

**INVESTIGATION OF SOME
SELECTED LANDSLIDE
INCIDENTS IN 1997
(VOLUME 4)**

GEO REPORT No. 90

Halcrow Asia Partnership Ltd.

**GEOTECHNICAL ENGINEERING OFFICE
CIVIL ENGINEERING DEPARTMENT
THE GOVERNMENT OF THE HONG KONG
SPECIAL ADMINISTRATIVE REGION**

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PREFACE

In keeping with our policy of releasing information which may be of general interest to the geotechnical profession and the public, we make available selected internal reports in a series of publications termed the GEO Report series. A charge is made to cover the cost of printing.

The Geotechnical Engineering Office also publishes guidance documents as GEO Publications. These publications and the GEO Reports may be obtained from the Government's Information Services Department. Information on how to purchase these documents is given on the last page of this report.



R.K.S. Chan
Head, Geotechnical Engineering Office
June 1999

EXPLANATORY NOTE

This GEO Report consists of four Landslide Study Reports on the investigation of selected slope failures that occurred in 1997. The investigations were carried out by Halcrow Asia Partnership Ltd (HAP) for the Geotechnical Engineering Office as part of the 1997 Landslip Investigation Consultancy.

The LI Consultancies aim to achieve the following objectives through the review and study of landslides:

- (a) establishment of an improved slope assessment methodology,
- (b) identification of slopes requiring follow-up action, and
- (c) recommendation of improvement to the Government's slope safety system and current geotechnical engineering practice in Hong Kong.

The Landslide Study Reports prepared by HAP are presented in four sections in this Report. Their titles are as follows:

<u>Section</u>	<u>Title</u>	<u>Page No.</u>
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The Landslip Investigation Division of the Geotechnical Engineering Office worked closely with the LI Consultants and provided technical input and assistance to the landslide studies.

**SECTION 1:
DETAILED STUDY OF THE
LANDSLIDE AT
ST. JOSEPH'S ANGLO
CHINESE SCHOOL
NGAU TAU KOK
ON 3 AUGUST 1997**

Halcrow Asia Partnership Ltd

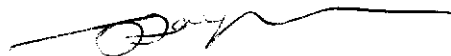
**This report was originally produced in November 1998
as GEO Landslide Study Report No. LSR 17/98**

FOREWORD

This report presents the findings of a detailed study of a landslide (GEO Incident No. K97/8/1) which occurred on 3 August 1997 and involved the collapse of an old rubble facing (stone pitching) on a soil/rock cut slope behind St. Joseph's Anglo Chinese School, Kwun Tong Road, Ngau Tau Kok. Debris from the landslide accumulated in a narrow walkway between the slope and the back of the school. No fatalities or injuries were reported.

The key objectives of the detailed study were to document the facts about the landslide, present relevant background information and establish the probable causes of the landslide. The scope of the study was generally limited to site reconnaissance, desk study and analysis. Recommendations for follow-up actions are reported separately.

The report was prepared as part of the 1997 Landslip Investigation Consultancy (LIC), for the Geotechnical Engineering Office (GEO), Civil Engineering Department (CED), under Agreement No. CE 68/96. This is one of a series of reports produced during the consultancy by Halcrow Asia Partnership Ltd (HAP). The report was written by Mr J Thompson and reviewed by Dr R Moore. The assistance of the GEO in the preparation of the report is gratefully acknowledged.



G. Daughton
Project Director/Halcrow Asia Partnership Ltd.

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1. INTRODUCTION

In the early morning of 3 August 1997, a landslide (GEO Incident No. K97/8/1) occurred on a soil/rock cut slope behind St. Joseph's Anglo Chinese School (hereafter referred to as St. Joseph's School), Kwun Tong Road, Ngau Tau Kok (Figure 1). The landslide involved the collapse of an old rubble face (stone pitching) and the soil behind. Debris from the landslide accumulated in a narrow walkway between the slope and the back of the school (Plate 1). No fatalities or injuries were reported.

Following the landslide, Halcrow Asia Partnership Ltd (the 1997 Landslip Investigation Consultants) carried out a detailed study of the failure for the Geotechnical Engineering Office (GEO), Civil Engineering Department (CED), under Agreement No. CE 68/96. This is one of a series of reports produced during the consultancy by Halcrow Asia Partnership Ltd (HAP).

The key objectives of the detailed study were to document the facts about the landslide, present relevant background information and establish the probable causes of the landslide. The scope of the study was limited to site reconnaissance, desk study and analysis. Recommendations for follow-up actions are reported separately.

This report presents the findings of the detailed study, which comprised the following key tasks :

- (a) a review of relevant documents relating to the history of the site,
- (b) analysis of rainfall records,
- (c) interviews with persons who witnessed or were involved in the incident,
- (d) detailed observations and measurements at the landslide site, and
- (e) diagnosis of the probable causes of the landslide.

2. THE SITE

2.1 Site Description

A location map is shown in Figure 1 and a detailed plan of the landslide is shown in Figure 2.

The landslide occurred on an 8 m-high southwest-facing cut slope (No. 11NE-A/C69) which is located at the northern corner of St. Joseph's School. The school occupies a platform below the slope and a Police Training College is located on the platform above. A 2 m-high masonry retaining wall, which supports the platform for the Police Training College is situated about 2 m behind the crest of the cut slope in the vicinity of the landslide. Kai Tak

Mansions occupy the neighbouring platform to the northwest of St. Joseph's School, below the same registered cut slope.

At the failure location the cut slope, which was inclined at about 65° to 70° to the horizontal, was formed mostly in slightly and moderately decomposed granite (Grade II & III) with 2 m to 3 m of highly decomposed granite (Grade IV) at the crest. An 8 m-long and 5 m-wide section of the slope was covered with rubble facing. The facing was formed of coarse dry-packed granite blocks with no weepholes (Plates 2 and 3). The slope, including the failed section, was heavily-vegetated. Parts of the slope behind the school were covered with chunam, which in places was in a poor condition.

Northwest of the failure, behind Kai Tak Mansions, the slope increases in height to about 17 m. Two berms divide the slope into three batters. The upper and middle batters are shotcreted and inclined at about 50° and 70° to the horizontal respectively. The lower section is bare rock, which stands at about 70° to 80° to the horizontal and is supported in places by concrete buttresses.

Behind St. Joseph's School, a 450 mm surface drainage U-channel directs water to the southeast along the crest of the slope in front of the masonry retaining wall. Site inspections by HAP in October 1997 and March 1998 noted that the drainage channel was partially blocked by a chamber housing a piezometer (Plate 4) and by soil and vegetation (Plate 5). Staff at the school reported that during heavy rainfall the U-channel often overflowed down the face of the slope.

Surface water run-off from the car park and grassed area at the southern corner of the upper platform drains southwest to a 450 mm concrete channel behind the masonry retaining wall. The channel was cracked in a number of places (Figure 2). The site inspection by HAP in March 1998 noted that the channel was partly blocked by vegetation causing localised ponding of water.

