INVESTIGATION OF SOME SELECTED LANDSLIDE INCIDENTS IN 1997 (VOLUME 2)

GEO REPORT No. 88

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 five 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 five sections in this Report. Their titles are as follows:

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 LANDSLIDES BELOW SHA TIN HEIGHTS ROAD ON 4 JUNE 1997

Halcrow Asia Partnership Ltd

This report was originally produced in July 1998 as GEO Landslide Study Report No. LSR 10/98

FOREWORD

This report presents the findings of a detailed study of two landslides (GEO Incident Nos. MW97/6/12 and MW97/6/23) which occurred on the heavily-vegetated hillside to the south of Sha Tin Heights Road on 4 June 1997. Debris from the landslides inundated a car park and a recreational area of the Woodcrest Hill development located at the toe of the hillside. No fatalities or injuries were reported.

The key objectives of the detailed study were to document the facts about the landslides, present relevant background information and establish the probable causes of the landslides. 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. It is one of a series of reports produced during the consultancy by Halcrow Asia Partnership Limited (HAP). The report was written by Mr M Riley and reviewed by Dr R Moore and Mr H Siddle. 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

On the morning of 4 June 1997, two landslides occurred on the heavily-vegetated hillside to the south of Sha Tin Heights Road, Sha Tin (Figure 1). The first landslide (GEO Incident No. MW97/6/12) occurred below the western block of Happy View House (No. 21 Sha Tin Heights Road) near the crest of the hillside. Debris from the landslide travelled down a natural gully line and inundated the garden of No. 9 Woodcrest Hill, part of a residential development located at the mouth of the gully. No fatalities or injuries were reported.

The second landslide (GEO Incident No. MW97/6/23) occurred at about mid-slope between Golden Time Villas (No. 33 Sha Tin Heights Road) and No. 12 Woodcrest Hill. Debris from the landslide inundated a playground and a car park. No fatalities or injuries were reported.

Following the landslides, 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. CE68/96. 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 landslides, present relevant background information and establish the probable causes of the landslides. 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 which comprised the following key tasks:

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

(b) analysis of rainfall records,

(c) interviews with witnesses and persons affected by the landslides,

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

(e) diagnosis of the probable causes of the landslides.

Seven other landslides occurred in and around the Sha Tin Heights area during 1997. The locations of these other landslides are shown in Figure 1 and key information relating to the incidents is summarised in Table 1. The GEO inspected these landslides and recommended necessary emergency actions and urgent repair works for these failures. The relevant information was reviewed by HAP. However, detailed study of these incidents is beyond the scope of this report.

2. THE SITE

2.1 Site Description

The landslides occurred on the southeast-facing hillside of a northeast to southwest trending ridge (Figure 1). Sha Tin Heights Road and a number of low-rise residential buildings have been constructed along the ridge crest. Tai Po Road and the Woodcrest Hill development are situated at the toe of the hillside.

The morphology of the hillside is characterised by alternating spurs and prominent gullies. The gullies form natural drainage lines which discharge into man-made drainage systems associated with the Woodcrest Hill development and Tai Po Road. The landslides occurred on the flanks of two of the gullies.

Incident No. MW97/6/12 occurred near the head of a gully which extends from between Happy View House and Albert Villa towards No. 9 Woodcrest Hill (Figure 2). The platform for Happy View House is supported by a masonry retaining wall (No. 7SW-D/R2) that has southeast and southwest facing sections. The two sections join at the highest part of the structure, where the height of the wall is about 7.5 m. Albert Villa was constructed behind a fill slope (No. 7SW-D/F3) that is about 4 m high, inclined at about 30° to the horizontal, with a retaining wall up to 4 m high at its toe. The gully is heavily vegetated and is typically inclined at about 25° to 35°, increasing to between about 45° and 55° near the retaining wall. Two drainage channels pass between Happy View House and Albert Villa and discharge into a stepped surface drainage channel that follows the centerline of the gully. Water within the channel passes downslope into a drainage system to the rear of the Woodcrest Hill development.

Incident No. MW97/6/23 occurred in a wider gully which extends downslope from between Golden Time Villas and Ascot Villa towards No. 12 Woodcrest Hill (Figure 2). Golden Time Villas is supported on a reinforced concrete frame that extends in part over the head of the gully. A vacant platform is located at the crest of the slope between Golden Time Villas and Ascot Villa. Slope angles immediately below Golden Time Villas are around 35° to 45°, but reduce to about 5° further downslope. No. 12 Woodcrest Hill and its associated covered car park, playground and sitting-out area are located at the mouth of the gully (Figure 2). An ephemeral stream within the gully discharges into a drainage system installed in the playground area.

The two landslides occurred principally on Government land (Figure 2). The main scarp of Incident No. MW97/6/12 affected the southern margin of private lot No. 1474 within which Happy View House was built. Other private lots associated with Golden Time Villas and Albert Villa at the crest of the slope were not affected by the landslides. Debris from both failures affected Sha Tin Town Lot (STTL) No. 117, occupied by Woodcrest Hill.

2.2 Site History

2.2.1 General

The history of the site was determined from a review of aerial photographs, available

documentary information and records of past landslides in the area using information available in the GEO. Information sources consulted during the study are summarised in Table 2.

2.2.2 History of Development

According to aerial photographs, the platforms now occupied by Happy View House and Albert Villa were substantially constructed between 1954 and 1963 by excavation of the ridge and placement of fill at the crest (Figure 3). Fill Slope No. 7SW-D/F3, which forms part of the platform for Albert Villa, dates from this time but the retaining structure at Happy View House (Retaining Wall No. 7SW-D/R2) was constructed between 1963 and 1969. Golden Time Villas was a later development which, according to aerial photographs, commenced in 1978 and was completed by the early 1980s. The Woodcrest Hill development and associated cut Slope No. 7SW-D/CR169 were also constructed in the early 1980s.

In June 1997, a Geotechnical Assessment Report was prepared by MAA Engineering Consultants (HK) Limited (MAAEC) for a proposed development of a vacant lot at the northeast end of Albert Villa, upslope of the northeast end of Slope No. 7SW-D/F3 (Figure 3). In their review of the Building Plan submission, the GEO raised "no geotechnical objection to approval of the building plans". MAAEC and the architects involved in the development subsequently indicated that the project had been abandoned following rejection of the proposals by the Buildings Department (BD).

2.2.3 Previous Landslides

According to the GEO's records, only one previous landslide incident has been reported on the hillside in the immediate area of the 1997 landslides (Figure 3). This landslide (GEO Incident No. MW93/6/51) occurred on 18 June 1993 below No. 7 Golden Time Villas, involved an estimated 20 m^3 of fill and was reported to have been caused by "erosion" and "infiltration". After the landslide, the BD advised the GEO that the building foundations "are unlikely to be affected by the landslide". There was no deterioration in the condition of the landslide noted between inspections by the GEO on 18 June 1993 and 16 November 1993, and the GEO concluded that "it appeared that no action is required".

There are no past landslides in the area recorded in the GEO's current Natural Terrain Landslide Inventory, which identifies natural terrain failures using high-level aerial photography. However, low-level aerial photographs show that between 1980 and 1982 a landslide occurred in the gully downslope of Albert Villa from a similar location to Incident No. MW97/6/12. Aerial photographs reveal apparent shallow erosion of a small area downslope of No. 5 Golden Time Villas and a larger area downslope of Happy View House in 1984 and 1988 respectively. Aerial photographs further indicate the presence of shallow depressions which may be the revegetated scars of older failures in the locality of both of the gullies associated with the present landslides (Figure 3).

2.3 Previous Studies and Assessments

2.3.1 Slope Registration

Retaining Wall No. 7SW-D/R2 and Slope No. 7SW-D/F3 were registered in the 1977/78 Catalogue of Slopes by the consultants (Binnie & Partners) engaged by the Government to prepare the Catalogue.

Retaining Wall No. 7SW-D/R2 was inspected in April 1978 (Binnie & Partners, 1978). No seepage was noted but a previous crack was reported to have been mortared. No emergency action was considered necessary.

Slope No. 7SW-D/F3 was inspected in October 1977 (Binnie & Partners, 1977). No seepage or signs of distress were reported and no emergency action was considered necessary.

Retaining Wall No. 7SW-D/R2 was inspected in November 1994 and registered in the New Catalogue of Slopes under the GEO Consultancy Agreement entitled "Systematic Identification and Registration of Slopes in the Territory" (SIRST). The inspection report notes that no signs of distress were observed and no emergency action was considered necessary.

2.3.2 Actions under the Landslip Preventive Measures (LPM) Programme

The GEO's records indicate that Slope No. 7SW-D/F3 has not been studied under the LPM Programme.

A Stage 1 Study Report on Retaining Wall No. 7SW-D/R2 was prepared by the GEO in November 1992 (GEO, 1992). The report notes that no seepage or signs of distress were observed and no emergency action was considered necessary.

In January 1995, Retaining Wall No. 7SW-D/R2 was selected for a Stage 2 Study under CED Agreement No. CE 45/94 which was carried out by Ove Arup & Partners Limited (OAP). The Stage 2 Report (OAP, 1995) recorded that the previously noted cracking in the wall had re-opened, fracturing a glass tell-tale, and that a single-storey guardhouse upslope of the wall was noticeably tilted. At the GEO's recommendation, a Dangerous Hillside Order (DHO, No. DH20/NT/96/C) was served by Buildings Department on 25 June 1996 on the co-owners of Happy View House (BD, 1996). This required the co-owners to investigate the retaining wall and submit proposals for remedial measures.

Landslide Incident No. MW97/6/12 occurred on 4 June 1997, downslope of the above retaining wall. At the default of the co-owners, BD appointed Fugro (HK) Limited (FHL) on 4 June 1997 "to carry out the works required by the DHO and works to be necessary to make the land and structure safe" (BD, 1997). Inspections by FHL indicated the potential for "further widening and movement of existing cracks" and they recommended "demolition of part of the wall where instability has occurred be carried out immediately" (FHL, 1997). Demolition of part of the wall was completed by late July 1997.

FHL also recommended further geotechnical evaluation of the wall and ground

investigation works were carried out in November 1997. The fieldwork was undertaken by Enpack (HK) Limited (EHL), and the findings were summarised in a report dated December 1997 (EHL, 1997). Interpretation and analysis of the investigation by FHL was ongoing at the time of preparation of this report.

2.3.3 Water Leakages and Erosion Beneath Golden Time Villas

As a result of a complaint in November 1996 by one of the residents concerning water seepage and soil erosion beneath Nos. 1 to 5 Golden Time Villas, the GEO and Highways Department (HyD) jointly inspected the site and "found that serious leakage from the sewerage system had occurred due apparently to lack of maintenance, which resulted in soil erosion on the slope underneath the decked structure". Following the inspection, the GEO made recommendations to BD supporting issue of a Drainage Order to the owners of Golden Time Villas, requiring them to carry out works to prevent further leakages from their buildings.

Subsequent inspections and investigations by BD confirmed leakages from the ground floor slab, a suspended manhole and a broken pipe. Advisory Letters were served on the owners of Nos. 1 to 5 Golden Time Villas on 21 May 1997, requesting them to investigate and repair the drains and pipes and to report the results to BD. Inspection of the site by HAP in February 1998 indicated that foul and surface water continues to leak from the structure. A pipe discharging a continuous flow on to the slope downhill of the structure was also noted during the inspection.

The GEO have subsequently reiterated their recommendation to BD for issue of a Drainage Order to the owners of Golden Time Villas.

