period rather than emphasizing any one specific rainstorm. This report compiles important information from many sources throughout the government and it fully documents the work done by GCO in dealing with the landslide incidents.

2. RAINFALL

2.1 The Raingauge System

In the rugged terrain of Hong Kong, rainfall distribution over different geographical areas, as well as over different time periods, can vary dramatically during a rainstorm. The Royal Observatory has installed 127 raingauges at 91 locations around the Territory in order to provide sufficient coverage for a meaningful analysis of rainfall distribution. These raingauges range from a detailed automatic and instantaneous rate-of-rainfall recorder to raingauges which are read manually once a month. The "principal" gauge is located at the Royal Observatory's headquarters in Tsim Sha Tsui, and a continuous rainfall record has been made at this location since 1884. Weather summaries and rainfall statistics are normally based on the measurements made at this principal location.

Since 1978, the GCO, in co-operation with the RO, has installed a number of automatic raingauges which transmit the current rainfall data via telephone lines to the GCO's Emergency Control headquarters. Improvements have been made regularly and at present there are 46 GCO gauges and 21 RO gauges in this system, which provide up-to-date rainfall data every five minutes to the operation rooms of the GCO and RO. These data are also stored on computer tape and diskettes for future reference. The locations of these automatic raingauges (Figure 1) were selected to supplement the network of other types of raingauge and to provide specific information in areas of particular geotechnical interest. A major upgrading of this

system was completed in January 1989.

In this report, where a comparison is being made for "daily" rainfalls, the 24-hour maximum rainfall will be used instead of daily rainfall, since the latter is based on an arbitrary fixed period of midnight to midnight which does not necessarily represent the true rainstorm intensity. In addition, when a rainfall amount is quoted without reference to the location of measurement, this will be the amount measured at the RO headquarters.

2.2 Royal Observatory Records

The year's weather for 1988 was summarised by the Royal Observatory in the Monthly Weather Summary for December 1988. Their comments are as follows:

> The total rainfall in 1988 was 1 685.0 millimetres, 24 percent below the normal of 2 224.7 millimetres. Both the year's mean temperature of 22.8°C and mean relative humidity of 78 percent were the same as the normal figures. ...
>
> The total rainfall for June amounted to only 296.9 millimetres, 31 percent below normal. For the first half of 1988, a total of 548.0 millimetres of rain was recorded, making it the fourth lowest on record for the period. June was also drier and warmer than normal. The mean relative humidity of 78 percent, equalled in 1967, was the lowest on record for the month. The mean temperature of 28.6°C was the fourth highest on record for June. Due to the approach of an active trough of low pressure, thunderstorms and heavy showers affected Hong Kong during the period from 23 to 27 June. Consequently, 25 residents in Shaukeiwan had to be evacuated from their huts due to subsidence of the ground on 24 June. The Stand By Signal No. 1 was again on display from 28 to 29 June due to the approach of Tropical Storm Vanessa. Antecedent rain and heavy showers on 30 June caused a minor landslip in Kwai Chung where 27 residents had to be evacuated.
>
> July was the first month of the year with monthly rainfall slightly above normal. Most of the rainfall during the month was attributable to Typhoon Warren which required the hoisting of the Strong Wind Signal No. 3 for the first time this year. Almost 250 millimetres of rainfall were recorded at the Royal Observatory during 19 and 20 July and over 300 millimetres fell in parts of the northwestern New Territories where widespread severe flooding occurred...
>
> For the second consecutive month, rainfall in August was above normal. All rain events during

> the month could be attributed either to a trough of low pressure along the South China coastal areas or an active southwest monsoon. None was associated with a tropical cyclone. This was the second August since 1950 in which no tropical cyclone occurred over the South China Sea. A waterspout associated with severe thunderstorms occurred off the southeast coast of Ap Lei Chau at around noon on 16 August. The waterspout moved over land briefly and caused some minor damage before it dissipated. Flooding also occurred in various parts of the territory during the rain episodes on 14 and 18 August. The weather was also rainy on 30 and 31 August.
>
> Although Typhoon Kit posed a threat to Hong Kong in September and necessitated the hoisting of the Strong Wind Signal No. 3, it did not bring any significant amount of rain...

A summary of heavy rainstorms in 1988 is given in Table 1. This table shows all periods (mutually exclusive) in which 24-hour rainfall at the RO exceeded 50 mm. It also shows the fifteen-day antecedent rainfalls which occurred prior to the 24-hour periods. The highest 24-hour rainfall was 214 mm on 19 - 20th July. Other detailed information in Table 1 will be discussed in subsequent sections.

The rainfall data as recorded at the RO, Tsim Sha Tsui, are presented in Figures 2 to 5. Cumulative rainfall since 1st January is shown in Figure 2. Daily and monthly rainfalls are shown in Figures 3 and 4 respectively. Figure 5 shows the hourly rainfall for the highest 24-hour rainfall of 1988.

2.3 Geotechnical Control Office Records

Rainfall data are available from the GCO's 46 automatic raingauges. Current rainfall data can be found in the GCO's Rainfall Data Acquisition Centre and past data are kept in the Civil Engineering Library. A location map of the gauges is given in Figure 1.

In addition to the general RO rainstorm summary, data from some of the GCO raingauges are also given for the rainfall events in Table 1. The maximum rainfall recorded anywhere in the Territory on these occasions are given for three arbitrary durations of 24 hours, five hours and one hour.

The maximum 24-hour and one-hour rainfalls within the Territory during the year were 265 mm on 19-20th July and 79 mm on 19th July respectively.

Appendix B shows hourly rainfall data obtained from GCO's raingauges for the heaviest rainstorm over 24-hour period ending on 20th July.

2.4 Rainfall Distribution

A rainfall map, for 24-hour duration taken from RO records, are shown in Figure 6 for the heaviest rainstorm of the year. This rainstorm was

discussed in the annual RO weather summary quoted in section 2.2. Generally, rainfall was spread out fairly evenly over the Territory. The distribution of rainfall had a significant effect on the occurrence of landslides, and this will be discussed further in Section 3.4.

2.5 Warnings issued by the Royal Observatory

Relevant warnings issued by the RO, and the Landslip Warning jointly issued by the GCO and the RO, are summarised in Table 2.

In 1988, there were 67 Thunderstorm Warnings, eleven Flood Warnings, one Landslip Warning and seven Tropical Storm Warnings. The highest Tropical Storm Warning signal number raised during the year was No. 3, which was issued on four occasions. All of these warnings were issued in the period from March to October.

A Landslip Warning is issued after consultation between the GCO and the RO on the basis of predetermined rainfall criteria. The frequency of this warning in 1988 was the least among the rainfall-related warnings issued by the RO. A warning was issued on 19th July (Table 2). A comparison of rainstorm damage in this event with those on all other notable rainfall-landslide days is shown in Table 1. Forty-one incidents are known to have occurred during 19-20th July, while there were less than six incidents on any one day for the rest of the year. In this event, of the total reported incidents for which time of landslide occurrence is known to within one hour (Section 3.1), eighteen occurred after the warning was issued, and none occurred before the warning was issued. Those events not shown in Table 1 had rainfall of less than 50 mm in 24 hours and less than five landslides on any one day.

2.6 Comparison with Past Rainstorms

Maximum rainfall amounts of various durations recorded at the GCO and RO raingauges for heavy rainstorms in 1988 are shown in comparison with the three recent major rainstorms of May and August 1982 and June 1983 in Table 1. The highest 24-hour rainfall recorded at the RO in 1988 was only 54% of that for the May 1982 rainstorm. The highest one-hour rainfall recorded anywhere in 1988 was 79 mm, in comparison with more than 95 mm for the three major rainstorms listed above.

The return periods of heavy rainstorms in 1988 were estimated, and are shown in Table 3, for rainfall durations of one hour to fifteen days. No rainstorms of very long return period occurred, but the one-hour rainfall of 65 mm on 19th July is notable. It may be concluded, therefore, that rainfall in the year 1988 was not exceptional. For the rainstorm on 19-20th July, both the amount of rainfall and the number of resulting incidents (41) were the highest in 1988, although these were much less than the corresponding figures for the three major rainstorms of 1982-83.

In Figure 2, cumulative rainfall for 1988 is shown in comparison with the average (1951-1980), the wettest year (1982) and the driest year (1963) since records began in 1884. The annual cumulative rainfall was much lower than the average amount. Figure 4 shows monthly rainfalls in 1988 in comparison with the recorded maximum (since 1884) and mean (1951-1980) monthly rainfalls. The monthly rainfall generally fell far below the mean value with the exception of those in July, August and December which were

slightly higher than the mean values.

3. LANDSLIDES

3.1 Landslide Occurrence in 1988

The numbers of incidents reported to various Government departments during 1988 are shown in Table 4. The numbers of incidents affecting various types of area (building, road etc.) in Hong Kong, Kowloon and the New Territories are shown in Table 5. The number of major failures are also given in this table. There were five major landslides in 1988.

A list containing details of all 157 incidents reported to the GCO is provided in Appendix A. A location map for all these incidents is shown in Drawing No. GCSP 19/1. Selected incidents are illustrated in Plates 1 to 14. More details of these incidents are contained in the incident files of the GCO District Divisions and the 1:5 000 incident location maps housed in the Civil Engineering Library.

Wherever possible, the dates and times of the landslides were ascertained by the Geotechnical Engineers during site inspection. Some incidents were not reported for several days or weeks, particularly those which occurred in the New Territories. Therefore, it was difficult to determine the exact times of occurrence for these incidents. Out of 157 incidents, times of occurrence were known to within one day for 110 incidents. The daily numbers of these incidents are plotted in Figure 3. Of these 110 incidents, times of occurrence were determined to within one hour for 54 incidents.

The highest number of incidents in a rainstorm was 41 on 19-20th July and the next highest was five on 17-18th August. These occasions are included in Table 1, where the number of incidents reported in the newspapers and by the Fire Services Department are also shown for comparison. For those events not shown in Table 1, there were less than five incidents on any one day of the year.

It is likely that there were other failures which were not known to the GCO, including minor failures of no consequence, such as failures in remote areas, open spaces and construction sites. This should be borne in mind in reading the following landslide statistics.

3.2 Areas Affected by Incidents

The numbers of incidents, as reported to Government departments, which affected various categories of area are given in Table 5. It should be noted that one incident may affect more than one area category. Landslide consequences, classified according to the type of failure, are shown in Table 6.

3.2.1 Squatter Areas

A total of 68 incidents affected squatter areas. Of these, 41 occurred in Kowloon and eighteen in the New Territories. Most of those occurring in Kowloon were in the Kowloon East region, and the majority of those occurring in the New Territories were in Tsuen Wan and Sha Tin.

Two major failures affected squatter areas : incidents MW 6/2 in Hang Hau Village, Tsuen Wan (Plates 1 & 2; Section 4.3) and HK 6/4 (Plate 3; Section 4.2). Other failures in squatter areas were incidents MW 7/4 (Section 4.4), MW 7/21 (Section 4.6) and K 8/2 (Plate 6; Section 4.9) which resulted in injury to one person.

Incidents in squatter areas required permanent evacuation of 106 huts and temporary evacuation of 26 huts. Fifty percent of these evacuations resulted from failures of soil cut slopes (Table 6).

3.2.2 Buildings

There were 38 incidents affecting buildings. One of these was major failure : incident HK 8/4 (Plates 7 & 8; Section 4.2). The examples of minor failures affecting buildings are incidents K 7/12 (Plates 4 & 5; Section 4.7), ME 8/2 (Section 4.8), and HK 11/1 (Plates 13 & 14; Section 4.12).

Incidents in this category resulted in partial closure of four buildings.

3.2.3 Roads and Access

48 incidents affected roads and access (including footpaths), one of which was major failure : incident K 10/1 (Plates 9 & 10; Section 4.11). Examples of minor failures in this category are incidents MW 7/20 (Section 4.5), K 7/12 (Plates 4 & 5; Section 4.7) and MW 11/1 (Plates 11 & 12).

Due to these incidents, 39 sections of road or access were closed to traffic.

3.2.4 Construction Sites

There were five incidents affecting construction sites, and three of these were major failures. They were incidents HK 6/4 (Plate 3; Section 4.2), HK 8/4 (Plates 7 & 8; Section 4.2) and ME 8/11 (Section 4.10).

3.2.5 Catchwaters and Reservoirs

Incidents affecting catchwaters and reservoirs were dealt with separately by the Water Supplies Department. There were nineteen reported cases, fourteen of which occurred in July and the rest occurred in August.

3.2.6 Country Parks and Open Areas

Eight incidents in country parks and AFD Special Areas were reported by the Agriculture and Fisheries Department. In addition, the GCO inspected seven incidents in open areas.

