SECTION 2: DETAILED STUDY OF THE LANDSLIDE BEHIND BLOCKS 3 AND 4 WONDERLAND VILLAS, KWAI CHUNG ON 8 MAY 1997

Halcrow Asia Partnership Ltd

This report was originally produced in May 1998 as GEO Landslide Study Report No. LSR 11/98

FOREWORD

This report presents the findings of a detailed study of a landslide (GEO Incident No. MW97/5/1) that occurred at the crest of the natural hillside south of Blocks 3 and 4, Wonderland Villas, Kwai Chung. In the morning of 8 May 1997, debris from the landslide travelled down the slope and partly blocked the south-bound lane of Wah King Hill Road. 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 is generally limited to site reconnaissance, desk study and analysis. Recommendations for follow-up actions are reported separately.

This 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. It is one of a series of detailed study reports produced during the consultancy by Halcrow Asia Partnership Limited (HAP).

G. Daughton
Project Director/Halcrow Asia Partnership Ltd.

CONTENTS

1. INTRODUCTION

On the morning of 8 May 1997, a landslide occurred at the crest of a natural hillside below Wonderland Villas, Kwai Chung (Figure 1). Landslide debris travelled about 200 m downslope onto Wah King Hill Road and partly blocked the south-bound lane. The failure caused superficial damage to a roadside cut slope (No. 11NW-A/C33) and disruption to traffic on Wah King Hill Road.

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

The key objectives of the 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.

This report presents the findings of the detailed study, carried out between May 1997 and May 1998, which comprised the following key tasks:

(a) a review of all known relevant documents relating to the history of the site,

(b) analysis of rainfall records,

(c) interviews with witnesses to the landslide,

(d) detailed observations and measurements at the landslide site,

(e) theoretical stability analysis of the failure, and

(f) diagnosis of the probable causes of the failure.

2. THE SITE

2.1 Site Description

The location of the landslide is shown in Figure 2. The failure occurred at the crest of a natural hillside at approximately 220 mPD, behind Blocks 3 and 4 Wonderland Villas, Kwai Chung and above Wah King Hill Road. The failure comprised a detachment scar at the slope crest with a run out track (Plate 1). A drainage line intercepted the run out track at about 150 mPD and diverted the landslide debris onto cut slope No. 11NW-A/C33 and then onto Wah King Hill Road.

The natural hillside at the location of the landslide has a total height of about 120 m.

The general slope profile along the failure track was planar with an inclination of between 33° and 35°. At the location of the detachment scar the slope profile was slightly concave with an inclination of up to 40°. In plan, the detachment scar was located within a topographical depression, which appears to be the head of a poorly developed drainage line (Figure 2). The natural hillside has a dense vegetation cover of low shrubs and trees (Plate 1).

The rear gardens of Wonderland Villas, some 10 m to 20 m wide, separate the residential blocks from the natural hillside (Figure 2). The general fall of the gardens was towards the south with a slight local depression in the ground at the location above the detachment scar. A small earth bund, present along most of the western edge of the garden strip, prevents surface water run off from reaching the natural hillside. Such a bund was absent at the location of the landslide. No surface drainage channels are present along the crest of the hillside.

The natural hillside to the north and south of the landslide was drained by several drainage lines which discharge into the existing drainage systems along Wah King Hill Road (Figure 2).

The landslide occurred within unallocated Government land.

2.2 Site History

The site history (Table 1) was determined from interpretation of a sequential series of aerial photographs and a review of available documentary records.

The earliest available aerial photographs, taken in 1963, show the site of Wonderland Villas as natural hillside, with a north-south oriented ridge line that was heavily eroded and denuded of vegetation. Castle Peak Road crossed the lower hillside about 100 m to the west of the ridge.

The site of the 1997 failure was located at the head of a poorly defined drainage line below the ridge. The drainage line, like much of the hillside, was covered with low shrub vegetation. From the 1963 aerial photographs, no previous instability is evident in the vicinity of the recent failure, though within the drainage lines to the north numerous relict landslide scars are present (Figure 1).

In 1972, development was taking place on the lower hillside with the construction of Wah King Hill Road and associated cuttings and earthworks for Wah Yuen Chuen Estate (Figure 1). Construction of the Wonderland Villas development had not yet commenced.

By 1976, the construction of the Wonderland Villas platform was complete. The platform was formed in cutting and the aerial photographs indicate no readily observable fill material having been placed on the slope at the location of the 1997 landslide. Platform drainage was facilitated by outfalls positioned along the western side of the platform that discharged into the head of the natural drainage lines. A bund was also constructed along the western edge of the platform and this, in part, is still present today. By 1984, building of the residential blocks of Wonderland Villas was underway and the construction was completed by 1986.

A review of the GEO landslide incident records shows that there is one previous reported landslide (Incident No. MW93/5/16) within the vicinity of the 1997 failure. The 1993 landslide occurred at the head of a drainage line, some 50 m to the north of the 1997 failure (Figure 1), and was classified as a wash out of fill material with a volume of 10 m^3. The GEO's Natural Terrain Landslide Inventory identified a minor failure which occurred in 1981 within a drainage line on the hillside some 270 m to the north of the 1997 failure (Figure 1).

The natural hillside that failed in 1997 is not included in the GEO's New Catalogue of Slopes as it does not satisfy the registration criteria in that it is not a "sizeable man-made feature".

2.3 Previous Studies

A review of previous studies and reports covering the site was undertaken. Ground investigation information is available for several phases of the Wonderland Villas development from 1980 onwards (Freeman Fox and Partners (FFP), 1980a). The locations of boreholes in the vicinity of the 1997 landslide are shown in Figure 2. The ground investigation information indicated that generally thin colluvial deposits covered the site and were underlain by fine- to coarse-grained weathered granite.

As part of the design of the Wonderland Villas development, the developer appointed consultants FFP to carry out a geotechnical appraisal of the ground conditions beneath the development site. This included an investigation of the long-term stability of the slopes surrounding the development. In 1980, FFP produced a geotechnical study report and stability report for the development site. In the stability report, FFP (1980b) stated "The factor of safety of the existing natural slopes along the western site boundary, were considered adequate and the slopes are considered stable". The reports were subsequently submitted to the Geotechnical Control Office (GCO) for checking.

In 1982, in response to GCO's comments, FFP submitted a revised geotechnical assessment. The revisions included some modification to soil parameters and more detailed stability analyses along sections of the site boundary. The stability analysis for the slope behind Block 3 (see cross-section 1-1 on Figure 2 and Appendix A) indicated a factor of safety of 1.29. The stability analysis examined the possibility of shear failure above rockhead. The analysis adopted a "1 in 1000 years storm" to determine the water table with shear strengths parameters for completely decomposed granite of $c' = 11$ kPa and $\phi' = 38°$, and for colluvium of $c' = 10$ kPa and $\phi' = 33°$.

Supplementary geotechnical reports were submitted by FFP to the GCO to assess the effect of foundation loads for individual blocks, including Blocks 3 and 4, on the natural hillside below. In 1984, FFP reported that the stability analysis of the soil portion of the hillside below Block 4 (see cross-section 2-2 on Figure 2 and Appendix A) indicated a minimum factor of safety of 1.33.

2.4 Subsurface Conditions

The Hong Kong Geological Survey 1:20 000 scale Sheet 11 (GCO, 1986) shows the site to be underlain by major intrusive granite. Previous ground investigation information indicated that the general lithological sequence of the natural hillside below Blocks 3 and 4 comprised a covering of colluvial deposits which thin upslope, overlying weathered granite with bedrock rising towards the surface upslope. A section along the landslide track is shown in Figure 3.

The granite within the area was generally pinkish grey fine- to coarse-grained and porphyritic with greenish grey chloritisation from thermo-metamorphism and much tectonic influence (FFP, 1980a). Several dykes also intrude into the granite disturbing and altering the rock within the contact zone.

A dolerite dyke, aligned parallel to and outcropping within the crest area of the natural hillside, was identified by FFP (1980a), see Figure 3. The dyke, 0.3 m to 4 m wide, was located about 5 m behind the head of the detachment scar. The dyke had a dip of 65° to 85° towards 240° to 260° and several minor faults, 0.05 m to 0.22 m wide, were parallel to it.