The masonry retaining wall was cracked at two locations (Figure 2). Immediately above the 1997 landslide site, there is a 1 mm- to 2 mm-wide open crack, the lower part of which had been partly covered over with shotcrete after the landslide (Plate 6). The second crack is located about 15 m along the wall from the failure (Plate 7). This crack is about 10 mm wide and the southeastern part of the wall had moved forward by about 10 mm. There is evidence of previous repairs to this crack.

The landslide was located on private land within the boundary of St. Joseph's School (Lot No. NKIL 6039) and the maintenance responsibility rests with the lot owners.

2.2 Site History

2.2.1 General

The history of the site was determined from a review of aerial photographs (Table 1), documentary records and information from GEO's landslide database. Information sources consulted during the study are summarised in Table 2.

2.2.2 History of Development

Aerial photographs taken in 1949 show that the southeastern end of the cut slope and the crest retaining wall had already been constructed and the surrounding area developed. The platform above the slope, constructed during the 1930's, was used for military accommodation. The area beneath the cut slope was divided into two lots. In the corner of the southeastern lot a small residential structure occupied the site of the present St. Joseph's School. In the northwestern lot there was a derelict structure on the site now occupied by Kai Tak Mansions.

By late 1963, additional buildings had been added to the lower platform to form St. Joseph's School. The northwestern end of the slope had been further excavated by about 6 m to form a single level platform upon which Kai Tak Mansions were constructed. Two berms had been added to the chunam-covered slope behind Kai Tak Mansions. No change was visible to the densely-vegetated part of the slope behind the school.

Photographs taken during 1985 show that one of the original buildings of St. Joseph's School was constructed directly against the lower 2 m to 3 m of the slope (Plate 8). The upper two thirds of the slope above the building was covered by a rubble facing. The surrounding cut slope was partly covered by chunam.

By early 1986, as part of the construction of a new eight-storey school building, the original St. Joseph's School buildings were demolished. The toe the slope below the rubble facing was excavated during construction of the new school foundations in November 1986 (Plate 9). After construction of the new school building the level of the platform at the base of the slope was raised by about 2.5 m with mass concrete infill between the lowest two floors of the school and the slope. At this time, the slope on either side of the rubble facing was sealed with additional chunam (Plate 3). To provide space for vehicular access to the school, a contiguous cantilever caisson wall was constructed at the southeastern end of the cut slope (Figure 3 and Plate 9). Construction of the new school was completed by mid-1988. The aerial photographs show no evidence of major works on the slope behind the school between 1988 and 1997.

Default works on the cut slope behind Kai Tak Mansions commenced in early 1996 (Section 2.3.3) and were completed by June 1996.

2.2.3 Previous Landslides

According to GEO's landslide database, three previous landslide incidents (Nos. K89/5/141, K95/7/1 and K92/5/2) have been reported on the northwestern part of cut slope No. 11NE-A/C69 (Figure 3). Incident No. K89/5/141 involved about 35 m³ of slip debris and was recorded in GEO's Incident Report to have been attributed to washout and infiltration. Incident No. K95/7/1 involved about 3 to 5 m³ of weathered granite rock and was recorded in GEO's Incident Report to have been attributed to infiltration and insufficient maintenance. Incident No. K92/5/2, caused by infiltration according to GEO's Incident Report, occurred behind Block C of Kai Tak Mansions and was less than 2 m³ in volume.

Photographic and other documentary records provide evidence of three further failures. A failure scar approximately 6 m by 12 m towards the base of the slope behind Block D of Kai Tak Mansions was noted on aerial photographs dated December 1975 (Figure 3). A report by Maunsell Geotechnical Services (MGS, 1985) refers to a small failure that occurred behind the school sometime between 1975 and 1977. The failure was reported to have occurred "at the bottom part of the slope about 8 to 10 years ago. A rock overhang was left there and hence two I-beam/concrete composite columns have been cast to support the overhang. No further instability has been reported either before or since then." The exact location of this failure is not known.

In the MGS report, there is no reference to the rubble facing at the location of the 1997 landslide. It would appear that the rubble facing was concave prior to failure, since the Stage 1 Study Report by GCO (1990) describes "A concavity covered by dry packed rubble masonry face was also found on the rock slope behind the NW corner of the School". The presence of a concavity would suggest that the rubble facing was probably constructed to repair a previous failure.

2.3 Previous Studies and Assessments

2.3.1 Slope Registration and Stage 1 Study

The cut slope (No. 11NE-A/C69) was registered in the 1977/78 Catalogue of Slopes by consultants engaged by the Government to prepare the catalogue.

The first recorded inspection of the slope was carried out by Binnie and Partners Limited (B & P, 1977) in May 1977. Signs of seepage were noted and recorded as "Fe-staining of rock joints" but no signs of distress were noted.

In 1990 a Stage 1 Study was carried out by the Planning Division of the Geotechnical Control Office (GCO) for Slope No. 11NE-A/C69 (GCO, 1990). The Study considered the slope behind Kai Tak Mansions but did not include the slope behind the school because "the stability of the southeastern portion of the feature (behind St. Joseph's School) had been checked and approved by BOO." Stability analyses were carried out for the critical section behind Kai Tak Mansions. Shear strength parameters of $c' = 7$ to 10 kPa and $\phi' = 37^\circ$ to 39° were adopted for the "partially weathered granite with 0 – 30% rock content." The report stated that "Kinematic stability analysis and field inspection indicate that in general, the rock section of the slope is stable and satisfactory." It also concluded, "the soil slope possesses inadequate factors of safety under the current GCO standard." On the recommendation of the GCO, the Buildings Ordinance Office (BOO) served a DH Order on the owners of Kai Tak Mansions in July 1991.

In 1992, the GEO initiated the consultancy agreement entitled "Systematic Inspection of Features in the Territory" (SIFT) which, inter alia, aims to identify features not registered in the 1977/78 Catalogue of Slopes and update information on registered slopes based on studies of aerial photographs and limited site inspection. In January 1993, the SIFT study confirmed that the slope was a cut slope of registerable status (GEO, 1994).

In 1994, the GEO initiated the consultancy agreement entitled "Systematic Identification and Registration of Slopes in the Territory" (SIRST) to update the 1977/78 Catalogue of Slopes and to prepare the New Catalogue of Slopes. Default works were in progress on the adjacent part of the slope behind Kai Tak Mansions in 1996 and a "work in progress" (WIP) status was assigned to the work. The slope was subsequently included in a review of previous WIP features and a field inspection was carried out in June 1998.

2.3.2 Redevelopment of St. Joseph's School

In 1985, prior to the redevelopment of the school, MGS carried out an investigation and stability assessment of the slope behind the school. The shear strength parameters, obtained by back analysis of a section about 30 m to the southeast of the 1997 landslide, were $c' = 17$ kPa and $\phi' = 42^\circ$ for Grade IV/V material.

A contiguous cantilevered caisson wall was constructed along the eastern boundary of the site to provide space for vehicular access to the school from Choi Shek Lane (Figure 3). It would appear that only minor trimming and chunam repairs were considered necessary for the rest of the slope.