3.3 Types of Incidents

The incidents inspected by the GCO have been classified into six types of failure and the number in each type is shown in Table 7. Damage resulting from these types of failure is shown in Table 6.

3.3.1 Fill Slopes

There were fifteen fill slope failures, forming ten percent of all incidents reported. One of them was major : incident K 10/1 (Plates 9 & 10; Section 4.11). This occurred due to rupture of two water mains.

3.3.2 Cut Slopes

There were 73 cut slope failures, forming 46% of all incidents reported. These were classified further according to types of material, i.e. soil, soil/rock and rock cut slope failures.

There were 61 soil cut slope failures. Three of these were major: incidents HK 6/4 (Plate 3; Section 4.2), HK 8/4 (Plates 7 & 8; Section 4.2), and ME 8/11 (Section 4.10). Examples of minor soil cut slope failures are incidents MW 7/4 (Section 4.4), ME 8/2 (Section 4.8), and K 8/2 (Plate 6; Section 4.9) which resulted in injury to one person.

There were seven soil/rock cut slope failures. None of them was major.

There were five rock cut slope failures. None of these was major. An example of minor rock cut slope failure is incident MW 11/1 (Plates 11 & 12).

3.3.3 Retaining Walls

There were fourteen retaining wall failures, forming nine percent of all incidents reported. None of these was major. Examples of minor retaining wall failures are incidents MW 7/21 (Section 4.6), K 7/12 (Plates 4 & 5; Section 4.7), and HK 11/1 (Plates 13 & 14; Section 4.12).

3.3.4 Natural Slopes

There were seven natural slope failures, forming four percent of all incidents reported. One of these was major : incident MW 6/2 (Plates 1 & 2; Section 4.3). An example of a minor natural slope failure is incident MW 7/20 (Section 4.5).

3.3.5 Rock and Boulder Falls

There were 22 cases of rock and boulder falls, forming fourteen percent of all incidents reported, none of which was major.

3.3.6 Other Failures

Other failures are incidents which cannot be classified according to the above categories. These included cases of collapse of excavations, ground settlement and collapse of huts. There were 26 failures of this type, forming seventeen percent of all incidents reported. None of these was major.

3.4 Rainfall-Landslide Relationships

The primary cause of the large majority of all failures was rainfall. Other failures were mostly isolated incidents caused by such factors as construction work, leakage of services and indiscriminate activities relating to earthworks and drainage alterations in squatter areas.

A simple relationship between rainfall and landslides is demonstrated by the plot of daily rainfall and daily number of landslide occurrences throughout 1988 in Figure 3. The majority of landslides tend to occur at times of heavy rainfall, in particular during the rainstorm on 19-20th July. The geographical distribution of rainfall also has a considerable influence on the occurrence of landslides in various areas. Figure 6 shows the location of landslides for which dates of occurrence are known (see Section 3.1), imposed on the 24-hour rainfall maps for the corresponding time period for the event on 19-20th July. This rainstorm is noteworthy : it had the highest rainfall of all rainstorms in 1988 (the hourly rainfall was more than 70 mm), and it resulted in 41 incidents out of a total of 157 incidents for the whole year.

More detailed and comprehensive discussions on rainfall-landslide relationships and failure mechanisms can be found in Brand et al (1984) and Premchitt et al (1985), where extensive data from the past twenty years have been analyzed.

4. NOTABLE INCIDENTS

4.1 Introduction

Eleven out of the 157 incidents are discussed in more detail in this section. These are presented in chronological order. The nature of the incident is referenced under the caption for each incident. These incidents have been selected mainly on the bases of size and consequences of failure.

4.2 Incidents HK 6/4 & HK 8/4, Island Road Government School, Aberdeen

(Dates : 28th June and 31th August. Major soil cut slope failures affecting squatters and building, Plates 3, 7 & 8.)

This slope, catalogued as 11SW-D/CR52, was under reconstruction as a part of the Landslip Preventive Measure Programme (LPM). The site is covered by colluvium and underlain mainly by weathered coarse ash vitric tuff. The slope had a gradient of about 25° and a height of about 25 m. The area at the top of the slope was partly occupied by squatter huts. A two-storey school building was about 5 m away from the toe of the slope. In 1988, two major failures occurred in this slope, on 28th June and 31th August respectively. Prior to the first failure, reconstruction of the

slope was in progress. This included removal of vegetation cover from the slope surface and cutting for access. Further excavation into the slope face for future rock filling had been carried out before the second failure.

The first major failure occurred after a prolonged rainy period from 23rd to 27th June (285 mm in 5 days at GCO gauge H05, Aberdeen). A large soil mass movement occurred with a 17 m long tension crack appeared on the slope face near the top of the slope and had a vertical displacement of about 1 m. The estimated displaced volume was about 100 cu m. As a result of this failure, ten huts at the top of the slope near the tension crack were permanently evacuated. Remedial work was then carried out.

The second major failure, the largest one in 1988, occurred at about 1145 hours on 31st August and involved about 800 cu m of slide debris. This was preceded by a much smaller failure in the same area at 0930 hours, and involved about 50 cu m of the debris. There had been a period of almost continuous rainfall from the 10th to 20th August (5 to 50 mm per day for a total of 283 mm). On the 31th August, there was more than 80 mm of rain prior to the failure at 1145 hours. The failure debris was observed to be very wet. A part of this debris fell into the flooded school yard and struck the rear wall of the school building. The mud-like debris flowed into some rooms on the ground floor, which were vacant at the time. As a result of this second failure, a total of eight rooms in the school were temporarily closed, and the remedial work started immediately after the failure.

4.3 Incident MW 6/2, Hang Hau Village, Shek Lei, Tsuen Wan
(Date : 30th June. Major failure of a natural slope affecting squatters, Plates 1 & 2.)

This major landslide occurred at about 0700 hours on 30th June, during a period of rainfall. It occurred in a natural slope which was a part of Smugglers Ridge in Tsuen Wan area. The failure was about 10 m wide and 15 m long. The debris volume was estimated to be about 100 cu m. The failure also involved a number of trees on the slope. The debris struck a hut at the toe of the slope and the rear portion of the hut collapsed. The huts in the vicinity were endangered by this landslide incident. As a result, three huts were permanently evacuated. The slide debris and the evacuated huts were subsequently cleared from the area.

4.4 Incident MW 7/4, Kin Yip San Tsuen, Yau Kam Tau, Tsuen Wan
(Date : 19th July. Soil cut slope failure affecting squatters.)

This incident occurred at about 2300 hours on 19th July, during the period of heaviest rainfall of the year (the daily rainfall was 204 mm). It involved two nearby but separate slope failures in a squatter area. The total failure debris volume was estimated to be about 15 cu m. The debris damaged a number of huts in the vicinity. As a result of this incident, eleven huts were permanently evacuated. The debris and the huts were subsequently cleared from the area.

4.5 Incident MW 7/20, DD 375 So Kwun Wat Village, Tuen Mun
(Date : 19th July. Natural slope failure affecting footpath and stormwater channel.)

This failure occurred on 19th July, the day with highest rainfall of the year (see Section 4.4 above). It occurred in a 9 m high natural slope. The width of the failure was about 5 m and the volume of the debris was approximately 40 cu m. It was observed that there was a 225 mm drainage channel discharging water at the top-centre of the failure surface. The debris completely blocked a 1 m wide open stormwater channel and a footpath at the toe of the slope. The subsequent repair works included removal of the debris, diversion of the drainage channel and provision of surface protection.

4.6 Incident MW 7/21, Tse Tin Tsuen, Tuen Mun
(Date : 21st July. Retaining wall failure affecting squatters.)

This incident occurred in the morning of 21st July, one day after a period of heavy rainfall during 19 - 20th July. It occurred in a 10 m long section of a 3 m high (maximum) rubble wall. This wall supported a small terrace above and it rested on a 4 m high cut slope. The debris volume was estimated to be about 30 cu m. As a result of this failure, two squatter huts at the toe of the slope and wall were temporarily evacuated. The subsequent remedial works involved diversion of the surface drainage away from the failure and reinstatement of the failure scar.

4.7 Incident K 7/12, Caritas Medical Centre, Sham Shui Po
(Date : 27th July. Retaining wall failure affecting road, Plates 4 & 5.)

This incident was reported to have occurred at about 1725 hours on 27th July during a period of light rain (32 mm for the day). It occurred in a 20 m long section of a 1 m high concrete parapet which had been erected above a 1 m high toe wall with a catch-pit behind. This catch-pit received surface drainage water from a 10 m high, 1 m wide cascade. The catch-pit appears to have been silted up completely before the failure. This build-up of silt and water caused the wall to collapse. The total debris volume was estimated to be about 10 cu m. The debris fell on to Wing Hong Street and hit two cars parked in the vicinity. As a result of this failure, the two cars were damaged, the ground floor of two shops on the opposite side of the street were temporarily evacuated and the street was closed. The shops were reoccupied the following morning and a repair was subsequently carried out on the failure.

4.8 Incident ME 8/2, Nam Chung Lo Uk, North District
(Date : Early August. Soil cut slope failure affecting building lot)

This failure occurred in early August, when there was a persistent rainfall from 10th to 20th August. It occurred in the upper part of a 9 m high soil cut slope. The failure surface was shallow, being less than 1 m below the existing slope face. The debris volume was estimated to be about 45 cu m. The debris piled up 2 m high against the back wall of a row of village houses at the toe of the slope. As a result, three village houses were temporarily evacuated until the completion of the remedial works.

4.9 Incident K 8/2, Ma Wan Village, Lei Yue Mun
(Date : 14th August. Soil cut slope failure affecting squatters, one person injured, Plate 6.)

This incident occurred at about 1700 hours on 14th August after a period of rainfall (more than 30 mm since midnight). It occurred in the top part of a steep, 15 m high cut slope, possibly a part of an old quarry. The total slide debris was only 2 cu m. However, a small part of the floor of a hut at the crest of the slope gave way and a person fell through the resulting hole, down the 15 m high slope and was injured. Subsequently, three huts in the area were permanently evacuated and the failure was repaired.

4.10 Incident ME 8/11, Lot 796 DD 216, Tai Wan, Sai Kung
(Date : Mid August. Major soil cut slope failure affecting construction site)

This incident occurred in mid August when a long period of persistent rainfall occurred (see Section 4.8 above). It occurred in a temporary cutting which was formed to provide access into a construction site. Two failures occurred and the volumes of the debris were estimated to be 65 and 10 cu m respectively. The debris blocked the access road and was subsequently removed to provide access to the site. A number of natural soil pipes were observed on the failure scar and they may have been a factor causing these failures. As a part of the final road works, the upper cutting was trimmed back to 35° and the lower part was supported by a retaining wall.

4.11 Incident K 10/1, 45 - 47 Broadcast Drive, Kowloon
(Date : 4th October. Major failure of a fill slope affecting footpath, Plates 9 & 10.)

This failure occurred in the evening of 4th October due to the rupture of two 300 mm diameter water mains at the site near a staircase which led to a walkway connecting Waterloo Road and Broadcast Drive, between houses no. 45 and 47 Broadcast Drive. The ruptured mains discharged a large amount of water which caused extensive erosion-type failure of the 5 m high fill slope below the staircase. The volume of the debris was about 120 cu m and it blocked the walkway completely. The debris also flowed into nearby building lots and on to Broadcast Drive. The staircase was damaged extensively by this failure. Immediately after the failure, the existing mains were shut off and a new main was laid, the debris was removed and the staircase was reinstated.

4.12 Incident HK 11/1, 81 Wong Nai Chung Road, Happy Valley
(Date : 24th November. Retaining wall failure affecting a construction site and a building lot, Plates 13 & 14.)

This incident occurred at about 1130 hours on 24th November, during driving of sheet piles in a construction site. It occurred in a 10 m long section of a 5.5 m high masonry retaining wall. The debris volume was approximately 20 cu m. The repeated vibration effects from driving of the sheet piles (U-shape channels), to act as a shoring to the pile cap excavation, may have contributed to the initiation of this failure. As a result, a part of the playground of St. Paul Primary School at the top of

the failure was fenced off. The construction schedule for the site at the toe of the wall was also affected. The failure was subsequently reinstated by the developer of the site.

5. CONCLUSIONS

Rainfall amounts for various durations during 1988 can be considered normal ; there were no exceptionally heavy and intense rainstorms. Over the whole year, 157 landslides and related incidents were reported to the GCO District Divisions, and the damage resulting from these incidents may be summarised as follows : one person injured, 132 huts evacuated, four buildings partially closed, and 39 sections of road and access closed. Most of this damage occurred during or shortly after rainstorms. The most intense and damaging storm occurred on 19-20th July, when 41 incidents occurred. A Landslip Warning was issued on this occasion. There was no other Landslip Warning and there were less than six incidents on any one day for the rest of the year.