The material identified in the detachment scar was orange brown clayey silty sand with occasional angular cobbles within a mass weathering zone of PW 0/30, comprising principally completely decomposed granite, over a weathering zone of PW 50/90 that contained moderately decomposed fine- to coarse-grained granite (Figure 4).

Jointing within the granite (mass weathering zone PW 50/90) exposed in the scar was generally closely spaced (60 mm to 200 mm) with a rough planar surface and blocky appearance.

Groundwater monitoring from piezometers in boreholes sunk in the natural hillside during the investigation for the Wonderland Villas development was undertaken in the early 1980's. Monitoring records indicated that the base groundwater level at the location of the 1997 failure was below rockhead (Figure 3).

In general, the base groundwater level would be expected to be depressed in the upper slope where the potential groundwater catchment is small. No evidence of groundwater seepage was observed in the landslide scar at the time of HAP's inspection at about 15:00 hours on the day of the failure (see Section 3.2).

3. THE LANDSLIDE

3.1 Sequence of Events

Interviews with witnesses were conducted to assist in establishing the sequence of events. The following accounts are based on statements taken on 8 May 1997 by GEO and from site observations by HAP.

A caretaker at Wah Yuen Chuen Estate to the south of the landslide reported the time of failure to be about 10:30 hours on 8 May 1997. A petrol pump attendant at the service station

next to Tai Wo interchange, which directly faces the slope, recalled an initial failure at 08:00 hours, with the scar developing fully by about 10:00 hours on 8 May 1997.

A resident and caretaker of Block 4 Wonderland Villas, though not witnessing the landslide, recalled that during the rainstorm in the morning of 8 May 1997 flooding occurred in the footpath next to Block 3. The footpath, which is partly beneath the garden level, was located some 10 m to 20 m away from the crest area above the landslide. The depth of the floodwater was reported as being "waist-height" within the footpath.

The landslide was reported to the GEO at 10:40 hours on 8 May 1997, and staff from the GEO subsequently inspected the site (GEO Incident No. MW97/5/1). Following inspection, the GEO advised the Highways Department (HyD) to close the south-bound lane of Wah King Hill Road, divert surface water flow, cover and fence off the affected slope, and trim and provide surface protection to the affected slope. In addition, the management office at Wonderland Villas was warned of possible danger during further heavy rain. By the afternoon the road was re-opened and minor repair works to slope No. 11NW-A/C33 were substantially completed.

The above corroborative information suggests that the most likely timing of the failure was between 10:00 hours and 10:30 hours on 8 May 1997. There is a possiblity that some initial signs of instability might have developed as early as about 08:00 hours, although no other witnesses apart from the petrol station attendant were able to confirm this.

3.2 Description of the Landslide

A walk-over survey was undertaken at the site on 8 May 1997 to establish details of the incident. The observations are presented in Figure 2 and a cross-section through the landslide detachment scar is shown in Figure 4. The landslide involved two phases of movement: initial sliding of in situ material from beneath the slope crest followed by the detached material over-riding the existing ground surface along the run out track. The failed material entered a drainage line, in which it was washed downstream over slope No. 11NW-A/C33 and onto Wah King Hill Road.

The detachment scar is located about 2 m below the crest of the natural hillside between 208 mPD and 218 mPD. The scar is spoon-shaped, about 8 m wide, 16.5 m in length, with an average depth of less than 1 m and a maximum depth of 1.5 m (Plate 2). The volume of the scar is estimated to be about 80 m^3.

Exposed within the lower section of the scar was a mass weathering zone of PW 50/90 that comprised intact moderately decomposed fine- to coarse-grained granite with some rough planar surfaces orientated downslope at 26° to 40° (Plate 3). The upper section of the scar comprised principally completely decomposed granite of mass weathering grade PW 0/30 with a thin covering of topsoil (Figure 3). Inspection of the adjacent slope area revealed some construction and domestic waste materials, apparently tipped onto the slope surface.

No seepages were evident in the scar at the time of inspection at about 15:00 hours on 8 May 1997, though minor gully erosion due to action of surface water was present in the main scarp.

The mode of detachment appears to be a shallow sliding failure involving generally completely decomposed granite and was controlled, in part, by the orientation of the underlying existing weathered rock surfaces.

The landslide run out track from the detachment scar to its intersection with a drainage line was approximately 120 m long and 6 m to 8 m wide (Figure 2 and Plate 4). The inclination of the track was typically between 33° and 35°. Inspection of the track showed that the landslide debris over-rode the existing ground surface, flattening and stripping vegetation along its path. Along the center-line of the track were areas of exposed bedrock (Plate 4), possibly the result of removal of the overlying thin soil deposits by the passage of landslide debris. On the outer margins of the track, low deposition levées were present. The net volume of the failed material appeared to have remained almost constant throughout its travel.

At about 150 mPD the landslide debris was intercepted by a natural drainage line that obliquely intersected the run out track (Figure 2). Deposition of landslide debris upslope of the drainage line suggests that the momentum of the debris was decreasing as it entered the drainage line, where it was contained (Plate 5). Debris was subsequently washed downstream, some 40 m, to where the drainage line meets a man-made drainage channel at the crest of slope No. 11NW-A/C33. Inundation of the channel by the debris caused overtopping of the channel resulting in minor erosion of the slope surface and deposition of debris onto the footpath and Wah King Hill Road below.

The travel angle of the landslide debris, as measured from where the debris entered the drainage line to the crest of the landslide scar, is about 34°. This is comparable to that commonly observed in other landslides in Hong Kong where the debris movement has not been subjected to significant influence by surface running water (Wong & Lam, 1998). The mobility of the debris of this landslide is therefore not considered unusual.

4. RAINFALL

The nearest GEO automatic raingauge No. N04 is located at Kai Kwong Lau, Cho Yiu Estate, Lai King, about 0.9 km southwest of the landslide. The daily rainfall recorded between 1 April and 13 May 1997, and hourly rainfall between 6 and 8 May are shown in Figure 5. The 12-hour and 24-hour rainfall recorded prior to 10:30 hours on 8 May 1997, by which time the failure had occurred, were 162 mm and 167 mm respectively. Rainfall on 8 May 1997 started at about 04:00 hours and intensified significantly from 08:45 hours peaking at about 10:30 hours.

An isohyet plot of the rainstorm prior to failure is shown in Figure 6. This shows that the peak rainfall intensity prior to the failure was centred northwest of the site, with a cumulative rainfall at the landslide site of between 160 mm and 200 mm.

Table 2 shows the maximum rolling rainfall for selected durations prior to 10:30 hours on 8 May 1997, together with the corresponding estimated return periods. The most severe rainfall was the hourly rainfall between 09:30 and 10:30 hours with an estimated return period of 12 years.

A comparison of the pattern of the rainfall prior to the landslide with those of previous

major rainstorms recorded at raingauge No. N04 since its installation in 1978 is shown in Figure 7. The rainfall preceding the 1997 landslide was the highest recorded at the raingauge for durations of less than 4 hours but was comparatively less intense than some of the previous rainstorms for rainfall durations of 1 day or more.

5. THEORETICAL STABILITY ANALYSIS

Theoretical stability analysis was used to determine the probable operating shear strengths in the initial sliding detachment, given the possible groundwater conditions at the time of failure. For this purpose, a range of likely shear strengths for completely decomposed granite of $c' = 2$ kPa to 6 kPa and $\phi' = 35°$ to $40°$ were assumed based on site observations within the detachment scar and experience of similar materials in Hong Kong. The analysis was undertaken using the rigorous method of Morgenstern and Price (1965). The geometry of the failure surface was based on the topographic survey undertaken by HAP and the pre-feature profile established from topographic maps.

The results of the analysis (Figure 8) indicate that for the lower bound shear strengths, the factor of safety approaches unity when the water approaches to within about 0.6 m of the ground surface. For the upper bound shear strength parameters, failure is predicted when the groundwater approaches close to the surface.

It is considered likely that the groundwater level could establish itself close to the ground surface due to the formation of a water table perched above the less weathered PW 50/90 zone identified at the base of the detachment scar (see Section 3.2).

The shear strength parameters used by FFP (1984) to analyse the hillside as part of the design of Wonderland Villas were higher than those used in the present analysis (see Figure 8). The higher factors of safety calculated by FFP (1984) were obtained by stability analyses of a different part of the slope, where the rockhead and the corresponding groundwater level were at greater depth.