2.3.3 Action on Slope behind Kai Tak Mansions

Following the inspection by B & P (Section 2.3.1), an Advisory Letter was issued by the BOO in April 1978 to request the owners of Kai Tak Mansions to carry out maintenance works. A 'Type 2' Advisory Letter was served on the owners of Kai Tak Mansions on 22 June 1989 following landslide incident No. K89/5/141.

Following the DH Order served in July 1991 (Section 2.3.1) which was subsequently defaulted, Greg Wong & Associates were engaged by the Buildings Department to investigate the slope behind Kai Tak Mansions and design the upgrading works. The design groundwater level was taken at 1 m above bedrock and the shear strength parameters adopted were as follows:

completely decomposed granite	$c' = 6$ kPa and $\phi' = 39^\circ$, and
highly decomposed granite	$c' = 8$ kPa and $\phi' = 39^\circ$.

The upgrading works included cutting back and shotcreting of the soil cut slope together with the construction of a number of buttresses to the rock slope below. These works were completed by June 1996.

2.4 Subsurface Conditions

Sheet 11 of the Hong Kong Geological Survey 1:20 000-scale Map Series (GCO, 1986) and Geological Memoir No. 2 (Strange and Shaw, 1986) indicate that the site is predominantly underlain by fine-grained granite. The geology however may be more variable as nearby boreholes and geological mapping indicate that the granite is generally fine- to medium-grained and occasionally coarse-grained.

The locations of exploratory holes and a trial pit carried out prior to redevelopment of the school are shown in Figure 3. A review of the borehole records indicates that the top of the moderately to slightly decomposed granite bedrock dips towards the southwest, approximately following the pre-development contours of the original natural terrain.

A geological section specific to the location of the landslide (Figure 4) was prepared using information from borehole D1 and the report by MGS (1985). Borehole D1, located on the berm immediately upslope of the landslide, encountered about 2 m of highly decomposed granite, described as very dense pinkish yellowish brown silty sand with relict structure. Below this about 4 m of moderately decomposed granite with bands of highly decomposed rock was proved. The former, possibly corestones, was described as weak to moderately strong yellowish brown coarse-grained moderately decomposed granite. Between 5.7 m and 12 m below the berm, moderately to slightly decomposed granite was encountered. This material was described as strong mottled light grey and pink medium-grained closely to widely jointed slightly to moderately decomposed granite. The thickness of completely decomposed granite and highly decomposed granite increases to the northwest and southeast of borehole D1, possibly reflecting the differential weathering profile of the spur through which the slope was excavated.

Four distinct joint sets were recognised on the rock face (GCO, 1990). Two sets dip at about 70° and 80° respectively and daylight in the rock face. One joint set strikes almost parallel to the trend of the slope and dips moderately into the slope face. The fourth set is steeply inclined and its strike intercepts the slope at an oblique angle. In general, the joints were found to be tight, medium-spaced, smooth to rough and stepped with a persistence of more than 2 m. During an inspection by HAP on 13 March 1998 it was observed that some of the daylighting joints behind St. Joseph's School were open, as a result of tree root penetration.

Piezometers and standpipes were installed in both the superficial deposits and bedrock in boreholes D1 to D3, D5 and D6. The maximum water level measured between 12 and 31 August 1985 was about 13 mPD (MGS, 1985). The piezometer installed in borehole D1 was monitored on 11 June 1998, 2 days after a Black Rainstorm, and a water level of 14.1 mPD was recorded (Figure 4).

3. THE LANDSLIDE

3.1 Time of Failure

There were no eye-witnesses to the landslide but a member of staff, who was on the upper floor of the school, recalled hearing a loud noise from behind the school at about 02:00 hours on 3 August 1997. The school caretaker discovered the failure the next morning. The time of the failure is therefore taken to be 02:00 hours on 3 August 1997.

3.2 Description of the Landslide

A detailed plan of the landslide is shown in Figure 2 and a representative section through the landslide is presented in Figure 4. Photographs of the failure are shown in Plates 1 and 10.

The landslide affected almost the full height of the cut slope. The main scarp was about 8 m long and 5 m wide. It was difficult to assess the depth of the landslide since the urgent repair works had already been completed by the Buildings Department before HAP inspected the site. Nevertheless the volume of the failed material was estimated to be about 25 m³.

The failure involved the collapse of the rubble facing covering a concavity within the slope. The failure surface extended from the U-channel on the crest to close to the toe of the slope. The main scarp, which was inclined at about 50° to 60° to the horizontal, exposed about 2 m of highly to completely decomposed granite at the crest whilst the remaining section of the scarp was obscured by dense vegetation (Plate 10). Although the northwest flank of the main scarp was concave, the southeast flank was generally planar, with a similar orientation to one of the major joint sets (dip/dip direction of 81°/293°). The granite blocks present within the debris were generally less than 400 mm thick. The location and shallow profile of the landslide together with the composition of the debris indicate that it was primarily the rubble facing that failed.

The debris was deposited on the 4 m-wide yard at the back of the school and accumulated against the wall at the back of the school to a maximum height of about 1.5 m. It consisted of rubble blocks, weathered granite, chunam and vegetation. The travel angle of the debris could not be established because the debris was obstructed by the wall.

Following the landslide, the GEO recommended trimming the loose material from the failure scar, applying shotcrete cover and reconstructing the damaged surface U-channel at the crest of the slope. Plate 11 shows the slope after completion of the urgent repair works by the Buildings Department.

4. RAINFALL

The nearest GEO automatic raingauge No. K04 is located at Lee Cheung House, Shun Lee Estate, Lee On Road, about 1.5 km to the east of the site of the landslide. The daily rainfall recorded in July and early August 1997 and the clock hourly rainfall from 31 July 1997 to 3 August 1997 are shown in Figure 5. Figure 5a shows that the early August rainstorm associated with the landslide followed two periods of significantly wet weather in July. If the reported time of failure of 02:00 hours on 3 August 1997 is correct, the landslide occurred sometime after the peak of the rainstorm (Figure 5b). The isohyets of rainfall prior to the landslide are shown in Figure 6.

The estimated return periods of the maximum rolling rainfall for selected durations based on historical rainfall data at the Hong Kong Observatory (Lam & Leung, 1994) are

presented in Table 3. Return periods for the rainstorm were in the range of only one to three years.

5. PROBABLE CAUSES OF FAILURE

The close correlation between the rainstorm on 2 and 3 August 1997 and the time of the landslide indicates that the landslide was probably triggered by rainfall.

Based on site observations, there is no evidence of the failure being triggered by a significant rise in groundwater. Limited piezometric monitoring records also suggest that the groundwater table was below the toe of the slope.

The most likely source of water ingress was overflow from the blocked U-channel at the crest of the slope, due in part to the presence of a piezometer chamber and lack of maintenance. This would have led to surface infiltration through the crest area and open joints in the facing blocks. This is consistent with eye-witness reports of water flow down the face of the slope during periods of heavy rainfall (see Section 2.1). The infiltration probably resulted in saturation of the near-surface soils and the build-up of water pressure behind the facing, in turn leading to the failure.