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LIST OF TABLES

Table 1 - Rainfall-Landslide Events in 1988 with 24-hour Rainfall Greater than 50 mm

Date	Maximum Rainfall (mm)								Landslide Consequences				
	Royal Observatory					GCO Raingauges			Number of Landslides			Persons Killed or Injured	Number Huts Evacuated Permanently
	24-hr	5-hr	1-hr	Antecedent 4-day	Antecedent 15-day	24-hr	5-hr	1-hr	GCO	Newspaper	FSD		
19-20/7/88	214	136	65	1	35	265	141	79	41	5	1	-	37
30-31/8/88	101	58	37	0	205	128	94	59	1	-	-	-	-
26/6/88	89	79	35	132	164	132	115	53	4	-	1	-	2
23-24/6/88	87	48	23	13	36	107	67	50	2	-	-	-	-
17-18/8/88	84	41	17	96	229	88	57	25	5	-	-	-	2
14-15/8/88	51	43	13	62	133	77	55	35	3	-	-	1 injured	3
Recent Major Rainstorms (For Comparison Only)													
29/5/82	394	153	44	1	11	430	237	111	551	498	15	48	1153
16/8/82	362	159	68	0	346	370	290	95	138	62	6	9	200
17/6/83	347	274	69	2	77	460	303	101	155	114	5	2	149

Notes : (1) The events are arranged in order of magnitude of 24-hour rainfall at the Royal Observatory, Tsim Sha Tsui.
(2) For the rest of 1988, there were less than 5 landslips reported to GCO on any one day.
(3) Newspapers searched are South China Morning Post and Hong Kong Standard.

Abbreviation : GCO = Geotechnical Control Office ; FSD = Fire Services Department ; RO = Royal Observatory

Table 2 - Type and Date of Warnings Issued by the Royal Observatory in 1988

Month	Dates of Warnings			
	Thunderstorm	Flood	* Landslip	Tropical Storm
January	-	-	-	-
February	-	-	-	-
March	22	-	-	-
April	7, 8, 11, 12, 20 21, 22, 28, 30	-	-	-
May	5, 9, 10, 11, 12, 22, 24, 26, 31	-	-	31 (No. 1 signal, Susan)
June	21, 23, 24, 25, 26, 27, 30	23, 24, 26	-	1 (No. 1 signal, Susan) 28-29 (No. 1 signal, Vanessa)
July	1, 3, 10, 11, 12, 13, 19, 20, 21, 27, 28, 29, 30	19, 20, 27	19 (4a.m.) to 20 (10a.m.)	18-20 (No. 1-3 signals, Warren)
August	2-5, 8-18, 20, 25, 30, 31	9, 14, 18, 19, 31	-	-
September	1, 4, 5, 13, 15-17, 23, 24	-	-	21-22 (No. 1-3 signals, Kit)
October	-	-	-	21-22 (No. 1-3 signals, Pat) 25-28 (No. 1-3 signals, Ruby)
November	-	-	-	-
December	-	-	-	-
TOTAL NUMBER	67	11	1	7

Legend :

* Landslip warnings were issued after consultation between GCO & RO

Table 3 - Maximum Rainfalls during 1988 and Estimated Return Periods

Duration	*Rainfall (mm)	Ending Time		†Estimated Return Period (Year)
		Date	Hours	
1 hour	65.5	19/7	0400	4
5 hours	136.8	19/7	0800	3
12 hours	140.8	19/7	1500	< 2
24 hours	214.2	20/7	0300	2
2 days	247.7	20/7	2400	2
4 days	250.6	22/7	2400	< 2
7 days	252.2	25/7	2400	< 2
15 days	309.4	2/8	2400	< 2

Legend :

* Rainfall at Royal Observatory, Tsim Sha Tsui

† Gumbel equation, Peterson & Kwong (1981)

Table 4 - Number of Incidents Reported to Various Offices/Departments during 1988

Office / Department	Total Number	Types of Incident		
		Landslide	Flooding	Others
Agriculture & Fisheries Department	8	8	-	-
Civil Engineering Office, CESD	339	-	339	-
Fire Services Department	26	2	22	2
Geotechnical Control Office, CESD	157	131	1	25
Highways Department	45	42 *	-	3
Housing Department	4	4	-	-
Water Supplies Department	19	17	-	2

Legend :

* Landslides reported to HyD were referred to GCO and are included in the GCO incident

Table 5 - Number of Incidents Affecting Different Areas in 1988

Affected Area	Hong Kong	Kowloon	New Territories	All Districts
Squatters	9 (1)	41	18 (1)	68 (2)
Buildings	12 (1)	1	25	38 (1)
Roads	14	5 (1)	29	48 (1)
Construction Sites	4 (2)	-	1 (1)	5 (3)
Catchwaters	-	-	-	-
Country Parks / Open Areas	2	1	4	7

Legend :

( ) Number of major failures

Note : One incident may affect more than one type of area.

Table 6 - Consequence Related to Type of Failure in 1988

Type of Failure		No. of Huts Evacuated		Closure of Part of Building	Road/ Access Blocked	Injury
		Permanent	Temporary			
Fill Slope		7	-	-	6	-
Cut Slope	Soil	52	12	2	12	1
	Soil/Rock	7	4	-	1	-
	Rock	-	-	-	3	-
Retaining Wall		7	4	1	4	-
Natural Slope		4	-	-	2	-
Rock/ Boulder Fall		4	4	-	7	-
Others		25	2	1	4	-
TOTAL		106	26	4	39	1

Table 7 - Number of Incidents Reported to GCO during 1988 Classified by Type of Failure

Type of Failure		Number	Percentage
Fill Slope		15 (1)	10 %
Cut Slope	Soil	61 (3)	39 %
	Soil / Rock	7	4 %
	Rock	5	3 %
Retaining Wall		14	9 %
Natural Slope		7 (1)	4 %
Rock / Boulder Fall		22	14 %
Others		26	17 %
TOTAL		157	100 %

Legend :

( ) Number of major failures

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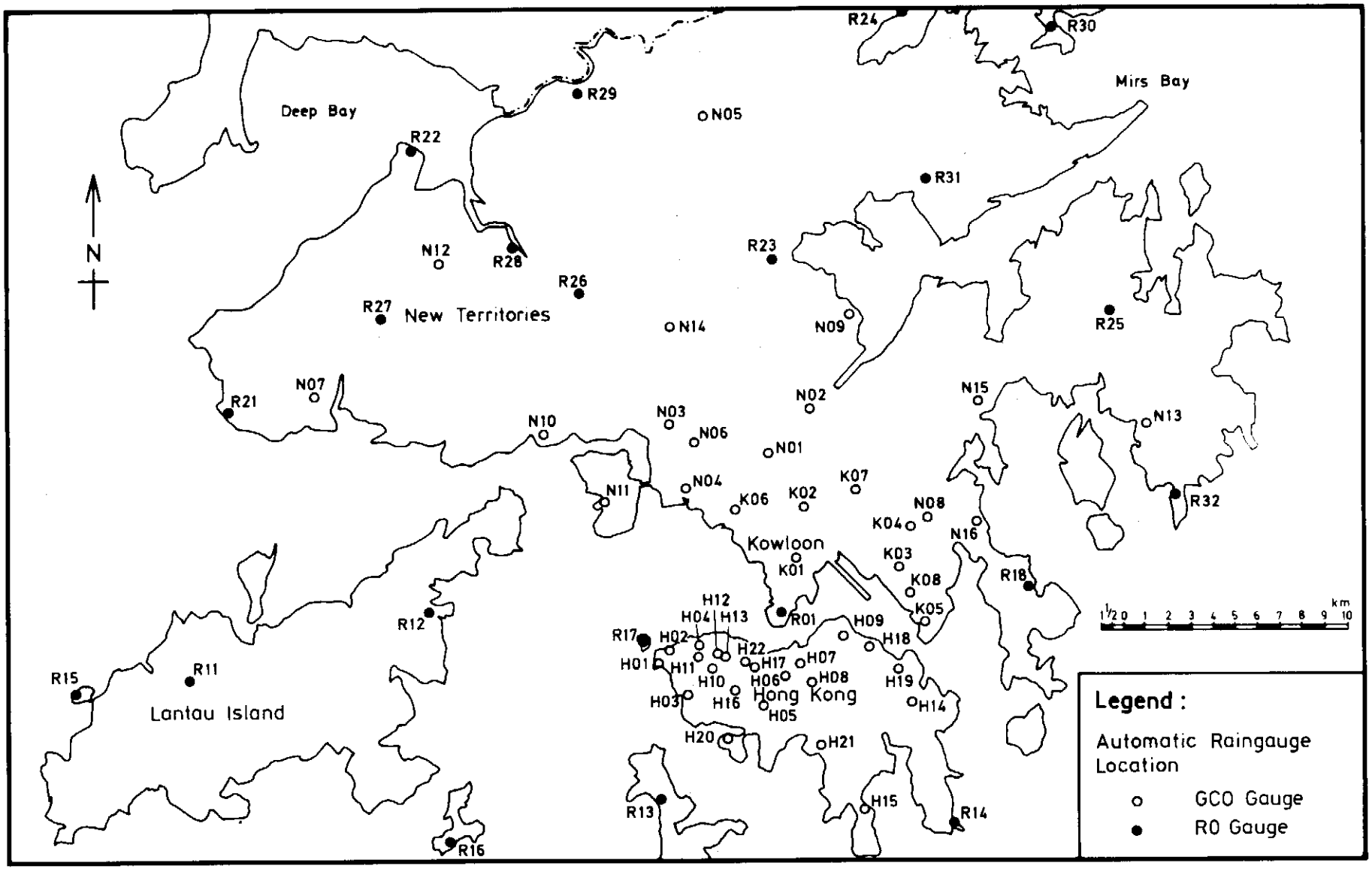

Figure 1 - Location of GCO and RO Automatic Raingauges

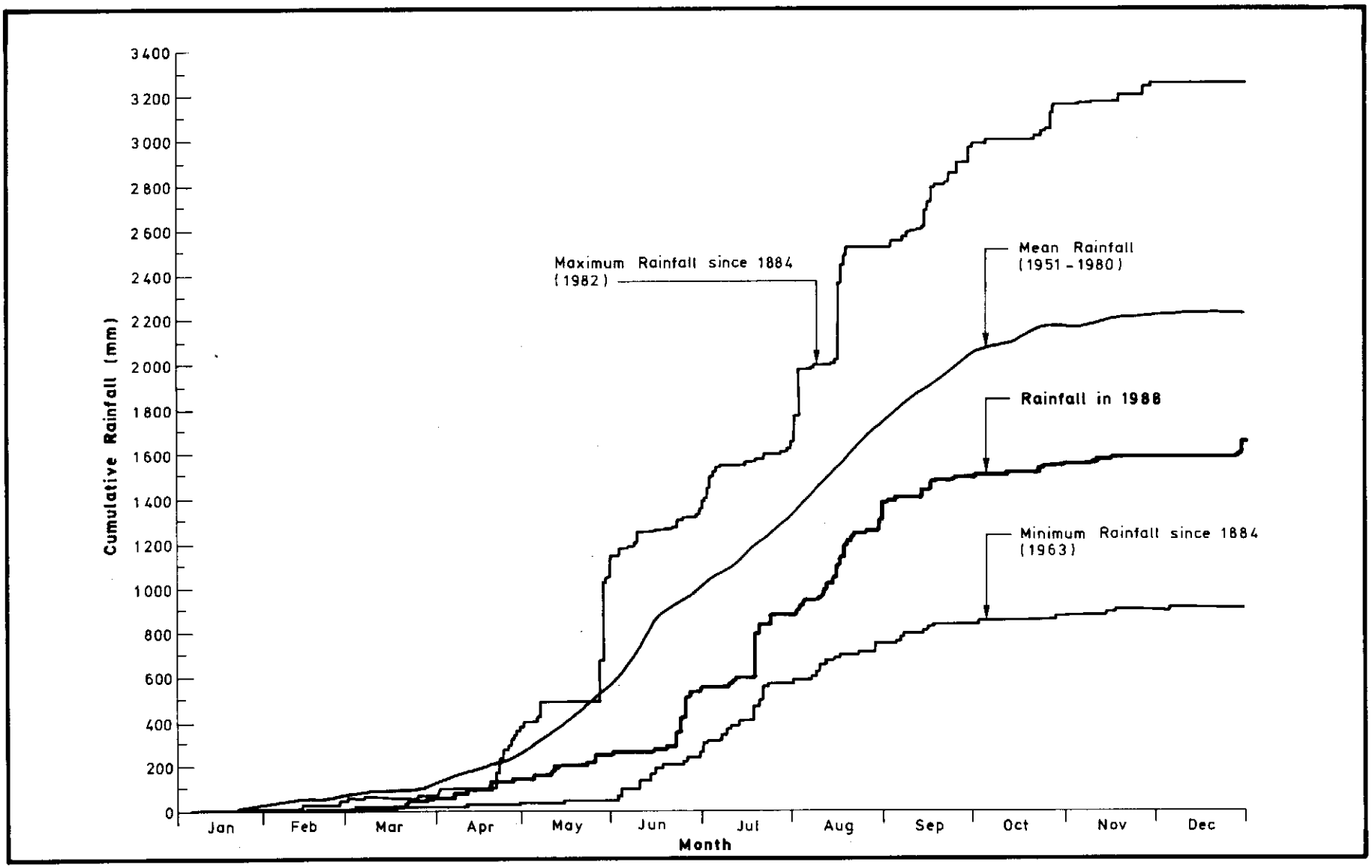

Figure 2 - Cumulative Rainfall for 1988 and the Recorded Maximum, Mean and Minimum Cumulative Rainfalls