2.4 Subsurface Conditions

Sheet 7 of the Hong Kong Geological Survey 1:20 000 Map Series (GCO, 1986) indicates that the site is predominantly underlain by coarse-grained granite (Figure 4). The southeast part of the hillside, adjacent to Tai Po Road is underlain by fine-grained granite. The geological map also shows a north-northwest to east-southeast trending fault line that extends through the Woodcrest Hill development and beneath Golden Time Villas (Figure 4).

The Geotechnical Area Studies Programme (GASP) Engineering Geology map for the area (GCO, 1987) confirms the granitic bedrock and shows a body of colluvium at the mouths of three of the gullies at the location of the Woodcrest Hill development (Figure 4). Slopes to the northeast of Woodcrest Hill, shown as areas of "general instability" on the GASP plan (Figure 4), predominantly exclude the areas of the 1997 landslides considered by the present study.

The locations of exploratory holes sunk for the recent geotechnical investigation of Retaining Wall No. 7SW-D/R2 (see Section 2.3.2 above) are shown on Figure 4, and the materials encountered are summarised in Table 3. Of particular significance to the damage to the retaining wall, trial pit TP4 indicates that the southwest corner of the structure is founded at a depth of about 1.75 m on material described as fill, which was recorded to a depth of 2.7 m. Completely decomposed coarse-grained granite was encountered beneath the fill. Trial pit TP5,

also at the toe of the retaining wall and within the main scarp of the landslide, identified 0.5 m of fill, overlying 1.5 m of residual soil, which overlay on 1 m of completely decomposed granite (Table 3). This pit did not, apparently, expose the foundations of the wall.

A single piezometer was installed in borehole BH1 on 17 November 1997 within moderately decomposed granite at a depth of about 20 m below ground. Monitoring during the dry season between 18 November and 25 November 1997 indicated a groundwater level of about 11.8 m below ground. Higher groundwater could be expected during the wet season.

3. THE LANDSLIDES

3.1 Incident No. MW97/6/12

3.1.1 Time of the Landslide

Records held at Tin Sum Police Station, Sha Tin, show that Incident No. MW97/6/12 was reported to the Police by a resident at 08:41 hours on 4 June 1997. Residents in the area and employees of the management company of Woodcrest Hill interviewed by HAP all estimated the time of failure to be between 07:00 hours and 09:00 hours. The landslide, therefore, probably occurred at some time between 07:00 hours and 08:41 hours. No other witnesses could provide a more precise timing for the failure. The landslide was reported to the GEO by a resident of Woodcrest Hill at 11:00 hours on the same day. A landslip warning was issued at 07:40 hours on 4 June 1997.

3.1.2 Description of the Landslide

Details and observations of the landslide made during site inspections are summarised in Figure 5, and a representative cross-section through the landslide is presented in Figure 6. Photographs of the landslide are presented in Plates 1 to 5.

The landslide originated near the crest of the slope at the toe of the cracked section of Retaining Wall No. 7SW-D/R2 (Plate 1). The main scarp was about 20 m long and 15 m wide, with an average depth of about 1.5 m (Plate 2, Figures 5 and 6). The volume of failed material was estimated to be about 150 m^3.

The majority of displaced material travelled down the natural gully and came to rest within the garden area of a first floor flat at No. 9 Woodcrest Hill (Plate 3). The debris stripped the dense vegetation along a parallel-sided track, 9 m to 10 m wide, in the base of the gully.

The debris, which consisted of pale-orange, coarse-grained silty sand, was very wet and was deposited in a layer typically between 0.1 m and 0.2 m thick. An intact raft of material, heavily vegetated with bamboo, came to rest at the toe of the slope (Plate 4).

A second, larger raft of about 30 m^3 of the vegetated hillslope remained near the western part of the main scarp, from which it had been displaced by only about 1 m.

The maximum horizontal travel distance of the failed mass was about 90 m. The travel angle of the landslide debris, measured from the crest of the failure to the distal end of the debris raft in the second raised garden area (Figure 6), was 28°. According to Wong & Lam (1996), the debris mobility is comparable to that of other natural terrain landslides which could have been subjected to some influence of surface water.

It was not possible to safely access the main scarp of the failure, but the exposed material appeared to be significantly more granular than the underlying residual soil encountered in trial pit TP5, formed subsequently at the central part of the main scarp (Figures 4 and 6). This observation, together with the known deposition of fill in the head of the gully during the development of Happy View House, suggest that the material involved in the failure was predominantly fill. The failure appeared to have originated as a sliding failure within this material.

An 80 mm diameter metal pipe, which previously crossed the area, was ruptured by the landslide, and a 10 m long segment was evident on the displaced raft (Figure 5). Records obtained from the Water Supplies Department (WSD) indicate that this pipe was a private mains supply installation. Reports from the Management Office of Woodcrest Hill indicate that the supply to the pipe was turned off after the failure in order to restrict discharge of water on to the slope.

The approximate layout of the drainage pathways associated with Happy View House is shown in Figure 5. Stormwater and the principal underground foulwater outlets from the buildings, together with run-off from the platform above Retaining Wall No. 7SW-D/R2, discharge to a septic tank northeast of the landslide location. Surface water channels also transmit used water from Happy View House and Albert Villa into a channel at the toe of the southwest face of Retaining Wall No. 7SW-D/R2. This channel is believed to have connected with the stepped channel at the centerline of the gully.

Following the landslide, HyD cleared the landslide debris and applied a surface protection of shotcrete, in accordance with the GEO's recommendations. Further movements of the retaining wall were noted by FHL ten days after the landslide, prompting the urgent works as described in Section 2.3.2. During HAP's inspections, it was noted that there were considerable signs of distress immediately upslope of the wall. In addition to the tilted guardhouse noted by OAP (1995), there are cracks in the adjacent hardstanding area and within the northeast wall around Albert Villa (Figure 5).

3.2 Incident No. MW97/6/23

3.2.1 Time of the Landslide

Incident No. MW97/6/23 was reported to the GEO by the Management Office of the Woodcrest Hill development at 17:00 hours on 5 June 1997. An employee of the Management Office indicated that the failure had occurred at 08:00 hours on 4 June 1997. No other witnesses to the landslide were identified. A landslip warning had been issued at this time (Section 3.1.1 above).

3.2.2 Description of the Landslide

Observations of the landslide made during site inspections are summarised in Figure 7, and a representative cross-section through the landslide is presented in Figure 8. Photographs of the landslide are presented in Plates 6 to 12.

The landslide originated in apparent natural terrain, from an area of the slope about 15 m southeast of Golden Time Villas. The failure produced a main scarp about 25 m long, up to 11.5 m wide and with an average depth of 1.5 m (Plate 7, Figures 8 and 9). The volume of the failed mass was estimated to be about 170 m^3.

The failure occurred predominantly in colluvium and the overlying fill. A heavily stained surface of highly decomposed granite was exposed beneath these superficial materials in the upper part of the main scarp. The morphology of the main scarp suggests that the landslide may have occurred in three phases (Figure 7). The initial failure was probably the largest, with an estimated volume of 130 m^3. Debris from this failure, including a vegetated raft, which travelled about 65 m down the gully and was deposited in a relatively flat area above a retaining wall behind No. 12 Woodcrest Hill (Plate 11 and Figure 7). Some of the debris from this phase of the failure was deposited within the stream bed near the toe of the main scarp. Debris from two subsequent, retrogressive failures totalling about 40 m^3 in volume, appeared to have been retained largely within the main scarp. Material retained in the main scarp had been subjected to significant erosion by post-failure surface water flow.

The travel angle of the landslide debris, as measured from the crest of the failure to the distal end of the debris raft, was 23°. This indicates a relatively high debris mobility, which is probably related to the influence of surface water (Wong & Lam, 1996).

A number of water-carrying pipes were noted on the southeast wall of the podium of Golden Time Villas (Figure 7). Two pipes at the southwest corner of the podium, appear to discharge stormwater into the ephemeral streamcourse northwest of the landslide location. A further vertical stormwater drain pipe is attached to the podium at a position directly upslope of the landslide location (Figure 7). At this location, two smaller diameter pipes also emerge horizontally from the podium structure. One of these was observed to emit apparently clean water with estimated flows of between about 5 and 10 litres per minute during numerous inspections by HAP throughout the investigation. The second pipe has not been observed to discharge water but is associated with abundant growth of algae and vegetation and a strong odour, and appears to be a foulwater discharge pipe.

Retrogression of the landslide, and the narrowing of the main scarp in an upslope direction, suggest that a concentrated source of water may have initiated the development of the failure. Three erosion pipes were also observed within the colluvium and fill which indicate that groundwater flows had occurred in the near-surface materials at the landslide site. It is possible that the groundwater flow that formed the erosion pipes is related to the ongoing discharge of water on to the slope from Golden Time Villas. No seepages were observed from the erosion pipes during an inspection of the landslide site on the day following the failure.

Substantial re-working of the debris occurred after the failure and resulted in progressive inundation of the playground and carpark area near No. 12 Woodcrest Hill. It appears likely that

this was predominantly the result of stormwater flow within the streamcourse, but also by surface water flow through the main scarp, possibly originating from Golden Time Villas. An incised streambed was also observed downstream of the catchpit at the toe of Slope No. 7SW-D/C167, which suggests that strong surface water flows may have been generated at that location. These may also have contributed to the reworking of the landslide debris.

Another landslide (Incident No. MW97/7/25) occurred on 2 July 1997 to the northwest of Incident No. MW97/6/23, affecting the ground next to the southwest corner of Golden Time Villas (Figure 1). According to the GEO Incident Report, this failure involved about 10 m^3 of fill or residual soil and was attributed to infiltration. The debris travelled down the gully and also inundated the recreational areas of No. 12 Woodcrest Hill.

4. RAINFALL

The nearest GEO automatic raingauge (No. N01) is located at the Administration Block of Sha Tin Water Treatment Works, about 750 m south of the landslides. Daily rainfall recorded at the raingauge between 4 May 1997 and 8 June 1997, and hourly rainfall between 1 June and 4 June 1997, are shown in Figures 9a and 9b respectively. Figure 10 shows the location of GEO raingauge No. N01 and presents the isohyets of rainfall recorded between 01:45 hours and 10:00 hours on 4 June 1997.

Rainfall on 4 June 1997 started at about 01:00 hours and continued until about 10:00 hours. The storm was at its most intense between 06:00 hours and 09:00 hours when 209 mm of rainfall was recorded. The maximum rolling hourly rainfall prior to both incidents was 81.5 mm, recorded between 06:15 hours and 07:15 hours on 4 June 1997.

Tables 4 and 5 present estimated return periods of maximum rolling rainfall recorded before each failure for selected durations, based on historical rainfall data at the Hong Kong Observatory (Lam & Leung, 1994). The analysis for Incident No. MW97/6/12 includes rainfall recorded before 08:40 hours, approximately the time when the failure was reported to the Police. The analysis for Incident No. MW97/6/23 includes only rainfall recorded before 08:00 hours, the probable time of the failure. The 4-hour rainfall for Incident No MW97/6/12, and the 2-hour rainfall for Incident No. MW97/6/23, were the most severe, with a corresponding estimated return period of 22 years and 9 years respectively.

