

**DETAILED STUDY OF
THE 7 JUNE 2008
LANDSLIDE BEHIND
EWAN COURT,
KENNEDY ROAD,
WANCHAI**

GEO REPORT No. 278

Fugro Scott Wilson Joint Venture

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

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**This report is largely based on GEO Landslide Study Report
No. LSR 8/2009 produced in September 2009**

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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. The GEO Reports can be downloaded from the website of the Civil Engineering and Development Department (<http://www.cedd.gov.hk>) on the Internet. Printed copies are also available for some GEO Reports. For printed copies, a charge is made to cover the cost of printing.

The Geotechnical Engineering Office also produces documents specifically for publication in print. These include guidance documents and results of comprehensive reviews. They can also be downloaded from the above website.

The publications and the printed GEO Reports may be obtained from the Government's Information Services Department. Information on how to purchase these documents is given on the second last page of this report.



H.N. Wong
Head, Geotechnical Engineering Office
May 2013

FOREWORD

This report presents the findings of a detailed study of a landslide (Incident No. 2008/06/0182) that occurred on the hillside behind Ewan Court, Kennedy Road, Wanchai on 7 June 2008. Both Landslip Warning and Black Rainstorm Warning were in effect at the time of the failure. The landslide involved a failure volume of about 200 m³ with a runout distance of about 80 m. The landslide debris came to rest at the rear alleyway of Ewan Court. A security booth and a section of concrete parapet wall of Ewan Court were damaged by the landslide debris. There were no casualties as a result of the landslide and no evacuation of the residents from the building.

The report was prepared as part of the Landslide Investigation Consultancy for landslides occurring in Hong Kong Island and Outlying Islands in 2008 and 2009, for the Geotechnical Engineering Office of the Civil Engineering and Development Department, under Agreement No. CE 40/2007 (GE). This is one of a series of reports produced during the consultancy by Fugro Scott Wilson Joint Venture.



Y.C. Koo
Project Director
Fugro Scott Wilson Joint Venture

Agreement No. CE 40/2007 (GE)
Study of Landslides Occurring in
Hong Kong Island and Outlying
Islands in 2008 and 2009 –
Feasibility Study

CONTENTS

	Page No.
Title Page	1
PREFACE	3
FOREWORD	4
CONTENTS	5
1. INTRODUCTION	7
2. DESCRIPTION OF THE SITE	7
3. THE 7 JUNE 2008 LANDSLIDE	7
4. MAINTENANCE RESPONSIBILITY	8
5. SITE HISTORY AND PAST INSTABILITY	8
6. PREVIOUS SLOPE INSPECTIONS AND STUDIES	9
7. ACCOUNTS OF WITNESSES	10
8. ANALYSIS OF RAINFALL RECORDS	10
9. POST-LANDSLIDE OBSERVATIONS	11
9.1 Inspections by Geotechnical Engineering Office	11
9.2 Inspections by Fugro Scott Wilson Joint Venture	11
10. SUBSURFACE CONDITIONS	11
11. DIAGNOSIS OF THE 7 JUNE 2008 LANDSLIDE	12
11.1 Mode and Nature of the Failure	12
11.2 Diagnosis of Causes and Mechanism of Failure	13
12. CONCLUSIONS	13
13. REFERENCES	13
LIST OF TABLES	15
LIST OF FIGURES	17

	Page No.
LIST OF PLATES	29
APPENDIX A: AERIAL PHOTOGRAPH INTERPRETATION	45

1. INTRODUCTION

Between 7:00 a.m. and 7:30 a.m. on 7 June 2008, when both Landslip Warning and Black Rainstorm Warning were in effect, a major landslide (Incident No. 2008/06/0182) occurred on the north-facing hillside above Bowen Road overlooking the residential blocks of Ewan Court at Nos. 54-56 Kennedy Road, Wanchai (Figure 1 & Plate 1).

Fugro Scott Wilson Joint Venture (FSW) has been engaged by the Geotechnical Engineering Office (GEO) of the Civil Engineering and Development Department (CEDD) to establish the probable causes of the landslide. This report documents the findings.

2. DESCRIPTION OF THE SITE

The 7 June 2008 landslide occurred on the north-facing hillside above Bowen Road between about 130 mPD and 145 mPD (Figures 2 to 4). The natural hillside at the location of the landslide is relatively steep with an average gradient of about 40° and generally densely vegetated. A gently incised ephemeral drainage line is present immediately to the east of the source area of the landslide (Figure 2).

The ground at the crest of the landslide is an unpaved fill platform, which is about 6.5 m wide by 15 m long and was previously used as horticultural ground. The unpaved fill platform comprised a fill body, which was about 45 m long. Only the eastern portion of the fill body, about 15 m long, failed on 7 June 2008 (Figure 2). The unfailed portion of the fill body is about 4.2 m high, comprising a 0.7 m high, 40° steep fill batter at the crest and a 1.5 m high subvertical cement plastered wall at mid-slope as well as a 2 m high fill batter with a slope angle of about 40° at the toe (Plate 2). The ground to the west of the unpaved fill platform is a paved frontage of a two-storey house, viz. Caronia, at No. 17 Bowen Road (Figure 2 & Plate 2).

A soil cut slope No. 11SW-D/C1401 is located immediately above the unpaved fill platform, which is up to 3.5 m high and inclined at 75° (Figure 2).

Bowen Road traverses the hillside at about 114 mPD, where rock outcrops are exposed on the natural hillside with overhangs supported by concrete buttresses (Plate 3). The section of Bowen Road immediately below the 7 June 2008 landslide is elevated and supported by rectangular columns (Figure 3 & Plate 1).

3. THE 7 JUNE 2008 LANDSLIDE

The landslide, with a failure volume of about 200 m³ occurred between 7:00 a.m. and 7:30 a.m. on 7 June 2008. The source area of the landslide measured about 15 m wide by 20 m long, with an average depth of about 1.5 m. The landslide mainly involved the natural hillside above Bowen Road and a portion of an unpaved fill platform at its crest (Figure 2).

The landslide did not enter the ephemeral drainage line to the east of the landslide trail and did not involve any major entrainment of material. The landslide debris travelled down the natural hillside with a runout distance of about 80 m and came to rest at the rear alleyway

of Ewan Court (Plates 4 to 6). As a result of the landslide, a security booth, which was unoccupied at the time of the failure, and a section of the concrete parapet wall at the rear of Ewan Court were severely damaged (Plates 4 & 5). A section of the fence at the crest of the toe wall of slope No. 11SW-B/CR506 was also damaged by the landslide debris (Plate 7).

4. MAINTENANCE RESPONSIBILITY

Based on the information obtained from Lands Department (Lands D), the 7 June 2008 landslide occurred on unleased and unallocated government land. The unpaved fill platform at the crest of the landslide is also on unleased and unallocated government land.

5. SITE HISTORY AND PAST INSTABILITY

The development history and past instability of the landslide site has been established from an interpretation of the available aerial photographs, together with a review of relevant documentary information (Figure 5). Detailed observations from the aerial photograph interpretation (API) are presented in Appendix A.

Based on the earliest aerial photographs taken in 1945, the landslide site was a densely vegetated natural hillside and Bowen Road below had already been formed. The unpaved fill platform and the adjacent slopes were possibly being formed in 1949. In the 1972 aerial photographs, an area of high reflectivity, possibly relating to anthropogenic activity, is evident at the unpaved fill platform at the 7 June 2008 landslide location. Between 1976 and 1978, the residential buildings at Kennedy Road, viz. Ewan Court and Sakura Court, were built and a drainage channel was constructed on the natural hillside below Bowen Road to the southeastern corner of Ewan Court.

On 29 May 1982, a landslide (Incident No. HK82/68), with no record on the failure volume, occurred on the natural hillside below Bowen Road (Figure 6). The landslide debris had a runout distance of about 40 m, reaching the rear alleyway of Ewan Court and blocking the access ramp to the carpark area. The 1982 landslide is also registered in the Enhanced Natural Terrain Landslide Inventory as landslide No. 11SWB0008E and the concerned hillside catchment is classified in the Historical Landslide Catchment Inventory as catchment No. 11SW-B/OH1 (Figure 6).

The Building Authority subsequently issued a Dangerous Hillside Order (DHO) under Section 27A of the Buildings Ordinance to the co-owners of Ewan Court in August 1982, requiring the implementation of necessary remedial works and an investigation of the stability of the concerned natural slope. By November 1984, the remedial works, including trimming and turfing of the landslide scar and provision of surface drainage system, were completed. The surface drainage system comprised a stepped channel and several U-channels on the natural hillside below Bowen Road (Plate 8).

Between 1983 and 1984, concrete buttresses (Figure 2 & Plate 3) were constructed to provide support to rock overhangs exposed on the natural hillside near Bowen Road as part of the upgrading works for slope No. 11SW-B/C216 under the 1982/83 Landslip Preventive Measures Programme of the Government.

On 28 March 2001, a minor landslide (Incident No. HK2001/03/0002), with a failure volume of about 10 m³, occurred on the natural hillside above slope No. 11SW-B/C216 about 30 m to the northwest of the 7 June 2008 landslide (Figure 6). By May 2001, urgent repair works, comprising the removal of landslide debris, trimming of overhanging surface, application of slope surface protection and provision of surface drainage channels, were completed by Highways Department.

6. PREVIOUS SLOPE INSPECTIONS AND STUDIES

No studies had been conducted for the natural hillside that failed in the 7 June 2008 rainstorm. A number of inspections of the fill body below the unpaved platform were carried out between 1996 and 2005. Key observations and related issues pertaining to the landslide site are summarised below.

In December 1996, the fill body was identified and registered as slope No. 11SW-D/F525 under the Systematic Identification and Registration of Slopes in the Territory (SIRST) Project (Figure 5). The slope was designated as a Class 'B1' feature, i.e. a fill feature that had been formed or substantially modified before 30 June 1978. The SIRST inspection report noted that the fill feature was less than 5 m in height with significant cracking on the paved frontage of Caronia.

In June 2001, an Advisory Letter was issued by the GEO to the owners of the private lot at No. 17 Bowen Road, recommending urgent maintenance works be carried out to slope No. 11SW-D/F525. The recommended works included sealing off uncontrolled discharge points of surface water at the slope crest and provision of suitable drainage system for collection and discharge of surface water from the crest platform.

In July 2001, an Engineer Inspection (EI) of slope No. 11SW-D/F525 was carried out by the consultants of Lands D, who was the responsible maintenance party. The EI report noted the presence of a cement plastered wall of up to 1.5 m high at the slope crest, together with a small crest wall of about 1 m high with cement plaster facing at the eastern portion of the slope that failed on 7 June 2008 (Plates 9 & 10). No signs of distress or seepage were observed. Routine maintenance Works (RMW) and Preventive Maintenance Works (PMW) were recommended, including the provision of surface drainage channels. The EI report also recommended paving the horticultural area at the crest of the fill feature (i.e. the unpaved fill platform), in order to minimize infiltration during rainfall. However, no records indicating the completion of the recommended works could be found and the horticultural area remained unpaved at the time of the 7 June 2008 landslide.

In August 2005, a Routine Maintenance Inspection (RMI) of slope No. 11SW-D/F525 was carried out by Lands D. The RMI record noted a severe crack (estimated to be about 25 mm to 50 mm wide) on the 1 m high crest wall at the eastern portion of the slope (Figure 6 & Plate 10), which marked the western flank of the 7 June 2008 landslide. The recommended RMW, including sealing of the crack, were completed in April 2006.

In December 2005, slope No. 11SW-D/F525 was de-registered from the Government's Slope Catalogue as per the recommendation of the consultants of GEO under a project to implement the Application of New Priority Classification System. Based on the information

available at that time, the slope was considered not eligible for registration as it was only about 2 m high with a relatively low consequence to life (i.e. Consequence-to-life Category 3) in the event of failure.

7. ACCOUNTS OF WITNESSES

Relevant observations relating to the timing of the 7 June 2008 landslide and the process of the landslide were collated from accounts given by three witnesses.

According to the security guard of Sakura Court who witnessed the landslide process, the landslide debris slid down from the eastern end of Caronia, passing through the gaps between the columns that support Bowen Road and continuing downslope towards Ewan Court at about 7:00 a.m. on 7 June 2008. The timing of this observation is corroborated by the account given by another security guard of Sakura Court, who heard a loud noise of the landslide at around 7:00 a.m.

A resident of Sakura Court who also witnessed the process of the landslide recalled that the landslide occurred at about 7:30 a.m. when she heard a loud but low tone roaring sound from the hillside. It was raining extremely heavily. She first saw some soil debris, hard fragments and trees sliding down from the lower part of the hillside below Bowen Road. A few minutes later, she saw another chunk of material, comprising mainly soil debris with a lot of water, coming down from the hillside above Bowen Road. Thereafter, only small bits of hard fragments slid down from the hillside intermittently.

