REVIEW OF THE 27 MAY 2007 BOULDER FALL INCIDENT ON THE SLOPING GROUND ABOVE RETAINING WALL NO. 11SW-A/R677, PO SHAN ROAD

GEO REPORT No. 268

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 2/2009 produced in May 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.

Y.C. Chan
Head, Geotechnical Engineering Office
May 2012

FOREWORD

This report presents the findings of a review of a boulder fall (Incident No. 2007/05/0016) that occurred on 27 May 2007 on the sloping ground above the crest of retaining wall No. 11SW-A/R677 situated at Po Shan Road, Mid-levels. The failure involved the detachment of a boulder with an estimated volume of about 0.4 m^3 that came to rest on Po Shan Road. No casualties were reported as a result of the incident.

The key objectives of the review were to document the facts about the incident, the site history and pertinent observations. The scope of the review does not include any ground investigation. Recommendations for follow-up actions are reported separately.

The report was prepared as part of the Landslide Investigation Consultancy (LIC) for Hong Kong Island and Outlying Islands, for the Geotechnical Engineering Office (GEO) of the Civil Engineering and Development Department (CEDD), under Agreement No. CE 49/2005 (GE). This is one of a series of reports produced during the consultancy by Fugro Scott Wilson Joint Venture (FSW).

Y C Koo
Project Director
Fugro Scott Wilson Joint Venture

Agreement No. CE 49/2005 (GE)
Study of Landslides Occurring in Hong Kong Island and Outlying Islands in 2006 and 2007

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1. INTRODUCTION

On the afternoon of 27 May 2007, a boulder fall (Incident No. 2007/05/0016) occurred on the sloping ground above the crest of retaining wall No. 11SW-A/R677[1]. The source area of the boulder fall is situated above Po Shan Road, and below the residential development at No. 8 Po Shan Road, viz. Hamilton Court (Figure 1). The incident involved the detachment of a boulder with an estimated volume of about 0.4 m^3 that came to rest on Po Shan Road (Plate 1), resulting in temporary closure of the road to traffic. No casualties were reported as a result of the incident. The fallen boulder caused minor damage to the pavement of the west-bound lane of Po Shan Road.

Following the incident, Fugro Scott Wilson Joint Venture (FSW), the Landslide Investigation Consultants for Hong Kong Island and Outlying Islands, carried out a review of the landslide for the Geotechnical Engineering Office (GEO) of the Civil Engineering and Development Department (CEDD), under Agreement No. CE 49/2005 (GE).

This review report documents the facts about the incident, site history and pertinent observations made by FSW. The scope of the review does not include any ground investigation.

2. THE SITE

2.1 Site Description

The general landform in the vicinity of the May 2007 incident comprises a north-facing hillside, incorporating a number of catchments below Victoria Peak (The Peak, see Figure 1). Po Shan Road traverses the hillside locally at an elevation of about 175 mPD, falling towards the west at a gradient of about 4% and comprising a single 2-lane carriageway (about 6.5 m wide), with a 1 m wide pedestrian pavement and handrail on the northern (east-bound) side. The heavily vegetated natural hillsides extending above the south of Po Shan Road are typically inclined at angles of between 25° and 35°, increasing to the range of 35° to 45° above an elevation of approximately 320 mPD.

The residential development, Hamilton Court, at No. 8 Po Shan Road comprises a 20-storey apartment block constructed on a levelled building platform above and to the south of Po Shan Road at an elevation of about 189 mPD. It has been excavated into a northwest-southeast trending spur ridge plunging at an angle of about 25° towards the northwest (Figure 1). A well-defined drainage line extends along the eastern flank of the spur ridge adjacent to Hamilton Court and is culverted beneath Po Shan Road.

A 32 m high vegetated cut slope No. 11SW-A/C178 (Figure 1), which is inclined at around 35°, extends above the southern portion of the Hamilton Court building platform and comprises the repaired scar of a major landslide that occurred in 1972 (see Section 4). The podium area within the Hamilton Court development mostly comprises an elevated platform that is supported by reinforced concrete beams and columns (Plate 2). It covers a basement

[1] Subsequent to the May 2007 boulder fall incident, the feature boundary of retaining wall No. 11SW-A/R677 was amended to include the slope above its crest (i.e. the sloping ground where the May 2007 boulder fall incident occurred) and re-registered as feature No. 11SW-A/FR276 (Appendix A) in July 2007.

carpark area extending beneath the main building structure (Figure 2). The southern portion of the podium comprises slab-on-grade construction.

Retaining wall No. 11SW-A/R677 (Plate 3) comprises a 60 m long, 4 m high dressed block masonry faced retaining wall extending above the Po Shan Road carriageway and below Hamilton Court. Based on GEO's Slope Information System (SIS), the existing Combined New Priority Classification System (CNPCS) score for the retaining wall is 0.49. The feature extends between the driveway entrance to Hamilton Court in the east and the driveway entrance to the adjacent property, viz. Piccadilly Mansion, at No. 6 Po Shan Road, to the west. The face of the retaining wall is inclined at around 75° and incorporates 80 mm diameter weepholes at 2 m staggered centres. A 420 mm wide by 120 mm deep concrete coping is present along the wall crest. A large tree with an extensive root system is located on the wall face at the western end of the retaining wall.

The sloping ground extending from the crest of retaining wall No. 11SW-A/R677 to the lot boundary of I.L. 2427 (i.e. Hamilton Court) where the May 2007 boulder fall source area is located (Figure 2 and Plate 3), comprises a 5 m to 10 m strip of hillside with a gradient of between 35° and 50°. A number of small- to medium-sized boulders/corestones (typically less than 1 m in diameter) are exposed on the slope surface. The area is variably vegetated with small to large trees, ferns, succulents and assorted undergrowth, with a resultant accumulation of leaf litter and a number of dead tree stumps. There are no surface drainage provisions within this area.

The face of retaining wall No. 11SW-A/R677 and the sloping ground above are traversed by two approximately 90 mm diameter above-ground PVC pipelines of unknown purposes from Hamilton Court, approximately 33 m and 39 m from the eastern end of the feature respectively (Figure 2 and Plate 4). A 150 mm downpipe is located at the eastern end of the wall adjacent to the Hamilton Court driveway and connects to a 300 mm wide U-channel extending upslope to the lot boundary of Hamilton Court (Figure 2 and Plate 5).

Three other pipes, comprising a 80 mm diameter gas main, a 150 mm diameter foulwater sewer and an approximately 90 mm diameter galvanized iron pipe of unknown purpose, are exposed on the face of retaining wall No. 11SW-A/R677, about 3 m from the western end of the feature (Figure 2 and Plate 6).

2.2 Water-carrying Services

Records of the Water Supplies Department (WSD) indicate that there is a buried 12-inch diameter freshwater main extending along the toe of retaining wall No. 11SW-A/R677 underneath the Po Shan Road carriageway (Figure 3). This feeds a 2-inch diameter buried supply main serving Hamilton Court and two ¾-inch diameter supply mains serving Piccadilly Mansion.

Records of the Drainage Services Department (DSD) indicate that there is a buried 150 mm diameter foulwater sewer extending along Po Shan Road within the carriageway, which drains a buried 150 mm diameter foulwater sewer exiting Hamilton Court at the eastern end of retaining wall No. 11SW-A/R677 and the 150 mm diameter foulwater sewer traversing the face of retaining wall No. 11SW-A/R677 at the western end of the

feature (Figure 3). A 300 mm diameter buried stormwater drain also exits Hamilton Court at the eastern end of retaining wall No. 11SW-A/R677 and discharges into the culvert beneath Po Shan Road to the east.

3. MAINTENANCE RESPONSIBILITY

According to the Slope Maintenance Responsibility Information System of the Lands Department, the maintenance responsibility of retaining wall No. 11SW-A/R677 rests with the Highways Department (HyD) at the time of the May 2007 boulder fall incident. The area of the sloping ground extending between the crest of retaining wall No. 11SW-A/R677 and the lot boundary of Hamilton Court, which contains the source location of the May 2007 boulder fall incident, is unallocated Government Land.

4. SITE DEVELOPMENT AND PREVIOUS INSTABILITIES

4.1 Site Development

The site development history has been established from a review of file records in the GEO and interpretation of the aerial photographs (API) taken between 1924 and 2006. A detailed account of the API for the present study is given in Appendix B. The salient information of relevance to the history of the site is presented in Figure 4.

Po Shan Road is visible in the 1924 photographs on much the same alignment as the present arrangement. The hillside above Po Shan Road remains largely undeveloped and the spur ridge extending above and below Po Shan Road at the present-day location of Hamilton Court as well as the adjacent streamcourse to the east are visible. A strip of hillside (about 5 m to 10 m wide), possibly disturbed by some drainage works, which extends upslope from Po Shan Road on the western flank of the streamcourse and the southern portion of the Hatton Road service reservoir, is visible about 200 m on plan upslope. A cutting is visible at the present-day location of retaining wall No. 11SW-A/R677 and the ground above has a cover of sparse vegetation.

The 1945 aerial photographs show that the original development of the ground above Po Shan Road, comprised levelled building platforms at the present-day locations of Hamilton Court and Po Shan Mansions to the east, and Piccadilly Mansion to the west, all of which are occupied by low-rise residences. The building platforms are generally smaller than the present-day podiums, aligning along the southern boundary, but not extending as far to the north. Cuttings are visible along the southern edges of the platforms and fill slopes extend below the northern edges. Retaining wall No. 11SW-A/R677 is visible and conforms to the present-day arrangement. The sloping ground above the crest of retaining wall No. 11SW-A/R677 has a cover of dense vegetation.

From 1945 onwards, retaining wall No. 11SW-A/R677 and the sloping ground above are generally completely obscured by mature vegetation, which becomes progressively heavier with time, and no major local changes can be detected. The residences at the present-day locations of Po Shan Mansions and Piccadilly Mansion underwent redevelopment during the mid-1960s, which comprised the enlargement of the platform/podium area to the north and construction of high-rise apartment buildings, two at Po Shan Mansions and one at

Piccadilly Mansion. Po Shan Road was also possibly widened along the northern edge during this period.

Redevelopment of the former residence at the present-day location of Hamilton Court was underway in the 1972 aerial photographs, which also show the scar and debris trail of the 1972 Po Shan landslide (Cooper, 1992) to the east of Po Shan Mansions, as well as the scar and debris trail of a large natural terrain landslide that occurred above the southern edge of the building platform at Hamilton Court. The landslide scar above Hamilton Court extends over the full length of the platform and about 35 m on plan upslope. Debris from the landslide is visible on the building platform and extends as far as Po Shan Road, depositing also on the sloping ground above the crest of retaining wall No. 11SW-A/R677 at the eastern end of the feature.

The 1973 photographs show the ongoing redevelopment works at Hamilton Court. The 1972 landslide debris has been completely removed from the building platform, which has been extended further north, matching with the current arrangement. The landslide scar has been trimmed back to form slope No. 11SW-A/C178 to the current geometry, involving three batters separated by berms and the provision of a surface drainage system. The Hamilton Court redevelopment is completed in the 1974 aerial photographs. Seepages can be seen issuing from three locations on the lowest batter of slope No. 11SW-A/C178, which are also visible in the 1975, 1977, 1979, 1980, 1981 and 1982 aerial photographs.

The 1975 aerial photographs indicate that the sloping ground immediately below the podium of Hamilton Court has been provided with a hard surface cover of chunam that extends about mid-way to the crest of retaining wall No. 11SW-A/R677. The appearance and shape of the chunam suggest that it was placed as slope protection to part of the sloping ground immediately below Hamilton Court and not in association with any obvious instability. From 1975 onwards, no obvious changes are observed in respect of the general arrangement of Hamilton Court or the ground to the north, including retaining wall No. 11SW-A/R677 and the sloping ground above.

4.2 Previous Instabilities

According to the GEO's landslide database, no previous landslide incidents have been recorded on retaining wall No. 11SW-A/R677 or on the sloping ground above. A number of minor landslide incidents have been reported on the man-made slopes in the general vicinity of the subject retaining wall between 1985 and 2002 (see Table 1 and Figure 5). The majority of these incidents involved small scale failures (less than 2 m^3) that were reported as involving colluvium or boulder falls. The largest landslide (Incident No. HK92/5/6), which has a failure volume of 40 m^3, was recorded at slope No. 11SW-A/C177 (see Figure 5) located below Po Shan Mansions immediately to the east and was reportedly caused by the rupture of a water main.

No obvious past instabilities in the sloping ground above slope No.11SE-A/R677 could be identified from aerial photographs. Two major landslides affecting the existing cuttings along the southern edges of the building platforms associated with the original developments at Piccadilly Mansion and Hamilton Court have been identified in the 1967 and 1972 aerial photographs respectively (see Section 4.1 and Figure 5), with the former

occurring in 1966. Additionally, two major landslides that occurred in 1966 have been identified on the natural hillsides above Po Shan Mansions in the 1967 aerial photographs. The 1972 Po Shan landslide (Cooper, 1992), located above Po Shan Road to the east of Po Shan Mansions has also been documented.

The GEO's Enhanced Natural Terrain Landslide Inventory (ENTLI) identifies four previous landslides in the general vicinity of the May 2007 boulder fall incident (Figure 5).

The upper 1966 landslide is also recorded in the GEO's Large Landslide Database (reference No. 11SWAL006).

5. PREVIOUS ASSESSMENTS

5.1 Binnie & Partners Study

In April 1978, retaining wall No. 11SW-A/R677 and the sloping ground above were inspected by Binnie & Partners (B&P) under the "Phase 1 Re-appraisal of Cut & Natural Slopes & Retaining Walls Study". Retaining wall No. 11SW-A/R677 was subsequently registered in the 1977/78 Catalogue of Slopes. The field sheet for this feature recorded that the retaining wall was in fair condition and signs of distress in the form of cracking were observed along the retaining wall, with tell-tales dated August 1975 installed on the wall. The western end of the retaining wall was reportedly "damp" over the full height (but the weepholes were dry), and tree roots were also reported at the western end. The sloping ground above the retaining wall, which was inclined at about 35° to 45° and 4 m high (max), was recorded as being in fair condition and comprised "decomposed volcanic colluvium", as reported in the field sheet.

5.2 Mid-Levels Study

The findings from the Mid-levels Study (GCO, 1982), which was carried out by consultants engaged by the Geotechnical Control Office (GCO, renamed GEO in 1991) in the early 1980s, indicate that the sloping ground above retaining wall No. 11SW-A/R677 comprises mainly "Class 2" colluvium about 3 to 4 m in thickness, which is described as commonly comprising 0% to 50%, and up to 80%, of sub-angular to sub-rounded, mainly moderately to highly decomposed, occasionally slightly decomposed cobbles and boulders with a firm to stiff, clayey sandy silt matrix. The Study also indicates an exposure of decomposed volcanic rock without any overlying colluvium on the southwestern portion of the sloping ground above retaining wall No. 11SW-A/R677 immediately below the podium of Hamilton Court (Figure 6).

5.3 Stage 1 Study

In October 1992, the Design Division (renamed LPM Division 2 in July 2004) of the GEO completed a Stage 1 Study for retaining wall No. 11SW-A/R677. Records in GEO's District Division (viz. Island Division) file ref. GCI 4/23/2 associated with the Stage 1 Study 1992/93 Programme indicate that the subject feature had been inspected

in October 1986 under the Mid-levels Study and found to be in fair condition. This Stage 1 Study did not cover the sloping ground above retaining wall No. 11SW-A/R677.

5.4 SIFT and SIRST Studies

In June 1994, under GEO's "Systematic Inspection of Features in the Territory" (SIFT) project, retaining wall No. 11SW-A/R677 was categorised as a Class 'B1' feature, i.e. fill features "assumed not to have been checked by GEO (assumed formed pre-1978 or illegally tipped fill)".

In February 1998, retaining wall No. 11SW-A/R677 was inspected under GEO's "Systematic Identification and Registration of Slopes in the Territory" (SIRST) project. The SIRST field sheet notes that the weepholes were clear and dry, but that there were signs of seepage on the wall face. The wall was recorded as having "Minimal" distress at the mid-portion and no inferred past instability. The area above the crest of the feature was recorded as having 25% of the surface area sealed, with no potential for ponding. The consequence-to-life category of the subject retaining wall was rated as '3'.

5.5 GEO File Records

Records in GEO file ref. GCI 2/E1/11SW-A indicate that a tree fall incident occurred at the crest of retaining wall No. 11SW-A/R677 during the heavy rainstorm on 22 July 1994. No details on the exact location of the fallen tree were identified by FSW under the present study. Correspondence from GEO to HyD following a joint inspection on 26 July 1994 indicated that the tree had been removed by the then Urban Services Department. It also mentioned that the tree root remained "precariously near the top of the wall" and that a number of small boulders had been loosened as a result of the tree fall incident. The GEO recommended that the tree root and any loose boulders be removed and any holes left in the slope be filled with "compacted material". Records indicating the completion of the works could not be located by FSW.