6. DISCUSSION

The 1997 failure occurred on a slope that had previously been subjected to a detailed stability assessment in the mid-1980's based on site-specific ground investigation and laboratory testing.

The slope has a history of past failures and the 1997 landslide was a local failure involving the rubble facing close to the northern corner of St. Joseph's School. This part of the slope was possibly the location of past instability. It would appear that the rubble facing and the possible past failure at that location were not referred to and considered in the previous detailed assessment.

The 1997 landslide occurred during a rainstorm that was not particularly heavy. The fact that the slope had previously been exposed to more severe rainstorms without failure suggests that deterioration of the rubble facing and lack of slope maintenance might have been relevant factors in the failure.

7. CONCLUSIONS

It is concluded that the landslide behind St Joseph's School on 3 August 1997 was triggered by rainfall. The failure occurred on a cut slope that had previously been subjected to a detailed stability assessment, based on site specific ground investigation and laboratory testing.

The probable cause of the local failure was saturation of the near-surface soils and the build-up of water pressure behind the rubble facing, which was probably constructed to repair a previous failure.

The landslide occurred during a rainstorm that was not particularly heavy. This suggests that lack of maintenance and deterioration of the rubble facing may also have been relevant factors in the failure.

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Table 1 – Summary of Aerial Photograph Interpretation (Sheet 1 of 3)

Year	Photographic Reference No.	Altitude	Observations
1949	Y01749/50	8000 ft	Slope No. 11NE-A/C69, the retaining wall and platforms above and below are already constructed. The RAF Officer Accommodation is already constructed on the upper platform. A derelict structure occupies the site of Kai Tak Mansions, three 1.5 m to 2.0 m high retaining walls form a terrace from the toe of the slope to Kwun Tong Road. A small residential building occupies the lower platform to the southeast, a single 2 m to 3 m high retaining wall forms the front of the site. The two sites are divided by a northwest-facing retaining wall, ranging in height from about 2 m to 5 m. The slope is densely vegetated.
1963	Y07988/89	2700 ft	A number of extensions have been added to the building on the southeast of the lower platform, the back of these structures appear to be either built against or very close to the slope. Surface drainage can be seen leading to a stepped channel to the east of the slope. The part of the slope behind the school remains densely vegetated. The slope to the northwest had been deepened by about 6 m and the terraces in front removed to form a single level platform upon which Kai Tak Mansions was constructed. The natural hillside above shows extensive erosion and gullyng.
1967	Y13408/09	4000 ft	Cut slope (No.11NE-A/C70) formed to the east of the slope. Slope behind Kai Tak Mansions densely vegetated.
1968	Y14312	4000 ft	Ping Shek Estate under construction to the west of the site.
1969	Y14987	4000 ft	No apparent change.
1973	5254/55	5000 ft	Construction of a large cut platform upslope of the site for the Ping Shek Temporary Housing commenced. Widening work ongoing at Choi Shek Lane.
1974	10186/87	4000 ft	Construction of Ping Shek Temporary Housing ongoing. Kwun Tong road extension commenced, construction of a footbridge across Kwun Tong is ongoing.

Table 1 – Summary of Aerial Photograph Interpretation (Sheet 2 of 3)

Year	Photographic Reference No.	Altitude (ft.)	Observations
1975	11484/85	2000 ft	Small shallow failure behind block D of Kai Tak Mansions noted (Close to and similar in size to the 1997 failure).
1976	15362/63	4000 ft	Construction of Ping Shek Temporary Housing completed.
1978	24118/19	4000 ft	The vegetation on the slope behind the school has been partially cleared and the slope either shotcreted or chunam covered.
1979	27303/04	4000 ft	No visible change.
1980	30125/26	4000 ft	No visible change.
1984	53983/84	4000 ft	No visible change.
1984	56954/55	4000 ft	Vegetation cleared from slope behind the school. At the southeast end of slope, by Choi Shek Lane, a new cut slope has been excavated.
1986	A04342/43	4000 ft	School buildings are being demolished.
1987	A08683/84	4000 ft	Excavation underway at the southeast end of the slope, staircase under construction. New school building under construction.
1988	A12831/32	4000 ft	Construction of new school building completed.
1989	A16805/06	4000 ft	No visible change.
1990	A24897/98	4000 ft	What appears to be a shotcreted failure scar is visible on the west end of the slope, behind block A of Kai Tak Mansions.
1991	A27475/76	4000 ft	No visible change.
1992	A32812/13	4000 ft	Possible small failures visible at northwest end of slope, the same location as the 1990 failure, and behind the Police Training College.
1993	A35576/76	4000 ft	No visible change.
1993	CN4606/07	4000 ft	Slope densely vegetated
1995	CN11305/06	3500 ft	Fire damage of the vegetation on the slope visible. Ping Shek Temporary Housing is in the process of being demolished.

Table 1 – Summary of Aerial Photograph Interpretation (Sheet 3 of 3)

Year	Photographic Reference No.	Altitude (ft.)	Observations
1996	CN15731/32	5000 ft	On the part of the slope behind Kai Tak Mansions the vegetation has been removed and the slope shotcreted and buttresses have been added to the lower section of the slope. The part of the slope behind the school, no work has been carried out.
1997	CN17238/39	4000 ft	No visible change.

Table 2 – Summary of Information Sources (Sheet 1 of 2)

Information Source	References	Principal Relevant Contents/Comments
GEO Mainland East Division	File No. GCMd 5/3/12	Relating to the redevelopment of St. Joseph's School
	File No. DH 275/77/K	Relating to the maintenance responsibility of slope No. 11NE-A/C69
	File No. GCME 2/E1/11 NE-A/C69	Relating to the maintenance and action on slope No. 11NE-A/C69 behind Kai Tak Mansions
	File No. GCME DH349/73/K	Correspondence between GEO, BD and the Director of Education with reference to the maintenance of the retaining wall supporting the platform for the Police Training College
	File No. GCME 2/E2/97-1/K	Instructions for urgent repair works to slope No. 11NE-A/C69 behind St. Joseph's School
	File No. GCMd 3/5/6/4014/84	Construction records for the redevelopment of St. Joseph's School
	File No. GCME 3/5/DH 275/77 part II	(a) Relating to the issuance of 'D' Notice for slope No. 11NE-A/C69 (b) Greg Wong & Associates Ltd. - Preliminary Investigation Report of the Slope Stability at 53,53A, 55 & 55A Kwun Tong Road, Kowloon
GEO Design Division	Report No. 15200	Reconstruction of St. Joseph's Primary School at N.K.I.L 5112 Kwun Tong Report by Maunsell Geotechnical Services dated November 1985
	Report No. 15201	Report on Redevelopment of Anglo - Chinese School by Maunsell Geotechnical Services dated December 1985
	Fill Slope / Cut Slope Master Lists, LPM Quarterly Reports and Stage 1 and 2 Study Registers	Status of slope

Table 2 – Summary of Information Sources (Sheet 2 of 2)

