REVIEW OF THE 4 MAY 2007 ROCKFALL INCIDENT ON SLOPE NO. 11NE-C/C62 AT HONG NING ROAD KWUN TONG

GEO REPORT No. 246

Halcrow China Limited

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 1/2008 produced in January 2008

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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. These include guidance documents and results of comprehensive reviews. These 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.

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April 2009

FOREWORD

This report presents the findings of a review of a rockfall (Incident No. 2007/05/0008) which occurred on slope No. 11NE-C/C62 at Hong Ning Road, Kwun Tong, Kowloon on 4 May 2007. The incident involved the detachment of a rock block, with a failure volume of about 0.03 m^3, from the northeastern end of the slope. The rock block broke into several pieces upon landing at a catchpit and came to rest on the pedestrian pavement at the slope toe. As a result of the incident, the pedestrian pavement and a section of the northbound carriageway of Hong Ning Road were temporarily closed. No casualties were reported.

The key objectives of this review were to document the facts about the incident and to present relevant background information and pertinent site observations made under this review. The scope of the review does not include any ground investigation or detailed diagnosis of the causes of the incident. Recommendations for follow-up actions are reported separately.

The report was prepared as part of the 2007 Landslide Investigation Consultancy for landslides occurring in Kowloon and the New Territories in 2007, for the Geotechnical Engineering Office, Civil Engineering and Development Department, under Agreement No. CE 53/2006 (GE). This is one of a series of reports produced during the consultancy by Halcrow China Limited.

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Agreement No. CE 53/2006 (GE)
Study of Landslides Occurring in Kowloon and the New Territories in 2007 – Feasibility Study

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1. INTRODUCTION

At about 6:30 p.m. on 4 May 2007, a rockfall incident (Incident No. 2007/05/0008) occurred on slope No. 11NE-C/C62 at Hong Ning Road, Kwun Tong, Kowloon (Figure 1). The incident involved the detachment of a rock block, with a failure volume of about 0.03 m^3, from the northeastern end of the slope. The rock block broke into several pieces upon landing at a catchpit and came to rest on the pedestrian pavement at the slope toe. As a result of the incident, the pedestrian pavement and a section of the northbound carriageway of Hong Ning Road were temporarily closed. No casualties were reported.

Following the incident, Halcrow China Limited (HCL), the 2007 Landslide Investigation Consultants for Kowloon and the New Territories, carried out a review of the failure for the Geotechnical Engineering Office (GEO) of the Civil Engineering and Development Department (CEDD) under Agreement No. CE 53/2006 (GE).

This review report documents the facts about the incident, and presents relevant background information and pertinent observations made by HCL. The scope of the review does not include any ground investigation or detailed diagnosis of the probable causes of the incident.

2. THE SITE

2.1 Site Description

The subject slope is a soil/rock cut of about 82 m long with height increasing from about 5 m at the southwestern end to about 22 m at the northeastern end. A site layout plan showing the registered boundary of the slope, together with the approximate location of the May 2007 rockfall, is presented in Figure 2. A general view of the slope is shown in Plate 1.

The northeastern portion of the cut slope comprises two batters (about 6 m high in the upper batter and 16 m high in the lower batter) with an intervening berm of 1 m in width. The upper batter is predominantly soil covered with shotcrete and is inclined at about 55^o, while the lower batter is predominantly rock and has slope angles of between 55^o and 80^o. The upper part of the lower batter is covered with shotcrete, and the lower part is bare rock where dense vegetation is growing. An approximately 30 m long concrete buttress with height ranging from about 3 m to 7 m is located at the slope toe.

The southwestern portion of the cut slope is predominantly soil and it comprises two batters (about 4 m high in the upper batter and 7 m high in the lower batter), separated by a 1 m wide intervening berm. This slope portion is inclined at about 55^o and is vegetated with shrubs and grass.

A pedestrian pavement, up to 2 m wide, is located at the slope toe, and in front of it is Hong Ning Road, a four-lane, two-way carriageway. Beyond the crest of the northeastern portion of the cut slope, two fill slopes, slope No. 11NE-C/F86 and slope No. 11NE-C/F87 are present. Two other registered cut slopes, viz slopes Nos. 11NE-C/C61 and 11NE-C/CR63, adjoin the subject slope to the northeast and southwest respectively (Figure 1).

The surface drainage system for the subject slope comprises surface channels, catchpits and a downpipe. The surface drainage channels on the slope are generally 300 mm wide. The layout of the drainage system is shown in Figure 2. A downpipe of 400 mm in diameter is located on the northeastern boundary of the slope and serves as the outlet pipe of the surface drainage system for slope No. 11NE-C/F87 located at the crest of the subject slope. This downpipe carries the water towards Catchpit HN2 (Plate 2). Runoff collected in the catchpits at both ends of the slope is then discharged to the drainage system along Hong Ning Road.

2.2 Geological Setting

According to Sheet 11 of the Hong Kong Geological Survey (HKGS) 1:20 000 scale map series HGM20 (GCO, 1986), the solid geology at the subject slope comprises fine to medium-grained granite. It is also noted that a northeast trending basalt dyke is mapped to run close to the eastern end of the slope (Figure 3).

2.3 Maintenance Responsibility

According to the Slope Maintenance Responsibility Information System (SMRIS) of the Lands Department, the subject cut slope is under the maintenance responsibility of the Highways Department (HyD).

2.4 Water-carrying Services

Based on the information provided by the Water Supplies Department and the Drainage Services Department, the approximate alignments of water-carrying services in the vicinity of the site are shown in Figure 4. No buried water-carrying services are located on the subject slope and no unrecorded water pipes were observed by HCL during the post-failure inspections.

3. SITE HISTORY AND PAST SLOPE INSTABILITIES

3.1 Site History

The development history of the site has been established from a review of aerial photographs and inspection of the available relevant documentary records (Figure 5). A detailed account of the aerial photograph interpretation (API) is presented in Appendix A. Salient aspects of the key observations are summarised below.

As seen from the earliest available aerial photographs taken in 1949, the whole area of Kwun Tong is undeveloped. The subject slope was part of a southeast facing natural hillside of uniform gradient, which was truncated by two northwest to southeast trending valleys near the ends of the present slope. Natural drainage lines are noted to exist in the valleys and severe surface erosion is visible on the hillside.

By 1959, an access road is noted to have been constructed on the hillside above the

location of the subject slope, with a section of the road passing through its upper portion. This road appears to have been formed by cut and fill.

By 1963, a road is observed to be traversing the hillside above the location of the slope and leading to a construction site for the Kwun Tong High Level Reservoir at the summit. Slopes (including slope No. 11NE-C/F86 and slope No. 11NE-C/F87 at the crest of the subject slope) are observed to be under formation in association with the road construction. The cutting in the hillside for slope No. 11NE-C/C61 appears to have commenced.

By 1964, the formation of slope No. 11NE-C/F87 had been completed and a platform above this slope was formed alongside the road observed in the 1963 aerial photographs. Another fill platform is seen to have been formed at the location of the subject slope, which appears to have been used to facilitate the slope filling work above. One cutting (i.e. slope No. 11NE-C/CR63) for Hong Ning Road is observed to have been completed. To the northeast of the subject slope, a cutting (i.e. slope No. 11NE-C/C61) for another section of Hong Ning Road was in progress and the alignment of Hip Wo Street to the east is visible.

In the 1972 aerial photographs, the formation of the subject slope and the section of Hong Ning Road at the toe are seen to have been completed. It appears that the slope was formed some time between 1964 and 1972. The middle and northeastern portions of the slope are observed to have a rough surface texture, which suggests these slope portions are rock. Also, dark toned staining is observed at the northeastern end of the slope, suggesting the presence of water seepage. A localised failure is observed to have occurred on the southwestern end of slope No. 11NE-C/C61. The failure mass appears to be a mixture of soil and rock and is dark toned within the failed area, which suggests possible water seepage at the back scarp.

By 1975, hard slope surfacing (possibly chunam) is visible on the upper (soil) part of the subject slope, except in the northeastern portion, where growth of vegetation is observed. By 1978, new hard slope surfacing (possibly chunam) is observed to have been applied to the upper (soil) portion of the subject slope and to the southwestern portion of slope No. 11NE-C/C61. The location of the 2007 rockfall is seen to be covered with vegetation. Between 1978 and 1992, little change is observed, other than a general increase in vegetation density at the subject slope, especially at the location of the 2007 rockfall. In the 1993 aerial photographs, shotcrete is observed to have been applied to the southwestern portion of the subject slope but no change is observed in the other portions.

By 1996, shotcrete had been applied to the northeastern portion of the subject slope; however, a bare slope surface near the location of the 2007 rockfall is observed. The coverage of vegetation at this location appears to have reduced in comparison with aerial photographs of previous years. The cause of this reduction in the vegetation coverage is not known but it might be related to the adjacent slope surfacing work.

In the 1999 aerial photographs, slope No. 11NE-C/F87, at the crest of the subject slope, is seen to have been trimmed back and a platform is observed to have been formed above the location of the 2007 rockfall. A linear structure (possibly a drainage downpipe) is observed to be spanning between the platform above and the toe of the subject slope. Trees are identifiable next to the linear structure. Slope works are visible at the subject slope. The upper part of the northeastern portion of the slope is seen to have been covered with recently

applied shotcrete (possibly applied in 1996) while the lower part is obscured by a building and shadow.

By 2000, a concrete wall is observed to have been built at the toe of the northeastern portion of the subject slope, and trees at the location of the 2007 rockfall observed in the aerial photographs of previous years are still visible.

In the 2001 aerial photographs, vegetation cover is observed to have been applied to the southwestern portion of the subject slope and mature trees are present in the northeastern end, around the downpipe.

In the aerial photographs taken between 2002 and 2006, little change is observed other than a general increase in vegetation density at the subject slope. The coverage of vegetation near the location of the 2007 rockfall is seen to have increased.

3.2 Past Slope Instabilities

According to the GEO's landslide database, there are no records of any previous reported landslides on the subject slope, but two landslide incidents occurred in the vicinity of the subject slope. The approximate locations of these incidents are shown in Figure 5.

The first incident is inferred from the 1972 aerial photograph (dated 14 July 1972) and is seen to have occurred at about 20 m to the northeast of the 2007 rockfall location, in the southwestern portion of slope No. 11NE-C/C61 near the slope toe. Details of the incident were masked by the poor quality of the aerial photograph, but it appears that an approximately 15 m long section of the pavement in front of the slope was covered by the landslide debris.

The second failure is a reported rockfall incident (GEO Incident No. K94/7/1), which occurred near the southwestern end of the subject slope on 6 July 1994. According to the incident report prepared by the GEO, the rockfall involved the detachment of rock blocks, with a total volume of less than 1 m^3, from the northeastern end of slope No. 11NE-C/CR63. The contributory cause of the failure was reported to be probably due to infiltration. No casualties were reported.

4. PREVIOUS ASSESSMENTS AND SLOPE MAINTENANCE

4.1 Phase 1 Landslide Studies by Binnie & Partners

The subject slope was registered as slope No. 11NE-C/C62 in the 1977/78 Catalogue of Slopes and was investigated under the Landslide Studies Phase 1 by Binnie & Partners (B&P) for the Geotechnical Control Office (GCO, renamed GEO in 1991) in 1977. According to the Re-Appraisal Report prepared by B&P in July 1977, the condition of the slope was then assessed as "fair". It was also noted in the report that signs of distress including "chunam cracked" and "erosion at top and toe", and "trickle seepage from joints of rock" were identified at the slope. Works including "repairing cracked chunam and extending chunam over top to protect eroded area" were recommended by B&P. There are, however, no records available to confirm whether the works were carried out.

4.2 Phase IIC Landslide Study by Binnie & Partners

In September 1977, a study on the stability of the subject slope was completed by B&P under the Landslide Study Phase IIC for the GCO. As part of the study, rock joint data were collected from the slope and a kinematic analysis of the data was carried out. It was concluded in the study that "while odd loose blocks may become detached from the face, the joints observed do not combine to give any possible failure mechanism which can be seen in the field". Also, the recommendations given were to install weepholes in the chunam and to repair the areas of eroded chunam.

4.3 Stage 1 Study by GEO

In July 1991, a Stage 1 Study of the subject slope was carried out by the Planning Division of the GEO. According to the study report, a moderate amount of water seepage was observed through the rock joints, and "rock slope at northern end needs work" was recommended.

4.4 SIFT and SIRST Studies

In November 1994, under the study entitled "Systematic Inspection of Features in the Territory" (SIFT) initiated by the GEO, the subject slope was designated as being of SIFT Class 'C1' (i.e. cut slopes that have been formed or substantially modified before 30 June 1978).

In November 1995, the subject slope was inspected by GEO's consultants as part of the study entitled "Systematic Identification and Registration of Slopes in the Territory" (SIRST). According to the inspection records, the overall maintenance condition of the slope was assessed as "fair" and its consequence-to-life category was classified as "2". It also noted that "moderate amount of seepage through rock joints" and "rock slope at northern end needs work".

4.5 Stage 3 Study by Fugro (Hong Kong) Ltd

In July 1999, a Stage 3 Study of the subject slope was completed by Fugro (Hong Kong) Ltd (FHK) under Agreement No. CE 88/96 (FHK, 1999).

As part of the Stage 3 Study, site-specific ground investigation was carried out at the slope. The ground investigation revealed that the cut slope comprised completely to moderately decomposed fine- to medium-grained granite, overlain by localised fill/residual soil. The profile of the slope was represented using three cross-sections. The nearest design slope profile (i.e. Figure 5 of the Stage 3 Study Report No. S3R 30/99) was about 20 m to the southwest of the 2007 rockfall location and comprised two slope batters. The lower batter was shown as a cutting inclined at angles of between 53^{o} and 65^{o}, mostly in moderately to slightly decomposed granite (M/SDG) and overlain by completely decomposed granite (CDG), with the soil/rock interface at about 15 m above the slope toe. The upper batter was shown as a 50^{o} cutting in CDG, overlain by residual soil and localised fill.

A survey of exposed rock joints in the northeastern portion of the slope was carried out by FHK in January 1999. The survey data are reproduced in Figures B1 to B9 of Appendix B. The data showed that a 36 m long portion of the slope toe was surveyed and that the rock joint measurements were confined only to the slope portion up to about 3 m above the toe (Figures B10 and B11 refer).

In the kinematic analysis, the 36 m long portion of exposed rock was subdivided into four portions with respect to the dip angle and dip direction of the slope face. The subdivision (i.e. 'Part D' as indicated in the Stage 3 Study Report No. S3R No. 30/99) in which the 2007 rockfall occurred, covered a 15 m long portion from the northeastern boundary of the subject slope and had a slope face at $80^{o}/130^{o}$. The stereoplot of the joint data measured in the sub-division is given in Figure B12. The results of the kinematic analysis indicated that possible wedge failure could occur between the intersection of joint sets D2 and D3. Planar, wedge and toppling modes of failure were also identified in the stereoplots of the other three sub-divisions.

According to the geotechnical design for the 36 m long rock portion of the subject slope, FHK proposed to install a series of 2 m to 6 m long rock dowels to the rock portion and to construct a concrete buttress at the toe. In addition, FHK proposed typical rock slope treatment works including scaling and trimming of loose and overhanging blocks, installation of raking drains along the slope toe and provision of reinforced sprayed concrete to the rock slope portion. The construction drawing entitled "Plan of Works" shows that sprayed concrete and other stabilization works are to be provided to the general area of the rock slope, including the 2007 rockfall location, with the extent of works to be determined by the Engineer on site. Section 1-1, which is about 20 m from the 2007 rockfall location, shows that no sprayed concrete is required for the rock portion of the cut slope.

The above slope upgrading works were undertaken by Barbican Construction Company Limited, between 21 June and 30 December 1999, under Contract No. GE/98/07. A general view of the subject slope after completion of the upgrading works is shown in Plate 3. According to the as-built drawing No. LPM9807/34/02A of the slope (Figure B13), 'Part D' of the rock portion, which includes the 2007 rockfall location, was recorded to be covered with reinforced sprayed concrete, and steel rock dowels of 32 mm in diameter and 4 m in length were installed about 2 m to the southwest of the 2007 rockfall source area.

According to FHK, the existing sprayed concrete surfacing at the northeastern portion of the slope (as observed in the 1996 aerial photographs) was assessed during construction as being in good condition and therefore, the proposed reinforced sprayed concrete to the whole rock portion of the slope was not considered necessary and rock dowels were installed in the rock cut. FHK has advised that the as-built drawing has mistakenly included the existing sprayed concrete surfacing as part of the works under Contract No. GE/98/07 and also inadvertently extended it to cover the 2007 rockfall source area.

4.6 Engineer Inspection by Maunsell Geotechnical Services Limited

In December 2003, Maunsell Geotechnical Services Limited (MGSL) carried out an Engineer Inspection (EI) for maintenance of the subject slope for the HyD (MGS, 2003). The overall state of slope maintenance was assessed as being of "Class 1" (i.e. none or only

minor defects were identified). The defects identified by the inspection at the slope included blocked weepholes in the sprayed concrete at the middle slope portion. MGSL recommended some routine maintenance works, i.e. clearance of the weepholes.

According to the 2003 EI record, MGSL reported that slight to moderate water seepage was observed below the mid-height of the slope, or from isolated rock joints. However, the locations of the seepage were not given and the "Inspection Form for Rock Slope Condition" was also missing. In the EI record, it is also stated that "the access to the subject slope for maintenance inspections was adequate".

4.7 Routine Maintenance Inspections/Works by HyD

Annual/routine maintenance inspections (RMI) of the subject slope have been carried out by the HyD since 1983. The last RMI was conducted in 2006. A review of all the available inspection records was carried out by HCL as part of this landslide study and the salient findings are summarised below.

According to the 1983 slope inspection – maintenance report, minor cracking of chunam, minor "rock movement" on the slope surface, overgrown of vegetation, and silted slope channels and catchpits were identified at the subject slope. However, the details of the observations, especially the rock movement on the slope surface, were not given in the report. The recommendations given were to clear the slope channels and vegetation and to carry out minor remedial works to the slope surface.

In the 1993 RMI record, sprayed concrete is noted to have recently been applied to the southwestern portion of the slope (also observed in the 1993 aerial photographs). It was recorded that the subject slope was then in "good condition" and "no works or investigation" were needed.

In the 1996 RMI record, reinforced sprayed concrete was recommended to replace the defective chunam cover (as observed in the 1978 aerial photographs) in the upper part of the northeastern portion of the subject slope. The recommended works were then carried out between June and August 1996, under HyD's Term Contract No. 16/HY/95. This new hard slope surface is visible in the 1996 aerial photographs (Section 3.1). In a record photograph of the 1996 RMI (Plate 4), the reinforced sprayed concrete did not cover the slope portion at the 2007 rockfall source area.

The subject slope was selected for upgrading under the LPM Programme as indicated in the 1997 RMI record, and therefore no maintenance works were recommended. A record photograph of the RMI (Plate 5) shows a general view of the subject slope in 1997, from which little change can be observed other than a general increase in vegetation density at the slope.

The first RMI, following the completion of the LPM slope upgrading works in December 1999 to the subject slope, was carried out in 2001. The recommendations given in the RMI record were to clear debris in drainage channels, remove surface debris and vegetation, and unblock weepholes. These recommended works were carried out in conjunction with those recommended for slope No. 11NE-C/F86 at the crest of the subject

slope under HyD's Term Contract No. 17/HY/1998. A record photograph of the RMI (Plate 6) shows the general view of the subject slope in 2001. In this photograph, the reinforced sprayed concrete applied under the above LPM slope upgrading works did not cover the slope portion at the 2007 rockfall source area.

In the records of the remaining RMIs up to 2006, the recommendations given were mainly to clear debris in drainage channels, remove surface debris and vegetation, and unblock weepholes. In the 2003 RMI record, the sprayed concrete surface at the southwestern portion of the subject slope had been changed to a vegetation cover (Figure 6 and Plate 1). According to the RMI record, this vegetation cover is a proprietary vegetation system (Rockgrass) and was applied to the sprayed concrete surface of the southwestern portion of the slope by the HyD in May 2001.

Based on the available records, it would appear that no specific slope maintenance works had been recommended and carried out at the location of the 2007 rockfall since the LPM slope upgrading works.

5. THE 4 MAY 2007 ROCKFALL AND POST-FAILURE OBSERVATIONS

5.1 Description of the Incident

According to the incident report prepared by the GEO, the rockfall occurred on slope No. 11NE-C/C62 at Hong Ning Road, Kwun Tong, Kowloon on 4 May 2007 at about 6:30 p.m. The incident was reported by the HyD to the GEO at 6:55 p.m. At the time of the failure, the weather was dry and only 5 mm of rainfall were recorded at the nearest GEO automatic raingauge to the site earlier on that day (Section 6). The incident involved the detachment of a rock block, with a failure volume of about 0.03 m^3 (Plate 7), from the rock cut portion at the northeastern end of the slope. The rock block fell from a height of about 10 m and broke into several pieces upon landing at a catchpit, before coming to rest on the pedestrian pavement at the slope toe. The pedestrian pavement and a section of the northbound carriageway of Hong Ning Road were temporarily closed. No casualties were reported as a result of the incident.

5.2 Post-Failure Observations of the Rockfall Site

HCL first inspected the rockfall site on 8 May 2007 at about 2:30 p.m., by which time most of the debris had been removed. During the inspection, the source area of the rockfall was identified to be on the bare rock surface of the subject slope, at about 10 m above the slope toe, at the northeastern end (Figures 6 and 7). However, a detailed inspection of the source area could not be carried out until late May 2007 when scaffolding was erected by the HyD for carrying out remedial works to the slope.

HCL subsequently made several visits to the rockfall site between 25 May and 12 June 2007. The source area of the rockfall was observed to be on a rock slope face generally dipping at about $80^o/130^o$ and comprising strong to moderately strong, pinkish grey, slightly to moderately decomposed, fine- to medium-grained granite, with generally closely to medium spaced joints (Plate 8). Two side-release joint planes (dipping at about $68^o/037^o$ and $88^o/160^o$ respectively) and a back-release joint plane (dipping at about $27^o/280^o$) were

identified at the scar (Plate 8). On these release planes, black and dark reddish brown stains were observed, which were possibly manganese and iron oxides (Plate 9). Such staining is indicative of water migration, weathering and possible opening of the rock joints prior to the detachment of the rock block in the 2007 incident. Tree roots of up to about 8 mm diameter were also observed on the side-release joint plane dipping at about 68º/037º (Plate 9). A growth of moss on the shotcrete and rock surface was observed near the rockfall source. During the inspection on 12 June 2007, minor water seepage was noted at the bare rock/shotcrete interface at about 1 m to the northeast of the 2007 rockfall source area (Figure 8).

About 1 m below the rockfall source area, a tree with a main trunk of about 100 mm in diameter was growing on the bare rock surface (Figures 7 & 8 and Plate 10), with its roots covering much of the rock surface. Some scratch marks were observed on the tree roots (Plate 10), indicating the probable path of the rockfall. There were also scratch marks observed on the concrete covers and steel grating of Catchpit HN2 at the slope toe, below the rockfall source area (Plate 11). Two of the bars of the steel grating were observed to be severely deformed and rock fragments were found both on the grating and inside Catchpit HN2 during the inspection on 8 May 2007. The scratch marks on Catchpit HN2 suggest that it was probably the landing point of the detached rock block (Figure 8 and Plate 2).

At about 2 m below the rockfall source area, sub-vertical joint sets dipping at about 80º/110º were observed on the bare rock face (Figure 7 and Plate 12). Some of the rock joints were found to have been jacked open (10 mm maximum) by tree roots, and a potentially unstable rock block (about 500 mm by 200 mm by 20 mm in size) was found to have detached from the rock surface (Plate 12). Another unstable rock block (about 300 mm by 200 mm by 20 mm in size) was also hanging on a tree root of about 5 mm in diameter, just below the detached rock block. These unstable rock blocks were subsequently removed and the rock face was covered with rock mesh netting by the HyD upon the advice of the GEO.

At about 4 m below the rockfall source area, a relatively flat area (dipping at about 15º to 20º) was observed (Figure 7). This area was covered with 'old shotcrete' which appeared to be different in colour, as compared to the reinforced sprayed shotcrete applied as part of the LPM works in 1999. The uneven surface of this 'old shotcrete' indicated that wire mesh reinforcement was unlikely to have been incorporated. Two trees were growing on this flat area with their roots covering the slope surface in the vicinity. A crack (about 300 mm long by 3 mm wide) was noted in the shotcrete surface (Plate 12).

At the crest of the subject slope just above the rockfall source area, a ditch of about 300 mm in width was identified. Sandy materials were observed to have been deposited in the ditch during the inspection on 8 May 2007 (Plate 13).

5.3 Kinematic Analysis

Rock joint data in the vicinity of the rockfall source area were collected by HCL. A kinematic analysis adopting the techniques of stereographic projections was carried out to assist with the diagnosis of the failure mechanism of the 2007 rockfall.

The rock joint data collected, including those of the release planes (i.e. A, B and C) of

the rockfall source area, are presented in a stereoplot (Figure 9). According to the stereoplot, the intersection of the two side-release planes (B and C) is kinematically unstable with respect to the rock slope face dipping at $80^{o}/130^{o}$, and potential wedge failure is indicated.

6. ANALYSIS OF RAINFALL RECORDS

Rainfall data were obtained from the nearest GEO automatic raingauge (No. K03), which is located at the PMG Radio Monitoring Station, Hong Ning Road, about 370 m to the south of the subject slope (Figure 1). This raingauge records and transmits rainfall data at 5-minute intervals via a telephone line to the Hong Kong Observatory and the GEO. According to the landslide incident report prepared by the GEO, the rockfall incident occurred on 4 May 2007 at about 6:30 p.m.

The daily rainfall for the period of 31 days before the incident and the hourly rainfall between 3 and 4 May 2007 are presented in Figure 10. The record of the daily rainfall shows that only 5 mm of rainfall was recorded on 4 May 2007. On the day of the rockfall, the record of the hourly rainfall shows that all the 5 mm of rainfall was recorded between 11:00 a.m. and 3:00 p.m., some three hours before the reported time of the rockfall.

The return period for the rainfall recorded at Raingauge No. K03 preceding the rockfall was estimated based on historical rainfall data at the Hong Kong Observatory (Lam & Leung, 1994). The maximum rolling rainfall for various durations was derived and is given in Table 1. The result shows that the return period of the 4 May 2007 rainstorm is less than 2 years. The return period was also assessed based on the statistical parameters derived by Evans & Yu (2001) for rainfall data recorded by Raingauge No. K03. The return periods estimated using data of Lam & Leung (1994) and Evans & Yu (2001) respectively are very similar in this case (Table 1).

A comparison of the maximum rolling rainfall of the 4 May 2007 rainstorm with that of the past major rainstorms recorded by Raingauge No. K03 is presented in Figure 11. The rainstorm of 4 May 2007 was insignificant.

