

**REVIEW OF THE  
11 AUGUST 2005 LANDSLIDE  
BELOW BLOCK J OF PRINCESS  
MARGARET HOSPITAL,  
KWAI CHUNG**

**GEO REPORT No. 213**

**Maunsell Geotechnical Services Limited**

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

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Prepared by:

Geotechnical Engineering Office,  
Civil Engineering and Development Department,  
Civil Engineering and Development Building,  
101 Princess Margaret Road,  
Homantin, Kowloon,  
Hong Kong.

## 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.



R.K.S. Chan

Head, Geotechnical Engineering Office

October 2007

## FOREWORD

This report presents the findings of a review of the landslide (Incident No. 2005/08/0279) that occurred on the hillside below Block J of Princess Margaret Hospital, Kwai Chung at 5:00 a.m. on 11 August 2005. The incident was probably triggered by the leakage of water from a 150 mm diameter buried fresh water pipe behind the hillside. As a result of the landslide, Lai King Hill Road was closed completely until 12:40 a.m. on 12 August 2005.

The key objectives of the review were to document the facts about the landslide incident, including the site development history, the installation and maintenance records of the water-carrying services and the pertinent observations of the landslide made under this review. Except for the excavation of shallow inspection pits for the purpose of locating and inspecting the suspected leaky water pipe, the scope of the review does not include any detailed ground investigation. The review does not contain detailed diagnosis of the causes of the incident. Recommendations for follow-up actions are reported separately.

The report was prepared as part of the 2005 Landslide Investigation Consultancy for landslides occurring in Kowloon and the New Territories in 2005, for the Geotechnical Engineering Office, Civil Engineering and Development Department, under Agreement No. CE 15/2004 (GE). This is one of a series of reports produced during the consultancy by Maunsell Geotechnical Services Limited.



Dr. L.J. Endicott  
Project Director  
Maunsell Geotechnical Services Limited

Agreement No. CE 15/2004 (GE)  
Study of Landslides Occurring in Kowloon  
and the New Territories in 2005 -  
Feasibility Study

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## 1. INTRODUCTION

At about 5:00 a.m. on 11 August 2005, a landslide (Incident No. 2005/08/0279) occurred on the terrain above slope No. 11NW-A/C49 at Lai King Hill Road, Kwai Chung (Figure 1 and Plate 1), below Block J of Princess Margaret Hospital (PMH). No Rainstorm Warning or Landslip Warning was in effect at the time of the incident. The estimated volume of the landslide was about 15 m<sup>3</sup>. As a result of the landslide, a section of Lai King Hill Road was closed completely until 12:40 a.m. on 12 August 2005 (Plate 2).

Following the incident, Maunsell Geotechnical Services Limited (MGSL), the 2005 Landslide Investigation Consultant (LIC) for Kowloon and the New Territories, carried out a review of the landslide for the Geotechnical Engineering Office (GEO), Civil Engineering and Development Department (CEDD) under Agreement No. CE 15/2004 (GE).

The report documents the facts about the incident, the site development history, installation and maintenance records of the water-carrying services and pertinent observations made by MGSL after the incident. Except for the excavation of shallow inspection pits for the purposes of locating and inspecting the suspected leaky water pipe, the scope of the review does not include any detailed ground investigation. The review does not contain a detailed diagnosis of the causes of the incident. Recommendations for follow-up actions are reported separately.

## 2. THE SITE

### 2.1 Site Description

The landslide occurred on a vegetated northeast-facing hillside inclined at approximately 35°. The hillside is situated on a north-south trending rounded spur overlooking Lai King Hill Road, with a relatively small catchment area. Above the landslide is PMH, which comprises a cluster of buildings with Block J being located immediately above the landslide site. A layout plan and cross section of the site are presented in Figures 2 and 3.

The hillside where the August 2005 landslide occurred is located just below a small concrete platform, which is underneath an elevated deck of the podium at Block J of PMH (Plate 3). Three exposed ductile iron pipes (two of 150 mm in diameter and one of 200 mm in diameter), which are supported by concrete haunches, run along the concrete platform. Another ductile iron pipe (150 mm in diameter) is suspended from the elevated podium deck. There are also two surface U-channels (one is a 300 mm UC with cast iron grating and the other is a 225 mm open channel) alongside the edge of the concrete platform.

Immediate to the north of Block J of PMH is a pump house, from which water pipes protrude, which lead to the concrete platform (Figure 5).

Slope No. 11NW-A/C49, which is approximately 135 m long with a maximum height of about 46 m, is located on the uphill side of Lai King Hill Road (Figures 2 and 3). The upper part of the slope comprises a soil cut with soil nails installed (see Section 4 below), and a rock cut forms the lower part of the slope. The rock cut, which is partly bare and partly

covered with shotcrete, has a maximum height of about 26 m and an inclination of between 65° and 70°. The elevation of the landslide site is approximately 55 m above the road level of Lai King Hill Road.

A 1.2 m diameter abandoned pipe is present at about 13 m below the landslide scarp, just above the crest of the northern portion of slope No. 11NW-A/C49 (Figures 2 and 3 and Plate 4). Further downhill, a retaining wall, which is approximately 45 m long and up to 2.5 m high, is located immediately above the rock cut portion of the slope (Figures 2 and 3). Lai Chi Kok Bay Garden is located on the downhill side of Lai King Hill Road, opposite to the landslide site.

Slopes Nos. 11NW-A/C150 and 11NW-A/C403 adjoin slope No. 11NW-A/C49 at its northern and southern ends respectively (Figure 1). At the time of the landslide, slope No. 11NW-A/C150 was being upgraded under the Landslip Preventive Measures (LPM) Programme.

An ephemeral drainage line traverses in an eastward direction across the hillside between slopes Nos. 11NW-A/C49 and 11NW-A/C150. Another south-eastward ephemeral drainage line is located to the south of the August 2005 landslide site (Figure A1 in Appendix A).

## 2.2 Maintenance Responsibility and Land Status

Based on the information from the Lands Department, the hillside where the 11 August 2005 landslide occurred is on Government land.

According to the letter from the Architectural Services Department (Arch SD) dated 13 September 2005, the maintenance of PMH "has been fully devolved to the Hospital Authority w.e.f. 1 April' 05".

## 2.3 Regional Geology

According to the Hong Kong Geological Survey 1:20,000 Solid and Superficial Geology Map Sheet 11 - Hong Kong & Kowloon (GCO, 1986), the solid geology at slope No. 11NW-A/C49 and the hillside above comprises fine-grained granite.

## 2.4 Water-carrying Services

Based on the information provided by the Water Supplies Department (WSD) and the Drainage Services Department (DSD), no public water-carrying services under their control are present at, or in the vicinity of, the crest platform above, and the hillside below, the August 2005 landslide.

According to the site plan of Block J of PMH attached to PMH's letter dated 1 September 2005 (Figure 8), there are three existing 150 mm diameter cold water supply pipes in the area of the platform above the 2005 landslide site. PMH clarified in their letter

of 1 September 2005 that, apart from the above site plan of Block J, "The hospital do not have the utility layout plan for water carrying services laying on surface or buried underground with [*sic*] the area of interest" and that "There is no record showing pre-existing or abandoned services within the area".

Based on the information provided by Arch SD in April 2006, Arch SD's drawing No. 3/112MHRI/02/A/076a dated 23 February 1995 shows the same utility information as that in the site plan provided by PMH (Figure 8), and drawing No. A/128073 dated March 1987 (Figure 9) shows that three earthenware pipes (EWP) (two 225 mm and one 600 mm in diameter), together with one 200 mm diameter fire services asbestos cement (A.C.) pipe, are present in the podium area of Block J of PMH<sup>1</sup>. The drawings indicate that the 200 mm diameter fire services pipe buried but do not indicate whether the three water pipes are exposed or buried.

As revealed from the inspection pits formed by the ground investigation (GI) contractor for Agreement No. CE 15/2004 (GE), Inter Pacific Limited, following the August 2005 landslide (Section 6.2), there are three utility pipes buried at about 800 mm below ground at the concrete platform behind the landslide scarp. The pipes include one severely corroded 150 mm diameter steel pipe, which is suspected to be leaking, one 200 mm diameter galvanised mild steel pipe, which is probably the fire services pipe, and one 100 mm diameter uPVC pipe (Plate 8).

### 3. SITE HISTORY AND PAST INSTABILITY

#### 3.1 Site History

Based on aerial photograph interpretation, the southern and northern portions of slope No. 11NW-A/C49 were formed by cutting into the toe of the hillside in 1963 and 1976 respectively. The construction of PMH was in progress in 1967. Blocks E and F of PMH had been constructed in 1973, while Block J and its associated podium were constructed together with the adjacent basketball court in 1976. The section of Lai King Hill Road below Block J of PMH was formed by cutting and filling works in 1977.

Road widening works for Lai King Hill Road involving further cutting into the hillside were in progress in 1986. Since then, slope No. 11NW-A/C49 has been modified to its present-day layout. In 1988, a retaining wall was constructed along the crest of the rock cut portion of the slope, and the soil portion of slope No. 11NW-A/C49 and the hillside above remained unchanged in the same year. The 1989 aerial photographs show that Lai King Hill Road had been constructed to its present-day alignment, and seepage can be seen on the surface of slopes Nos. 11NW-A/C49 and 11NW-A/C150.

In 2003, slope upgrading works were being carried out on slope No. 11NW-A/C49 under LPM Programme, which were completed on 30 April 2004.

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<sup>1</sup> Block J of PMH is formerly known as Block B of Lai Chi Kok Hospital (see Figure 7).

### 3.2 Past Instability

On 9 July 1985, a landslide (Incident No. MW85/7/5) occurred at the northern end of slope No. 11NW-A/C403 (Figure 2). According to the incident report prepared by the Geotechnical Control Office (GCO, renamed GEO in 1991), the landslide involved approximately 40 m<sup>3</sup> of rock and soil debris and the slope failed "due to extensive infiltration" of surface runoff. Signs of concentrated flow of water were observed on the northern side of the failure scar. Urgent repair works, including removal of loose soil, trimming of the landslide scar, provision of surface protection, clearance of drains at the slope crest and vegetation around the scar, were recommended by GCO in the incident report.

On 21 May 1989, a minor landslide was reported to have occurred at slope No. 11NW-A/C49 (Figure 2) by P&T Wallace Evans Ltd., the consulting engineers to the Tsuen Wan New Town Development Office (TWNTDO) of the then Territory Development Department (TDD), during the course of the site formation works under NTDD Works Contract No. 19/TW/82: Kau Wah Keng Approach Road and Drainage administered by TWNTDO. The site formation works comprised rock cutting and provision of mass concrete buttress to the slope. The incident report prepared by P&T Wallace Evans Ltd. states that "the minor slip was related to an increase in groundwater pressures caused by the convergence of natural drainage channels carrying stormwater during the prolonged storm". The incident report also recommended that "immediate measures", including the construction of a boulder fence along the top of the retaining wall below the landslide scar to prevent soil/rock debris from falling onto Lai King Hill Road, should be carried out after the landslide.

The 1990 aerial photographs revealed that a patch of bare surface noted on the hillside near the crest of slope No. 11NW-A/C49 might be an area of instability (Figures 2 and A1). However, no records in relation to this instability could be located in the documentary records of the GEO.

## 4. PAST ASSESSMENT

No previous study has been carried out for the hillside below Block J of PMH.

The rock cut portion of slope No. 11NW-A/C49 was formed in 1989 under NTDD Works Contract No. 19/TW/82 following the recommendations given in the Geotechnical Report on Kau Wah Keng Approach Road and Drainage prepared by P&T Geotechnics Limited, which contained no detailed study of the soil portion of the slope. The GCO in a memorandum dated 8 November 1989, indicated that there were no adverse comments on the proposed works.

Slope No. 11NW-A/C49 was included in the LPM Programme in 2002. MGSL carried out an LPM Stage 3 Study for the slope, which recommended slope upgrading works comprising installation of soil nails and prescriptive raking drains, rock slope treatment and provision of a combination of hard and vegetated surface covers. The LPM upgrading works were completed on 30 April 2004. The slope was then handed over to HyD in May 2005 for maintenance.

## 5. MAINTENANCE AND REPAIR RECORDS

### 5.1 Maintenance and Repair of Water-carrying Services

According to a series of HyD's memoranda to Arch SD during the period of 1998 to 2003, there had been repeated complaints of effluent emanating from the hillside below Block J of PMH and in the vicinity of slope No. 11NW-A/C49 (Figure 5). HyD notified Arch SD in their memorandum dated 9 December 1998 that "seepage of dark stained water was found on the above slope" and believed that "the dark stained water comes from the buried pipe from PMH". They also mentioned in the same memorandum that "In fact, leakage problem previously occurred from such buried pipe in 1996". On 4 February 1999, HyD sent another memorandum to Arch SD stating "According to our recent inspection, seepage of dark stained water was still found on the above slope". Arch SD noted in their reply memorandum dated 20 July 2001 to HyD that "we had cleared the blockage of the sewer pipes every time you informed us but it blocked again". On 19 July 2002, HyD sent another memorandum to Arch SD stating "no response has been given by you so far". In response to HyD's queries, Arch SD pointed out in their memorandum of 22 July 2002 that "we had already rectified the defect every time" when they received HyD's advice. During the course of the present study, records of the rectification works to the sewer pipe could not be located by Arch SD.

Following the promulgation of one of the initiatives on "Slope Safety" by the then Works Bureau in the 2001 Policy Address, viz. "to complete the systematic inspection and necessary repair works of underground water pipes, sewers and drains within government buildings and affecting slopes", Arch SD undertook leakage detection and the necessary repair works of the water-carrying services at PMH in 2001. According to the information provided by Arch SD, they carried out a Leak Noise Correlation (LNC) survey and a Mechanical Leak Detection (MLD) survey of the pipes run along the crest of slope No. 11NW-A/C150 to the north of the Block J of PMH (Figure 1) in October 2001 and no leakage was found. However, details regarding the alignment(s) of the surveyed water pipe(s) are not available in Arch SD's records and it is therefore uncertain as to whether the three buried water-carrying services below Block J of PMH were subject to leakage testing or not before the 11 August 2005 incident.