8. ANALYSIS OF RAINFALL RECORDS

Rainfall data were obtained from GEO automatic raingauges Nos. H06 and H17, which are located at approximately 0.7 km to the east and 0.6 km to the west of the 7 June 2008 landslide site respectively (Figure 1). The raingauges record and transmit rainfall data at 5-minute intervals to Hong Kong Observatory (HKO) and GEO. The landslide was assumed to have occurred at 7:30 a.m. on 7 June 2008 for the purposes of the rainfall analysis.

The daily rainfall recorded by raingauge No. H17 from 4 May to 10 June 2008, together with the hourly rainfall for the period between 6 and 7 June 2008, are presented in Figure 7. The maximum 24-hour and 12-hour rolling rainfall preceding the landslide were 269 mm and 153.5 mm respectively.

Table 1 presents the estimated return periods for the maximum rolling rainfall for various durations recorded by raingauge No. H17 with reference to the historical rainfall data at HKO in Tsim Sha Tsui (Lam & Leung, 1994) and the local rainfall data of raingauge No. H17 (Evans & Yu, 2001). The results show that the 1-hour rolling rainfall of 80.5 mm was the most severe, with a corresponding return period of 3 to 4 years.

The maximum rolling rainfall for the rainstorm on 7 June 2008 has been compared with the past major rainstorms between 1983 and 2008 as recorded at raingauges Nos. H06 and H17 (Figure 8). In general, the maximum rolling rainfall for the rainstorm on 7 June 2008 at the landslide site was less severe than that of the past major rainstorms.

9. POST-LANDSLIDE OBSERVATIONS

9.1 Inspections by Geotechnical Engineering Office

The landslide site was inspected by GEO on 10 June 2008. It was observed that most of the landslide debris mixed with vegetation was deposited at the rear alleyway of Ewan Court (Figure 2 & Plate 6). Some landslide debris was retained by dense trees at the mid-slope below Bowen Road (Plate 11). Fragments of the crest walls and planter pots, as well as a 5 m by 5 m large raft of landslide debris, were found on the western flank of the landslide, about 3 m below the original position of the unpaved fill platform (Plate 12). The remaining unfailed portion of the platform above the landslide was unpaved with a number of abandoned planter pots (Plate 13).

Two stepped channels (300 mm & 400 mm wide respectively), generally in good condition, are present below Bowen Road, connecting to the surface drainage system to the east of Ewan Court (Plate 8). No significant signs of erosion were observed in the area along the two channels.

9.2 Inspections by Fugro Scott Wilson Joint Venture

A number of inspections of the 7 June 2008 landslide site were carried out by FSW between July 2008 and June 2009. At the time of the first inspection on 2 July 2008, landslide debris, comprising mainly orangish brown, gravelly silt/sand with cobble-sized and boulder-sized rock and rootlets, was being removed from the source area and the landslide trail.

At the western flank of the unpaved fill platform, a covered flat channel (about 150 mm deep by 300 mm wide) is present, which collects surface water from a 400 mm crest U-channel of slope No. 11SW-D/C1401 (Figure 2, Plates 14 & 15). The 400 mm crest U-channel also connects with and collects surface water from the surface drainage systems of two adjacent slopes Nos. 11SW-D/C1399 and 11SW-D/C1411. It was observed that the inlet to the flat channel was completely blocked by leaf debris during an inspection in September 2008 (Plate 15). The covered flat channel was in a reasonably good condition.

The inspection also covered the natural hillside above the 7 June 2008 landslide site, which was heavily vegetated. No observable drainage features were noted.

10. SUBSURFACE CONDITIONS

The subsurface conditions at the 7 June 2008 landslide site were determined from a review of pre-failure ground investigation (GI) information and field mapping of the landslide scar, together with post-failure GI.

As part of this study, GI works, comprising six trial pits (Nos. TP1 to TP6), one trial trench (TT1), three surface strips (Nos. SS1, SS1A & SS2) and two inspection pits (Nos. IP-A and IP-B), were carried out on the landslide scar and its vicinity by DrilTech Ground Engineering Limited between late 2008 and early 2009. In addition, a number of previous GI

stations were located on the hillside below Bowen Road. The locations of these GI stations are shown in Figure 9. An interpreted geological section through the source area of the landslide is shown in Figure 4, which indicates that the site comprises a layer of colluvium of up to about 1.5 m thick, overlying highly to moderately decomposed tuff (H/MDT) of Ap Lei Chau Formation (Figure 10). The colluvium could be generally described as greyish brown sandy clayey silt with some sub-angular fine to coarse gravel and cobbles.

A layer of fill material, which was probably associated with the formation of the platform at the crest of the landslide, was found overlying the upper part of the natural hillside. A trial pit (No. TP5) was excavated at the fill body and encountered a layer of fill of up to 1.2 m thick, overlying 0.5 m of colluvium before reaching H/MDT. The fill material comprises soft, pale brown slightly sandy clayey silt with some gravels, cobbles and boulders of tuff, brick and other refuse fragments and some roots.

Another trial pit (No. TP4) locating on the hillside to the east of the landslide scar encountered a thin layer of fill of up to 0.3 m thick, overlying 0.6 m of colluvium before reaching MDT.

A 15 m long trial trench (No. TT1) was also excavated on the hillside about 10 m to the west of the landslide site and exposed a layer of bouldery colluvium without the presence of any overlying fill material over a length of about 0.3 m on the upper stretch of the trench. For the remaining length, the trial trench encountered a thin veneer of fill of up to 0.4 m thick overlying a layer of colluvium up to 1.0 m in thickness. This thin veneer of fill material contains predominantly fine materials, which may have been washed down from the hillside above due to outwashing action.

Within the landslide scar, trial pits and surface strips revealed that the rupture surface of the 7 June 2008 landslide was largely within the colluvium or HDT, with the upper 2 m of the rupture surface through the fill body of the unpaved platform (Figure 4). The post-failure GI did not encounter any adverse relict joints in H/MDT, nor any weak geological features in the near-surface groundmass. No seepage was observed on the landslide scar.

11. DIAGNOSIS OF THE 7 JUNE 2008 LANDSLIDE

11.1 Mode and Nature of the Failure

According to the witness accounts, the 7 June 2008 landslide probably occurred between 7:00 a.m. and 7:30 a.m. during heavy rainfall. Although the exact sequence of the landslide event is not known, it might have involved two phases of debris movement separated by a few minutes. It is plausible that the initial phase of debris movement was associated with the main failure above Bowen Road, as the landslide debris reportedly contained uprooted trees and possibly parts of the unpaved fill platform. The subsequent debris movement was probably due to displacement or remobilisation of the perched soil debris on the landslide scar during heavy rainfall.

11.2 Diagnosis of Causes and Mechanism of Failure

The close correlation between the rainfall and the timing of the failure suggests that the landslide was probably triggered by the rainfall preceding the landslide. The failure could have been caused by saturation of the near-surface groundmass and build-up of transient groundwater pressure in the groundmass following the rainfall.

The site setting is adverse in that the hillside is steeply inclined at about 40° and has a history of past instability. Moreover, the hillside had been disturbed by the formation of the unpaved fill platform, which was formed in late 1940s when there was very limited control of geotechnical works at that time. Prior to the 7 June 2008 landslide, soil suction probably developed in the groundmass, which contributed to maintaining the stability of the hillside. During heavy rainfall, direct infiltration into the failed hillside and through the unpaved fill platform at the crest could have wetted up the groundmass and led to a reduction of the soil suction and a gradual reduction of the shear strength of the groundmass against failure. In addition, transient groundwater pressure could have built up locally within the colluvium above the colluvium/decomposed tuff interface, which further contributed to destabilizing the hillside.

The situation could have been aggravated by additional water ingress into the groundmass, resulting from the blockage of the inlet to the 300 mm flat channel at the western flank of the landslide (Plate 15), which collects surface water from the nearby slopes. Blockage of the channel inlet would have led to uncontrolled over-spilling of surface water onto the adjoining unpaved fill platform and additional water ingress into the groundmass at the location of the landslide. In addition, the unpaved fill platform might have been subject to deterioration and possibly movement, as evidenced by the pre-existing crack of up to 50 mm wide on the crest wall in August 2005, which was subsequently sealed, and the significant cracking on the adjoining frontage of Caronia in December 1996 (Section 6). Should continual deterioration occur, the pre-existing crack could have opened up and new cracks might have been developed, leading to additional water ingress into the groundmass.

12. CONCLUSIONS

The 7 June 2008 landslide involved the failure of a natural hillside and an unpaved fill platform at the crest. The failure was probably triggered by rainfall, leading to saturation of the near-surface groundmass and possible build-up of transient groundwater pressure. Water ingress through the unpaved fill platform would have contributed to destabilizing the hillside, which has a history of past instability. The blockage of the inlet to a surface drainage channel adjacent to the unpaved fill platform and deterioration of the unpaved fill platform could have resulted in additional water ingress into the groundmass.

13. REFERENCES

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LIST OF TABLES

Table No.		Page No.
1	Maximum Rolling Rainfall at GEO Raingauge No. H17 for Selected Durations Preceding the 7 June 2008 Landslide and Estimated Return Periods	16

Table 1 - Maximum Rolling Rainfall at GEO Raingauge No. H17 for Selected Durations Preceding the 7 June 2008 Landslide and Estimated Return Periods

Duration	Maximum Rolling Rainfall (mm)	End of Period	Estimated Return Period (Years)	
			Lam & Leung (1994)	Evans & Yu (2001)
5 Minutes	11.0	6:05 a.m. on 7 June 2008	< 2	< 2
15 Minutes	24.5	6:30 a.m. on 7 June 2008	< 2	< 2
1 Hour	80.5	6:45 a.m. on 7 June 2008	3	4
2 Hours	103.0	7:30 a.m. on 7 June 2008	2	3
4 Hours	114.5	7:20 a.m. on 7 June 2008	< 2	< 2
12 Hours	153.5	6:45 a.m. on 7 June 2008	< 2	< 2
24 Hours	269.0	7:30 a.m. on 7 June 2008	3	3
2 Days	272.0	7:30 a.m. on 7 June 2008	2	< 2
4 Days	329.0	7:30 a.m. on 7 June 2008	2	< 2
7 Days	417.0	7:30 a.m. on 7 June 2008	3	2
15 Days	547.5	7:30 a.m. on 7 June 2008	3	2
31 Days	624.0	7:30 a.m. on 7 June 2008	< 2	< 2
<p>Notes: (1) The landslide is assumed to have occurred at 7:30 a.m. on 7 June 2008 for assessing the maximum rolling rainfall.</p> <p>(2) The nearest GEO raingauge to the landslide site is raingauge No. H17, which is located at about 580 m to the west of the landslide site and is operational since 20 September 1995.</p> <p>(3) Maximum rolling rainfall was calculated from 5-minute rainfall data recorded at raingauge No. H17.</p> <p>(4) Return periods were derived from the statistical parameters extracted from Table 3 of Lam & Leung (1994) and the statistical parameters of raingauge No. H17 extracted from Appendix B of Evans & Yu (2001).</p>				

LIST OF FIGURES

Figure No.		Page No.
1	Location Plan	18
2	Site Layout Plan and Field Observations	19
3	Section A-A through the Landslide	20
4	Geological Section of the Source Area of the Landslide	21
5	Site Development History	22
6	Past Instability and Signs of Distress	23
7	Daily and Hourly Rainfall Recorded at GEO Raingauge No. H17	24
8	Maximum Rolling Rainfall for Previous Major Rainstorms at GEO Raingauge No. H17	25
9	Location Plan of Ground Investigation Stations	26
10	Regional Geology	27
11	Locations and Directions of Plates	28