Historical records of rainfall at GEO raingauge No. N01 are presented in Figure 11. The figure shows that the maximum hourly rainfall on 4 June 1997 (72 mm recorded between 06:00 hours and 07:00 hours and also between 07:00 hours and 08:00 hours), was the fifth highest since records began in 1984. The daily rainfall on 4 June 1997 was the highest on record, though only 296.5 mm of this fell before 08:40 hours, around the time that Incident No. MW97/6/12 was reported to the Police. 240 mm of the daily rainfall total fell before the reported time of Incident No. MW97/6/23 at 08:00 hours. It should be noted, however, that figures derived from clock-based rainfall data do not provide a basis for direct comparison of the relative severity of the rainfall events in the periods covered.

5. PROBABLE CAUSES OF THE LANDSLIDES

5.1 Incident No. MW97/6/12

This landslide is considered to have resulted from a combination of the following factors:

(a) the topographic setting involving a pre-existing gully and drainage line which provided a location for the disposal of fill,

(b) a lack of control in the placement of fill, which was probably inadequately compacted, the absence of a protective surface to the fill, and locally oversteep slope faces,

(c) discharge of foulwater from developments at the slope crest onto the natural hillside below, and

(d) heavy rainfall.

The landslide involved a shallow sliding failure along a surface which may have followed the base of the fill. The landslide coincided with the heavy rainfall on 4 June 1997 which probably triggered the failure. The intensity of the rain which fell in the four hours before the failure was severe, having an estimated return period of 22 years.

Five possible sources of water at the landslide site were considered, namely:

(a) localised run-off or discharge of stormwater from the platform and/or the drainage system,

(b) leakage of water from the mains water supply pipe which crossed the landslide area,

(c) seepage of groundwater from the fill platform upslope,

(d) discharge of foulwater from the drainage systems of Happy View House and Albert Villa on to the slope, and

(e) direct infiltration of rainfall.

The drainage system of the platform area is designed to collect and transmit stormwater to a septic tank away from the landslide location (Figure 5). Interviews with residents of Happy View House indicated that the system generally functions properly and that accumulation and flow of water from the platform area was not observed prior to the failure and has not been seen during previous heavy rainfall events. Run-off or stormwater discharge from the platform, therefore, appears to be an unlikely source of water. Similarly, there was no evidence, according to the residents, to indicate that leakage of water from the pipe occurred before the landslide.

The drainage system at the crest does, however, discharge used water from both Albert Villa and Happy View House into the stepped channel in the gully in the area of the main scarp. It is probable that leakage of water on to the slope from these channels, which appear to be old and in a generally poor condition, has occurred for many years. This probably contributed little to triggering the failure but may have helped to maintain a higher degree of saturation at the part of the slope where the failure occurred. The possibility that water leaking from the underground foulwater sewers in the platform also entered the landslide area cannot be discounted.

It is considered that direct infiltration of heavy rainfall was probably the principal source of water. The retaining wall dictated the upslope extent of the failure and may have provided a line of concentrated infiltration of rainfall running down the face of the wall. Rainfall infiltrated the unprotected, relatively permeable fill and it is possible that transient seepage pressure or a perched water table developed near the base of the fill at its interface with the underlying more cohesive and probably less permeable materials. Wetting of the fill and increase in porewater pressure would have resulted in a reduction in the available shear strength, leading to failure.

5.2 Incident No. MW97/6/23

The landslide is considered to have resulted from a combination of the following factors:

(a) the topographic setting within an essentially natural drainage line in which there is evidence of earlier minor failure on its steep flanks, and a tendency for headward retreat by the ongoing natural processes of gully development,

(b) the leakage or discharge of water from pipes associated with Golden Time Villas onto the hillside below,

(c) the presence of unprotected fill and colluvium on the slope above the failure into which the water sources generated from Golden Time Villas infiltrate, and

(d) heavy rainfall.

The landslide was a shallow sliding failure at the base of a layer of colluvium underlain by highly decomposed granite. The colluvium was overlain by a thin layer of fill. The landslide coincided with the heavy rainfall on 4 June 1997 which probably triggered the failure.

It is probable that groundwater pressure developed in the fill and colluvium above the interface with the underlying weathered rock. Infiltration into the slope above the landslide would have been facilitated by the presence of the unprotected fill. Groundwater flow towards the landslide site was assisted by erosion pipes, which were subsequently exposed within the main scarp.

Stormwater flows discharging from Golden Time Villas and heavy rainfall were probably the main sources of water infiltration into the hillside. Intermittent discharges of smaller volumes of foulwater probably made relatively little contribution to the failure but

would have helped to maintain a higher degree of saturation at the part of the slope where the failure occurred. The effect of the possible discharge of clean water is less certain. If, as seems probable, there were discharges since the time of the GEO's inspection in February 1997, which noted "a splashing sound associated with free fall of water", this source would also have contributed to the maintenance of the wet condition in the slope. The discharge may also have influenced the secondary failures with the main scarp of the landslide which retrogressed towards the point of discharge onto the slope.

Assuming the reliability of the single witness, Incident No. MW97/6/23 may have occurred earlier in the storm than Incident No. MW97/6/12, and would therefore have received less rainfall prior to failure. This may suggest that water emanating from Golden Time Villas could be of greater influence in causing the landslide than water entering the slope by direct infiltration of rainfall.

The mobility of the landslide debris and its travel distance were significantly increased by the surface water flow within the stream. The flow would have been high at the time of the failure because of stormwater discharged into the stream from Golden Time Villas, and run-off from Slope No. 7SW-D/C167, below Ascot Villas (Figure 3). The topographic catchment of the gully is much larger than that of the landslide below Happy View House (Incident No. MW97/6/12). It is also possible that the rainfall intensity at the time of Incident No. MW97/6/23 was greater. These factors may help to explain the greater apparent mobility of the debris from Incident No. MW97/6/23.

6. CONCLUSIONS

The landslides described in this detailed study were part of a cluster of nine landslides that occurred in the Sha Tin Heights area during 1997.

Incident No. MW97/6/12 was a shallow sliding failure from a body of fill which had been deposited at the crest of the slope during construction of the adjacent Happy View House in the 1960's. The failure was probably caused primarily by infiltration of rainfall, which was relatively severe in the period immediately before the landslide, together with possible prolonged leakage from the drainage channels in the area. The infiltration would have resulted in wetting up of the slope and may have enabled transient groundwater pressures to develop in the fill above the more cohesive underlying materials, thereby reducing the available shear strength and causing failure.

Incident No. MW97/6/23 was a shallow sliding failure within fill and colluvium above the interface with the underlying weathered granite on the steep flank of a natural gully. It is concluded that this landslide may have been affected by the discharge of stormwater from Golden Time Villas. Water from these sources may have led to the development of transient groundwater pressures in colluvium above the underlying weathered granite thereby reducing the available shear strength and causing failure.

7. REFERENCES

Buildings Department (1996). Retaining Wall No. 7SW-D/R2 at Lot 1474 in DD189 Sha Tin, N.T. Buildings Department Correspondence to Lot Owner, reference BD/DH/399/95/NT, dated 25 June 1996, 6 p.

Buildings Department (1997). DH Order No. DH20/NT/96/C Retaining Wall No. 7SW-D/R2 at 19-23 Sha Tin Heights Road, Sha Tin, New Territories – Lot 1474 in DD189. Correspondence to John Ip & Co., Solicitors to Owners of No. 23 Sha Tin Heights Road, reference DH399/95/NT, dated 19 June 1997.

Binnie & Partners (1977). Preliminary Studies for the Special Investigation into Fill Slopes: Slope No. 7SW-D/F3. Technical Report, Binnie & Partners (HK) Limited, Consulting Engineers to Hong Kong Government, 2 p.

Binnie & Partners (1978). Landslide Studies Phase 1 Re-appraisal Cut & Natural Slopes & Retaining Walls: Feature No. 7SW-D/R2. Technical Report, Binnie & Partners (HK) Limited, Consulting Engineers to Hong Kong Government, 2 p.

Enpack (HK) Limited (1997). Default Works at 19-23 Sha Tin Heights Road, Sha Tin New Territories. Final Ground Investigation Fieldwork Report, Enpack (Hong Kong) Limited, Term Consultants to Hong Kong Government, under Contract No. GE 95/10 and Agreement No. CE 84/95, December 1997, 9 p, plus 2 tables and 11 appendices.

Fugro (HK) Limited (1997). Default Case No. 14 – Nos. 19-23 Sha Tin Heights Road, New Territories, Urgent Repair Works. Correspondence to Buildings Department, reference U11824/CF/3574, dated 14 June 1997, Fugro (HK) Limited, Consulting Engineers to Buildings Department, 2 p.

Geotechnical Control Office (1986). Sha Tin : Superficial and solid geology. Hong Kong Geological Survey, Map Series HGM 20, Sheet 7, 1:20 000 scale. Geotechnical Control Office, Hong Kong.

Geotechnical Control Office (1987). Geotechnical Area Studies Programme – Central New Territories. Geotechnical Control Office, Hong Kong, GASP Report No. II, 165 p, plus 4 maps.

Geotechnical Engineering Office (1992). Feature No. 7SW-D/R2, Behind No. 23 Sha Tin Heights Road. Stage 1 Study Report, Geotechnical Engineering Office, Hong Kong, 2 p.

Lam, C.C. & Leung, Y.K. (1994). Extreme rainfall statistics and design rainstorm profiles at selected locations in Hong Kong. Royal Observatory, Hong Kong, Technical Note no. 86, 89 p.

Ove Arup & Partners Limited (1995). Slope No. 7SW-D/R2 Behind No. 23 Sha Tin Heights Road, Sha Tin. Geotechnical Control Conference (GCC) Paper No. 333, 2 p, plus 2 figures, 3 plates and 2 appendices.

Wong, H.N. & Lam, K.C. (1996). 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).

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Table 1 – Summary Characteristics of 1997 Landslide Incidents in the Sha Tin Heights Road Area

GEO Incident No.	Location	Date of Failure	Estimated Volume (m^3)	Affected Feature Type	Failed Materials	Consequence
MW97/4/1	Sha Tin Heights Road, near Pink House	16 April 1997	2	Soil Cut Slope	Residual Soil / Completely Decomposed Granite	Partial blockage of road
MW97/6/12	Sha Tin Heights Road, below Happy View House	4 June 1997	150	Apparent Natural Terrain	Fill?	Building lot affected
MW97/6/23	Sha Tin Heights Road, below Golden Time Villas	4 June 1997	170	Apparent Natural Terrain	Fill, Colluvium, Weathered Granite	
MW97/7/6	Sha Tin Heights Road, below platform of No. 11 Pink House	2 July 1997	5	Soil Cut Slope	Residual Soil	Partial blockage of road
MW97/7/15	Below No. 19 Sha Tin Heights Road	2 July 1997	600	Apparent Natural Terrain	Debris flow deposits / Residual Soil / Weathered Granite	Debris piled up against building of No. 8004 Tai Po Road; minor damage to windows
MW97/7/25	Adjacent to Golden Time Villas	2 July 1997	10	Apparent Natural Terrain	Fill / Residual Soil	Debris inundated car park at mouth
MW97/7/90(A)	Natural terrain below Pink House	Unknown	30	Apparent Natural Terrain	Residual Soil	Building lot affected
MW97/7/90(B)	Natural terrain below Pink House	Unknown	30	Apparent Natural Terrain	Residual Soil	
MW97/7/16	Sha Tin Heights Road, below Pink House	2 July 1997	25	Masonry-faced / soil cut slope	Residual Soil	Road blocked

Notes: (1) Refer to Figure 1 for locations of the above landslide incidents.