In response to the enquiries raised by MGSL for the present landslide review regarding the previous maintenance of the water-carrying services in the vicinity of Block J of PMH, Arch SD advised that they could not locate any records, except for two Works Orders dated 10 November 2001 and 20 January 2003 respectively. The former Works Orders involved the replacement of a damaged 100 mm diameter galvanised iron (G.I.) pipe at the northern end of Block J whereas the latter covered the replacement of a broken 150 mm G.I. pipe immediately outside the southern end of Block J (Figure 5). Arch SD indicated that they could not locate any records showing the completion of the works.

In November 2003, during the course of LPM upgrading works for slope No. 11NW-A/C49, the resident site staff (RSS) of the LPM works noted and reported to the then Works Division (renamed LPM Division 3 in July 2004) of the GEO that seepage was observed on the slope surface above the abandoned 1200 mm diameter concrete pipe (Plate 4) and leakage was found at the exposed water supply lines (not known as fresh water or salt water supply) at the southern end of slope No. 11NW-A/C49 (Figure 5 and Plate 5). The LPM RSS advised that it had not been raining on the day of the inspection. On

10 December 2003, the Works Division of the GEO forwarded the above site observations to Arch SD, and recommended that repair works should be carried out. No information showing Arch SD's response can be located in Arch SD and GEO, and it is uncertain whether Arch SD had dealt with the leaky pipe. Six additional raking drains were installed immediately above the abandoned 1200 mm diameter concrete pipe under the LPM works.

In response to MGSL's enquiry, PMH noted in their letter dated 1 September 2005 that "There is no maintenance records of all water carrying services as informed by our current maintenance agent, EMSD. Before 2004/05, the maintenance agent was Arch SD". In the above letter, PMH provided two sets of records, which were taken during the joint visual inspections by the Electrical and Mechanical Services Department (EMSD) and WSD on 5 August 2005 and 8 August 2005 respectively, noting the leakage of surface water pipes at three locations (Figure 5). One of the pipes was located near the scarp of the August 2005 landslide. Based on the available records, PMH's contractor had been instructed to carry out urgent repair works to the leaky pipes. No records of the urgent repair work could be obtained from PMH. Water leakage of surface water pipes at one of the above three locations at the platform of Block J was observed during the site inspection by MGSL on 12 August 2005. According to EMSD, the three leakage points observed on 5 August 2005 and 8 August 2005 were repaired by 9 August 2005, and the leakage did not result in water ingress into the slope below during the above period.

Arch SD advised in their letter dated 13 September 2005 to MGSL that the maintenance of PMH "has been fully devolved to the Hospital Authority w.e.f. 1 April' 05", and that "all available records/documents/plans of the relevant buildings and slopes had been forwarded to the corresponding Hospitals".

## 5.2 Maintenance of Slopes

Engineer Inspections (EIs) were carried out for slope No. 11NW-A/C49 by Fugro Mouchel Rendel Joint Venture and MGSL, who were the EI consultants to HyD, in July 1995 and February 2001 respectively. Minor routine maintenance works, including repair of damaged slope surfacing, clearance of drainage channels and repair of cracked channels, were recommended in the EI reports. No signs of seepage were reported in both of the EI reports.

Routine Maintenance Inspections (RMIs) for slope No. 11NW-A/C49 were carried out annually by HyD between 1999 and 2002. No Routine Maintenance Works (RMW) was recommended in the RMIs, except for the clearance of raking drains on the slope recommended after the 2002 RMI.

In 2003 and 2004, MGSL was engaged by HyD to carry out RMIs for slope No. 11NW-A/C49. In the 2003 RMI carried out in March, seepage was observed on the shotcreted slope surface at the bottom of the feature. Subsequently, HyD issued a Works Order for the clearance of the blocked channel. The 2004 RMI did not identify any signs of seepage or distress on the slope and no RMW was recommended.

In 2005, Chiu Hing Construction and Transportation Co. Ltd., as the consultant to HyD, carried out an RMI for slope No. 11NW-A/C49. Following the recommendations of the 2005 RMI, a Works Order was issued by HyD for carrying out RMW, including clearance of

debris and unplanned vegetation from drainage channels, clearance of blocked raking drains and weepholes as well as repair of cracked drainage channels and impermeable surface cover.

## 6. THE 11 AUGUST 2005 LANDSLIDE AND POST-FAILURE OBSERVATIONS

### 6.1 The 11 August 2005 Landslide

The landslide occurred at about 5:00 a.m. on 11 August 2005. No Rainstorm Warning or Landslip Warning was in effect at the time. The landslide involved a shallow failure where the source area was about 5 m wide by 15 m long with a maximum depth of about 1 m. About 15 m<sup>3</sup> of landslide debris detached from the vegetated hillside below Block J of PMH. The landslide debris, which comprised mainly residual soil, fill, colluvium and mature trees with a girth up to about 500 mm, eroded the soil portion of slope No. 11NW-A/C49 and exposed several soil nail heads installed on the slope along the debris trail, which measured about 5.3 m in width, 50 m in length and maximum 0.2 m in depth.

Most of the landslide debris was deposited on the slope berms at the northern end of slope No. 11NW-A/C49. While some of the landslide debris came to rest at the toe of slope No. 11NW-A/C49 against the hoarding for the adjacent LPM site, a few small rock blocks and a small amount of soil debris overtopped the hoarding and were deposited on Lai King Hill Road, making a travel angle of about 35°. A stretch of the fence along the coping of the retaining wall at about mid-height of slope No. 11NW-A/C49 was severely damaged, and part of it was left over-hanging (Plate 1). As a result, Lai King Hill Road was temporarily closed (Plate 2) and no casualties were reported.

### 6.2 Post-failure Observations

During the post-failure inspection by MGSL at about 11:00 a.m. on 11 August 2005, it was noted that significant water flow, which was in general clear, was emanating from the main scarp of the landslide, just below Block J of PMH (Plate 1). At the time, the staff of PMH present at the landslide site were attempting to close the pipe valves in the pump house to the north of Block J (Figure 5). The water flow from the main scarp eventually stopped when one of the pipe valves was turned off by the staff of PMH at around noon that day. The PMH staff noted that the water flow was probably due to leakage from a buried fresh water pipe (i.e. the 150 mm diameter pipe with heavy corrosion as subsequently exposed in the inspection pits as discussed below) connecting to Blocks E and F of PMH. This leaky fresh water pipe was later disconnected and abandoned, as confirmed in PMH's letter dated 28 October 2005. According to Arch SD, the fresh water supply to Blocks E and F comprised a "dual pipes system" and the water supply would not be affected by turning off the valve of either one of the two water pipes.

After the landslide, the EMSD, the prevailing maintenance agent to PMH, excavated five inspection pits (Nos. P1 to P5) (Figure 4) on the platform at the crest of the landslide scar on 12 August 2005 to identify and inspect the buried services. Three pipes (one is a 150 mm diameter heavily corroded steel pipe, one is a 200 mm diameter steel pipe and the remaining one is a 100 mm diameter uPVC pipe) were exposed in the pits at a depth of about 200 mm (Plates 6 and 7). No leakage or evidence of void or soil pipe was observed in the inspection pits. No leakage check or closed-circuit television (CCTV) survey of the buried pipes was

carried out by the EMSD, and all the inspection pits were backfilled by EMSD on 15 August 2005.

Subsequent to the August 2005 landslide, water and soil samples were obtained from the landslip scar by Inter Pacific Limited, the GI contractor of MGSL for the LI consultancy Agreement, on 16 August 2005. The locations of the water samples are shown in Figure B1 in Appendix B. Chemical tests were carried out on the water and soil samples to identify the nature and origin of the leakage. The results of the chemical tests (see Appendix B) indicate that the water samples collected from the landslip scar and the 'used' water collected after washing the soil sample with distilled water is likely to have originated from a fresh water supply.

In order to locate the suspected leaky water pipe, five inspection pits (IP1 to IP5) at the platform behind the crest of the failed slope were dug by Inter Pacific Limited with the agreement of PMH. The locations of the five inspection pits are shown in Figure 4.

Three underground pipes were found at a depth of about 800 mm in Inspection Pits Nos. IP1 and IP2 (Figure 6 and Plate 8). Based on the drawings provided by Arch SD and post-failure site observations, the three underground pipes included a 150 mm diameter G.I. water pipe, which supplied fresh water to Blocks E and F of PMH, a 200 mm diameter fire services watermain and an unrecorded 100 mm diameter uPVC pipe. The surface of the 150 mm diameter G.I. water pipe was found severely corroded (Plate 7).

In Inspection Pit No. IP2, a soil pipe about 20 mm high by 150 mm wide, which extended in a direction towards the landslide site, was found near the 150 mm diameter water pipe (Plates 9 and 10).

Further excavation behind the landslide scrap to investigate the conditions of the buried pipes was initially considered. However, in view of the risk of potential damage to the exposed pipes, which supply water to various buildings of PMH, no further excavation of inspection pits was carried out.

CCTV survey has been considered as an alternative. However, this could not be carried out without damaging parts of the pipe of concern. It is noteworthy that LNC survey could not be carried out to locate the damaged part of the subject water pipe since there was no pressurised water running inside the abandoned water pipe.

As a result, the leaky part(s) of the subject buried pipe could not be located in full. Based on the information collected from Arch SD and PMH together with the post-failure inspections, the leaky pipe was likely to be the severely corroded fresh water pipe exposed in the inspection pits, which supplied fresh water to Blocks E and F of PMH.

## 7. ANALYSIS OF RAINFALL RECORDS

Rainfall data were obtained from GEO automatic raingauge No. N04, which is the nearest raingauge to the landslide site and located approximately 700 m to the northwest at Kai Kwong Lau, Cho Yiu Estate, Kwai Chung.

The landslide occurred at about 5:00 a.m. on 11 August 2005. The daily and hourly rainfalls recorded by raingauge No. N04 prior to the August 2005 landslide are presented in Figure 10. The records show that there was only light rainfall before the 11 August 2005 landslide occurred, and the maximum rolling rainfall for one-hour and 24-hour periods are only 9 mm and 45 mm respectively (Table 1).

Table 1 presents the estimated return periods for the maximum rolling rainfall for various durations recorded by raingauge No. N04 with reference to historical rainfall data at the Hong Kong Observatory in Tsim Sha Tsui (Lam & Leung, 1994). The results show that the return periods of the rainstorm preceding the landslide were less than two years.

The return periods were also assessed based on the statistical parameters derived by Evans & Yu (2001) for rainfall data recorded by raingauge No. N04. The results show that the return periods of the rainstorm preceding the landslide are similar to those estimated by the historical rainfall data at the Hong Kong Observatory.

The maximum rolling rainfall for the 11 August 2005 incident has been compared with the past major rainstorms recorded by raingauges No. N04 between 1987 and 2002 (Figure 11). It is noted that the rainfall on 11 August 2005 is much less severe than the previous major rainstorms.

## 8. DISCUSSION

Based on the present study, the 11 August 2005 landslide was probably primarily triggered by leakage from a dilapidated, buried fresh water main above the source area of the landslide. The landslide debris, with a travel angle of 35°, was not particularly mobile. It was also fortuitous that part of the debris and rock fragments were retained by the fence within slope No. 11NW-A/C49 as well as the temporary site hoarding near the toe. The debris caused some scouring of slope No. 11NW-A/C49 along its trail but there was no genuine instability of the cut slope, which was previously upgraded using soil nails.

The maintenance responsibility of the water-carrying services of PMH was handed over from the previous maintenance agent (Arch SD) to PMH, with EMSD as the new maintenance agent, some four months before the 2005 landslide incident. Following the observation of excessive water flow/leakage and the reporting of the incident, the corresponding valve for the subject water main was not turned off until some seven hours later, during which time the locations of the leaky pipe and the valve, together with the pipe ownership, were being identified. Special care was probably called for given the setting of a large number of water-carrying pipes serving PMH and the risk of inadvertently closing off another service pipe for essential hospital operations, which emphasizes the importance of the timely retrieval of records of buried water-carrying services especially under an emergency situation.

The subject GI pipe was probably about 30 years old, forming part of the services to the PMH buildings, which were constructed in the mid-1970's. The subject pipe is located largely along the crest of the sloping ground (viz. a hillside 'pocket') above several registered man-made slopes adjoining Lai King Hill Road at the toe. It is not certain whether the subject pipe would have been included in the systematic leakage detection programme of the

maintenance agent, given the absence of a comprehensive inventory and/or maintenance manual of all the related water-carrying services serving PMH and full records of the corresponding maintenance and repair works and leakage detection.

Leakage detection (viz. LNC and MLD surveys) was undertaken in the general vicinity of the 2005 landslide site in 2001. However, the rather rudimentary referencing and indexing of water-carrying services subjected to testing meant that there is uncertainty as to whether or not the subject water main was included in that particular testing programme.

During the course of the inquiry into the incident, the subject water main was found to be part of a dual water supply system, in which water loss from any one of the two pipes would be compensated by the other pipe. As a result, prolonged and not insignificant leakage could have taken place over a period of time without the users in PMH or the responsible maintenance agent noticing the more commonly observed accompanying signs of incipient problems with leaky pressurised water mains, such as a drop in pressure.

Extensive search of the available file records revealed that there has been a history of leakages or suspected leakages affecting the hillside of concern and/or the man-made slopes below in the few years preceding the 2005 landslide incident. Given the poor maintenance condition of the subject water main as depicted in the inspection pits, it is possible that leakage from this dilapidated pipe had been occurring for some time before the 11 August 2005 landslide. This postulation is supported by the presence and deposition of the observed soil pipe on the downhill side of the subject water main. Should prolonged leakage have taken place, the affected ground mass would have been subjected to progressive wetting up and deterioration in the slope condition. The enhanced water ingress provided an adverse condition in terms of slope stability for the affected area of the hillside, which corroborates, to some extent, with the observation that the 11 August 2005 incident took place following fairly light rainfall.