5.6 Routine Maintenance Inspections

Routine Maintenance Inspections (RMIs) of retaining wall No. 11SW-A/R677 were carried out by HyD in September 1998, July 1999, July 2000, February 2002 and November 2003 respectively. An RMI was undertaken by Maunsell Geotechnical Services Ltd. (MGS), the consultant to the HyD, in November 2002. RMIs were also conducted by another RMI consultant to HyD, Wong & Cheng Consulting Engineers Ltd. (Wong & Cheng), in May 2005, July 2005 and July 2006 respectively.

The findings of the RMIs carried out by HyD, MGS and Wong & Cheng were generally similar, with the observations of blockage of surface drainage channels and local cracking of the masonry wall as a result of unplanned vegetation. The locations of the observations were not indicated in the RMI reports. Recommended follow-up maintenance actions included removal of undesirable vegetation on the wall face, repair of pointing in the

masonry wall and clearance of weepholes. Based on the available records, the RMIs mainly focused on the condition of the masonry retaining wall.

5.7 Engineer Inspections

Engineer Inspections (EIs) were carried out by HyD's consultants, Fugro Mouchel Rendel Joint Venture and MGS in September 1995 and November 2000 respectively. The EI records identified blockage of the surface drainage system, unplanned vegetation on the wall face and the mortar pointing in the masonry wall being in a fair to poor condition. Recommended maintenance works comprised clearance of drainage channels and weepholes, removal of vegetation from the face of the masonry wall and repair of mortar pointing.

As for the RMIs, the EIs mainly focused on the masonry retaining wall and did not cover the sloping ground above, which was not registered.

6. THE 27 MAY 2007 INCIDENT AND POST-FAILURE OBSERVATIONS

6.1 Description of the 27 May 2007 Incident

The 27 May 2007 incident comprised a boulder fall that occurred on the sloping ground at about 1.3 m above the crest of retaining wall No. 11SW-A/R677 and about 3 m below the private residential property, Hamilton Court, at No. 8 Po Shan Road. The timing of the failure was approximately 4:25 p.m., based on the reported time in the incident report prepared by the GEO.

The fallen boulder measured about 1 m by 0.8 m by 0.5 m in size (Plate 1). It came to rest on the pavement of the north-bound lane of Po Shan Road near lamp post No. 39967 (Plate 1). The fallen boulder was subsequently removed by the HyD's term contractor on 27 May 2007. Two cobble-sized rock fragments were also reported by the GEO to have been deposited on Po Shan Road. A photograph taken by HyD during the course of removal of the boulders shows that other rock fragments appeared to have been present (Plate 7).

As a result of the boulder fall incident, one lane of Po Shan Road was closed temporarily. No casualty or damage of property was reported as a result of the incident.

6.2 Post-failure Observations by the GEO

The Island Division of the GEO inspected the site following the boulder fall in late May 2007 and early June 2007 while the term contractor of HyD was undertaking vegetation clearance on the portion of sloping ground immediately above the crest of retaining wall No. 11SW-A/R677. Record photographs taken by the GEO during these inspections identified a number of loose boulders (Plate 8), which were either removed or stabilised in-situ by cement mortar by HyD subsequent to the May 2007 incident (Plate 9), together with dead tree trunks (Plate 10), construction debris (Plate 11) and rubbish (Plate 12).

Inspection of the Hamilton Court podium by the GEO identified a 220 mm surface drainage channel that collects stormwater from the Hamilton Court apartment building as well as the podium area (Figure 2 and Plate 13), and extends to the northern edge of the podium. The channel was observed to discharge surface water through a 140 mm diameter 'spitter' pipe (Plate 14) directly onto the sloping ground behind retaining wall No. 11SW-A/R677 above the source area of the May 2007 boulder fall. In a joint site meeting attended by GEO, HyD and the management office of Hamilton Court on 1 June 2007, the GEO advised the management office of Hamilton Court to divert the flow from the surface drainage channel to a suitable discharge point. The diversion work had been completed at the time of a site inspection by FSW in mid-July 2007 (Plate 15).

6.3 Post-failure Observations by FSW

FSW first inspected the site on 5 June 2007, during which time the weather was fine. At the time of the inspection, the fallen boulder and the cobble-sized rock fragments had been removed. A row of oil drums had been placed and a bamboo scaffolding had been erected by HyD's term contractor along the full length of retaining wall No. 11SW-A/R677 (Plate 16).

The sloping ground extending between the crest of retaining wall No. 11SW-A/R677 and the Hamilton Court podium was covered by an assortment of vegetation, including small to large trees, ferns, shrubs succulents and grass, with dead tree stumps, a considerable accumulation of leaf litter as well as construction debris and rubbish.

The source location of the detached boulder (Plates 17 and 18) was identified on the sloping ground above retaining wall No. 11SW-A/R677 approximately 3 m from the wall crest (Figure 2). The source area comprised a depression exposing bare ground that measured about 1.8 m long by 1.4 m wide by 0.3 m deep. The boulder trail had created a scar on the ground. The overall inclination of the sloping ground in the vicinity of the source area was about 42º, whilst the ground immediately above the source area was inclined at around 25º.

The source area exposed slightly silty sand with many sub-angular to sub-rounded, gravel- and cobble-sized, moderately decomposed rock fragments and a number of tree roots of about 10 mm in diameter, with the largest one being of about 40 mm. No signs of groundwater seepage were observed within the source area at the time of the inspection.

The trajectory of the boulder (Figure 7) is inferred from the impact marks on the pavement of the westbound lane of Po Shan Road. The point of initial impact was at about 3.5 m to the west of the original location of the boulder and 1.5 m from the toe of retaining wall No. 11SW-A/R677 (Plate 19). The initial impact marks on the Po Shan Road pavement measured about 300 mm long by 50 mm wide by 20 mm deep (Plate 20). Less severe impact marks were also visible on the road pavement between the initial impact point and the final position of the boulder, approximately 2 m (on plan) adjacent to the lamp post No. 39967 on the northern side of Po Shan Road. The nature of the impact marks on Po Shan Road indicates that the boulder might have initially bounced upon impact and primarily rolled along the carriageway before coming to rest.

A number of other boulders (up to about 3 m in diameter, but typically less than 1 m in diameter) were observed on the sloping ground in the vicinity of the source location of the

May 2007 incident (Figure 8). At the time of inspection, the term contractor of HyD was in the process of applying cement mortar around the base of a number of these boulders, which formed part of the urgent repair works recommended by the GEO (Plate 21).

Further inspections of the site were carried out by FSW in October 2007 to appraise the condition of the sloping ground between the crest of retaining wall No. 11SW-A/R677 and the Hamilton Court podium, as well as the retaining wall itself. Detailed mapping of the sloping ground was carried out to identify exposed boulders and the slope-forming deposits, together with the major trees growing in the area (Figure 8). Notable observations made during the mapping exercise include the identification of the chunam surface cover noted in the 1975 aerial photographs, which was cracked and had disintegrated in some areas (Plate 22), as well as the identification of construction debris and some bouldery fill immediately below the western portion of the Hamilton Court podium (Plates 23 and 24). In addition, a void was also observed on the slope surface immediately above the source location of the May 2007 boulder fall, which measured about 200 mm wide by 300 mm deep (Plate 25). The exact cause of the void formation (e.g. animal burrow or erosion) is not clear. No signs of significant surface erosion were noted on the sloping ground below the 'spitter' pipe (see Section 6.2) at the time of FSW's inspections.

Rock outcrops/corestones comprising light brownish grey, moderately decomposed fine ash vitric tuff were observed to be protruding from the ground surface to the east of the May 2007 boulder fall source area (Figure 8). Steeply inclined joints stained with black manganese oxide were observed in the rock outcrops/corestones (Plate 26). The residual soil surrounding the rock outcrops/corestones comprised dense to very dense fine-grained silty sand with some gravel.

Inspection of retaining wall No. 11SW-A/R677 indicated that the masonry wall was in fair condition, with signs of minor cracking through the mortar pointing and masonry blocks, possibly caused by unplanned vegetation (Plate 27), but there were no signs of significant recent movement. Probing of the weepholes achieved penetrations ranging between 0.2 m near the crest and 1.9 m towards the toe.

7. RAINFALL RECORDS

Rainfall data were obtained from GEO automatic raingauge No. H04, which is the nearest raingauge to the May 2007 boulder fall site and located at Knowles Building, Hong Kong University, approximately 380 m northwest of the site (Figure 1). The raingauge records and transmits rainfall data at 5-minute intervals to the Hong Kong Observatory (HKO) and the GEO.

Based on the incident report prepared by the GEO, the boulder fall incident occurred at 4:25 p.m. on 27 May 2007. The daily rainfall recorded by raingauge No. H04 over the month preceding the boulder fall, together with the hourly rainfall readings for the period between 12:00 a.m. on 26 May 2007 and 9:00 p.m. on 27 May 2007, are presented in Figure 9. The maximum 24-hour and 12-hour rolling rainfall before the failure were 56.5 mm and 55 mm respectively.

Table 2 presents the estimated return periods for the maximum rolling rainfall for various durations recorded by raingauge No. H04 with reference to historical rainfall data at the HKO in Tsim Sha Tsui (Lam & Leung, 1994), where rainfall records began in 1884. The estimated return periods for all rainfall durations were less than 2 years.

The return periods were also assessed based on the statistical parameters derived by Evans & Yu (2001) for rainfall data recorded by the local raingauge No. H04 between 1984 and 1997 (Table 2). It is noted that the estimated return periods of the May 2007 rainstorm based on rainfall data at the local raingauge are similar to those estimated by the historical rainfall data at the HKO.

The maximum rolling rainfall for the rainstorm on 27 May 2007 has been compared with the past major rainstorms between 1992 and 2006 recorded by raingauge No. H04, which came into operation in the late-1970s (Figure 10). The maximum rolling rainfall for the rainstorm on May 2007 is generally much less severe than the previous significant rainstorms.

8. DISCUSSION

The close correlation between the rainstorm and the timing of the boulder fall suggests that the incident was probably rain-induced. However, the relatively light rainfall preceding the incident suggests that other factors in addition to rainfall may have contributed to the cause of the incident.

The site setting of the source area of the boulder fall is adverse in that it is located on a disturbed hillside scattered with construction debris and loose boulders, together with an unfavourable topography involving relatively steep, sloping ground where the boulder in question was perched.

Apart from the above, the groundmass of the area in question was subject to local deterioration due to the adverse effect of tree root action from unplanned vegetation, and lack of maintenance as evidenced by the presence of construction debris. The deterioration may have been further exacerbated by the uncontrolled discharge of stormwater from the private development above, which could have contributed to progressive soil erosion surrounding the perched boulder and loss of support.

9. REFERENCES

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Table 1 – Summary of Reported Landslide Incidents Affecting Slopes above Po Shan Road

Incident No.	Date of Failure	Approximate Location of Landslide Source Area	Approximate Failure Volume (m^3)	Debris Description	Possible Causes of Failure	Consequence
HK85/9/10	10 Sep 1985	Behind 4-6 Po Shan Road, Piccadilly Mansion	1	Colluvium	Groundwater and infiltration	Nil
HK92/5/6	8 May 1992	No. 10 Po Shan Road (Slope No. 11SW-A/C177)	40	Colluvium	Piping and rupture of water main	2 lanes of road blocked and carparks affected
HK93/10/1	Not known	Near to No. 30 Po Shan Road	< 0.25	Colluvium (boulder)	Infiltration and lack of maintenance	Nil
HK94/7/7	Not known	West of No. 30 Po Shan Road	0.5	Weathered rock	Infiltration	1 lane of road blocked
2002/9/141	22 Sep 2002	No.6 Po Shan Road	2	Colluvium	Infiltration	Building access affected

Note: See Figure 5 for locations of incidents

Table 2 - Maximum Rolling Rainfall at GEO Raingauge No. H04 for Selected Durations Preceding the Boulder Fall Incident on 27 May 2007 and the Estimated Return Periods

Duration	Maximum Rolling Rainfall (mm)	End of Period	Estimated Return Period (Years) (See Notes 2)	
			Lam & Leung (1994)	Evans & Yu (2001)
5 Minutes	7.5	2:30 p.m. on 27 May 2007	< 2	< 2
15 Minutes	16.5	2:30 p.m. on 27 May 2007	< 2	< 2
1 Hour	29	3:05 p.m. on 27 May 2007	< 2	< 2
2 Hours	32	4:05 p.m. on 27 May 2007	< 2	< 2
4 Hours	32.5	4:20 p.m. on 27 May 2007	< 2	< 2
12 Hours	55	3:45 p.m. on 27 May 2007	< 2	< 2
24 Hours	56.5	4:20 p.m. on 27 May 2007	< 2	< 2
48 Hours	56.5	4:20 p.m. on 27 May 2007	< 2	< 2
4 Days	56.5	4:20 p.m. on 27 May 2007	< 2	< 2
7 Days	221.5	4:25 p.m. on 26 May 2007	< 2	< 2
15 Days	309.5	4:20 p.m. on 27 May 2007	< 2	< 2
31 Days	320	4:20 p.m. on 27 May 2007	< 2	< 2

Notes:
(1) Maximum rolling rainfall was calculated from 5-minute rainfall data.
(2) Return periods were derived from the rainfall data recorded at Hong Kong Observatory between 1884 and 1939 and between 1947 and 1990 (Lam & Leung, 1994) as well as the data recorded at local raingauge No. H04 between 1984 and 1997 (Evans & Yu, 2001).
(3) The boulder fall was assumed to have occurred at 4:25 p.m. on 27 May 2007 (as stated in GEO's Incident Report) for the purpose of rainfall analysis.
(4) The nearest GEO raingauge to the 27 May 2007 boulder fall incident is raingauge No. H04, which is located about 380 m to the northwest and has been operational since 12 September 1978.

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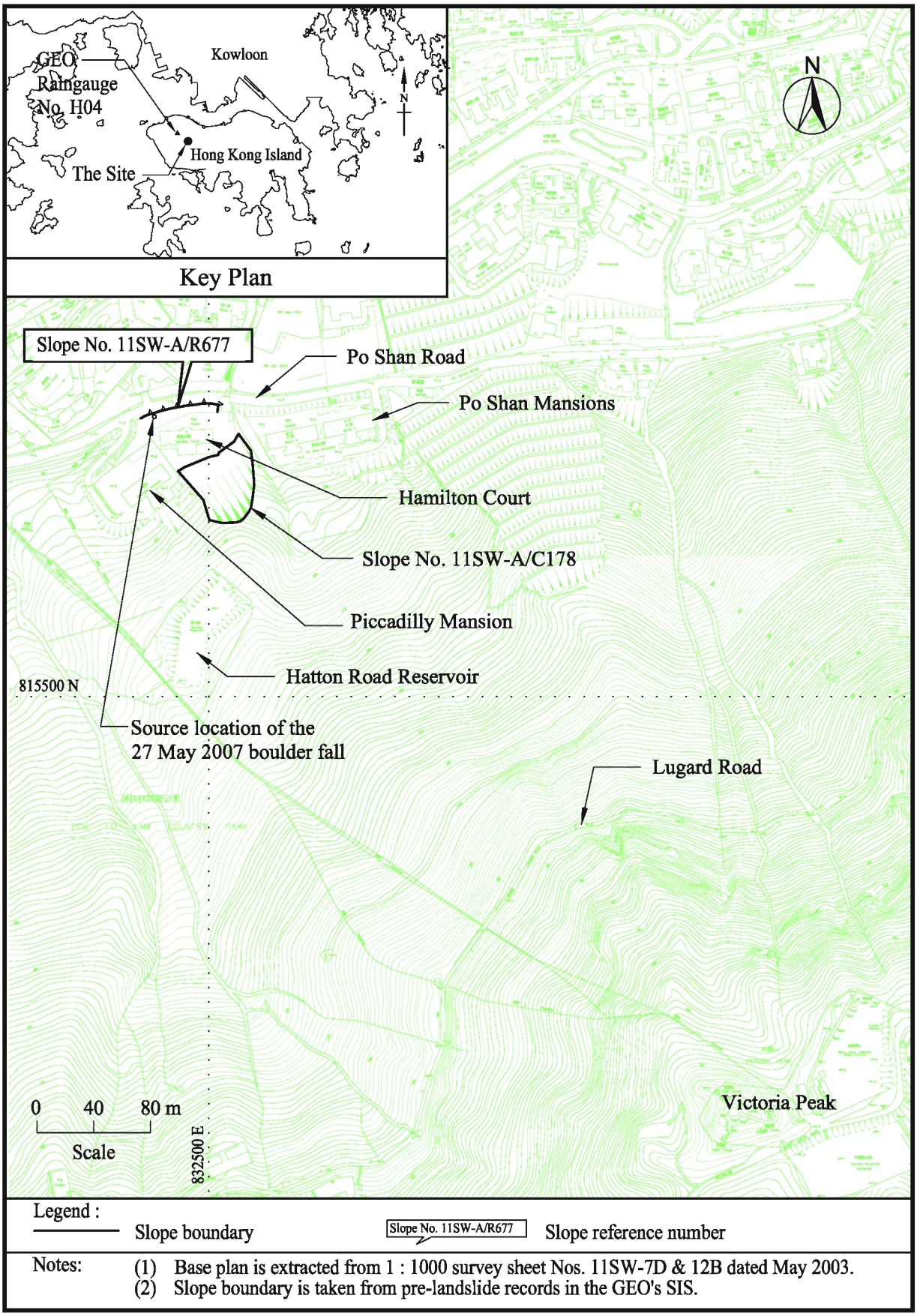