(2) Information based principally on GEO Incident Reports and HAP Inspection Records, where available.

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

Information Source	Reference	Principal Relevant Content/Comment
Mainland West Division, GEO	File No. 6/9200/94	Relating to development between Happy View House and Albert Villas: (a) Geotechnical Assessment Report by Greg Wong and Associates Ltd. dated September 1994. (b) Geotechnical Assessment Report by MAA Engineering Consultants Ltd. dated June 1997.
	File No. DH667/93/NT	Relating to Incident MW93/6/51 and leakage of foulwater from Golden Time Villas.
	GCMW 2/9123/97	Geotechnical Approval of Building Plans for the development site between Happy View House and Albert Villas.
	File No. 6/9372/79	Relating to the construction of a water tank at Woodcrest Hill (not relevant to this study).
	DH399/95/NT	Relating to issue of Dangerous Hillside Order for Retaining Wall No. 7SW-D/R2.
	GCMW 7SW-D/R2	Relating principally to issue of Dangerous Hillside Order for Retaining Wall No. 7SW-D/R2.
Design Division, GEO	GCD 2/A1/7SW-D/R2	Details relating to issue of Dangerous Hillside Order for Retaining Wall No. 7SW-D/R2.
	GCD 2/A1/7SW-D/F3	General information relating to slope which was not directly relevant to the study.
	Stage 1 Study Report for Feature No. 7SW-D/R2	Completed in 1992; identified no signs of distress but further study recommended.
	Fill slope and Cut Slope Master Lists, LPM Quarterly Reports and Stage 1 and 2 Study Registers, etc.	Status of relevant features within the LPM Programme.

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

Information Source	Reference	Principal Relevant Content/Comment
Planning Division, GEO	Natural Terrain Landslide Inventory	No natural terrain landslides identified in the area.
	SIFT Reports for Feature Nos. 7SW-D/R2 and 7SW-D/F3 and Cut Slope No. 7SW-D/CR169	Construction date, geometry, general condition and recommendations for further study.
	File No. GCP 1/3/250 f(36)	Not relevant to study area.
Slope Safety Division, GEO	SIRST Reports for Features 7SW-D/R2 and 7SW-D/F3 and Cut Slope No. 7SW-D/CR169	1995 SIRST inspection records for Retaining Wall No. 7SW-D/R2. SIRST background information check and inspection report for Slope No. 7SW-D/F3 were not available at time of preparation of this report.
Published Reports and Documents	Geotechnical Area Studies Programme Report II: Central New Territories	Background geological and geomorphological information of area
	Hong Kong Geological Survey Memoir No. 1: Sha Tin	
	Hong Kong Geological Survey Geological Sheet No. 7 Sha Tin (1:20 000 Scale)	
Note: A review of the information database maintained by the GIU identified no information relating to Feature Nos. 7SW-D/R2, 7SW-D/F3 and 7SW-D/CR169.		

Table 3 – Summary of Materials Encountered by Exploratory Holes Completed During the Geotechnical Investigation of Retaining Wall No. 7SW-D/R2 (after EHL,1997)

Classification of Materials Encountered	Typical Description Given on Borehole/Trial Pit Logs	Depths (and Thickness) of Material Encountered in Particular Exploratory Holes (m)					
		BH1	TP1	TP2	TP3	TP4	TP5
Fill	Concrete pavement over sandy silty clay/sandy clayey silt with some to many gravel, cobble and occasional boulder sized quartz, rock, concrete, metal, wood and plastic fragments.	0.0-3.1 (3.10)	0-3 (>3)	0-2.7 (>2.7)	0-2.3 (2.3)	0-2.7 (2.7)	0-0.5 (0.5)
Granitic Residual Soil	Soft to firm reddish-brown sandy silty clay with some to much fine quartz gravel.	3.1-3.6 (0.5)	-	-	2.3-3.0 (>0.7)	-	0.5-2.0 (1.5)
Completely Decomposed Granite (CDG)	Extremely weak, yellowish grey to whitish grey, completely decomposed rock. (Sandy clayey SILT with some to many gravel and occasional cobble size quartz and rock fragments.)	3.6-11.1 (7.5)	-	-	-	2.7-3.0 (>0.3)	2.0-3.0 (>1)
Completely to Highly Decomposed Granite (CDG/HDG)	Extremely weak to very weak, yellowish grey to reddish brown, completely to highly decomposed rock. (Silty SAND with many gravel and occasional cobble sized quartz and rock fragments.)	11.1-11.9 (0.8)	-	-	-	-	-
Highly to Slightly Decomposed Granite (HDG/SDG)	Very weak to strong, yellowish-brown to grey highly/slightly decomposed rock.	11.9-20.06 (>8.16)	-	-	-	-	-

Table 4 – Maximum Rolling Rainfall at GEO Raingauge No. N01 for Selected Durations Preceding Incident No. MW97/6/12 and The Corresponding Estimated Return Periods

Duration	Maximum Rolling Rainfall (mm)	End of Period	Estimated Return Period (Years)
5 minutes	12.5	06:35 hours on 4 June 1997	2
15 minutes	28.5	06:45 hours on 4 June 1997	2
1 hour	81.5	07:15 hours on 4 June 1997	3
2 hours	144	09:00 hours on 4 June 1997	9
4 hours	225.5	09:00 hours on 4 June 1997	22
12 hours	305	09:00 hours on 4 June 1997	13
24 hours	308.5	09:00 hours on 4 June 1997	5
2 days	339	09:00 hours on 4 June 1997	4
4 days	341	09:00 hours on 4 June 1997	2
7 days	342	09:00 hours on 4 June 1997	2
15 days	346	09:00 hours on 4 June 1997	1
31 days	758.5	09:00 hours on 4 June 1997	3

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.

Table 5 – Maximum Rolling Rainfall at GEO Raingauge No. N01 for Selected Durations Preceding Incident No. MW97/6/23 and The Corresponding Estimated Return Periods

Duration	Maximum Rolling Rainfall (mm)	End of Period	Estimated Return Period (Years)
5 minutes	12.5	06:35 hours on 4 June 1997	2
15 minutes	28.5	06:45 hours on 4 June 1997	2
1 hour	81.5	07:15 hours on 4 June 1997	3
2 hours	144	08:00 hours on 4 June 1997	9
4 hours	176	08:00 hours on 4 June 1997	7
12 hours	240	08:00 hours on 4 June 1997	5
24 hours	246.5	08:00 hours on 4 June 1997	3
2 days	274	08:00 hours on 4 June 1997	2
4 days	276	08:00 hours on 4 June 1997	2
7 days	277	08:00 hours on 4 June 1997	1
15 days	281	08:00 hours on 4 June 1997	1
31 days	699	08:00 hours on 4 June 1997	2

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 upto one hour and from hourly data for longer rainfall durations.

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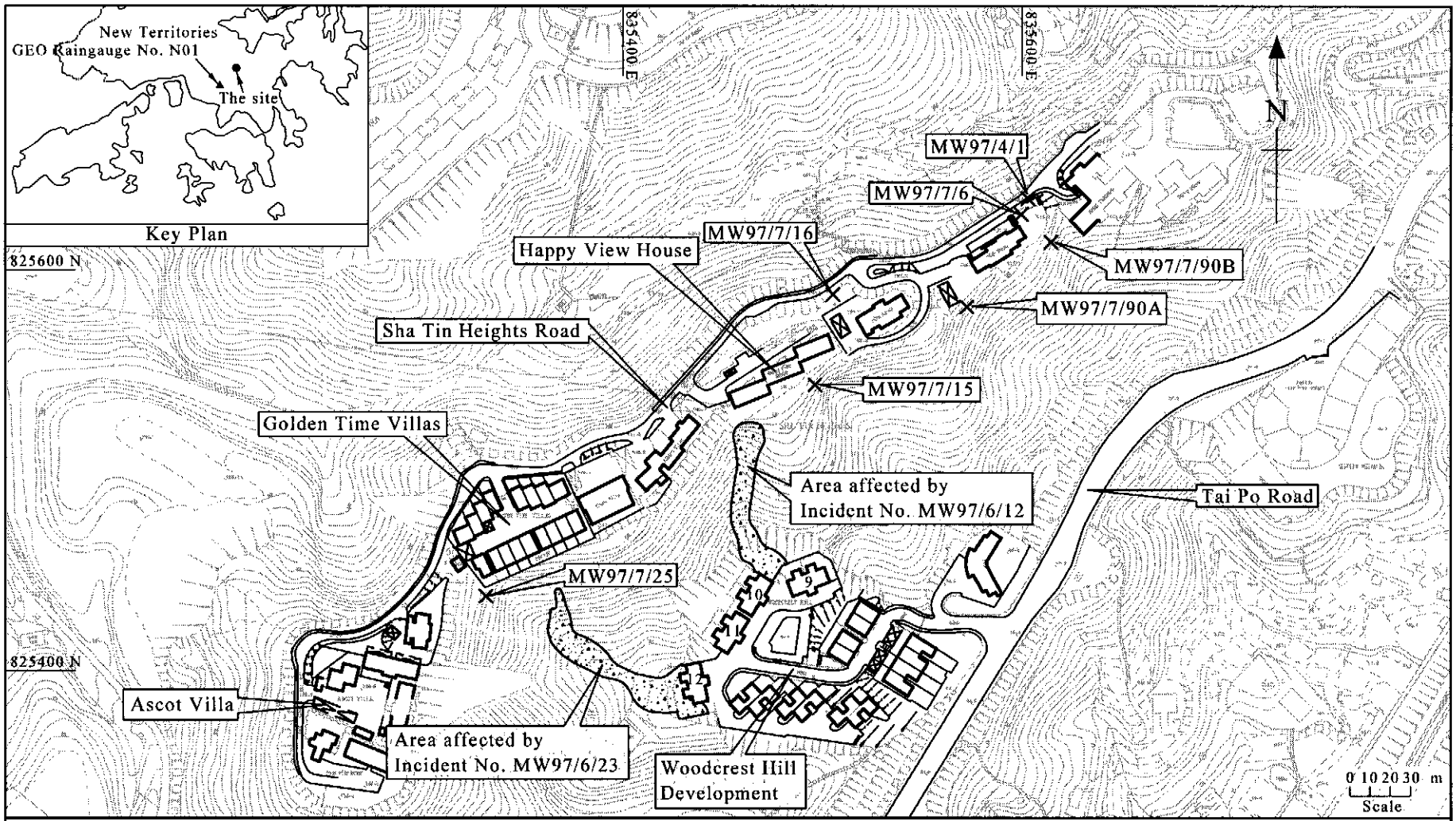


Notes : (1) Base map is extracted from Survey Sheet Nos. 7SW-19C and 7SW-19D dated October 1992 (Original scale 1:1 000).
(2) ✕ MW97/7/25 denotes location of main scarp and the GEO Incident No. of other 1997 landslides in the area.