7. DISCUSSION

The 4 May 2007 rockfall, which involved the detachment of a small rock block (about 0.03 m^3) from a steep, engineered rock cut, occurred after a few hours of light rainfall with a return period of less than 2 years. The correlation between the rainfall and the rockfall suggests that the 4 May 2007 rockfall was probably triggered by rainfall. The source area of the 2007 rockfall was close to a former natural drainage line, located at the northeastern end of the subject slope, where there may be concentrated subsurface water flow (Section 3.1 and Figure A2). This could explain why signs of water seepage from rock joints were recorded during previous assessments (Sections 4.1, 4.3 and 4.6). The minor water seepage observed at the bare rock/shotcrete interface near the 2007 rockfall source area (Section 5.2) further suggests that the slope may be susceptible to the build-up of cleft water pressure within the rock joints at the northeastern portion of the slope. The kinematic analysis carried out as part of this review indicates that the release planes in the area of the 2007 rockfall are adversely orientated, and together with the possible build-up of transient water pressure

within the joint planes, the slope is susceptible to small, localised wedge failure.

At the 2007 rockfall source area, much of the bare rock surface was covered with tree roots (Plate 12). Post-failure inspections indicated that the growing of these tree roots on the rock surface may have caused the rock mass to deteriorate progressively by way of joint dilation and fracture. Two small rock blocks were identified to have separated from the rock mass (Plate 12), and this appeared to be the result of the wedging action of the tree roots on the rock joints. At the rockfall source area, a small tree root of about 8 mm in diameter was present on the release plane (Plate 9). The effect of this tree root on the joint dilation leading to the 2007 rockfall was not certain, but it appeared to be one of the contributory factors for this particular minor rockfall incident. It is worth noting that the joint dilation and fracture of the rock mass can be exacerbated by unplanned vegetation, whereby failure can be triggered by relatively light rainfall, as the rock mass suffers progressive deterioration. In this particular incident, the rockfall from a height of 10 m could be hazardous to the public, although the detached rock block itself was small in size.

FHK concluded in their Stage 3 Study of the subject slope that potential wedge failures could occur on 'Part D' rock cut portion where the 2007 rockfall occurred (Section 4.5). According to the as-built drawings, this sub-division was shown to be wholly covered with reinforced sprayed concrete. However, site observations made by HCL revealed that the source area of the 2007 rockfall was a bare rock cut (about 5 m by 6 m), covered by unplanned vegetation without sprayed concrete or rock mesh netting and without evidence of sprayed concrete having been locally removed. This discrepancy in the as-built drawings was subsequently clarified by FHK during the course of this landslide study that the existing sprayed concrete applied to the northeastern portion of the slope in 1996 had been mistakenly included as part of the LPM works and inadvertently extended to cover the 2007 rockfall source area. Apart from this discrepancy, the slope works for the rest of the cutting are generally consistent with that shown on the as-built drawings.

In the 2003 EI report, it was recorded that the access to the subject slope for maintenance inspections was adequate. However, it was observed during the site inspections by HCL that there is no proper, safe access to the rock cut at the northeastern end of the slope, including the area of the 2007 rockfall (Section 5.2). It is uncertain whether the rock cut at the northeastern portion of the slope was covered by the 2003 EI, as the "Inspection Form for Rock Slope Condition" was missing in the EI report.

Based on the field inspections, no obvious signs of incipient large-scale instability were observed during the course of this study.

8. REFERENCES

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Evans, N.C. & Yu, Y.F. (2001). Regional Variation in Extreme Rainfall Values. Geotechnical Engineering Office, Hong Kong, 81 p. (GEO Report No. 115).

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

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

Maunsell Geotechnical Services Limited. (2003). Record of Engineer Inspection - 11NE-C/C62 at Hong Ning Road For Maintenance, Highway Department, 32 p.

LIST OF TABLES

Table 1 - Maximum Rolling Rainfall at GEO Raingauge No. K03 for Selected Durations Preceding the Rockfall on 4 May 2007 and Estimated Return Periods

Duration	Maximum Rolling Rainfall (mm)	End of Period (Hours) (see Note 4)	Estimated Return Period (Years) (see Note 3)	
			A	B
5 minutes	0.5	15:10 hours on 4 May 2007	1	< 2
15 minutes	1	14:40 hours on 4 May 2007	1	< 2
1 hour	1.5	15:25 hours on 4 May 2007	1	1
2 hours	2.5	15:30 hours on 4 May 2007	1	< 2
4 hours	4.5	15:20 hours on 4 May 2007	1	< 2
12 hours	5	18:30 hours on 4 May 2007	1	1
24 hours	5	18:30 hours on 4 May 2007	1	1
2 days	5	18:30 hours on 4 May 2007	1	1
4 days	5	18:30 hours on 4 May 2007	1	< 2
7 days	8	18:30 hours on 4 May 2007	1	< 2
15 days	91.5	18:30 hours on 4 May 2007	1	< 2
31 days	118.5	18:30 hours on 4 May 2007	1	< 2

Notes:
(1) Maximum rolling rainfall was calculated from 5-minute rainfall data.
(2) The nearest GEO raingauge to the rockfall site is Raingauge No. K03 located at the PNG Radio Monitoring Station, Hong Ning Road about 370 m to the south of the rockfall site.
(3) Return periods were derived from Table 3 of Lam & Leung (1994) (Column A refers) and using data of Raingauge No. K03 from Evans & Yu (2001) (Column B refers). The return periods obtained by data of Lam & Leung (1994) and Evans & Yu (2001) do not show a significant difference.
(4) For the purpose of rainfall analysis, the rockfall was assumed to occur at 18:30 hours on 4 May 2007.

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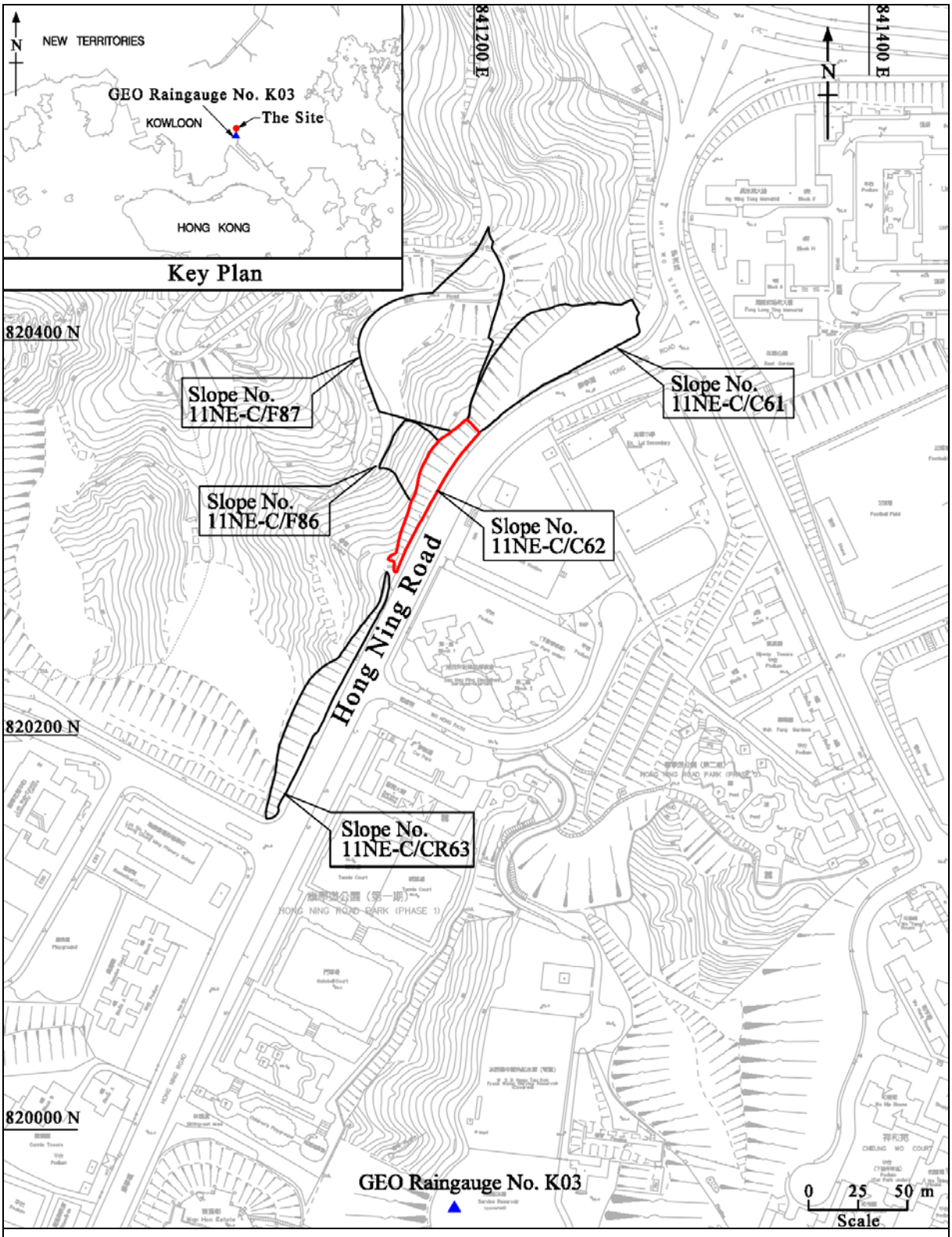

Legend:

Slope boundary of 11NE-C/C62 from SIS

Slope boundary of adjacent slopes from SIS

Note: Base map is extracted from survey sheet Nos. 11NE-13D & 18A, Scale 1:1000.

Figure 1 - Location Plan

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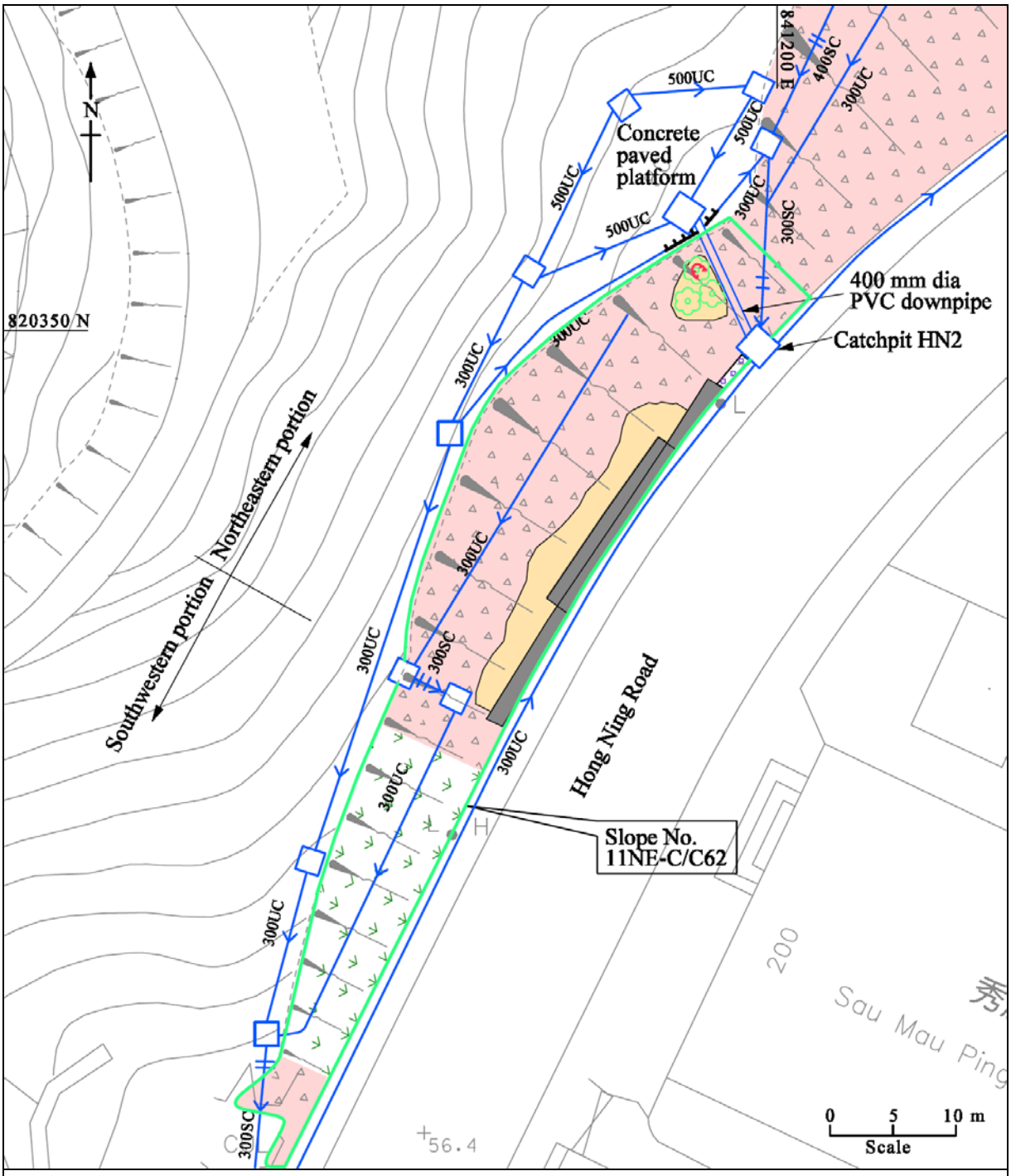

Note: Base map is extracted from survey sheet No. 11NE-18A, scale 1:1000.

Figure 2 - Site Layout Plan

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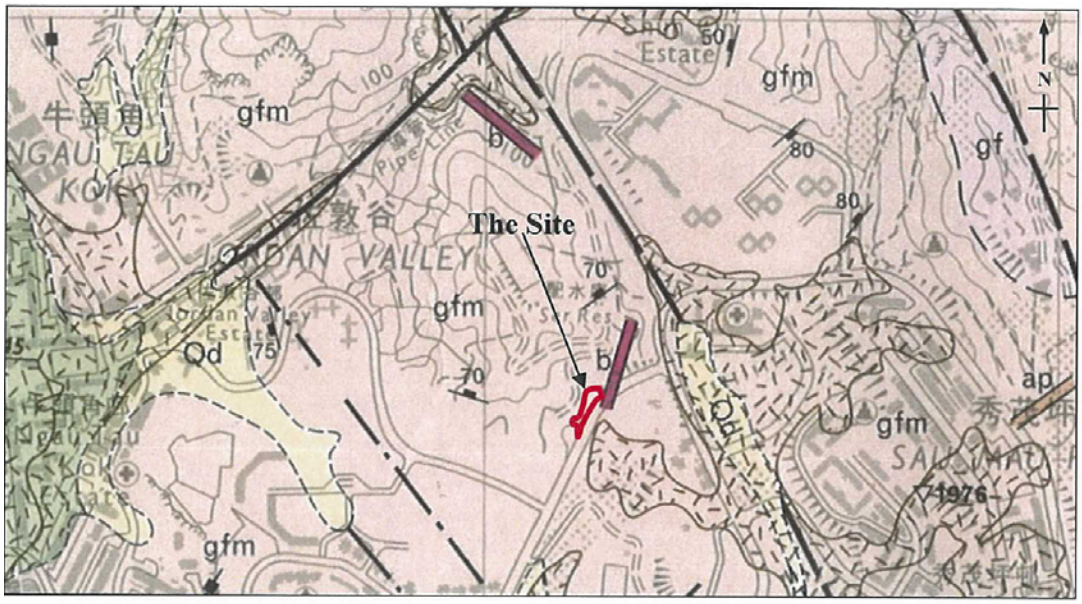


LEGEND:

SUPERFICIAL DEPOSITS

Qd — Debris flow deposits

Fill

SOLID GEOLOGY

gfm — Fine-to medium-grained granite

b — Basalt

GEOLOGICAL LINES

Geological boundary, superficial deposit

1982 — Fill boundary, with limit of reclamation at date shown

Geological boundary, solid rock (* Broken line denote uncertainty)

Fault (* Broken line denote uncertainty)

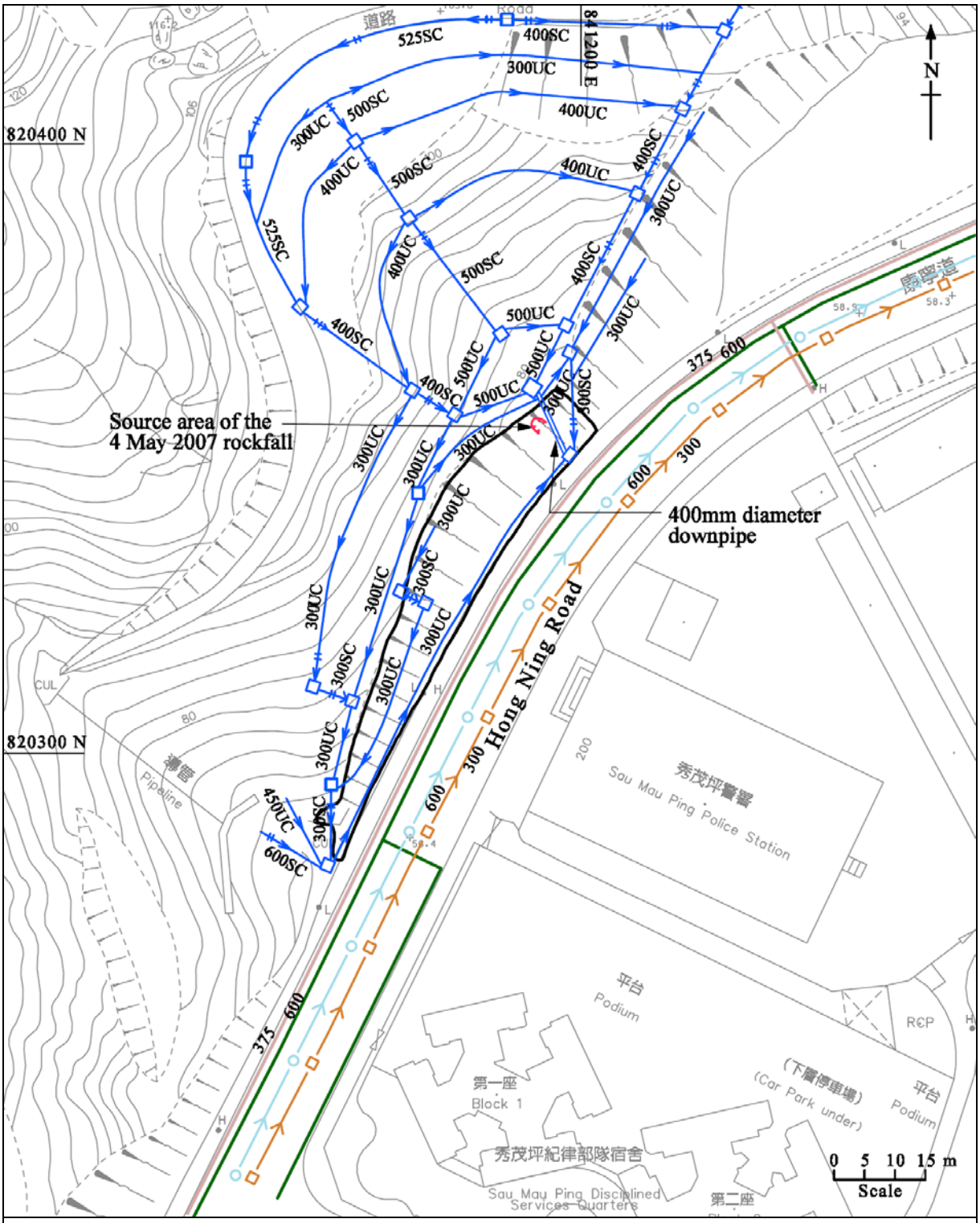
Photogeological lineament

STRUCTURAL SYMBOLS

Inclined 20 — Jointing

Note: Extracted from Hong Kong Geological Survey Map Series HGM20, Sheet No. 11, 1:20,000 scale (GCO, 1986).

Figure 3 - Regional Geology



Note: Base map is extracted from survey sheet No. 11NE-18A, scale 1:1000.

Figure 4 - Location of Water-carrying Services

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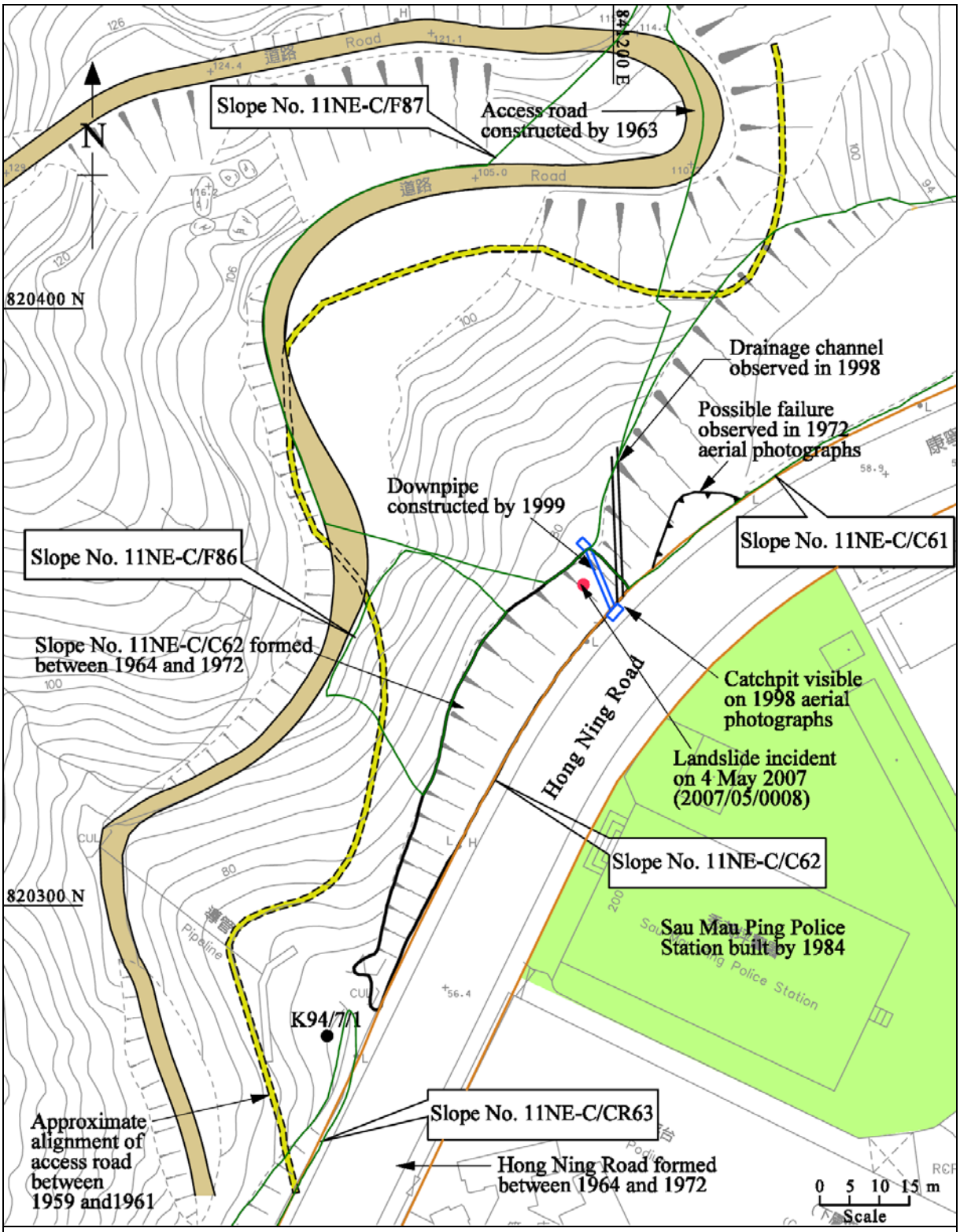

Legend:

Possible failure scar visible on aerial photographs

Slope Boundary

K94/7/1 Landslide incident No. K94/7/1

Note: Base map is extracted from survey sheet Nos. 11NE-13D & 18A, scale 1:1000.

Figure 5 - Site Development and Past Instabilities

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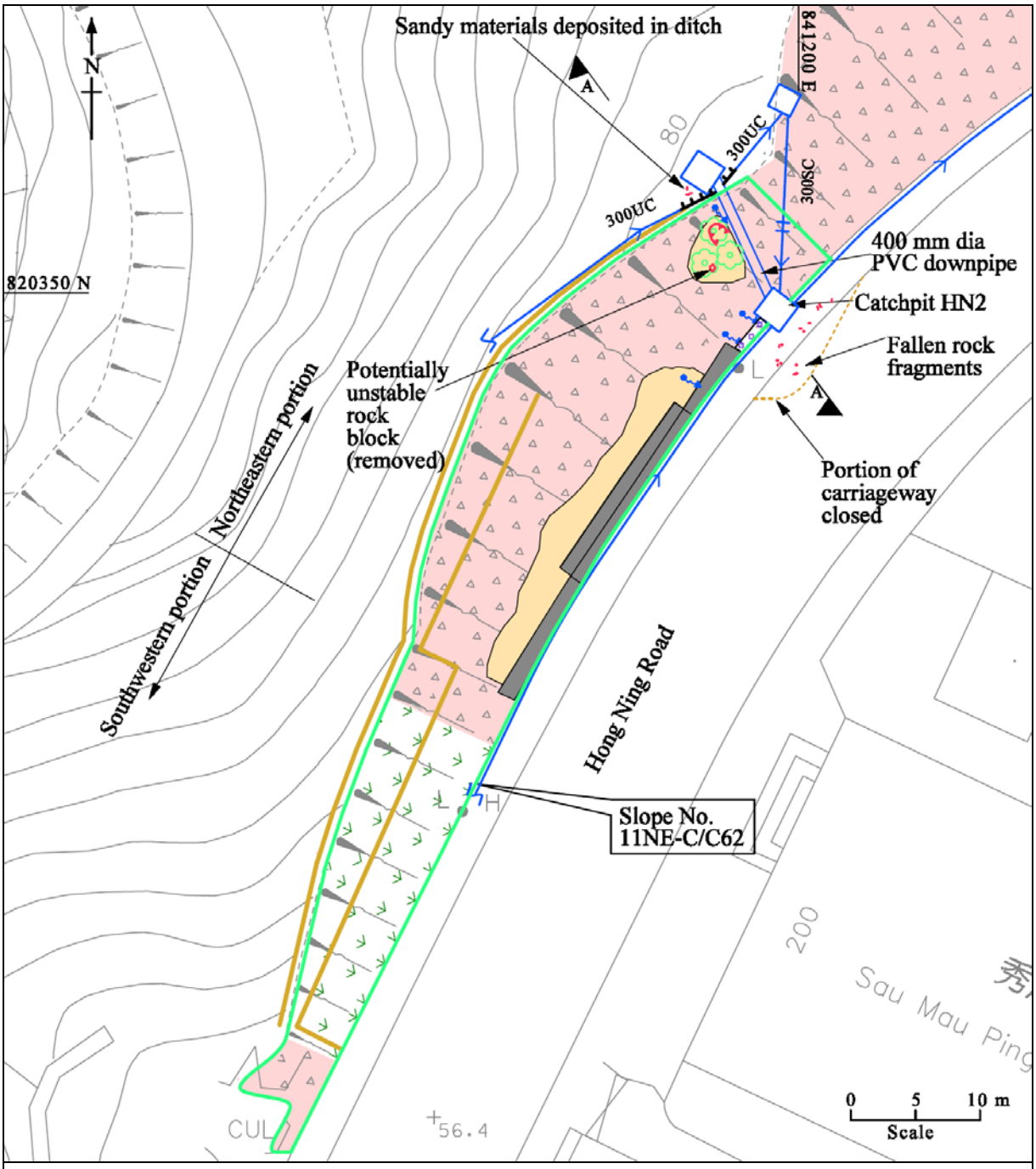

Note: Base map is extracted from survey sheet No. 11NE-18A, scale 1:1000.