Figure 1 - Site Location Plan

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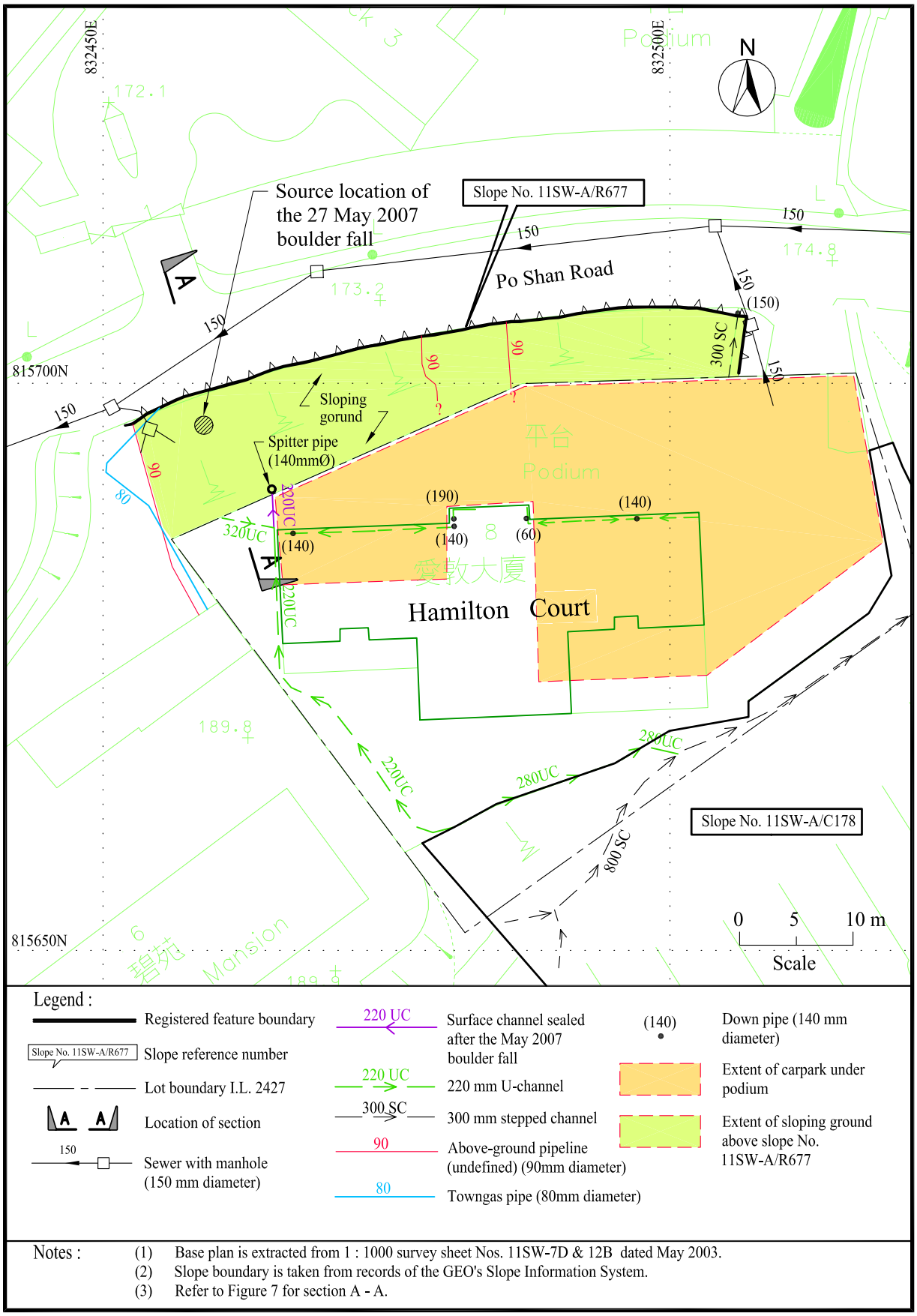

Figure 2 - Site Plan

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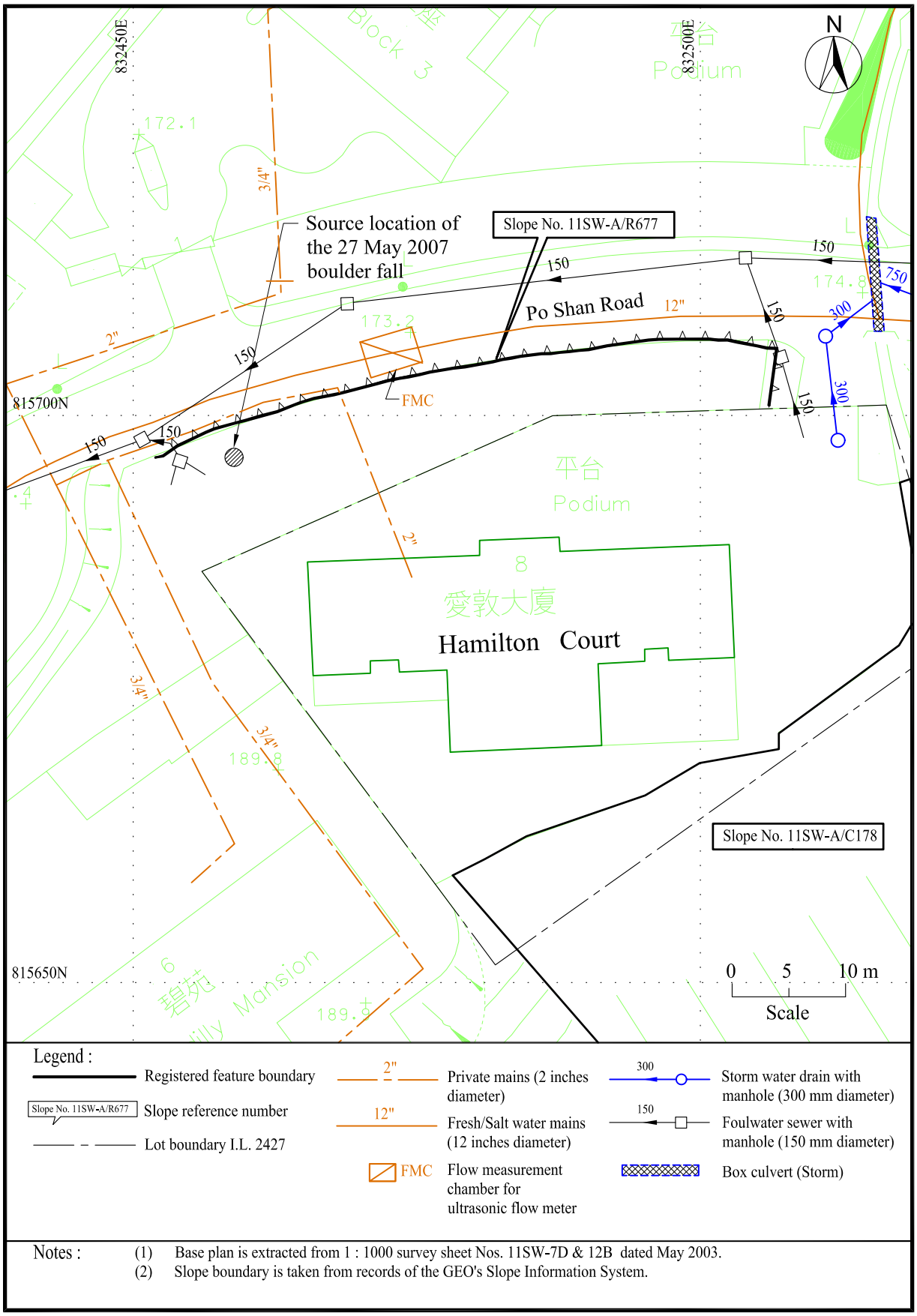

Figure 3 - Water-carrying Services Recorded in DSD and WSD

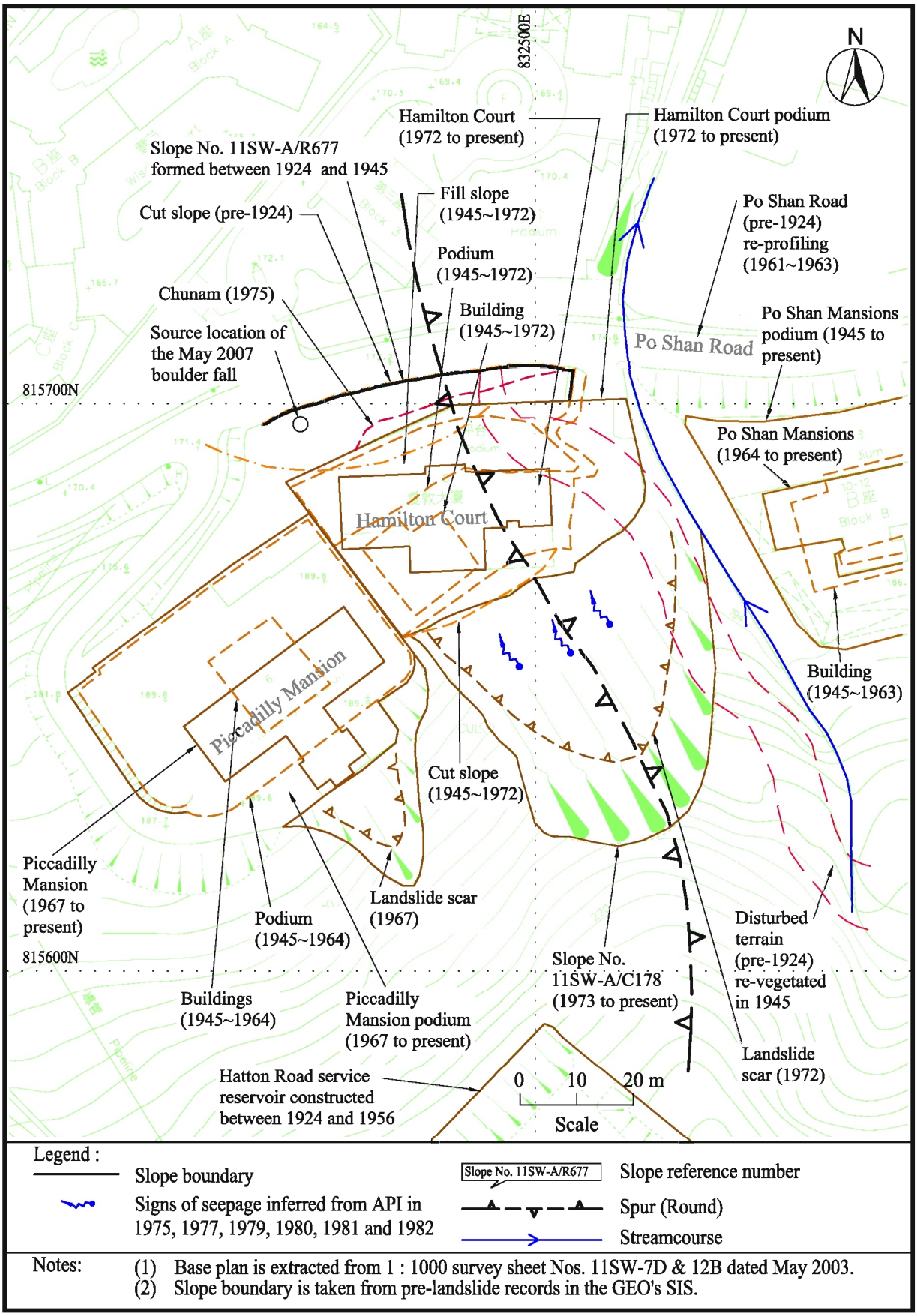

Figure 4 - Site History Plan

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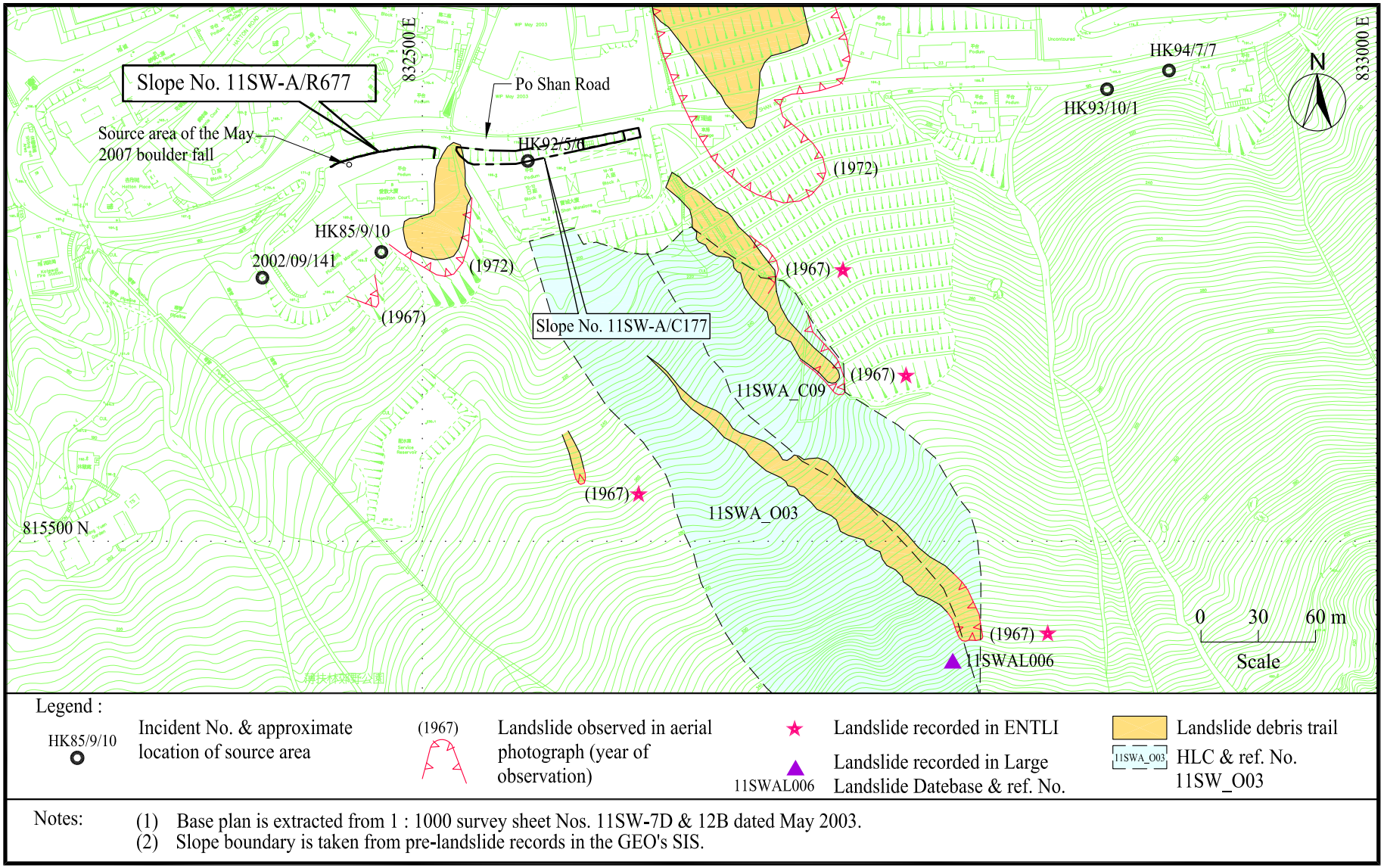
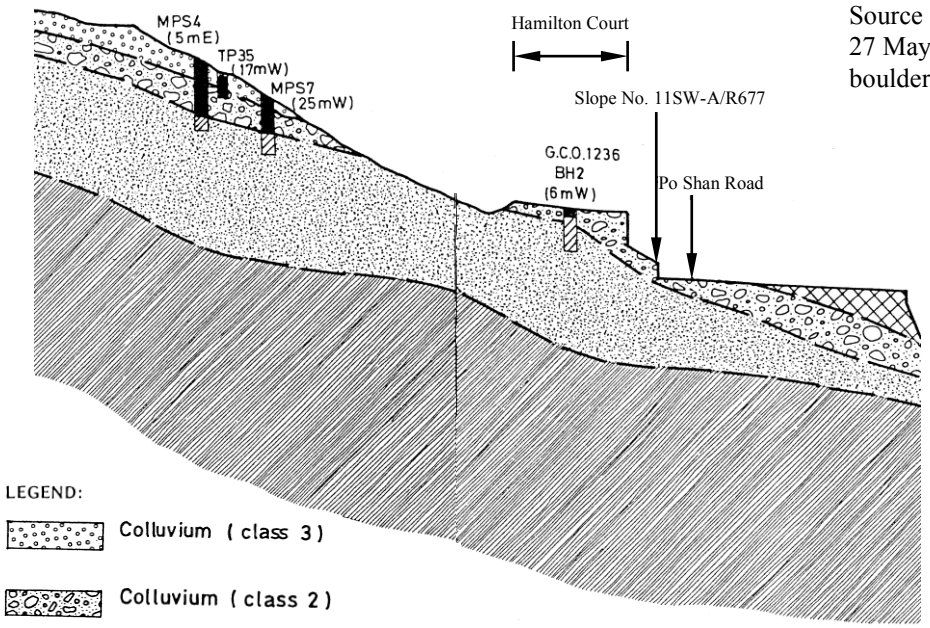
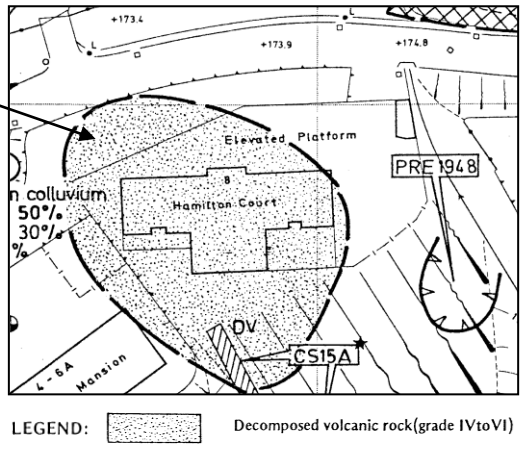