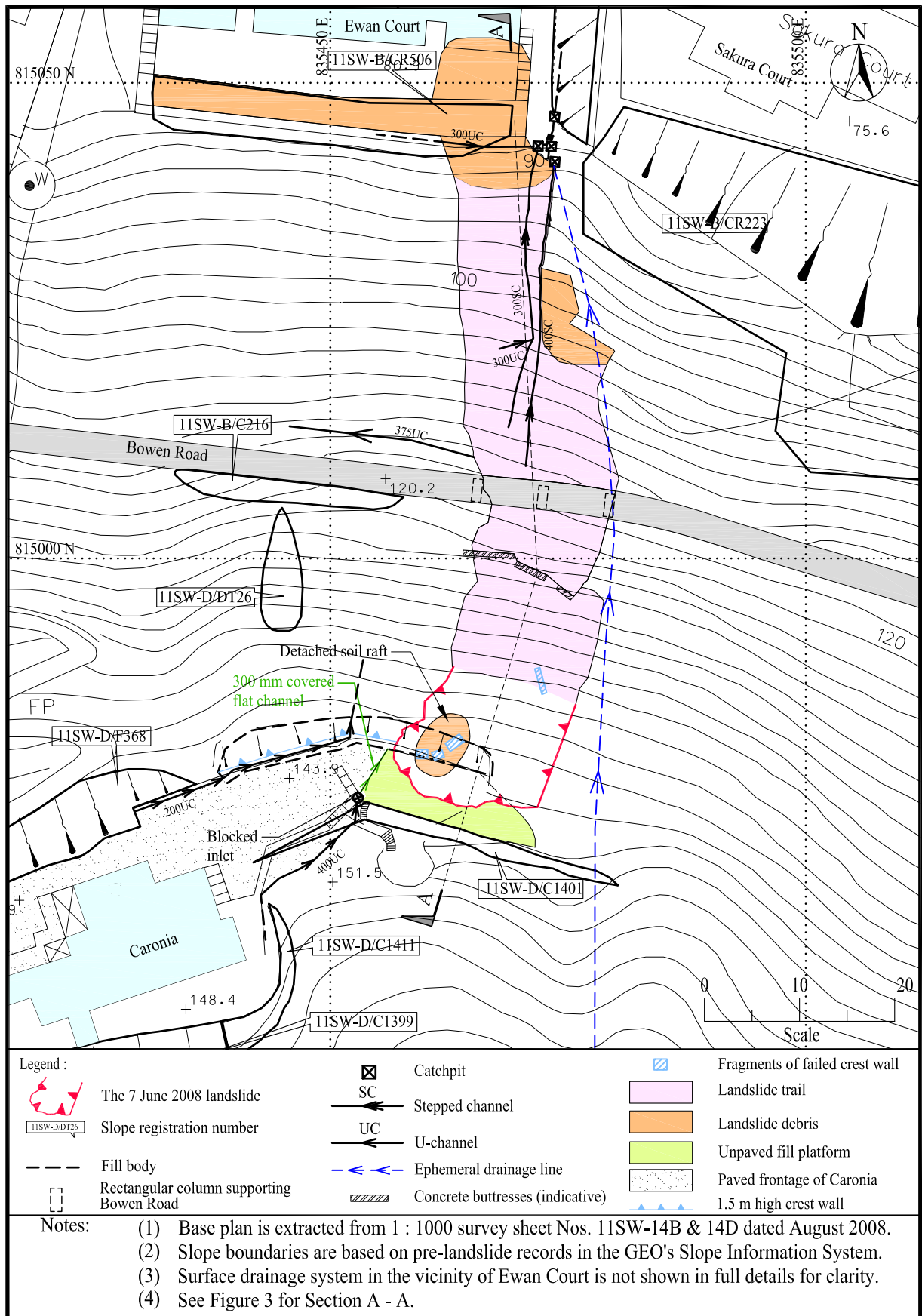


Figure 2 - Site Layout Plan and Field Observations

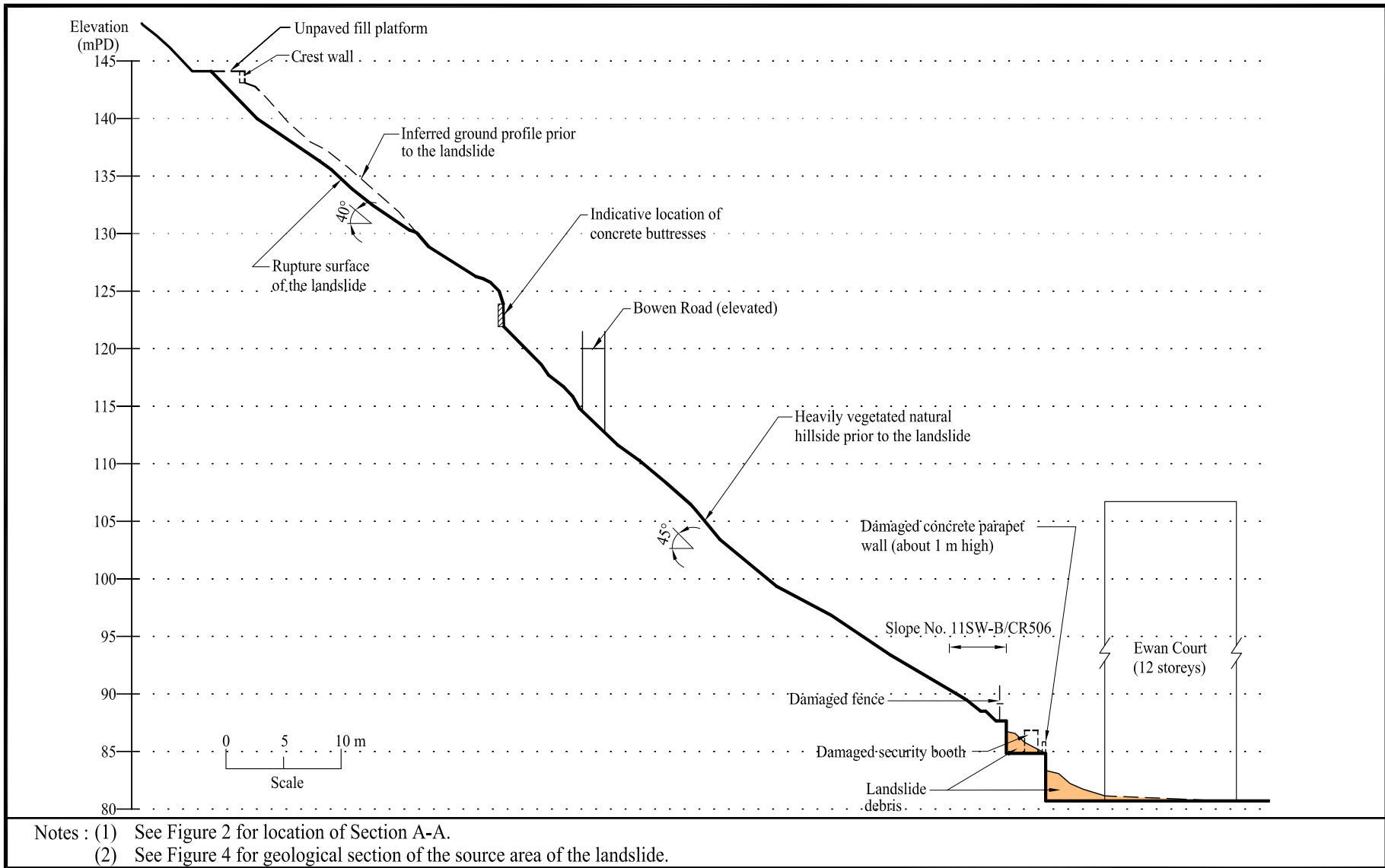


Figure 3 - Section A-A through the Landslide

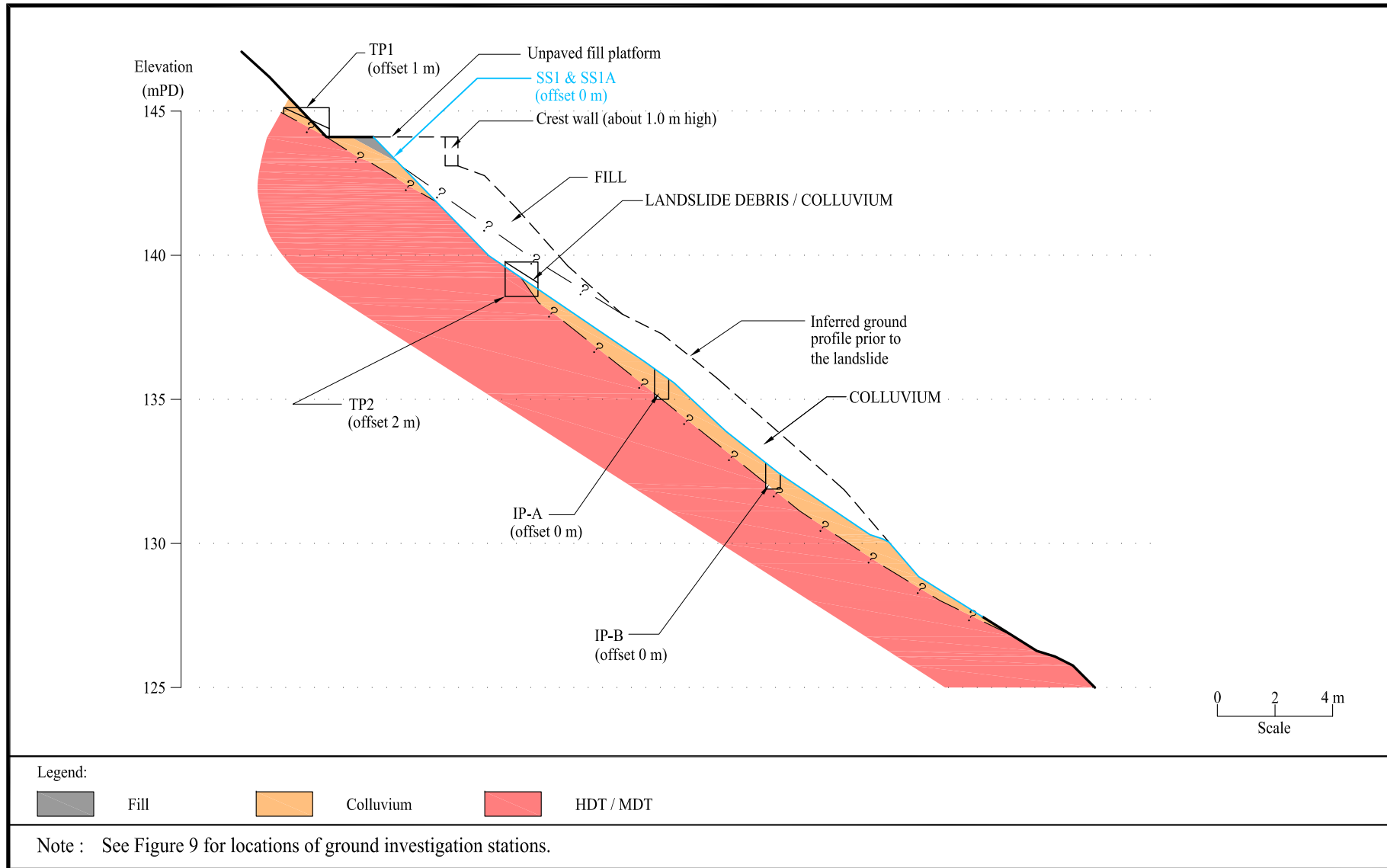


Figure 4 - Geological Section of the Source Area of the Landslide

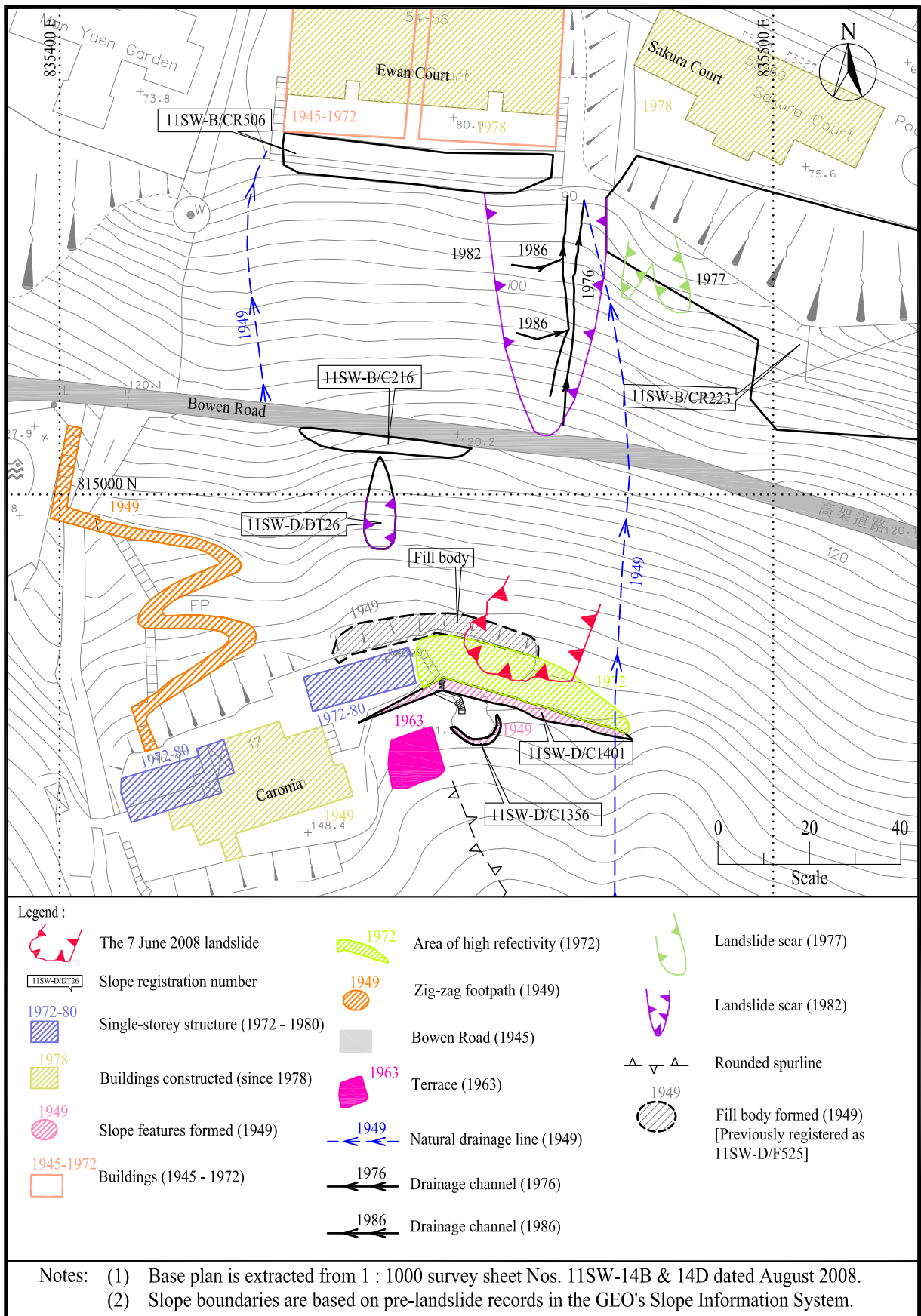


Figure 5 - Site Development History