Legend : 1997 landslide & GEO Incident No. considered in detail by this report

Figure 1 - Location Plan

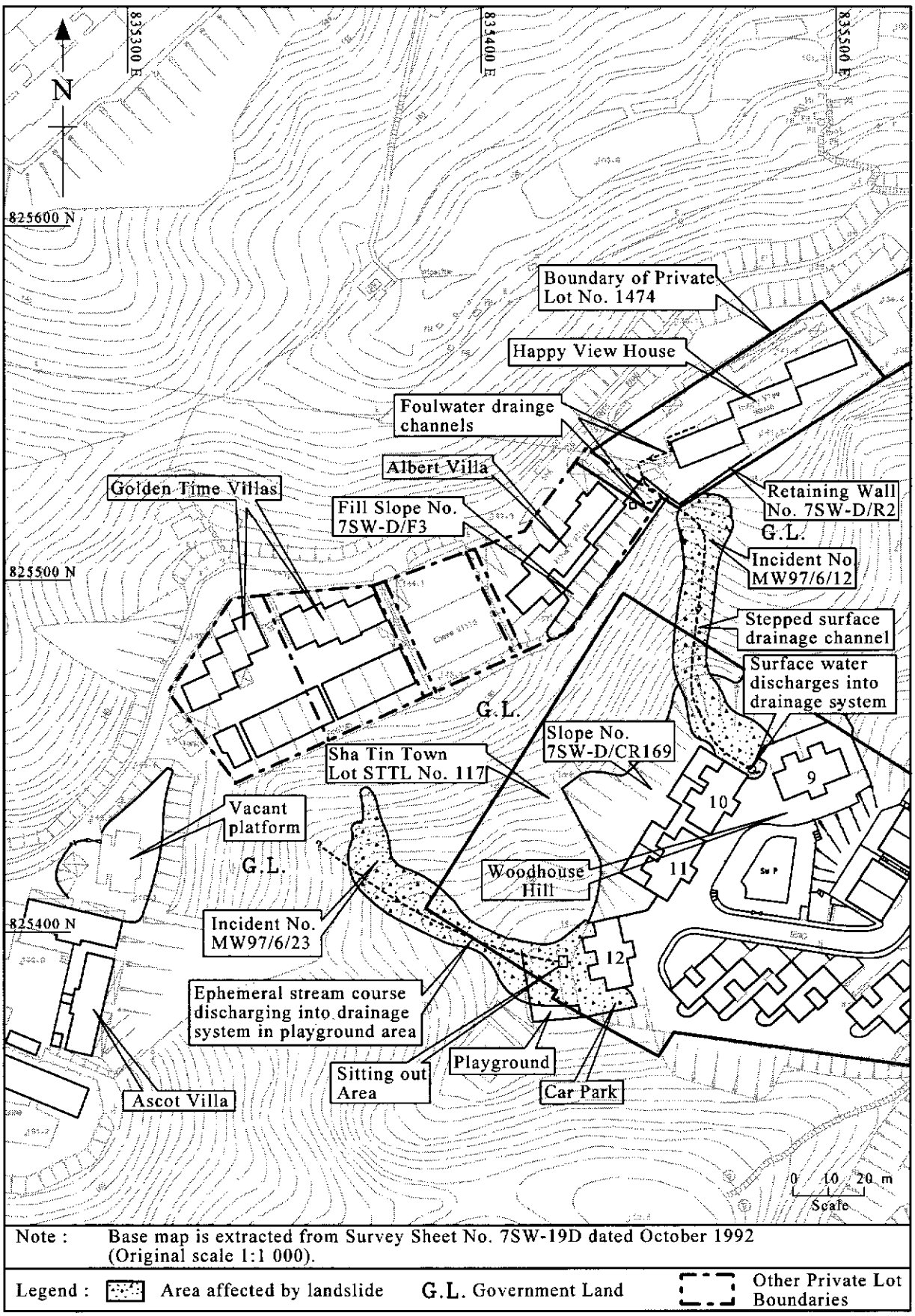


Figure 2 - Site Plan

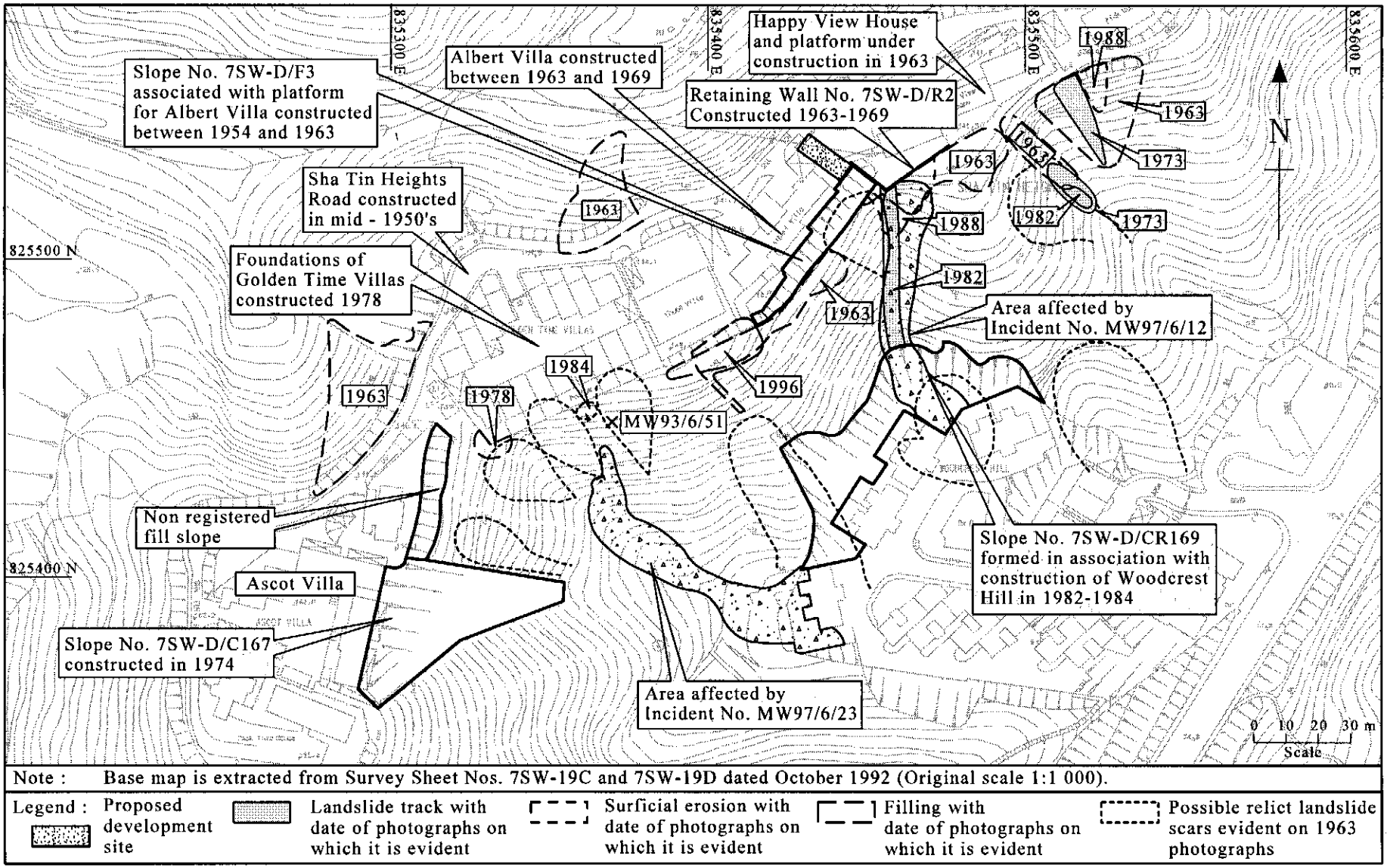


Figure 3 - Site History

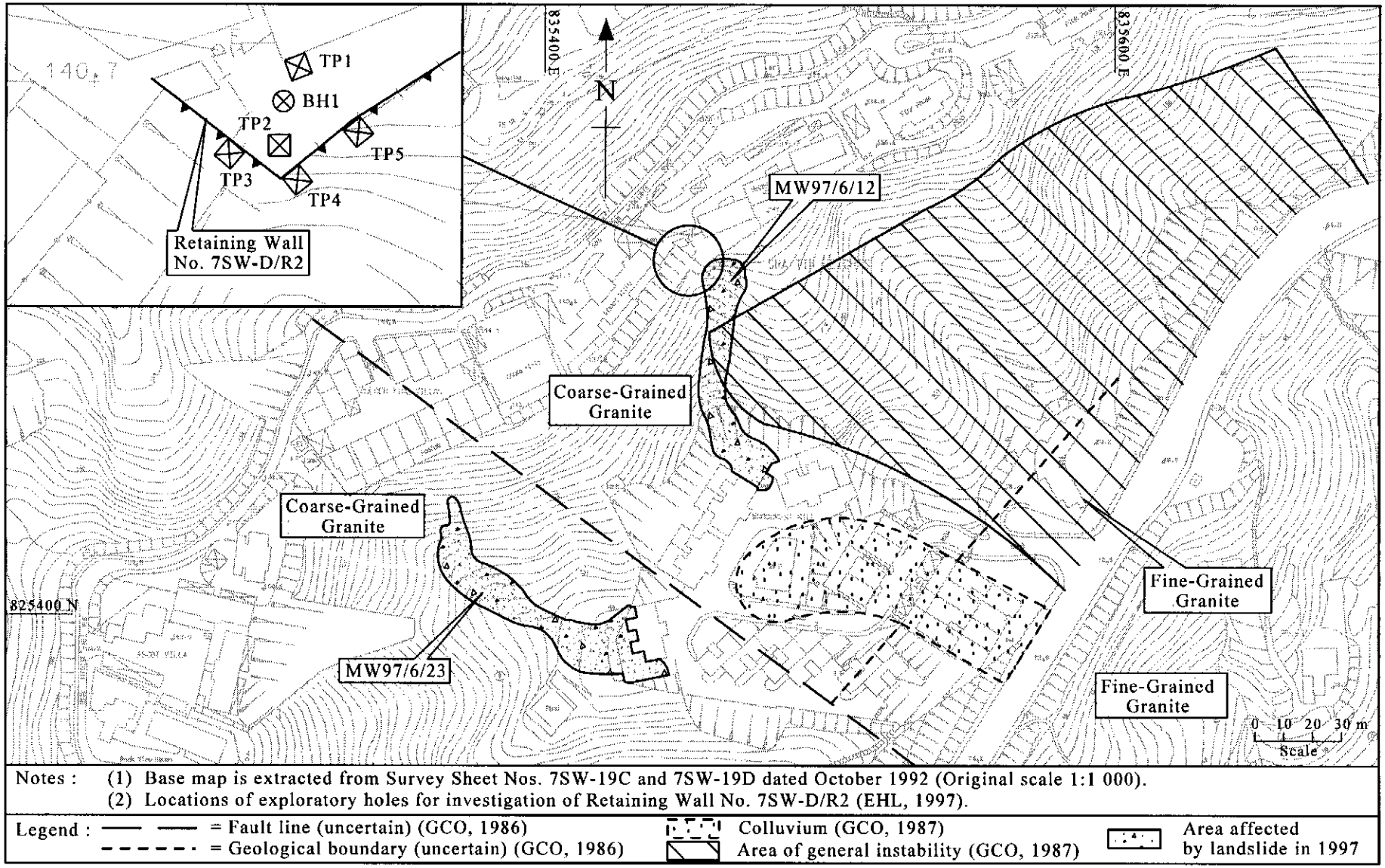
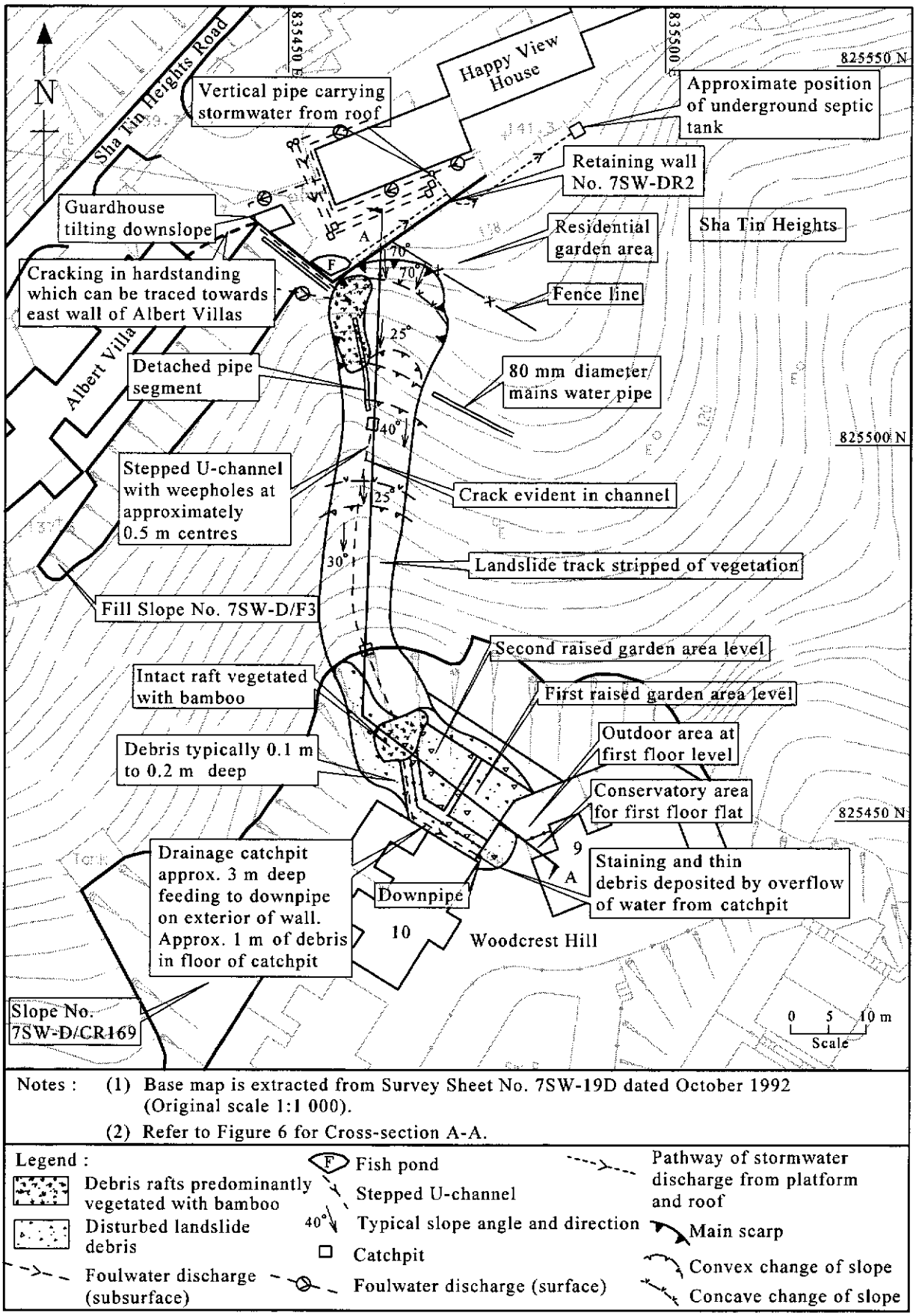