Figure 5 - Previous Instabilities Affecting Slopes and Hillsides above Po Shan Road

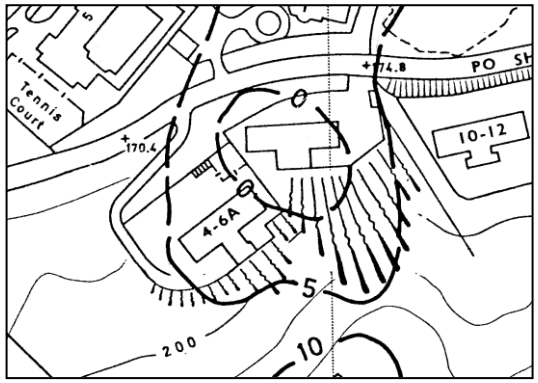


Geological section through Hamilton Court and Po Shan Road (extracted from drawing No. G17 of Mid-levels Study (GCO, 1982))

* Section is located at about 12 m from the eastern end of the slope No. 11SW-A/R677.



Geological map (extracted from drawing No. G34 of Mid-levels Study (GCO, 1982))



Present colluvium thickness (extracted from drawing No. G22 of Mid-levels Study (GCO, 1982))

Figure 6 - Information Extracted from Mid-levels Study (GCO, 1982)

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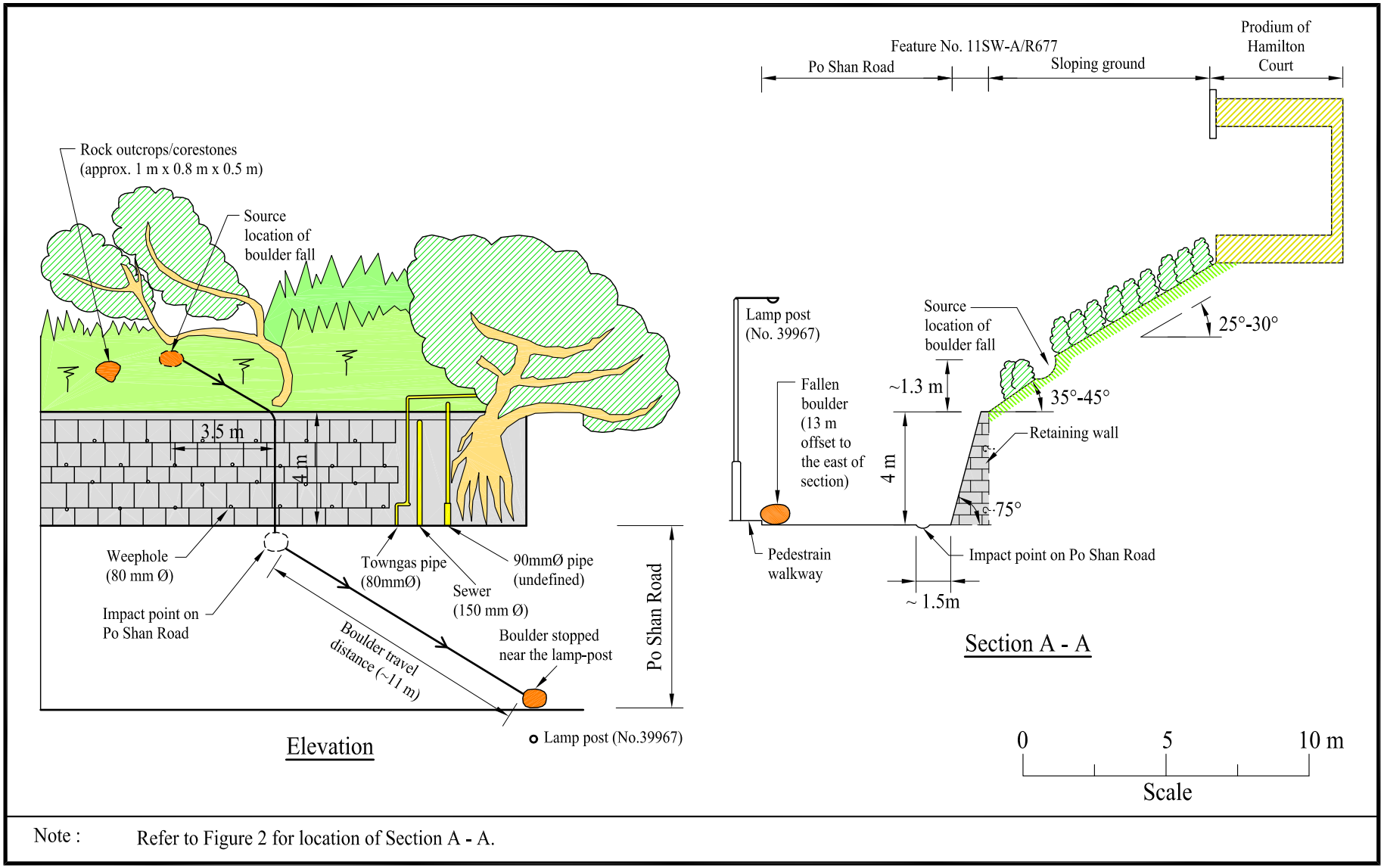

Note : Refer to Figure 2 for location of Section A - A.

Figure 7 - Elevation View and Cross-section A - A Through Boulder Fall Trajectory

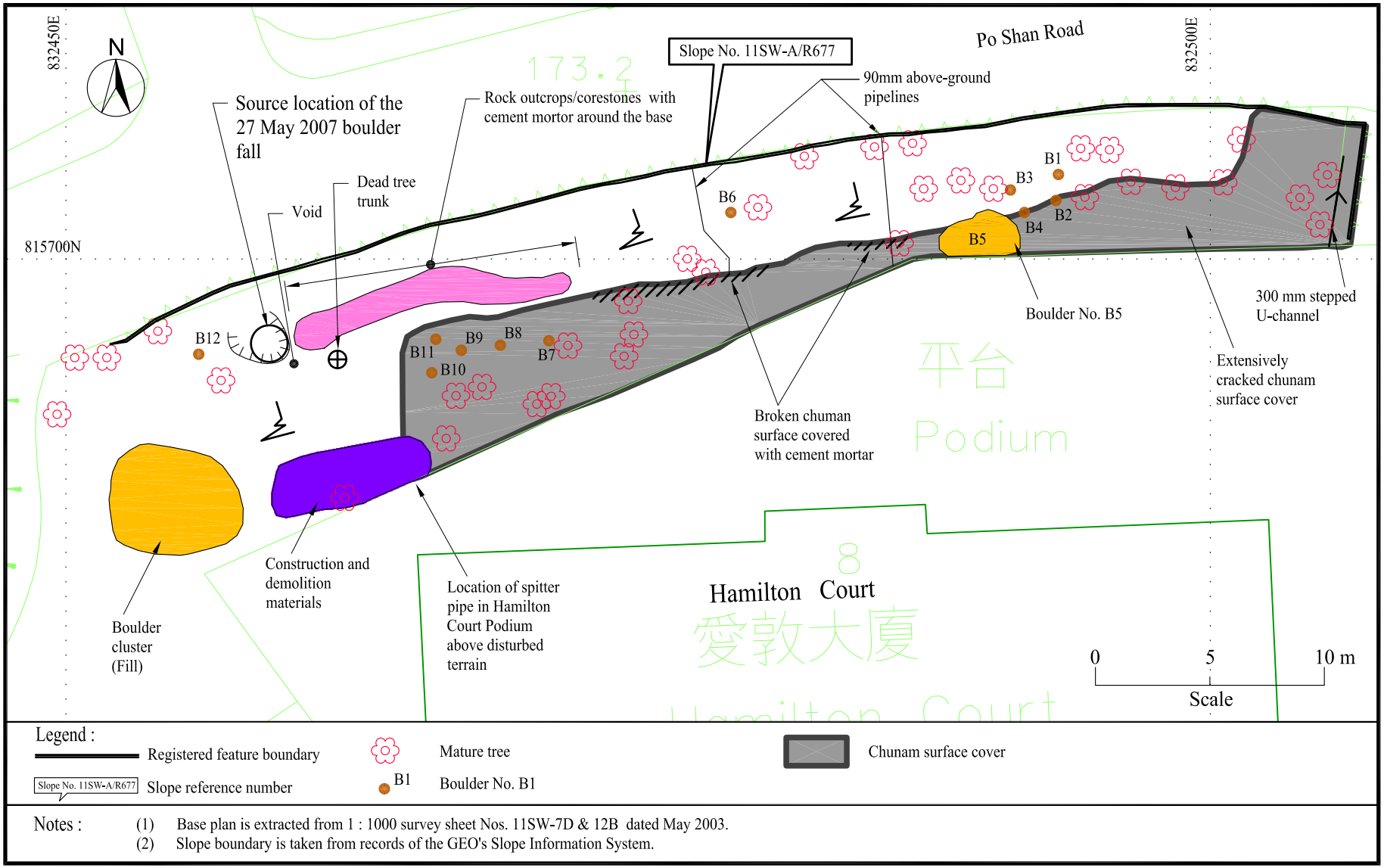

Figure 8 - Detailed Mapping of the Sloping Ground above Retaining Wall No. 11SW-A/R677