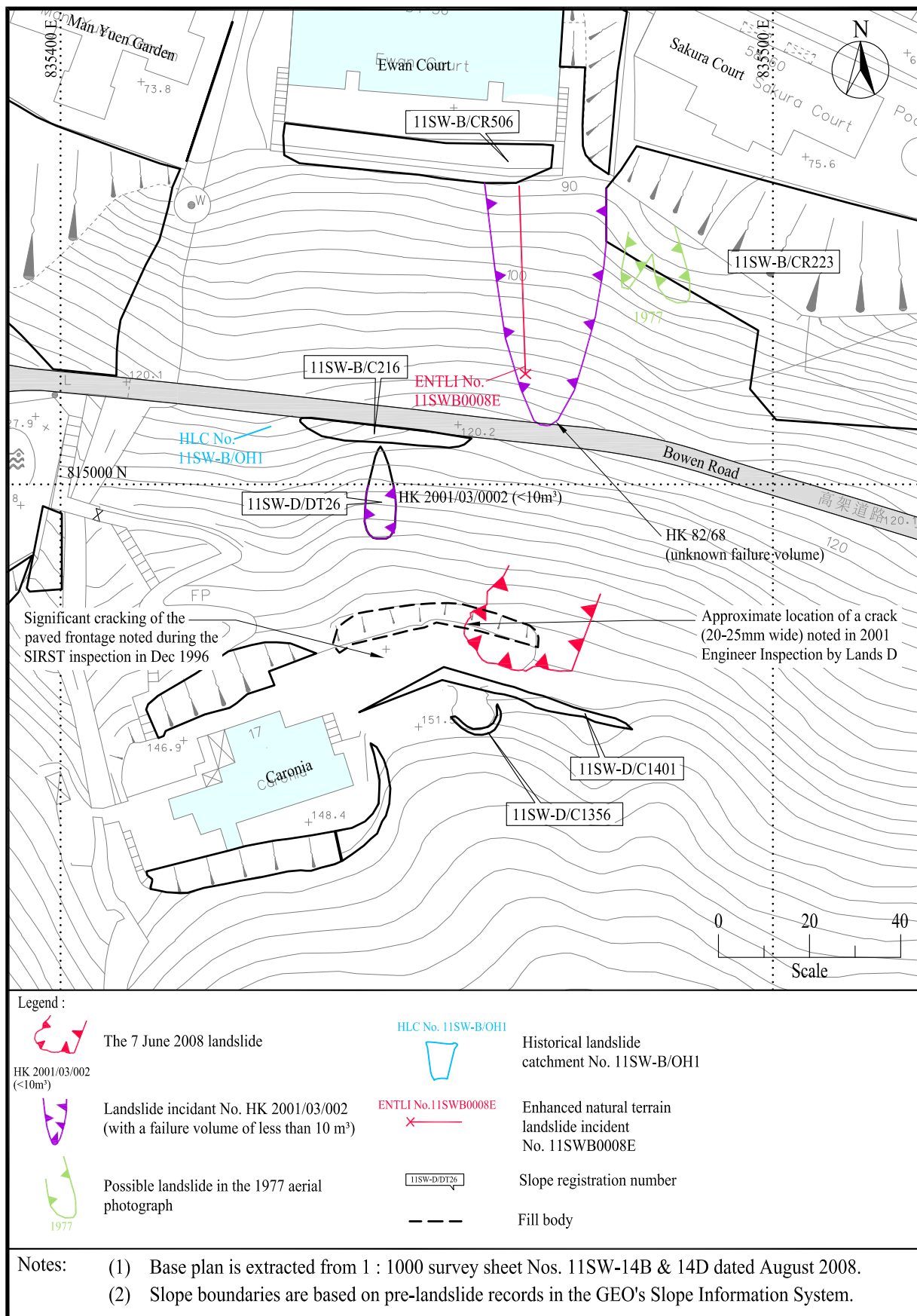


Figure 6 - Past Instability and Signs of Distress

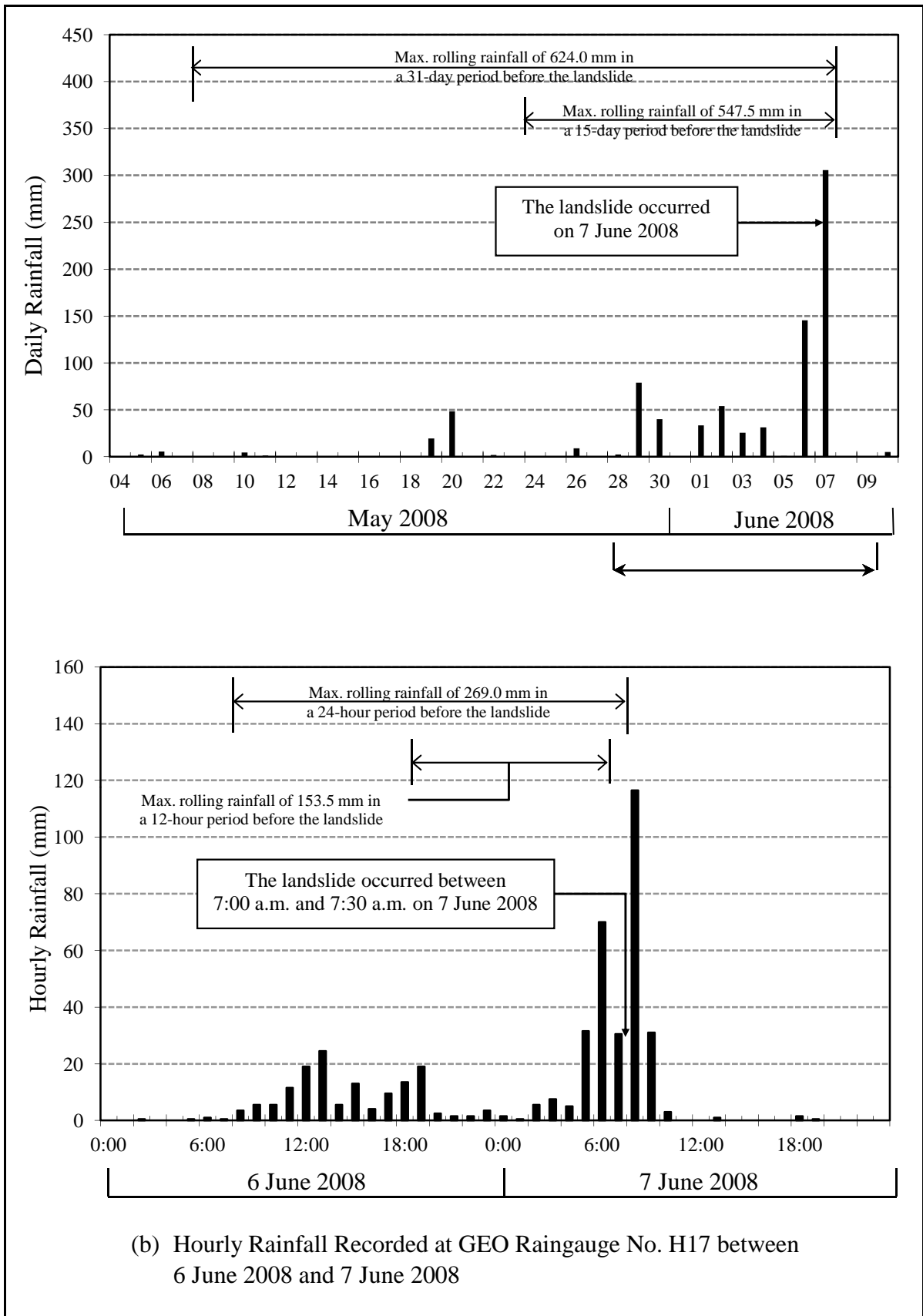


Figure 7 - Daily and Hourly Rainfall Recorded at GEO Raingauge No. H17

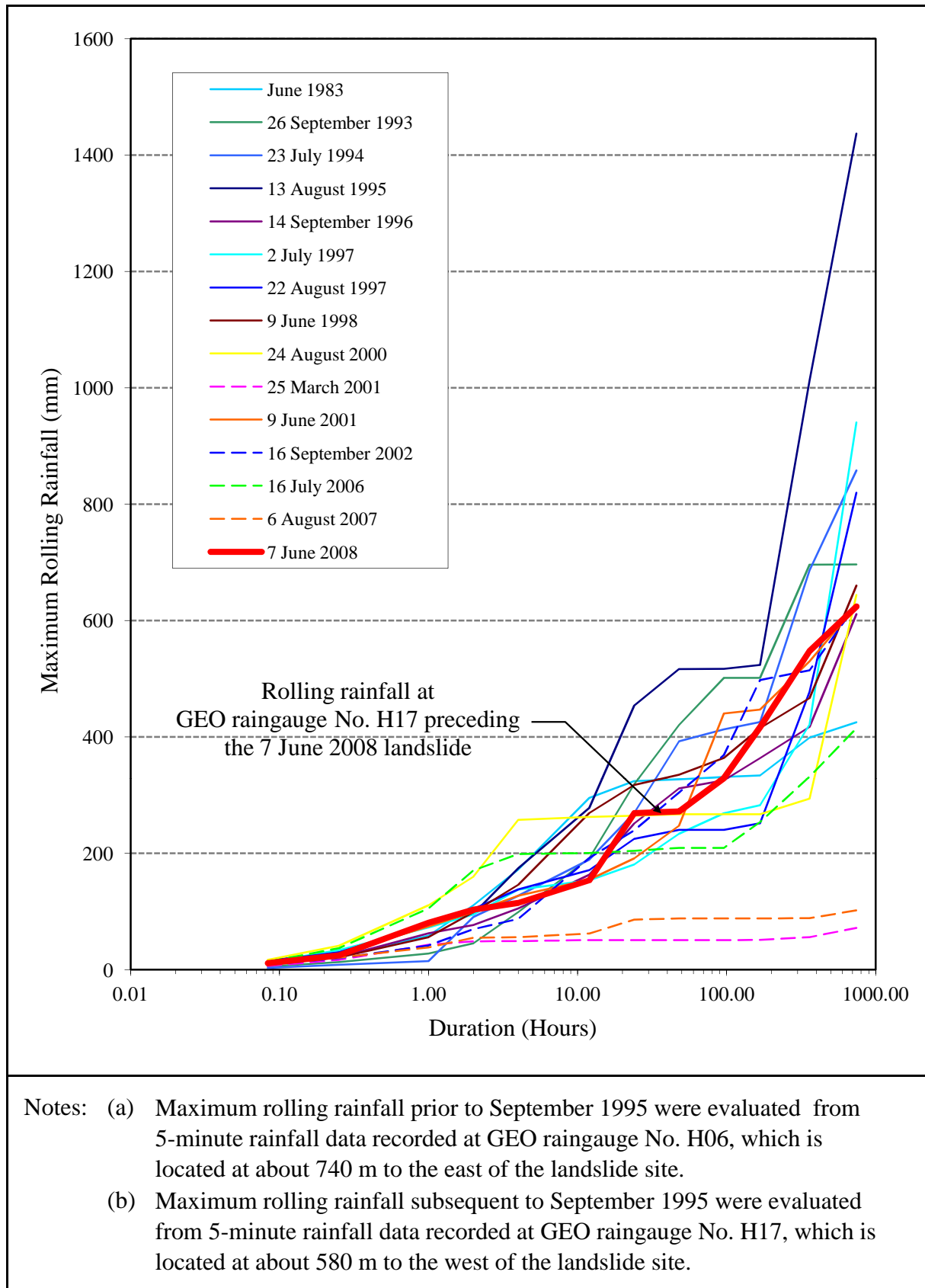


Figure 8 - Maximum Rolling Rainfall for Previous Major Rainstorms at GEO Raingauge No. H17