Figure 6 - Site Observations in the Vicinity of the 4 May 2007 Rockfall Location

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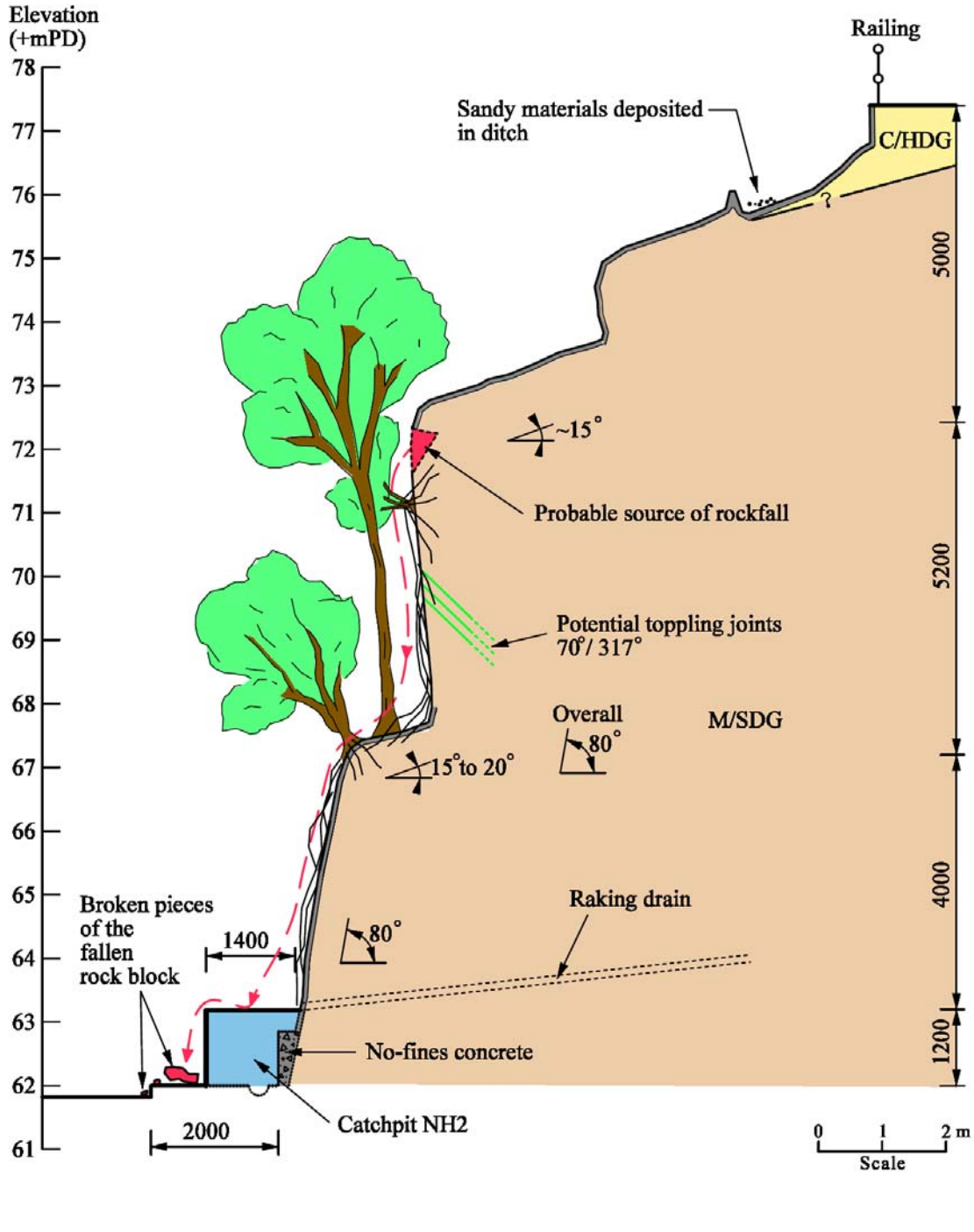


Legend:

Shotcrete surface

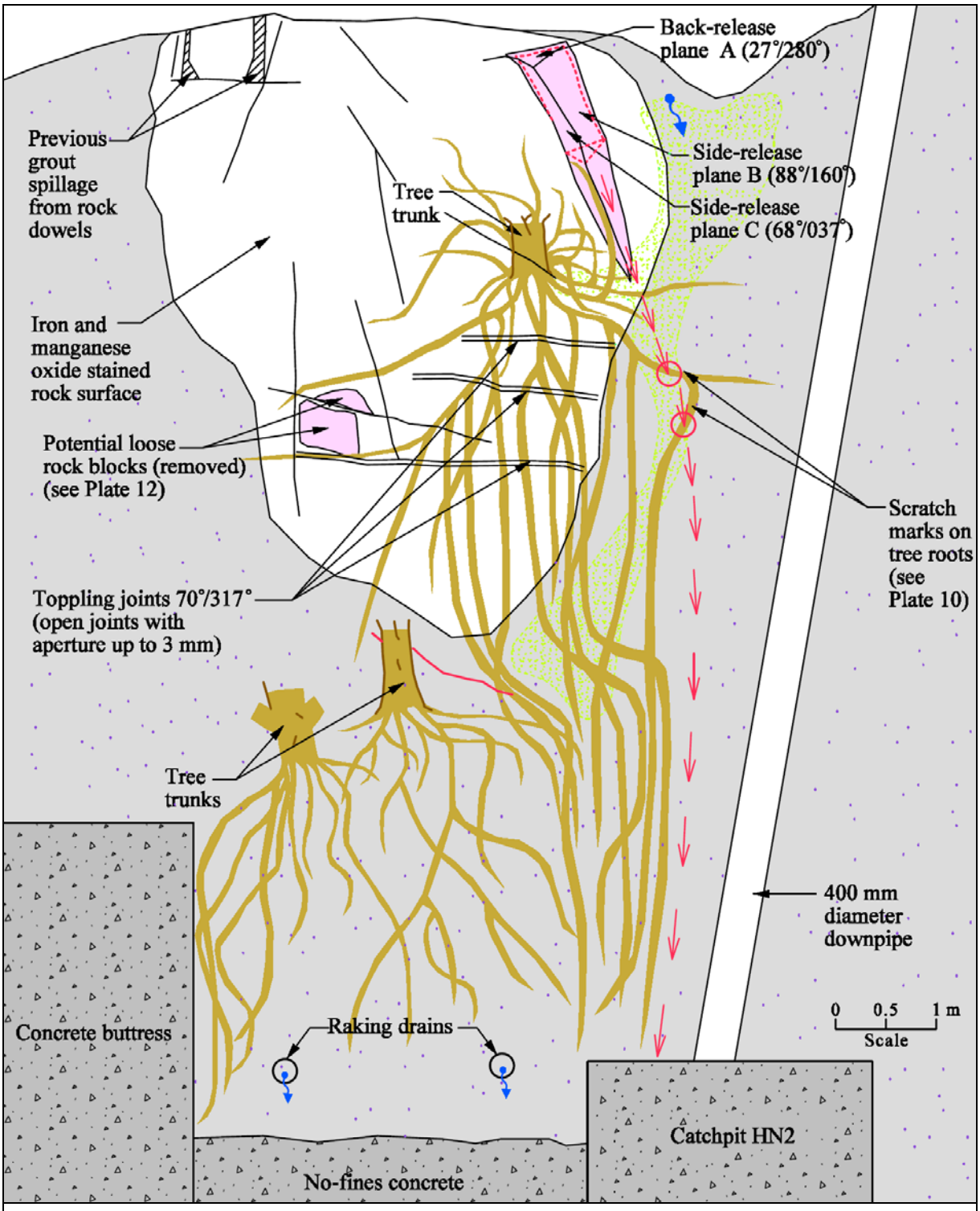
M/SDG — Moderately to slightly decomposed granite (Grade III/II)

C/HDG — Completely to highly decomposed granite (Grade IV/V)

Probable path of rockfall

Note: See Figure 6 for location of section.

Figure 7 - Section A-A through the 4 May 2007 Rockfall Location



Note: The orientation of the slope surface is 130°.

Figure 8 - Sketch of the 4 May 2007 Rockfall Source Area - Elevation View

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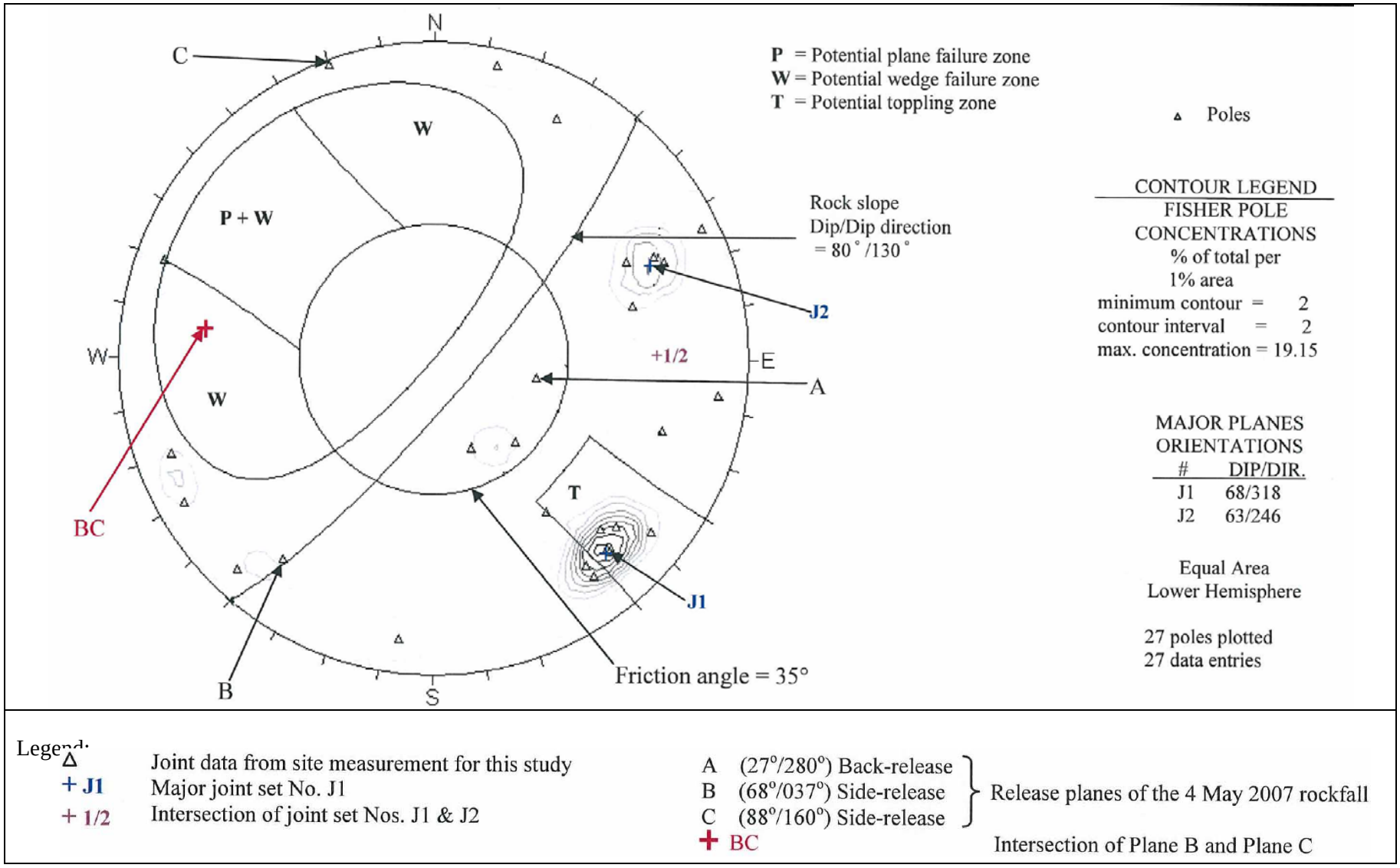
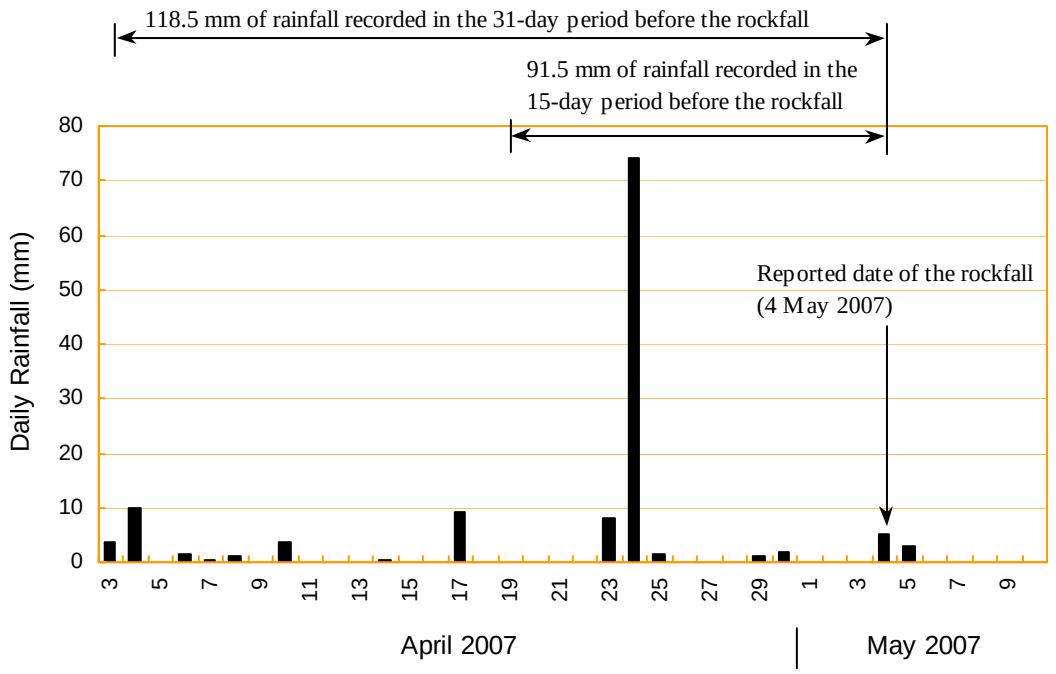
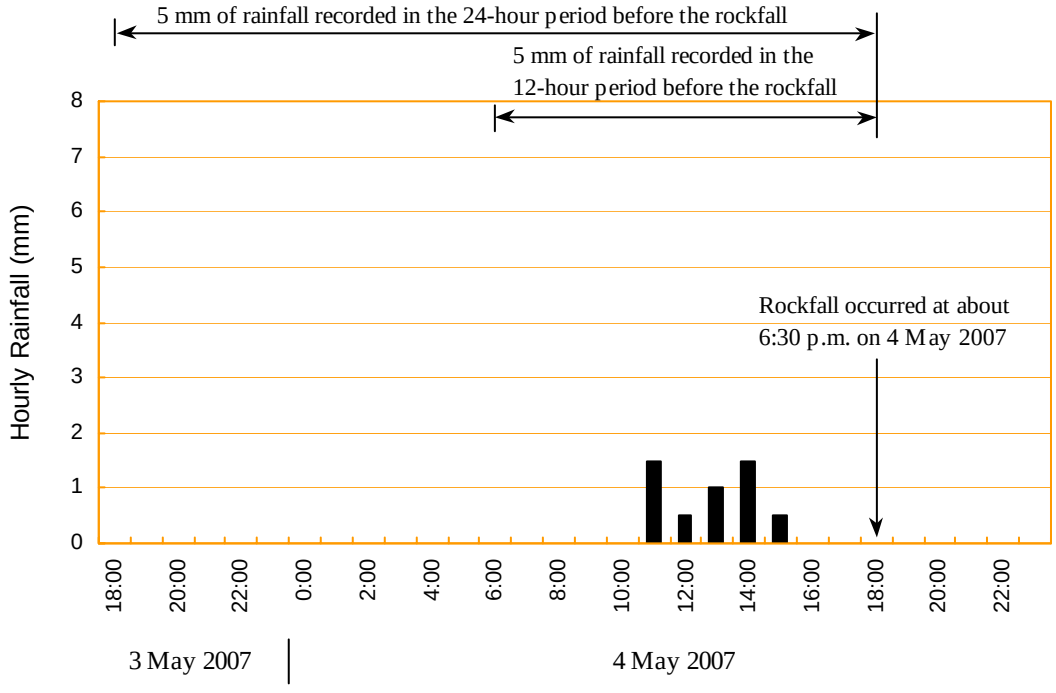


Figure 9 - Kinematic Analysis of Joint Orientations near the May 2007 Rockfall Location

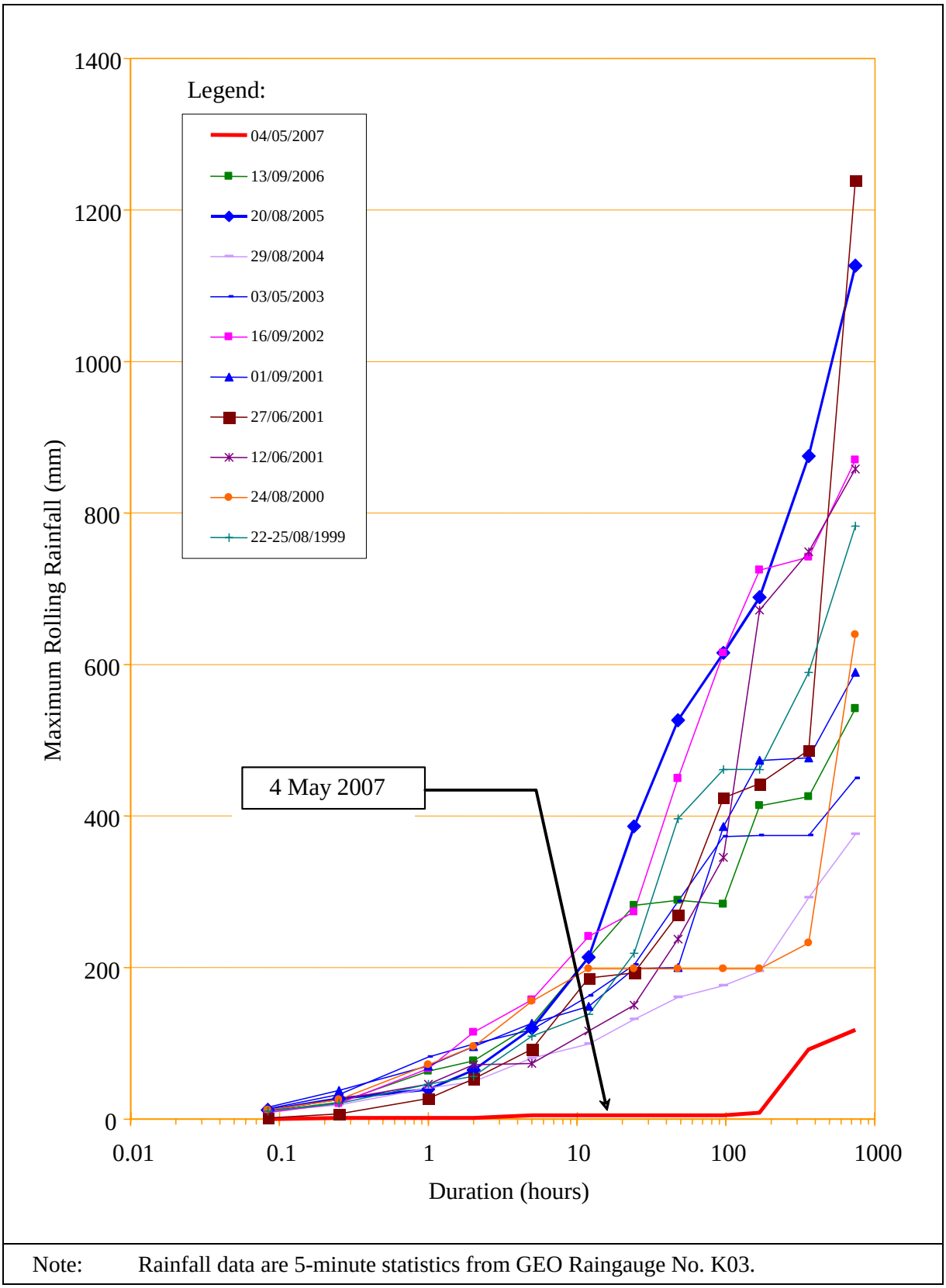


(a) Daily Rainfall Recorded between 3 April and 10 May 2007



(b) Hourly Rainfall Recorded between 18:00 hour on 3 May and 24:00 hour on 4 May 2007

Figure 10 - Daily and Hourly Rainfall Recorded at GEO Raingauge No. K03



Note: Rainfall data are 5-minute statistics from GEO Raingauge No. K03.

Figure 11 - Maximum Rolling Rainfall for Previous Major Rainstorms at GEO Raingauge No. K03 between August 1999 and May 2007

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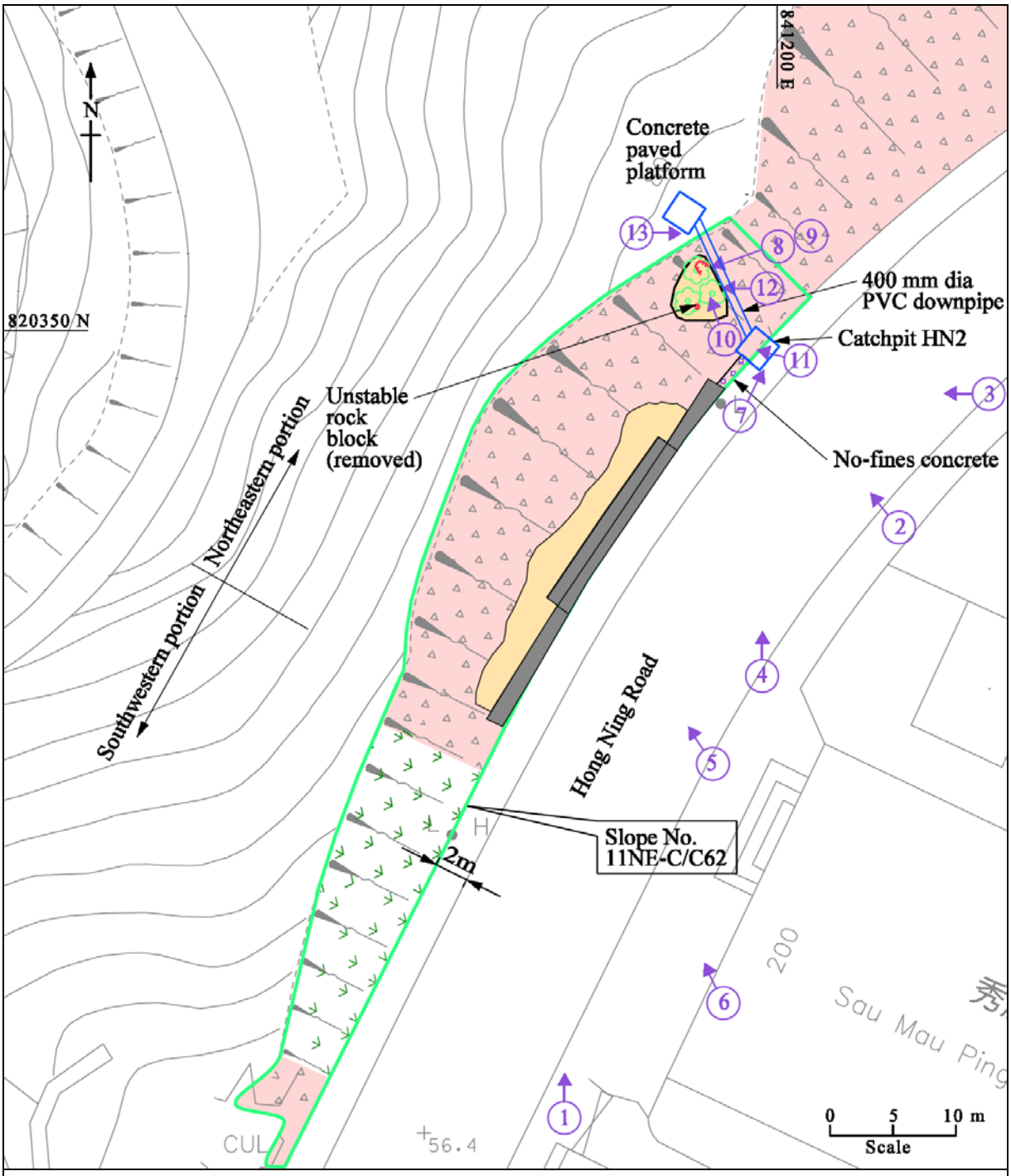

Note: Base map is extracted from Survey Sheet No. 11NE-18A, scale 1:1000.