Figure 4 - Geology and Location of Existing Exploratory Holes



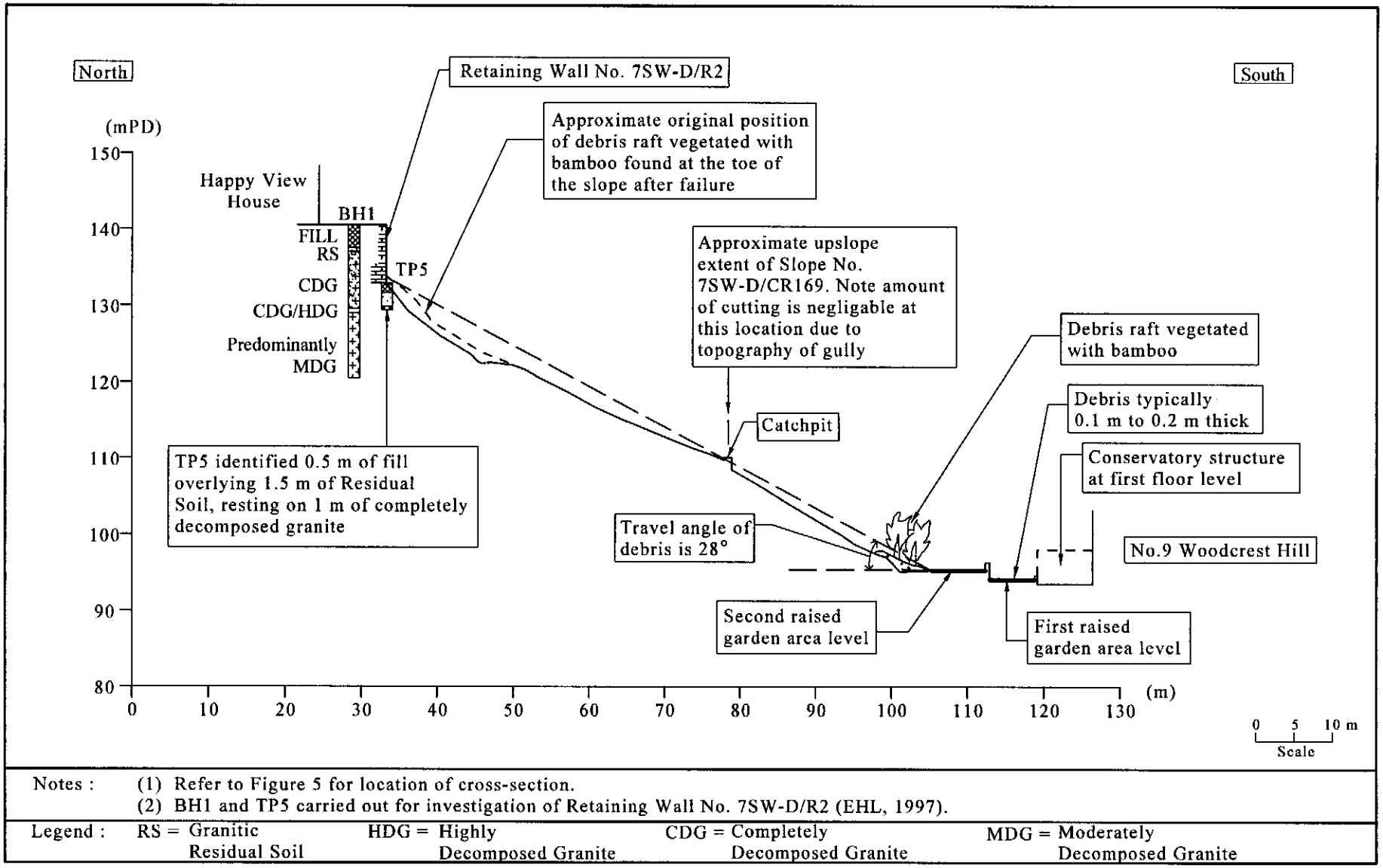
Notes : (1) Base map is extracted from Survey Sheet No. 7SW-19D dated October 1992 (Original scale 1:1 000).

(2) Refer to Figure 6 for Cross-section A-A.

Legend :

- Debris rafts predominantly vegetated with bamboo
- Disturbed landslide debris
- Foulwater discharge (subsurface)
- Fish pond
- Stepped U-channel
- 40° Typical slope angle and direction
- Catchpit
- Foulwater discharge (surface)
- Pathway of stormwater discharge from platform and roof
- Main scarp
- Convex change of slope
- Concave change of slope

Figure 5 - Site Plan and Details of Landslide Incident No. MW97/6/12



Notes : (1) Refer to Figure 5 for location of cross-section.
(2) BH1 and TP5 carried out for investigation of Retaining Wall No. 7SW-D/R2 (EHL, 1997).

Legend : RS = Granitic Residual Soil; HDG = Highly Decomposed Granite; CDG = Completely Decomposed Granite; MDG = Moderately Decomposed Granite