## 9. REFERENCES

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Table 1 - Maximum Rolling Rainfall at GEO Raingauge No. N04 for Selected Durations Preceding the Landslide on 11 August 2005 and the Estimated Return Periods

Duration	Maximum Rolling Rainfall (mm)	End of Period	Estimated Return Period (Years)	
			By Lam & Leung (1994)	By Data of N04 from Evans & Yu (2001)
5 Minutes	6.0	11:10 p.m. on 10 August 2005	< 2	< 2
15 Minutes	8.5	11:20 p.m. on 10 August 2005	< 2	< 2
1 Hour	9.5	11:20 p.m. on 10 August 2005	< 2	< 2
2 Hours	15.0	11:20 p.m. on 10 August 2005	< 2	< 2
4 Hours	16.5	2:10 a.m. on 10 August 2005	< 2	< 2
12 Hours	29.5	3:25 a.m. on 11 August 2005	< 2	< 2
24 Hours	45.0	11:20 p.m. on 10 August 2005	< 2	< 2
48 Hours	86.5	2:10 a.m. on 11 August 2005	< 2	< 2
4 Days	93.0	3:25 a.m. on 11 August 2005	< 2	< 2
7 Days	93.0	3:25 a.m. on 11 August 2005	< 2	< 2
15 Days	282.0	3:25 a.m. on 11 August 2005	< 2	< 2
31 Days	422.0	3:25 a.m. on 11 August 2005	< 2	< 2
<p>Notes:</p> <ul style="list-style-type: none"> <li>(1) Maximum rolling rainfall was calculated from 5-minute rainfall data.</li> <li>(2) Return periods were derived from Table 3 of Lam &amp; Leung (1994) and using data from Evans &amp; Yu (2001).</li> <li>(3) According to the eye-witnesses' accounts, the landslide occurred before 5:00 a.m. on 11 August 2005.</li> <li>(4) The nearest GEO automatic raingauge to the landslide site is raingauge No. N04 located about 0.68 km to the northwest of the landslide site.</li> </ul>				

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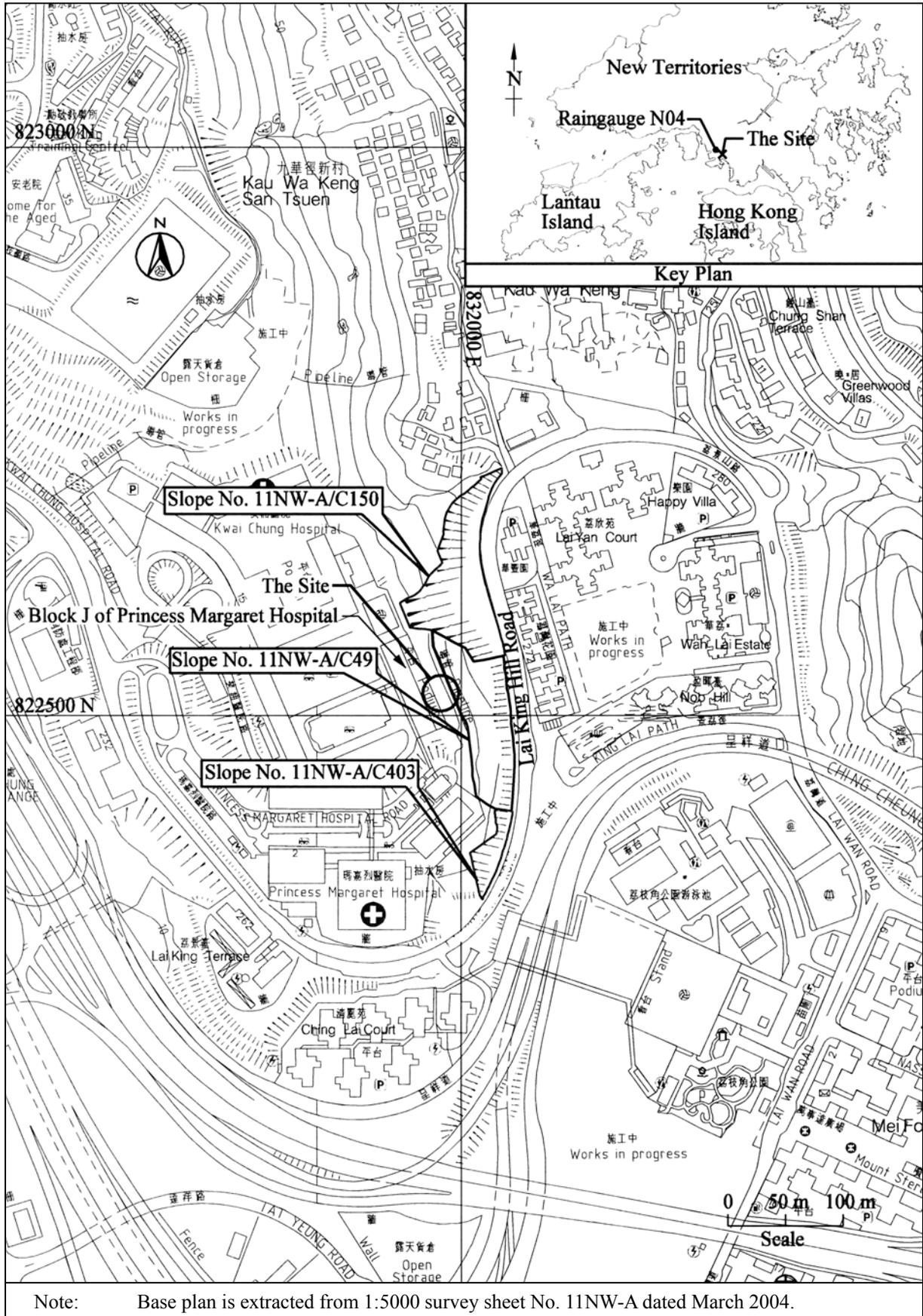