Figure 12 - Locations and Directions of Photographs Taken

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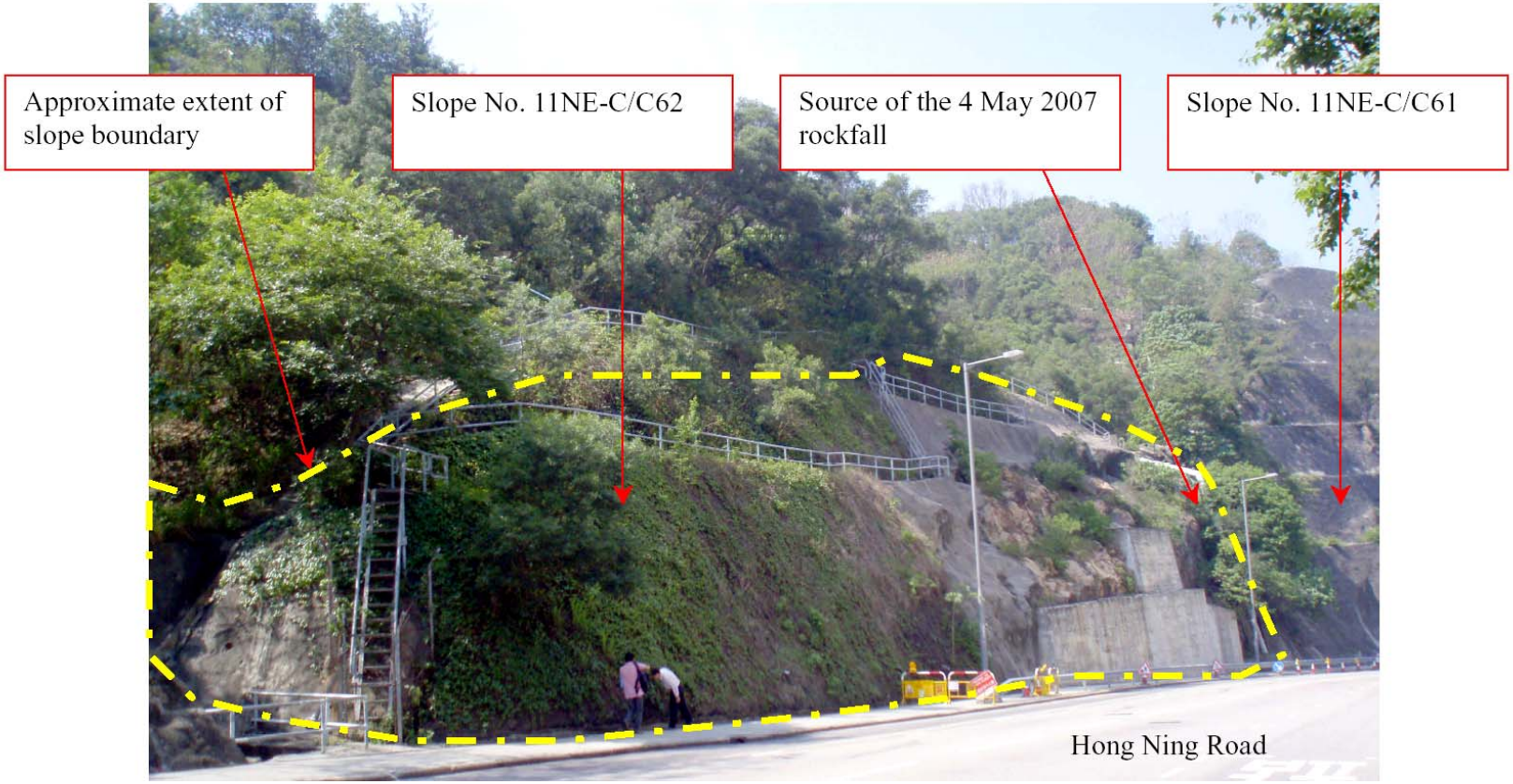

Plate 1 - General View of Slope No. 11NE-C/C62 (Photograph taken on 8 May 2007)

Note: See Figure 12 for location and direction of photograph.

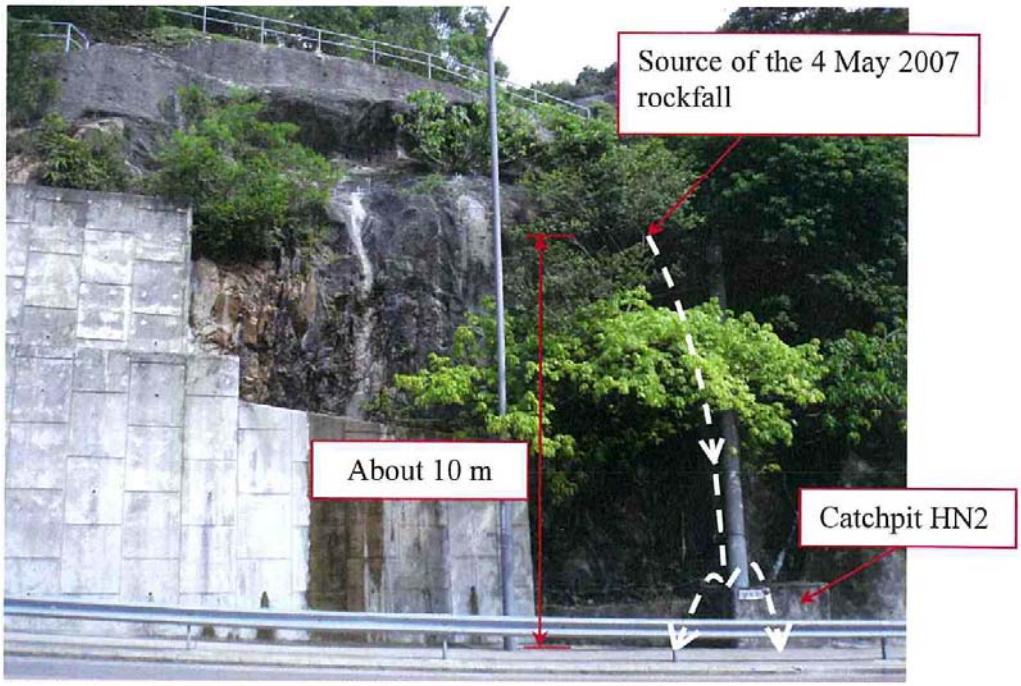

Plate 2 - Northeastern End of Slope No. 11NE-C/C62
(Photograph taken on 25 July 2007)

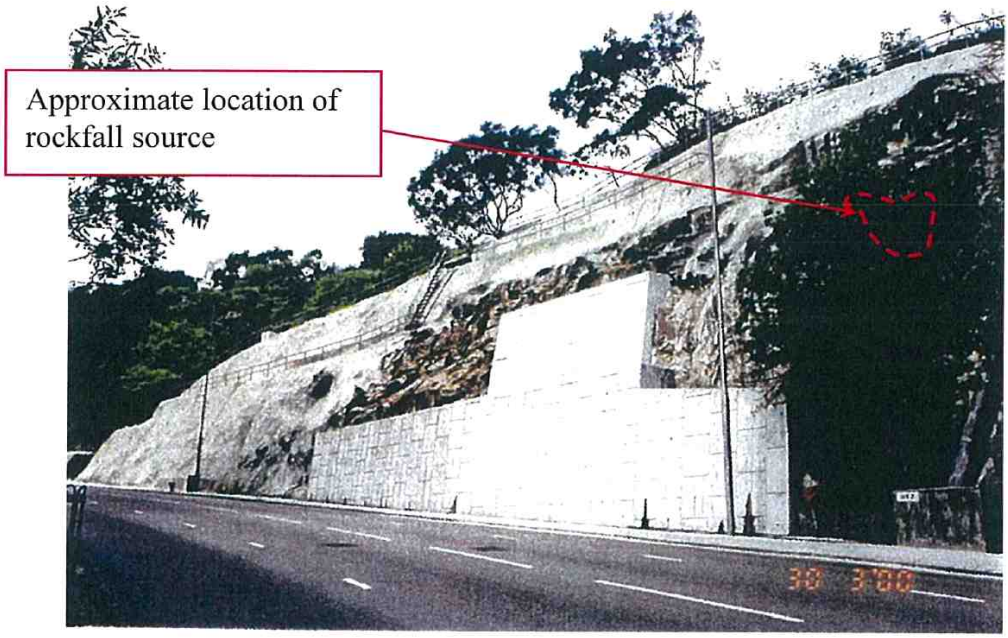

Plate 3 - General View of Slope No. 11NE-C/C62 after LPM Works
(Photograph taken on 30 March 2000)

Note: See Figure 12 for locations and directions of photographs.

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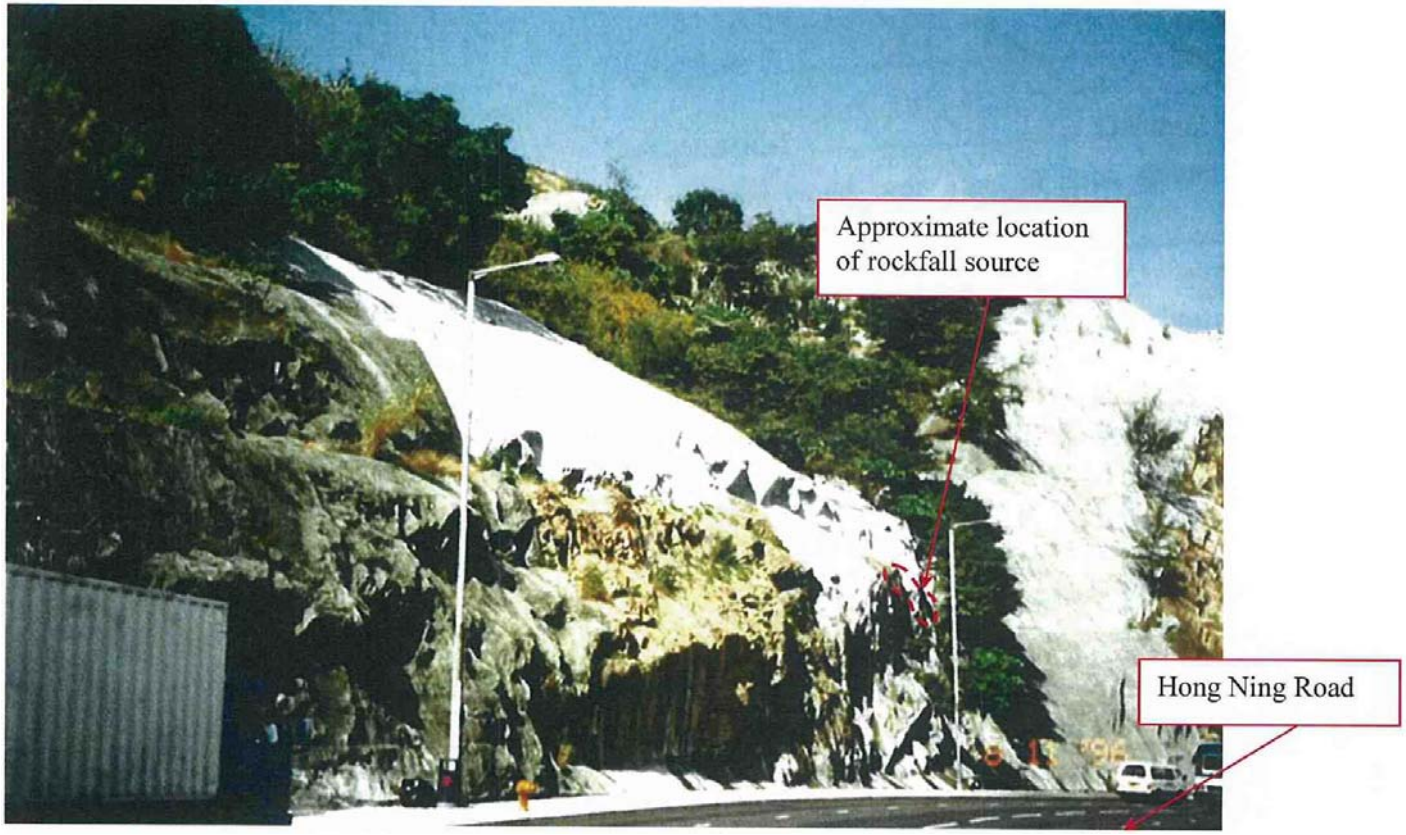

Plate 4 - General View of Slope No. 11NE-C/C62 in 1996 (Photograph taken on 8 November 1996)

Note: See Figure 12 for location and direction of photograph.

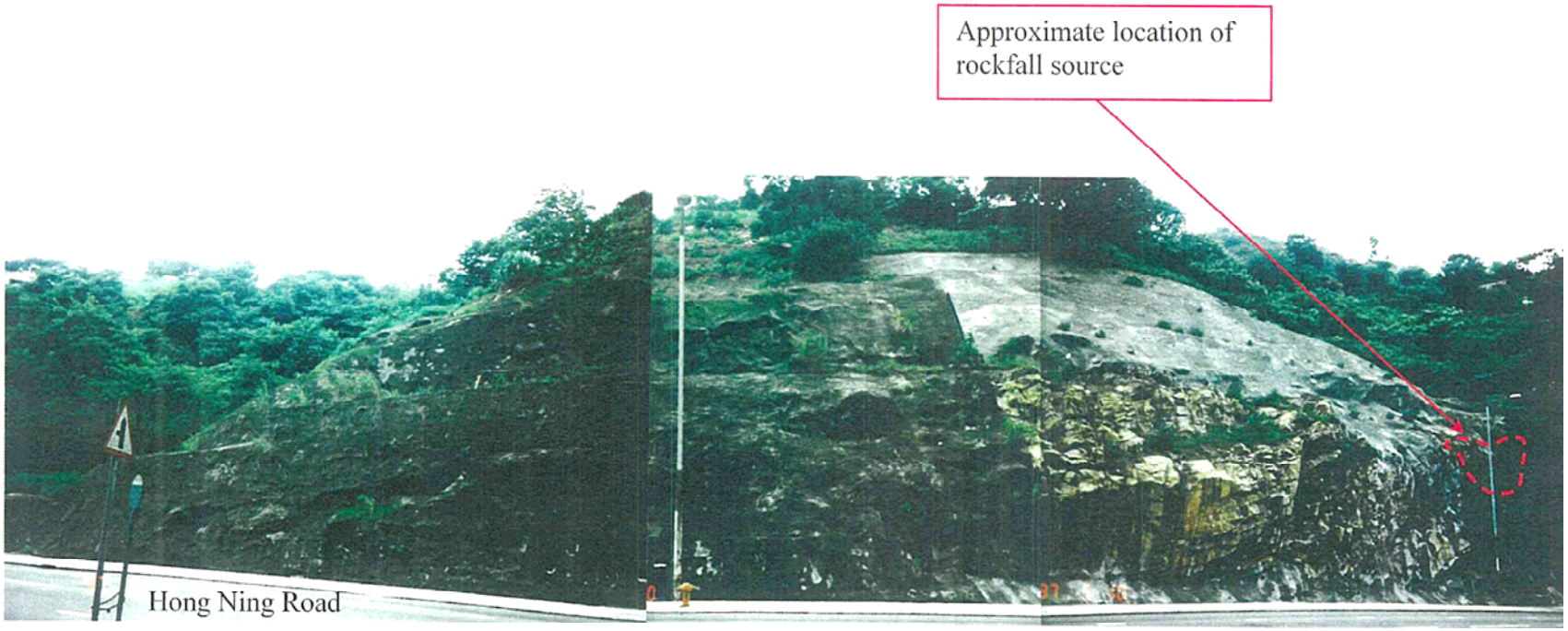

Plate 5 - General View of Slope No. 11NE-C/C62 in 1997 (Photograph taken on 10 May 1997)

Note: See Figure 12 for location and direction of photograph.

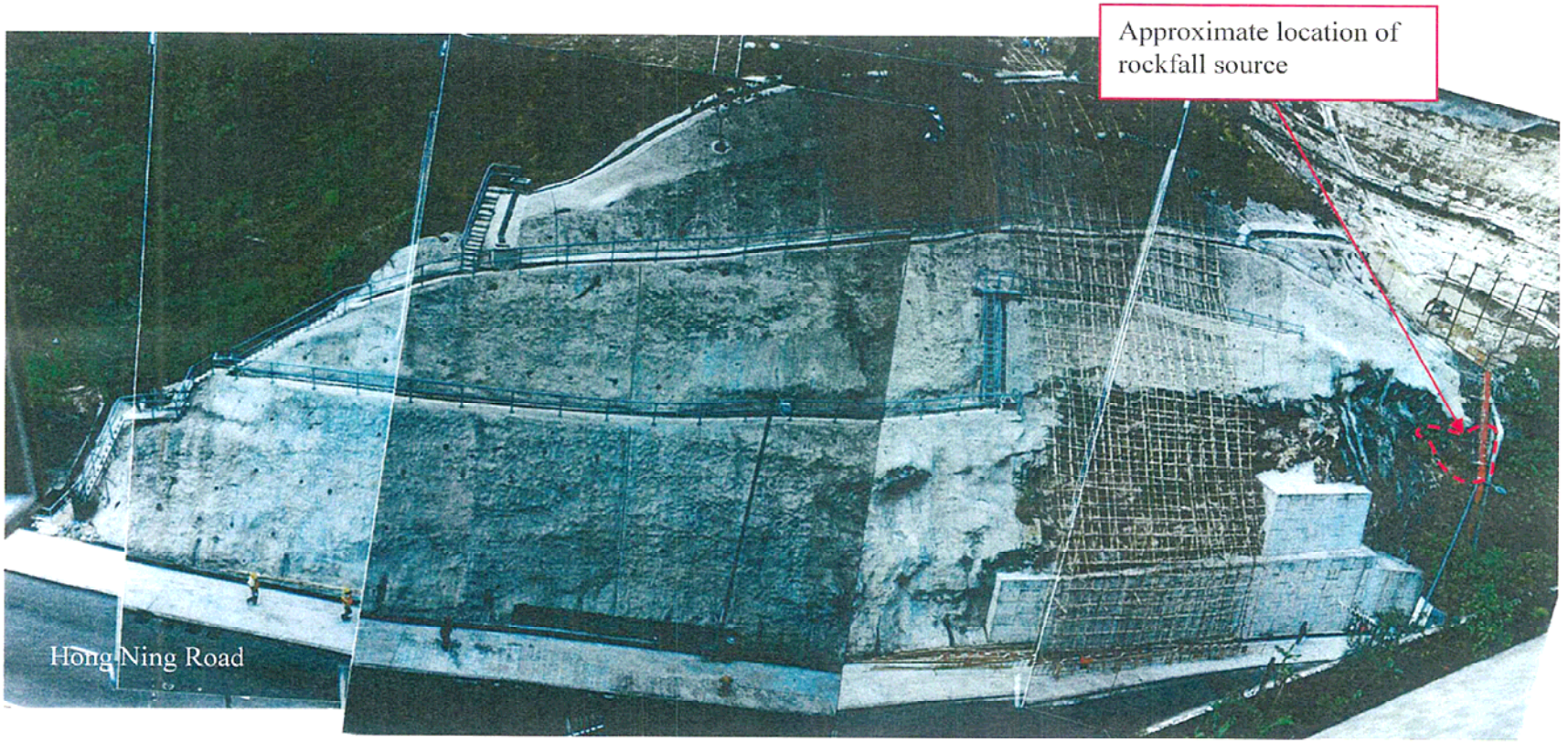

Plate 6 - General View of Slope No. 11NE-C/C62 in 2001 (Photograph taken on 18 January 2001)

Note: See Figure 12 for location and direction of photograph.

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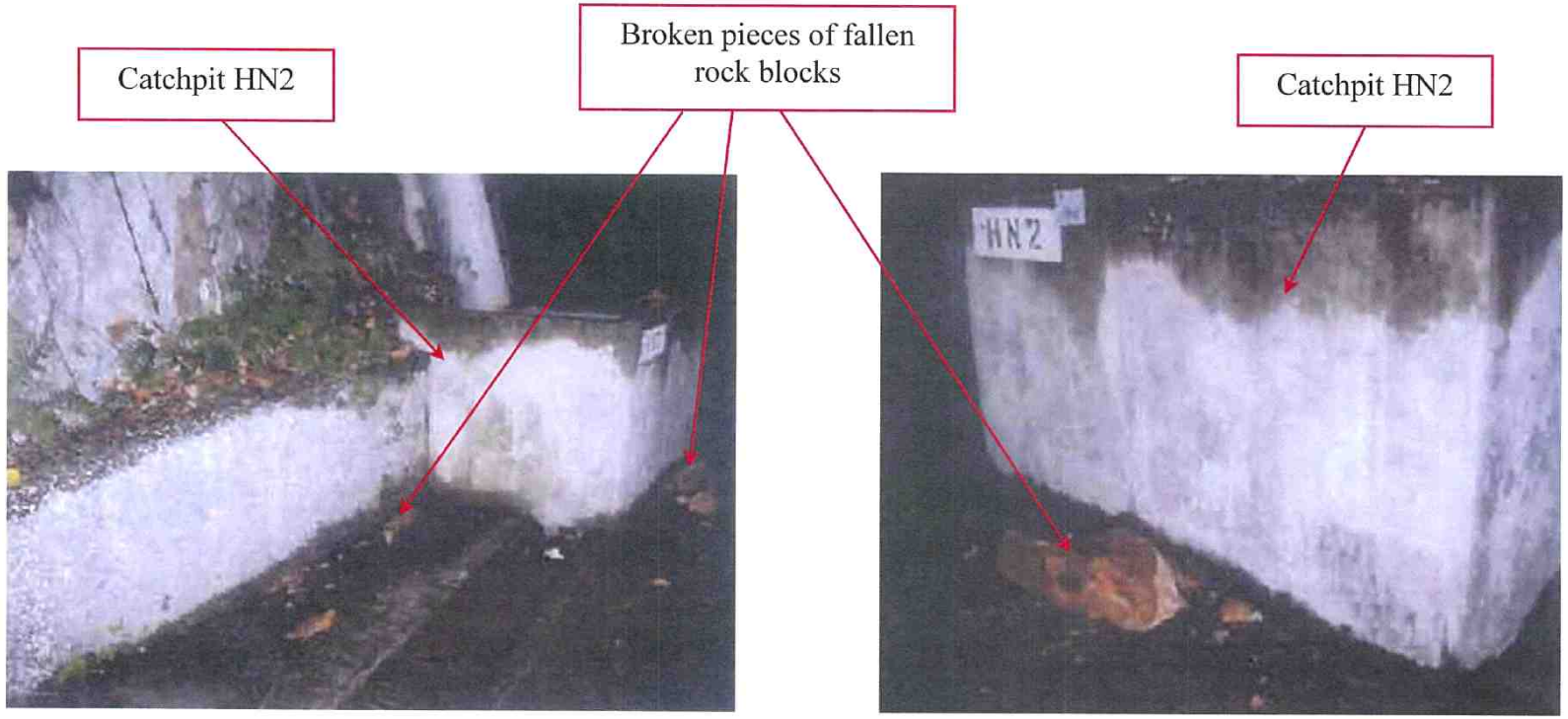

Plate 7 - Broken Pieces of Fallen Rock Block Deposited on Pedestrian Pavement
(Photograph taken on 4 May 2007, extracted from incident report No. 2007/5/0008)

Note: See Figure 12 for location and direction of photograph.

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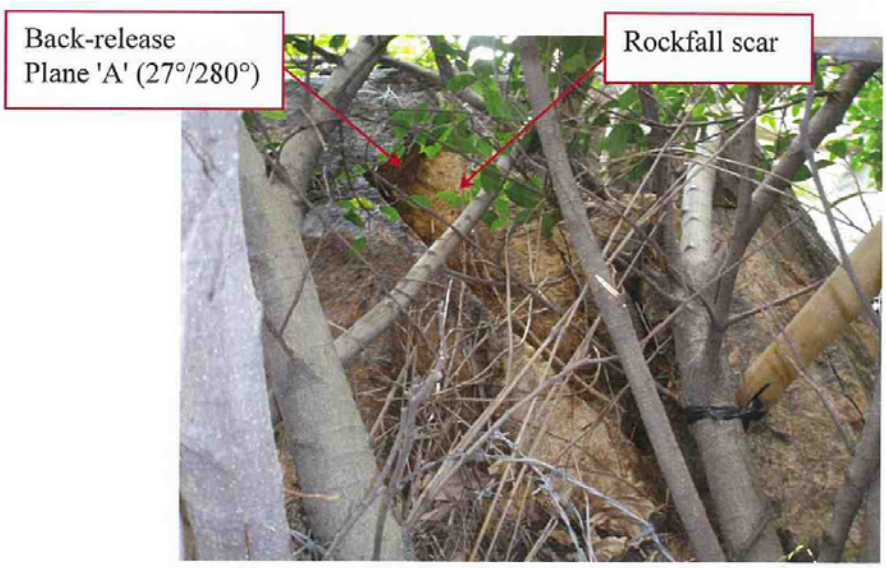

Plate 8 - General View of Rockfall Source Location (Photograph taken on 12 June 2007)

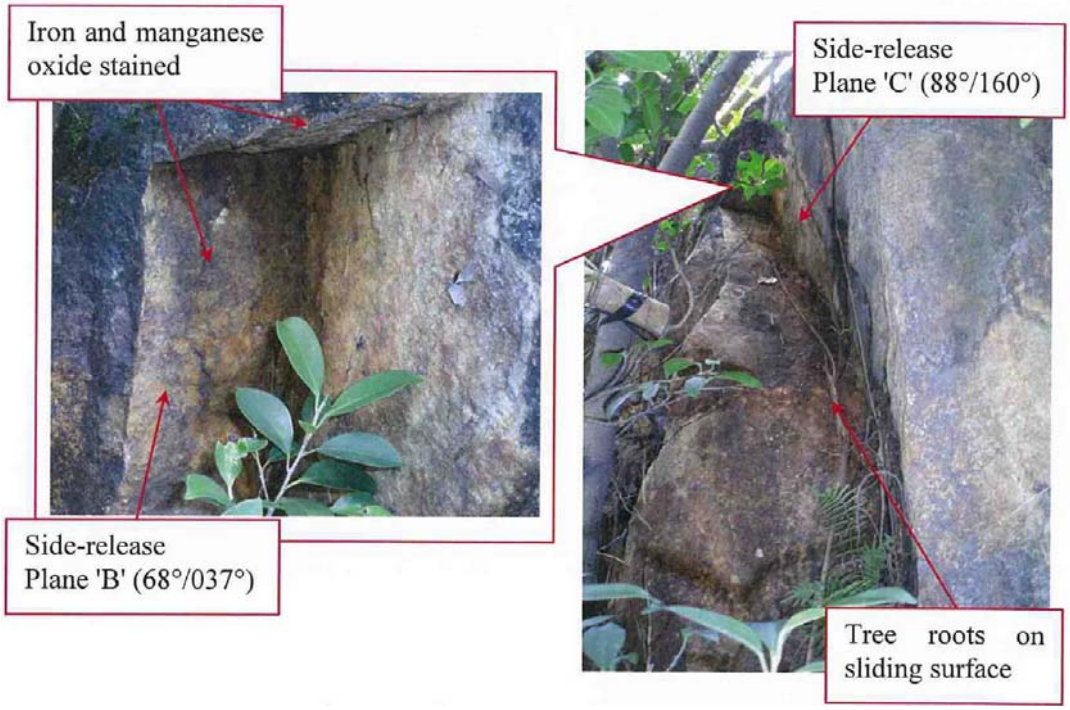

Plate 9 - Close-up View of Rockfall Source (Photograph taken on 12 June 2007)

Note: See Figure 12 for locations and directions of photographs.