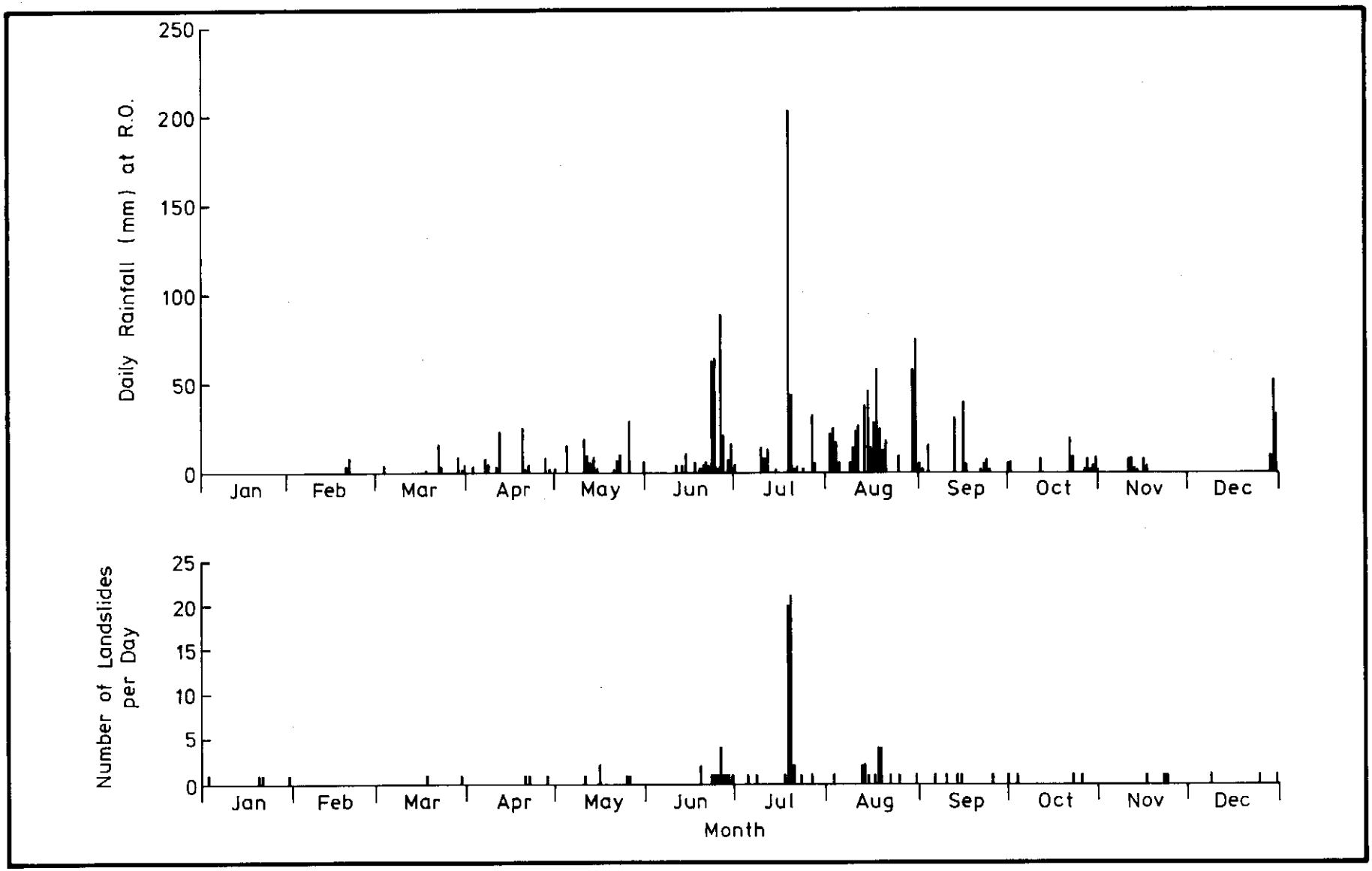

Figure 3 - Daily Rainfall and Distribution of Number of Landslides during 1988

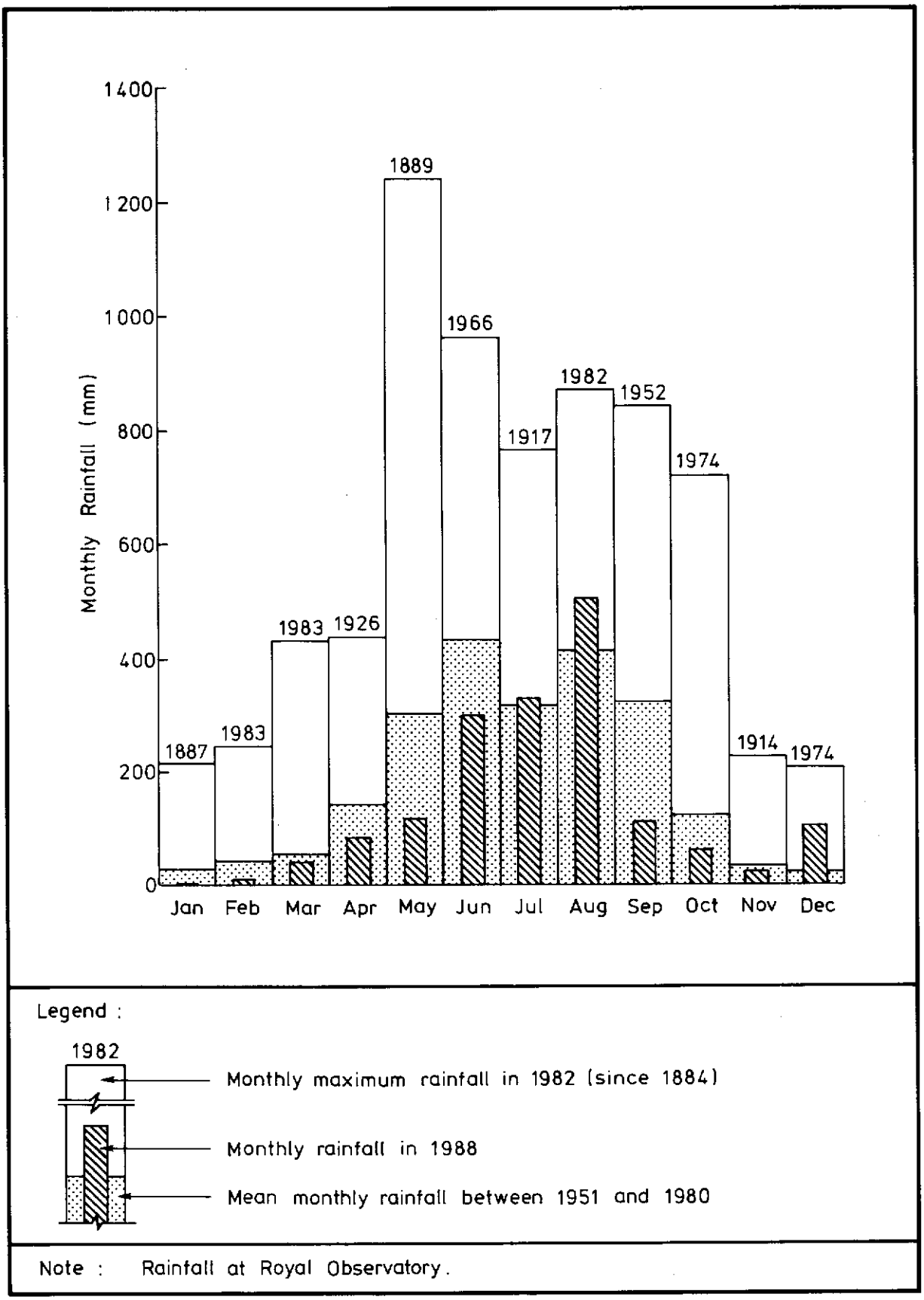

Figure 4 - Monthly Rainfalls in 1988 in Comparison with Recorded Maximum and Mean Monthly Rainfalls

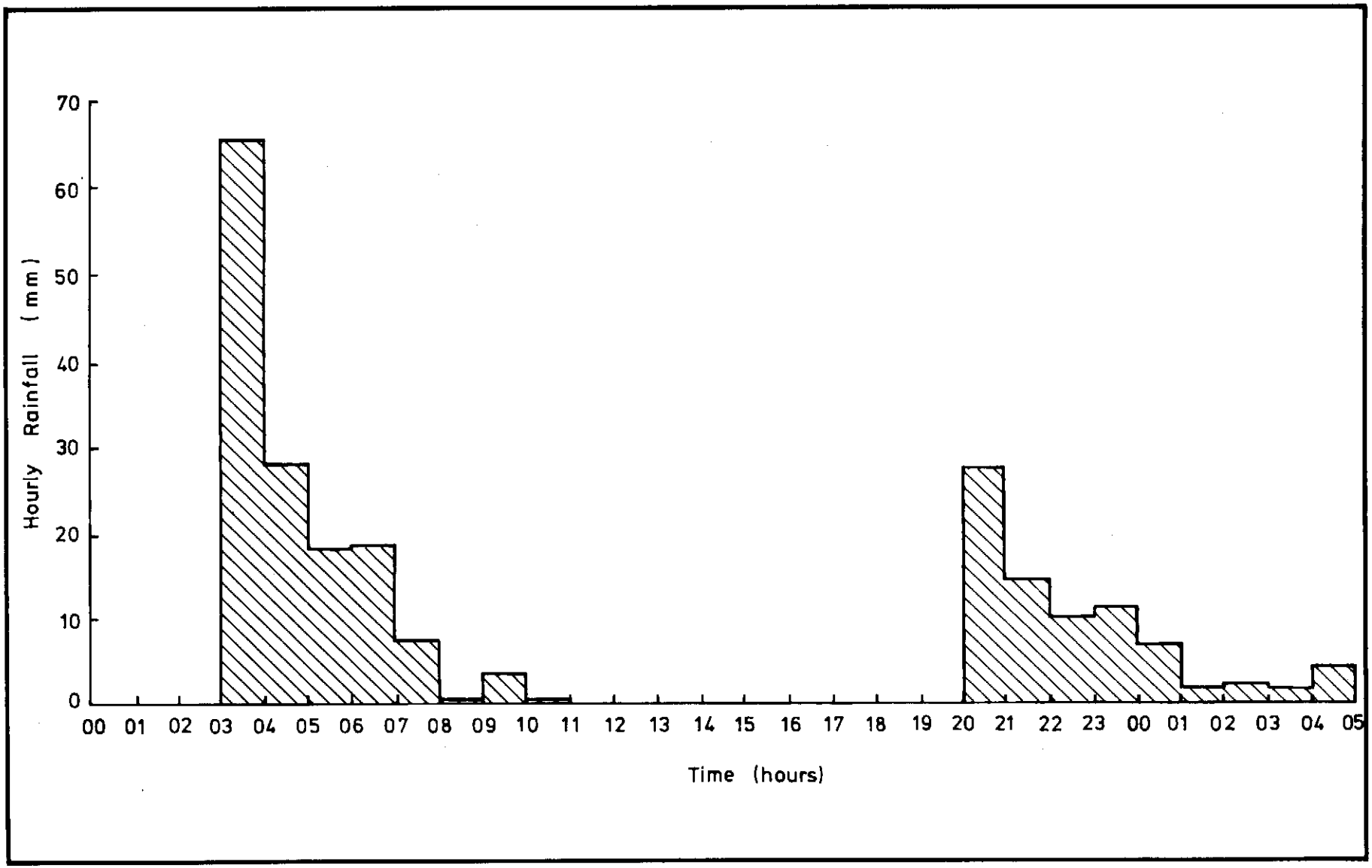

Figure 5 - Histograms of Hourly Rainfall at the Royal Observatory on 19th July 1988