Figure 1 - Location Plan

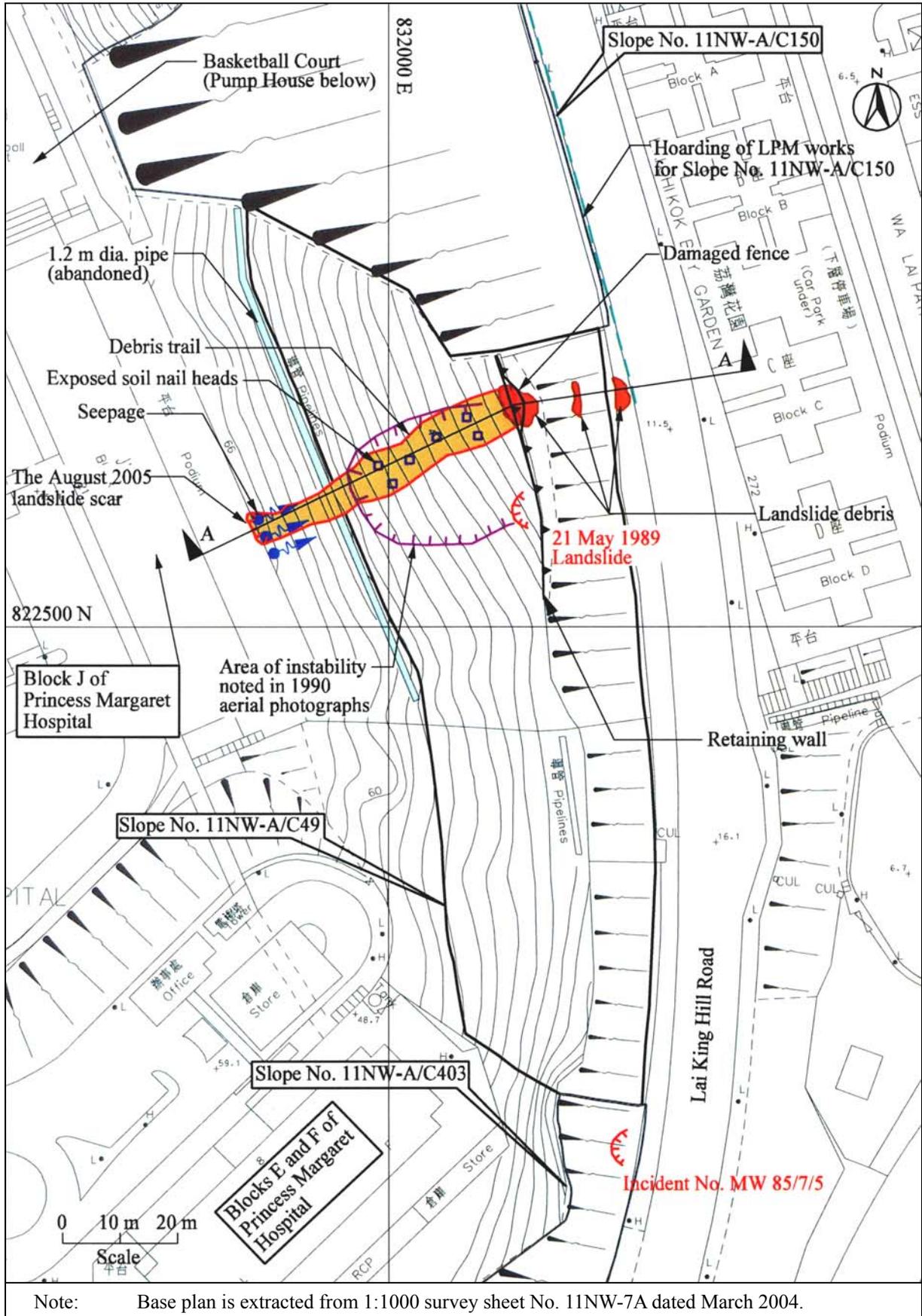


Figure 2 - Site Plan

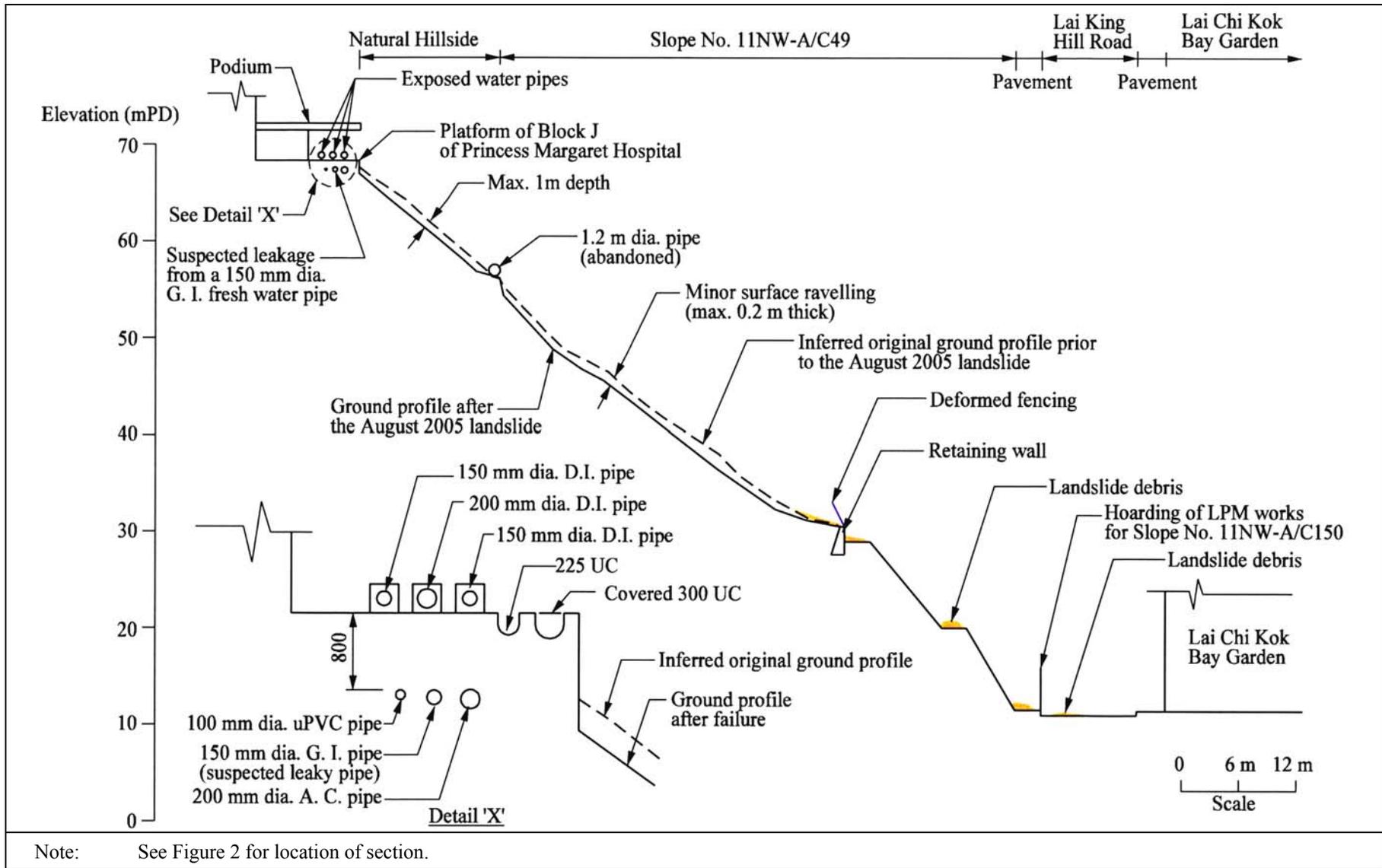


Figure 3 - Section A-A through the August 2005 Landslide



Figure 4 - Location Plan of Inspection Pits and Sources of Water for Sampling

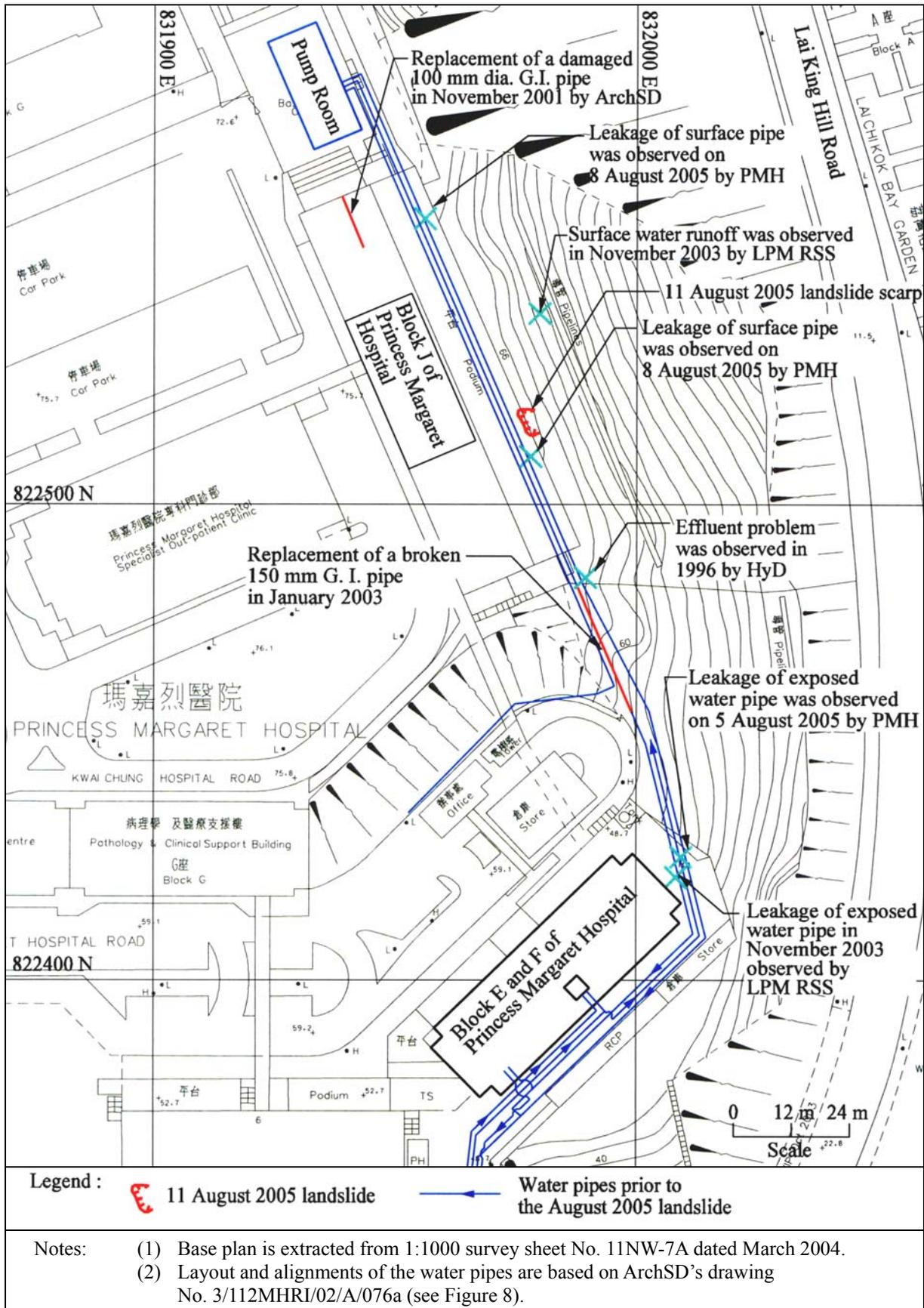


Figure 5 - Locations of Recorded Leakage in Water-carrying Services Prior to the August 2005 Landslide

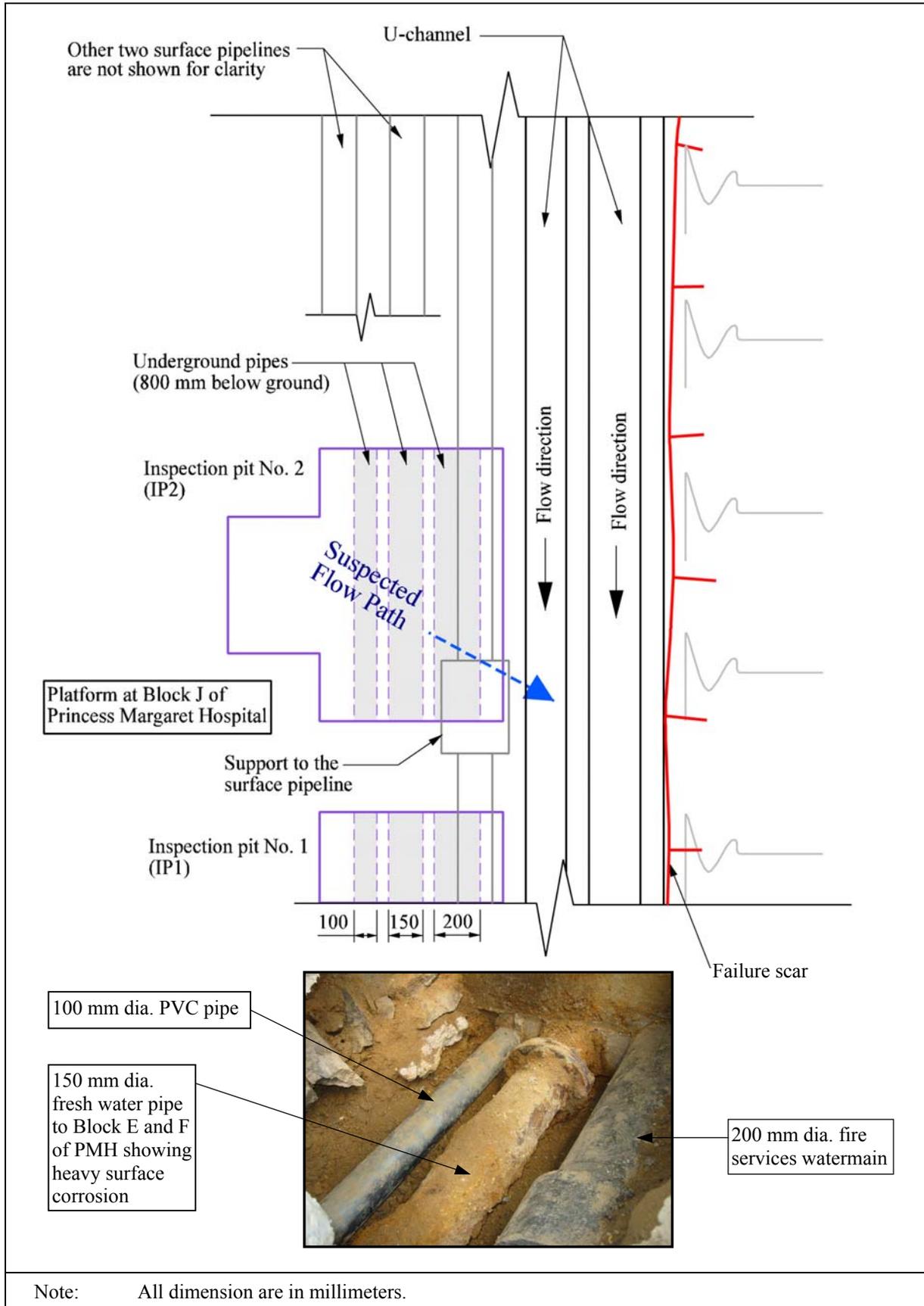
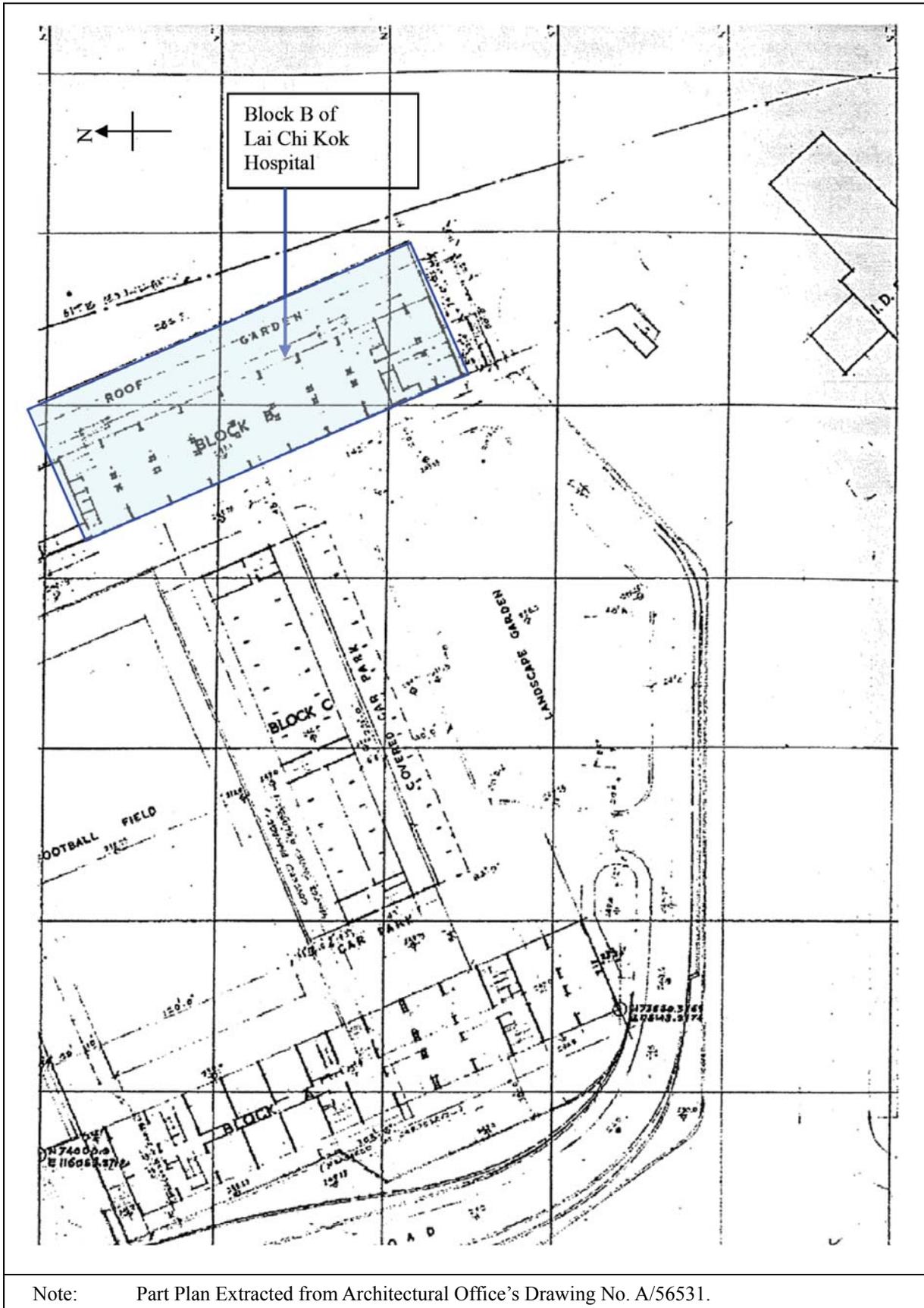


Figure 6 - Observations in Inspection Pits Nos. IP1 and IP2



Note: Part Plan Extracted from Architectural Office's Drawing No. A/56531.

Figure 7 - Location of Block B of Lai Chi Kok Hospital (now known as Block J of PMH)