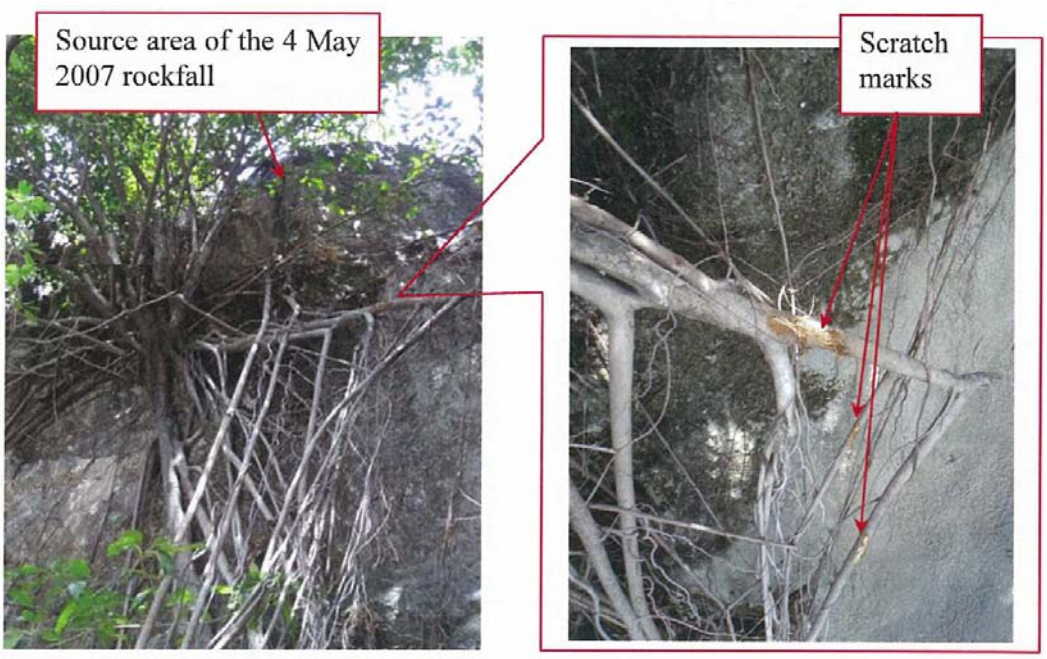

Plate 10 - Scratch Marks on Tree Roots below Rockfall Source Area
(Photograph taken on 25 May 2007)

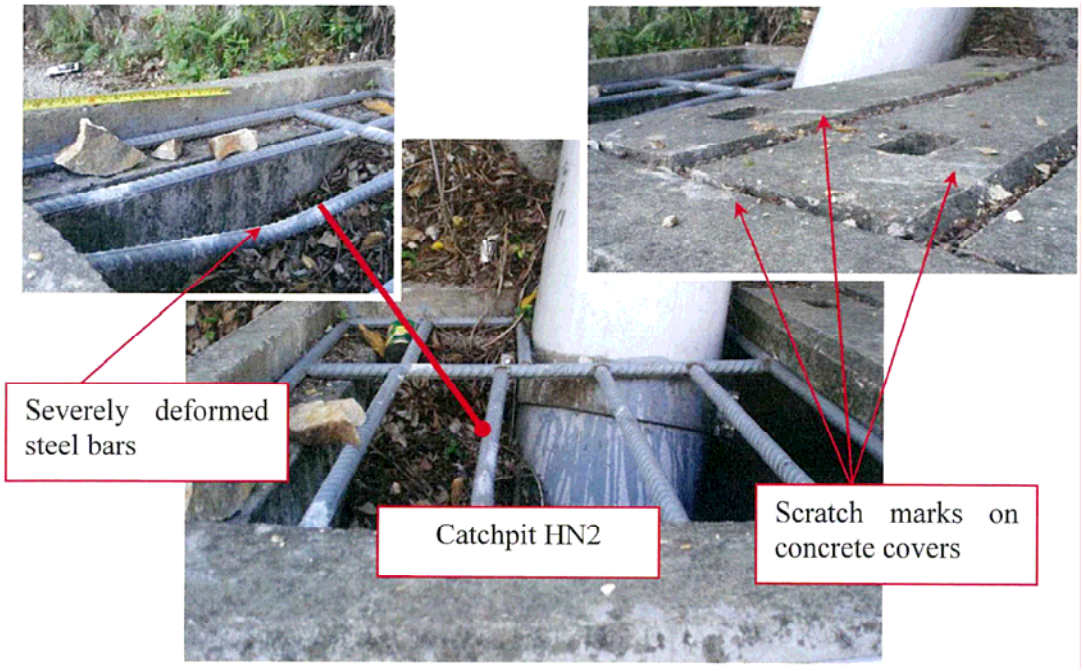

Plate 11 - Deformed Steel Bars and Scratch Marks at Catchpit HN2 below Rockfall Source
(Photograph taken on 8 May 2007)

Note: See Figure 12 for locations and directions of photographs.

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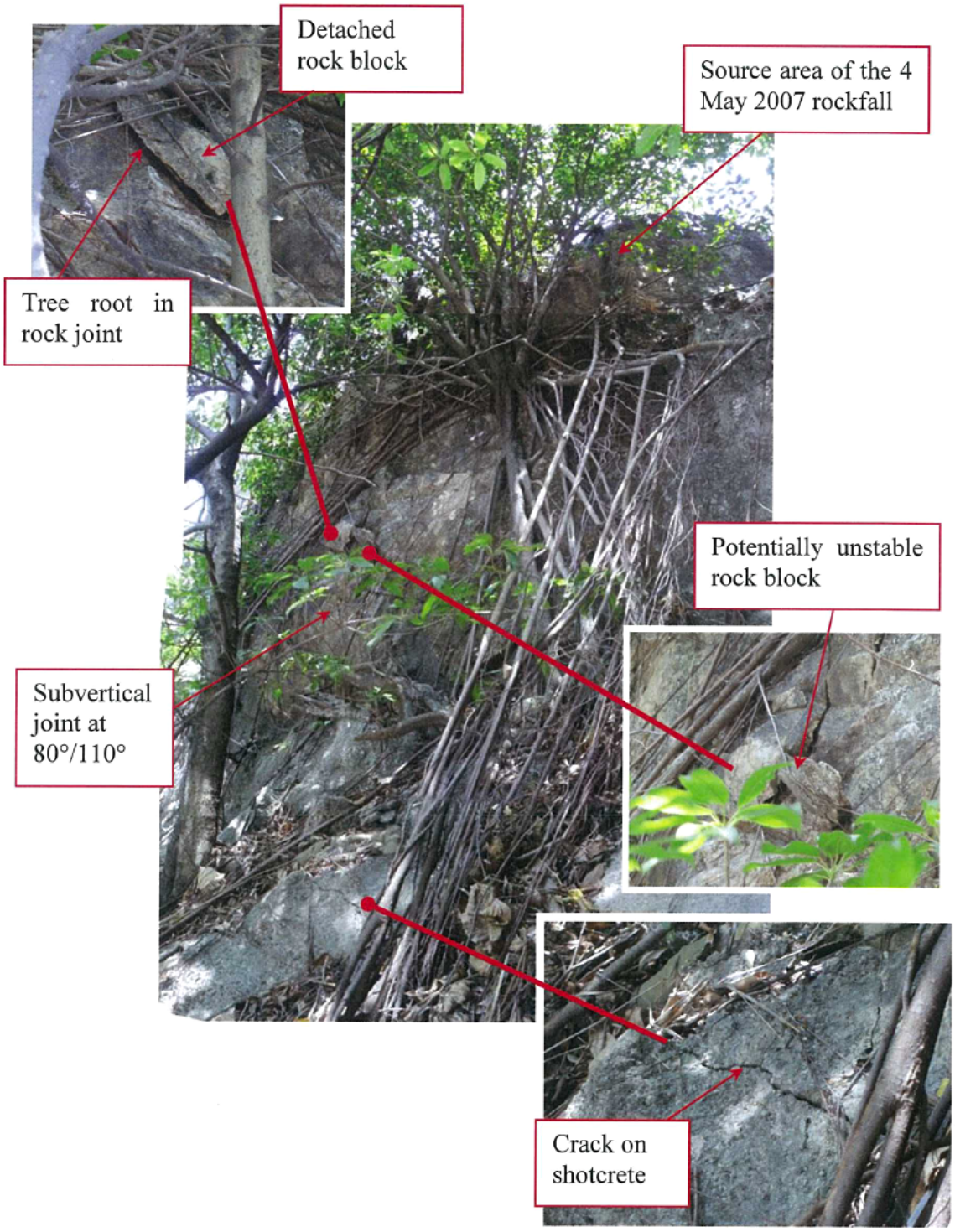

Plate 12 - Potentially Unstable Rock Blocks below Rockfall Source
(Photograph taken on 9 May 2007)

Note: See Figure 12 for locations and directions of photographs.

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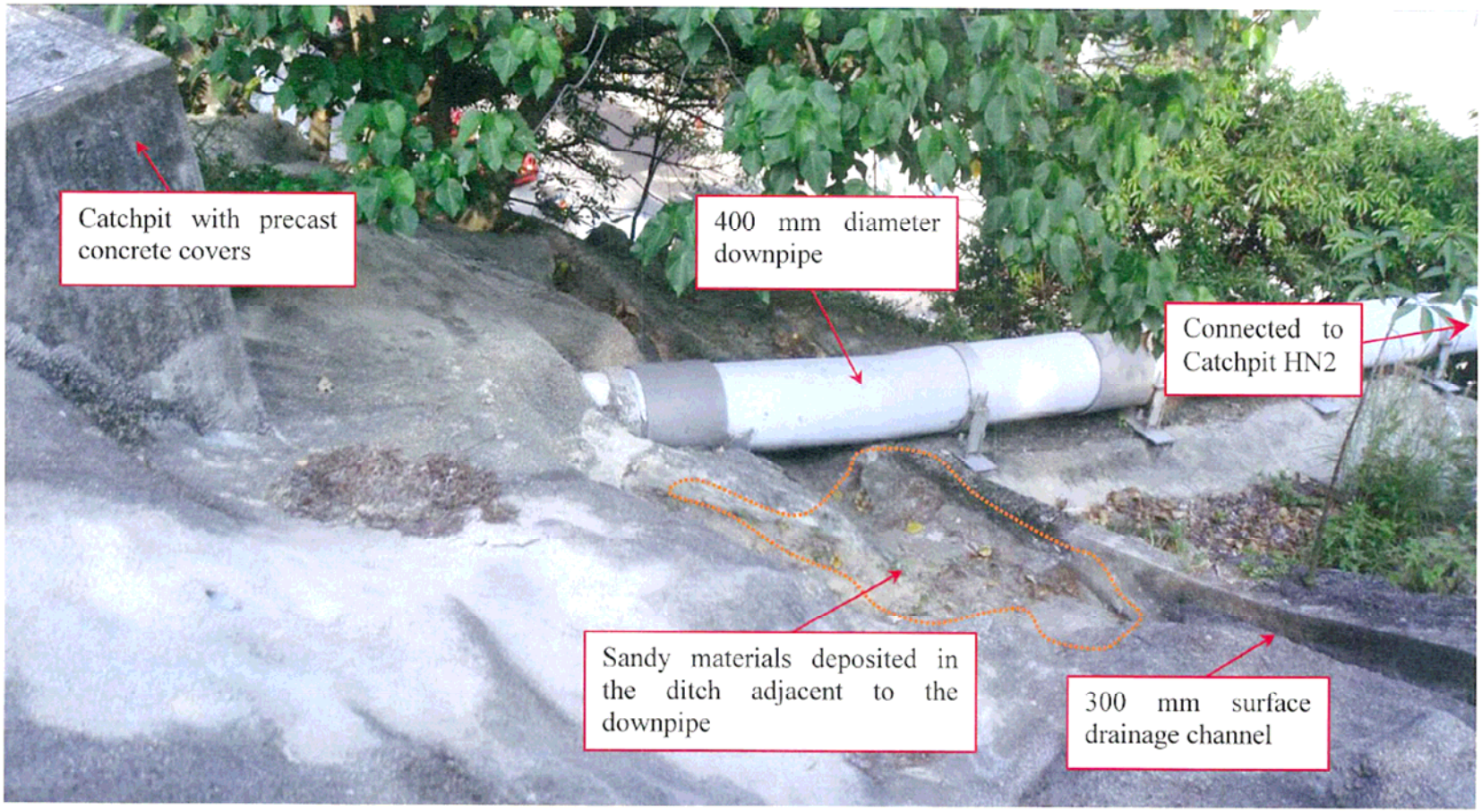

Plate 13 - Surface Drainage Channel above Rockfall Source (Photograph taken on 8 May 2007)

Note: See Figure 12 for location and direction of photograph.

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APPENDIX A

AERIAL PHOTOGRAPH INTERPRETATION

CONTENTS

A1. DETAILED OBSERVATIONS

The Following report comprises the detailed observations made from the examination of aerial photographs taken between 1949 and 2005. A list of aerial photographs examined in this study is presented in Table A1 and the main observations of the API are shown in Figure A1 and Figure A2.

YEAR	OBSERVATIONS
1949	Stereo pair of fair quality. The whole area of Kwun Tong was undeveloped apart from some agricultural activities in the valleys at lower elevation. No agricultural activities were observed on the study area. The feature area was part of a southeast facing hillside. The landscape in the vicinity of the feature area generally comprised a uniform slope with a localized shallow depression visible at an elevation close to the feature area. Two natural stream courses which converged at a lower elevation were located at both ends of the feature area. Thin vegetation cover was observed on the subject hillside and the hillside was undergoing severe erosion as evidenced by the presence of rills. A number of wider rills were observed to converge on the hillside close to the upper portion of the feature area. Angular boulders possibly tor stones were visible on the eroded surface upslope of the feature area. Accumulation of angular boulders could also be observed in the stream channel below the feature area.
1954	High elevation stereo pairs of fair quality. The topographic feature was exaggerated by the oblique sunlight. The subject hillside and the Kwun Tong area were still mostly undeveloped. The surface erosion on the hillside around Kwun Tong including the subject hillside appeared to be more severe. Rill erosion on the feature area appeared to be more apparent. A number of small ephemeral channels feeding to the stream channel at the northern end of the feature area were visible.

YEAR	OBSERVATIONS

1959 High elevation stereo pairs of poor quality.

A narrow road had been constructed traversing the subject hillside approximately at the upper portion of the feature area. The road, which was believed to be created by cut and fill, connected the new development located to the south of the feature area and the hillside area further north of the feature area. A patch of bare soil surface below the road possibly represented the extent of fill below the road. The hillside above the road still appeared to be unvegetated and was undergoing erosion. Rills could be visible on the feature area below the road.

On the spur to the south of the feature area, development associated with the construction of a series of cottages was observed. These cottages were believed to be built on small cut/fill platforms constructed parallel to the contours. To the east towards the lower laying land, extensive site formation works were visible. On the opposite flank of the valley, an area of agricultural terraces was visible.

1961 Stereo pairs of fair quality

No major changes were observed on the hillside around the feature area. The surface of the fill below the narrow road on the feature area appeared to be bare and with rill erosion.

1963 Low elevation high quality stereo pairs.

An access road had been constructed traversing the hillside above the feature area which subsequently connected to a construction site (covered reservoir) at the top of the hill. Cutting and filling were visible on the uphill side and downhill side of the road respectively. In association with the road construction, a fill slope (11NE-C/F86) was formed immediately above the feature area. The surface of this fill slope was bare and from its texture and tone appeared to be composed of soil with occasional boulders. Sheet and rill erosion could be observed on the fill slope surface and erosion debris was deposited on the feature area creating a number of debris lobes.

Boulders, generally angular in shape, were visible in the stream valley at the north-eastern end of the feature area. Further uphill above the newly constructed access road, an area of bare soil associated with a shallow surface depression was visible. Shallow failure may have occurred in this area during the construction of the access road.

Extensive excavation work was visible on the opposite flank of the valley and a small cut slope had been formed at the highest elevation of the excavation. This small cut slope was confirmed in later photographs to be the uppermost batter of feature 11NE-C/C61.

Reclamation work in association with the levelling of the valley area to the future Hong Ning Road was observed in the valley immediately below the feature area.

YEAR	OBSERVATIONS
1964	Low elevation high quality stereo pairs.

The valley in front of the feature area was filled up into a platform. The level of this newly formed platform was believed to be higher than the current level of Hong Ning Road (as compared with later photographs). The feature area was therefore believed to be covered by fill at the date of the photographs.

A fill slope (feature No. 11NE-C/F87) had been formed on the valley immediately at the north-eastern end of the feature area. A small curvilinear platform was created above the fill slope connecting to the road constructed by 1963.

Immediately above the feature area, the fill slope (11NE-C/F86) remained bare. Severe surface erosion could be observed on its surface with the rills extending from the spur line above the fill slopes.

Excavation work on Feature 11NE-C/C61 was still in-progress. To the east of feature 11NE-C/C61, the alignment of Hip Wo Street could be visible. To the west of the feature area, cut slope feature 11NE-C/CR63 was formed for the creation of the section of Hong Ning Road in front of it.

A new access road traversing the hillside had been constructed further uphill connecting to the covered reservoir at the top of the hill. This new road was also observed to be created partly by cutting and partly filling.

1972 Hong Ning Road had been created by lowering the platform immediately in front of the feature area with the road elevation ramping up from the junction with Hip Wo Street. Cut slopes were formed on both sides of Hong Ning Road including the subject feature (11NE-C/C62). The lower half of feature 11NE-C/F86 was cut and the subject features were formed immediately below it. The section of Hong Ning Road below the feature appeared to be a 4-lane carriageway.

The lower portion of the feature surface appeared to have a rough texture indicative of an area of rock outcrop. Dark toned staining could be observed at the north-eastern end of the feature area and was believed to be created by seepage.

A drainage channel was constructed along the crest of the subject feature which marked the crest boundary. Blockage of drainage channel was observed on the crest channel of the subject feature and evidence of erosion was visible on the surface of 11NE-C/F86 immediately above the blockage which suggested that the erosion debris from 11NE-C/F86 caused the blockage the crest channel.

Washout and erosion features were observed on feature 11NE-C/F87 and 11NE-C/FR36 located at the north-eastern and south-western side of the feature respectively.

Drainage channels connecting to the culvert at the uphill side of Hong Ning Road were constructed at the valley at the south-western end of the feature.

The hillside above feature 11NE-C/F86 still suffered from surface erosion.

YEAR	OBSERVATIONS
1972 (14.7.72)	Monograph with fair resolution.

A localised failure was observed at the south-western end of slope no. 11NE-C/C61 immediately adjacent to the subject feature. The absence of stereo pairs prohibited detailed observation of the scar but it could be estimated that about 15m of the pavement section immediately in front of slope 11NE-C/C61 were covered with debris.. Darker tones within the failed area suggested there may be seepage at the back scarp.

The smooth surface of the upper portion of the subject feature suggested that chunam surface had been applied on this portion of slope.

1972 (3.10.72) High elevation stereo pairs.

The debris in front of the failed portion of 11NE-C/C61 appeared to be cleared. Excavation work was visible at the north-eastern end of 11NE-C/C61.

Rock outcrop was visible from the center to the north-eastern end of the subject feature.

1973 High elevation stereo pairs.

No changes were observed on the subject feature. The north-eastern end of the feature appeared to have a rocky texture without surface protection.

The surface of feature 11NE-C/C61 appeared to be highly reflective with localised patches of duller tones. Trimming and localised surface protection might have been carried out after the failure.

Surface erosion on 11NE-C/F86 appeared to be less severe and denser vegetation could be observed.

1975 High elevation stereo pairs.

No changes on the subject feature were observed. Chunam surface could be visible on the upper batter of the feature except the north-eastern side where some vegetation growth could be observed.

On feature 11NE-C/F86 immediately above the subject feature, a trail and small platform were visible and were believed to be associated with some cultivation activities.

YEAR	OBSERVATIONS
1976	Monograph only. The feature surface could be observed. The north-eastern portion of the feature appeared to be rocky with rock joints apparently parallel to slope toe. Patches of vegetation could be observed on the north-eastern end of the slope surface. The south-western portion of the feature appeared to be smooth which possibly suggest it was covered by chunam surfacing.
1978	Monograph only. New surfacing could be visible on the upper portion of the feature. The surfacing was observed to be applied on the area above the rock outcrop to the hillside about 2m behind the crest channel. Berms were visible on the subject feature. The slope surface at the north-eastern end of the subject feature remained covered by vegetation. A lineament, possibly a drainage channel, was observed on the surface protection immediately above the vegetated surface at the north-eastern end of the feature. The south-western side of the adjacent feature 11NE-C/C61 was also protected with newly applied surfacing. A drainage channel and catchpit could be visible close to the boundary between the two features.
1979	No significant change since the 1978 photographs. The surfacing at the upper portion of the feature appeared to be highly reflective which contrast with the rock outcrops with dull and rough texture at the lower portion. The north-eastern end of the feature remained covered by vegetation. On the hillside to the north of the feature and above feature 11NE-C/C61, a small landslide was visible.
1980	Monograph only. No significant change since the 1978 photographs. It could be observed on the photograph that the crest channel was connected with the channel on the 2nd batter of the adjacent feature 11NE-C/C61.
1981	No significant changes observed as compared with the 1978 photographs. The hillside above feature 11NE-C/F86 remained bared around its spur.
1982	High elevation stereo pairs. Minor vegetation growth could be observed along the crest channel of the subject feature. The vegetation covering the north-eastern end of the feature appeared to be more mature.

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YEAR	OBSERVATIONS
1984	Good quality stereo pairs. The feature surface could be observed clearly. Staining could be observed on the surfacing. Isolated areas of vegetation growth could be visible on the rock outcrops, surface protection and along drainage channels suggesting inadequate maintenance work. The north-eastern end of the feature remained densely vegetated. An area of devegetation on the fill slope surface (11NE-C/F87) was observed and was believed to be a small surface washout. On the opposite side of Hong Ning Road, the Police Station had been constructed.
1985	High elevation stereo pairs More vegetation could be observed on the feature surface on the surface of rock outcrops and the surface protection.
1986	Good quality stereo pairs. No significant changes observed since earlier photographs. The extent of the vegetation at the north-eastern end of the feature appeared to be larger. A small shadow on the slope toe below the vegetation suggested there were trees within the vegetation.
1987	Monograph only. No observable changes observed on the feature. A small surface washout was observed on the hillside above the south-western side of the feature.
1988	Monograph only. No significant changes observed.
1989	Monograph only. The feature surface was generally obscured by the photo angle with only the crest channel being observed. Vegetation could be visible growing inside the channel. The north-eastern end of the feature was obscured by vegetation.
1990	No significant changes on the feature. The rock portion of the adjacent feature 11NE-C/C61 was clearly observed. Vegetation on the north-eastern end of the feature and the fill slopes above the feature were observed to be denser than at earlier dates. An area of agricultural terraces was observed on the fill slope above feature 11NE-C/C61.
1991	High elevation stereo pairs. No changes could be observed.
1992	Monograph only. No changes apart from the vegetation on the north-eastern end of the feature appeared to be more mature.

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YEAR	OBSERVATIONS
1993	First year of colour photographs. Shotcrete had been applied on the south-western portion of the feature. Old surfacing still remained on the upper portion of the north-eastern side of the feature. The rest of the feature surface remained unprotected rock surface with the north-eastern end of the feature covered by dense vegetation. The portion of adjacent feature 11NE-C/C63 closer to the subject feature was also shotcreted. The area of agricultural terraces above 11NE-C/C61 observed since 1990 had become enlarged.
1994	No change from 1993.
1995	Majority of the feature area was obscured by the photo angle. Trees could be observed on the north-eastern end of the feature adjacent to the drainage channel.
1996	Stereo pairs cover the north-eastern side only. Shotcrete had been applied on the north-eastern portion of the feature. An area of bare surface within the new shotcrete was visible. The area under the canopies of vegetation appeared to be reduced as compared with 1995 photographs. Vegetation clearance or trimming of the tree canopies might have been carried out during the shotcreting work. The adjacent feature 11NE-C/C63 had also been shotcreted. On the north-eastern side of feature 11NE-C/CR63, a pale toned surface forming a strip on the shotcreted face was visible which was thought to be related to the ground investigation work.
1997	High elevation stereo pairs. No significant change. Part of the feature was covered by the shadow of a building.
1998	Monograph only. Part of the feature was obscured by a building. No significant change observed apart from the tree adjacent to the drainage channel at the north-eastern end of the feature appeared to be more mature.

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YEAR	OBSERVATIONS
1999	Monograph only. The lower north-eastern portion of the feature was obscured by a building and shadow. New shotcrete had been applied on the rest of the feature surface. Fill slope feature 11NE-C/F87 was observed to have been trimmed back and surface drainage channel was constructed. A small circular platform was created above the north-eastern side of the feature in association with the trimming back of the fill slope. A linear structure which was believed to be a down pipe had been constructed at the north-eastern end of the feature diverting the surface water from this circular platform to Hong Ning Road. Trees could be observed adjacent to the down pipe. Stockpiling possible related to the slope works was visible along the toe of the subject feature suggesting that slope works were in-progress.
2000	Monograph only. Buttress was visible at the toe of the central portion of the subject feature. Trees could be observed on both sides of the down pipe at the north-eastern end of the feature. Two rows of soil nail heads were visible on feature 11NE-C/F86 located immediately above the subject feature. Drainage channel was also constructed as part of the slope upgrading works of this feature. Patches of bared soil surface and possible erosion or washout debris could be observed on feature 11NE-C/F87.
2001 (15.3.01)	Monograph only. No observed change on the subject feature. The surface of Feature 11NE-C/F87 was observed to be covered with white mat possibly for erosion protection.
2001 (20.11.01)	Vegetation cover had been applied on the shotcreted area at the south-western side of the feature. Mature trees could be observed on the north-eastern end of the feature around the down pipe.
2002	No change observed.
2003	Blurred image. No change observed.
2004	Blurred image. South-western portion of the feature was covered by shadow. Trees remained on the north-eastern end of the feature.
2005	Monograph only. Tree canopies around the down pipe appeared to be enlarged. An area of devegetation was observed on feature 11NE-C/C59 located above feature 11NE-C/F87.
2006	No observable change.

LIST OF TABLES

Table A1 - List of Aerial Photographs (Sheet 1 of 2)

Date taken	Altitude (ft)	Photograph Number
24 April1949	8000	Y01677 - Y01678
02 November 1954	28,300	Y2646 - Y2647
5 October 1959	40,000	Y4615 - Y4616
17 January 1961	30,000	Y04869 - Y04870
27 January 1963	2700	Y7929 - Y7932
1964	12,500	Y12931 - Y12932
1972	unknown	32 - 33
14 July 1972	3,400	1959
3 October 1972	13,000	2273 - 2274
20 December 1973	12,500	8008 - 8009
24 December 1975	12,500	11989 - 11990
4 October 1976	4,000	15338
7 December 1978	4,000	24180
28 November 1979	10,000	28077 - 28078
24 January 1980	4,000	39074
26 October 1981	10,000	39074 - 39075
10 October 1982	10,000	44530 - 44531
5 November 1984	4,000	56957 - 56958
1 October 1985	10,000	67181 - 67182
22 September 1986	4,000	A06378 - A06379
10 June 1987	4,000	A09100 - A09101
6 October 1988	4,000	A14692
28 March 1989	4,000	A16804
13 November 1990	4,000	A23673 - A23674
20 October 1991	10,000	A28851 - A28852

Table A1 - List of Aerial Photographs (Sheet 2 of 2)

Date taken	Altitude (ft)	Photograph Number
16 April 1992	4,000	A30418
8 October 1993	4,000	CN4602 - CN4603
20 March 1994	10,000	CN6161 - CN6162
24 November 1995	10,000	CN12587 - CN12588
18 November 1996	5,000	CN15614 - CN15615
31 October 1997	10,000	CN18609 - CN18610
4 August 1998	4,000	CN20834
11 December 1999	4,000	CN25219
26 July 2000	4,000	CN27479, CN27497
15 March 2001	4,000	CN30218
20 November 2001	8,000	CW35859, CW35782 - CW35783
9 October 2002	8,000	CW45181 - CW45182
25 September 2003	8,000	CW50035 - CW50036
10 February 2004	8,000	CW55327 - CW55328
24 October 2005	4,000	CW65459
9 November 2006	8,000	CW75057 - CW75058
Note: All aerial photographs are in black and white except for those prefixed with CN, CW or RW.		