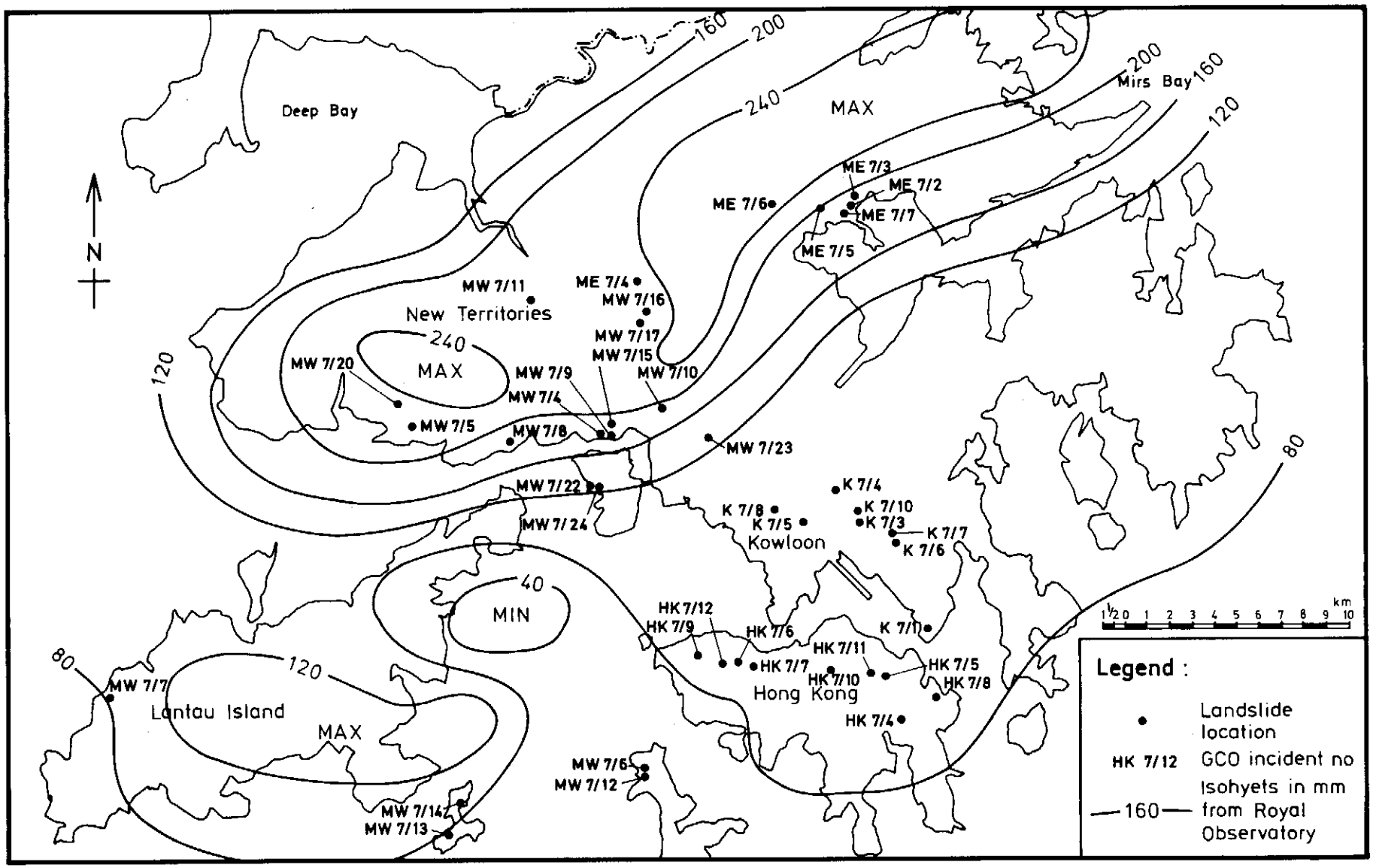

Figure 6 - 24-hour Rainfall Distribution Ending at 3 pm on 20th July 1988 and Location of GCO Incidents

LIST OF PLATES

Plate: 1 Negative No.: MW8819314 Date: 30.6.88

Plate: 2 Negative No.: MW8819414 Date: 30.6.88

Description : Major failure of a natural slope affecting squatters, three huts permanently evacuated.

Plate 1 & 2 - Hang Hau Village, Shek Lei, Tseun Wan (Incident No. MW 6/2)

Plate: 3 Negative No.: IE8817704 Date: 1.7.88

Description : Major failure of a soil cut slope affecting squatters and construction site, ten huts permanently evacuated.

Plate 3 - Island Road Government School, Aberdeen (Incident No. HK 6/4)

Plate: 4 Negative No.: ME8829612 Date: 28.7.88

Plate: 5 Negative No.: ME8829611 Date: 28.7.88

Description : Failure of a concrete wall due to silting up of a catch-pit, two cars damaged, two shops temporarily closed and a road closed.

Plates 4 & 5 - Caritas Medical Centre, Sham Shui Po
(Incident No. K 7/12)

Plate: 6 Negative No.: ME8832512 Date: 15.8.88

Description : Soil cut slope failure affecting squatters, one person fell down the slope and injured, three huts permanently evacuated.

Plate 6 - Ma Wan Village, Lei Yue Mun
(Incident No. K 8/2)

Plate: 7 Negative No.: IE8823407 Date: 31.8.88

Plate: 8 Negative No.: IE8823400 Date: 31.8.88

Description : Major failure of a soil cut slope affecting building, eight rooms of a school temporarily evacuated.

Plates 7 & 8 - Island Road Government School, Aberdeen
(Incident No. HK 8/4)

Plate: 9
Negative No.: ME8841922
Date: 5.10.88

Plate: 10
Negative No.: ME8841911
Date: 5.10.88

Description : Major failure of a fill slope due to rupture of water mains, footpath blocked.

Plates 9 & 10 - 45 - 47 Broadcast Drive
(Incident No. K 10/1)

Plate: 11
Negative No.: MW8831501
Date: 17.11.88

Plate: 12
Negative No.: MW8832001
Date: 18.11.88

Description : Rock cut slope failure affecting road, one lane of road blocked.

Plates 11 & 12 - Tuen Mun Highway Ch. 7550, Tsing Lung Tau
(Incident No. MW 11/1)

Plate: 13 Negative No.: IE8833918 Date: 24.11.88

Plate: 14 Negative No.: IE8833915 Date: 24.11.88

Description : Retaining wall failure affecting building lots, part of play ground above fenced off.

Plates 13 & 14 - 81 Wong Nai Chung Road, Happy Valley (Incident No. HK 11/1)

APPENDIX A

LIST OF INCIDENTS

APPENDIX A

LIST OF TABLES

Table A1 - List of Incidents on Hong Kong Island Reported to GCO in 1988 (Sheet 1 of 3)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
HK 1/1	Tai Hang Road above Maryknoll Sisters' School	21/1	HyD	21/1 (7am)	Fill slope	Minor	Building lot & road	2 lanes of road closed	
HK 1/2	Island Road Government School, Aberdeen	22/1	School	20/1 (3pm)	Rock cut slope	Minor	Playground	An area fenced off	LPM works in progess
HK 2/1	Stanley Boat Club	8/2	Public	NK	Soil cut slope	Minor	Building lot		
HK 2/2	Holy Cross Path Village, Shaukeiwan	26/2	DO	NK	Boulder	Minor	Squatters	4 huts permanently evacuated, 3 huts temporarily evacuated	
HK 3/1	Sir Cecil's Ride near Mt. Butler Quarry	8/3	Public	NK	Boulder	Minor	Footpath		
HK 4/1	Holy Cross Path Village, Shaukeiwan	22/4	Public	22/4 (am)	Soil/rock cut slope	Minor	Squatters	2 huts permanently evacuated	
HK 4/2	43 Stanley Village Raod	21/4	GCO	NK	Soil cut slope	Minor	Building lot		
HK 5/1	Lin Fa Kung Street East, Tai Hang	2/5	Public	NK	Boulder	Minor	Building lot		
HK 5/2	Lung Fu Shan footpath above Pokfulam Road	14/5	DO	NK	Soil cut slope	Minor	Country Park		
HK 6/1	15 Lin Fa Kung Street East, Tai Hung	25/6	Public	NK	Boulder	Minor	Building lot		
HK 6/2	Shan Pin Terrace, Shaukeiwan Main Street	24/6	HyD	24/6 (10pm)	Retaining wall	Minor	Squatters	4 huts temporarily evacuated, footpath closed	
HK 6/3	3 Pollock's Path, The Peak	24/6	BOO	23/6 (pm)	Retaining wall	Minor	Construction site		Temporary wall collapsed
HK 6/4	Island Road Government School, Aberdeen (11SW-D/CR52)	30/6	GCO	28/6 (am)	Soil cut slope	Major	Construction site, squatters	10 huts permanently evacuated	LPM works in progess
HK 6/5	25-27 Bisney Road, Pokfulam	26/6	BOO	NK	Soil cut slope	Minor	Building lot		
HK 7/1	Junction of Bridge Street and Shing Wong Street, Mid-Levels	5/7	ArchSD	5/7 (1pm)	Wash out	Minor	Footpath	Footpath closed	Water main burst due to drilling
HK 7/2	Wang Hang Tung Village, Shaukeiwan	13/7	DO	8/7	Subsidence	Minor	Squatters		

Table A1 - List of Incidents on Hong Kong Island Reported to GCO in 1988 (Sheet 2 of 3)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
HK 7/3	Tai Hang Road opposite Maryknoll Sisters' School	19/7	Police	NK	Boulder	Minor	Road		
HK 7/4	Shek O Road	19/7	HyD	19/7 (9am)	Soil/rock cut slope	Minor	Road	1 lane of road blocked	
HK 7/5	Salesian School, Shaukeiwan	20/7	Public	19/7 (9pm)	Boulder	Minor	Building lot		
HK 7/6	Chatham Path near May Road	20/7	HyD	20/7 (10am)	Soil/rock cut slope	Minor	Road	An area fenced off	
HK 7/7	17 Magazine Gap Road	20/7	HyD	20/7 (10am)	Soil cut slope	Minor	Footpath	Footpath closed	
HK 7/8	Yuen Dao Ngam Village, Chai Wan	20/7	DO	20/7 (am)	Soil/rock cut slope	Minor	Squatters	2 huts permanently evacuated	
HK 7/9	Kotewall Road near Conduit Road (11SW-A/CR185)	21/7	HyD	20/7 (am)	Soil cut slope	Minor	Road		
HK 7/10	Tai Hang Road near Broadwood Road	21/7	HyD	20/7 (am)	Boulder	Minor	Road		
HK 7/11	O Pui Lung Village, Shaukeiwan	20/7	GCO	20/7 (4am)	Soil cut slope	Minor	Squatters		Fallen trees
HK 7/12	11 May Road, The Peak	28/7	Public	19/7 (2pm)	Boulder	Minor	Road		
HK 8/1	208-212 Queen's Road, Central	15/8	BOO	15/8 (2pm)	Subsidence	Minor	Building lot, footpath	Part of building temporarily evacuated, footpath closed	
HK 8/2	Yuen Dao Ngam Village, Chai Wan	15/8	HyD	13/8 (10am)	Retaining wall	Minor	Squatters	2 huts permanantly evacuated	
HK 8/3	Opposite 34 Stubbs Road, Happy Valley	17/8	HyD	17/8 (am)	Natural slope	Minor	Road		Minor wash out

Table A1 - List of Incidents on Hong Kong Island Reported to GCO in 1988 (Sheet 3 of 3)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
HK 8/4	Island Road Government School, Aberdeen (11SW-D/CR52)	31/8	GCO	31/8 (12am)	Soil cut slope	Major	School, construction site	8 rooms temporarily evacuated	LPM works in progress, Failure volume >800 cu m. File : GCI-2/E1/11SW-D/CR51 & 52, GCP 2/C20/13, GCD 2/A1/11SW-D/CR52
HK 9/1	Aldrich Village, Shaukeiwan	1/9	Public	NK	Soil cut slope	Minor	Squatters	Footpath closed	
HK 9/2	Sai Wan Ho Fire Station	14/9	FSD	14/9 (1pm)	Rock cut slope	Minor	Building		
HK 9/3	29-35 Ventris Road, Happy Valley	16/9	Public	15/9 (11pm)	Rock fall	Minor	Building lot, footpath		
HK 11/1	81 Wong Nai Chung Road, Happy Valley	24/11	BOO	24/11 (12am)	Retaining Wall	Minor	Construction site, building lot	An area fenced off	Probably due to the driving of sheet piles
HK 12/1	Harlech Road, The Peak	25/12	HyD	25/12 (5pm)	Boulder	Minor	Road	Road blocked	