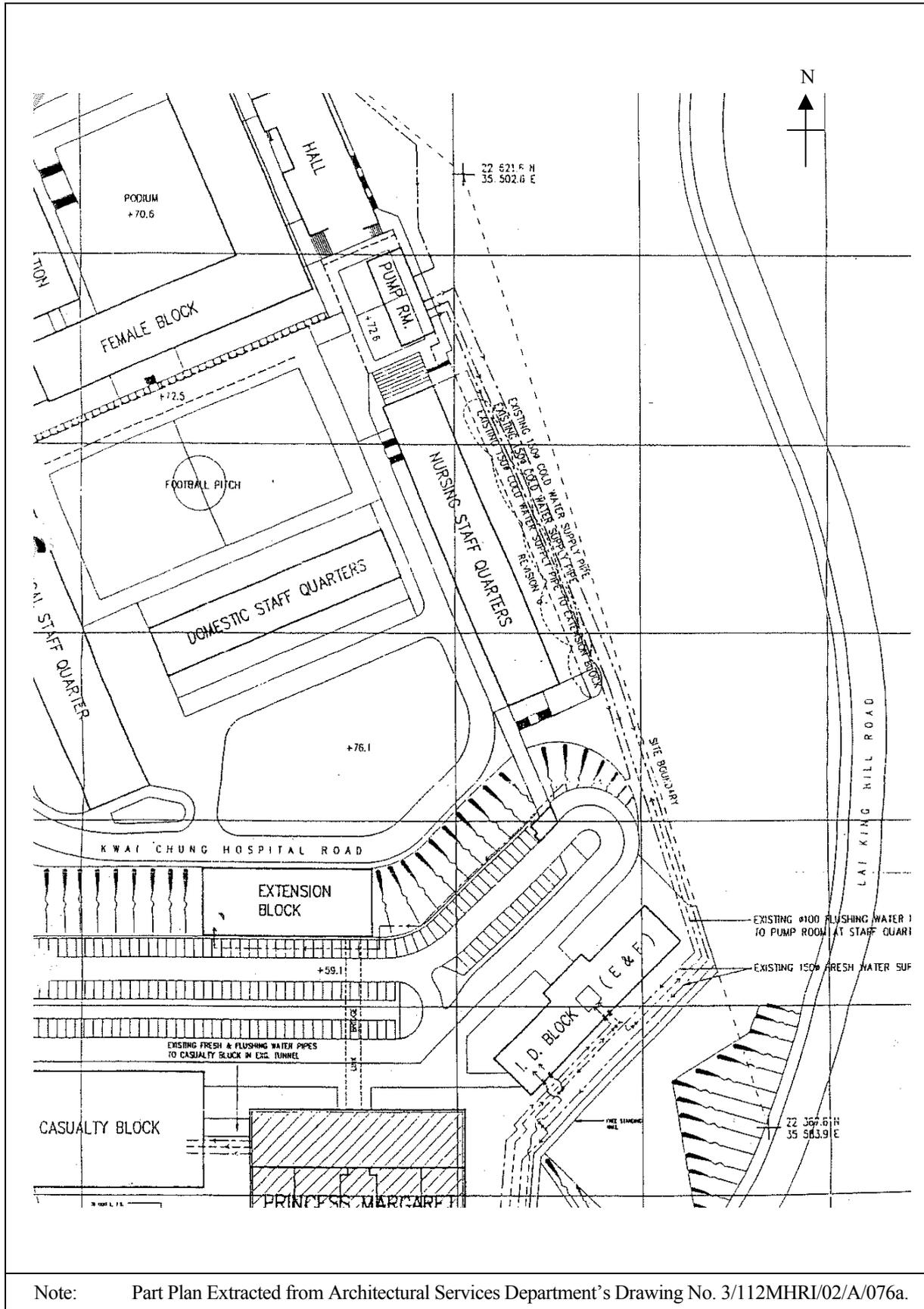
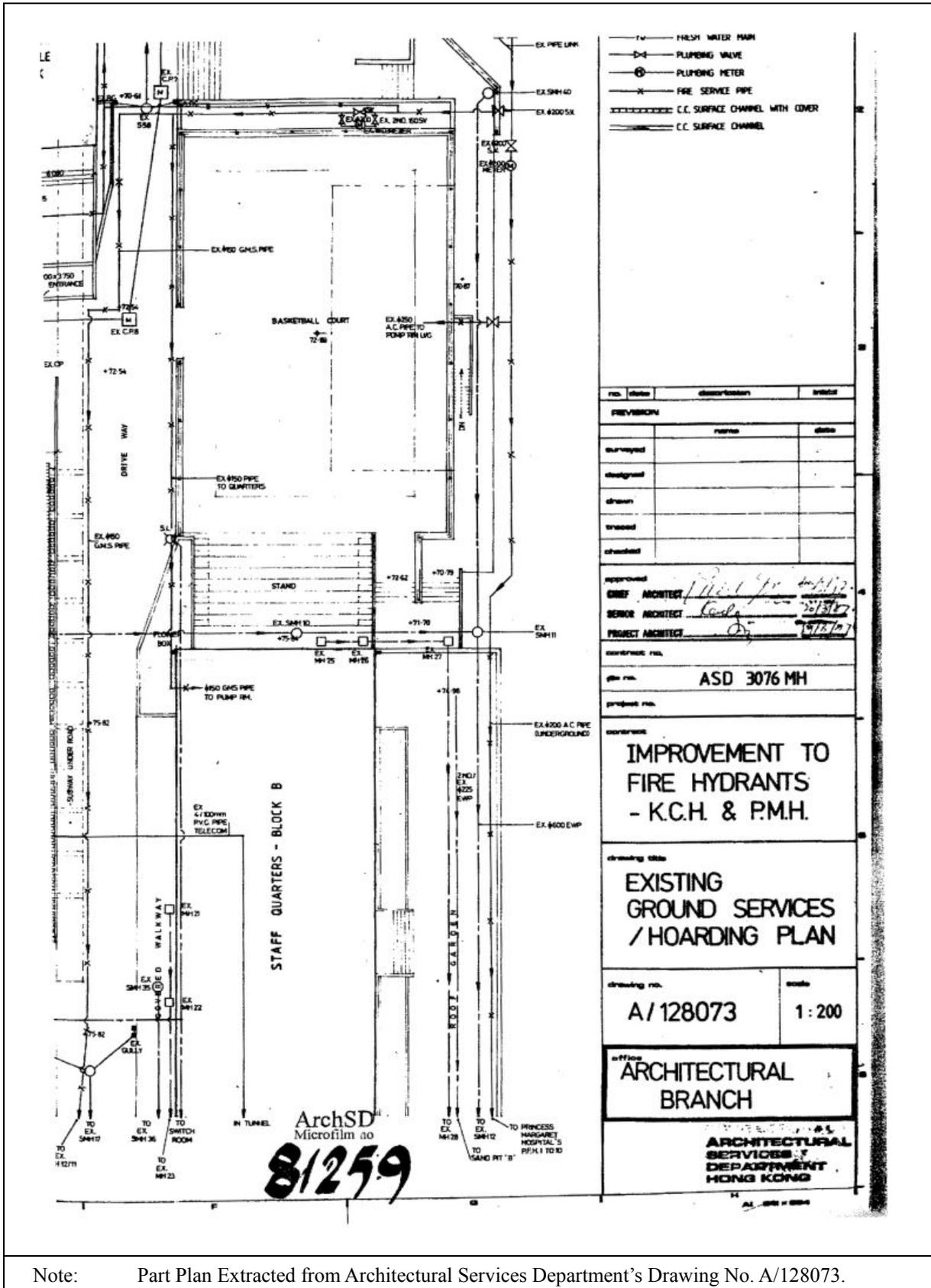
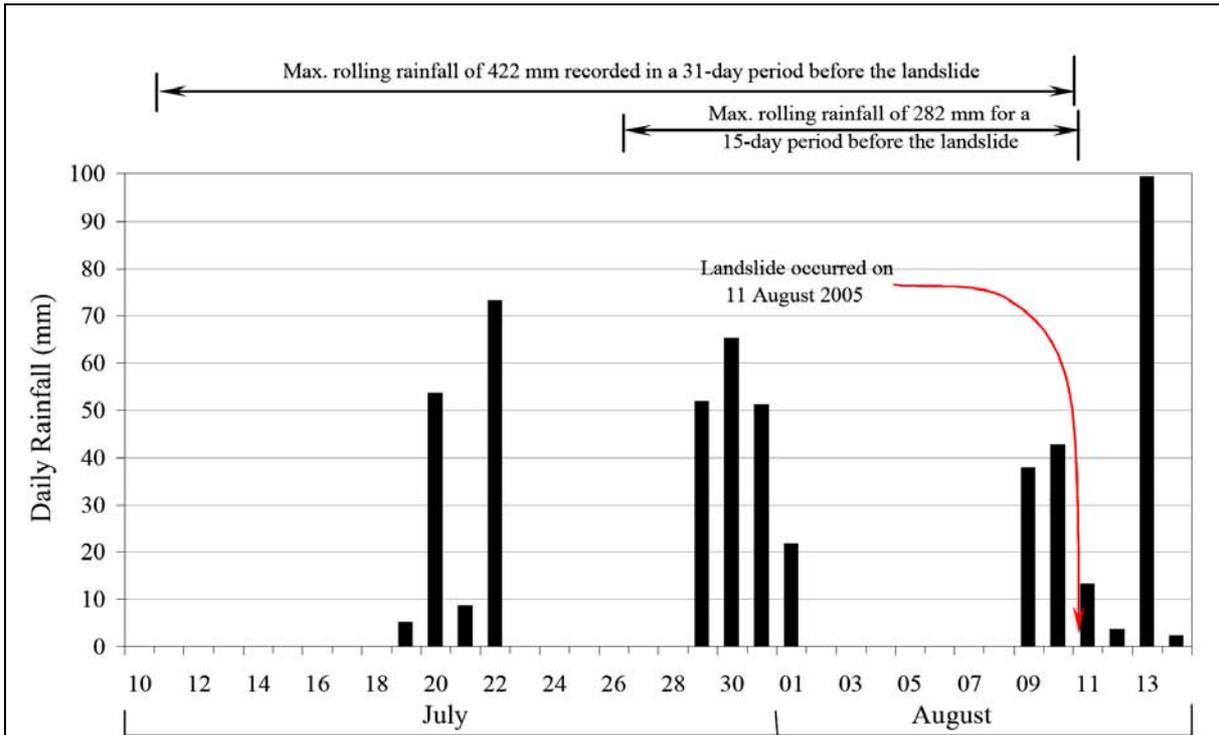


Figure 8 - Three Pipes Emerged from Pump House beneath a Basketball Court

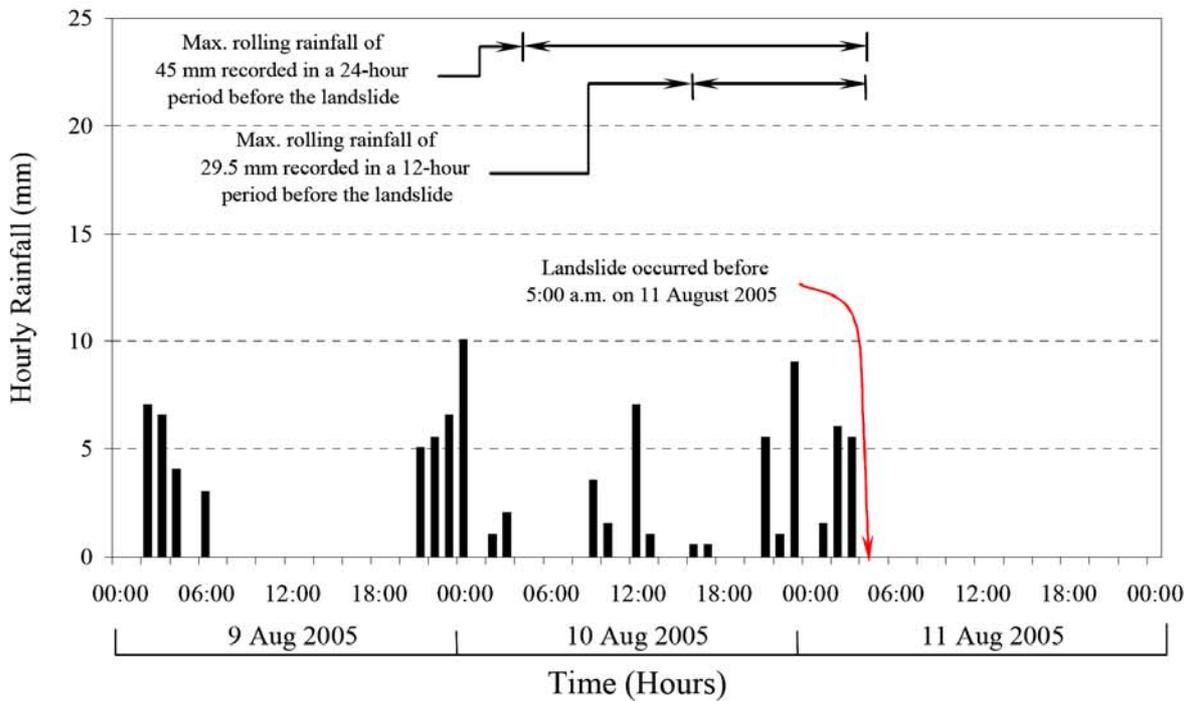


Note: Part Plan Extracted from Architectural Services Department's Drawing No. A/128073.

Figure 9 - Layout Plan of Water-carrying Services in the Vicinity of Block J of PMH (formerly known as Block B of Lai Chi Kok Hospital)



(a) Daily Rainfall Recorded at GEO Rain gauge No. N04 between 10 July 2005 and 14 August 2005



(b) Hourly Rainfall Recorded at GEO Rain gauge No. N04 between 9 August 2005 and 11 August 2005

Figure 10 - Daily and Hourly Rainfall Recorded at GEO Rain gauge No. N04

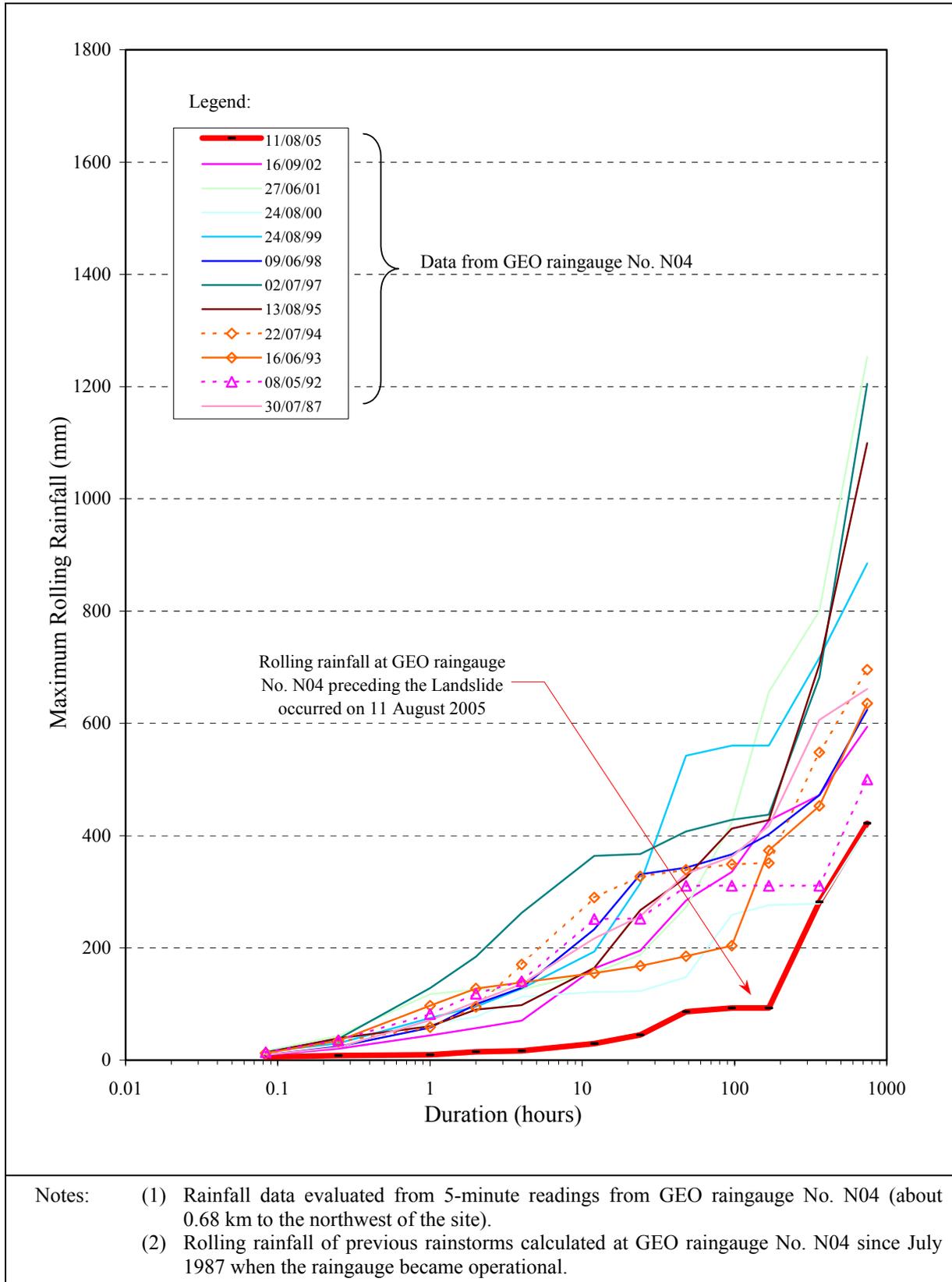


Figure 11 - Maximum Rolling Rainfall for Previous Major Rainstorms at GEO Raingauge No. N04