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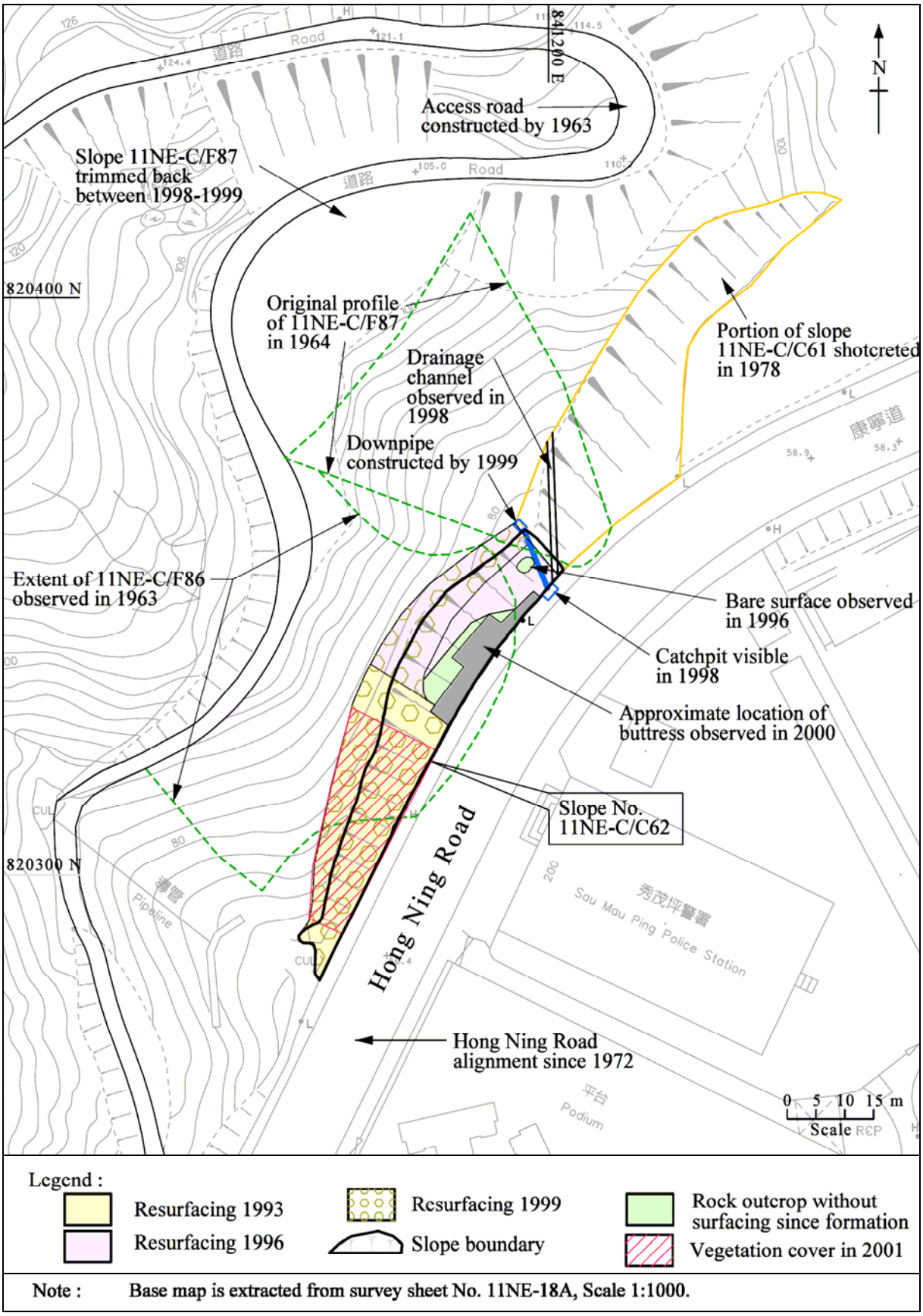

Figure A1 - Site Development History

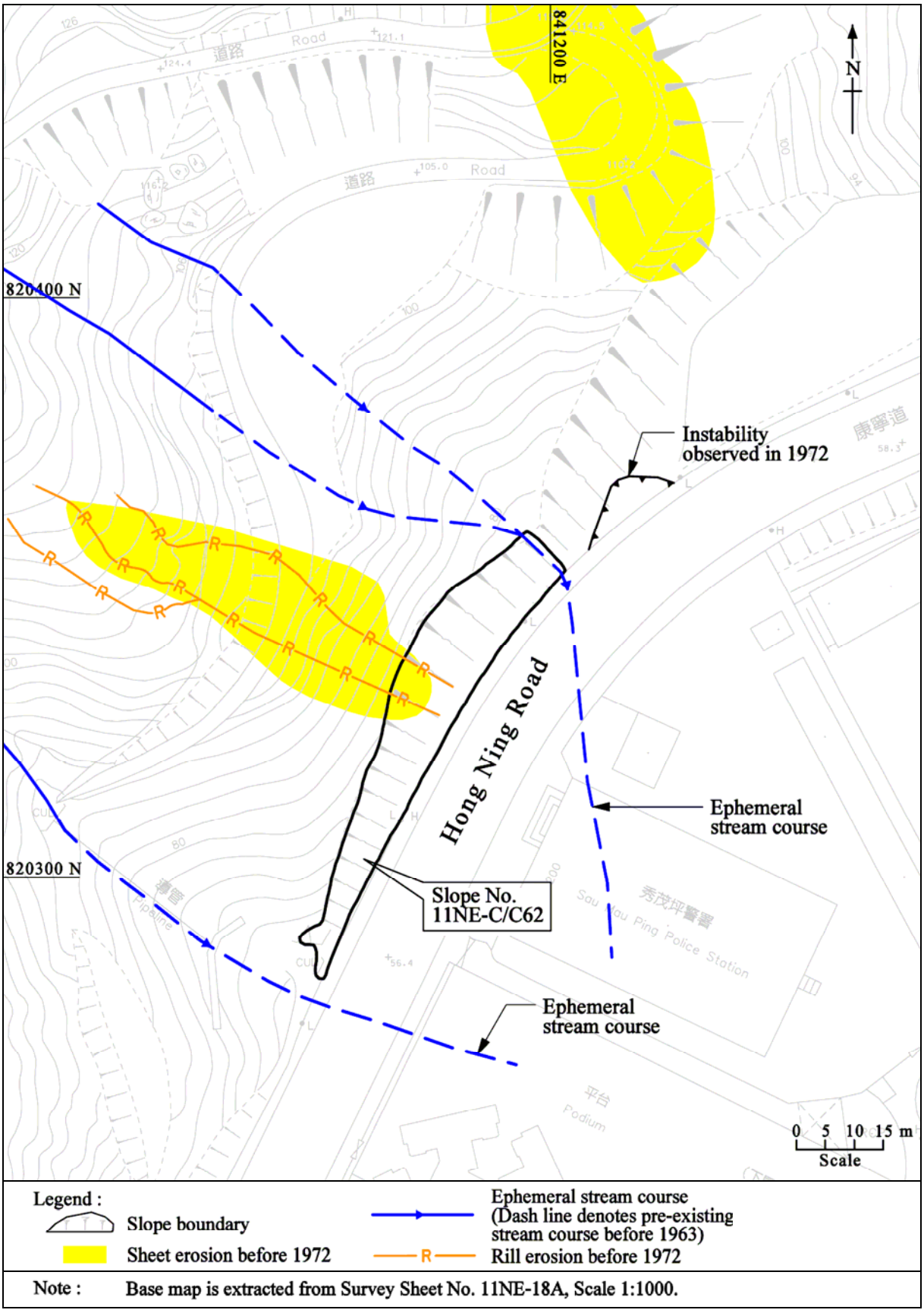

Figure A2 - API Findings

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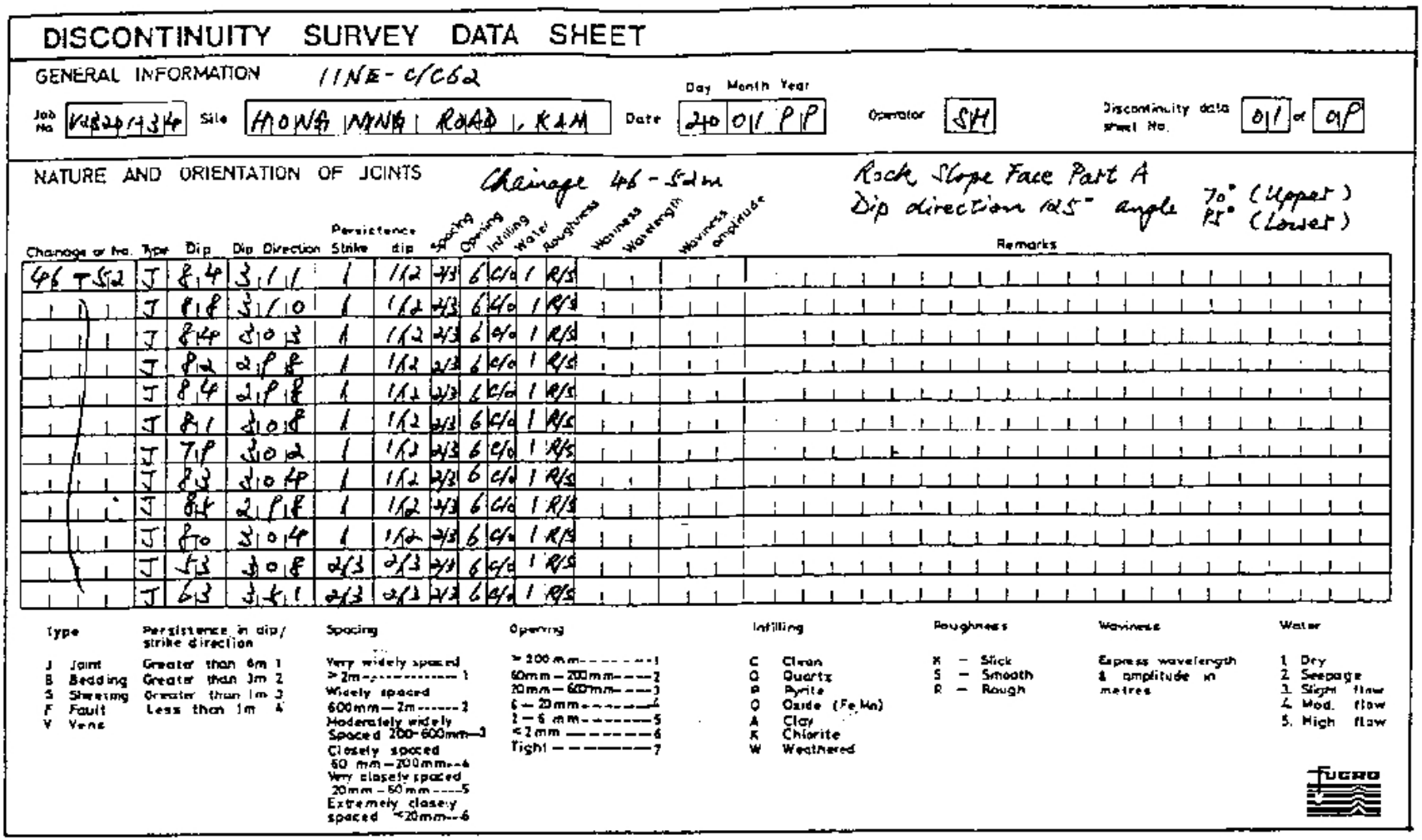
APPENDIX B

ROCK JOINT DATA AND AS-BUILT DRAWING RECORDED BY FUGRO (HONG KONG) LIMITED IN 1999 (AGREEMENT NO. CE 88/96)

LIST OF FIGURES



DISCONTINUITY SURVEY DATA SHEET

GENERAL INFORMATION 11NE-C/C62

Job No. V1820/4346 Site HONG NING ROAD, K4M Date (Day Month Year) 20 01 99 Operator SH Discontinuity data sheet No. 01 of 09

NATURE AND ORIENTATION OF JOINTS Chainage 46 - 52m

Rock Slope Face Part A
Dip direction 125° angle 70° (Upper) 85° (Lower)

Chainage or bh.	Type	Dip	Dip Direction	Persistence Strike	Persistence dip	Spacing	Opening	Infilling	Water	Roughness	Waviness	Wavelength	Waviness amplitude	Remarks
46 TO 52	J	84	311	1	1/2	2/3	6	C/O	1	R/S				
	J	81	310	1	1/2	2/3	6	C/O	1	R/S				
	J	84	313	1	1/2	2/3	6	C/O	1	R/S				
	J	82	218	1	1/2	2/3	6	C/O	1	R/S				
	J	84	218	1	1/2	2/3	6	C/O	1	R/S				
	J	81	310	1	1/2	2/3	6	C/O	1	R/S				
	J	71	302	1	1/2	2/3	6	C/O	1	R/S				
	J	83	310	1	1/2	2/3	6	C/O	1	R/S				
	J	84	218	1	1/2	2/3	6	C/O	1	R/S				
	J	80	314	1	1/2	2/3	6	C/O	1	R/S				
	J	43	308	2/3	2/3	2/3	6	C/O	1	R/S				
	J	63	311	2/3	2/3	2/3	6	C/O	1	R/S				

Type: J Joint; B Bedding; S Shearing; F Fault; V Vein

Persistence in dip/strike direction: Greater than 6m 1; Greater than 3m 2; Greater than 1m 3; Less than 1m 4

Spacing: Very widely spaced >2m 1; Widely spaced 600mm–2m 2; Moderately widely Spaced 200–600mm 3; Closely spaced 60 mm–200mm 4; Very closely spaced 20mm–60mm 5; Extremely closely spaced <20mm 6

Opening: >200 mm 1; 60mm–200mm 2; 20mm–60mm 3; 6–20mm 4; 2–6 mm 5; <2 mm 6; Tight 7

Infilling: C Clean; Q Quartz; P Pyrite; O Oxide (Fe,Mn); A Clay; K Chlorite; W Weathered

Roughness: R – Rough; S – Smooth; K – Slick

Waviness: Express wavelength & amplitude in metres

Water: 1. Dry; 2. Seepage; 3. Slight flow; 4. Mod. flow; 5. High flow

FUGRO

Note: Table Extracted from “Stage 3 Study Report - Feature No. 11NE-C/C62 Hong Ning Road” prepared by FHK in July 1999.

Figure B1 - Discontinuity Survey Data Collected by FHK in 1999 (Sheet 1 of 9)

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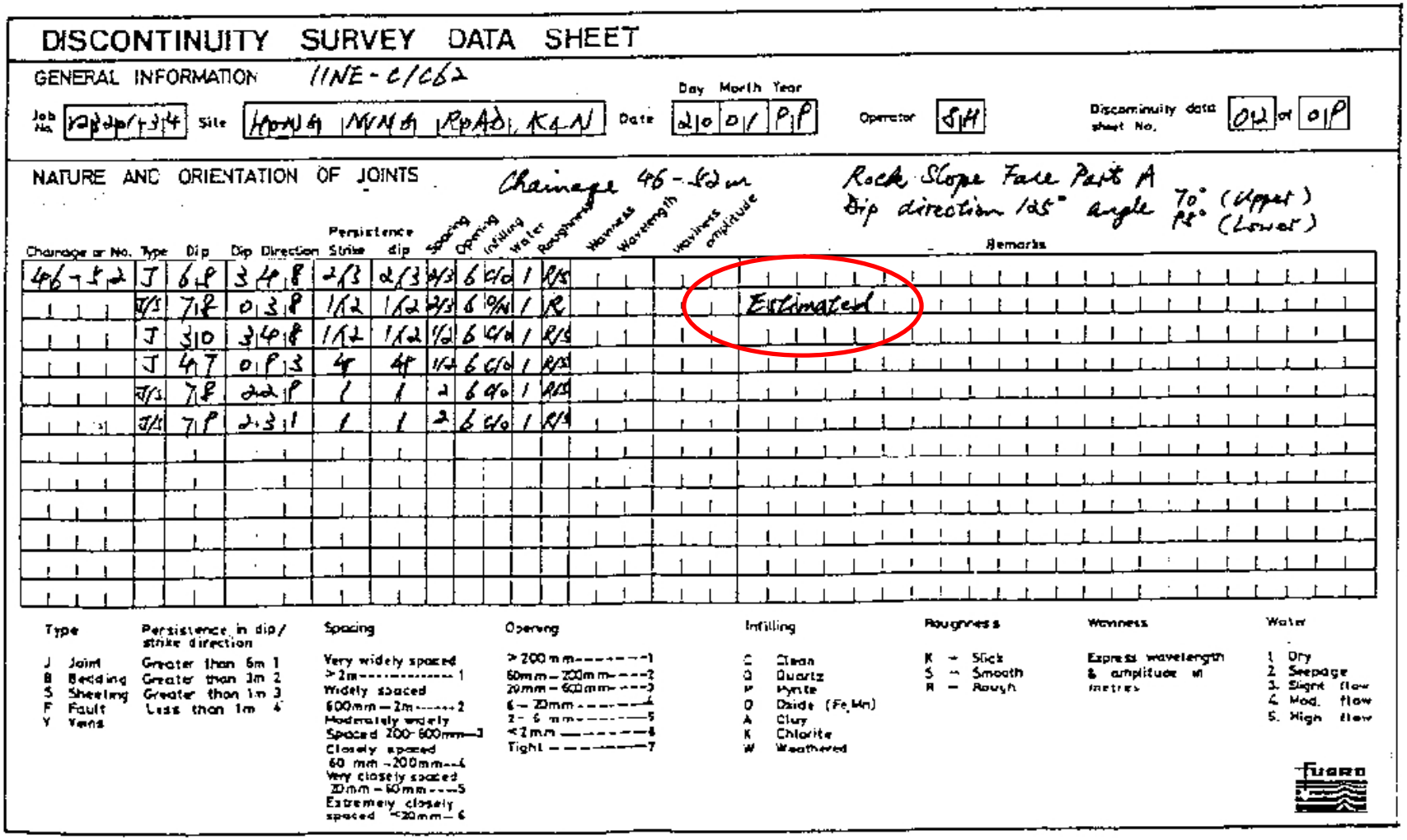


DISCONTINUITY SURVEY DATA SHEET

GENERAL INFORMATION 11NE-C/C62

Job No. 12824p/13/4 Site HONG NING ROAD, KAN Date Day 21 Month 01 Year 98 Operator SH Discontinuity data sheet No. 02 of 02

NATURE AND ORIENTATION OF JOINTS Chainage 46 - 62 m Rock Slope Face Part A Dip direction 125° angle 70° (Upper) 85° (Lower)

Chainage or No.	Type	Dip	Dip Direction	Persistence Strike	Persistence dip	Spacing	Opening	Infilling	Water	Roughness	Waviness wavelength	Waviness amplitude	Remarks
46 - 62	J	68	348	2/3	2/3	3/3	6	C/O	1	R/S			
	J/S	78	038	1/2	1/2	2/3	6	O/W	1	R			Estimated
	J	310	348	1/2	1/2	1/2	6	C/O	1	R/S			
	J	47	018	4	4	1/2	6	C/O	1	R/S			
	J/S	78	228	1	1	2	6	C/O	1	R/S			
	J/S	78	238	1	1	2	6	C/O	1	R/S			

Type: J Joint, B Bedding, S Shearing, F Fault, Y Veins

Persistence in dip/strike direction: Greater than 6m 1; Greater than 3m 2; Greater than 1m 3; Less than 1m 4

Spacing: Very widely spaced >2m 1; Widely spaced 600mm–2m 2; Moderately widely spaced 200–600mm 3; Closely spaced 60mm–200mm 4; Very closely spaced 20mm–60mm 5; Extremely closely spaced <20mm 6

Opening: >200mm 1; 60mm–200mm 2; 20mm–60mm 3; 6–20mm 4; 2–6mm 5; <2mm 6; Tight 7

Infilling: C Clean, Q Quartz, P Pyrite, O Oxide (Fe,Mn), A Clay, K Chlorite, W Weathered

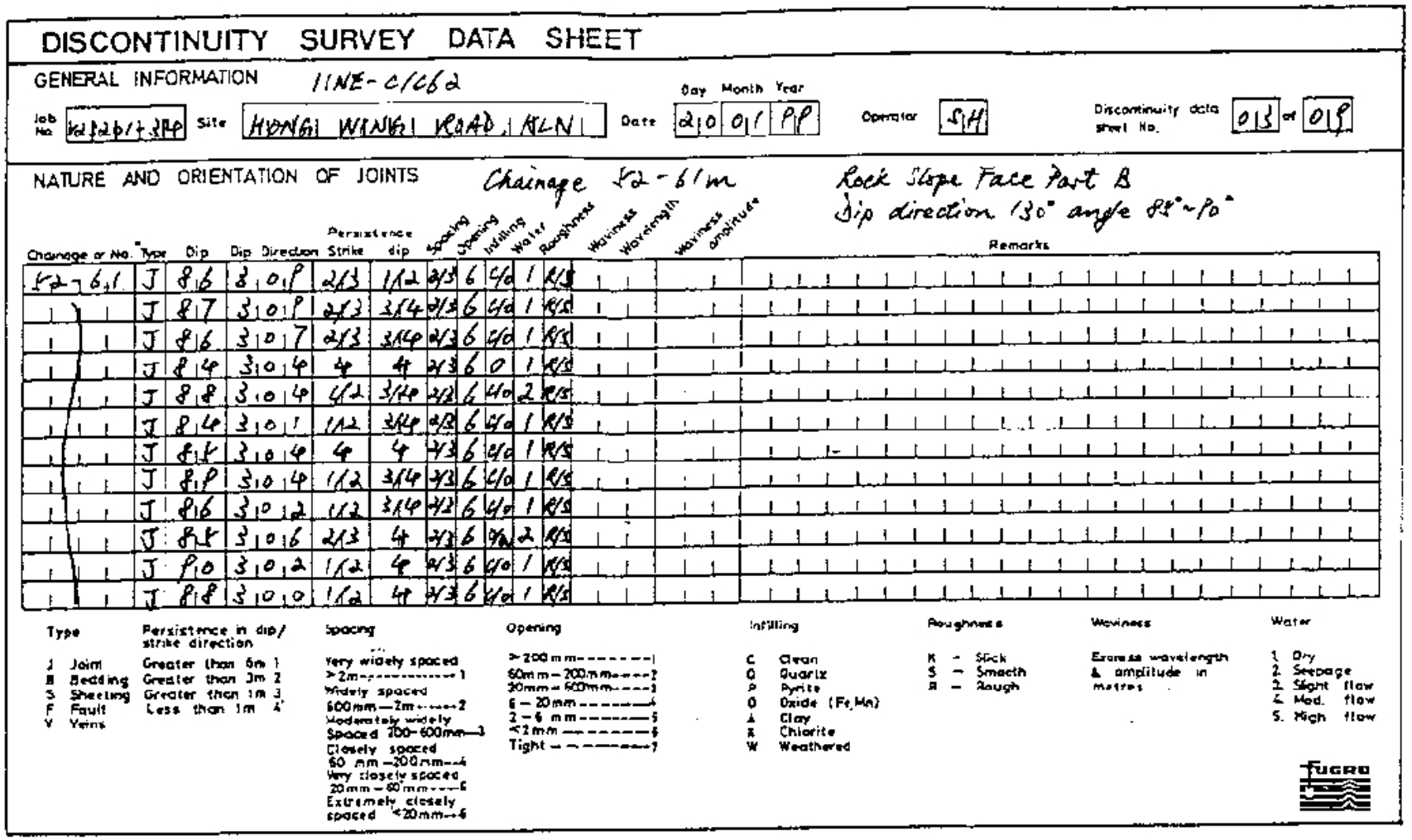
Roughness: K – Slick, S – Smooth, R – Rough

Waviness: Express wavelength & amplitude in metres

Water: 1 Dry, 2 Seepage, 3 Slight flow, 4 Mod. flow, 5 High flow

Note: Table Extracted from “Stage 3 Study Report - Feature No. 11NE-C/C62 Hong Ning Road” prepared by FHK in July 1999.

Figure B2 - Discontinuity Survey Data Collected by FHK in 1999 (Sheet 2 of 9)



DISCONTINUITY SURVEY DATA SHEET

GENERAL INFORMATION 11NE-C/C62

Job No. 92526/1.3PP Site HONG NING ROAD, KLN Date Day 21 Month 01 Year PP Operator SH Discontinuity data sheet No. 013 of 019

NATURE AND ORIENTATION OF JOINTS Chainage 52 - 61m Rock Slope Face Part B Dip direction 130° angle 85°-90°

Chainage or No.	Type	Dip	Dip Direction	Persistence Strike	Persistence dip	Spacing	Opening	Infilling	Water	Roughness	Waviness	Wavelength	Waviness amplitude	Remarks
52-61	J	86	301P	2/3	1/2	2/3	6	C/O	1	R/S				
	J	87	310P	2/3	3/4	2/3	6	C/O	1	R/S				
	J	86	310P	2/3	3/4	2/3	6	C/O	1	R/S				
	J	84	310P	4	4	2/3	6	O	1	R/S				
	J	88	310P	1/2	3/4	2/3	6	Ho	2	R/S				
	J	84	310	1/2	3/4	2/3	6	C/O	1	R/S				
	J	84	310P	4	4	2/3	6	C/O	1	R/S				
	J	81	310P	1/2	3/4	2/3	6	C/O	1	R/S				
	J	86	312	1/2	3/4	2/3	6	C/O	1	R/S				
	J	85	316	2/3	4	2/3	6	C/O	2	R/S				
	J	810	312	1/2	4	2/3	6	C/O	1	R/S				
	J	818	310	1/2	4	2/3	6	C/O	1	R/S				

Type: J Joint; B Bedding; S Sheeting; F Fault; V Veins

Persistence in dip/strike direction: Greater than 6m 1; Greater than 3m 2; Greater than 1m 3; Less than 1m 4

Spacing: Very widely spaced >2m 1; Widely spaced 600mm—2m 2; Moderately widely Spaced 200-600mm 3; Closely spaced 60 mm—200mm 4; Very closely spaced 20mm—60mm 5; Extremely closely spaced <20mm 6

Opening: >200mm 1; 60mm—200mm 2; 20mm—60mm 3; 6—20mm 4; 2—6 mm 5; <2mm 6; Tight 7

Infilling: C Clean; Q Quartz; P Pyrite; O Oxide (Fe, Mn); A Clay; K Chlorite; W Weathered

Roughness: R — Rick; S — Smooth; R — Rough

Waviness: Express wavelength & amplitude in metres

Water: 1. Dry; 2. Seepage; 3. Slight flow; 4. Med. flow; 5. High flow

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Note: Table Extracted from “Stage 3 Study Report - Feature No. 11NE-C/C62 Hong Ning Road” prepared by FHK in July 1999.