Table A2 - List of Incidents in Kowloon Reported to GCO in 1988 (Sheet 1 of 4)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
K 1/1	On Lok Village, Anderson Road	18/1	WSD	NK	Natural slope	Minor	Squatters	1 hut permanently evacuated	Wash out gully
K 1/2	69 Heung Yeung Village, Sha Tin Pass Road	1/2	HyD	30/1 (am)	Retaining wall	Minor	Squatters		
K 3/1	Ngau Chi Wan West Village	25/3	HyD	18/3	Subsidence	Minor	Squatters	3 huts permanently evacuated	
K 3/2	Tai Shing Village, Sau Mau Ping	30/3	HyD	30/3 (3pm)	Wash out	Minor	Squatters	2 huts permanently evacuated	
K 4/1	Heung Yeung Village, Tsz Wan Shan	21/4	DO	21/4	Retaining wall	Minor	Squatters		Temporary wall collapsed
K 5/1	On Lok Village, Sau Mau Ping	16/5	HyD	16/5 (am)	Soil cut slope	Minor	Squatters	1 hut permanently evacuated, footpath closed	
K 5/2	On Lok Village, Sau Mau Ping	16/5	HyD	16/5 (am)	Soil cut slope	Minor	Squatters	2 huts permanently evacuated	
K 5/3	On Tak Road Playgroud, Ngau Tau Kok (11NE-C/C25)	18/5	ArchSD	NK	Rock fall	Minor	Squatters	An area fenced off	
K 6/1	Ngau Chi Wan West Village	19/6	BOO	19/6 (10am)	Subsidence	Minor	Squatters	5 huts permanently evacuated	
K 6/2	Ngau Chi Wan West Village	23/6	DO	NK	Soil cut slope	Minor	Squatters	1 hut permanently evacuated	
K 6/3	Wo Ping Village, Anderson Road	26/6	DO	26/6 (2pm)	Fill slope	Minor	Squatters	2 huts permanently evacuated	
K 6/4	Ngau Chi Wan West Village	19/6	BOO	19/6 (10am)	Subsidence	Minor	Squatters	4 huts permanently evacuated	
K 6/5	Chung Luen Tsuen, Lung Chung Road	28/6	HD	27/6 (6pm)	Fill slope	Minor	Squatters	Footpath blocked	
K 6/6	Sau Mau Ping Village	28/6	GCO	NK	Fill slope	Minor	Squatters		
K 6/7	Lion Rock Lower Village	1/7	WSD	NK	Boulder	Minor	Squatters		

Table A2 - List of Incidents in Kowloon Reported to GCO in 1988 (Sheet 2 of 4)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
K 6/8	Ngau Chi Wan Village	11/7	DO	NK	Subsidence	Minor	Squatters	3 huts permanently evacuated	
K 7/1	Lei Yue Mun Village	19/7	Public	19/7 (am)	Wash out	Minor	Squatters		Mud/debris blocking drains
K 7/2	Tai Shing Village, Sau Mau Ping	20/7	HyD	NK	Soil cut slope	Minor	Squatters	3 huts permanently evacuated	
K 7/3	Ngau Chi Wan West Village	19/7	DO	19/7 (5am)	Subsidence	Minor	Squatters	1 hut permanently evacuated	
K 7/4	Tin Liu Village, Tsz Wan Shan	20/7	DO	20/7 (1am)	Soil cut slope	Minor	Squatters	5 huts temporarily evacuated	
K 7/5	Tat Chee Avenue, Yau Yat Tsuen	20/7	DO	20/7 (3am)	Soil cut slope	Minor	Squatters	1 hut temporarily evacuated	
K 7/6	On Lok Village, Sau Mau Ping	20/7	HyD	20/7	Soil cut slope	Minor	Squatters	3 huts permanently evacuated	
K 7/7	Sau On village, Sau Mau Ping	20/7	HyD	20/7 (4am)	Soil cut slope	Minor	Squatters	3 huts permanently evacuated	
K 7/8	Beacon Hill above Lung Chung Road	20/7	HyD	20/7 (am)	Boulder	Minor	WSD water main		
K 7/9	Tai Shing Village, Sau Mau Ping	21/7	HyD	21/7 (6am)	Wash out	Minor	Squatters	2 huts permanently evacuated	
K 7/10	Ngau Chi Wan Village	20/7	DO	19/7 (11pm)	Fill slope	Minor	Squatters	2 huts permanently evacuated	
K 7/11	Ngau Chi Wan East Village	25/7	HyD	23/7 (am)	Soil cut slope	Minor	Squatters	2 huts permanently evacuated	
K 7/12	Caritas Medical Centre, Wing Hong Street, Sham Shui Po	27/7	HyD	27/7 (5pm)	Retaining wall	Minor	Road, building	2 cars damaged, road blocked, 2 shops at G/F temporarily evacuated	Silting up of catch-pit at end of a cascade causing high water pressure and a con. parapet failed
K 8/1	Tai Shing Village, Sau Mau Ping	13/8	HyD	13/8 (am)	Soil cut slope	Minor	Squatters	2 huts temporarily evacuated	

Table A2 - List of Incidents in Kowloon Reported to GCO in 1988 (Sheet 3 of 4)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
K 8/2	Ma Wan Village, Lei Yue Mun	15/8	HyD	14/8 (5pm)	Soil cut slope	Minor	Squatters	1 person injured, 3 huts permanently evacuated	One person fell down the slope
K 8/3	Ma Wan Village, Lei Yue Mun	15/8	HyD	14/8 (4pm)	Soil cut slope	Minor	Squatters		
K 8/4	Tung Hang Lane, Tai Hang Tung	18/8	DO	18/8 (am)	Flooding	Minor	Squatters		
K 8/5	Ngau Chi Wan Village	19/8	HyD	19/8 (am)	Soil cut slope	Minor	Squatters	4 huts permanently evacuated	
K 8/6	Chung Luen Village, near So Uk	25/8	DO	25/8	Fill slope	Minor	Squatters		
K 9/1	Chung Luen Village, near So Uk	2/9	HD	NK	Retaining wall	Minor	Squatters		
K 9/2	Chung Luen Village, near So Uk	2/9	HD	NK	Soil cut slope	Minor	Squatters	2 huts permanently evacuated	
K 9/3	Sau On village, Sau Mau Ping	5/9	DO	NK	Soil cut slope	Minor	Squatters	1 hut permanently evacuated	
K 9/4	Bishop Ford Memorial School, Kowloon City	23/9	HyD	NK	Soil cut slope	Minor	Footpath		
K 10/1	45-47 Broadcast Drive	5/10	WSD	4/10 (pm)	Fill slope	Major	Footpath	Footpath blocked	Rupture of water mains
K 10/2	Sau On Village, Sau Mau Ping	7/10	HyD	NK	Subsidence	Minor	Squatters	Footpath blocked	
K 10/3	1B, Lai Chi Yuen, Junction Road, Kowloon City	5/10	DO	1/10	Retaining wall	Minor	Footpath	Footpath blocked	
K 10/4	Sau On Village, Sau Mau Ping	10/10	HyD	NK	Subsidence	Minor	Squatters	2 huts temporarily evacuated	
K 10/5	On Shin Road, Ngau Tau Kok	14/10	DO	NK	Boulder	Minor	Footpath		
K 10/6	Hong Ning Road Village, Sau Mau Ping	26/10	HyD	26/10 (1am)	Wash out	Minor	Squatters	2 huts permanently evacuated	
K 11/1	Sau On Village, Sau Mau Ping	25/11	HyD	23/11	Subsidence	Minor	Squatters		
K 12/1	Ngau Chi Wan Village	9/12	BOO	9/12 (am)	Subsidence	Minor	Squatters	1 hut permanently evacuated	

Table A2 - List of Incidents in Kowloon Reported to GCO in 1988 (Sheet 4 of 4)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
K 12/2	On Lok Village, Sau Mau Ping	3/1	HyD	31/12	Soil cut slope	Minor	Squatters	6 huts permanently evacuated	

Table A3 - List of Incidents in Eastern New Territories Reported to GCO in 1988 (Sheet 1 of 2)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
ME 5/1	Tai Mei Tuk Country Park Management Centre, Tai Po	12/5	DLO	11/5	Soil cut slope	Minor	Country Park		
ME 6/1	Lot 565 DD 230, Tai Hang Hau, Sai Kung	27/6	Public	26/6	Natural slope	Minor	Open space		
ME 6/2	Area 6, Sha Tin Tau Village, Sha Tin	27/6	HyD	25/6 (8am)	Soil cut slope	Minor	Squatters		
ME 7/1	Luk Hop Village, Sha Tin	1/7	HyD	29/6 (7pm)	Soil cut slope	Minor	Squatters		
ME 7/2	22 Chim Uk village, Tai Po	21/7	DLO	20/7 (6am)	Soil cut slope	Minor	Building lot		
ME 7/3	11A Chim Uk Village, Tai Po	21/7	DLO	20/7 (6am)	Soil cut slope	Minor	Building lot		
ME 7/4	Lam Kam Road near Kadoorie Farm, Shek Kong	21/7	HyD	20/7	Rock cut slope	Minor	Road	1 lane blocked	
ME 7/5	Plummer Village, Ting Kok Road, Tai Po	20/7	BOO	20/7 (am)	Soil/rock cut slope	Minor	Squatters	3 huts permanently evacuated, 4 huts temporarily evacuated	
ME 7/6	12D Nam Hang Village, Ting Kok Road, Tai Po	21/7	DO	20/7 (am)	Soil cut slope	Minor	Footpath		
ME 7/7	165 Chan Uk Village, Ting Kok Road, Tai Po	21/7	DLO	20/7 (pm)	Soil cut slope	Minor	Building lot	Footpath blocked	
ME 7/8	Pak Shek Wo Village, Clear Water Bay Road, Sai Kung	22/7	DO	NK	Soil cut slope	Minor	Road	1 lane of road blocked	
ME 8/1	41 & 42 New Fisherman's Village, Tap Mun Island, Tai Po	4/8	DO	3/8	Soil cut slope	Minor	Village house		
ME 8/2	15-17, Nam Chung Lo Uk, North District	17/8	DO	NK	Soil cut slope	Minor	Building lot	3 village houses temporarily evacuated	
ME 8/3	16, Hin Tin Village, Tai Wai, Sha Tin	18/8	HyD	18/8 (5pm)	Soil cut slope	Minor	Building lot	2 huts temporarily evacuated, footpath closed	
ME 8/4	119 Sam Mun Tsai New Village, Yim Tin Tsai, Tai Po	19/8	DLO	18/8	Soil/rock cut slope	Minor	Building lot		

Table A3 - List of Incidents in Eastern New Territories Reported to GCO in 1988 (Sheet 2 of 2)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
ME 8/5	MS 12, Clear Water Bay Road, near Miu Tsai, Sai Kung	19/8	DLO	19/8 (2pm)	Boulder	Minor	Road	1 lane of road blocked	
ME 8/6	Hang Hau Road, near Hang Hau Town, Sai Kung	20/8	HyD	19/8 (10am)	Rock fall	Minor	Road	1 lane of road blocked	
ME 8/8	12 Tai Om Village, Lam Kam Road, Tai Po	24/8	DO	18/8 (am)	Soil cut slope	Minor	Building lot		
ME 8/9	Hiram's Highway near Pak Sha Wan, Sai Kung	19/8	DO	19/8	Boulder	Minor	Road	Footpath blocked	
ME 8/10	Yau Oi Village, Sha Tin	26/8	DO	22/8	Boulder	Minor	Footpath	Footpath blocked	
ME 8/11	Lot 796 DD 216, Tai Wan, Sai Kung	23/8	GCO	NK	Soil cut slope	Major	Construction site	Road blocked	
ME 8/12	Near River Indus, Tin Ping Shan, Sheung Shui	5/9	DO	NK	Subsidence	Minor	Open space		Collapse of river bank due to erosion
ME 8/13	Tong Kung Leng Village, Sheung Shui	26/11	DLO	NK	Soil cut slope	Minor	Road		
ME 10/1	26 Second Street, Heung Fung Liu, Tai Wai, Sha Tin	24/10	DO	23/10 (10am)	Soil cut slope	Minor	Building lot		