6. PROBABLE CAUSES OF THE LANDSLIDE

The landslide occurred during a period of intense rainfall when the maximum rolling rainfall for durations of less than 4 hours was the highest recorded at the nearest automatic raingauge since its installation in 1978. It is considered that the short duration intense rainfall probably triggered the landslide.

The morphology of the landslide scar, together with the lack of any signs of erosion within the scar, indicate that the failure was a shallow translational slide, and that wash out due to concentrated surface water flow did not occur.

The landslide material comprised predominantly completely decomposed granite of mass weathering zone PW 0/30. The failure surface exposed in the lower section consisted of a less weathered zone PW 50/90 containing moderately decomposed granite with planar rock surfaces sub-parallel to the slope that provided, in part, the basal sliding surface.

Stability analysis of the initial sliding detachment demonstrated that a high groundwater level would be required to initiate failure given the nature of the materials identified.

The possible sources of water, which may have contributed to the landslide, are stormwater run off from the garden areas at the crest of the slope and direct rainfall on and adjacent to the landslide site. Observations at the head of the scar showed only minor surface water erosion. Therefore direct rainfall on to and adjacent to the landslide site is considered the most probable source of water. However, the possibility of surface water flow from the garden area resulting in concentrated ingress of water into the failure site cannot be ruled out. The detachment scar is in a natural concavity in the slope which would concentrate water flow.

The likely failure mechanism was that water infiltrated into the slope and caused the formation of a transient perched water table at a shallow depth above the mass weathering zone PW 50/90. The infiltrated water resulted in an increase in bulk unit weight of the overburden, loss of suction and development of positive porewater pressure. This reduced the available shear strength of the slope-forming material, leading to the failure.

7. CONCLUSIONS

It is concluded that the landslide on 8 May 1997 was triggered by intense short duration rainfall. The probable cause of the failure was the build-up of a transient perched water table above a less weathered (PW 50/90) zone at the base of the detachment scar. Water probably concentrated in the landslide area because of its topographic setting in a natural concavity within the hillside.

8. REFERENCES

Freeman Fox and Partners (1980a). Development at KCTL 369 Tai Wo Tsuen Geotechnical Report. Freeman Fox and Partners (Far East) Consulting Engineers, November 1980, vol. 1, 22 p. 3 appendices and 4 drawings.

Freeman Fox and Partners (1980b). Development at KCTL 369 Tai Wo Tsuen Stability Report. Freeman Fox and Partners (Far East) Consulting Engineers, November 1980, vol. 1, 2 appendices and 7 drawings.

Freeman Fox and Partners (1982). KCTL 369 – Tai Wai Tsuen Geotechnical Checking of New Works. Freeman Fox and Partners (Far East) Consulting Engineers, 22 January 1982, Letter (FE/186-2/JC/ic) to GCO with Supplemental Report enclosed.

Freeman Fox and Partners (1984). KCTL Tai Wo Tsuen Preliminary Analysis of Slope Adjacent to Block 3. Freeman Fox and Partners (Far East) Consulting Engineers, May 1984, 3 p. 3 figures and 1 drawing.

Geotechnical Control Office (1986). Hong Kong and Kowloon: Solid and superficial geology. Hong Kong Geological Survey, Map Series HGM 20, Sheet 11, 1:20 000 scale, Geotechnical Control Office, Hong Kong.

Lam, C. C. & Leung, Y.K. (1994). Extreme Rainfall and Design Rainstorm Profiles at Selected Locations in Hong Kong. Royal Observatory, Hong Kong, Technical Note No. 86, 89 p.

Morgenstern, N.R. & Price, V.E. (1965). The analysis of the stability of general slip surfaces. Géotechnique, volume 15, pp 79 – 93.

Wong, H.N. & Lam, K.C. (1998). The November 1993 natural terrain landslides on Lantau Island, Hong Kong. Proceedings of the Sixteenth HKIE Geotechnical Division Annual Seminar Slope Engineering in Hong Kong. Hong Kong (In press).

LIST OF TABLES

Table 1 – Summary of Aerial Photographic Interpretation

Year	Photographic Reference No.	Altitude (feet)	Observation
1963	Y10962, Y10963	2000 ft	Site of Wonderland Villas (WV) is a natural hillside, with a north-south ridge line. Ridge is heavily eroded and denuded of vegetation, further erosion on spurs between drainage lines on western slope. Vegetation cover on the slope comprises low shrubs. Site of recent failure is at the head of a poorly defined drainage line. Minor (possibly) failure scars apparent in the heads of streams to the north of the recent failure. Castle Peak Road (CPR) is present. Small buildings located within lower sections of drainage lines, adjacent and east of CPR.
1969	Y14871, Y14872, Y14873	-	No significant changes at WV site. Further buildings present within lower sections of drainage lines adjacent to CPR.
1972	261, 262	-	Earthworks underway at the Wah Yuen Chuen Site and along Wah King Hill Road (WKHR).
1976	14678 to 14682	12000 ft	WV platform is complete. No significant fill apparent at site of recent failure. Platform is tiered with east-west aligned inter-platform slopes. A bund (in earth?) is constructed along the western edge of the platform with drainage outfalls evidently feeding into the heads of the drainage lines. Minor instability in cutting (11NW-A/C33) adjacent to WKHR.
1980	32850, 32851	10000 ft	WV platform remains vacant. WKHR is complete, and building works are underway within Wah Yuen Chuen Estate site. Vegetation cover increasing on western slope beneath WV site. Erosion within stream heads on western slope is apparent where they connect with platform outfalls.
1984	56215, 56216	4000 ft	WV building works underway. Continued vegetation growth on western slope with trees evident on lower slope. Further cuttings along east of WKHR.
1986	A05763, A05764	4000 ft	WV buildings substantially complete. Re-modelling of the platform layout has removed the inter-platform slopes.
1992	A32693, A32694	4000 ft	WV development complete.

Table 2 – Maximum Rolling Rainfall at GEO Raingauge No. N04 for Selected Durations Preceding the 8 May 1997 Landslide and The Corresponding Estimated Return Periods

Duration	Maximum Rolling Rainfall (mm)	End of Period	Estimated Return Period (Years)
5 minutes	14	10:30 hours on 8 May 1997	3
15 minutes	37	10:30 hours on 8 May 1997	8
1 hour	107	10:30 hours on 8 May 1997	12
2 hours	127	11:00 hours on 8 May 1997	5
4 hours	137.5	11:00 hours on 8 May 1997	3
12 hours	162	11:00 hours on 8 May 1997	2
24 hours	167	11:00 hours on 8 May 1997	1
2 days	187	11:00 hours on 8 May 1997	1
4 days	223	11:00 hours on 8 May 1997	1
7 days	259	11:00 hours on 8 May 1997	1
15 days	262.5	11:00 hours on 8 May 1997	1
31 days	374.5	11:00 hours on 8 May 1997	1

Notes: (1) Return periods were derived from the Gumbel equation and data published in Table 3 of Lam & Leung (1994).

(2) Maximum rolling rainfall was calculated from 5-minute data for durations up to one hour and from hourly data for longer rainfall durations.