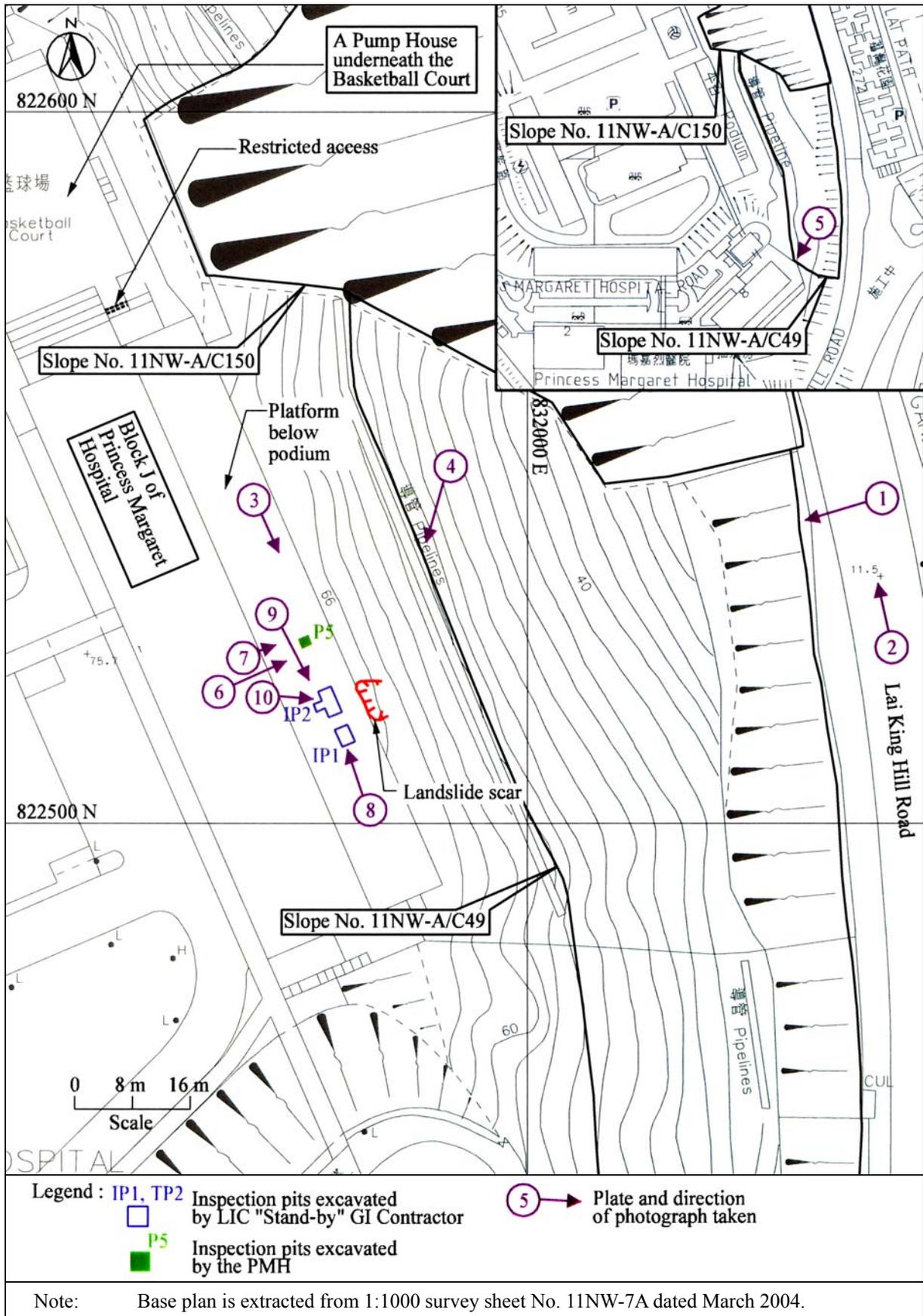


Figure 12 - Locations and Directions for Photographs Taken

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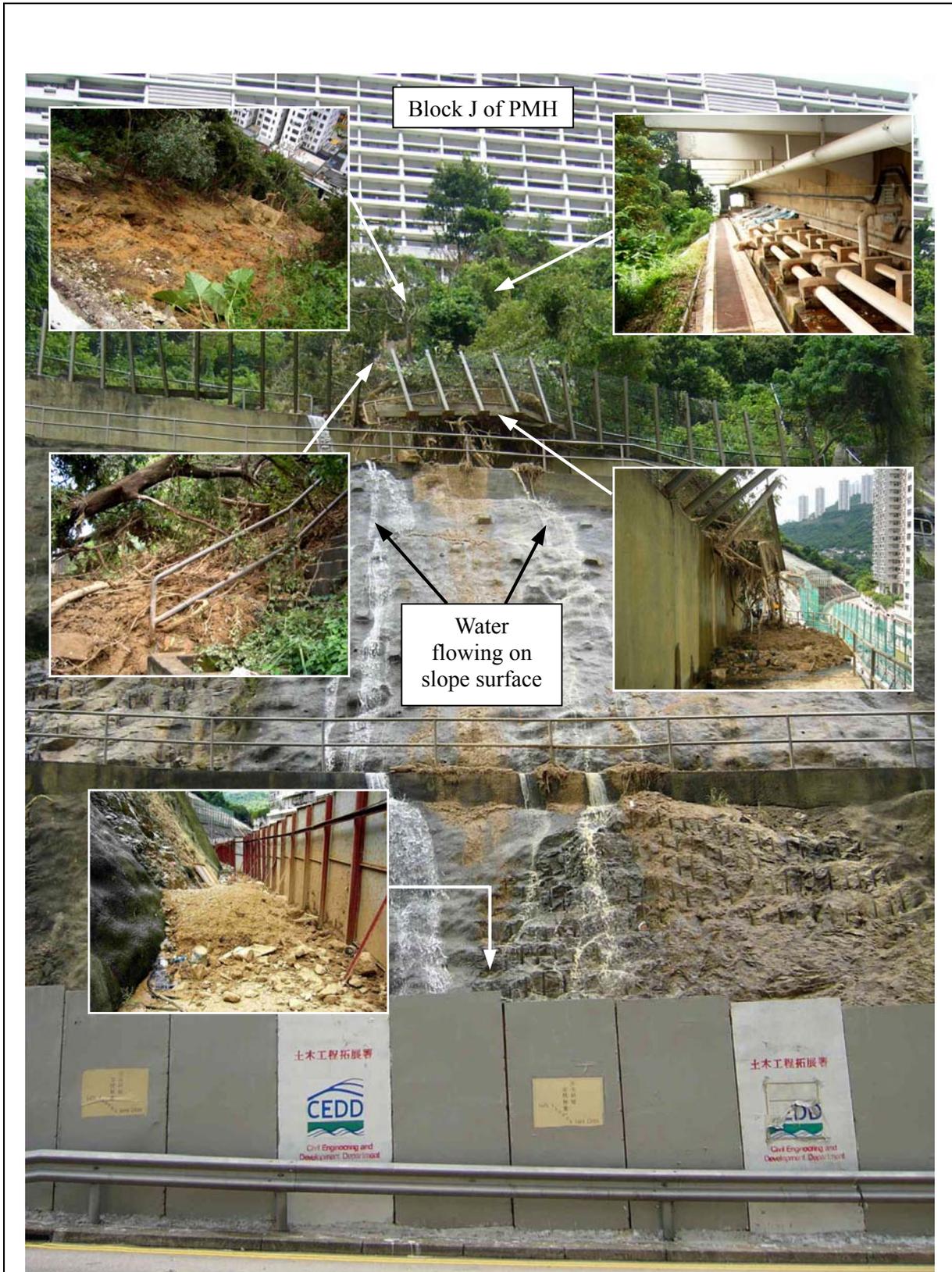


Plate 1 - General Views of the Landslide (Photographs taken on 11 August 2005)

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



Plate 2 - Lai King Hill Road Temporarily Closed (Photograph taken on 11 August 2005)

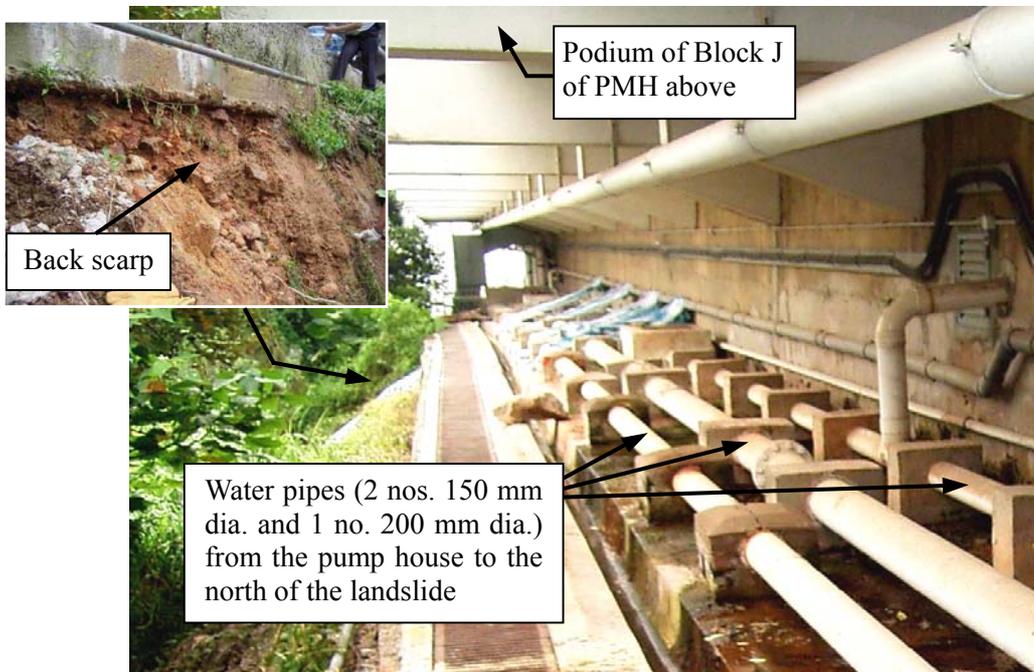


Plate 3 - Exposed Pipes Located at the Crest of Landslide (Photograph taken on 12 August 2005)

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



Plate 4 - View of the Abandoned 1.2 m dia. Pipeline above Slope No. 11NW-A/C49  
(Photograph taken in November 2003 by LPM RSS)



Plate 5 - Leakage of Exposed Water Pipe at the Southern End of Slope No. 11NW-A/C49  
(Photograph taken in November 2003 by LPM RSS)

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

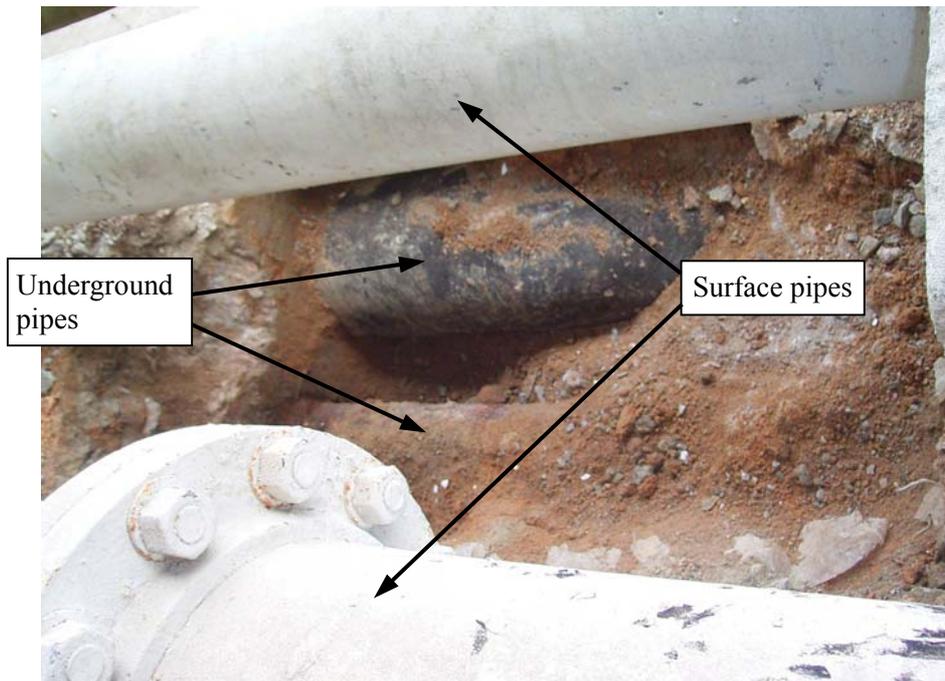


Plate 6 - Underground Pipes Exposed in Inspection Pit No. P5 Excavated by EMSD  
(Photograph taken on 12 August 2005)