Figure 6 - Cross-section A-A Through Landslide Incident No. MW97/6/12

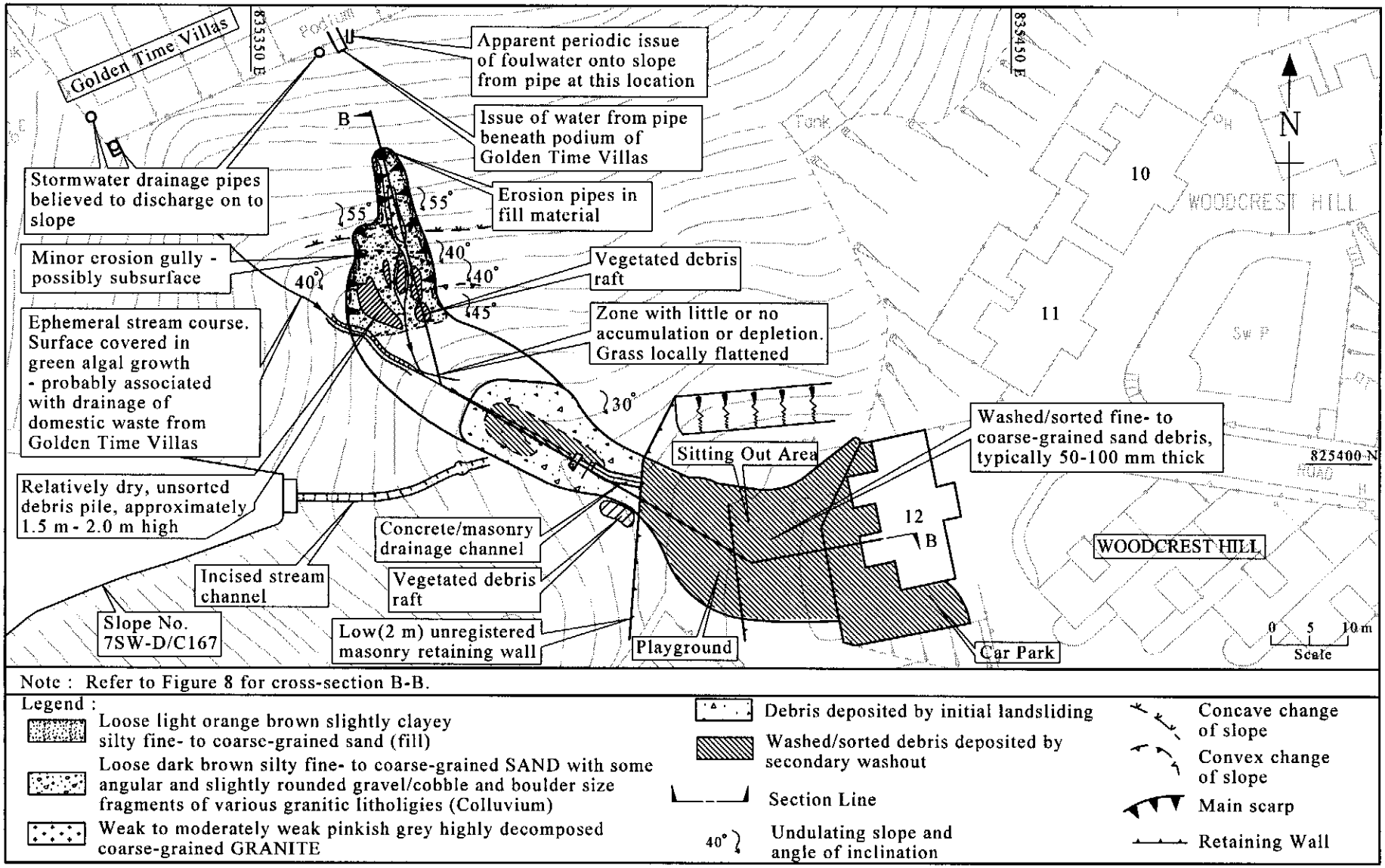
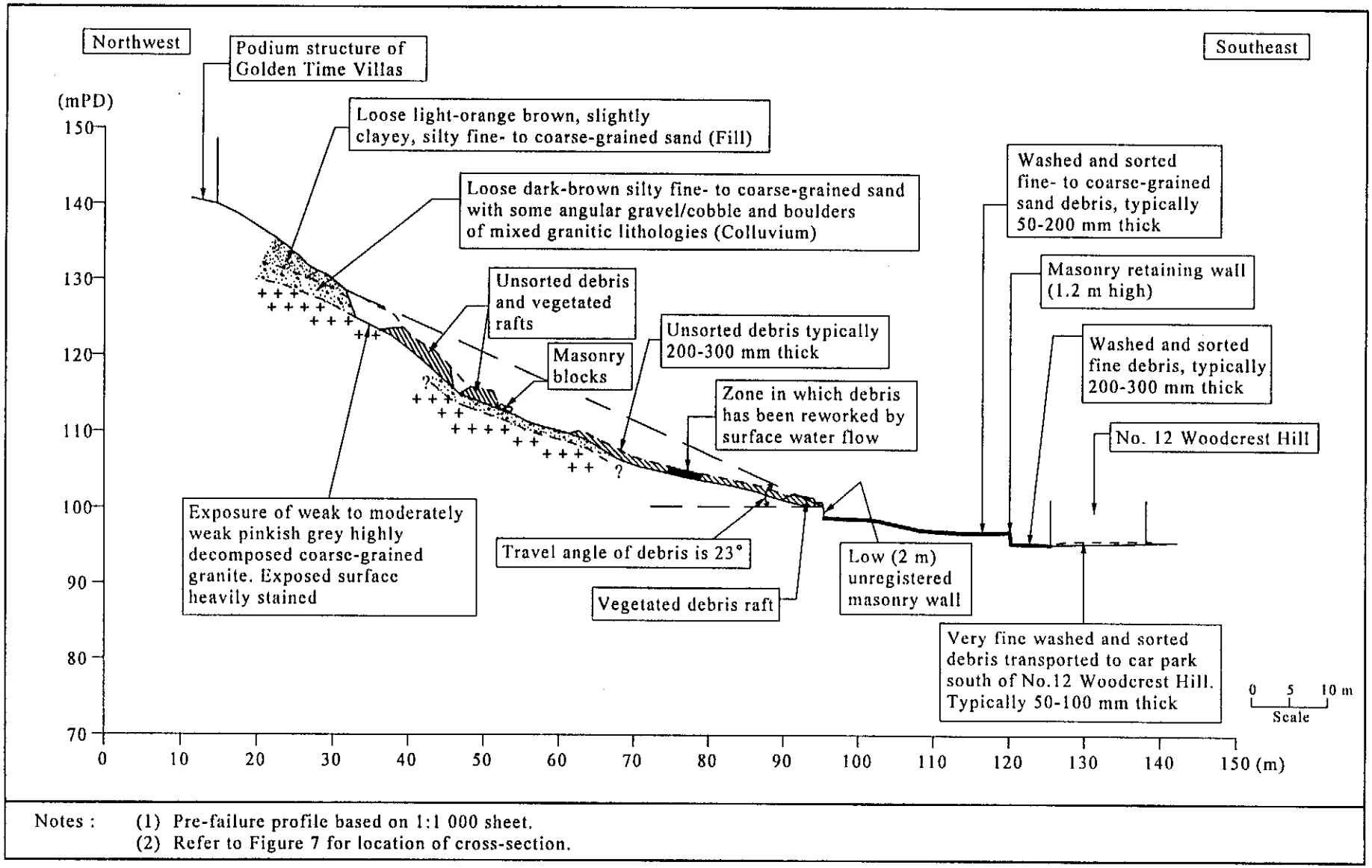
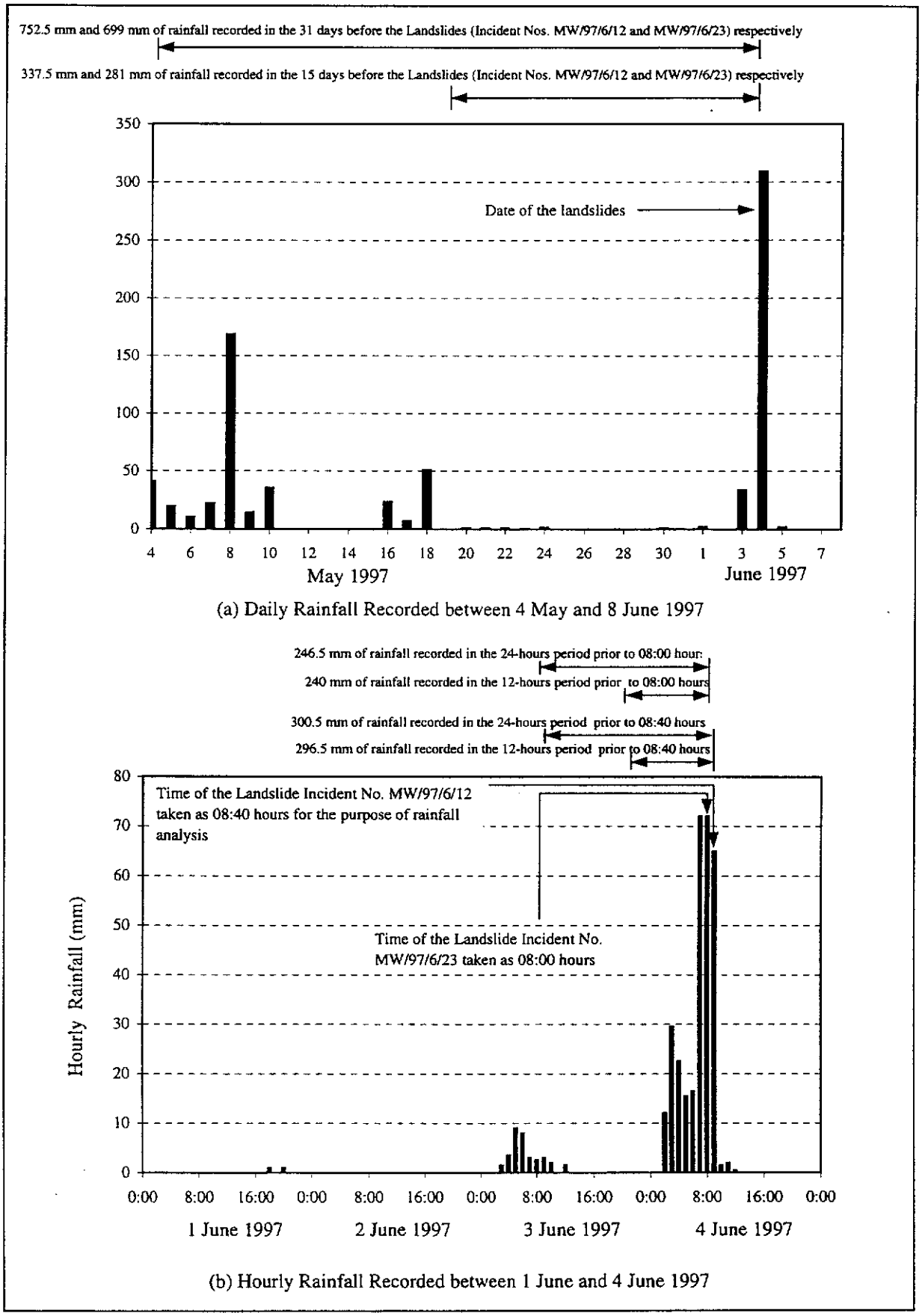


Figure 7 - Site Plan and Details of Landslide Incident No. MW97/6/23



Notes : (1) Pre-failure profile based on 1:1 000 sheet.
(2) Refer to Figure 7 for location of cross-section.

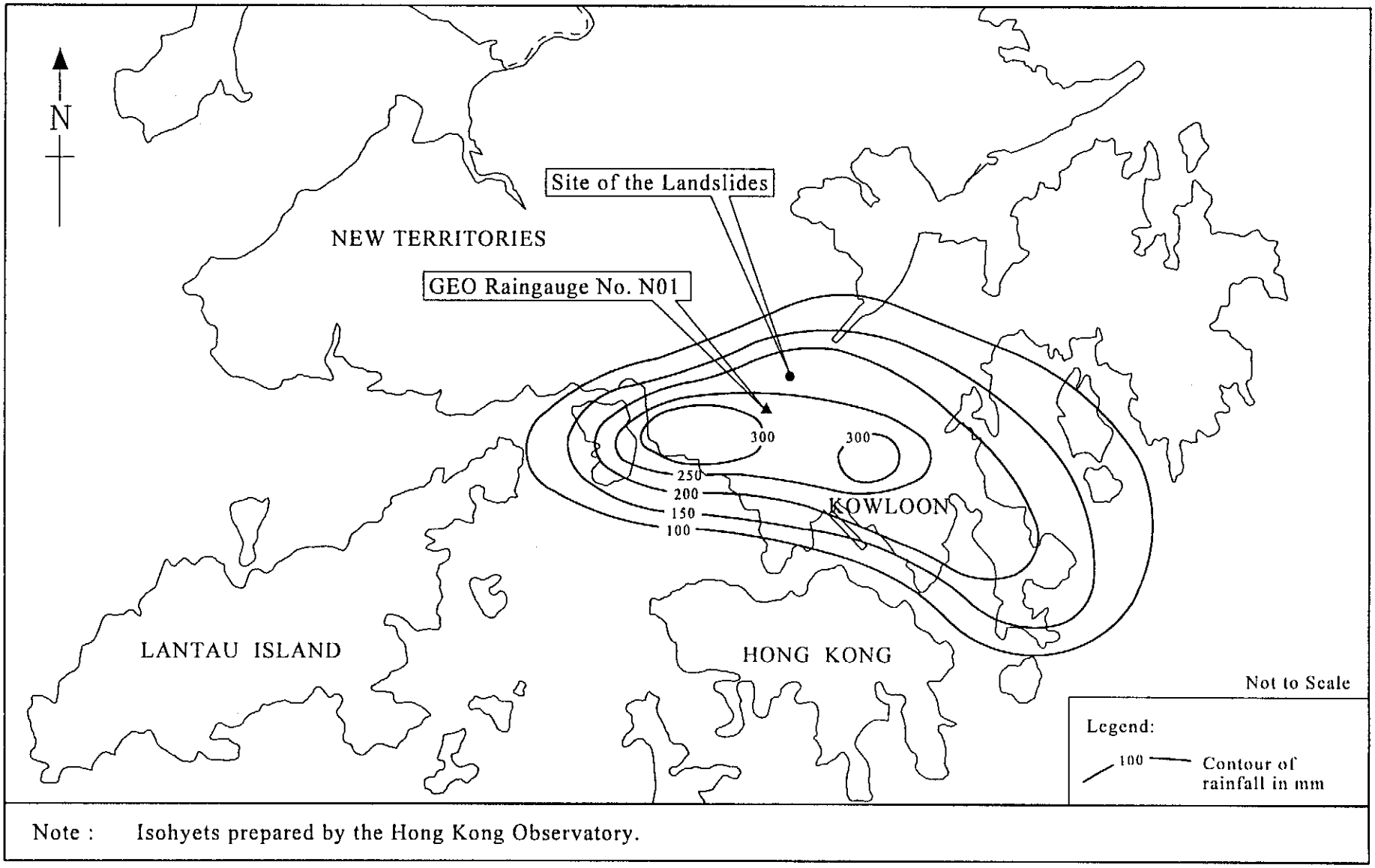
Figure 8 - Cross-section B-B Through Landslide Incident No. MW97/6/23



(a) Daily Rainfall Recorded between 4 May and 8 June 1997

(b) Hourly Rainfall Recorded between 1 June and 4 June 1997

Figure 9 - Rainfall Records at GEO Raingauge No. N01



Note : Isohyets prepared by the Hong Kong Observatory.