LIST OF FIGURES

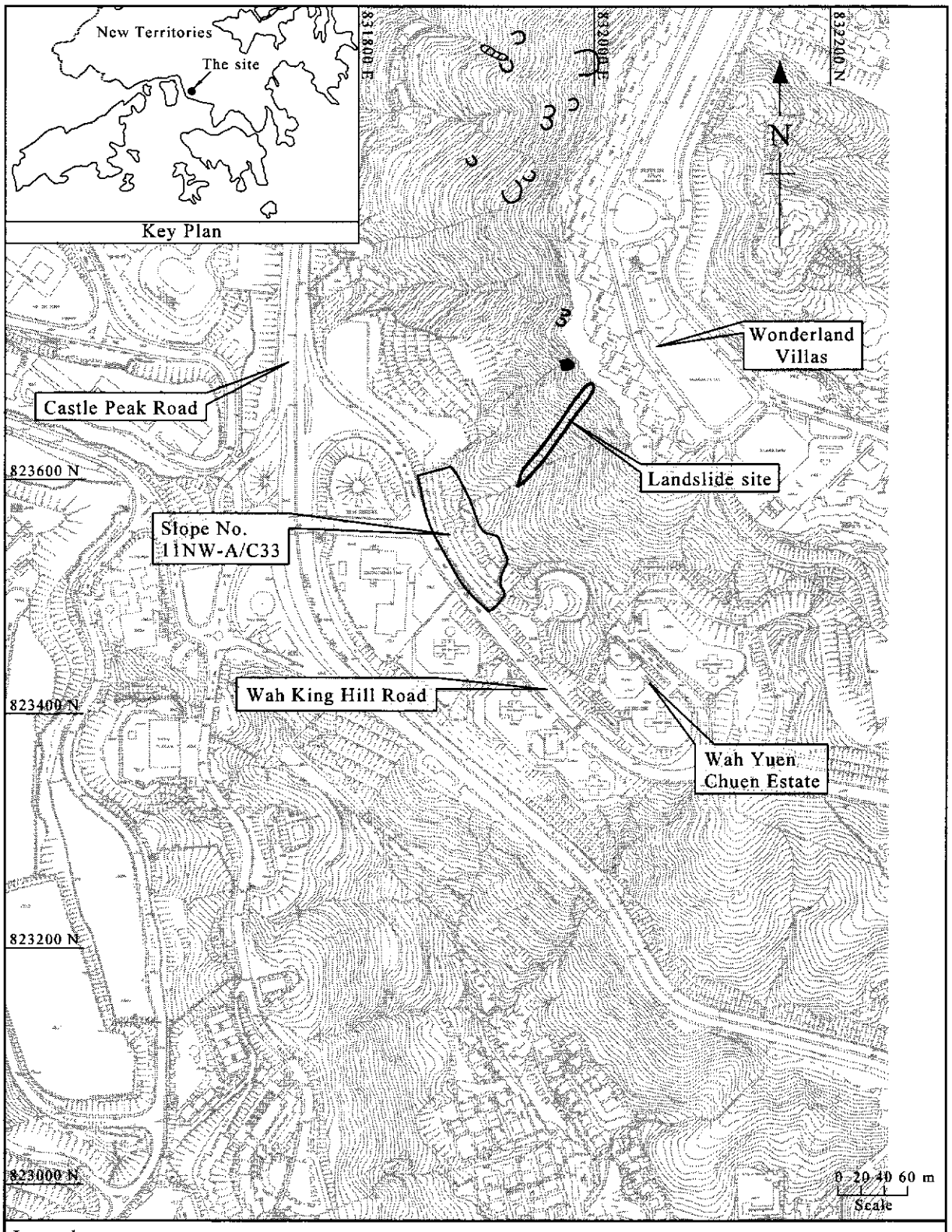
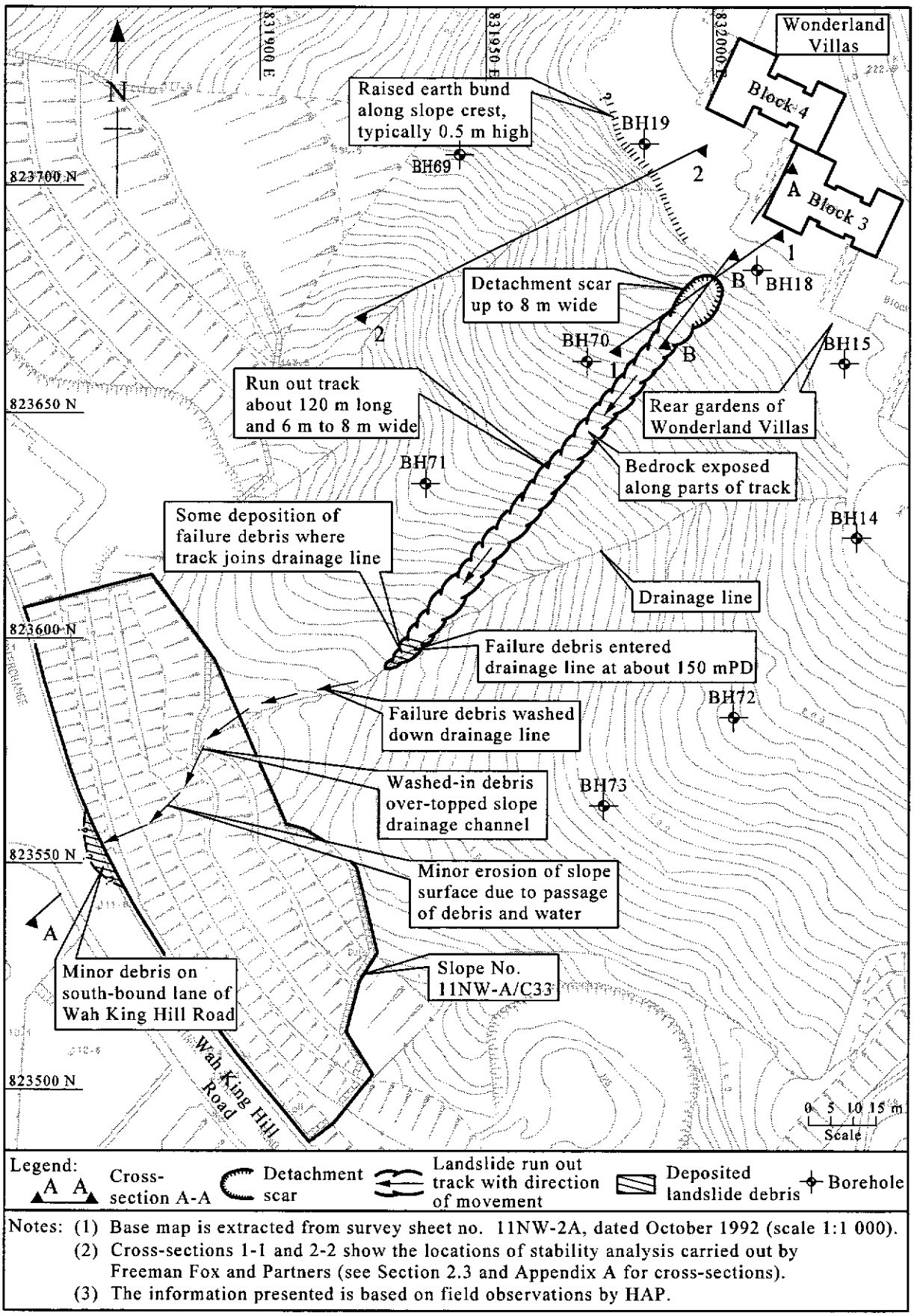
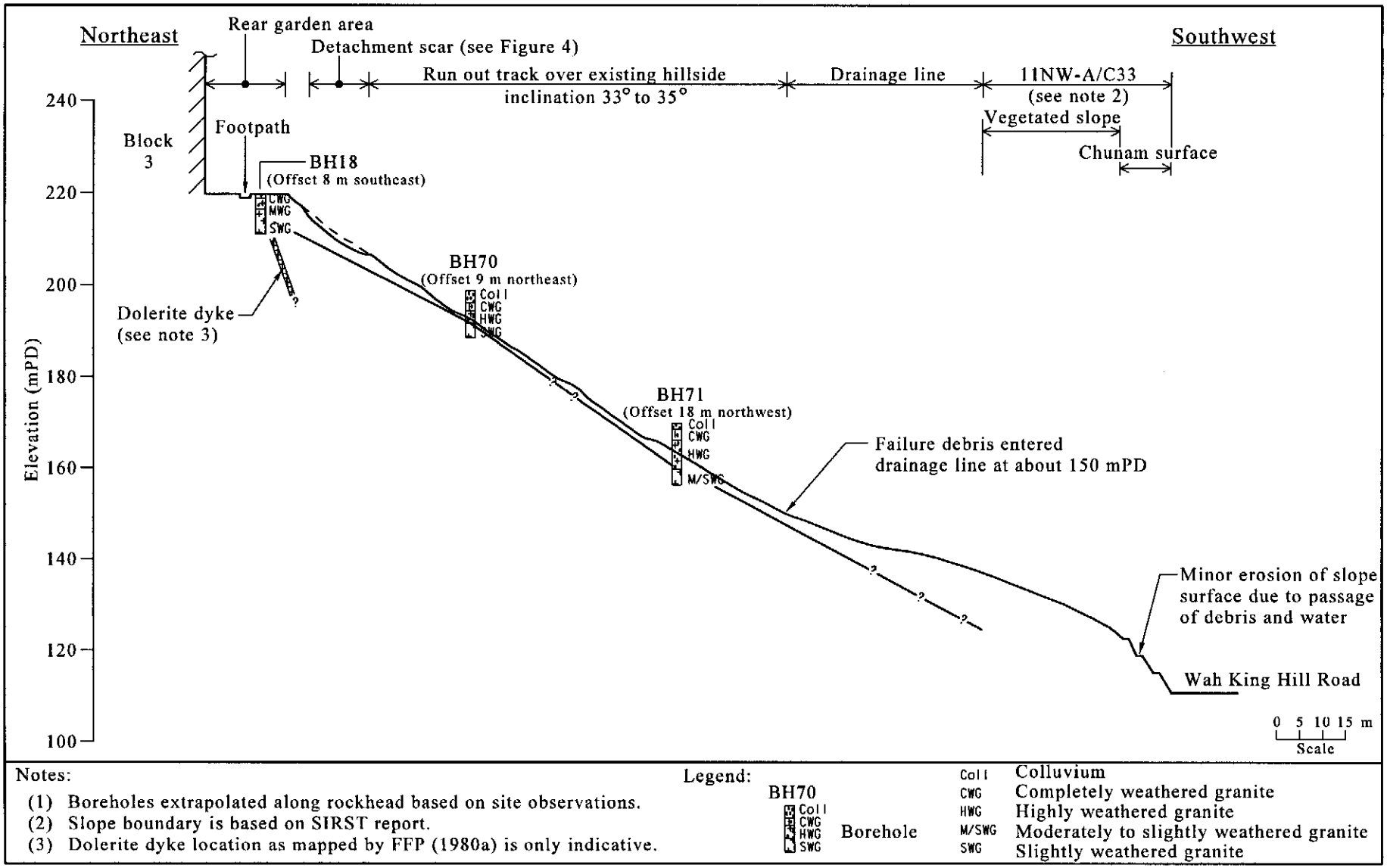