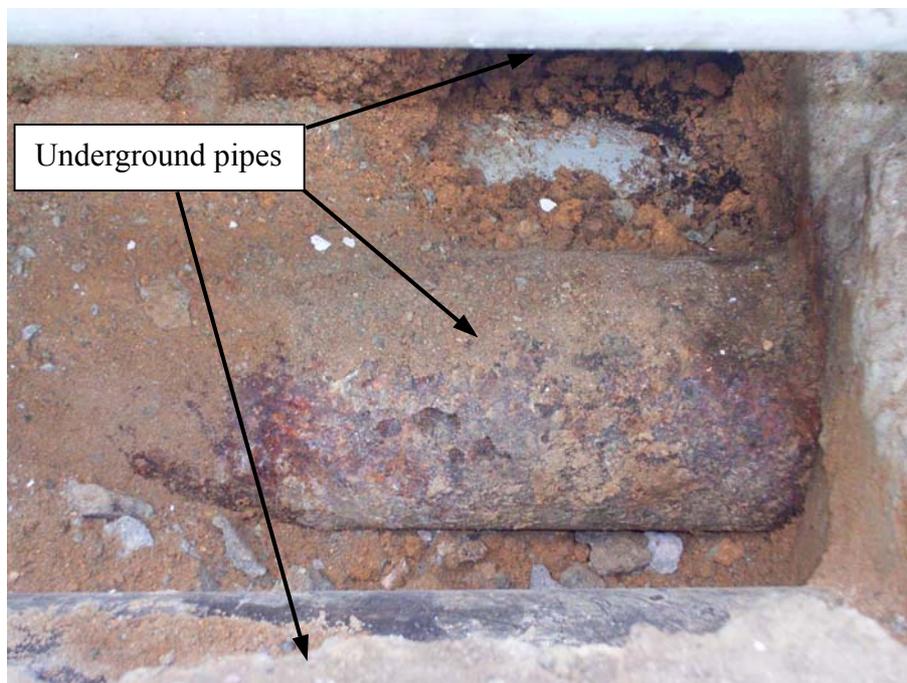


Plate 7 - Close-up View of the Underground Pipes Exposed in Inspection Pit No. P5 Excavated  
by EMSD (Photograph taken on 12 August 2005)

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

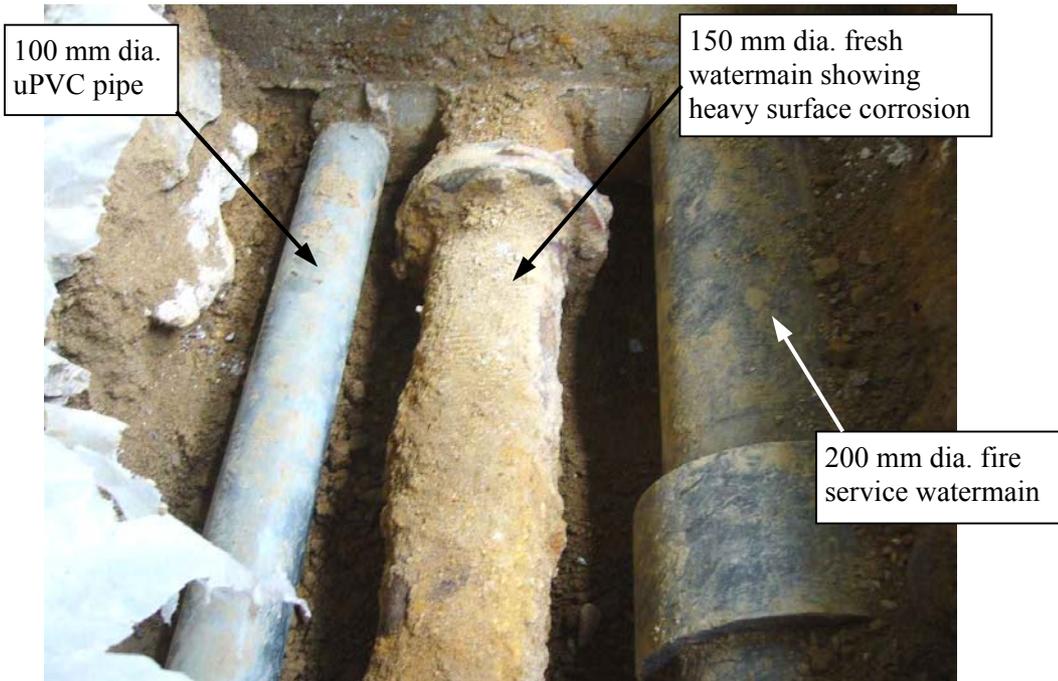


Plate 8 - Underground Pipes Exposed in Inspection Pit No. IP1 Excavated by LIC's Stand-by GI Contractor (Photograph taken on 27 March 2006)



Plate 9 - The Opening of the Suspected Water Flow Path in Inspection Pit No. IP2 Excavated by LIC's Stand-by GI Contractor (Photograph taken on 27 March 2006)

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

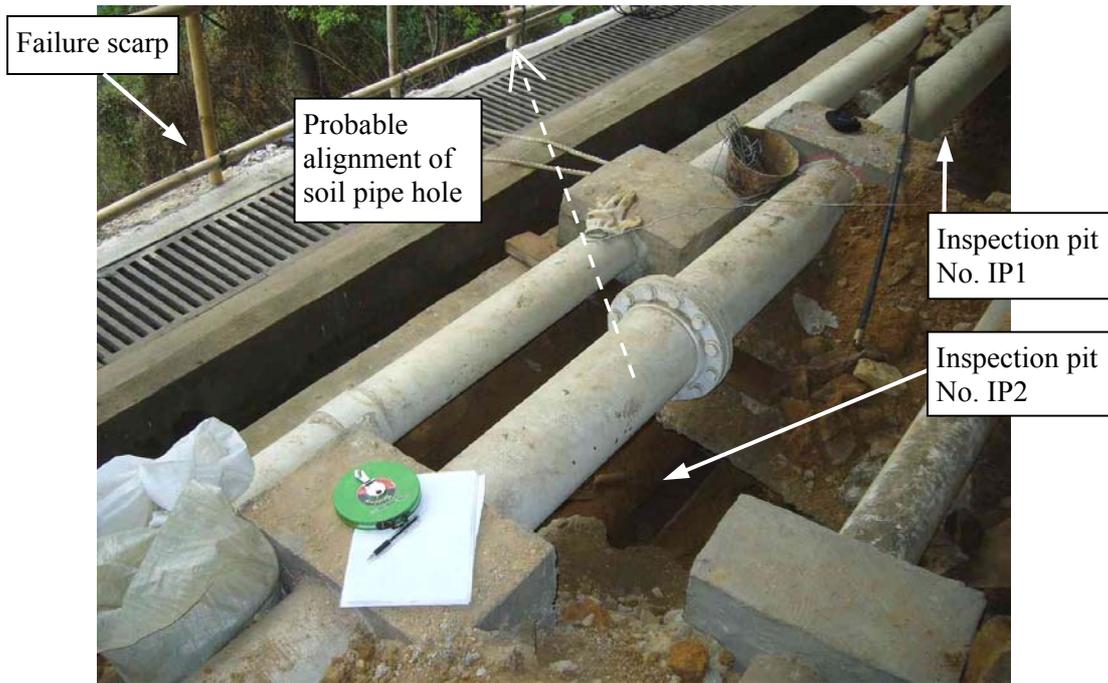


Plate10 - Suspected Leakage Flow Path Leading to the Landslide  
(Photograph taken on 27 March 2006)

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

APPENDIX A  
AERIAL PHOTOGRAPH INTERPRETATION

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## A1. DETAILED OBSERVATIONS

This appendix sets out the detailed observations made from an interpretation of aerial photographs taken between 1949 and 2004. A list of the aerial photographs studied is presented in Table A1 and the main observations of API are shown in Figure A1.

<u>YEAR</u>	<u>OBSERVATIONS</u>
-------------	---------------------

1949	The study area is located on the northeast-facing planar natural hillside of a north-south trending rounded spur, adjacent to the shoreline of Lai Chi Kok Bay and a broad valley. The hillside is generally sparsely vegetated.
------	--

The valley floor to the east of the study area comprises an amusement park with a pond and swimming pools. Several cut slopes have been formed along the toe of the natural hillside adjacent to the amusement park. A viewing pavilion has been built on the mid-slope of the natural hillside.

An apparent recent landslide scar is visible on the natural hillside, approximately 40 m uphill of the present-day location of slope No. 11NW-A/C150.

Five geomorphological features observed as shallow concave depressions (possibly relict instabilities) are visible on the natural hillside. Four of them are located to the south of the study area and the other one is located within the present-day boundary of slope No. 11NW-A/C150.

Minor unpaved tracks can be seen that traverse the natural hillsides. Various areas of anthropogenic disturbance, most probably as a result of military construction, consisting of shallow excavations and trenches are visible along the spurline and around the summit of the hill.

1963	The 1963 photographs are of good resolution and the terrain morphology is much clearer. Isolated rock outcrops are visible along the foothill area of natural hillside and in some locations on the mid-slope.
------	--

A roughly east running ephemeral drainage line traverses the natural hillside, near the present-day slope boundaries between slopes Nos. 11NW-A/C49 and 11NW-A/C150. Another southeast running ephemeral drainage line is located to the south of the study area.

A section of Lai King Hill Road (south of the study area) has been constructed to its present-day alignment. Slopes Nos. 11NW-A/C49 (southern lower portion) and 11NW-A/C403 (lower portion) have been formed by cutting into the natural hillside and appear to be bare. A man-made drainage channel can be seen along the crests of slopes Nos. 11NW-A/C49 and 11NW-A/C403.

The viewing pavilion has been demolished and a bare surface is visible. The natural hillside is generally covered with thin vegetation comprising grass and bushes.

**YEAR**      **OBSERVATIONS**

- 1964      The photographs only covered the northern portion of the study area.
- No observable changes.
- 1967      Extensive site formation works for the platforms of Princess Margaret Hospital (PMH) have been carried out along the spur.
- A squatter structure with its associated cut platform can be seen on the natural hillside, near the southern end of the present-day location of slope No. 11NW-A/C49.
- 1968      No observable changes, except site formation works of PMH were in progress.
- 1969      The foundation works of Blocks E and F of PMH was in progress.
- 1970      This single photograph shows no observable changes to the study area.
- 1972      Site formation works at Block J of PMH was in progress.
- A significant extent of fill material probably derived from construction of the platform of PMH was placed on the natural hillside, adjacent to the present-day locations of Block J and basketball court of PMH.
- 1973      Blocks E and F have been constructed and foundation works of Block J was in progress.
- A man-made drainage channel has been constructed, from Block J to Lai King Hill Road, traverses the natural hillside in December 1973.
- 1976      This single photograph shows Block J with associated podium and adjacent basketball court have been constructed.
- The construction of Lai Chi Kok Bay Garden was in progress. The northern portion of slope No. 11NW-A/C49 (lower portion) and southern portion of slope No. 11NW-A/C150 (lower portion) have been formed. Both slopes appear to be generally comprised of rock materials with uneven slope profiles.
- 1977      The construction of Lai Chi Kok Bay Garden has been completed together with an access road (a section of Lai King Hill Road) adjacent the study area.
- The works for the placement of pipelines along the mid-slope of the natural hillside (slope crest of the present-day slope No. 11NW-A/C49) was in progress.
- The natural hillside (the present-day upper portion of slope No. 11NW-A/C49) remains unchanged and covered with dense vegetation.
- The reclamation works at Lai Chi Kok Bay were in progress.

<u>YEAR</u>	<u>OBSERVATIONS</u>
1978	No observable changes.
1979	A patch of reflective material, possibly fill, can be seen on the natural hillside adjacent to the pipeline.
1980	No observable changes.
1981	No observable changes.
1982	This single photograph shows no observable changes to the study area.
1983	This single photograph shows no observable changes to the study area.
1985	A recent landslide scar can be seen at the toe of slope No. 11NW-A/C403.
1986	<p>The construction and widening works along the Lai King Hill Road were in progress by cutting into the natural hillside.</p> <p>The trim back of slopes Nos. 11NW-A/C49 (lower portion), 11NW-A/C150 and 11NW-A/C403 further uphill into the natural hillside was in progress.</p>
1987	No observable changes.
1988	<p>Slopes Nos. 11NW-A/C150, 11NW-A/C403 and the lower portion of slope No. 11NW-A/C49 have been formed to their present-day boundaries. Slope No. 11NW-A/C49 (lower portion) consists of 3 batters and a wall has been constructed along the slope crest. Slopes Nos. 11NW-A/C49, 11NW-A/C150 and 11NW-A/C403 are generally covered with hard surfaces (possibly chunam) with dull appearances, except the rock portions.</p> <p>Break in slopes are visible on the upper batter of slope No. 11NW-A/C49 and mid-slope of slope No. 11NW-A/C150, possibly failures occurred during formation of the captioned slopes.</p> <p>The natural hillside (the present-day upper portion of slope No. 11NW-A/C49) remains unchanged, except patches of reflective materials can be seen near the crest of the wall.</p>
1989	<p>Seepage can be seen on slope surfaces of slopes Nos. 11NW-A/C49 and 11NW-A/C150. A fence appears to have been erected along the coping of the retaining wall at about mid-height of slope No. 11NW-A/C49.</p> <p>Lai King Hill Road has been constructed and is in its present-day alignment.</p>
1990	A patch of bare surface can be seen on natural hillside near the crest of slope No. 11NW-A/C49, inferred as an area of instability.

<b><u>YEAR</u></b>	<b><u>OBSERVATIONS</u></b>
1992	The possible landslide scar mentioned in 1990 aerial photographs was generally covered with light vegetation.
1993	No observable changes.
1994	No observable changes.
1995	Single photograph. The study area is obstructed by Block J of PMH.
1996	No observable changes.
1997	No observable changes.
1998	No observable changes.
1999	No observable changes.
2001	No observable changes.
2002	No observable changes.
2003	Vegetation on the natural hillside (upper portion of slope No. 11NW-A/C49) appears to be cleared, possibly slope upgrading works were in progress.
2004	The upper portion of slope No. 11NW-A/C49 appears to be covered with hydroseeding net.

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Table A1 - List of Aerial Photographs used in Aerial Photograph Interpretation

Date Taken	Altitude (ft)	Photograph Number
24 April 1949	8000	Y01728-29
25 November 1963	2700	Y08096-97
27 December 1964	2700	Y10936-37
1968	2000	Y14235-36
1969	Unknown	Y14868-69
1970	1200	Y16012
28 December 1972	1600	2878-79
23 October 1973	6000	5313-14
10 December 1973	3000	6886
19 August 1976	2500	14755
21 December 1977	4000	20247
7 December 1978	4000	24098-99
1 October 1979	4000	27318
28 November 1979	10000	28073
17 April 1980	4000	30145-46
6 October 1982	4000	44169
28 September 1983	4000	49834-35
3 October 1984	4000	56208
4 October 1985	15000	A02654-55
22 September 1986	4000	A06298
4 October 1987	4000	A10580-81
6 October 1988	4000	A14707-08
29 March 1989	8000	CN2169-70
21 March 1990	4000	A20920-21
20 October 1992	4000	A32725-26
2 November 1993	4000	A36069-71
20 October 1994	4000	A39296-97
27 September 1995	3500	CN11317
15 May 1996	4000	CN13401-02
26 May 1997	4000	CN17284-85
31 October 1998	4000	CN21257-58
11 June 1999	2600	CN23207-08
15 March 2001	4000	CW30131-32
3 January 2002	2000	CW37943-44
26 November 2003	4000	CW53655-56
10 February 2004	8000	CW55355-56
20 April 2004	4000	CW57032
Note: All aerial photographs are in black and white except for those prefixed with CN, CW or RW.		