Figure 10 - Isohyets of Rainfall between 01:45 Hours and 10:00 Hours on 4 June 1997

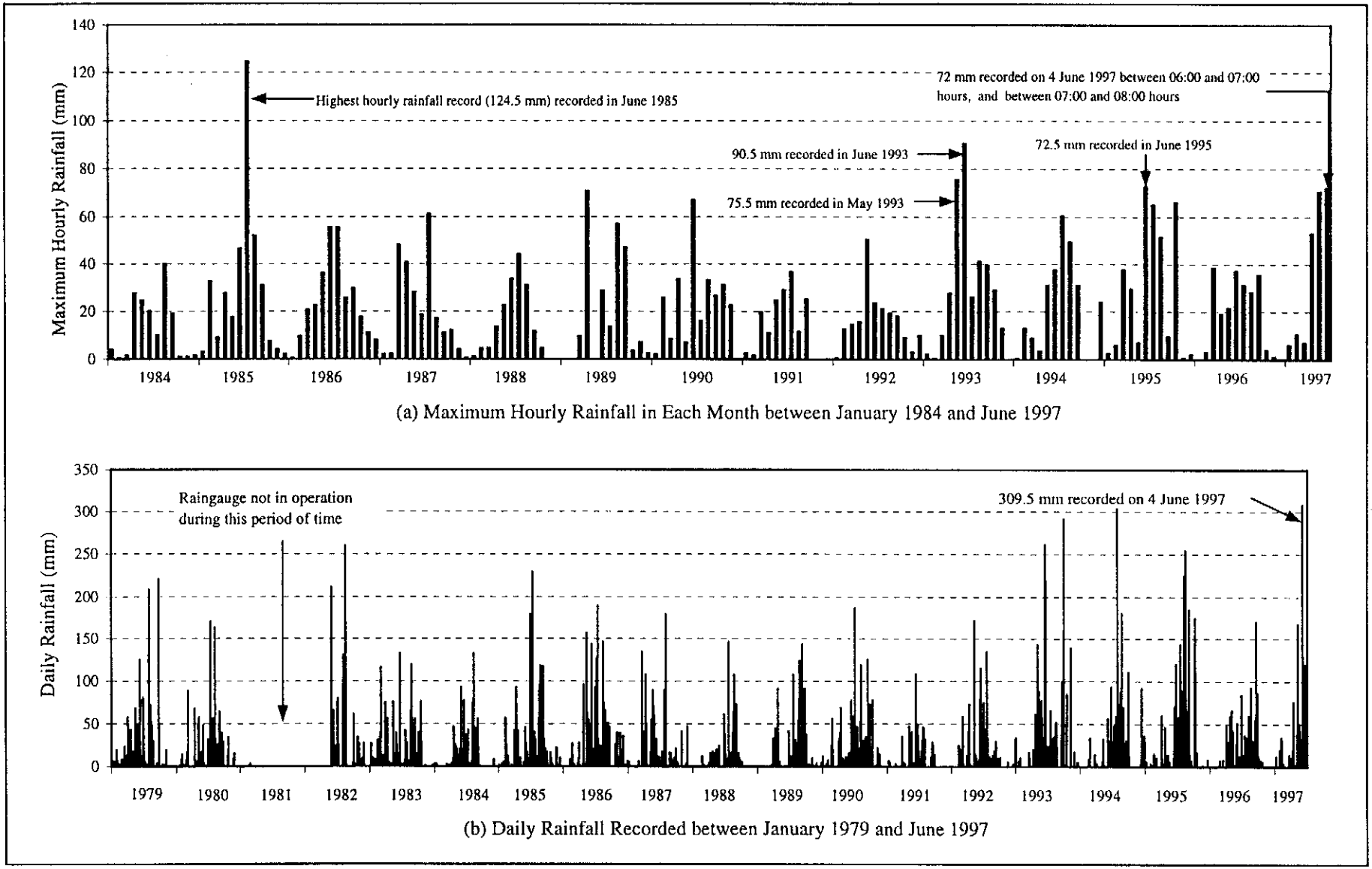


Figure 11 - Historical Rainfall Recorded at GEO Raingauge No. N01

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Plate 1 - General View of the Setting of Incident No. MW97/6/12 (Photograph Taken on 5 June 1997. Note Retaining Wall No. 7SW-D/R2 and the Buildings of Happy View House at the Crest, and the Pre-existing Stepped Drainage Channel along the Centre of the Debris Track)

Plate 2 - View Looking Northeast Across the Main Scarp of Incident No. MW97/6/12 (Photograph Taken on 5 June 1997)

Plate 3 - Southwestern View of the Lower Part of the Gully Showing the Distribution of Landslide Debris from Incident No. MW97/6/12 (Photograph Taken on 11 June 1997. Note the Vegetation Pile on the Right of the Frame and the Debris on the Patio Areas of Woodcrest Hill)

Plate 4 - Upslope View of the Gully at Incident No. MW97/6/12 (Photograph Taken on 6 June 1997. Note the Intact Raft of Landslide Debris Covered by Bamboo)

Plate 5 - View of Debris from Incident No. MW97/6/12 which Inundated the Patio of a First Floor Flat at No. 9, Woodcrest Hill (on left of frame) (Photograph Taken on 11 June 1997)

Plate 6 - Upslope View of Incident No. MW97/6/23
(Photograph Taken on 6 June 1997)

Plate 7 - Upslope View of the Main Scarp of Incident No. MW97/6/23 (Photograph Taken on 12 June 1997. Note the Algae Stained Streamcourse on Left of Frame)

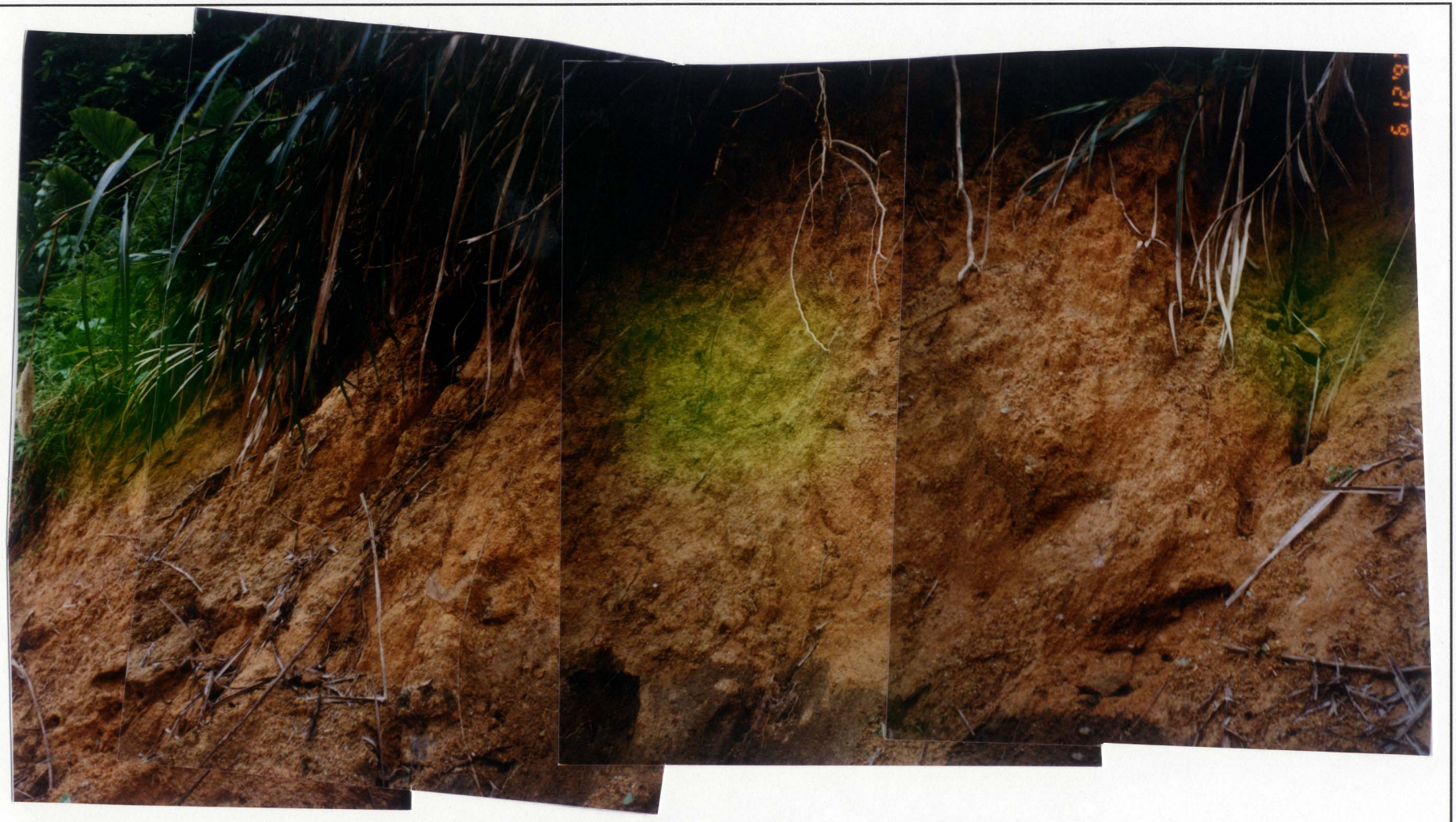

Plate 8 - Close-up of Western Flank of the Main Scarp of Incident No. MW97/6/23 (Photograph Taken on 12 June 1997. Note the Sub-horizontal Contact between the Pale Granular Fill and Underlying Material Interpreted as Colluvium, and Possible Pipes in Centre and Right of Frame)

Plate 9 - Close-up of Pipes in Colluvium in the Main Scarp of Incident No. MW97/6/23 (Photograph Taken on 12 June 1997)

Plate 10 - Downslope View of Incident No. MW97/6/23 (Photograph Taken on 12 June 1997. Note the Vegetated Raft of Debris Centre Frame)

Plate 11 - Upslope View of Lower Part of Debris Trail From Incident No. MW97/6/23 (Photograph Taken on 6 June 1997)

Plate 12 - View of Debris Run-out at Toe of Slope Following Incident No. MW97/6/23 (Photograph Taken on 6 June 1997)