Figure B3 - Discontinuity Survey Data Collected by FHK in 1999 (Sheet 3 of 9)

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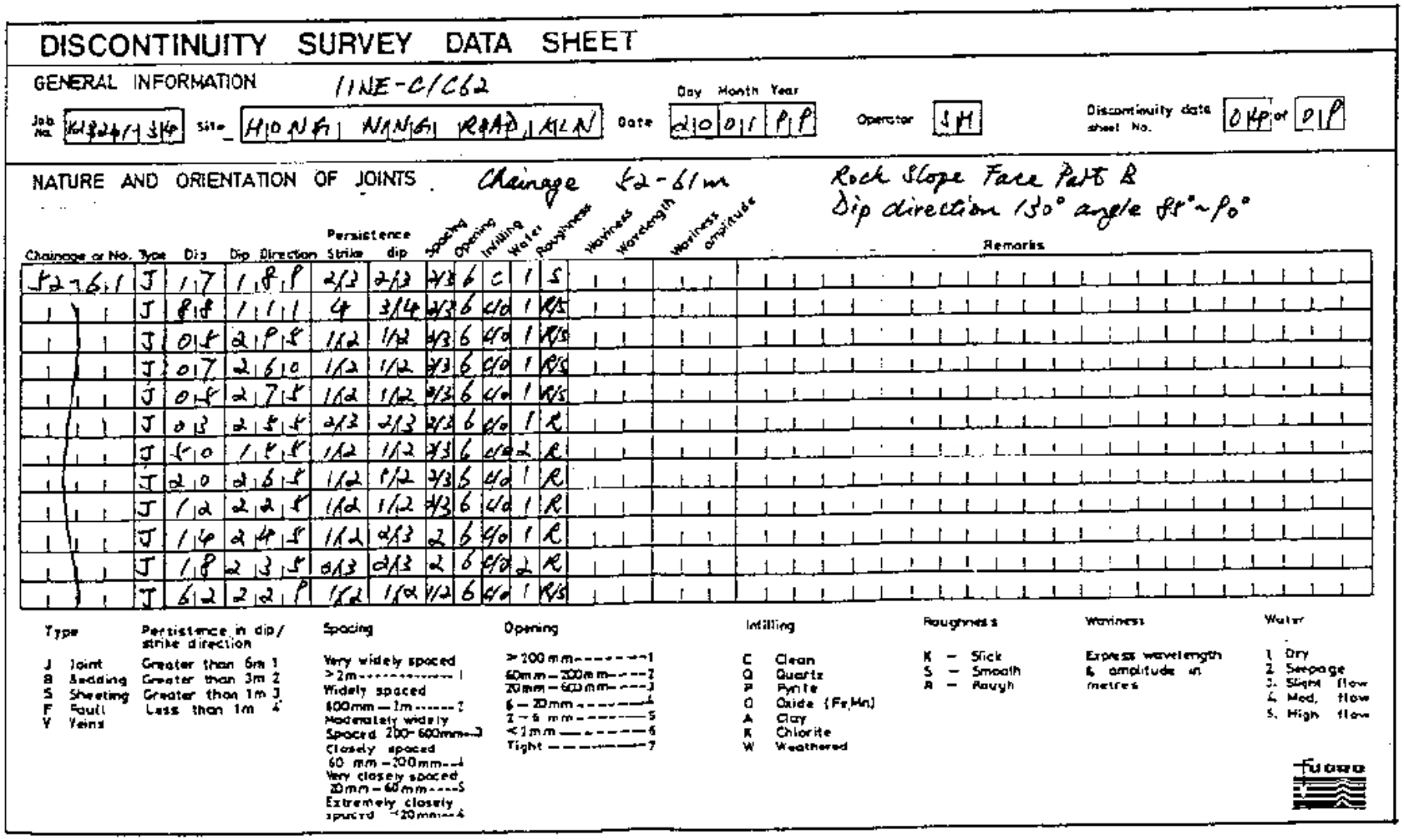


DISCONTINUITY SURVEY DATA SHEET

GENERAL INFORMATION 11NE-C/C62

Job No. K13824/13KP Site HONG NING ROAD, KLN Date Day 10 Month 01 Year 99 Operator SH Discontinuity data sheet No. 04P of 01P

NATURE AND ORIENTATION OF JOINTS. Chainage 52-61m Rock Slope Face Part R Dip direction 130° angle 88°~90°

Chainage or No.	Type	Dia	Dip Direction	Persistence Strike	Persistence dip	Spacing	Opening	Infilling	Water	Roughness	Waviness	Wavelength	Waviness amplitude	Remarks
52-61	J	17	188	2/3	2/3	4/3	6	C	1	S				
	J	818	111	4	3/4	4/3	6	C/O	1	R/S				
	J	014	218	1/2	1/2	4/3	6	C/O	1	R/S				
	J	017	260	1/2	1/2	4/3	6	C/O	1	R/S				
	J	014	278	1/2	1/2	4/3	6	C/O	1	R/S				
	J	013	258	2/3	2/3	4/3	6	C/O	1	R				
	J	410	168	1/2	1/2	4/3	6	C/O	2	R				
	J	210	268	1/2	1/2	4/3	6	C/O	1	R				
	J	112	228	1/2	1/2	4/3	6	C/O	1	R				
	J	114	248	1/2	2/3	2	6	C/O	1	R				
	J	118	238	2/3	2/3	2	6	C/O	2	R				
	J	612	222	1/2	1/2	1/2	6	C/O	1	R/S				

Type: J Joint; B Bedding; S Sheeting; F Fault; V Veins

Persistence in dip/strike direction: Greater than 6m 1; Greater than 3m 2; Greater than 1m 3; Less than 1m 4

Spacing: Very widely spaced >2m 1; Widely spaced 600mm—1m 2; Moderately widely Spaced 200-600mm 3; Closely spaced 60 mm—200mm 4; Very closely spaced 20mm—60mm 5; Extremely closely spaced <20mm 6

Opening: >100mm 1; 60mm—200mm 2; 20mm—60mm 3; 6—20mm 4; 2—6 mm 5; <2mm 6; Tight 7

Infilling: C Clean; Q Quartz; P Pyrite; O Oxide (Fe,Mn); A Clay; K Chlorite; W Weathered

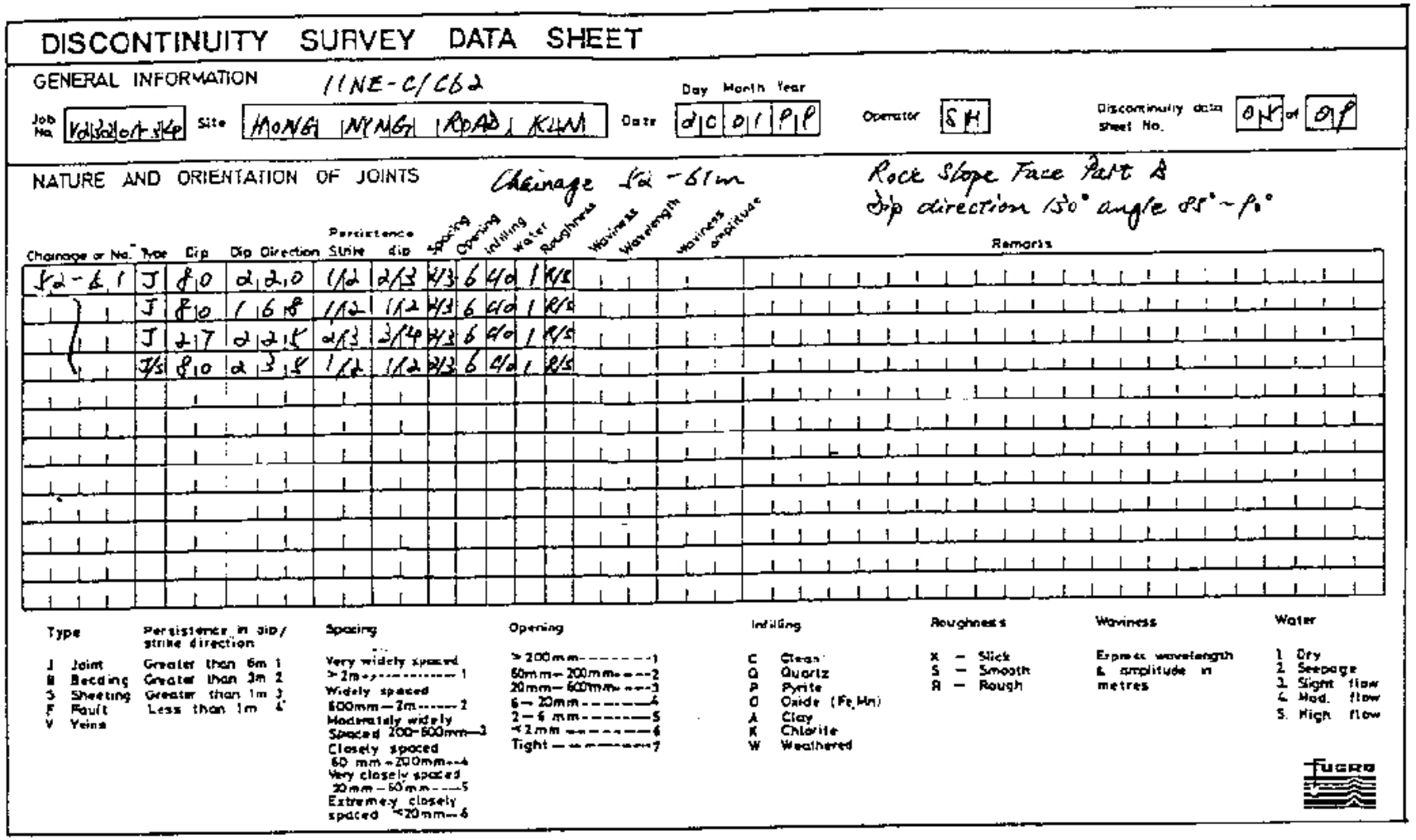
Roughness: K — Slick; S — Smooth; R — Rough

Waviness: Express wavelength & amplitude in metres

Water: 1 Dry; 2 Seepage; 3 Slight flow; 4 Med. flow; 5 High flow

Note: Table Extracted from “Stage 3 Study Report - Feature No. 11NE-C/C62 Hong Ning Road” prepared by FHK in July 1999.

Figure B4 - Discontinuity Survey Data Collected by FHK in 1999 (Sheet 4 of 9)



DISCONTINUITY SURVEY DATA SHEET

GENERAL INFORMATION 11NE-C/C62

Job No. Kowloon-Shek | Site HONG NING ROAD, KWN | Date Day 01 Month 01 Year 99 | Operator SH | Discontinuity data sheet No. 01 of 01

NATURE AND ORIENTATION OF JOINTS Chainage 52 - 61m

Rock Slope Face Part A

Dip direction 130° angle 85° - 90°

Chainage or No.	Type	Dip	Dip Direction	Persistence Strike	Persistence dip	Spacing	Opening	Infilling	Water	Roughness	Waviness Wavelength	Waviness amplitude	Remarks
52 - 61	J	80	210	1/2	2/3	4/3	6	4/0	1	R/S			
	J	80	168	1/2	1/2	4/3	6	4/0	1	R/S			
	J	27	215	2/3	3/4	4/3	6	4/0	1	R/S			
	J/S	80	230	1/2	1/2	4/3	6	4/0	1	R/S			

Type
J Joint
B Bedding
S Sheeting
F Fault
V Veins

Persistence in dip/strike direction
Greater than 6m 1
Greater than 3m 2
Greater than 1m 3
Less than 1m 4

Spacing
Very widely spaced >2m---1
Widely spaced 600mm—2m---2
Moderately widely Spaced 200-600mm---3
Closely spaced 60 mm-200mm---4
Very closely spaced 20mm-60mm---5
Extremely closely spaced <20mm---6

Opening
>200mm---1
60mm-200mm---2
20mm-60mm---3
6-20mm---4
2-6 mm---5
<2mm---6
Tight---7

Infilling
C Clean
Q Quartz
P Pyrite
O Oxide (Fe,Mn)
A Clay
K Chlorite
W Weathered

Roughness
X - Slick
S - Smooth
R - Rough

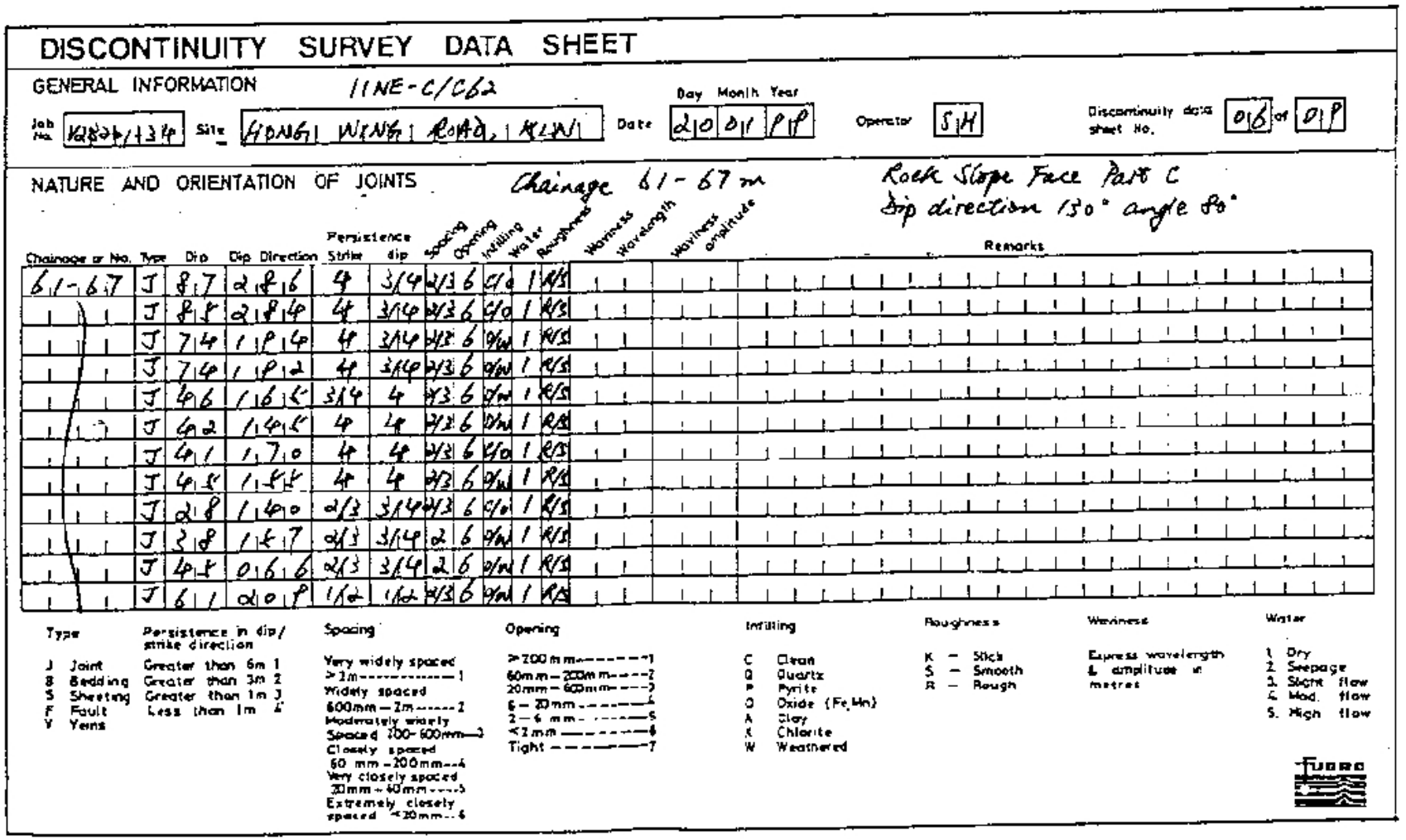
Waviness
Express wavelength & amplitude in metres

Water
1 Dry
2 Seepage
3 Slight flow
4 Mod. flow
5 High flow

GEO

Note: Table Extracted from “Stage 3 Study Report - Feature No. 11NE-C/C62 Hong Ning Road” prepared by FHK in July 1999.

Figure B5 - Discontinuity Survey Data Collected by FHK in 1999 (Sheet 5 of 9)



DISCONTINUITY SURVEY DATA SHEET

GENERAL INFORMATION 11NE-C/C62

Job No. K834/134 Site HONG NING ROAD, KLN Date Day 20 Month 01 Year 99 Operator SH Discontinuity data sheet No. 016 of 019

NATURE AND ORIENTATION OF JOINTS Chainage 61 - 67 m

Rock Slope Face Part C
Dip direction 130° angle 80°

Chainage or No.	Type	Dip	Dip Direction	Persistence Strike	Persistence dip	Spacing	Opening	Infilling	Water	Roughness	Waviness Wavelength	Waviness amplitude	Remarks
61-67	J	87	216	4	3/4	2/3	6	C	1	R/S			
	J	85	214	4	3/4	2/3	6	C	1	R/S			
	J	74	190	4	3/4	2/3	6	C	1	R/S			
	J	74	192	4	3/4	2/3	6	C	1	R/S			
	J	46	165	3/4	4	2/3	6	C	1	R/S			
	J	62	145	4	4	2/3	6	C	1	R/S			
	J	41	170	4	4	2/3	6	C	1	R/S			
	J	45	145	4	4	2/3	6	C	1	R/S			
	J	28	140	2/3	3/4	2/3	6	C	1	R/S			
	J	38	165	2/3	3/4	2	6	C	1	R/S			
	J	45	016	2/3	3/4	2	6	C	1	R/S			
	J	61	210	1/2	1/2	2/3	6	C	1	R/S			

Type
J Joint
B Bedding
S Sheeting
F Fault
V Veins

Persistence in dip/strike direction
Greater than 6m 1
Greater than 3m 2
Greater than 1m 3
Less than 1m 4

Spacing
Very widely spaced >2m 1
Widely spaced 600mm – 2m 2
Moderately widely spaced 200 – 600mm 3
Closely spaced 60 mm – 200mm 4
Very closely spaced 20mm – 60mm 5
Extremely closely spaced <20mm 6

Opening
>200 mm 1
60mm – 200mm 2
20mm – 60mm 3
6 – 20mm 4
2 – 6 mm 5
<2 mm 6
Tight 7

Infilling
C Clean
Q Quartz
P Pyrite
O Oxide (Fe, Mn)
A Clay
X Chlorite
W Weathered

Roughness
K – Stick
S – Smooth
R – Rough

Waviness
Express wavelength & amplitude in metres

Water
1. Dry
2. Seepage
3. Slight flow
4. Mod. flow
5. High flow

Note: Table Extracted from “Stage 3 Study Report - Feature No. 11NE-C/C62 Hong Ning Road” prepared by FHK in July 1999.

Figure B6 - Discontinuity Survey Data Collected by FHK in 1999 (Sheet 6 of 9)

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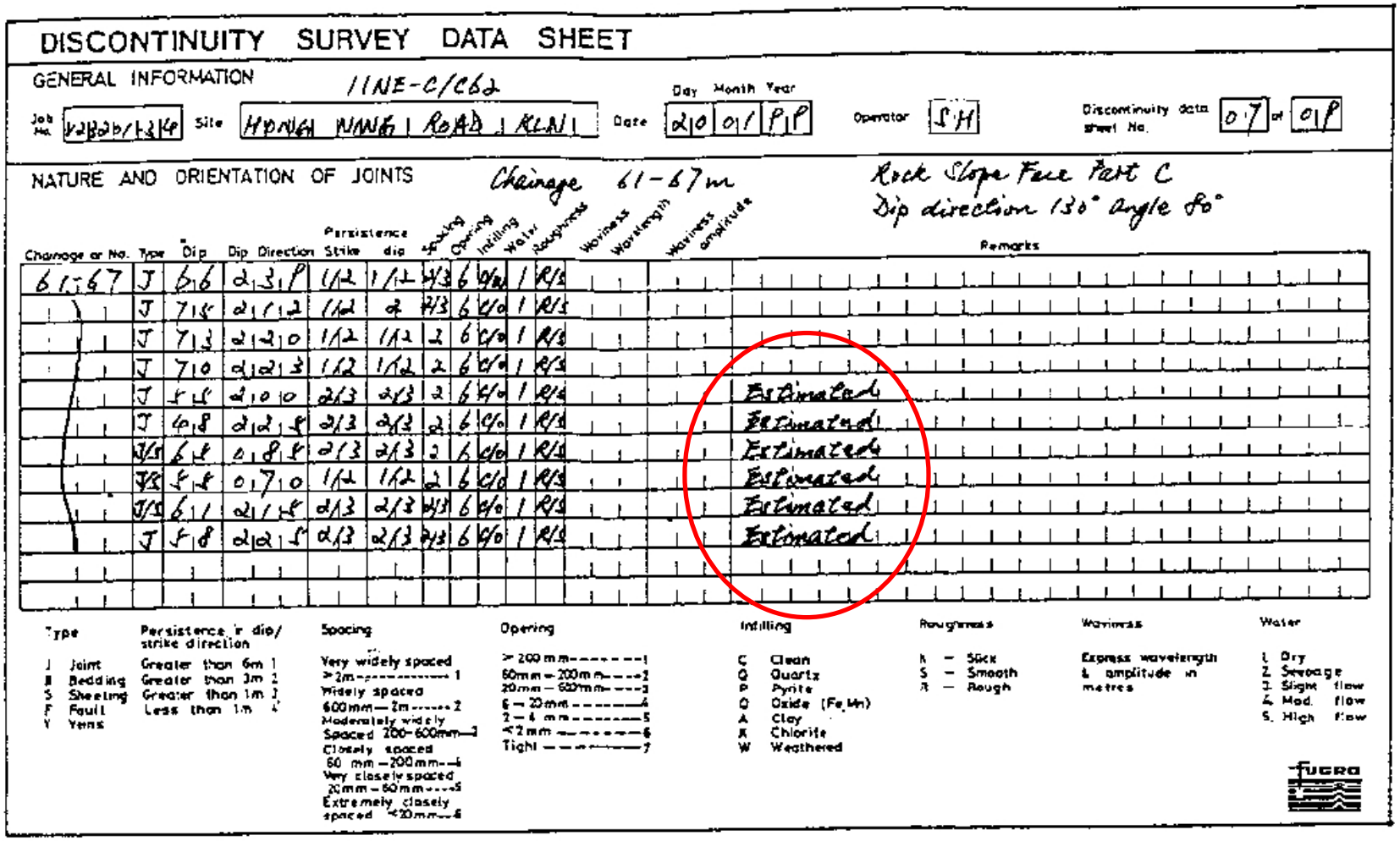

DISCONTINUITY SURVEY DATA SHEET

GENERAL INFORMATION 11NE-C/C62

Job No. V2B26/L3/K0 Site HONG NING ROAD, KLN Date Day 21 Month 01 Year 99 Operator SH Discontinuity data sheet No. 07 of 09

NATURE AND ORIENTATION OF JOINTS Chainage 61-67m

Rock Slope Face Part C
Dip direction 130° Angle 80°

Chainage or No.	Type	Dip	Dip Direction	Persistence Strike	Persistence dip	Spacing	Opening	Infilling	Water	Roughness	Waviness	Waviness Wavelength	Waviness amplitude	Remarks
61-67	J	86	231	1/2	1/2	3/3	6	C/O	1	R/S				
	J	75	212	1/2	2	3/3	6	C/O	1	R/S				
	J	73	210	1/2	1/2	2	6	C/O	1	R/S				
	J	70	213	1/2	1/2	2	6	C/O	1	R/S				
	J	45	010	2/3	2/3	2	6	C/O	1	R/S				Estimated
	J	68	212	2/3	2/3	2	6	C/O	1	R/S				Estimated
	J/S	64	018	2/3	2/3	2	6	C/O	1	R/S				Estimated
	J/S	48	017	1/2	1/2	2	6	C/O	1	R/S				Estimated
	J/S	61	211	2/3	2/3	3/3	6	C/O	1	R/S				Estimated
	J	48	212	2/3	2/3	3/3	6	C/O	1	R/S				Estimated

Type: J Joint, B Bedding, S Sheeting, F Fault, V Veins

Persistence in dip/strike direction: Greater than 6m 1, Greater than 3m 2, Greater than 1m 3, Less than 1m 4

Spacing: Very widely spaced >2m 1; Widely spaced 600mm–2m 2; Moderately widely spaced 200–600mm 3; Closely spaced 60mm–200mm 4; Very closely spaced 20mm–60mm 5; Extremely closely spaced <20mm 6

Opening: >200mm 1; 60mm–200mm 2; 20mm–60mm 3; 6–20mm 4; 2–6mm 5; <2mm 6; Tight 7

Infilling: C Clean, Q Quartz, P Pyrite, O Oxide (Fe,Mn), A Clay, K Chlorite, W Weathered

Roughness: R – Rock, S – Smooth, R – Rough

Waviness: Express wavelength & amplitude in metres

Water: 1 Dry, 2 Seepage, 3 Slight flow, 4 Mod. flow, 5 High flow

FUGRO

Note: Table Extracted from “Stage 3 Study Report - Feature No. 11NE-C/C62 Hong Ning Road” prepared by FHK in July 1999.