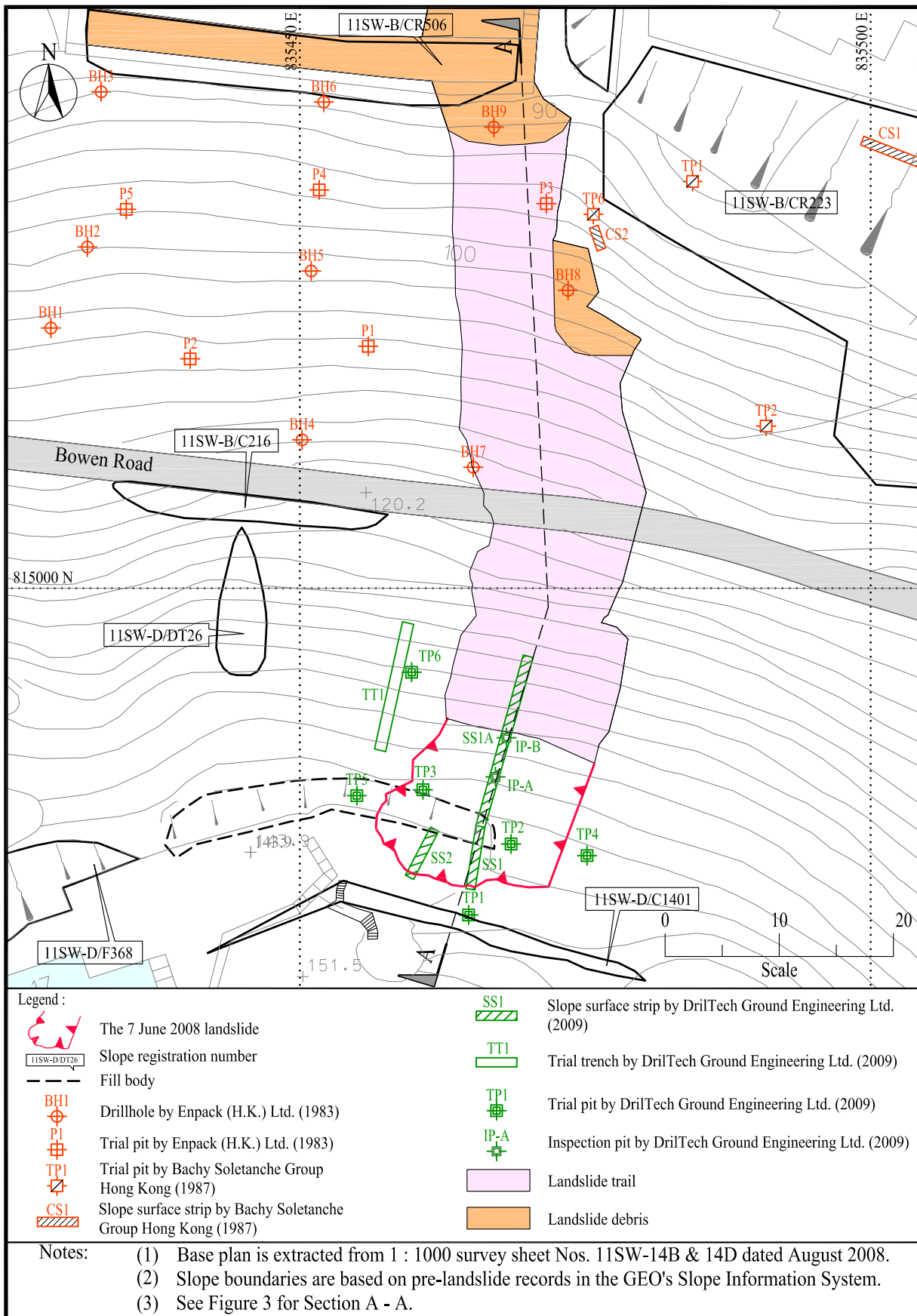
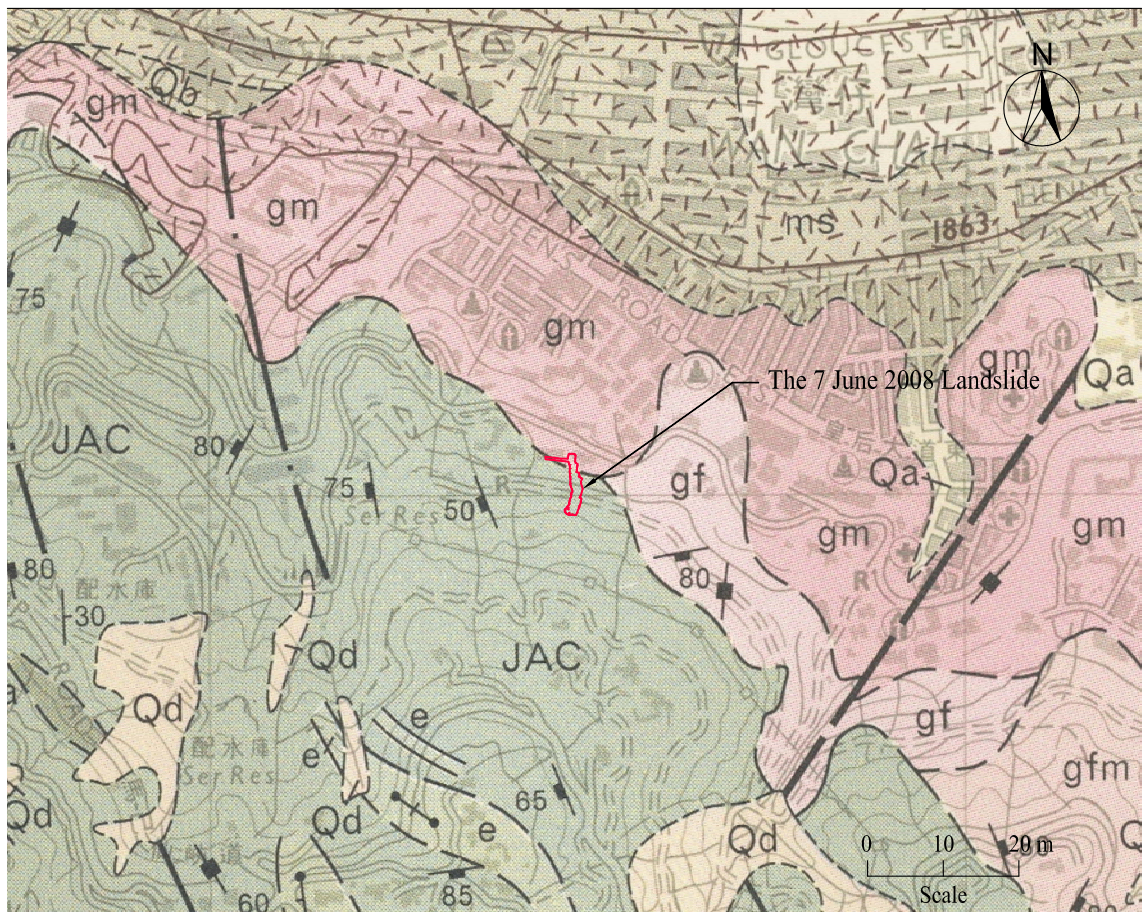


Figure 9 - Location Plan of Ground Investigation Stations



Legend :

SUPERFICIAL DEPOSITS

- Qa** Clay/silt, sand and gravel; well-sorted to semi-sorted (Alluvium)
- Qd** Unsorted sand, gravel, cobbles and boulders; clay/silt matrix (Debris flow deposits)
- Qb** Sand (Beach deposits)

SOLID GEOLOGY

SEDIMENTARY AND VOLCANIC ROCKS

- JAC** Fine ash vitric tuff
- e** Eutaxite

MAJOR INTRUSIVE IGNEOUS ROCKS

- gf** Fine-grained granite, < 2 mm
- gfm** Fine- to medium-grained granite
- gm** Medium-grained granite

GEOLOGICAL LINES

- Geological boundary, superficial deposit
- Fill boundary, with limit of reclamation at date shown
- Fault (crossmark indicates downthrow side)
- Mineral vein
- Photogeological lineament

STRUCTURAL SYMBOLS

- Inclined flow fabric
- Inclined jointing
- Inclined bedding
- Vertical flow fabric
- Vertical jointing
- Vertical bedding

- Notes : (1) The map is extracted from Hong Kong Geological Survey, Map Series HGM20, Sheet No. 11, 1:20000 scale (GCO, 1986).
 (2) Broken lines on map face denote uncertainty.
 (3) All dips and plunges measured in degrees from horizontal.