Table A4 - List of Incidents in Western New Territories Reported to GCO in 1988 (Sheet 1 of 4)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
MW 2/1	Shing Mun Catchwater near Tai Wo Tsuen, Tsuen Wan	30/1	BOO	30/1 (6pm)	Boulder	Minor	Squatters	1 hut temporarily evacuated	LPM work in progress GC 85/07
MW 3/1	Shu Chun Public School, Nim Shu Wan, Lantau Island	1/3	ASD	NK	Boulder	Minor	Building		
MW 3/2	Fu Yung Shan Road, San Tsuen, Tsuen Wan	31/3	DO	NK	Natural slope	Minor	Road	1 lane of road closed	
MW 4/1	362 Tan Kwai Tsuen, Yuen Long	30/4	BOO	28/4 (pm)	Retaining wall	Minor	Building	An area fenced off	
MW 5/1	Shek Lei Hang Village, Lei Muk Shu, Tsuen Wan	15/5	HD	15/5 (4am)	Fill slope	Minor	Squatters	3 huts permanently evacuated	
MW 5/2	Opposite 15-14 Yip Shing Street, Tsuen Wan	17/5	CEO	NK	Wash out	Minor	Road		Undermining the road due to erosion by water from damaged sewage drains
MW 5/3	Kam Sham Village, Shek Lei, Tsuen Wan	27/5	HD	26/5 (10pm)	Retaining wall	Minor	Squatters	1 hut permanently evacuated	
MW 5/4	Area 38E, Tuen Mun	20/5	DLO	NK	Soil cut slope	Minor	Building lot		
MW 5/5	Area 39, TMTL 296, Tuen Mun	27/5	GCO	NK	Fill slope	Minor	Building lot		
MW 6/1	Opposite Block 10, Shek Lei Estate, Lei Pui Street, Tsuen Wan	26/6	HyD	26/6 (3pm)	Rock cut slope	Minor	Road	1 lane of road closed	
MW 6/2	Hang Hau Village, Shek Lei, Tsuen Wan	30/6	HD	30/6 (7am)	Natural slopes	Major	Squatters	3 huts permanently evacuated	
MW 6/3	Mo Tat Wan, Lamma Island	28/6	Police	26/6	Boulder	Minor	Footpath	Footpath blocked	
MW 7/1	Pak Tin Pui Village, MS 9 Route Twisk, Tsuen Wan	6/7	Public	NK	Subsidence	Minor	Squatters	1 hut permanently evacuated	
MW 7/2	396 Sham Tseng West Village	8/7	DO	NK	Wash out	Minor	Building lot		
MW 7/3	Tsing Yi Road, opposite Power Station, Tsing Yi Island	19/7	Police	NK	Wash out	Minor	Road	1 lane of road closed	
MW 7/4	Kin Yip San Tsuen, Yau Kam Tau, Castle Peak Road, Tsuen Wan	20/7	Police	19/7 (11pm)	Soil cut slope	Minor	Squatters	11 huts permanently evacuated	

Table A4 - List of Incidents in Western New Territories Reported to GCO in 1988 (Sheet 2 of 4)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
MW 7/5	23 Siu Lam Village, So Kwun Wat, Tuen Mun	20/7	Police	19/7	Wash out	Minor	Squatters		Wash out silt from a stock pile area above
MW 7/6	72, Yung Shue Wan, Lamma Island	20/7	BOO	19/7	Soil cut slope	Minor	Building lot		
MW 7/7	1 Kat Hing Back Street, Tai O, Lantau	20/7	DLO	19/7 (8pm)	Soil/rock cut slope	Minor	Building lot		
MW 7/8	Public car park, MS 13 Castle Peak Road, Sham Tseng, Tsuen Wan	20/7	RSD	19/7	Wash out	Minor	Car park	Car park blocked	Possibly debris dumped on site
MW 7/9	Po Fung Terrace, MS9.5 Castle Peak Road, Tsuen Wan	20/7	RSD	19/7	Soil cut slope	Minor	Road	1 lane of road blocked	
MW 7/10	Kwog Pan Tin San Tsuen, Route Twisk, Tsuen Wan	20/7	HyD	19/7	Soil cut slope	Minor	Squatters		
MW 7/11	Shung Shan San Tsuen, Yuen Long	20/7	HD	20/7 (4am)	Soil cut slope	Minor	Squatters		
MW 7/12	9 Yung Shue Wan Main Street, Lamma Island	20/7	DLO	19/7	Soil cut slope	Minor	Building lot, footpath	Footpath closed	
MW 7/13	1 Sai Wan Road, Cheung Chau Island	20/7	BOO	19/7	Retaining wall	Minor	Building lot, foopath	Footpath closed	
MW 7/14	130 Pak She San Tsuen, Cheung Chau Island	20/7	HyD	19/7	Soil cut slope	Minor	Building lot		
MW 7/15	Yau Kam Tau Village, near Tuen Mun Highway, Tsuen Wan (6SE-D/F47)	20/7	HyD	20/7 (am)	Fill slope	Minor	Road		Natural pipe erosions at numerous locations
MW 7/16	MS 14 Route Twisk, Shek Kong	22/7	HyD	20/7 (am)	Boulder	Minor	Road	Footpath blocked	
MW 7/17	MS 13.7 Route Twisk, Shek Kong	22/7	HyD	20/7 (am)	Soil cut slope	Minor	Road	1 lane of road blocked	
MW 7/18	Shing Mun Catchwater Ch. 5150, Tsuen Wan	20/7	GCO	NK	Soil cut slope	Minor	Road	Access road blocked	LPM work in progress
MW 7/19	40 Pak She San Tsuen, Cheung Chau Island	22/7	DO	18/7	Soil cut slope	Minor	Building lot		
MW 7/20	DD 375, So Kwun Wat Village, Castle Peak Road, Tuen Mun	22/7	DO	19/7	Natural slope	Minor	Footpath	Footpath blocked	

Table A4 - List of Incidents in Western New Territories Reported to GCO in 1988 (Sheet 3 of 4)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
MW 7/21	Tse Tin Tsuen, Tuen Mun	26/7	DO	21/7 (am)	Retaining wall	Minor	Squatters	2 huts temporarily evacuated	
MW 7/22	26 Back Street, Ma Wan Island, Tsuen Wan	22/7	DLO	19/7 (11pm)	Soil cut slope	Minor	Building lot		
MW 7/23	Kam Shan Village, Shek Lei, Tsuen Wan	25/7	HD	19/7	Retaining wall	Minor	Squatters	2 huts permanently evacuated	
MW 7/24	5 Sports Road, Ma Wan Island, Tsuen Wan	22/7	DLO	19/7 (11pm)	Fill slope	Minor	Building lot		
MW 8/1	Sham Tseng East Village, Tsuen Wan	3/8	DO	NK	Soil cut slope	Minor	Squatters		
MW 8/2	45 Sham Tseng Tsuen, Tsuen Wan	3/8	DO	NK	Soil cut slope	Minor	Building lot		
MW 8/3	Tso Kung Tam Village, Tsuen Wan	22/8	HD	NK	Subsidence	Minor	Squatters	1 hut permanently evacuated	
MW 8/4	Pak Nai Approach Road, Yuen Long	18/8	ASD	NK	Soil cut slope	Minor	Road	1 lane of road blocked	
MW 9/1	Ting Kau Car Park, Ting Kau, Tsuen Wan (6SE-C/FR2)	26/8	DO	NK	Fill slope	Minor	Footpath	Footpath blocked	
MW 9/2	Hing Shing Road Playground, Kwai Chung, Tsuen Wan	2/9	RSD	NK	Fill slope	Minor	Footpath	Footpath blocked	
MW 9/3	Deep Bay Road, Lau Fau Shan, Yuen Long	6/9	DLO	NK	Fill slope	Minor	Open space		
MW 9/4	Lau Fau Shan Village, Yuen Long (2SW-C/C2)	7/9	DLO	NK	Soil cut slope	Minor	Car park		
MW 9/5	Tai Pak Tin Street, Shek Lei, Tsuen Wan (7SW-C/F20)	10/9	HyD	10/9 (7am)	Fill slope	Minor	Road	2 lanes of road closed	Rupture of water mains caused piping type failure
MW 9/6	26 Yau Kam Tau, Tsing Yi Island, Tsuen Wan	29/9	HD	26/9 (6pm)	Wash out	Minor	Squatters		
MW 10/1	Lui Ming Choi Lutheran College, Cheung Pei Shan Road, Tsuen Wan	29/9	HD	NK	Natural slope	Minor	Building		
MW 10/2	3 & 4 Wang Tong, Mui Wo, Lantau Island	15/10	DO	NK	Soil cut slope	Minor	Footpath		

Table A4 - List of Incidents in Western New Territories Reported to GCO in 1988 (Sheet 4 of 4)

Incident No.	Location	Call Received		Failure			Area Affected	Consequence	Remarks
		Date	From	Date (Time)	Type	Scale			
MW 11/1	Tuen Mun Highway Ch. 7550 near Tsing Lung Tau, Tsuen Wan (6SE-C/C34)	17/11	Police	17/11 (2am)	Rock cut slope	Minor	Road	1 lane of road blocked	
MW 11/2	St. Joseph Primary School, Ko Po Tsuen, Kam Tin, Yuen Long	8/11	DLO	6/9 (10am)	Soil cut slope	Minor	Building lot		
MW 12/1	Lam Tin Village, Tsing Yi Island, Tsuen Wan	31/12	Police	31/12 (8am)	Soil cut slope	Minor	Squatters	2 huts temporarily evacuated	Rupture of water mains

APPENDIX B

RECORDS FROM GCO RAINGAUGES

APPENDIX B

LIST OF FIGURES

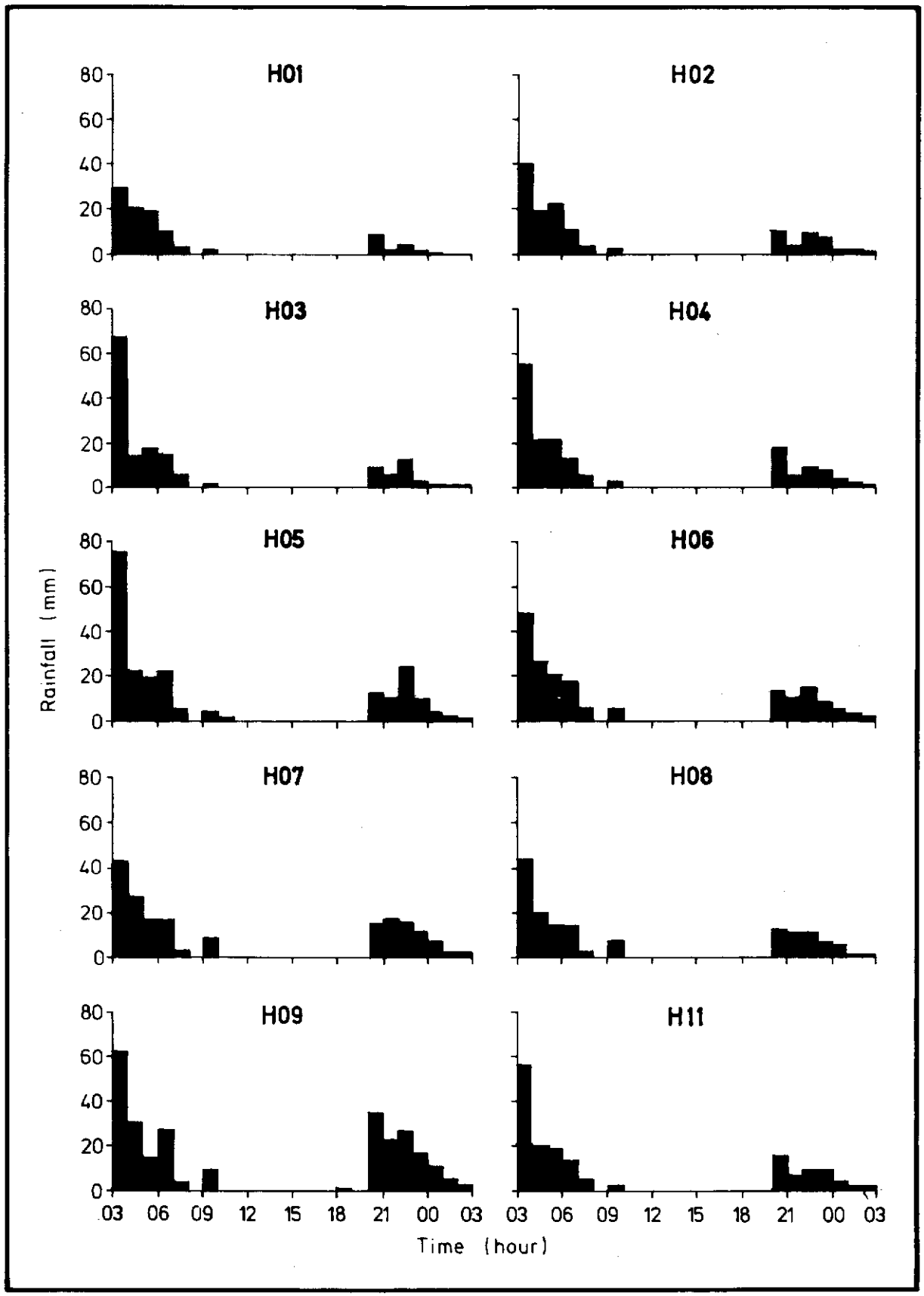

Figure B1 - Histograms of Hourly Rainfall Recorded by GCO Raingauges on 19th July 1988 (Sheet 1 of 4)