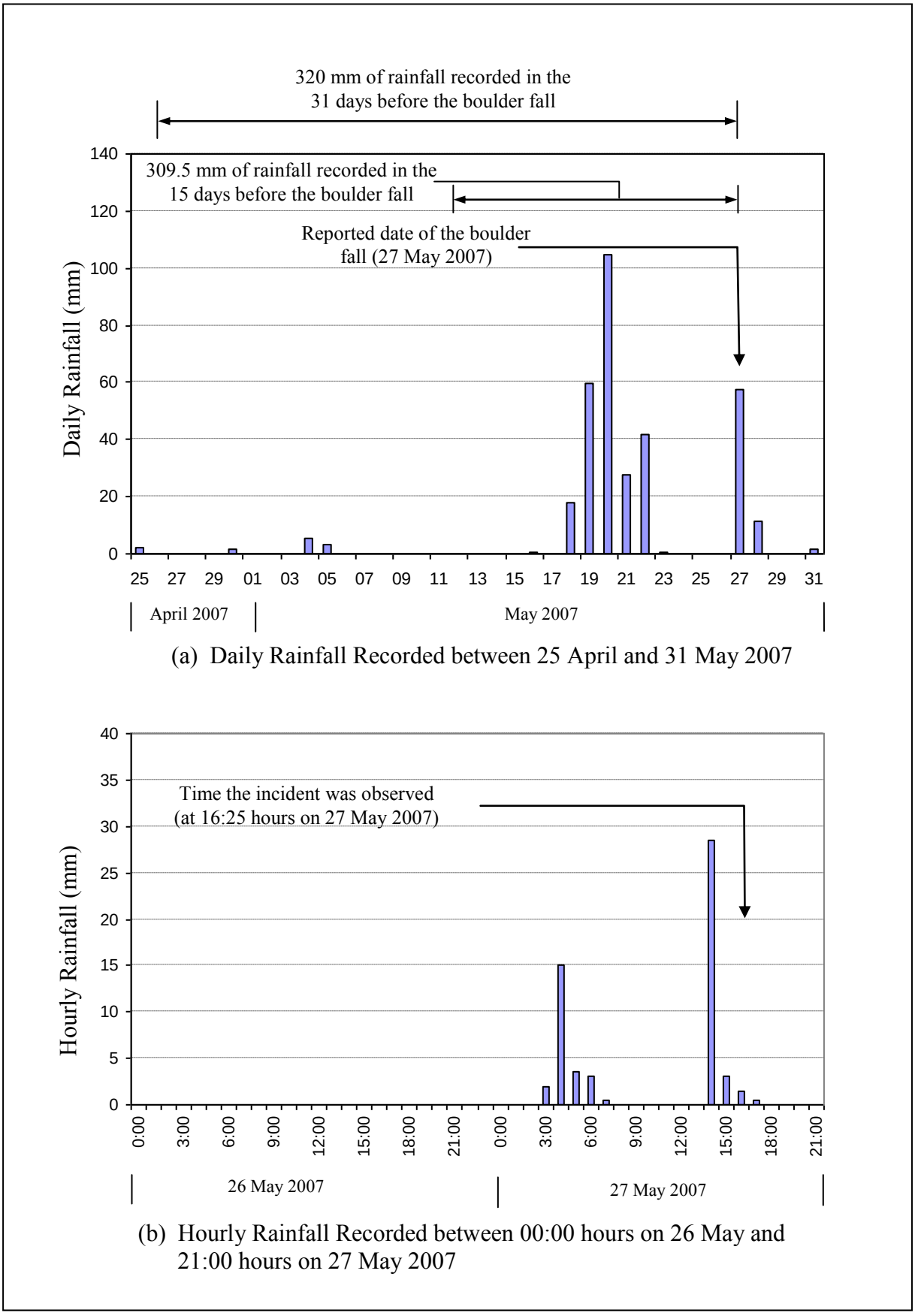

Figure 9 - Rainfall Recorded at GEO Raingauge No. H04

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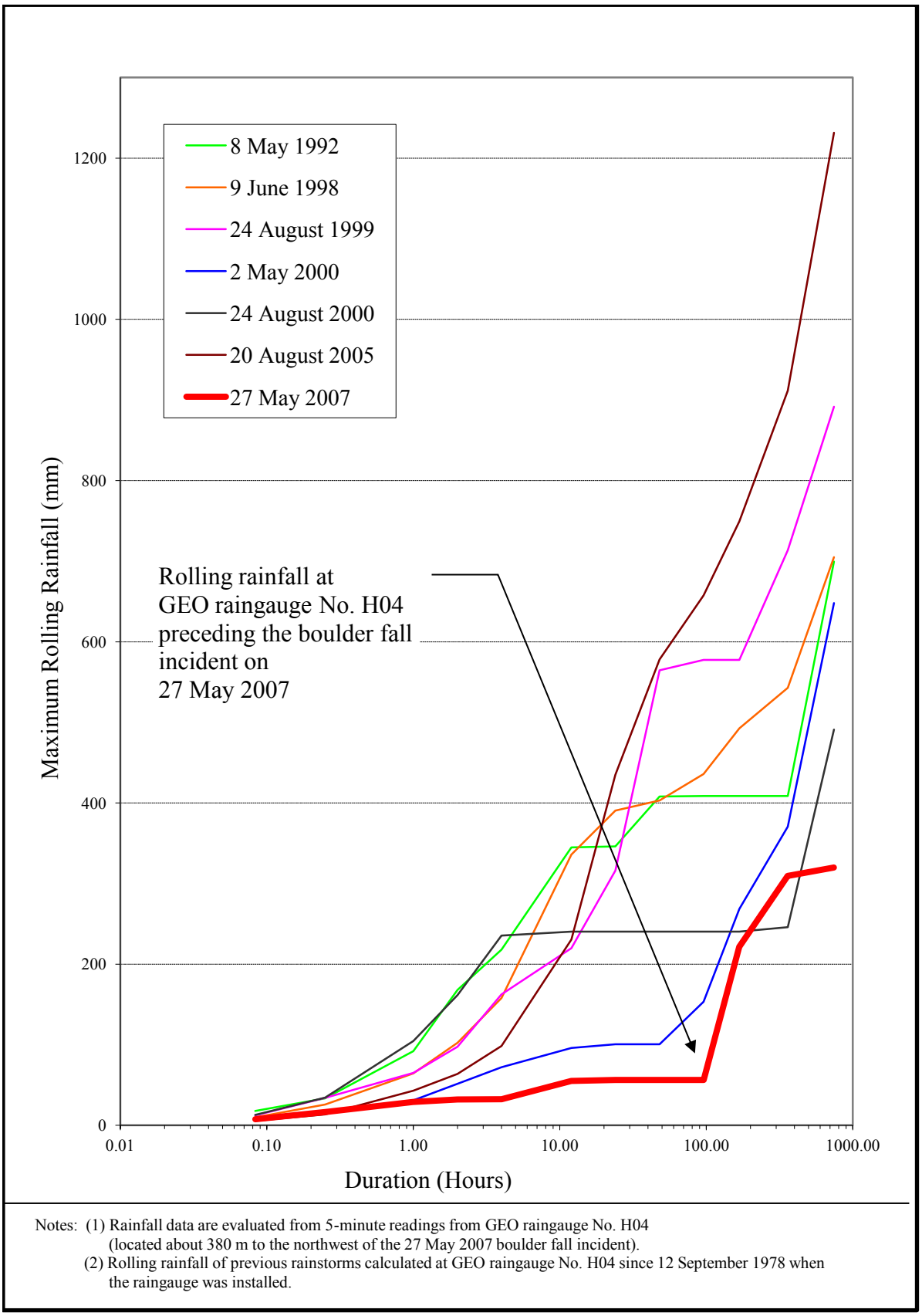

Notes: (1) Rainfall data are evaluated from 5-minute readings from GEO raingauge No. H04 (located about 380 m to the northwest of the 27 May 2007 boulder fall incident).
(2) Rolling rainfall of previous rainstorms calculated at GEO raingauge No. H04 since 12 September 1978 when the raingauge was installed.

Figure 10 - Maximum Rolling Rainfall Preceding the 27 May 2007 Boulder Fall Incident and Selected Previous Major Rainstorms Recorded at GEO Raingauge No. H04

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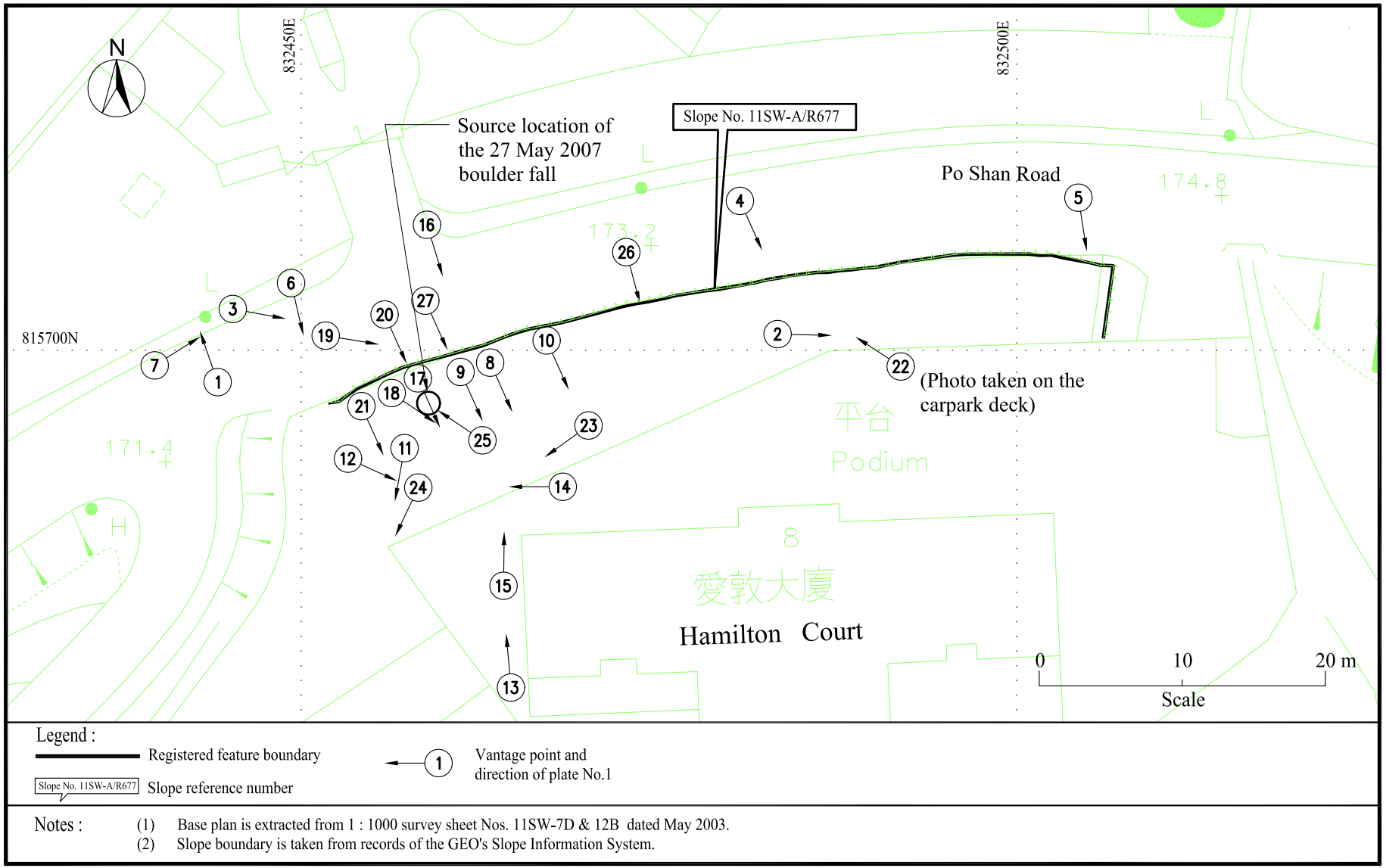

Figure 11 - Locations and Directions of Photographs

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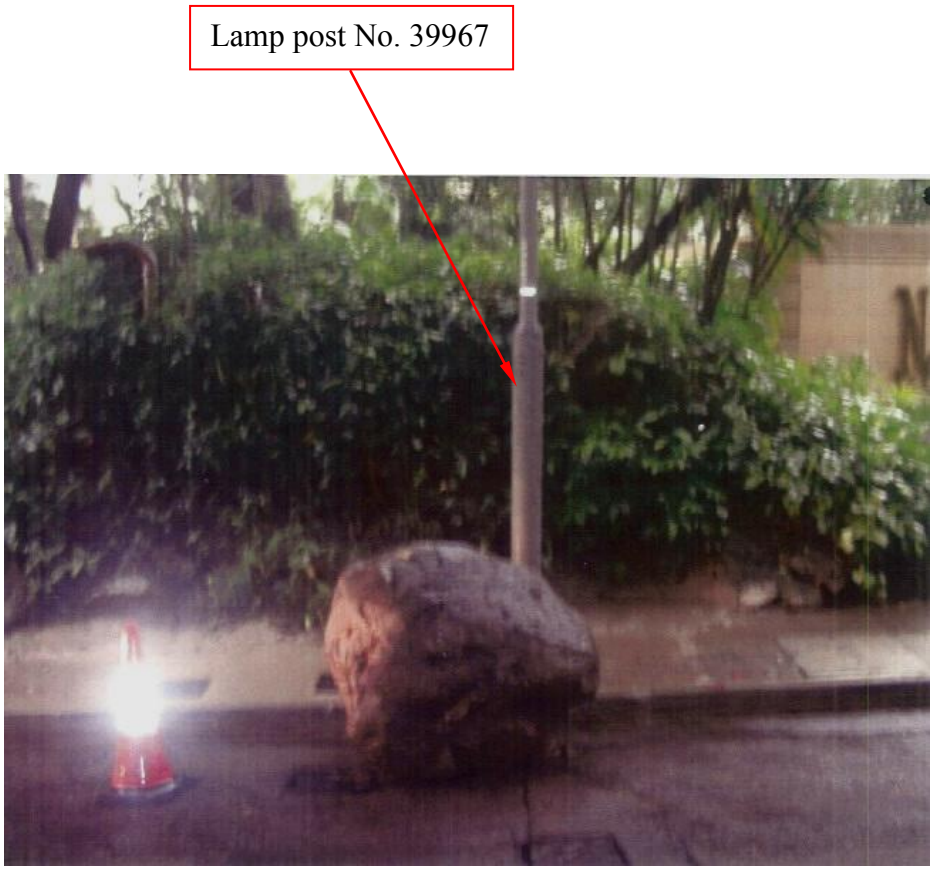

Plate 1 - Close View of Boulder Involved in the 27 May 2007 Incident
(Photograph taken by GEO on 27 May 2007)

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

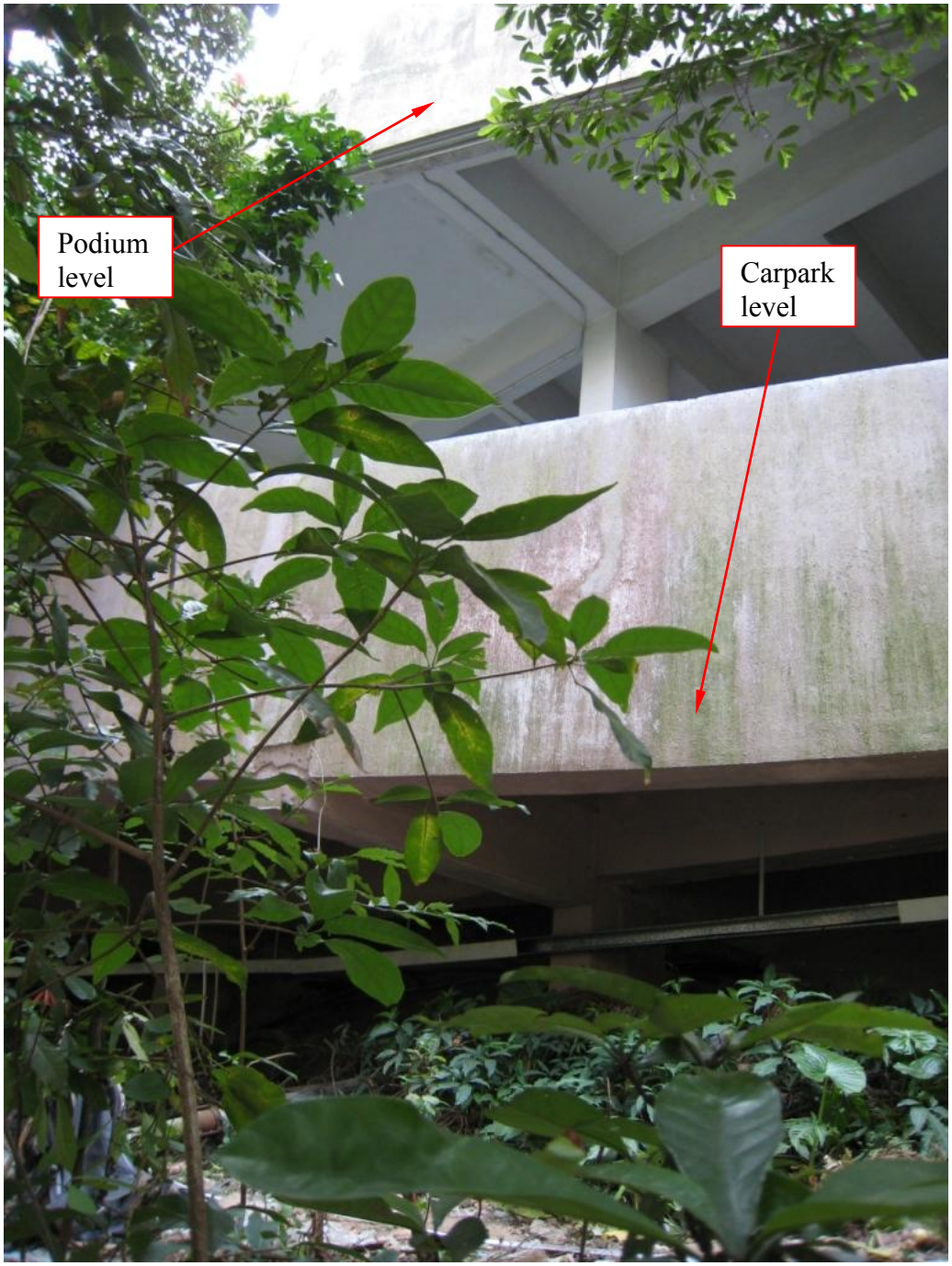

Plate 2 – General View of Hamilton Court Podium (Photograph taken on 13 November 2007)

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

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Plate 3 - General View of Retaining Wall No. 11SW-A/R677 (Photograph taken on 25 July 2007)

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

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Plate 4 – Exposed Pipelines on Retaining Wall No. 11SW-A/R677 (Photograph taken on 25 July 2007)

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

Plate 5 – Exposed Downpipe and U-channel at the Eastern End of Retaining Wall No. 11SW-A/F677 (Photograph taken on 5 September 2007)

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

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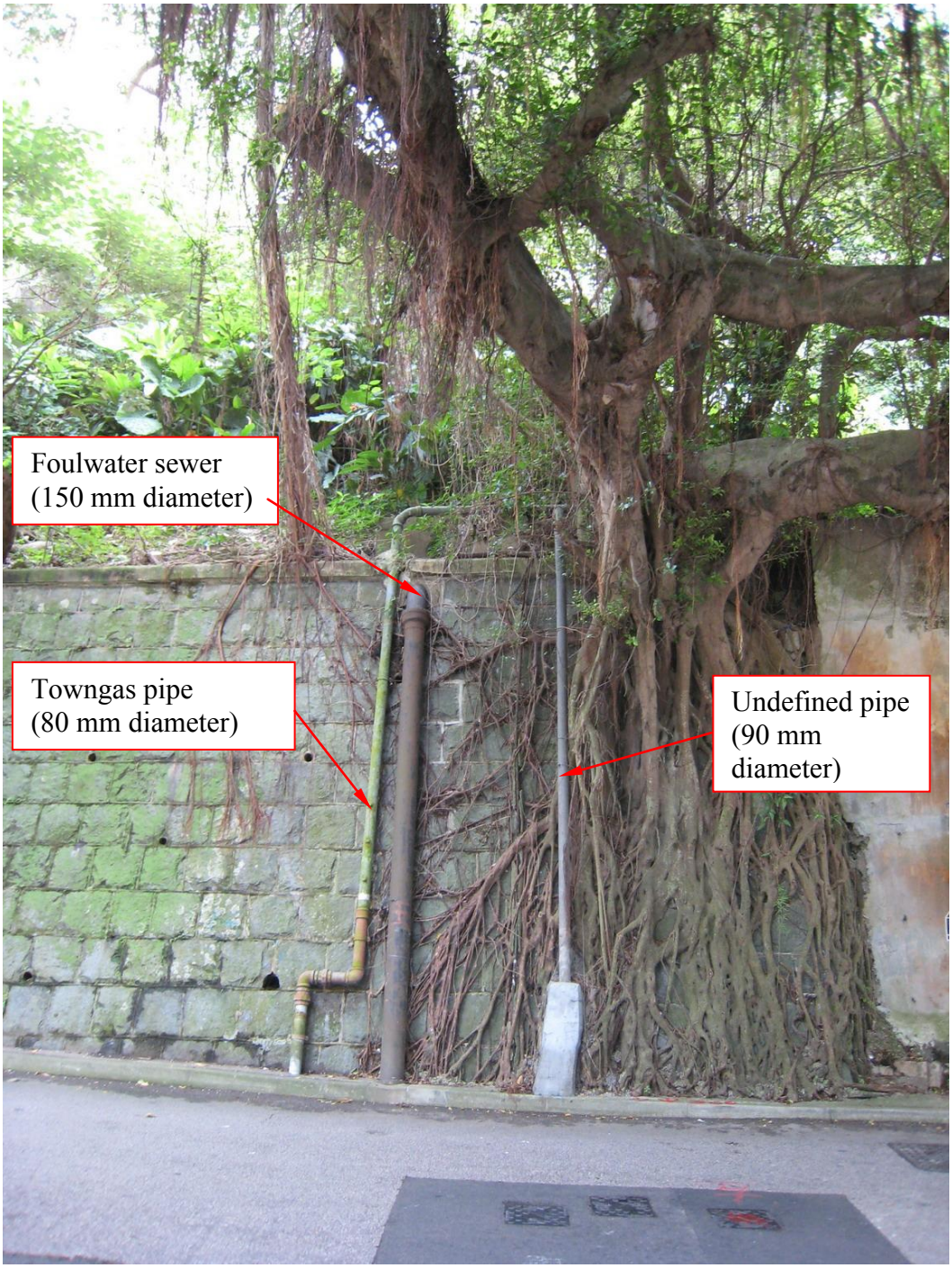