Figure 1 - Site Location Plan



Notes: (1) Base map is extracted from survey sheet no. 11NW-2A, dated October 1992 (scale 1:1 000).
(2) Cross-sections 1-1 and 2-2 show the locations of stability analysis carried out by Freeman Fox and Partners (see Section 2.3 and Appendix A for cross-sections).
(3) The information presented is based on field observations by HAP.

Figure 2 - Plan of Landslide



Notes:

(1) Boreholes extrapolated along rockhead based on site observations.
(2) Slope boundary is based on SIRST report.
(3) Dolerite dyke location as mapped by FFP (1980a) is only indicative.

Legend:

BH70
Colt
CWG
HWG
SWG
Borehole

Colt	Colluvium
CWG	Completely weathered granite
HWG	Highly weathered granite
M/SWG	Moderately to slightly weathered granite
SWG	Slightly weathered granite

Figure 3 - Cross-section A-A through Landslide Run Out Track

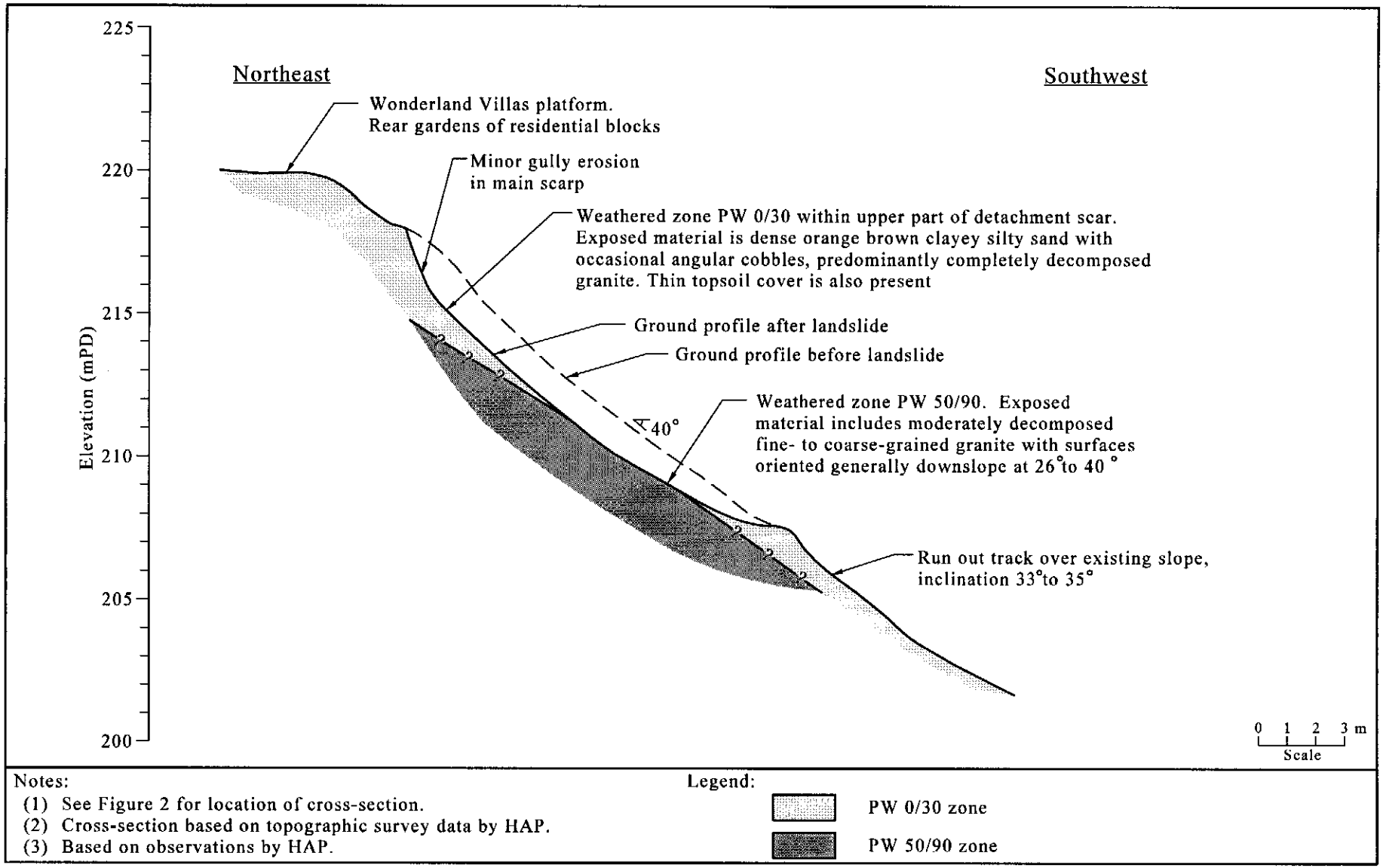
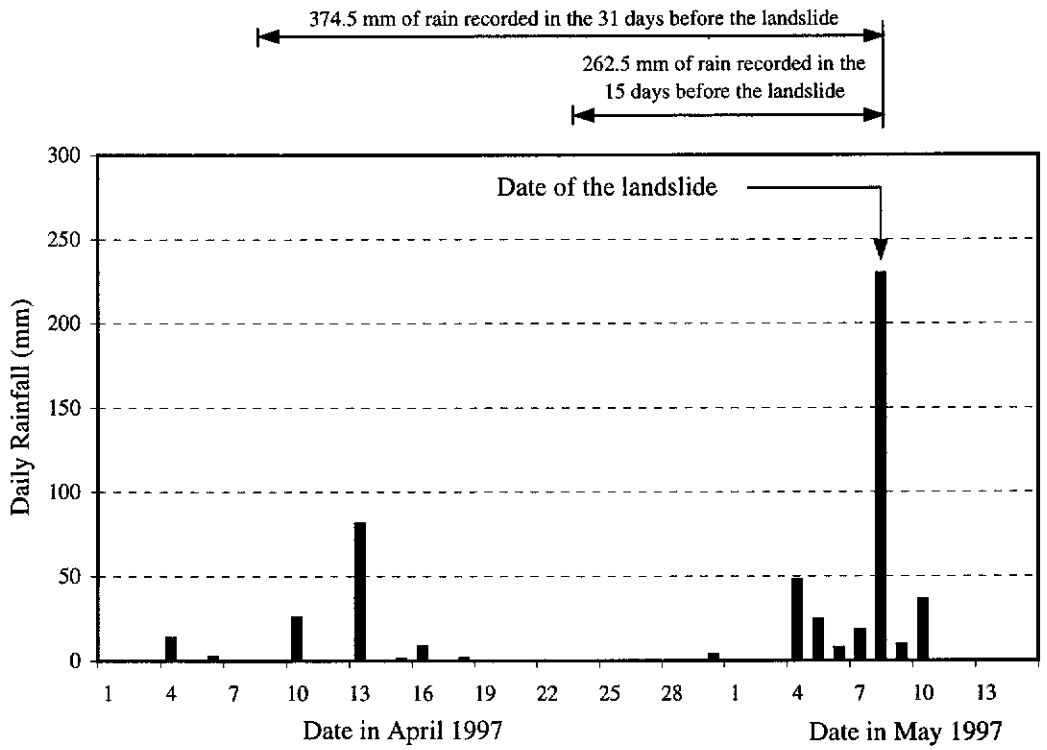
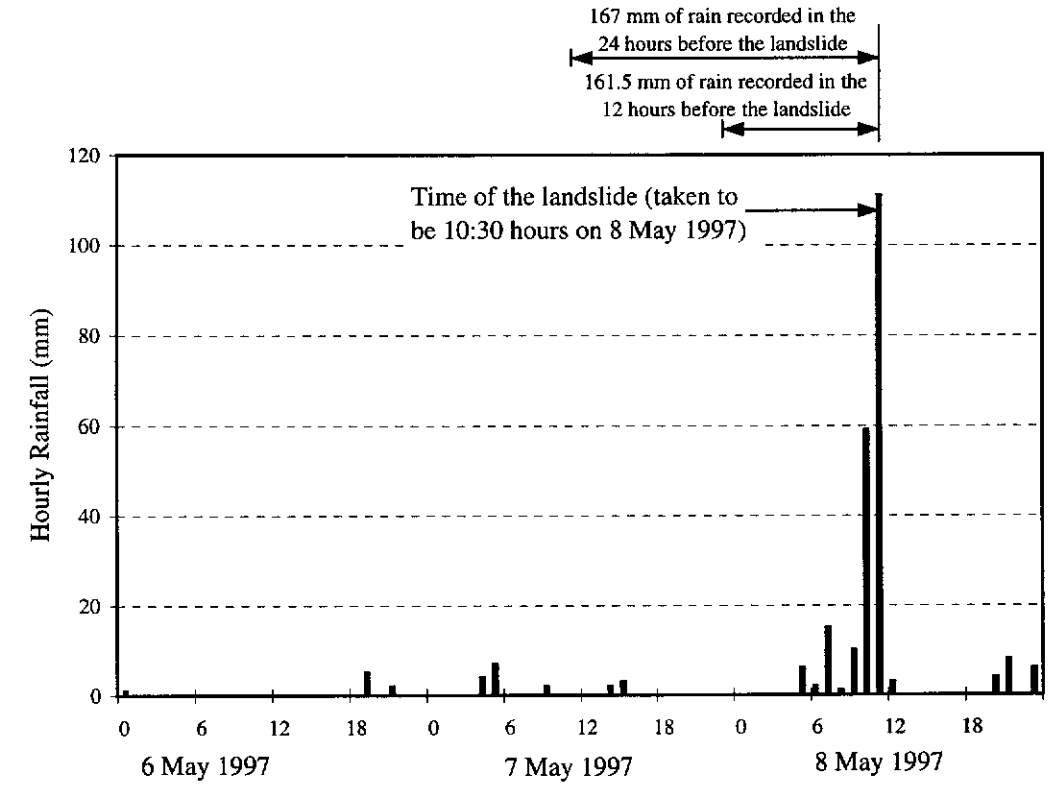