Figure 10 - Regional Geology

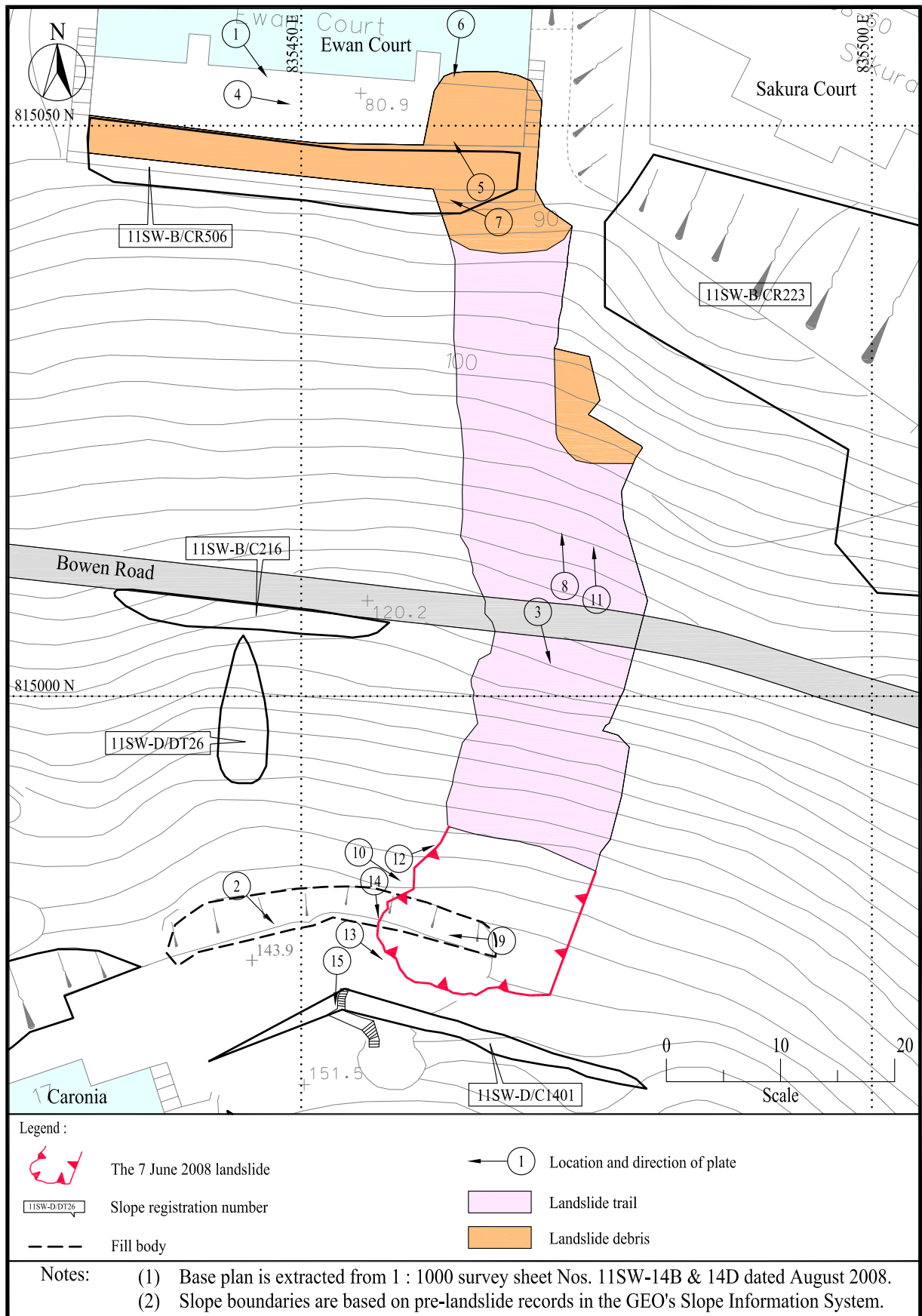


Figure 11 - Locations and Directions of Plates

LIST OF PLATES

Plate No.		Page No.
1	General View of the 7 June 2008 Landslide	30
2	General View of the Unfailed Portion of the Fill Body	31
3	Concrete Buttresses Supporting Rock Overhangs above Bowen Road	32
4	Landslide Debris Deposited at the Rear of Ewan Court	33
5	Damaged Security Booth and Concrete Parapet Wall at the Rear of Ewan Court	34
6	Landslide Debris Deposited at the Rear Alleyway of Ewan Court	35
7	Damaged Security Fence at the Crest of Retaining Wall of Feature No. 11SW-B/CR506 behind Ewan Court	36
8	Landslide Trail below Bowen Road	37
9	General View of the Unpaved Fill Platform at the Crest of the 7 June 2008 Landslide	38
10	Crack Identified in Routine Maintenance Inspection in 2005	39
11	Landslide Debris Retained by Dense Trees on the Hillside below Bowen Road	40
12	Source Area of the 7 June 2008 Landslide and the Detached Raft of Landslide Debris at the Western Flank of the Landslide	41
13	General View of the Unfailed Unpaved Fill Platform at the Crest of the 7 June 2008 Landslide	42
14	Condition of the 300 mm Covered Flat Channel	43
15	Blocked Inlet to the 300 mm Covered Flat Channel at the Toe of Feature No. 11SW-D/C1401	44

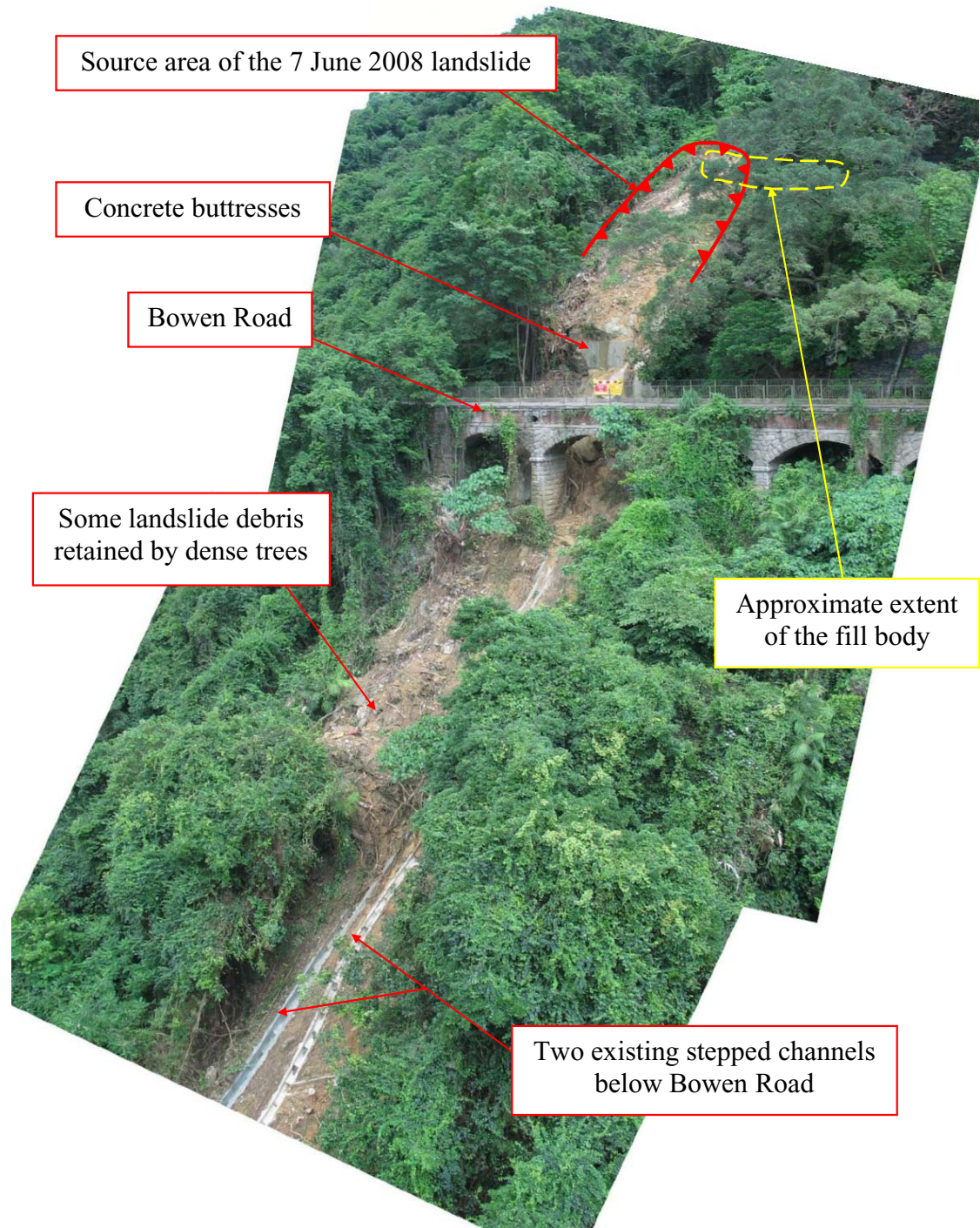


Plate 1 - General View of the 7 June 2008 Landslide
(Photograph taken on 10 June 2008)

Note: See Figure 11 for location and direction of photograph.



Plate 2 - General View of the Unfailed Portion of the Fill Body
(Photograph taken on 24 July 2001)

Note: See Figure 11 for location and direction of photograph.

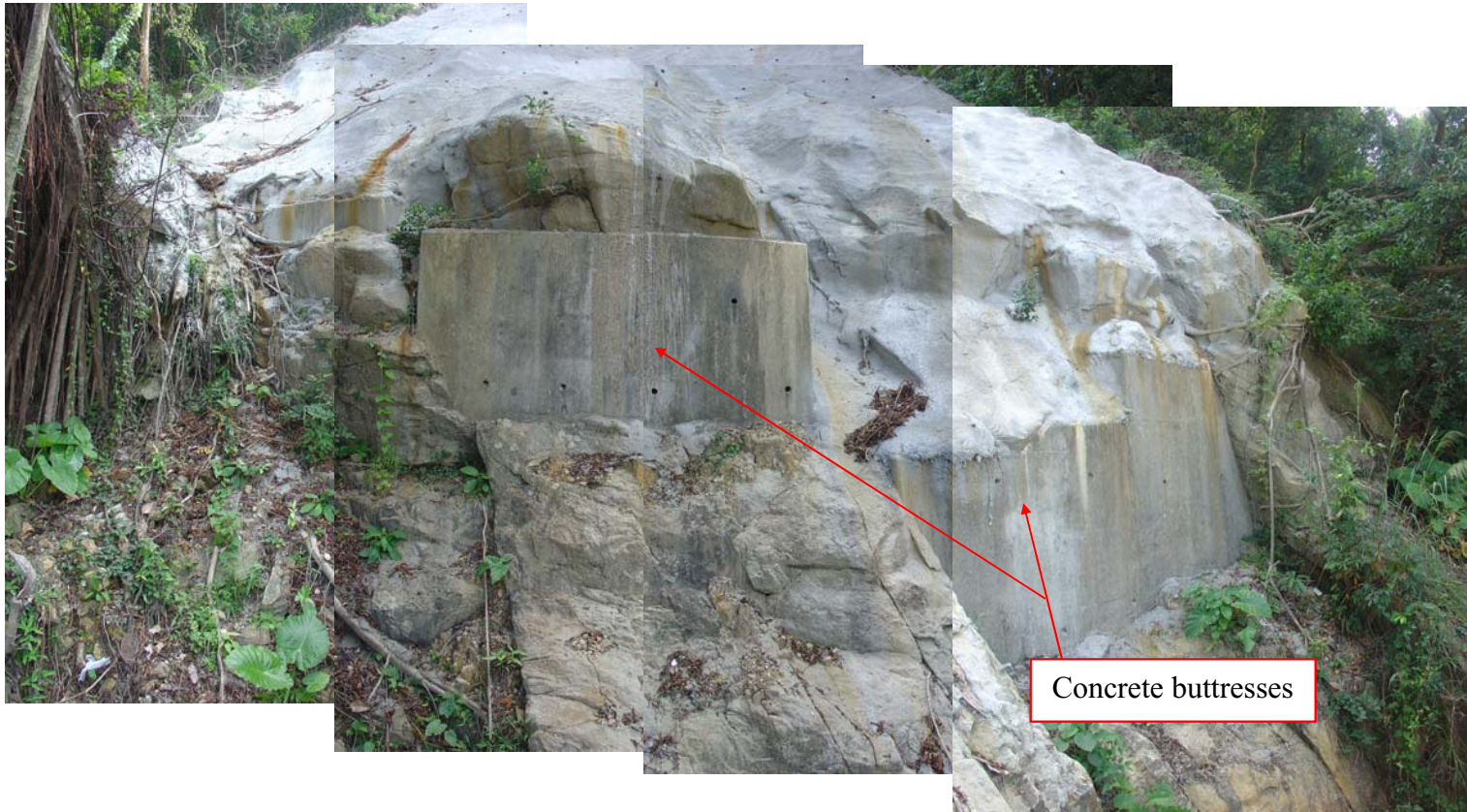


Plate 3 - Concrete Buttresses Supporting Rock Overhangs above Bowen Road
(Photograph taken on 30 October 2008)

Note: See Figure 11 for location and direction of photograph.



Plate 4 - Landslide Debris Deposited at the Rear of Ewan Court
(Photograph taken on 10 June 2008)

Note: See Figure 11 for location and direction of photograph.

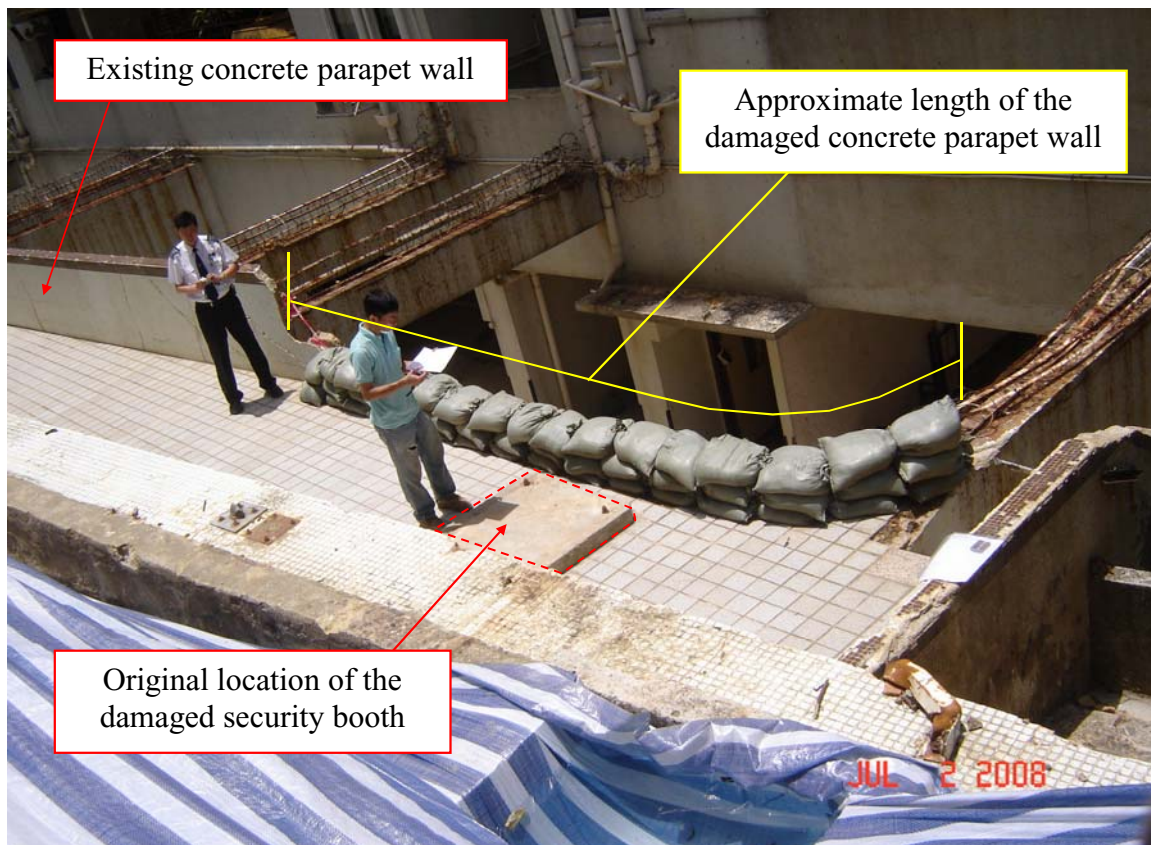


Plate 5 - Damaged Security Booth and Concrete Parapet Wall at the Rear of Ewan Court
(Photograph taken on 2 July 2008)

Note: See Figure 11 for location and direction of photograph.