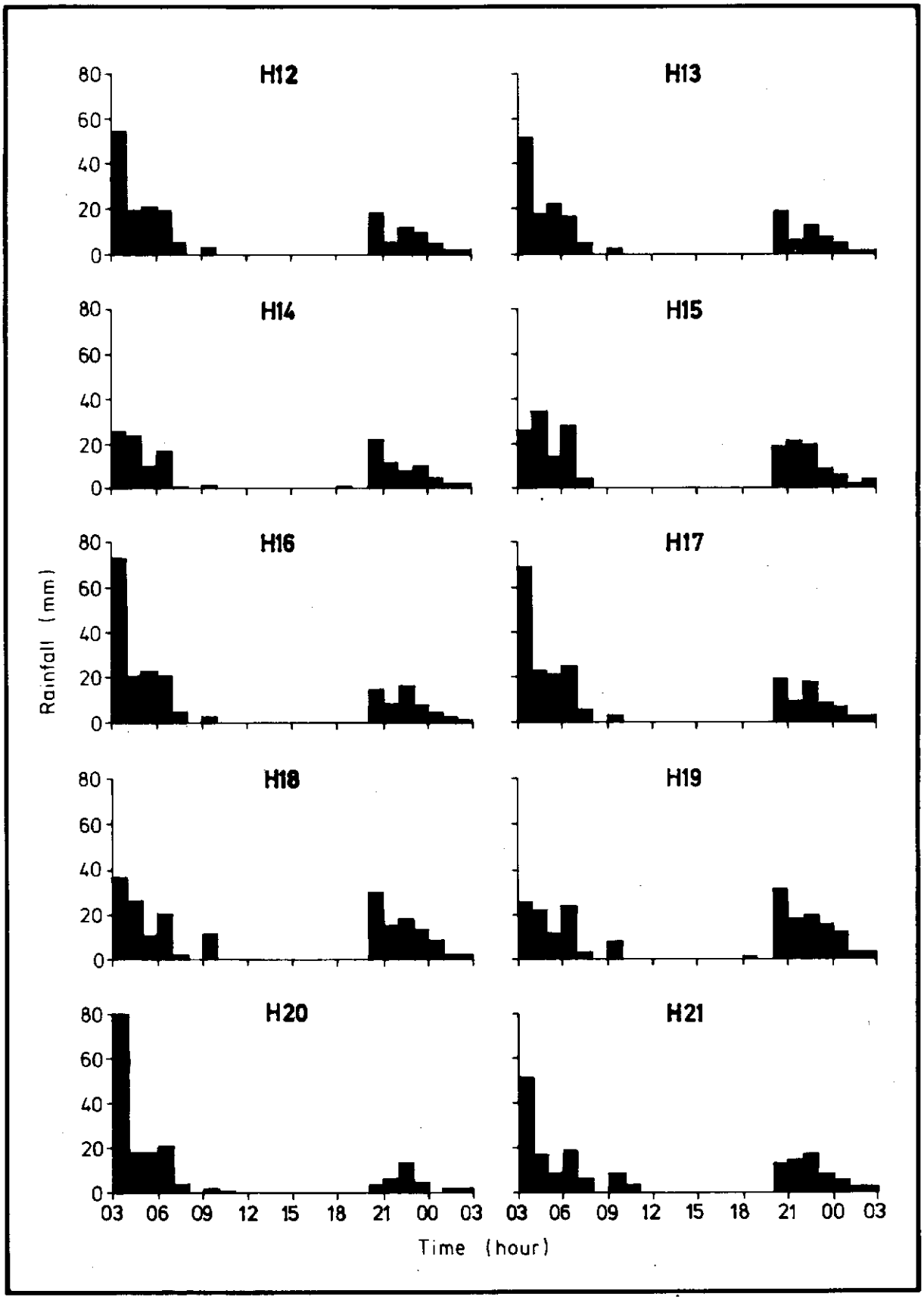

Figure B1 - Histograms of Hourly Rainfall Recorded by GCO Raingauges on 19th July 1988 (Sheet 2 of 4)

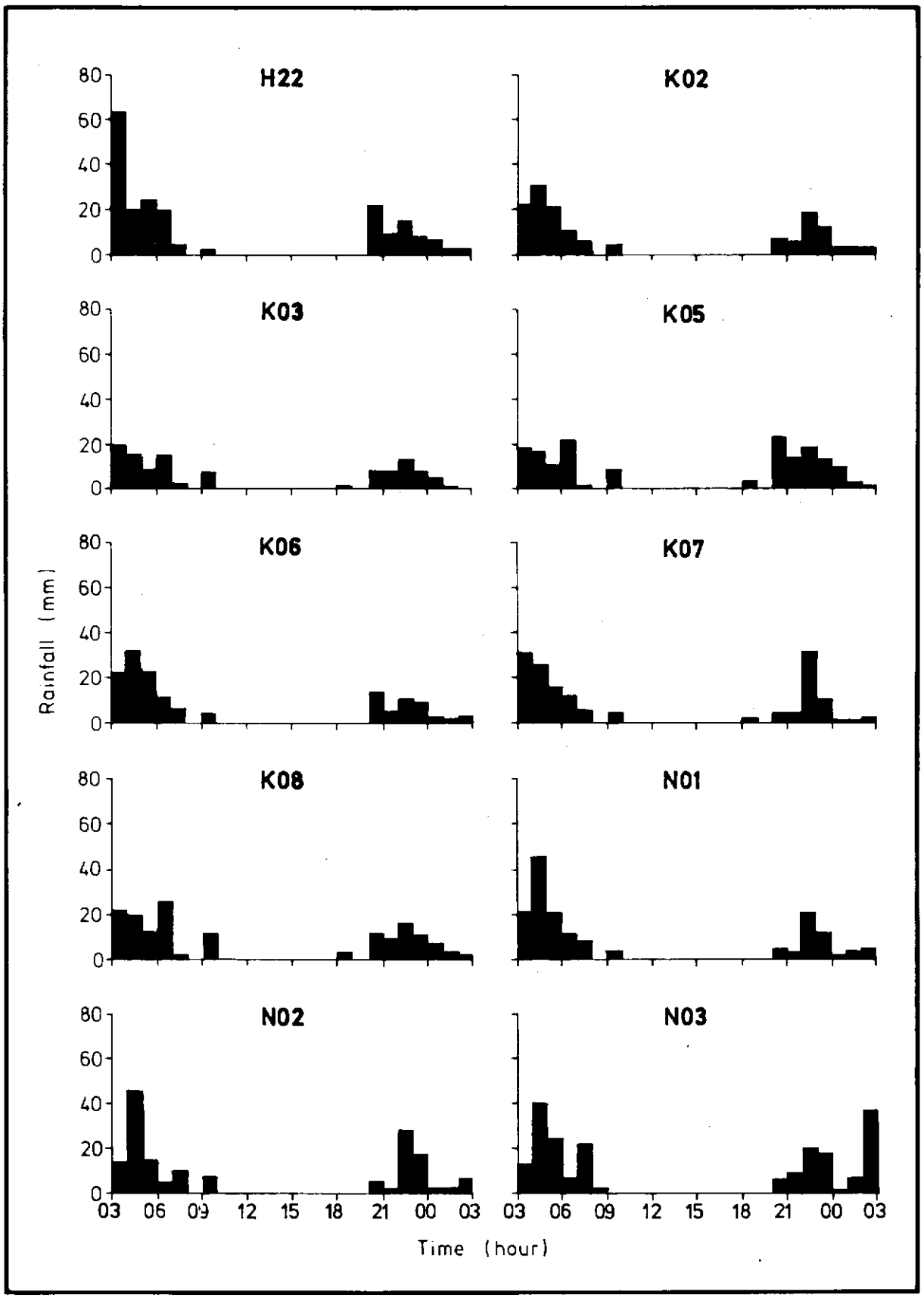

Figure B1 - Histograms of Hourly Rainfall Recorded by GCO Raingauges on 19th July 1988 (Sheet 3 of 4)

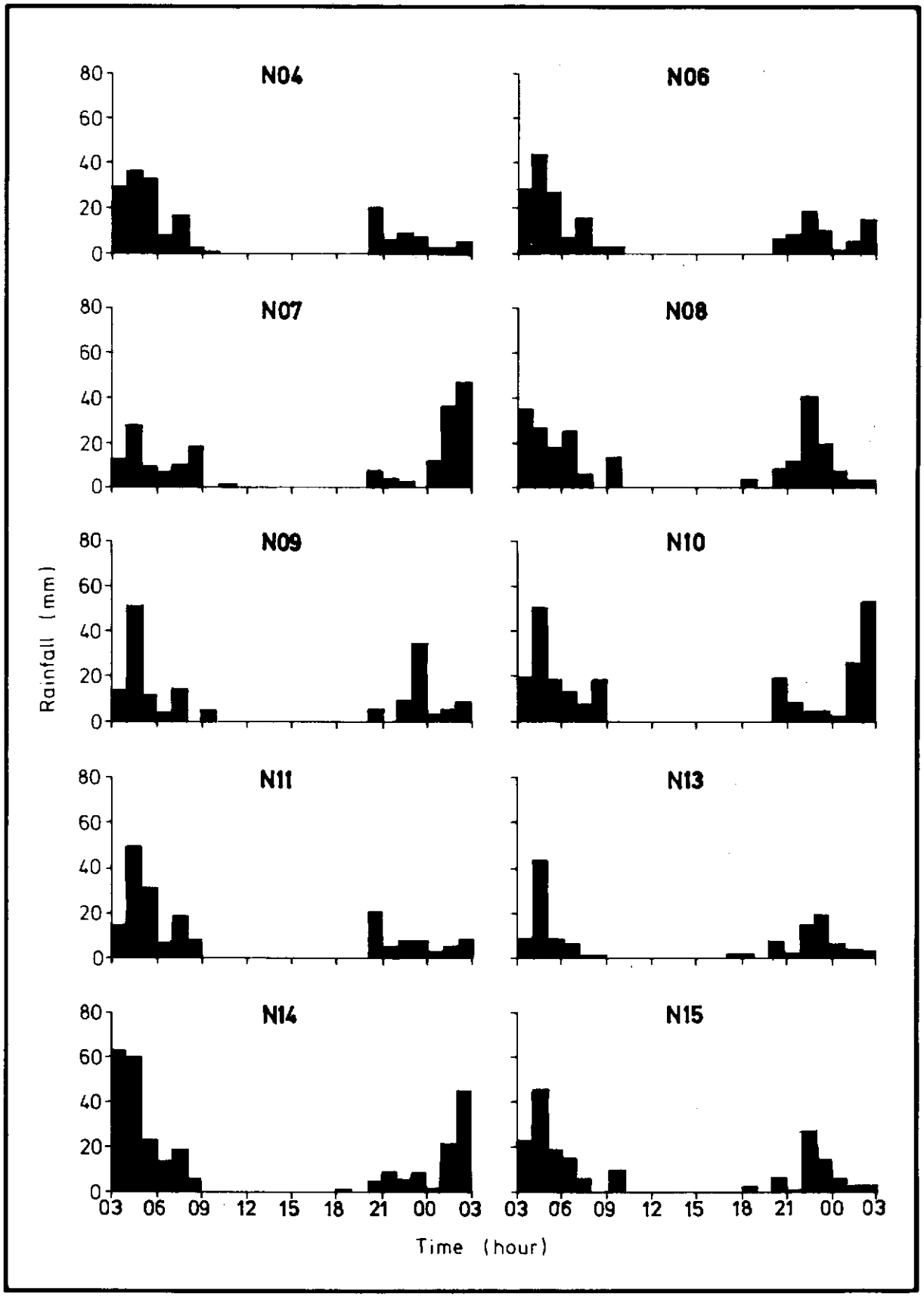

Figure B1 - Histograms of Hourly Rainfall Recorded by GCO Raingauges on 19th July 1988 (Sheet 4 of 4)

LIST OF DRAWING

Drawing No.	
GCSP 8/5	Location Map of Landslides and Related Incidents in 1988