Figure 4 - Cross-section B-B through Landslide Detachment Scar

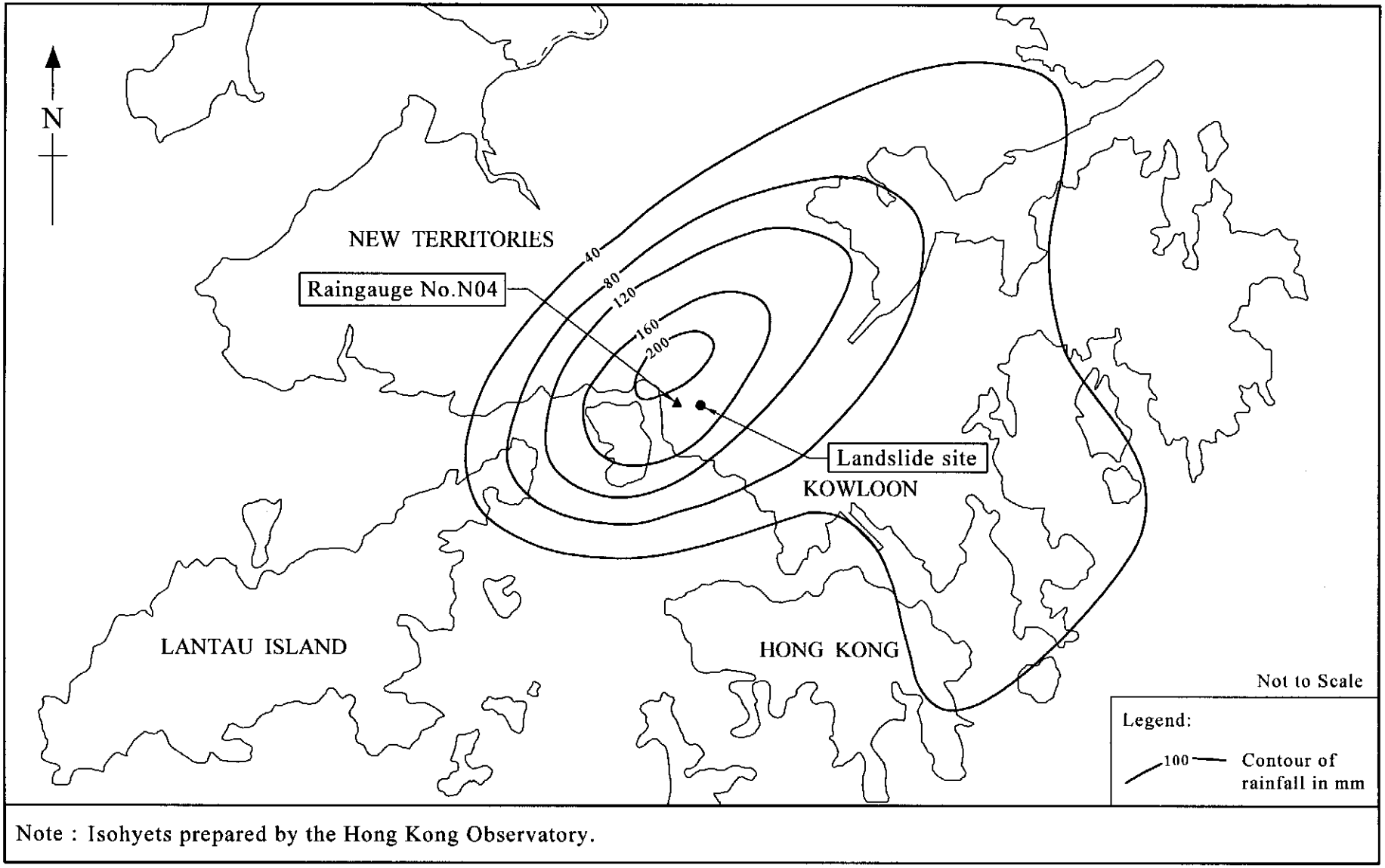


(a) Daily Rainfall Recorded between 1 April and 15 May 1997



(b) Hourly Rainfall Recorded between 6 May and 8 May 1997

Figure 5 - Rainfall Recorded at GEO Raingauge No. N04



Note : Isohyets prepared by the Hong Kong Observatory.