Plate 6 - Landslide Debris Deposited at the Rear Alleyway of Ewan Court
(Photograph taken on 10 June 2008)

Note: See Figure 11 for location and direction of photograph.

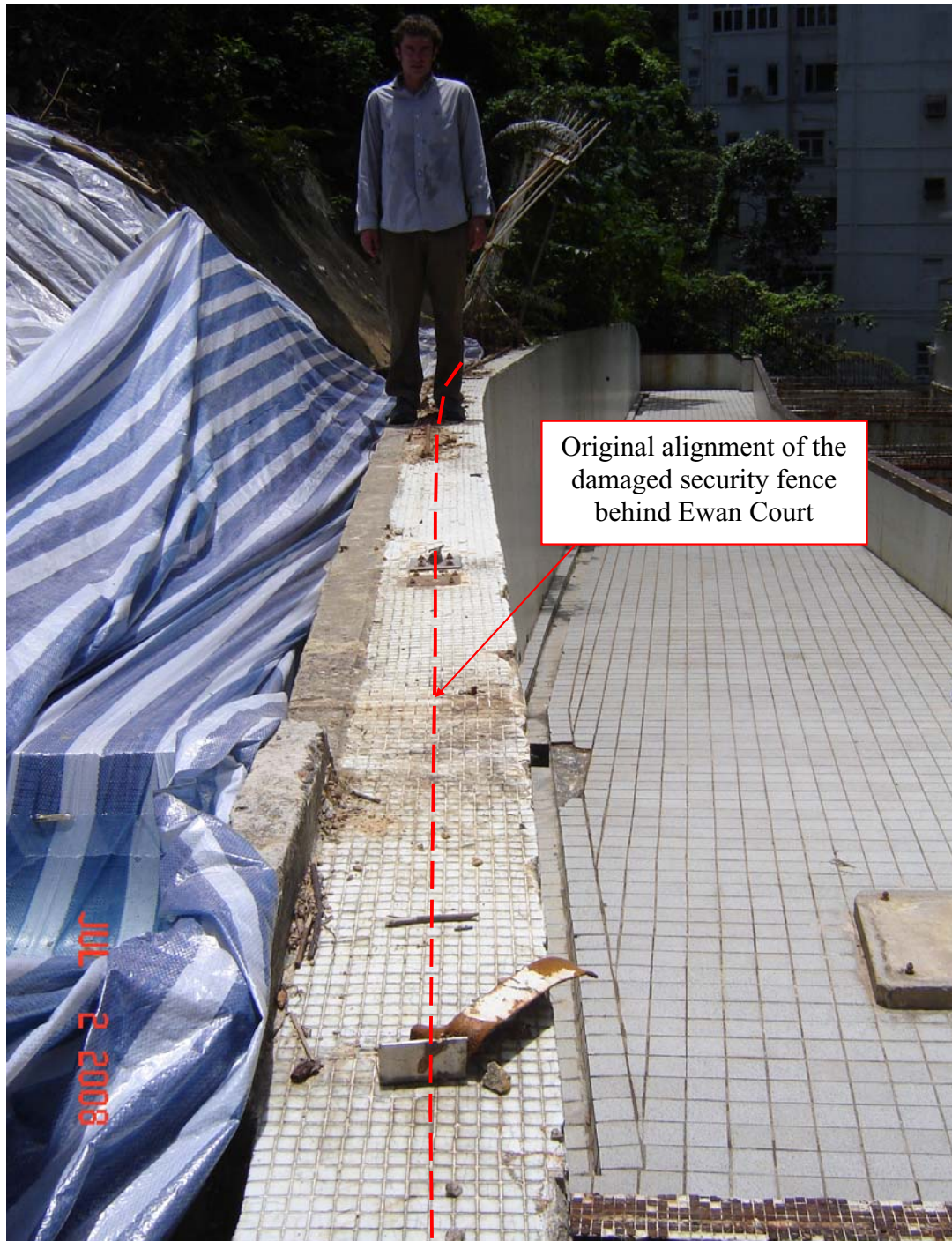


Plate 7 - Damaged Security Fence at the Crest of Retaining Wall of
Feature No. 11SW-B/CR506 behind Ewan Court
(Photograph taken on 2 July 2008)

Note: See Figure 11 for location and direction of photograph.



Plate 8 - Landslide Trail below Bowen Road
(Photograph taken on 10 June 2008)

Note: See Figure 11 for location and direction of photograph.



Plate 9 - General View of the Unpaved Fill Platform at the Crest of the
7 June 2008 Landslide
(Photograph taken on 24 July 2001)

Note: See Figure 11 for location and direction of photograph.

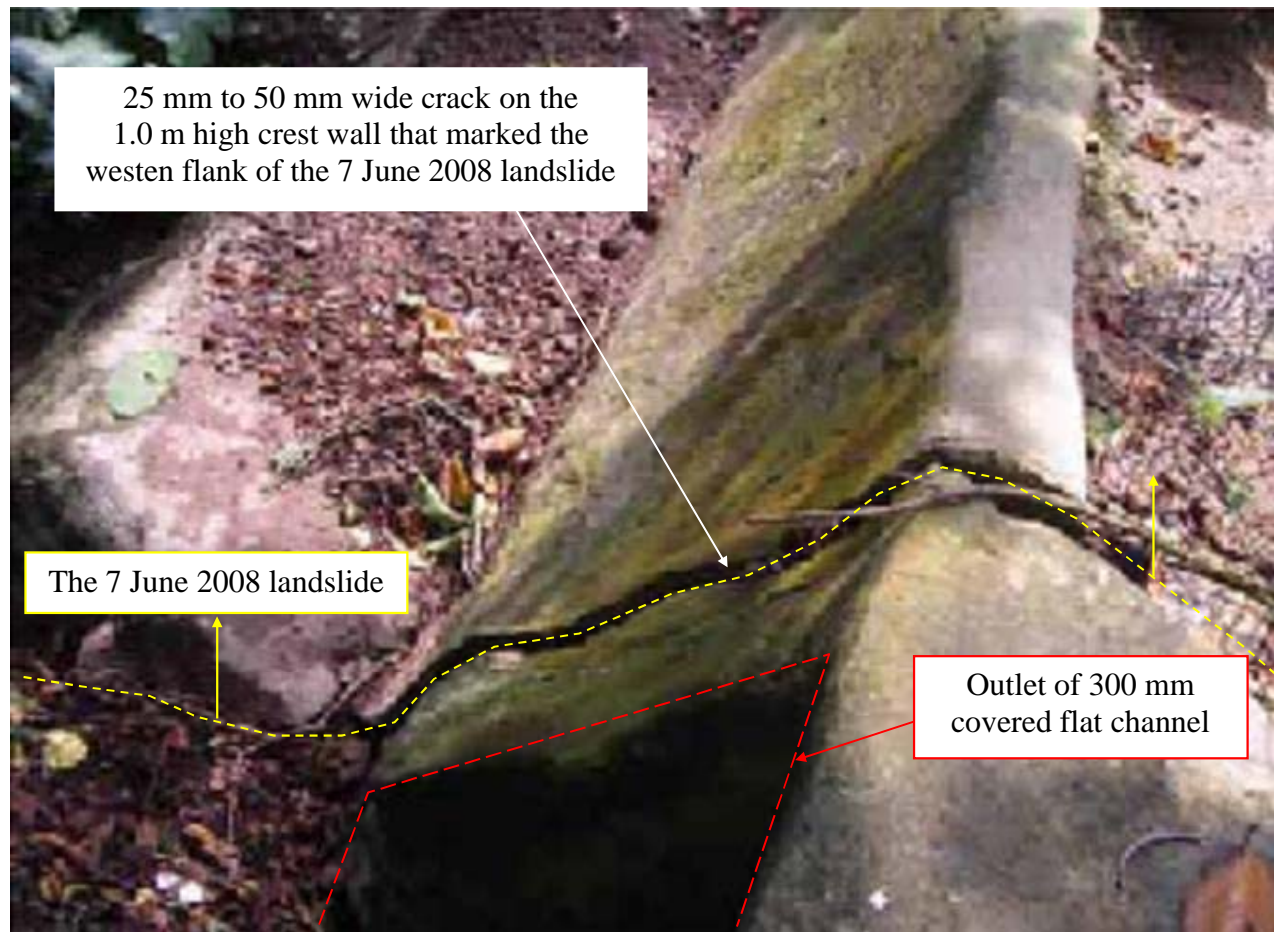


Plate 10 - Crack Identified in Routine Maintenance Inspection in 2005
(Photograph taken on 11 August 2005)

Note: See Figure 11 for location and direction of photograph.



Plate 11 - Landslide Debris Retained by Dense Trees on the Hillside below Bowen Road
(Photograph taken on 10 June 2008)

Note: See Figure 11 for location and direction of photograph.



Plate 12 - Source Area of the 7 June 2008 Landslide and the Detached Raft of Landslide Debris at the Western Flank of the Landslide
(Photograph taken on 10 June 2008)

Note: See Figure 11 for location and direction of photograph.



Plate 13 - General View of the Unfailed Unpaved Fill Platform at the Crest of the 7 June 2008 Landslide
(Photograph taken on 10 June 2008)

Note: See Figure 11 for location and direction of photograph.



Plate 14 - Condition of the 300 mm Covered Flat Channel
(Photograph taken on 23 April 2009)

Note: See Figure 11 for location and direction of photograph.



Plate 15 - Blocked Inlet to the 300 mm Covered Flat Channel at the Toe of Feature No. 11SW-D/C1401
(Photograph taken on 26 September 2008)

Note: See Figure 11 for location and direction of photograph.

APPENDIX A

AERIAL PHOTOGRAPH INTERPRETATION

CONTENTS

	Page No.
Title Page	45
CONTENTS	46
A1. DETAILED OBSERVATIONS	47
LIST OF TABLES	50
LIST OF FIGURES	52

A1. DETAILED OBSERVATIONS

Detailed observations from a review of the available aerial photographs taken between 1945 and 2008 are presented below. A list of the aerial photographs reviewed is given in Table A1 and the major site development history is shown on Figure A1.

YEAR OBSERVATIONS

1945 High altitude, single aerial photograph of limited resolution.

The fill body and the house at No. 17 Bowen Road (hereinafter referred to as “Caronia”) have not yet been formed, though an area of medium reflectivity (possibly showing the outline of the present-day Caronia) is visible at the concerned location.

Bowen Road has already been formed. A platform associated with two building blocks is evident at the present-day location of Ewan Court. An area (M1) on the hillside to the south of the platform is covered with thin vegetation, whereas the area above is covered with denser vegetation.

1949 A house at the present-day Caronia has been built. Areas of high reflectivity are generally evident at the location of the fill body and the associated crest platform, as well as at the locations of feature Nos. 11SW-D/C1356 and 11SW-D/C1401, possibly indicating that these slope features were being formed at that time. A zigzag footpath (M2) connecting Bowen Road and Caronia appears to have been formed to its present-day alignment. Bowen Road generally follows its present-day alignment. An ephemeral natural drainage line (S1) is evident at the eastern end of feature No. 11SW-D/C1401.

The vegetation at the hillside to the south of the present-day Ewan Court becomes denser and a natural drainage line (S2) is present to the west that apparently coincides with a south-southeast to north-northwest (SSE-NNW) trending photolineament.

A large depression (M3) with its crest extending to Bowen Road is evident to the south of the present-day Sakura Court, which is covered with thin vegetation. A small area of erosion (E1) is also evident at the crest of the depression. A spot of high reflectivity, possibly a boulder (B1), is evident on the hillside just below Bowen Road.