Plate 6 – Exposed Pipelines and Large Tree at Western End of Retaining Wall No. 11SW-A/R677 (Photograph taken on 5 September 2007)

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

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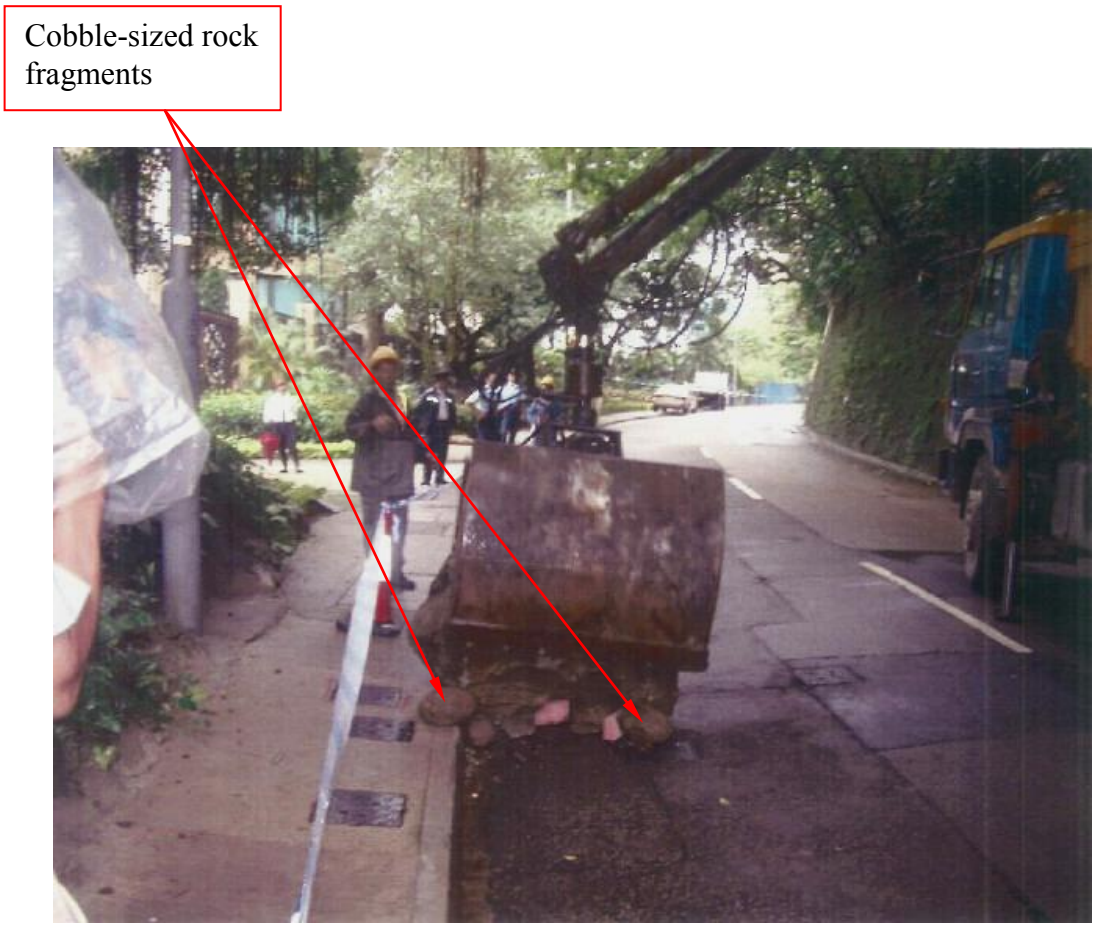

Plate 7 - Cobble-sized Rock Fragments Brought down with the Main Boulder (Photograph taken by HyD on 27 May 2007)

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

Plate 8 - Cluster of Loose Boulders Identified on Sloping Ground above Retaining Wall No. 11SW-A/R677
(Photograph taken by GEO on 4 June 2007)

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

Plate 9 - Boulder Stabilisation Works Completed by HyD following the 27 May 2007 Boulder Fall
(Photograph taken by GEO on 4 June 2007)

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

Plate 10 – Fallen Tree on Sloping Ground above Retaining Wall No. 11SW-A/FR677
(Photograph taken by GEO on 4 June 2007)

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

Plate 11 – Construction Debris on Sloping Ground above Retaining Wall No. 11SW-A/R677 (Photograph taken by GEO on 1 June 2007)

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

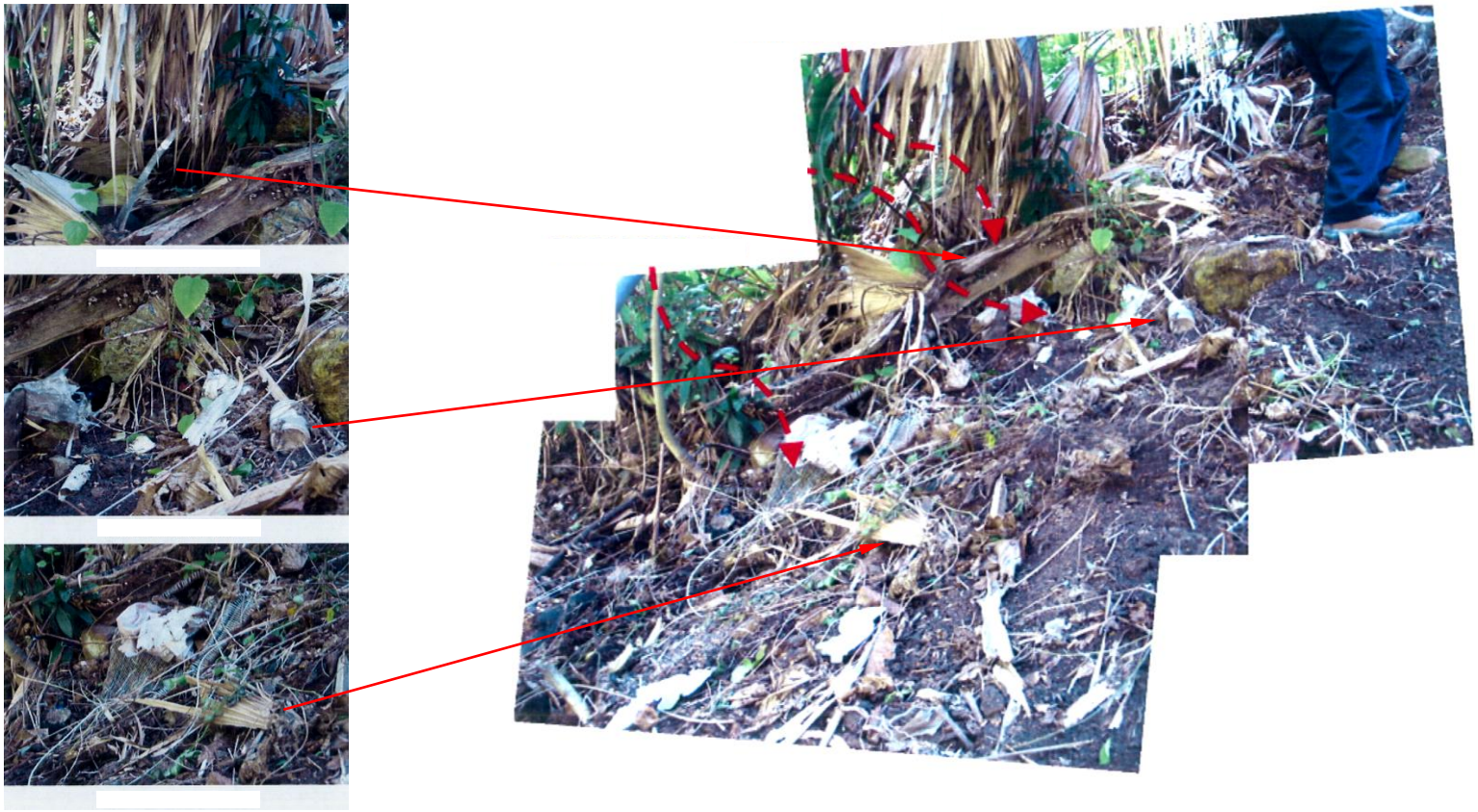

Plate 12 - General Rubbish on Sloping Ground above Retaining Wall No. 11SW-A/R677
(Photograph taken by GEO on 1 June 2007)

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

Plate 13 – Surface Drainage Channel on Hamilton Court Podium Discharging Collected Runoff to Spitter Pipe above the 27 May 2007 Boulder Fall Source Location (Photograph taken by GEO on 1 June 2007)

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

Plate 14 – Spitter Pipe on Hamilton Court Podium above the 27 May 2007 Boulder Fall Source Location (Photograph taken by GEO on 1 June 2007)

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

Plate 15 – Completed Diversion Works to Hamilton Court Podium Surface Drainage System (Photograph taken on 19 July 2007)

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

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Plate 16 – Source Location of the 27 May 2007 Boulder Fall (Photograph taken on 5 June 2007)

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

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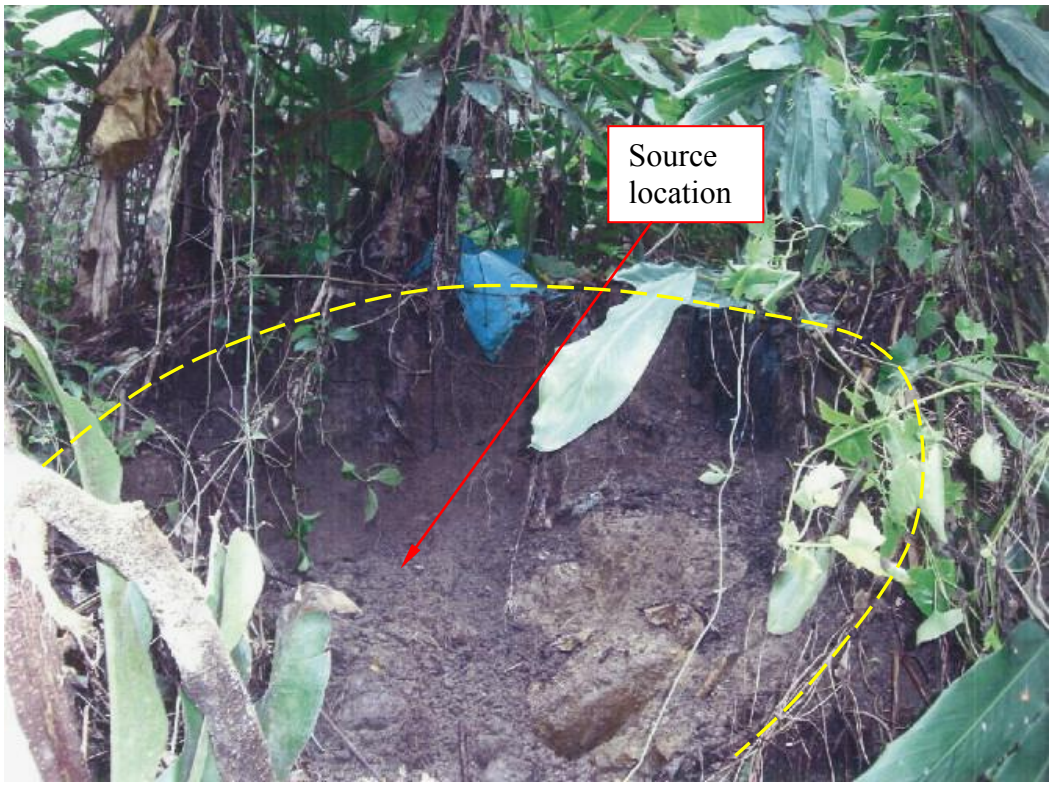

Plate 17 - Close View of Source Location of 27 May 2007 Boulder Fall (Photograph taken by HyD on 8 June 2007)

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

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Plate 18 – Condition of the Area in the Vicinity of the Source Location of the 27 May 2007 Boulder Fall Incident (Photograph taken on 5 June 2007)

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

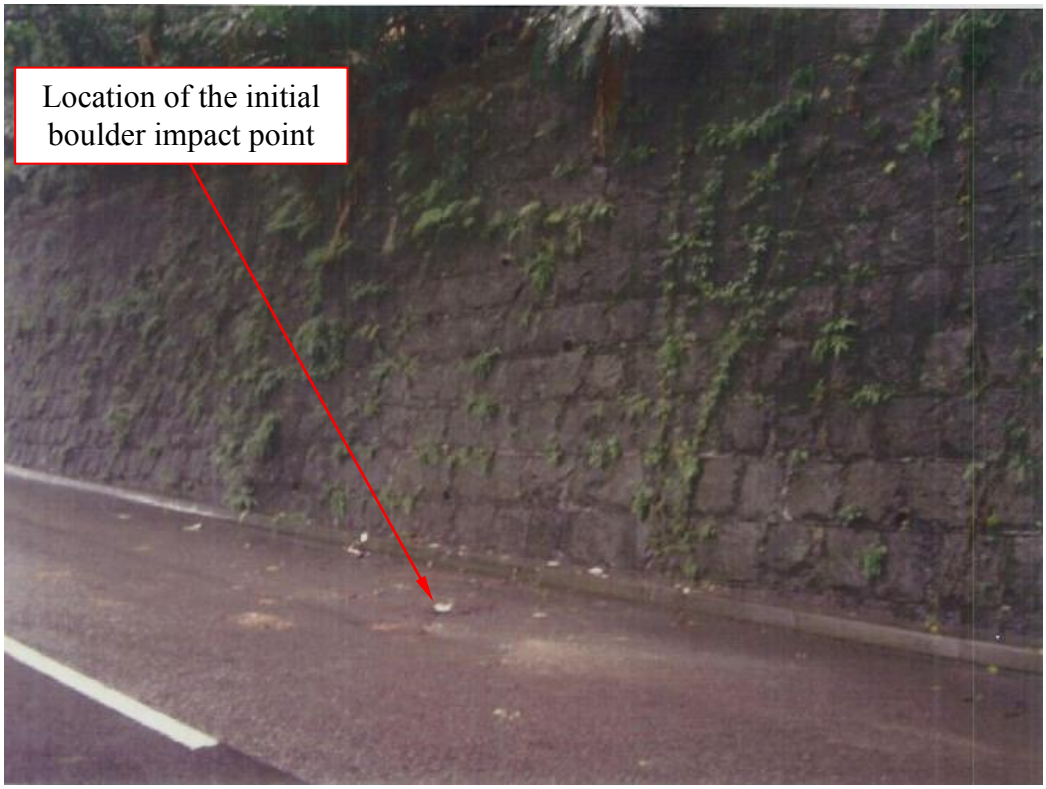

Plate 19 - Location of the Initial Boulder Impact Point on Po Shan Road
(Photograph taken by HyD on 27 May 2007)

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

Plate 20 – Impact Marks on Pavement of Po Shan Road (Photograph taken on 25 July 2007)

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

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Plate 21 – Boulder Stabilisation Works Completed by HyD following the 27 May 2007 Boulder Fall (Photograph taken on 5 June 2007)

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

Plate 22 - Condition of Chunam Surfacing (Photograph taken on 13 November 2007)

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

Plate 23 - Construction Debris and General Refuse on Sloping Ground above Retaining Wall No. 11SW-A/R677 (Photograph taken on 13 November 2007)

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

Plate 24 - Bouldery Fill on Sloping Ground above Retaining Wall No. 11SW-A/R677 (Photograph taken on 13 November 2007)