Figure 6 - Isohyets of Rainfall from 04:00 hours to 10:30 hours on 8 May 1997

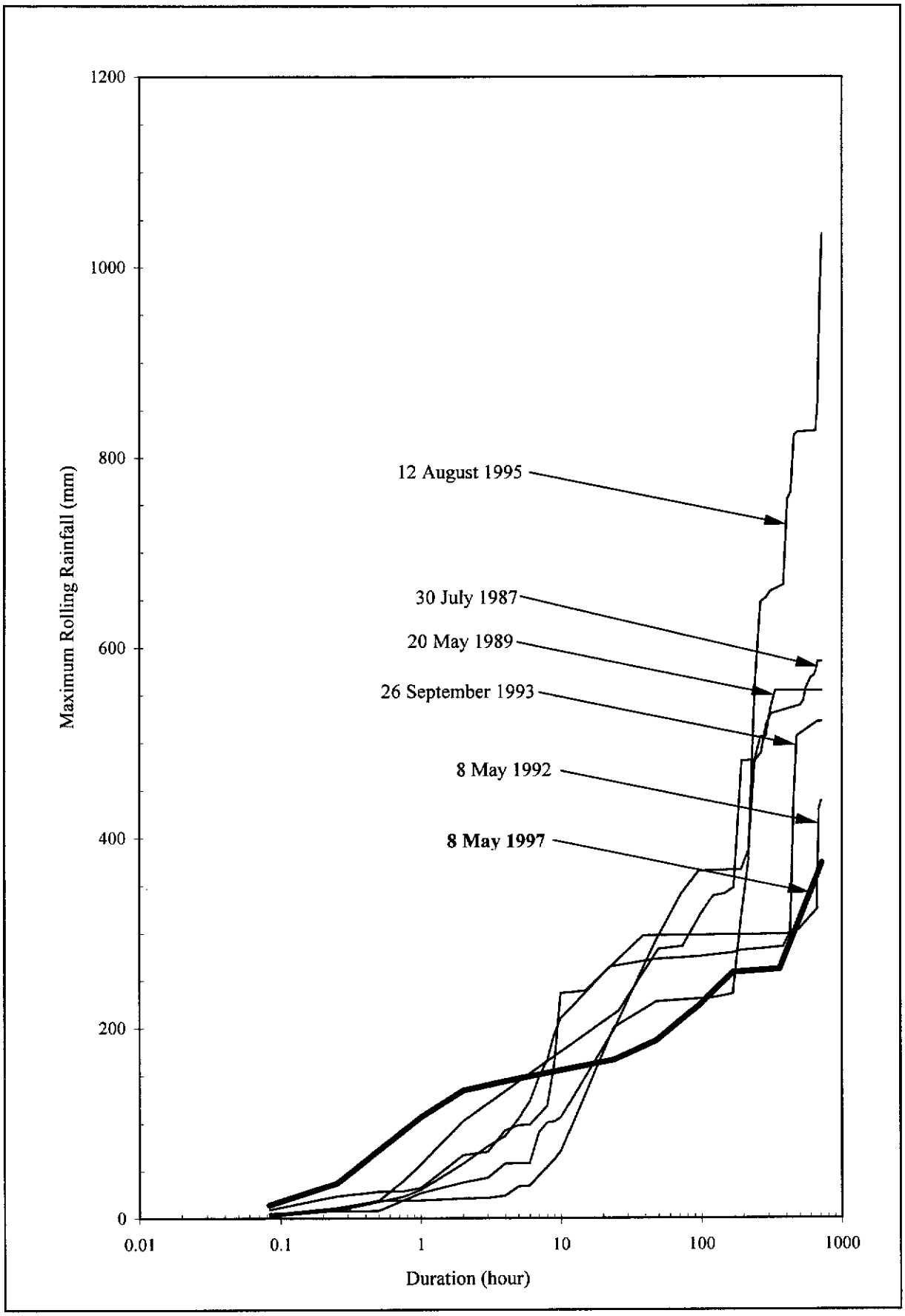
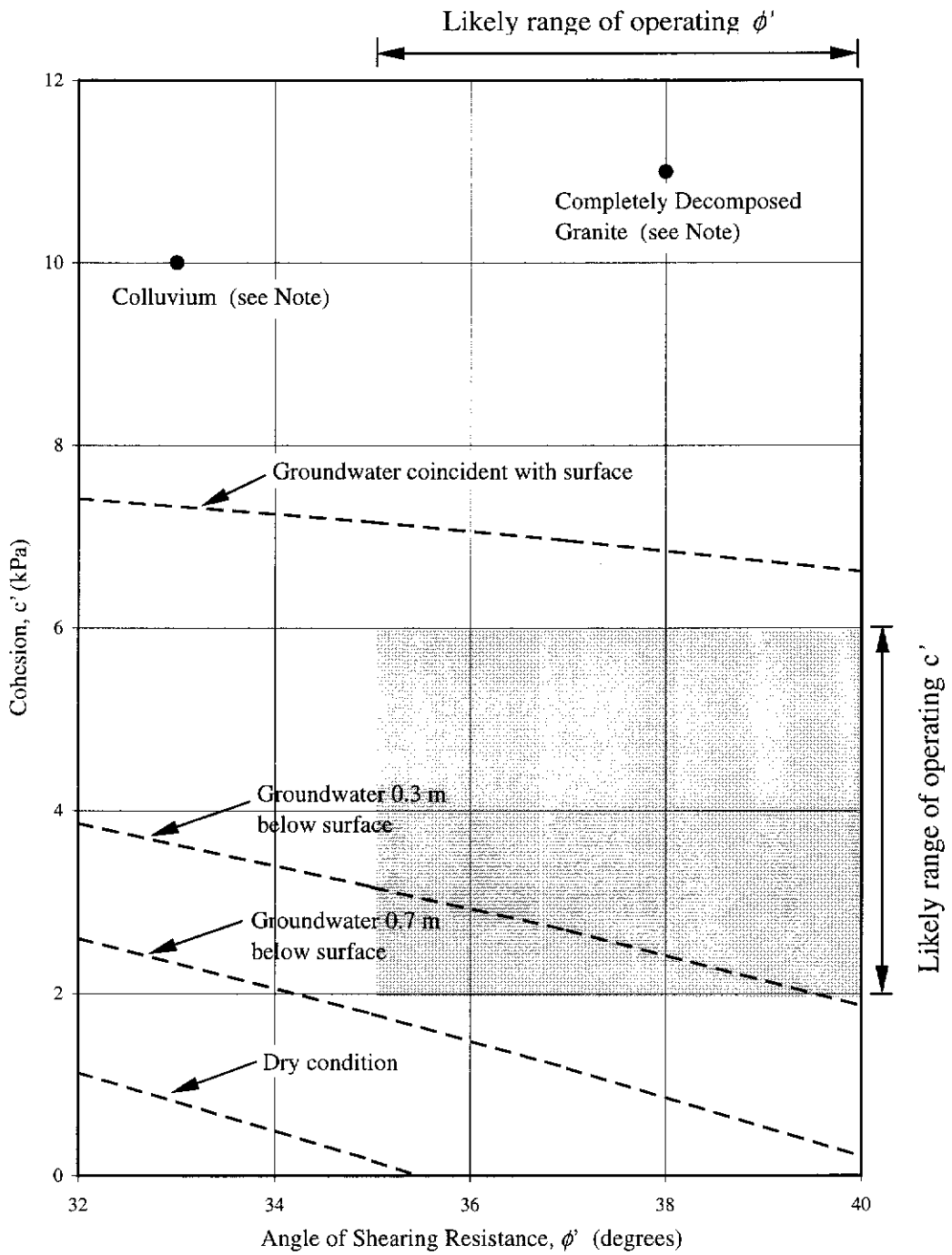


Figure 7 - Maximum Rolling Rainfall at GEO Raingauge No. N04 for Major Rainstorms



Legend: ------ Factor of safety equals unity (i.e. limiting equilibrium)

Note: Shear strengths of slope-forming materials are based on FFP (1984).