Figure B7 - Discontinuity Survey Data Collected by FHK in 1999 (Sheet 7 of 9)

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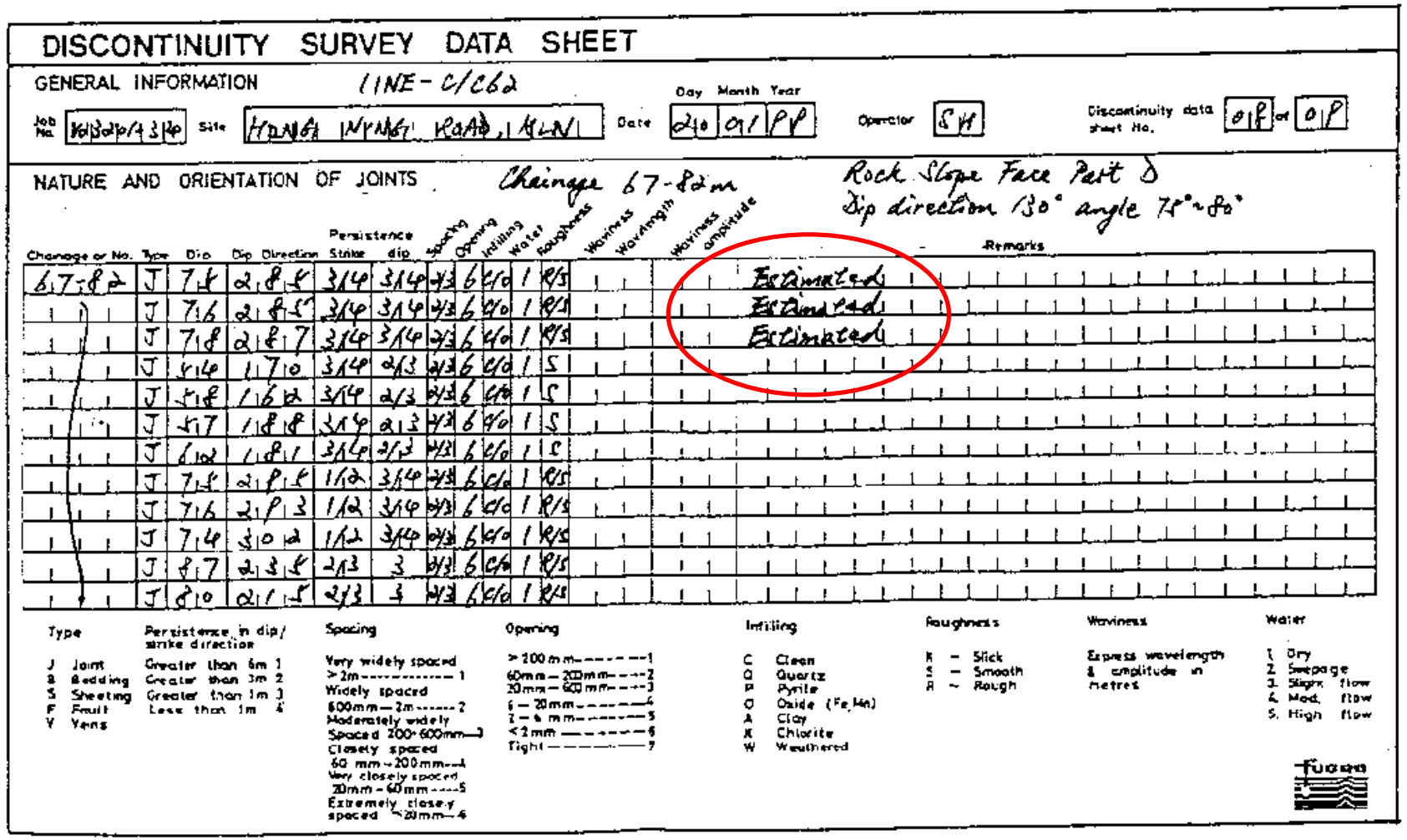

DISCONTINUITY SURVEY DATA SHEET

GENERAL INFORMATION LINE - C/C62

Job No. K13012P/43/00 Site HONG NING ROAD, KLN Date Day 24 Month 01 Year 99 Operator SW Discontinuity data sheet No. 01F of 01P

NATURE AND ORIENTATION OF JOINTS Chainage 67-82m

Rock Slope Face Part D
Dip direction 130° angle 72°~80°

Chainage or No.	Type	Dip	Dip Direction	Persistence Strike	Persistence dip	Spacing	Opening	Infilling	Water	Roughness	Waviness Wavelength	Waviness amplitude	Remarks
67-82	J	74	218 E	3/4P	3/4P	3/3	6	C/O	1	R/S			Estimated
	J	76	218 E	3/4P	3/4P	3/3	6	C/O	1	R/S			Estimated
	J	78	218 E	3/4P	3/4P	3/3	6	C/O	1	R/S			Estimated
	J	514	170	3/4P	2/3	3/3	6	C/O	1	S			
	J	518	162	3/4P	2/3	3/3	6	C/O	1	S			
	J	517	188	3/4P	2/3	3/3	6	C/O	1	S			
	J	102	181	3/4P	2/3	3/3	6	C/O	1	S			
	J	74	218 E	1/2	3/4P	3/3	6	C/O	1	R/S			
	J	76	213	1/2	3/4P	3/3	6	C/O	1	R/S			
	J	74	310	1/2	3/4P	3/3	6	C/O	1	R/S			
	J	87	234 E	2/3	3	3/3	6	C/O	1	R/S			
	J	810	211 E	2/3	3	3/3	6	C/O	1	R/S			

Type: J Joint; B Bedding; S Sheeting; F Fault; V Veins

Persistence in dip/strike direction: Greater than 6m 1; Greater than 3m 2; Greater than 1m 3; Less than 1m 4

Spacing: Very widely spaced >2m 1; Widely spaced 600mm–2m 2; Moderately widely Spaced 200-600mm 3; Closely spaced 60 mm–200mm 4; Very closely spaced 20mm–60mm 5; Extremely closely spaced <20mm 6

Opening: >100mm 1; 60mm–200mm 2; 20mm–60mm 3; 6–20mm 4; 1–6 mm 5; <2mm 6; Tight 7

Infilling: C Clean; Q Quartz; P Pyrite; O Oxide (Fe,Mn); A Clay; K Chlorite; W Weathered

Roughness: R – Slick; S – Smooth; R – Rough

Waviness: Express wavelength & amplitude in metres

Water: 1 Dry; 2 Seepage; 3 Slight flow; 4 Med. flow; 5 High flow

Note: Table Extracted from “Stage 3 Study Report - Feature No. 11NE-C/C62 Hong Ning Road” prepared by FHK in July 1999.

Figure B8 - Discontinuity Survey Data Collected by FHK in 1999 (Sheet 8 of 9)

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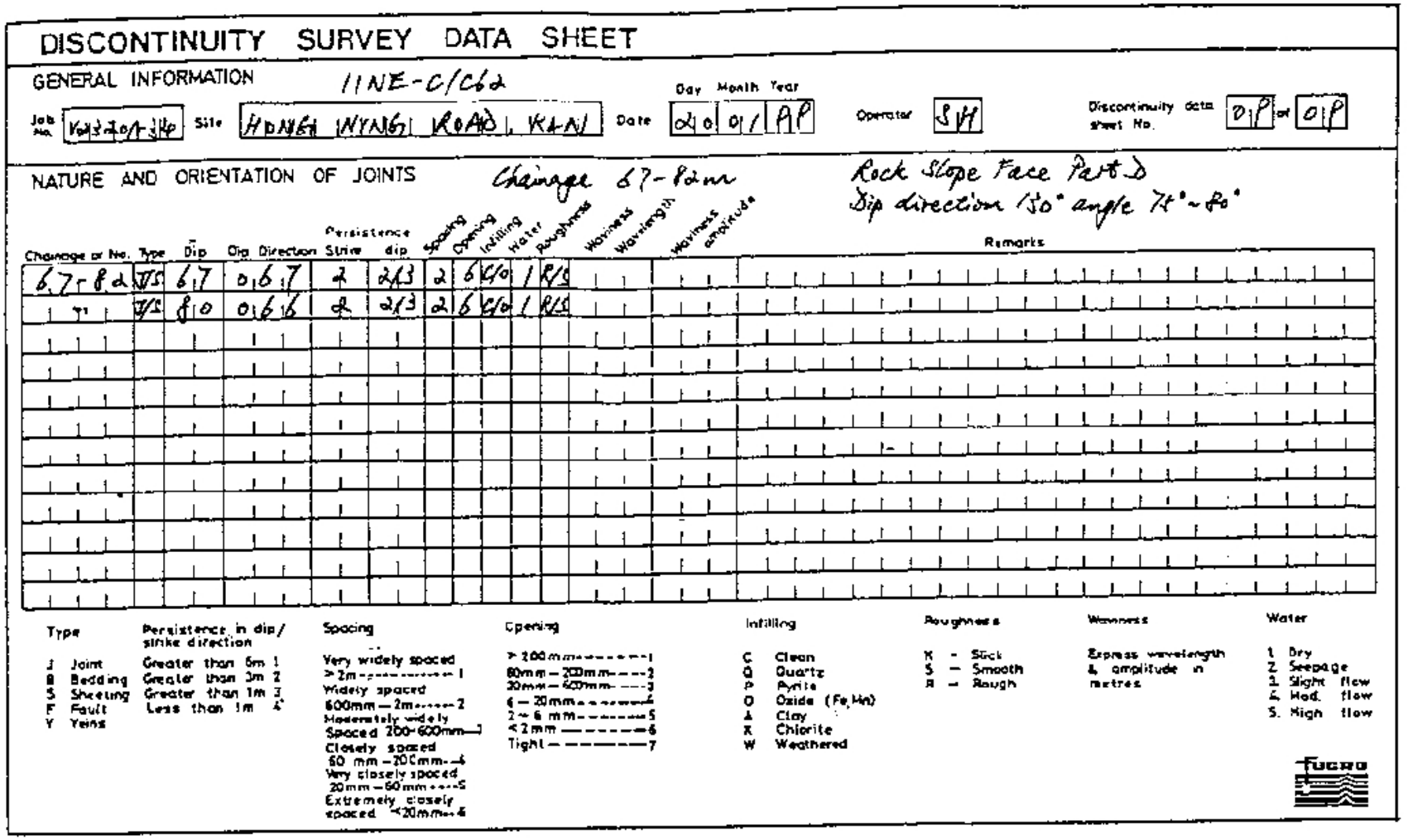


DISCONTINUITY SURVEY DATA SHEET

GENERAL INFORMATION 11NE-C/C62

Job No. Vol3 Pg1-3Hp Site HONG NYNG ROAD, KLN Date Day 20 Month 01 Year AP Operator SM Discontinuity data sheet No. 01P of 01P

NATURE AND ORIENTATION OF JOINTS Chainage 67-82m

Rock Slope Face Part D
Dip direction 130° angle 71°~80°

Chainage or No.	Type	Dip	Dip Direction	Persistence Strike	Persistence dip	Spacing	Opening	Infilling	Water	Roughness	Waviness	Wavelength	Waviness amplitude	Remarks
67-82	JS	67	016	4	2/3	2	6	C/O	1	R/S				
"	JS	80	016	4	2/3	2	6	C/O	1	R/S				

Type: J Joint; B Bedding; S Sheeting; F Fault; Y Veins

Persistence in dip/strike direction: Greater than 6m 1; Greater than 3m 2; Greater than 1m 3; Less than 1m 4

Spacing: Very widely spaced >2m—1; Widely spaced 600mm—2m—2; Moderately widely Spaced 200-600mm—3; Closely spaced 60 mm—200mm—4; Very closely spaced 20mm—60mm—5; Extremely closely spaced <20mm—6

Opening: >200mm—1; 60mm—200mm—2; 20mm—60mm—3; 6—20mm—4; 2~6 mm—5; <2mm—6; Tight—7

Infilling: C Clean; Q Quartz; P Pyrite; O Oxide (Fe,Mn); A Clay; X Chlorite; W Weathered

Roughness: R - Rough; S - Smooth; R - Rough

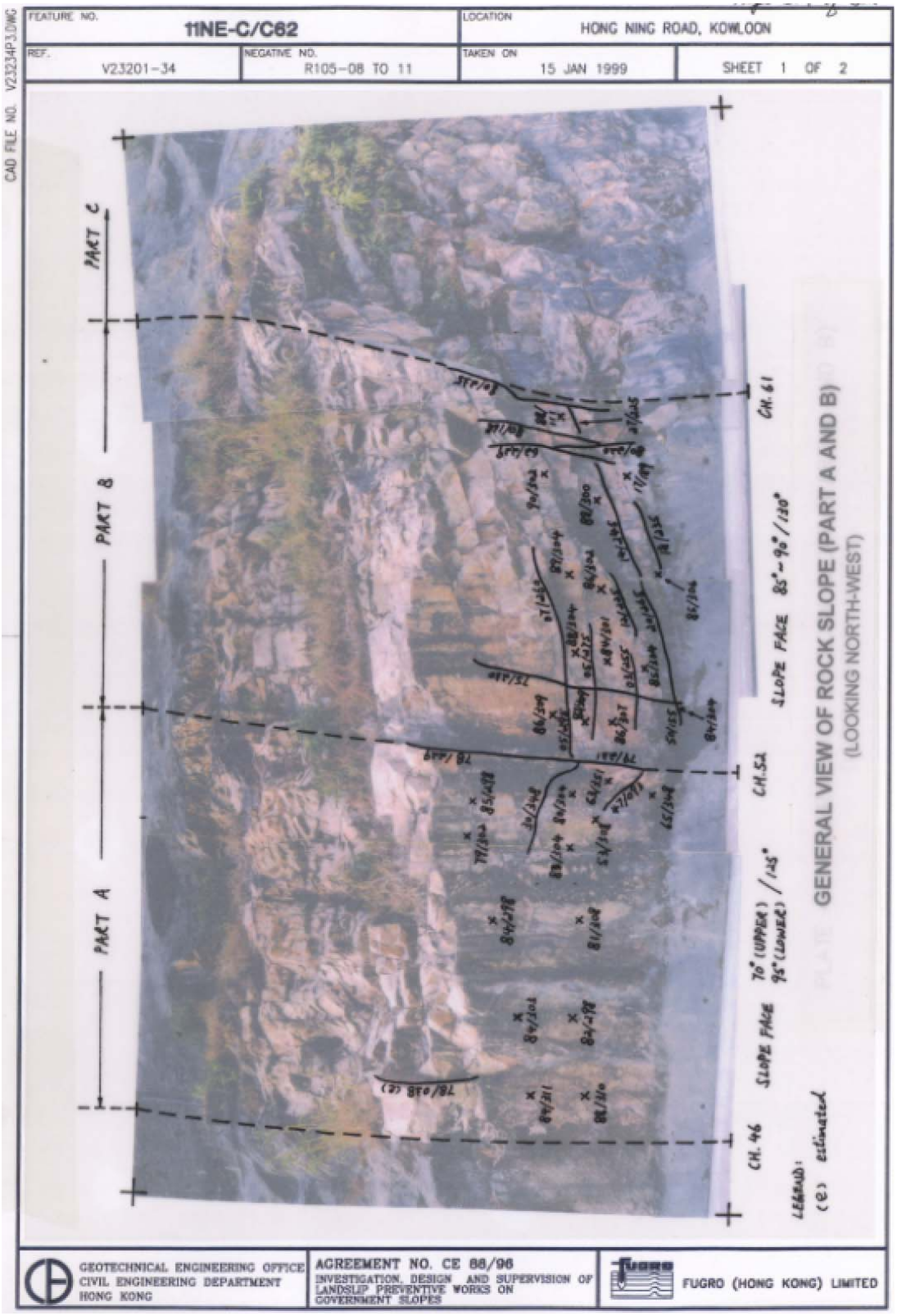
Waviness: Express wavelength & amplitude in metres

Water: 1 Dry; 2 Seepage; 3 Slight flow; 4 Mod. flow; 5 High flow

FUGRO

Note: Table Extracted from “Stage 3 Study Report - Feature No. 11NE-C/C62 Hong Ning Road” prepared by FHK in July 1999.

Figure B9 - Discontinuity Survey Data Collected by FHK in 1999 (Sheet 9 of 9)



Note: Table Extracted from "Stage 3 Study Report - Feature No. 11NE-C/C62 Hong Ning Road" prepared by FHK in July 1999.

Figure B10 - Overlays of Rock Discontinuity Measurements by FHK in 1999 (Sheet 1 of 2)

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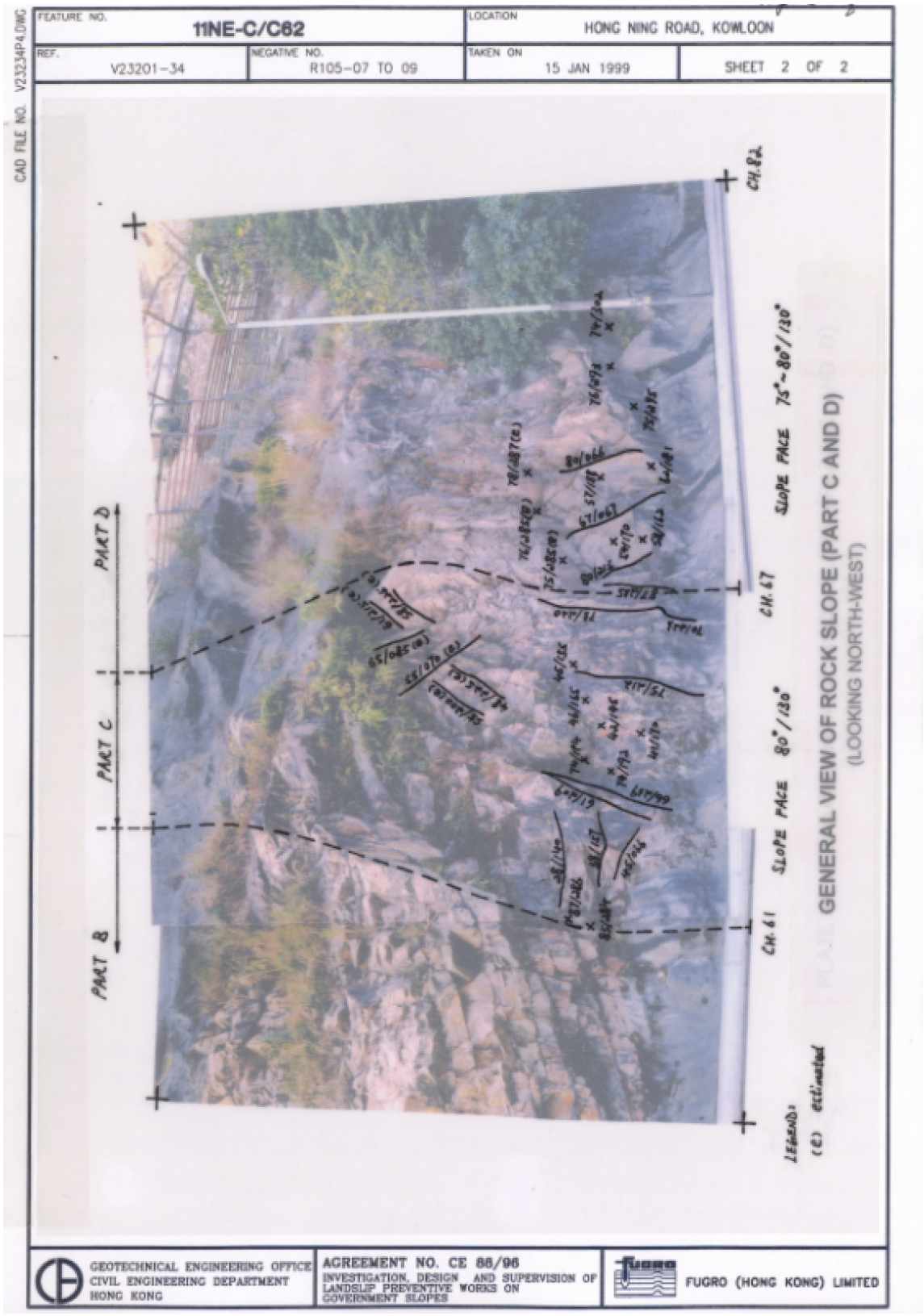

Note: Table Extracted from "Stage 3 Study Report - Feature No. 11NE-C/C62 Hong Ning Road" prepared by FHK in July 1999.

Figure B11 - Overlays of Rock Discontinuity Measurements by FHK in 1999 (Sheet 2 of 2)

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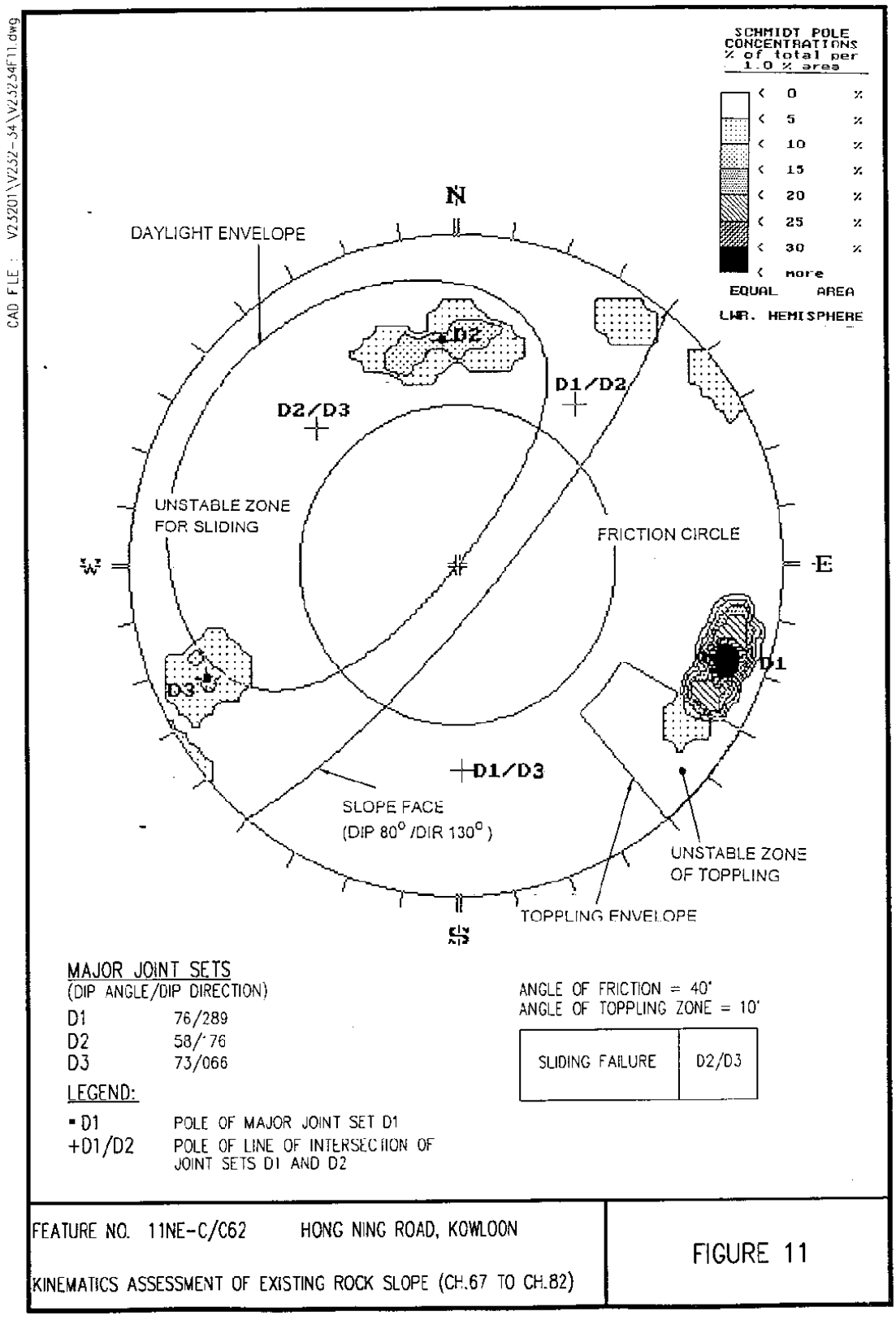

Note: Extracted from "Stage 3 Study Report - Feature No. 11NE-C/C62 Hong Ning Road" prepared by FHK in July 1999.

Figure B12 - Kinematic Assessment by FHK in 1999

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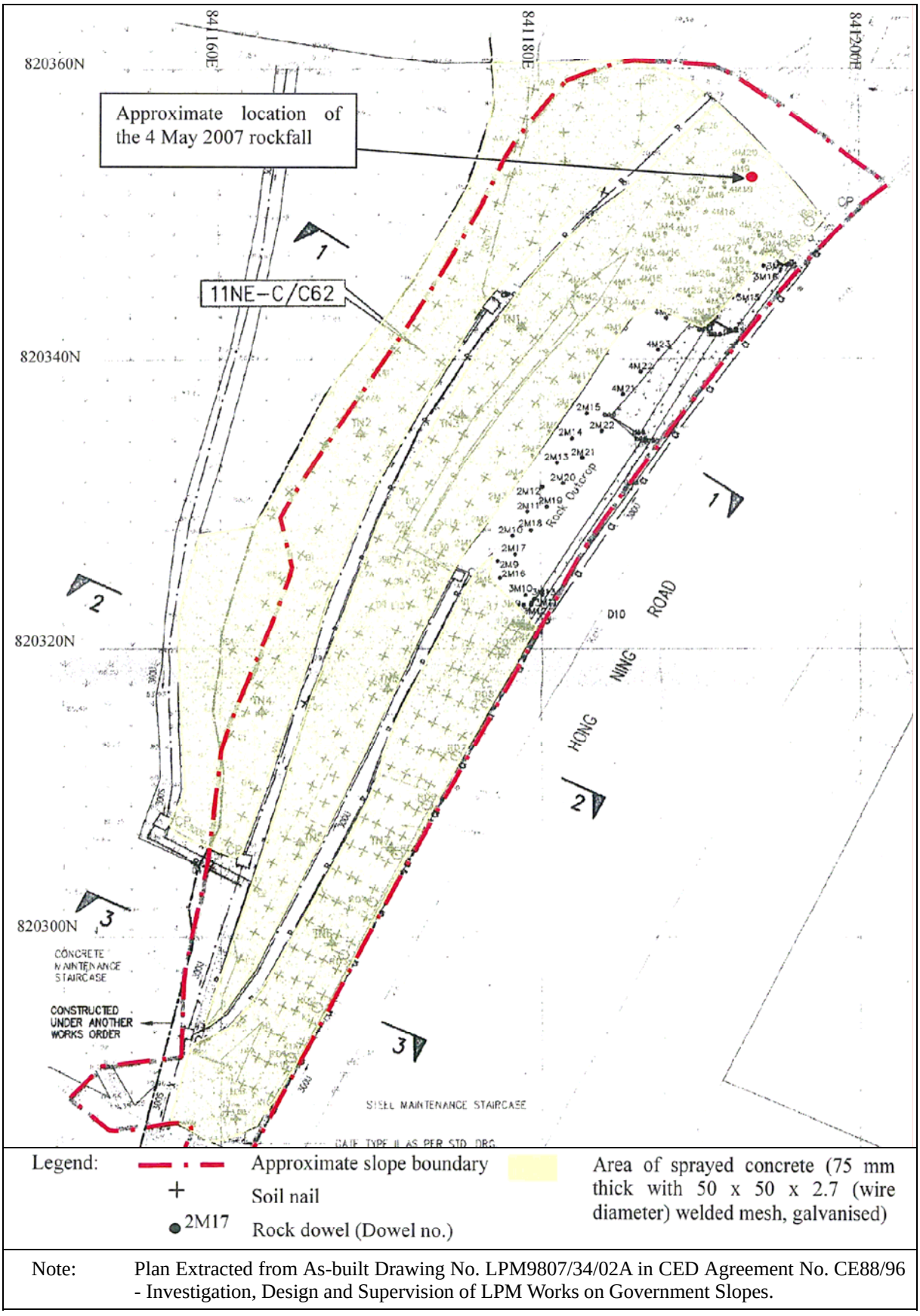

Note: Plan Extracted from As-built Drawing No. LPM9807/34/02A in CED Agreement No. CE88/96 - Investigation, Design and Supervision of LPM Works on Government Slopes.

Figure B13 - Layout of Constructed Slope Works Design by FHK in 1999

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土力工程處刊物及訂購資料

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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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土力工程處之主要刊物

GEOTECHNICAL MANUALS

Geotechnical Manual for Slopes, 2nd Edition (1984), 300 p. (English Version), (Reprinted, 2000).

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. 1/2000	Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls (2000), 146 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.

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