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

Plate 25 - Void in Ground Surface above 27 May 2007 Boulder Fall Source Location (Photograph taken on 25 October 2007)

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

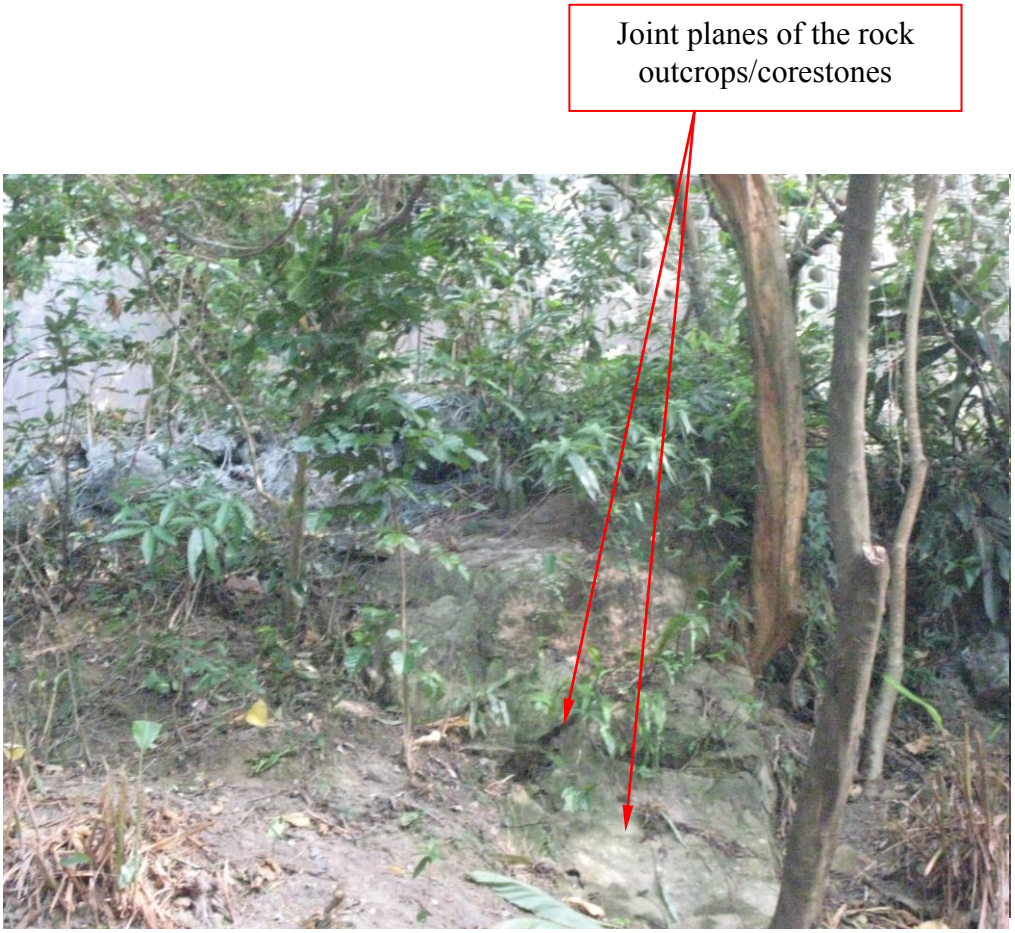

Plate 26 - Rock Outcrops/Corestones Exposed on Ground Surface above Crest of Retaining Wall No. 11SW-A/R677 (Photograph taken on 25 July 2007)

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

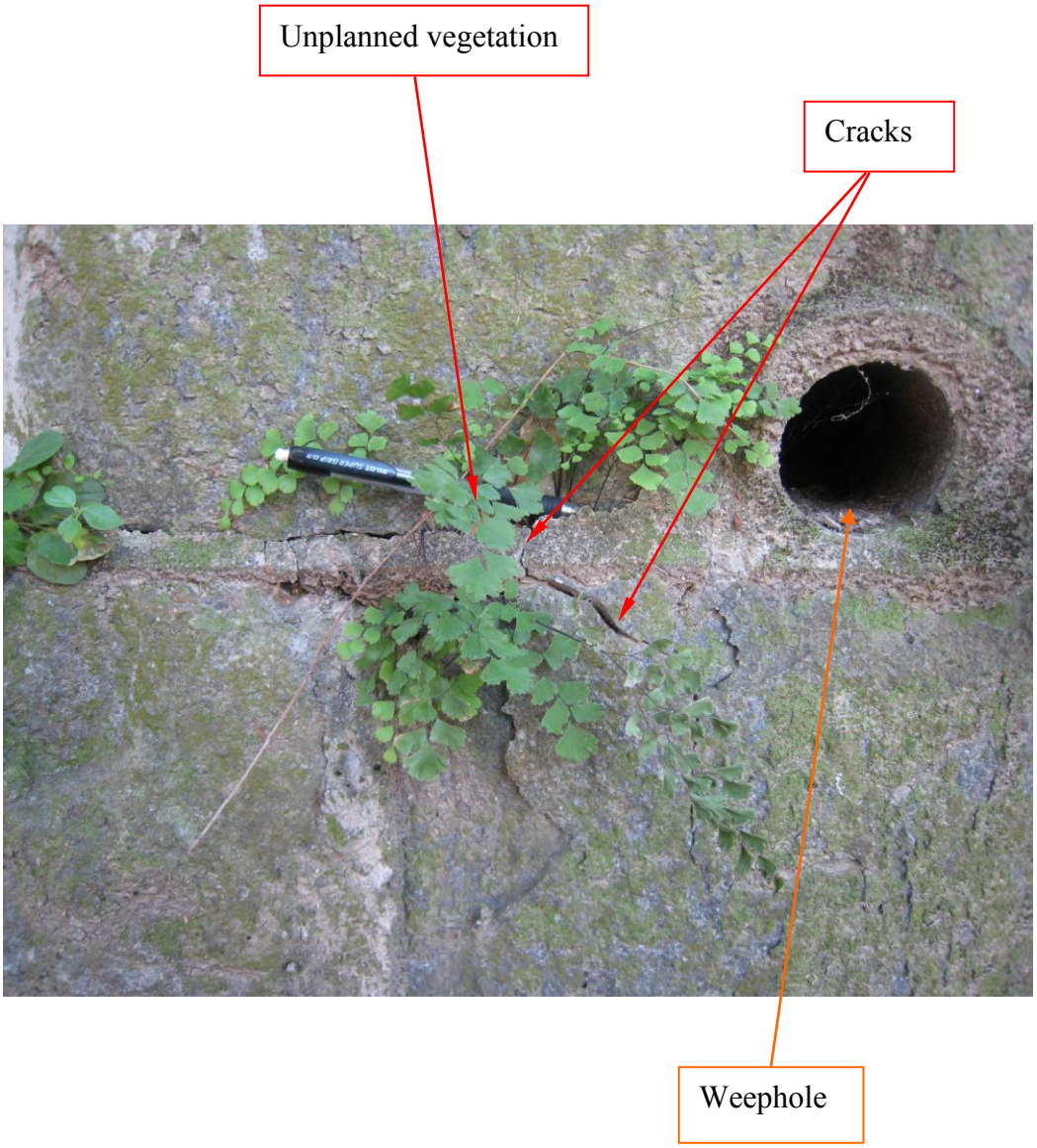

Plate 27 - Cracking Through Mortar Joint and Masonry Block of Retaining Wall No. 11SW-A/R677 (Photograph taken on 14 November 2007)

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

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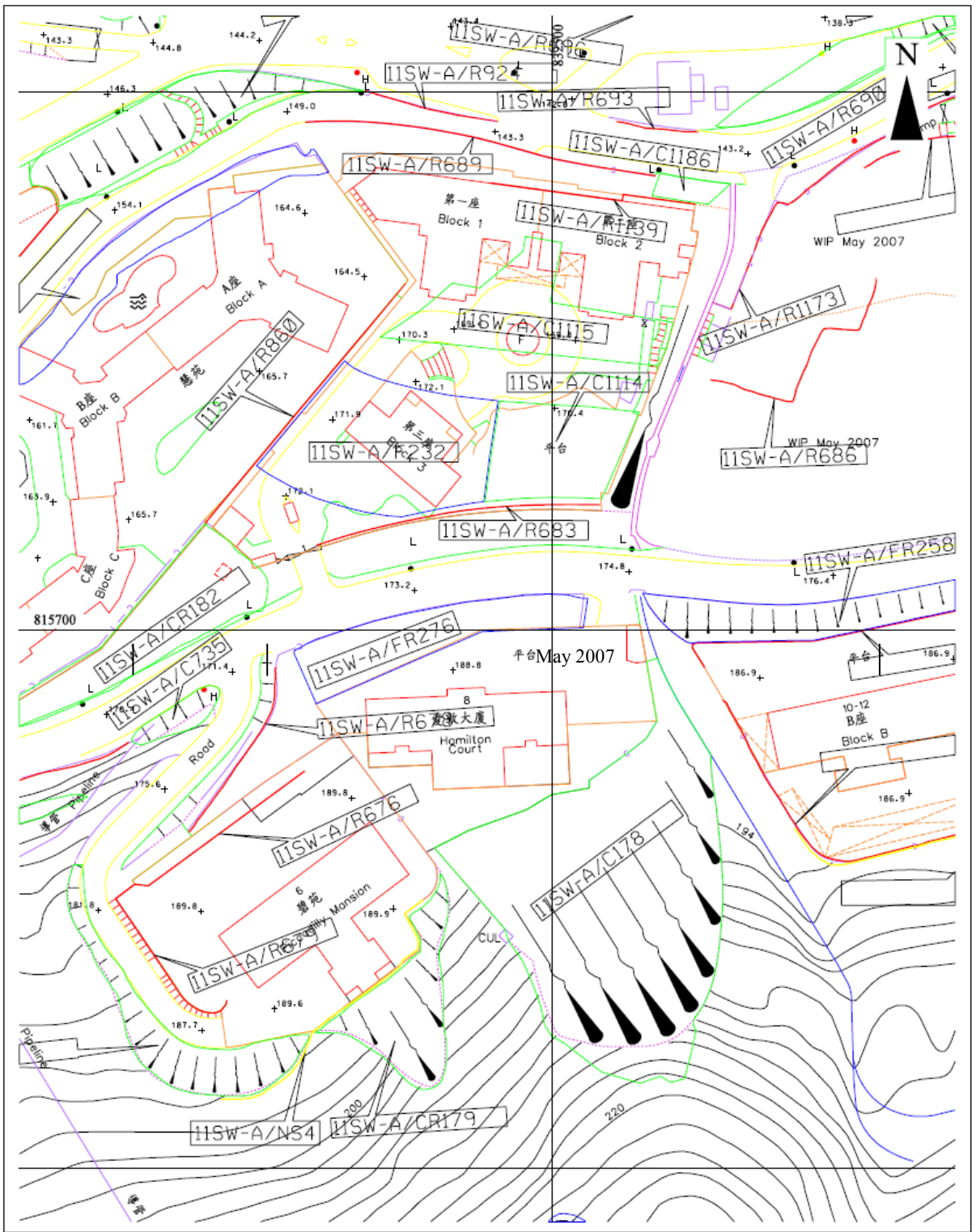
APPENDIX A

LOCATION PLAN OF SLOPE NO. 11SW-A/FR276



Geotechnical Engineering Office	Slope Location Plan
Slope No:11SW-A/FR 276	Date Print:06/ 5/2008
Easting: 832488	Northing: 815702
	Scale:1: 1000

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APPENDIX B

AERIAL PHOTOGRAPH INTERPRETATION

B.1 DETAILED OBSERVATIONS

The following comprise the detailed observations made from the aerial photographs studied (see Figure B1). A list of aerial photographs used in this study is given in Section B.2.

Slope No. 11SW-A/R677 first appears in the 1945 aerial photographs. A cut slope feature is identified at the location of the present-day slope No. 11SW-A/R677 in 1924, suggesting the slope No. 11SW-A/R677 was constructed sometime between 1924 and 1945.

The sloping ground above the slope No. 11SW-A/R677 has been covered by dense vegetation since 1945 and the retaining wall feature has been masked by mature trees growing on the area above since 1963, showing no significant changes.

Year	Observations
1924	No stereo pair. Po Shan Road has been formed to the present-day alignment. The present-day Hamilton Court, Piccadilly Mansion and Po Shan Mansion have not yet been developed. The southern portion of the present-day Hatton Road service reservoir located at about 200 m (on plan) to the south of Po Shan Road appears to be under construction. The area occupied by the present-day retaining wall No. 11SW-A/R677 appears to be a cut slope formed in association with the construction of Po Shan Road. The sloping ground immediately above the cut slope is covered by sparse vegetation comprising grass and shrubs. Formation of the slope involved cutting steeply into a rounded, NW-trending spur which extended below the present-day alignment of Po Shan Road. A streamcourse, roughly running NNW, is visible along the eastern boundary of the present-day Hamilton Court podium. A light toned, linear feature (estimated to be about 5 m to 10 m wide) of disturbed terrain, extending from the eastern extent of the cut slope to about the 210 mPD contour, is visible immediately to the west of stream course. A footpath, extending from the cut slope along the NW-trending spur to the service reservoir, is also visible. Two areas with high reflectivity, possibly anthropogenic disturbance, are noted on the hillside about 5 m and 70 m (on plan) respectively to the south of the cut slope.
1945	Retaining wall No. 11SW-A/R677 has been constructed and of similar geometry to the present-day arrangement. The area immediately behind the crest of retaining wall No. 11SW-A/R677 is completely covered by vegetation. A levelled platform and a building are visible in the southern portion of the present-day Hamilton Court podium. The platform, which is bordered by a fill slope on the northern boundary, is smaller than the present-day footprint of the Hamilton Court podium.

Year	Observations
1945 (cont'd)	An access path from Po Shan Road to the podium is visible immediately to the east of retaining wall No. 11SW-A/R677 at a similar location to the present-day Hamilton Court entrance driveway. A small cut slope appears to have been formed on the southern edge of the platform. Levelled platforms and buildings have also been formed to the east and southwest of the present-day Hamilton Court in the areas presently occupied by Po Shan Mansions and Piccadilly Mansions. An access road from Po Shan Road to the present-day Piccadilly Mansions platform is visible on the same alignment as the present-day driveway access. The construction of the southern portion of the Hatton Road service reservoir situated further upslope and the associated cut and fill slopes have been completed. Pipelines are visible extending from the western end of the reservoir to the western extent of Po Shan Road. Three linear strips, possibly comprising anthropogenic disturbance are noted adjacent to the northeast boundary of the service reservoir. The linear strip of disturbed terrain adjacent to the stream course observed in the 1924 photographs has re-vegetated. The footpath and the two areas of anthropogenic disturbance observed in 1924 photographs are no longer visible.
1956	Vegetation growing on the area immediately behind the crest of retaining wall No. 11SW-A/R677 is much heavier than in the 1945 photographs and mature trees are visible above the central and western portions of the feature. A small structure is visible on the hillside immediately above the eastern end of the building platform at the present-day location of Hamilton Court. A footpath extending upslope from between the adjacent building platforms at the present-day locations of Hamilton Court and Piccadilly Mansion is also visible. Two additional small structures are visible on the eastern side of the building occupying the building platform at the present-day location of Piccadilly Mansion. The northwestern portion of the Hatton Road service reservoir and has been constructed and conforms to the present-day arrangement.
1961	No significant changes are observed at the location of retaining wall No. 11SW-A/R677 or the adjacent area. The density of the vegetation has generally increased around the study area and retaining wall No. 11SW-A/R677 is completely obscured by the mature trees growing on the area immediately the crest of the feature.

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Year	Observations
1963	Retaining wall No. 11SW-A/R677 is completely obscure by vegetation of mature trees growing on the area above except for the eastern extent where the vegetation is more sparse. Some re-profiling of Po Shan Road may have been carried out along the northern edge of the carriageway, which now appears more linear and sharply defined, but the road does not appear to have been widened significantly from the alignment visible in the 1924 and 1945 photographs. A small terraced area is visible to the east of the small structure observed in 1956 photographs above the eastern end of the building platform at the present-day location of Hamilton Court. The buildings occupying the present-day Po Shan Mansions site initially observed in the 1945 photographs have been demolished and site formation works appear to be underway.
1964	No significant changes are apparent at retaining wall No. 11SW-A/R677 or the adjacent area. Retaining wall No. 11SW-A/R677 completely obscured by the vegetation growing from the area above. The buildings occupying the present-day Piccadilly Mansions site initially observed in the 1945 photographs have been demolished. The Po Shan Mansions site has been modified to the present-day arrangement comprising the podium area occupied by and two adjacent high-rise apartment buildings, with driveway access from Po Shan Road.
1967	No significant changes are apparent at retaining wall No. 11SW-A/R677 or the adjacent area. Retaining wall No. 11SW-A/R677 completely obscured by the vegetation growing from the area above. The Piccadilly Mansion site has been modified to the present-day arrangement comprising the podium area occupied by a single high-rise apartment building, with widened driveway access from Po Shan Road. Slopes Nos. 11SW-A/CR399 and 11SW-A/CR678 have been formed along the driveway access road. A landslide scar is visible immediately above the Piccadilly Mansion podium and extends about 18 m on plan upslope. Two landslide scars and associated debris trails are also visible on the hillside above Po Shan Mansions, with source areas located at around 476 mPD and 280 mPD respectively. The debris runout from the lower of the two landslides appears to have reached the Po Shan Mansions platform, whilst that from the upper landslide appears to have mostly deposited on the hillside, with minor debris washout extending below the main debris mass (see Figure 5 of the main report for the locations of the landslides).