Figure 8 - Limiting Equilibrium Condition in Terms of Different Shear Strengths and Groundwater Regime

LIST OF PLATES

Plate 1 - General View of Landslide (Photograph Taken on 21 May 1997)

Plate 2 - View of Detachment Scar (Photograph Taken on 26 May 1997)

Plate 3 - Close-up View of Zone PW 50/90 Exposed in Scar
(Photograph Taken on 8 May 1997)

Plate 4 - View Looking Up Run Out Track (Photograph Taken on 26 May 1997)

Plate 5 - View from within Drainage Line Showing Landslide Debris. Landslide Entered Stream from Right (Photograph Taken on 26 May 1997)

APPENDIX A

PREVIOUS STABILITY CROSS-SECTIONS

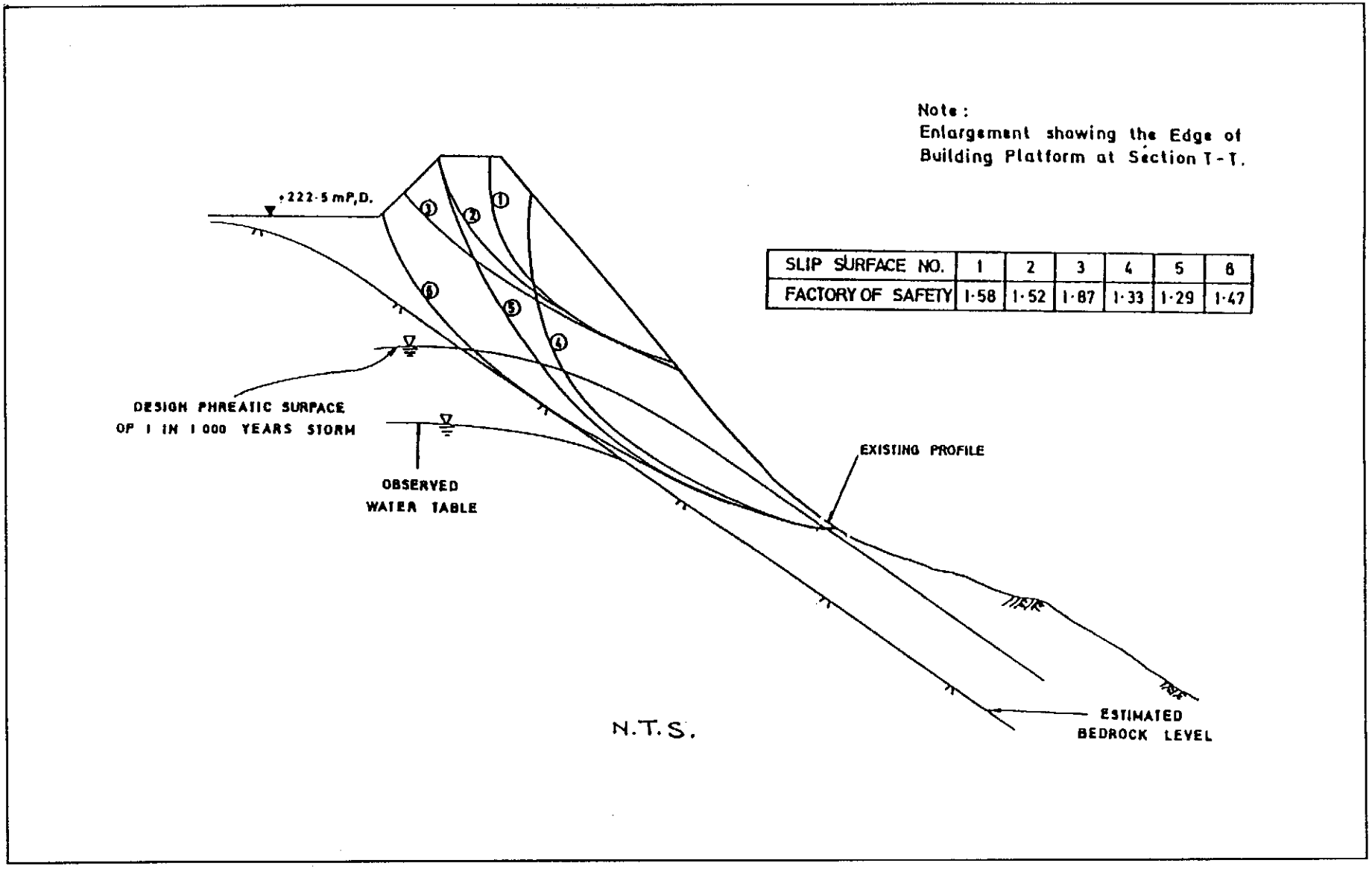


Figure A1 - Stability Cross-section 1 - 1 (FFP, 1982)

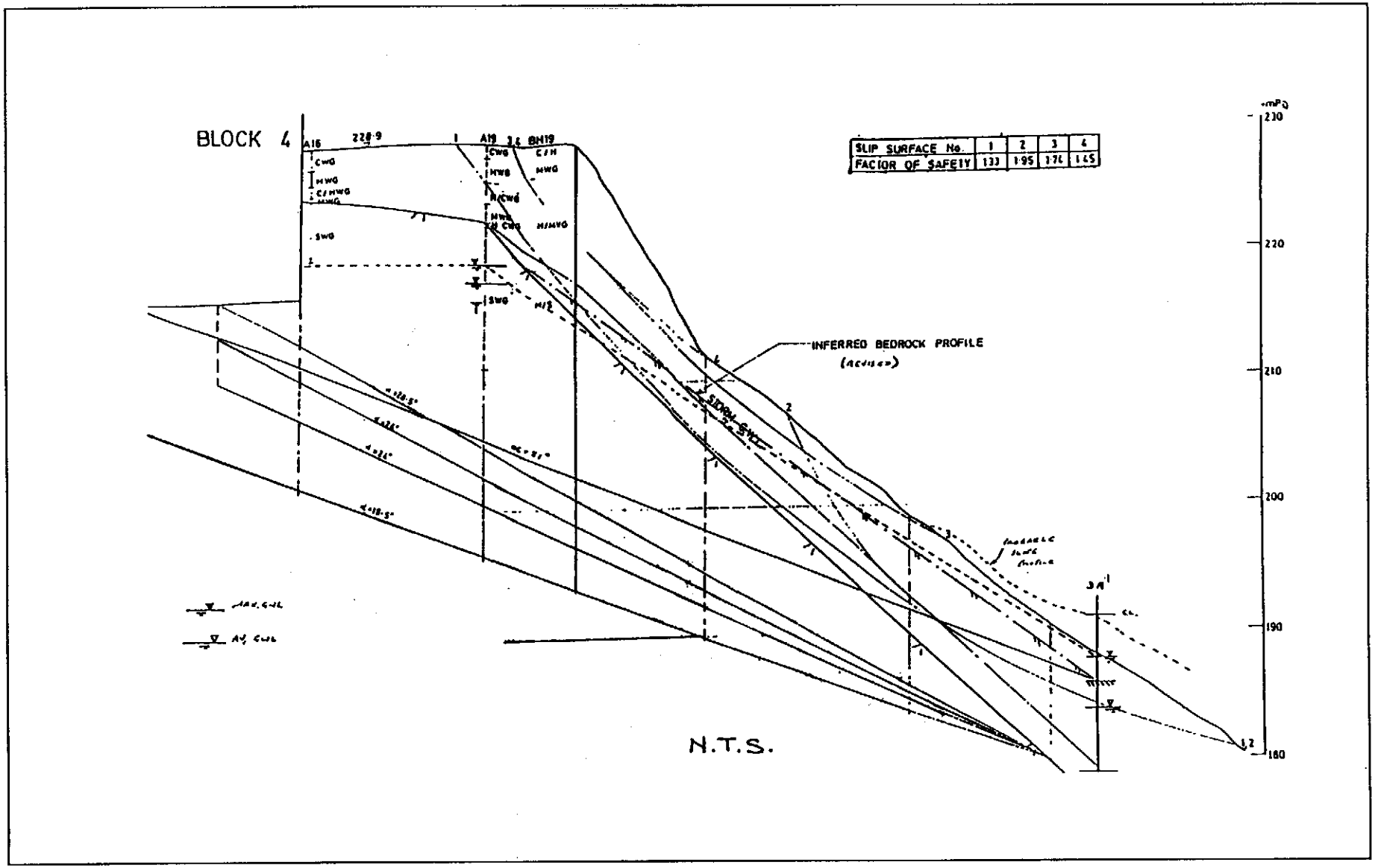


Figure A2 - Stability Cross-section 2 - 2 (FFP, 1984)