Information Source	References	Principal Relevant Contents/Comments
GEO Planning Division	Natural Terrain Landslide Inventory	No natural terrain landslides identified in the area
	Phase 2 SIFT Pilot Study Map Sheet Report 1:1 000 Map Sheet Number 11NE-12A	General Information
	Stage 1 Study Report Cut Slope No. 11NE-A/C69 Ngau Tau Kok North of Kwun Tong Road and South of RAF Area	Completed 1990 – Recommended that 'D' Notice should be served on that part of slope No. 11NE-A/C69 behind Kai Tak Mansions
GEO Slope Safety Division	SIRST Report for Slope No.11NE-A/C69 (In preparation)	SIRST field inspection was carried out in June 1998
Published Reports and Documents	Geotechnical Area Studies Programme- GASP Report No. 1 Hong Kong and Kowloon.	Background geological and geotechnical information
	Hong Kong Geological Survey Memoir No. 2 Geology of Hong Kong Island and Kowloon	
	Hong Kong Geological Survey Sheet No.11 Hong Kong and Kowloon	

Table 3 – Maximum Rolling Rainfall at GEO Raingauge No. K04 for Selected Durations Preceding the 3 August 1997 Landslide and The Corresponding Estimated Return Periods

Duration	Maximum Rolling Rainfall (mm)	End of Period	Estimated Return Period (Years)
5 minutes	4.5	16:00 hours on 2 August 1997	1
15 minutes	10	20:10 hours on 2 August 1997	1
1 hour	25	20:15 hours on 2 August 1997	1
2 hours	34.5	11:00 hours on 2 August 1997	1
4 hours	56	13:00 hours on 2 August 1997	1
12 hours	133	21:00 hours on 2 August 1997	1
24 hours	164.5	02:00 hours on 3 August 1997	1
2 days	222.5	02:00 hours on 3 August 1997	2
4 days	233	02:00 hours on 3 August 1997	1
7 days	233	02:00 hours on 3 August 1997	1
15 days	312	00:00 hours on 3 August 1997	1
31 days	716	02:00 hours on 3 August 1997	3
<p>Notes: (1) Return periods were derived from the Gumbel equation and data published in Table 3 of Lam & Leung (1994).</p> <p>(2) Maximum rolling rainfall was calculated from 5 minute data for durations of up to 1 hour and from hourly data for longer rainfall durations.</p>			

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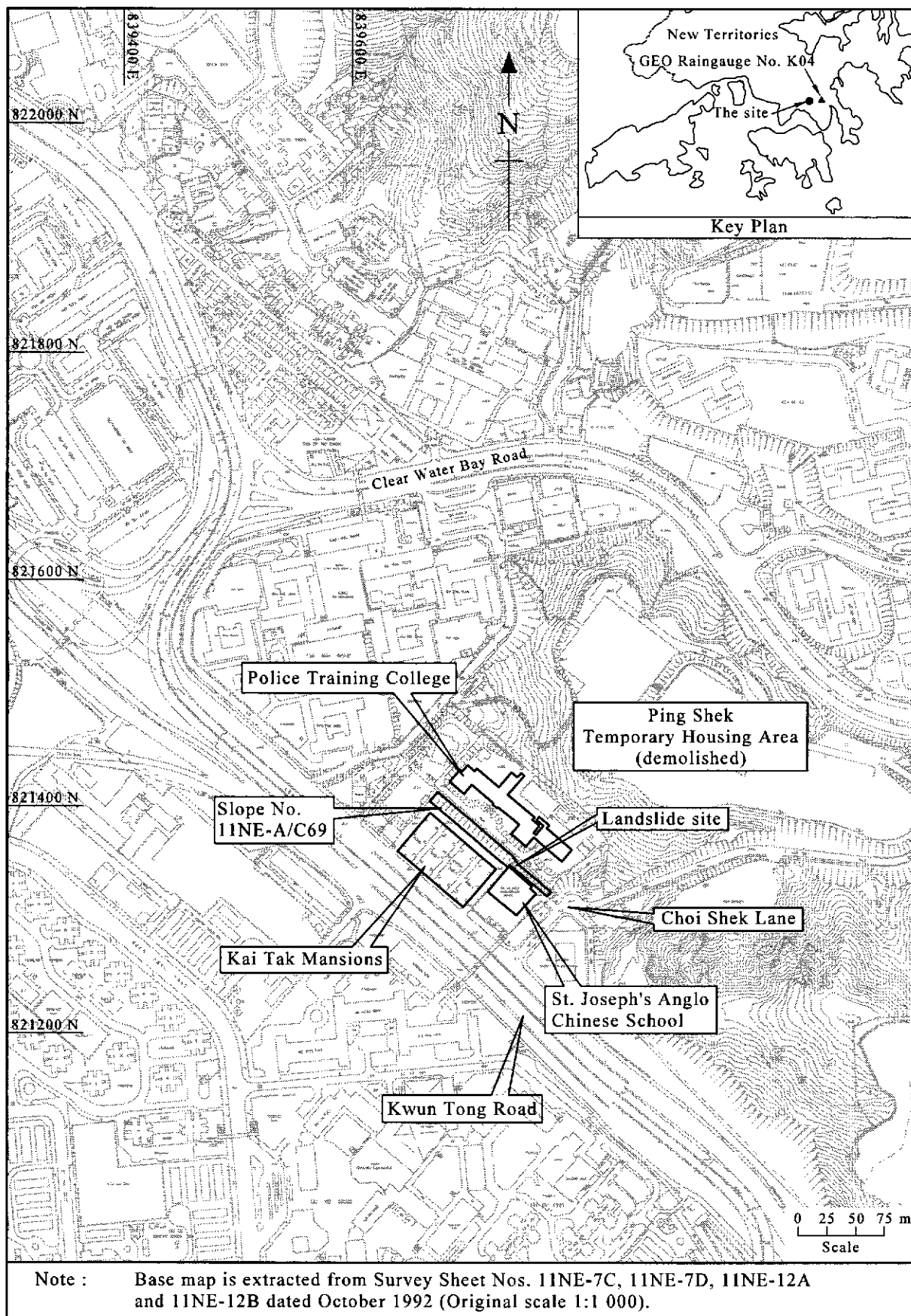