Year	Observations
1967 (cont'd)	A shallow landslide is also evident on the natural hillside to the south of Po Shan Mansions at around 250 mPD (see Figure 5 of the main report for the locations of the landslides)
1972	The building occupying the levelled platform at the present-day location of Hamilton Court observed in the 1945 photographs and the small structure observed above the platform in the 1956 photographs have been demolished. Construction works for the present-day arrangement of Hamilton Court comprising podium area occupied by a single high-rise apartment building are in progress. The Hamilton Court podium has been extended further to the north as compared to the earlier building platform to form the present-day geometry and covers the fill slope observed in the 1945 aerial photographs. A large landslide scar extending over the full width of the Hamilton Court podium and extending approximately upslope on plan by around 35 m is visible above the southern edge of the podium. Debris form the landslide extends across the podium and further to the north as far as Po Shan Road, partly depositing above the eastern portion of the area above retaining wall No. 11SW-A/R677. The central and western portions of retaining wall No. 11SW-A/R677 and the area above are obscured by dense vegetation. The 1972 Po Shan landslide scar and debris trail are visible to the east of Po Shan Mansions. The landslide scar above Piccadilly Mansion observed in the 1967 photographs has a hard surface cover. Sparse vegetation is visible on the upper portion of the landslide scar.
1973	No stereo pair. The debris from the 1972 landslide above the Hamilton Court podium has been completely removed from the podium area. Remedial works to the 1972 landslide scar forming the present-day geometry of slope No. 11SW-A/C178 have been completed and comprised a total of three batters separated by berms incorporating surface drainage channels. The slope face has been protected with hard surfacing. Construction works for the present-day Hamilton Court development are underway. Retaining wall No. 11SW-A/R677 and the area above are obscured by dense vegetation. Vegetation on the upper portion of the landslide scar behind Piccadilly Mansion observed in the 1967 photographs is heavier.

Year	Observations
1974	Construction of the present-day Hamilton Court development is completed. Retaining wall No. 11SW-A/R677 and the area above are completely obscured by the shadow of Hamilton Court. Vegetation on the hillside in the general area is heavier than in previous years.
1975	A light-toned area, possibly hard surface of chunam, is visible on the area above the eastern and central portions of retaining wall No. 11SW-A/R677, immediately below the northern extent of the Hamilton Court podium, extending about 5 m on plan downslope, but not as far as the crest of retaining wall No. 11SW-A/R677. The western portion of retaining wall No. 11SW-A/R677 and the area above are obscured by dense vegetation. Seepage is visible at three locations on the lowest batter of retaining wall No. 11SW-A/C178 behind Hamilton Court, comprising the remediated 1972 landslide scar.
1976	Retaining wall No. 11SW-A/R677 and the area above are completely obscured by Hamilton Court. No significant changes observed in the general area. No seepage is observed on the lower batter of retaining wall No. 11SW-A/C178.
1977	The eastern portion of retaining wall No. 11SW-A/R677 and the area above is obscured by the shadow of Hamilton Court and the western portion and the area above are obscured by dense vegetation. No major changes observed in the general area. Seepage observed in the 1975 photographs is visible on the lowest batter of slope No. 11SW-A/C178 behind Hamilton Court.
1979	Retaining wall No. 11SW-A/R677 and the area above are largely obscured by the shadow of Hamilton Court. Seepage observed in the 1975 photographs is visible on the lowest batter of slope No. 11SW-A/C178 behind Hamilton Court.
1980	Retaining wall No. 11SW-A/R677 and the area above are obscured by the shadow of Hamilton Court. Seepage observed in the 1975 photographs is visible on the lowest batter of slope No. 11SW-A/C178 behind Hamilton Court. No major changes observed in the general area.

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Year	Observations
1981	The eastern portion of retaining wall No. 11SW-A/R677 is obscured by the shadow of Hamilton Court. The western portion and the area above are masked by mature vegetation. Seepage observed in the 1975 photographs is visible on the lowest batter of slope No. 11SW-A/C178 behind Hamilton Court. No major changes observed in the general area.
1982	Retaining wall No. 11SW-A/R677 and the area above are completely masked by mature vegetation. Seepage observed in the 1975 photographs is visible on the lowest batter of slope No. 11SW-A/C178 behind Hamilton Court. No major changes observed in the general area.
1984	Retaining wall No. 11SW-A/R677 and the area above are completely masked by mature vegetation. A small playground is visible on the southeastern portion of the Hamilton Court podium. No seepage is observed on the lower batter of slope No. 11SW-A/C178. No major changes observed in the general area.
1986	The western portion of retaining wall No. 11SW-A/R677 is obscured by the shadow of Hamilton Court. The eastern portion and the area above are masked by mature vegetation. Unplanned vegetation is randomly located on the lower batter of the slope No. 11SW-A/C178. No seepage is observed. No major changes observed in the general area.
1987	No stereo pair. Retaining wall No. 11SW-A/R677 and the area above are obscured by the shadow of Hamilton Court. Unplanned vegetation on the lower batter of the slope No. 11SW-A/C178 becomes heavier. No seepage is observed on the lower batter. No significant changes observed in the general area.

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Year	Observations
1988	Retaining wall No. 11SW-A/R677 and the area above are completely masked by mature vegetation. No significant changes observed except vegetation density around the general area is heavier than in previous years. The lower batter of slope No. 11SW-A/C178 is masked by unplanned vegetation.
1989	No stereo pair. Retaining wall No. 11SW-A/R677 and the area above are completely masked by mature vegetation. No significant changes observed in the general area. Vegetation clearance appears to have been carried out on the lower batter of slope No. 11SW-A/C178. No seepage is observed on the lower batter.
1990	Retaining wall No. 11SW-A/R677 and the area above are completely masked by mature vegetation. No significant changes observed in the general area. Unplanned vegetation on the lower batter of the slope No. 11SW-A/C178 becomes heavier again. No seepage is observed on the lower batter.
1991	Retaining wall No. 11SW-A/R677 and the area above are completely masked by mature vegetation. The small playground area on Hamilton Court podium has been demolished and a swimming pool has been constructed at the same location. A rest garden/sitting out area is visible to the north of the swimming pool. The lower batter of slope No. 11SW-A/C178 is masked by unplanned vegetation.
1992	Retaining wall No. 11SW-A/R677 and the area above are completely masked by mature vegetation. No significant changes observed in the general area. Vegetation clearance appears to have been carried out on the lower batter of slope No. 11SW-A/C178. No seepage is observed on the lower batter.
1993	No stereo pair. Retaining wall No. 11SW-A/R677 and the area above are completely masked by mature vegetation. No significant changes observed in the general area. Slope No. 11SW-A/C178 is obscured by the shadow of Hamilton Court.

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Year	Observations
1994	Retaining wall No. 11SW-A/R677 and the area above are obscured by Hamilton Court. No significant changes observed in the general area. The lower batter of slope No. 11SW-A/C178 is covered by unplanned vegetation.
1995	Retaining wall No. 11SW-A/R677 and the area above are obscured by Hamilton Court. No significant changes observed except vegetation density around the general area is heavier than in previous years. The lower batter of slope No. 11SW-A/C178 is still covered by unplanned vegetation.
1996	Retaining wall No. 11SW-A/R677 and the area above are obscured by Hamilton Court. No significant changes observed in the general area. The lower batter of slope No. 11SW-A/C178 is still covered by unplanned vegetation.
1997	Retaining wall No. 11SW-A/R677 and the area above are completely masked by mature vegetation. No significant changes observed in the general area. Unplanned vegetation on slope No. 11SW-A/C178 has been removed and a new hard surface cover has been provided on slope No. 11SW-A/C178.
1998	Retaining wall No. 11SW-A/R677 and the area above are completely masked by mature vegetation. No significant changes observed in the general area. Unplanned vegetation is noted randomly located on slope No. 11SW-A/C178.
1999	Retaining wall No. 11SW-A/R677 and the area above are completely masked by mature vegetation. No significant changes observed in the general area.
2000	No stereo pair. Retaining wall No. 11SW-A/R677 and the area above are obscured by the shadow of Hamilton Court and are completely masked by mature vegetation. No significant changes observed in the general area.

Year	Observations
2001	Retaining wall No. 11SW-A/R677 and the area above are obscured by the shadow of Hamilton Court and are completely masked by mature vegetation. No significant changes observed in the general area.
2002	Retaining wall No. 11SW-A/R677 and the area above are completely masked by mature vegetation. No significant changes observed in the general area.
2003	Retaining wall No. 11SW-A/R677 and the area above are completely masked by mature vegetation. No significant changes observed in the general area.
2004	Retaining wall No. 11SW-A/R677 and the area above are completely masked by mature vegetation. No significant changes observed in the general area.
2005	Retaining wall No. 11SW-A/R677 and the area above are completely masked by mature vegetation. No significant changes observed in the general area.
2006	Retaining wall No. 11SW-A/R677 and the area above are completely masked by mature vegetation. No significant changes observed in the general area.

B.2 LIST OF PHOTOGRAPHS

Date	Reference No.	Altitude (ft)
1924	Y25, Y36	12,500
11 November 1945	Y465-6	20,000
27 December 1956	Y3175-6	16,700
17 January 1961	Y4794-5	30,000
1 February 1963	Y7604-5	2,700
13 December 1964	Y12826, Y12899	12,500
16 May 1967	Y13 299	6,250
20 June 1972	1650-1, 1816-7	1,300
24 June 1972	1813, 1816-7	2,000
12 December 1973	6989	3,000
12 December 1973	7073	4,000
21 November 1974	9692-9693	12,500
26 February 1975	10902-03	1,900
4 November 1976	15845-6	12,500
14 June 1977	18317, 19306-7	4,000
28 September 1979	27165, 27167-8	5,500
14 February 1980	29196	5,000
4 November 1980	31955-6	3,100
26 October 1981	39014-5	10,000
28 July 1982	43069-70	3,500
2 March 1984	53626-7	4,000
22 October 1984	56576-7	4,000
20 September 1986	A5940-1, A5952	4,000
9 September 1987	A10281	4,000
27 September 1988	A14383-4	4,000
15 August 1989	A17609	4,000
14 November 1990	A23755-6	4,000
2 October 1991	A27667-8	4,000
12 May 1992	A30890-1	4,000
9 July 1993	A35382	4,000
17 November 1994	CN7919-20	4,000
7 December 1995	CN12628-9	3,500
7 June 1996	CN14112-3	4,000
21 November 1996	CN16293	10,000
26 May 1997	CN17077-8	4,000
10 November 1998	CN22019-20	8,000
09 November 1999	CN25699-700	8,000
19 April 2000	CN26303	2,500
21 November 2001	CW36541-2	8,000
04 November 2002	CW45947-8	8,000
19 October 2003	CW50915-6	8,000
26 November 2003	CW53720-1	4,000
10 February 2004	CW55209-10	8,000
08 March 2005	CW63772-4	4,000
19 May 2006	CW71680	4,000

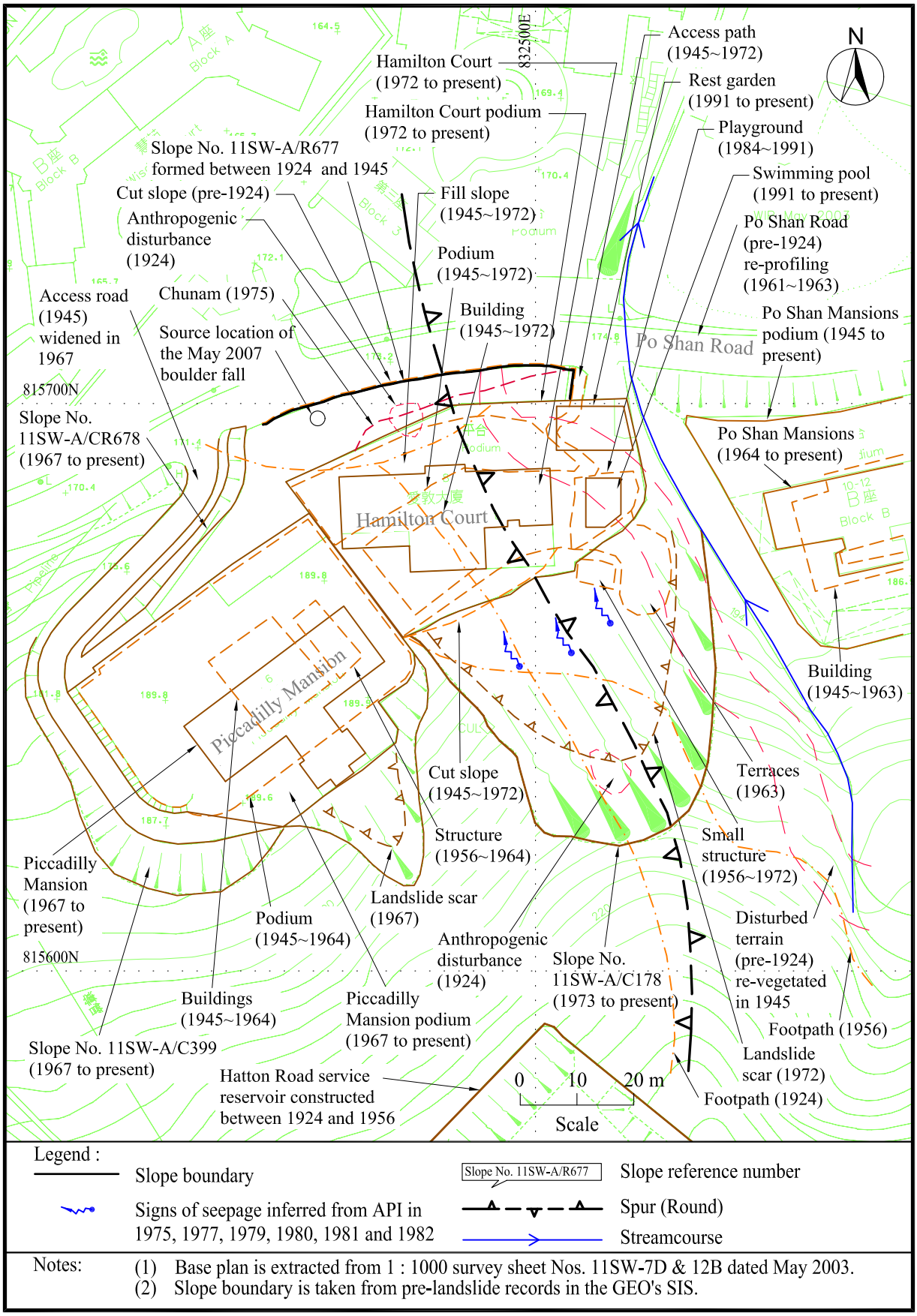

Figure B1 - Site Development Plan

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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.

部份土力工程處的主要刊物目錄刊載於下頁。而詳盡及最新的土力工程處刊物目錄，則登載於土木工程拓展署的互聯網網頁 http://www.cedd.gov.hk 的"刊物"版面之內。刊物的摘要及更新刊物內容的工程技術指引，亦可在這個網址找到。

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MAJOR GEOTECHNICAL ENGINEERING OFFICE PUBLICATIONS
土力工程處之主要刊物

GEOTECHNICAL MANUALS

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 No. 1/90	Review of Design Methods for Excavations (1990), 187 p. (Reprinted, 2002).
GEO Publication No. 1/93	Review of Granular and Geotextile Filters (1993), 141 p.
GEO Publication No. 1/2006	Foundation Design and Construction (2006), 376 p.
GEO Publication No. 1/2007	Engineering Geological Practice in Hong Kong (2007), 278 p.
GEO Publication No. 1/2009	Prescriptive Measures for Man-Made Slopes and Retaining Walls (2009), 76 p.
GEO Publication No. 1/2011	Technical Guidelines on Landscape Treatment for Slopes (2011), 217 p.

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