1963 The platform at the crest of the fill body is clearly observed and the natural hillside above comprises a north-northwest rounded spur and the associated sideslopes. The slope angles of the sideslopes are steep, while the slope angle of the spur is gentle. To the west of feature No. 11SW-D/C1356, a terrace (M4), comprising three vegetated batters, could be clearly seen on the spur.

The hillside to the south of the present-day Ewan Court is densely vegetated with trees and shrubs, concealing the SSE-NNW trending photolineament. The outline

YEAR OBSERVATIONS

- of the large depression to the south of the present-day Sakura Court is still observable, where the hillside becomes densely vegetated with trees and shrubs.
- 1967 No changes of significance are observed on the hillside above Bowen Road. The hillside to the south of the present-day Ewan Court is generally obscured by overhanging dense vegetation, whereas the large depression to the south of the present-day Sakura Court is covered with thin grass and shrub.
- 1968 No changes of significance are observed on the hillside above Bowen Road and the hillside to the south of the present-day Ewan Court, which is generally obscured by overhanging dense vegetation. An area of erosion (E2) is evident above the depression to the south of the present-day Sakura Court, which appears to have been extended to the south of Bowen Road.
- 1972 Low altitude, single aerial photograph of good resolution.
- Renovation of the house at the present-day Caronia appears to be underway and two single-storey structures (M5 & M6) have been constructed. An area of high reflectivity (M7), possibly relating to anthropogenic activities, is evident to the east of the structure (M5).
- No changes of significance are observed on the hillsides to the south of the present-day Ewan Court and Sakura Court.
- 1973 High altitude, single aerial photograph of good resolution.
- No changes of significance are observed, except that the buildings at Nos. 54-56 and Nos. 58-60 Kennedy Road are demolished.
- 1976 Low altitude, single aerial photograph of good resolution.
- No changes of significance are observed on the hillside above Bowen Road. A slightly curved linear feature (M8), possibly a drainage channel, appears running from Bowen Road downslope towards the southwestern corner of the construction site at Nos. 58-60 Kennedy Road. However, the details of this feature could not be observed. Site formation works are in progress at Nos. 54-56 and Nos. 58-60 Kennedy Road.
- 1977 The area of high reflectivity to the east of the structure (M5) observed in 1972 is obscured by vegetation.
- Construction of the present-day Ewan Court and Sakura Court are in progress. Extensive slope formation works (M9) is evident on the hillside to the south of the present-day Sakura Court, where the vegetation is stripped and rock is exposed. A possible landslide (LA1) is located above the present-day feature No. 11SW-B/CR223.

YEAR	OBSERVATIONS
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1978	No changes of significance are observed, except that Ewan Court and Sakura Court have been built.
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1979	No changes of significance are observed.
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1980	The two single-storey structures (M5 & M6) at Caronia have been demolished and the platform to the east of the structure (M5) is clearly visible in the form of an area of high reflectivity. Feature No. 11SW-B/CR506 and the platform at its toe are clearly apparent behind Ewan Court.
------	--

1981	No changes of significance are observed.
------	--

1982	No changes of significance are observed on the hillside above Bowen Road.
------	---

A landslide (LA2) is evident to the south of Ewan Court, but the details of the rupture surface could not be observed. Landslide debris partially encroaches on the rear alleyway of Ewan Court, which has not yet been cleared. Vegetation appears at the lower central portion of the landslide trail and material with a soil texture appears along the flanks of the landslide trail.

1984	No changes of significance are observed on the hillside above Bowen Road. The landslide scar (LA2) is still observable.
------	---

1986	No changes of significance are observed on the hillside above Bowen Road. The landslide trail of the landslide (LA2) is covered with short grasses. Three linear features are evident on the landslide trail, which appear to be a surface drainage system. This surface drainage system (M10) comprises two sub-parallel drainage channels, which both connect to a north-dipping drainage channel from the crown of the landslide to its toe.
------	---

1987 to 2008	No changes of significance are observed. The general study area is covered with dense vegetation.
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LIST OF TABLES

Table No.		Page No.
A1	List of Aerial Photographs Reviewed	51

Table A1 - List of Aerial Photographs Reviewed

Date Taken	Altitude (ft)	Photograph Number
11 November 1945	20,000	Y00426
8 May 1949	8,600	Y01469-70
1 February 1963	2,700	Y07458-59
16 May 1967	6,250	Y13302-03
1968	Unknown	Y14102-03
24 June 1972	2,500	1830
24 October 1973	12,500	5463
28 January 1976	4,000	12646
15 September 1977	4,000	19301-02
5 December 1978	4,000	23871-72
28 September 1979	5,500	27151-52
24 January 1980	2,000	28990-91
17 May 1981	4,000	37150-51
28 July 1982	3,500	43058-60
2 March 1984	4,000	53671-72
20 September 1986	4,000	A05957-58
9 September 1987	4,000	A10310-11
25 October 1988	2,000	A14809-10
7 July 1989	3,000	A17315
14 November 1990	4,000	A23803
2 October 1991	4,000	A27730-31
15 October 1992	4,000	A32544-45
8 October 1993	4,000	CN4715-16
23 November 1995	10,000	CN12143-44
7 June 1996	4,000	CN14107-08
31 October 1997	10,000	CN18636-37
31 May 2001	4,000	CW31235
4 November 2002	8,000	CW45944
11 May 2003	4,000	CW47302
5 October 2004	4,000	CW60159
6 March 2005	8,000	CW63552-54
19 May 2006	4,000	CW1764
12 July 2007	3,000	CW77039-40
1 March 2008	6,000	CS11475-76
Note: Aerial photographs are in black and white, except for those prefixed with CN, CW and CS.		

LIST OF FIGURES

Figure No.		Page No.
A1	Detailed API Observations	53

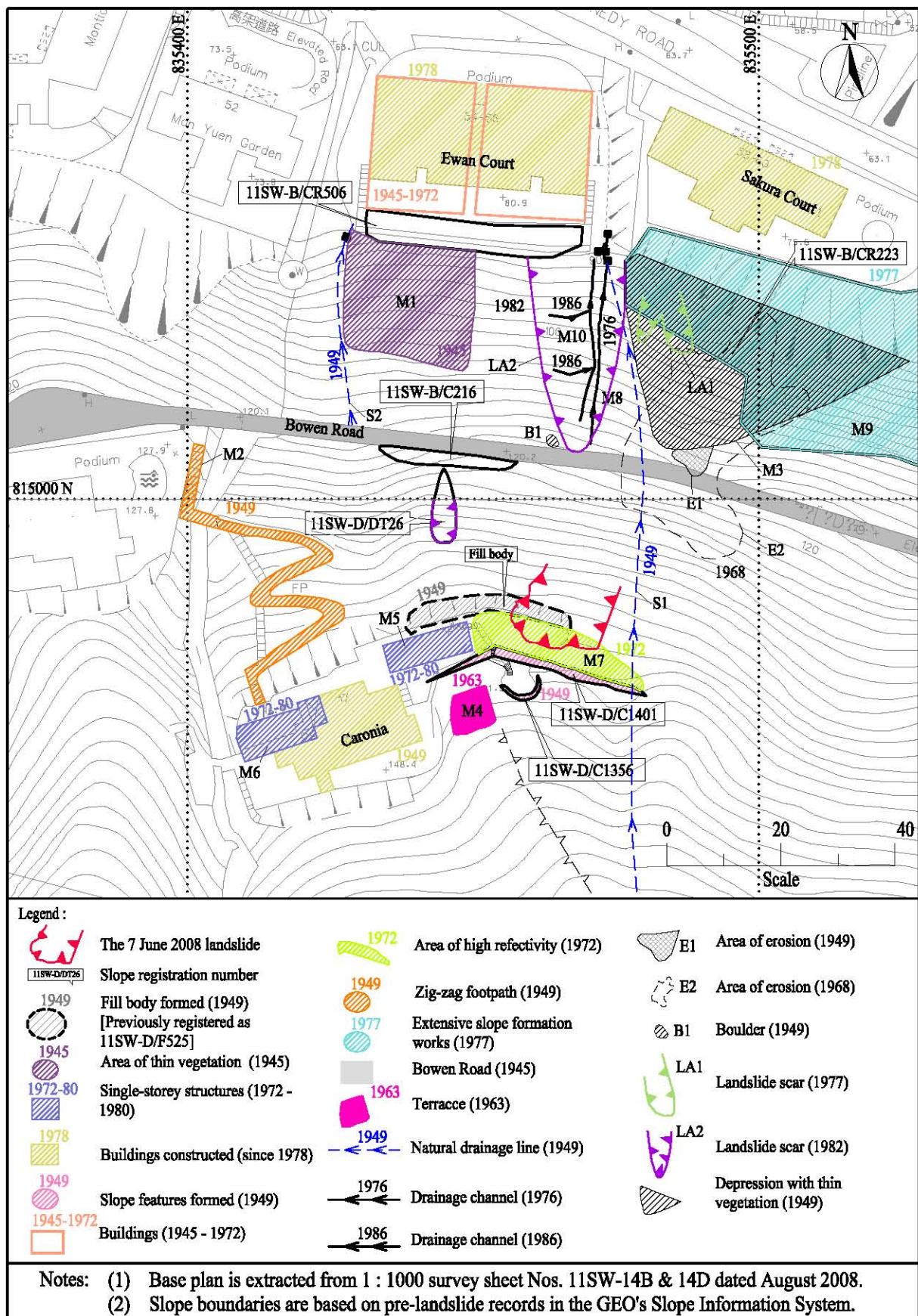


Figure A1 - Detailed API Observations

GEO PUBLICATIONS AND ORDERING INFORMATION

土力工程處刊物及訂購資料

A selected list of major GEO publications is given in the next page. An up-to-date full list of GEO publications can be found at the CEDD Website <http://www.cedd.gov.hk> on the Internet under "Publications". Abstracts for the documents can also be found at the same website. Technical Guidance Notes are published on the CEDD Website from time to time to provide updates to GEO publications prior to their next revision.

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- Calling the Publications Sales Section of Information Services Department (ISD) at (852) 2537 1910
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Geotechnical Manual for Slopes, 2nd Edition (1984), 302 p. (English Version), (Reprinted, 2011).

斜坡岩土工程手冊(1998)，308頁(1984年英文版的中文譯本)。

Highway Slope Manual (2000), 114 p.

GEOGUIDES

Geoguide 1 Guide to Retaining Wall Design, 2nd Edition (1993), 258 p. (Reprinted, 2007).

Geoguide 2 Guide to Site Investigation (1987), 359 p. (Reprinted, 2000).

Geoguide 3 Guide to Rock and Soil Descriptions (1988), 186 p. (Reprinted, 2000).

Geoguide 4 Guide to Cavern Engineering (1992), 148 p. (Reprinted, 1998).

Geoguide 5 Guide to Slope Maintenance, 3rd Edition (2003), 132 p. (English Version).

岩土指南第五冊 斜坡維修指南，第三版(2003)，120頁(中文版)。

Geoguide 6 Guide to Reinforced Fill Structure and Slope Design (2002), 236 p.

Geoguide 7 Guide to Soil Nail Design and Construction (2008), 97 p.

GEOSPECS

Geospec 1 Model Specification for Prestressed Ground Anchors, 2nd Edition (1989), 164 p. (Reprinted, 1997).

Geospec 3 Model Specification for Soil Testing (2001), 340 p.

GEO PUBLICATIONS

GCO Publication Review of Design Methods for Excavations (1990), 187 p. (Reprinted, 2002).
No. 1/90

GEO Publication Review of Granular and Geotextile Filters (1993), 141 p.
No. 1/93

GEO Publication Foundation Design and Construction (2006), 376 p.
No. 1/2006

GEO Publication Engineering Geological Practice in Hong Kong (2007), 278 p.
No. 1/2007

GEO Publication Prescriptive Measures for Man-Made Slopes and Retaining Walls (2009), 76 p.
No. 1/2009

GEO Publication Technical Guidelines on Landscape Treatment for Slopes (2011), 217 p.
No. 1/2011

GEOLOGICAL PUBLICATIONS

The Quaternary Geology of Hong Kong, by J.A. Fyfe, R. Shaw, S.D.G. Campbell, K.W. Lai & P.A. Kirk (2000), 210 p. plus 6 maps.

The Pre-Quaternary Geology of Hong Kong, by R.J. Sewell, S.D.G. Campbell, C.J.N. Fletcher, K.W. Lai & P.A. Kirk (2000), 181 p. plus 4 maps.

TECHNICAL GUIDANCE NOTES

TGN 1 Technical Guidance Documents