Figure 1 - Site Location Plan

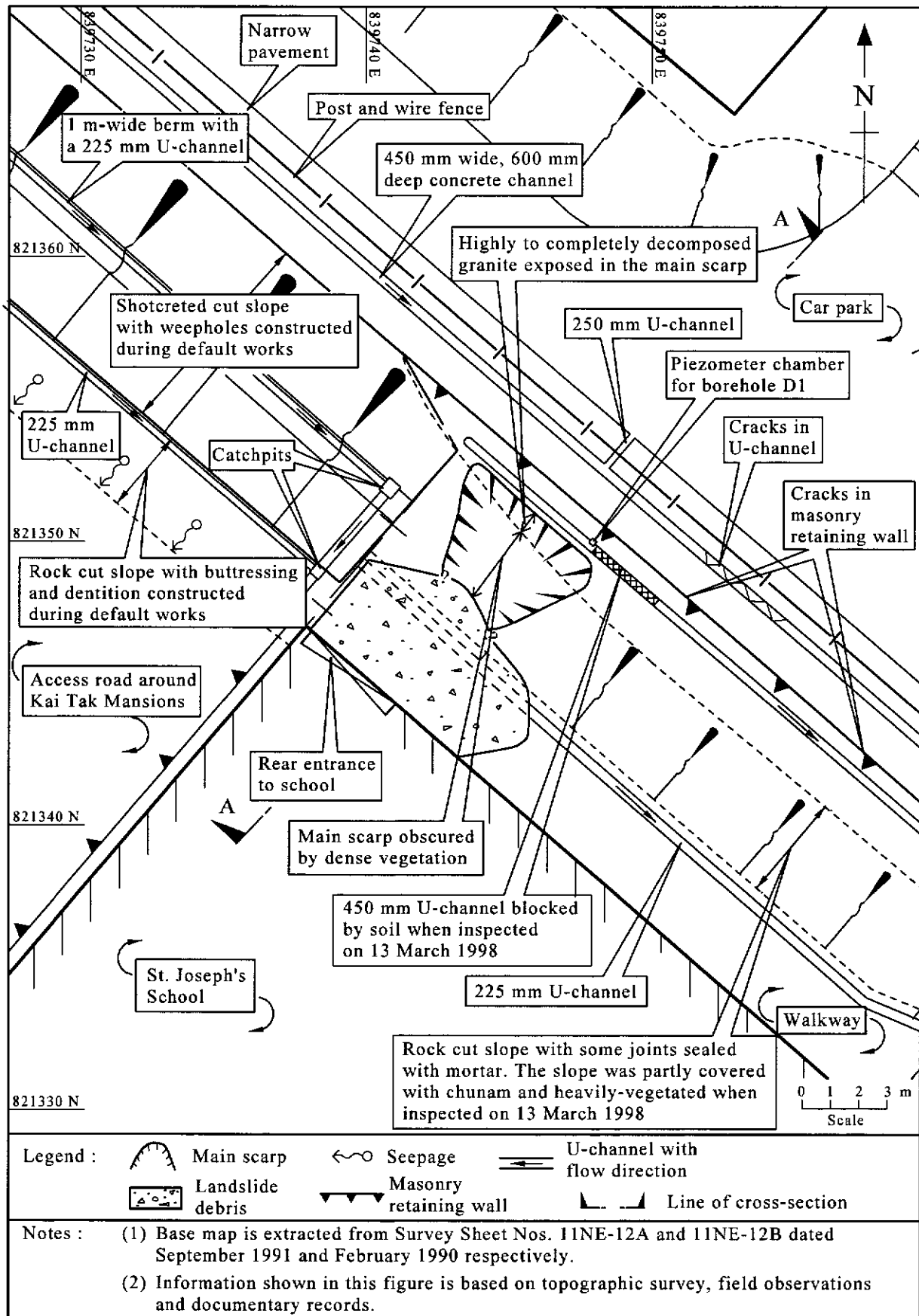


Figure 2 - Plan of the Landslide Site

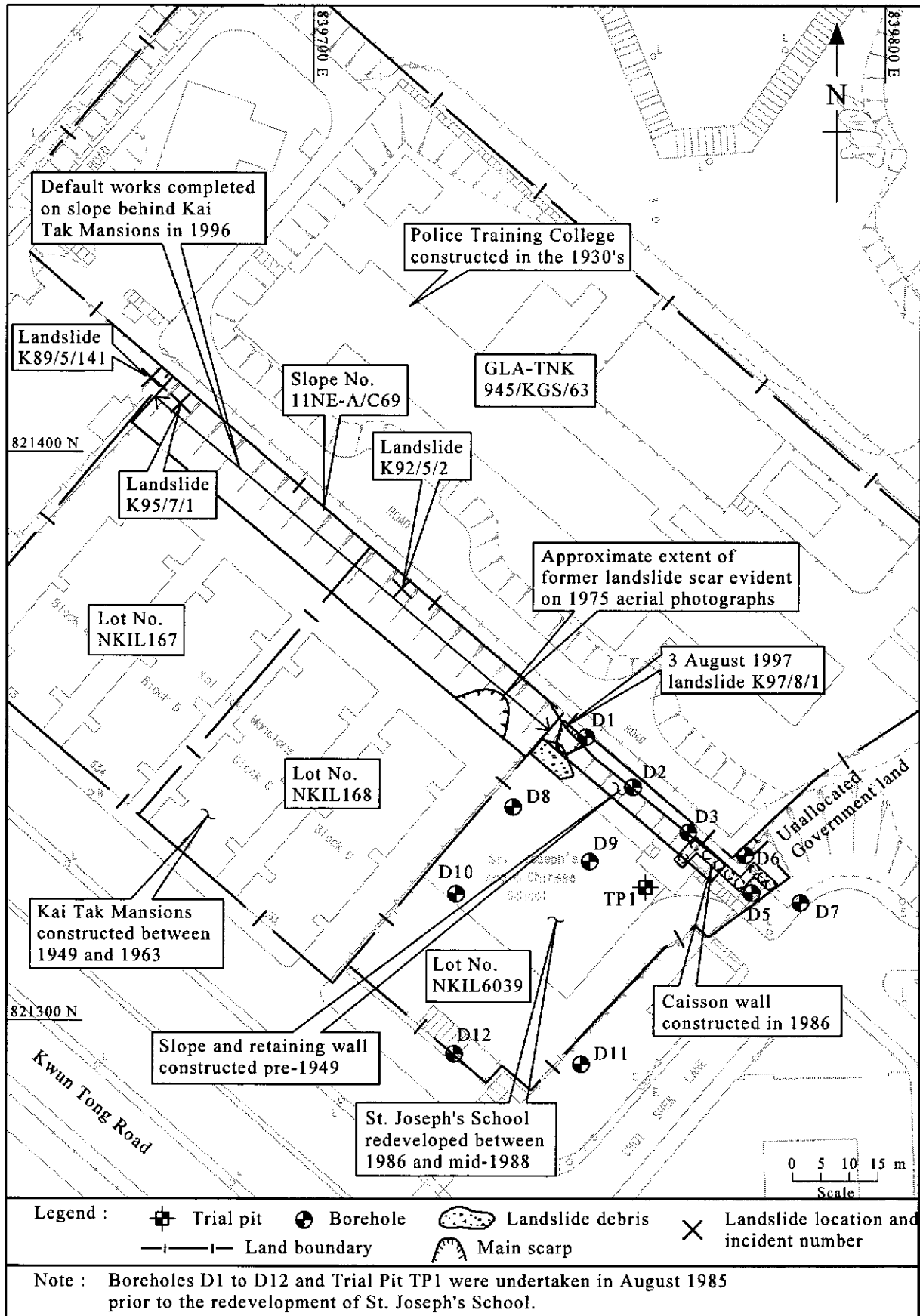


Figure 3 - Land Status and History of Development

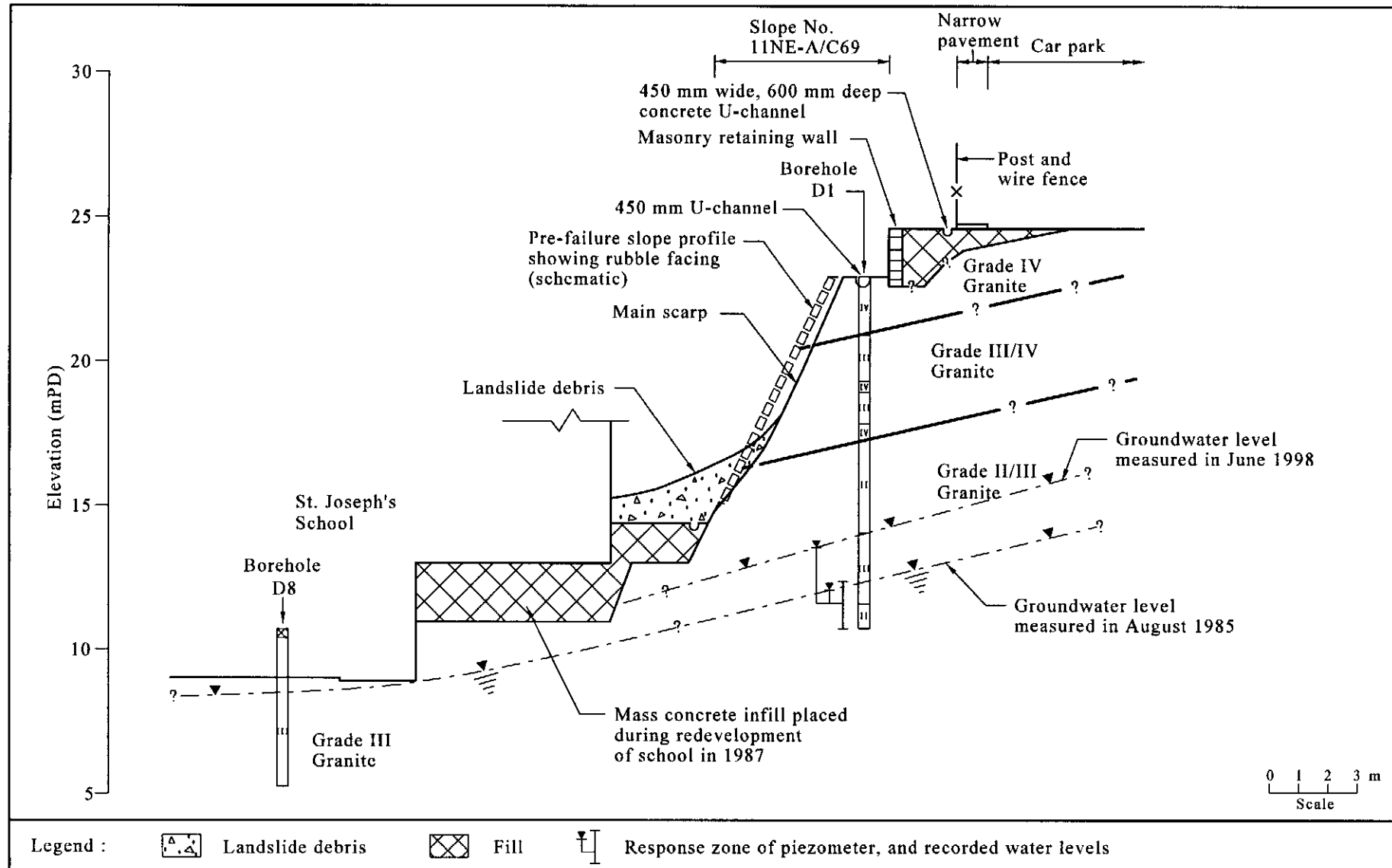
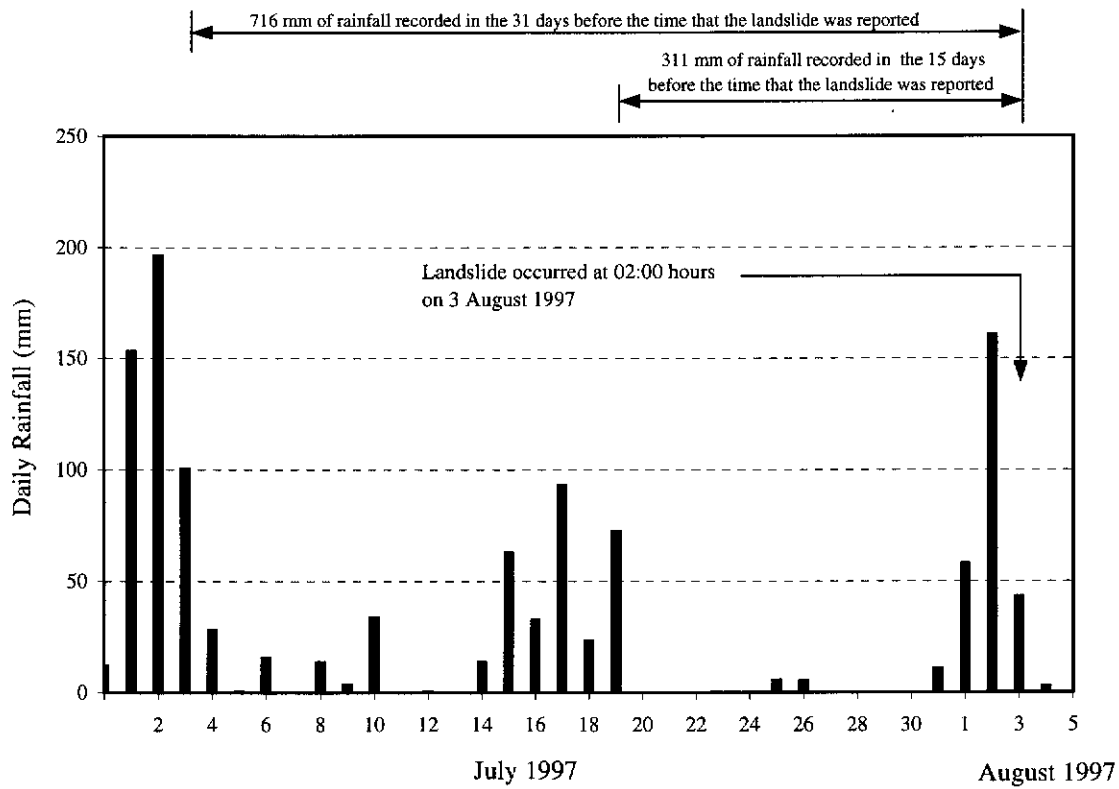
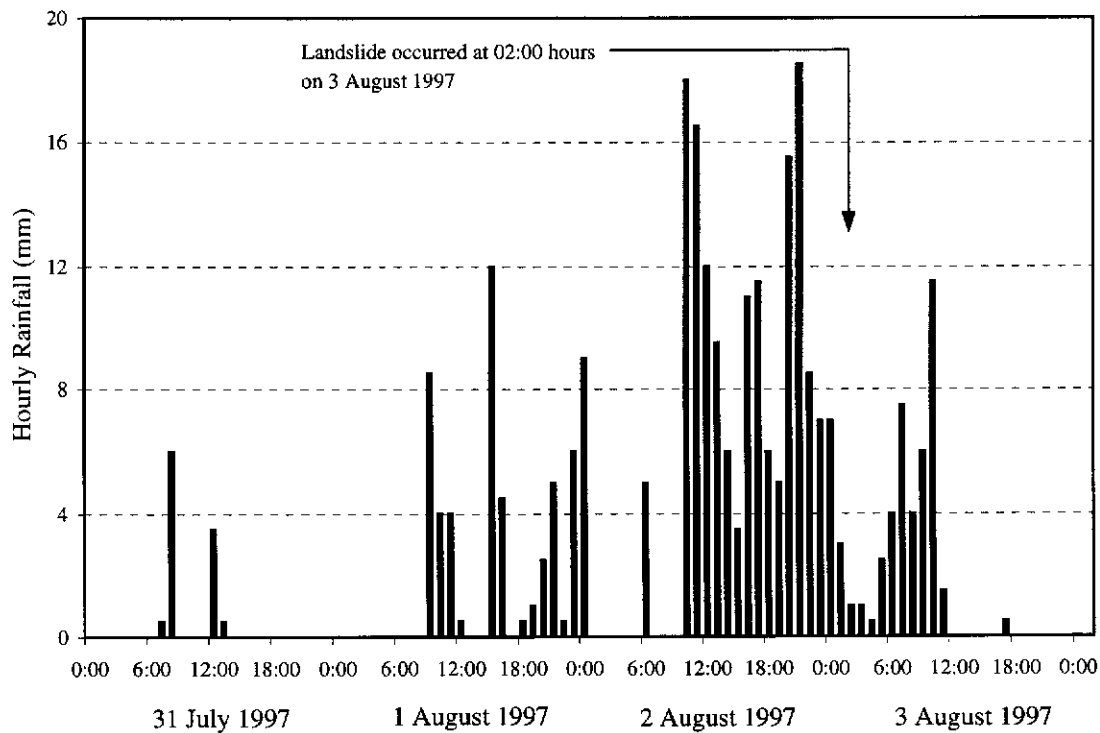


Figure 4 - Geological Cross-section A-A through the Landslide



(a) Daily Rainfall Recorded between 1 July and 5 August 1997



(b) Hourly Rainfall Recorded between 31 July and 3 August 1997

Figure 5 - Rainfall Recorded at GEO Raingauge No. K04

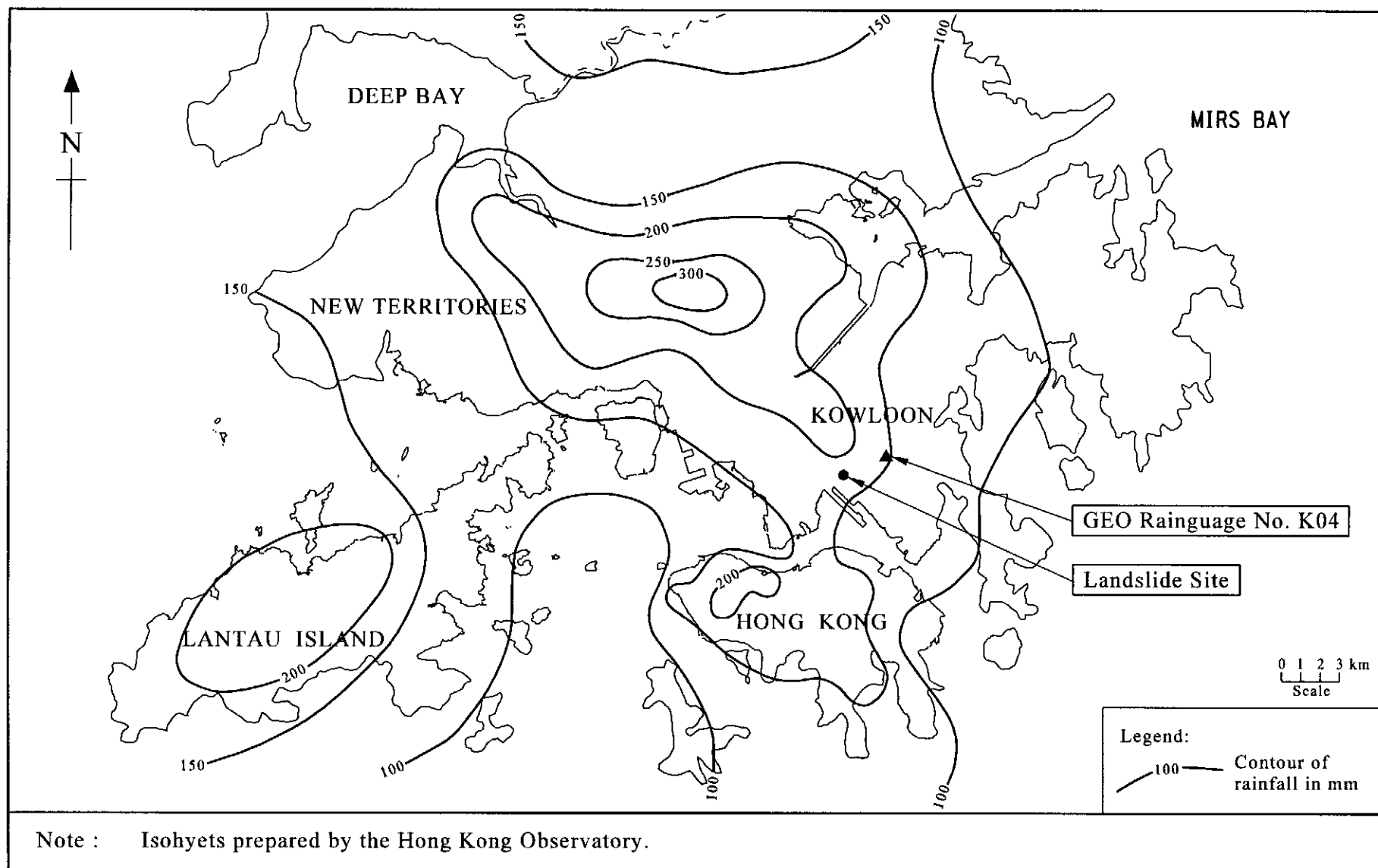


Figure 6 - Isohyets of Rainfall between 09:00 Hours on 2 August 1997 and 02:00 Hours on 3 August 1997

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Plate 1 - Landslide Debris between the Slope and School Wall
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Plate 2 - View of the Rubble Facing before Redevelopment of
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Plate 3 - View of the Rubble Facing during the Redevelopment of St. Joseph's School (Photograph Taken on 20 July 1987)



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