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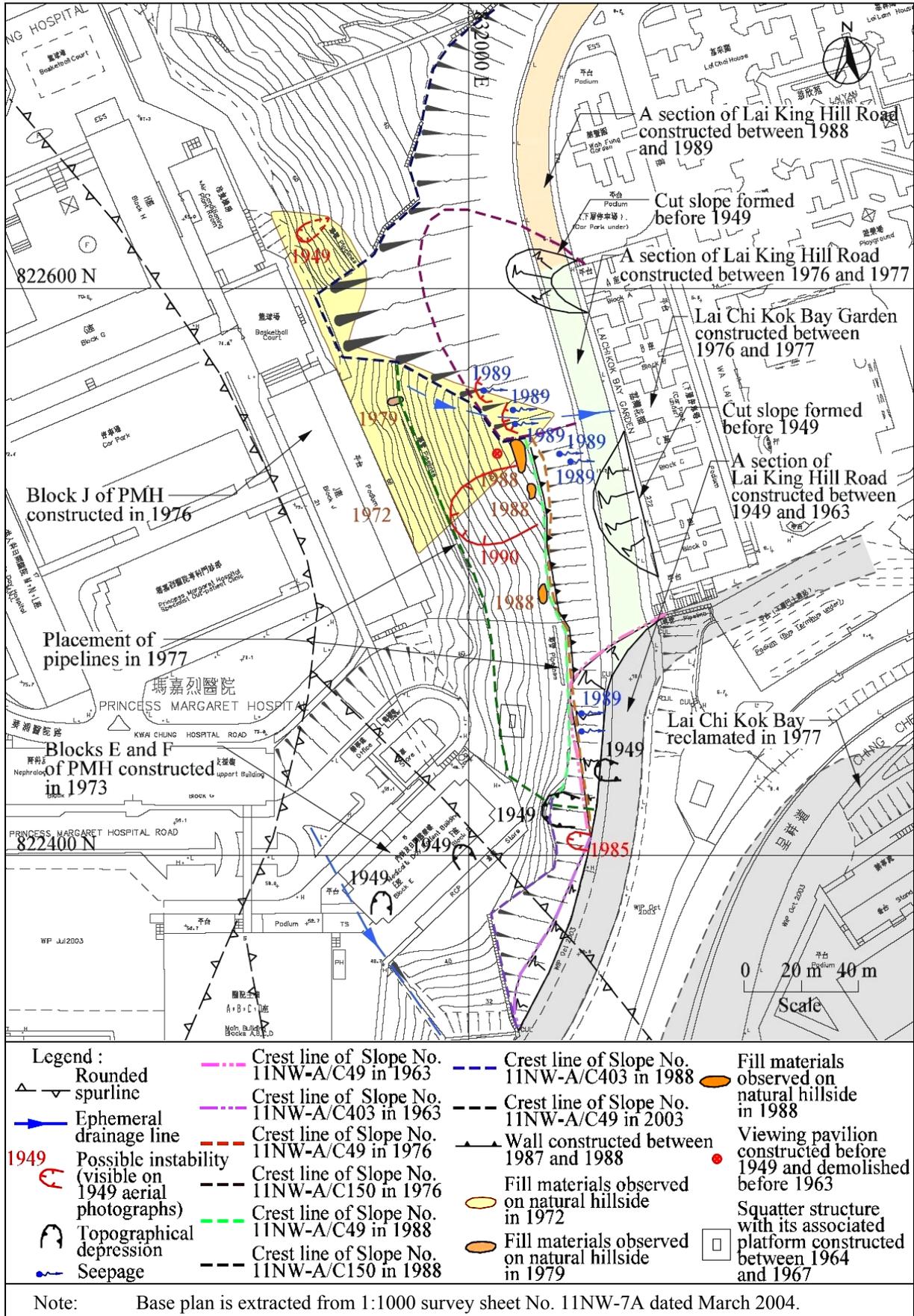


Figure A1 - Aerial Photograph Interpretation

APPENDIX B

LABORATORY TEST RESULTS OF WATER SAMPLES

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ALS TECHNICHEM (HK) Pty Ltd



**ALS Environmental**  
**CERTIFICATE OF ANALYSIS**

<b>CONTACT:</b>	MR ALLEN CHENG	<b>Batch:</b>	HK38474
<b>CLIENT:</b>	INTER PACIFIC LIMITED	<b>Sub Batch:</b>	0
<b>ADDRESS:</b>	FLAT B 11/F KIU FU COMM BLDG NO 300 LOCKHART ROAD WANCHAI HONG KONG	<b>LABORATORY:</b>	HONG KONG
		<b>DATE RECEIVED:</b>	16/08/2005
		<b>DATE OF ISSUE:</b>	02/09/2005
		<b>SAMPLE TYPE:</b>	WATER
<b>ORDER No.:</b>	50205/LKHR/GI-1	<b>No. of SAMPLES:</b>	6
<b>PROJECT:</b>	LAI KING HILL ROAD		

**COMMENTS**

Water samples were received in a chilled condition. Samples analysed on an as received basis. Results reported on an as received basis. The completion date of analysis is 29 August, 2005. Project Name: Landslide Site at Natural Hillside above Slope No. 11NW-A/C49, Lai King Hill Road, Kwai Chung, N.T.

**NOTES**

This is the Final Report and supersedes any preliminary reports with this batch number. Results apply to sample(s) as submitted. All pages of this report have been checked and approved for release.

**ISSUING LABORATORY: HONG KONG**

**Address**

ALS Technichem (HK) Pty Ltd  
11/F.,  
Chung Shun Knitting Centre,  
1-3 Wing Yip Street  
Kwai Chung, N.T.,  
Hong Kong.

**Phone:** 852-2610 1044  
**Fax:** 852-2610 2021  
**Email:** hongkong@alsenviro.com

  
\_\_\_\_\_  
Alice W M Wong  
Laboratory Manager - Hong Kong

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Santiago  
Antofagasta  
Lima

Abbreviations: % SPK REC denotes percentage spike recovery  
CHK denotes duplicate check sample  
LOR denotes limit of reporting  
LCS % REC denotes Laboratory Control Sample percentage recovery

**Batch:** HK38474  
**Sub Batch:** 0  
**Date of Issue:** 02/09/2005  
**Client:** INTER PACIFIC LIMITED  
**Client Reference:** LAI KING HILL ROAD

## CERTIFICATE OF ANALYSIS



		SAMPLE IDENTIFICATION											
		Laboratory I.D.		1	2	3	4	5	6				
		Date Sampled		16/08/2005	16/08/2005	16/08/2005	16/08/2005	16/08/2005	16/08/2005				
METHOD	ANALYSIS DESCRIPTION	UNIT	LOR	T1	T2	T3	T4	T5	T6				
EA-002	pH Value @ 25°C		0.1	7.7	7.2	7.7	7.2	8.0	7.6				
EA-010	Conductivity @ 25°C	uS/cm	1	54	2790	1410	3450	32	216				
EA-020	Salinity	g/L	0.1	<0.1	1.4	0.7	1.8	<0.1	<0.1				
ED-045	Chloride	mg/L	1	2	794	372	993	2	45				
EK-055A	Ammonia as N	mg/L	0.01	0.04	0.04	0.03	1.95	0.04	0.04				
EP-026	Chemical Oxygen Demand	mg/L	2	<2	5	9	7	<2	<2				

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**Batch:** HK38474  
**Sub Batch:** 0  
**Date of Issue:** 02/09/2005  
**Client:** INTER PACIFIC LIMITED  
**Client Reference:** LAI KING HILL ROAD

## QUALITY CONTROL REPORT



		SAMPLE IDENTIFICATION									
		Laboratory I.D.	200	201							
		Date Sampled									
METHOD	ANALYSIS DESCRIPTION	UNIT	LOR	BLANK	LCS % REC						
		CHECKS AND SPIKES									
EA-002	pH Value @ 25°C		0.1	---	---						
EA-010	Conductivity @ 25°C	uS/cm	1	<1	99%						
EA-020	Salinity	g/L	0.1	---	---						
ED-045	Chloride	mg/L	1	<1	101%						
EK-055A	Ammonia as N	mg/L	0.01	<0.01	101%						
EP-026	Chemical Oxygen Demand	mg/L	2	---	110%						

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CERTIFICATE OF ANALYSIS

<b>CONTACT:</b>	MR ALLEN CHENG	<b>Batch:</b>	HK38474
<b>CLIENT:</b>	INTER PACIFIC LIMITED	<b>Sub Batch:</b>	1
<b>ADDRESS:</b>	FLAT B 11/F KIU FU COMM BLDG NO 300 LOCKHART ROAD WANCHAI HONG KONG	<b>LABORATORY:</b>	HONG KONG
<b>ORDER No.:</b>	50205/LKHR/GI-1	<b>DATE RECEIVED:</b>	16/08/2005
<b>PROJECT:</b>	LAI KING HILL ROAD	<b>DATE OF ISSUE:</b>	26/08/2005
		<b>SAMPLE TYPE:</b>	WATER
		<b>No. of SAMPLES:</b>	6

COMMENTS

Sample analysed on an as received basis. Results reported on an as received basis.

NOTES

This is the Final Report and supersedes any preliminary report with this batch number. Results apply to sample(s) as submitted. All pages of this report have been checked and approved for release.

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**Address**

ALS Technichem (HK) Pty Ltd  
11/F  
Chung Shun Knitting Centre  
1-3 Wing Yip Street  
Kwai Chung  
HONG KONG

**Phone:** 852-2610 1044  
**Fax:** 852-2610 2021  
**Email:** hongkong@alsenviro.com

Ivan S H Leung  
Supervisor - Microbiology & Ecotoxicology

*Other ALS Environmental Laboratories*

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*Abbreviations: % SPK REC denotes percentage spike recovery  
CHK denotes duplicate check sample  
LOR denotes limit of reporting  
LCS % REC denotes Laboratory Control Sample percentage recovery*

# CERTIFICATE OF ANALYSIS



**Batch:** HK38474  
**Sub Batch:** 1  
**Date of Issue:** 26/08/2005  
**Client:** INTER PACIFIC LIMITED  
**Client Reference:** LAI KING HILL ROAD

				SAMPLE IDENTIFICATION							
				1	2	3	4	5	6		
				16/08/2005	16/08/2005	16/08/2005	16/08/2005	16/08/2005	16/08/2005		
				T1	T2	T3	T4	T5	T6		
METHOD	ANALYSIS DESCRIPTION	UNIT	LOR								
EM-002	E. coli	cfu/100 mL	1	20	2.5x10 <sup>2</sup>	9.6x10 <sup>2</sup>	1.2x10 <sup>2</sup>	1.8x10 <sup>5</sup>	4.0x10 <sup>4</sup>		

**Test Method :**

E. coli (MFM) determination was conducted in accordance with Bacteriological Examination of Drinking Water Supplies 1982, Department of the Environment (1983), Section 7.8 & 7.9. plus in-situ urease test (Dufour AP & Cabelli VJ (1975) Appl. Environ. Microbiol. 29: 826-833.)

**Confirmation Test :**

E. coli (MFM) : Lactose peptone water for acid & gas productions. Tryptone water and Kovacs' reagent for indole Test.

**Note :**

MFM' = membrane filtration method, 'cfu' = colony forming unit, '<1' = Not Detected

Sampling Method :	Sample was collected by client.	Sample Receiving Time :	16/08/2005	11:00
Conditions of Sample(s) Received :	Sample, in glass bottles labelled sterile, was received in a cool condition, with 0.2mL of 1.8% sodium thiosulphate solution.	Test Starting Time :	17/08/2005	09:00
Quantity of Each Sample Received :	100mL	Testing Period:	17-19/08/2005	

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**CERTIFICATE OF ANALYSIS**

<b>CONTACT:</b>	MR ALLEN CHENG	<b>Batch:</b>	HK38474
<b>CLIENT:</b>	INTER PACIFIC LIMITED	<b>Sub Batch:</b>	2
<b>ADDRESS:</b>	FLAT B 11/F KIU FU COMM BLDG NO 300 LOCKHART ROAD WANCHAI HONG KONG	<b>LABORATORY:</b>	HONG KONG
<b>ORDER No.:</b>	50205/LKHR/GI-1	<b>DATE RECEIVED:</b>	16/08/2005
<b>PROJECT:</b>	LAI KING HILL ROAD	<b>DATE OF ISSUE:</b>	02/09/2005
		<b>SAMPLE TYPE:</b>	SOIL
		<b>No. of SAMPLES:</b>	1

**COMMENTS**

soil sample was received in a chilled condition. Samples analysed on an as received basis. Results reported on an as received basis. pH determined and reported on 1:5 soil/water extract. The completion date of analysis is 29 August,2005.

**NOTES**

This is the Final Report and supersedes any preliminary reports with this batch number. Results apply to sample(s) as submitted. All pages of this report have been checked and approved for release.

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**Address**

ALS Technichem (HK) Pty Ltd  
11/F.,  
Chung Shun Knitting Centre,  
1 Wing Yip Street  
Kwai Chung, N.T.,  
Hong Kong.

**Phone:** 852-2610 1044  
**Fax:** 852-2610 2021  
**Email:** hongkong@alsenviro.com

  
\_\_\_\_\_  
Alice W M Wong  
Laboratory Manager - Hong Kong

**Other ALS Environmental Laboratories**

**AUSTRALASIA**

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*Abbreviations: % SPK REC denotes percentage spike recovery*

*CHK denotes duplicate check sample*

*LOR denotes limit of reporting*

*LCS % REC denotes Laboratory Control Sample percentage recovery*

ALS TECHNICHEM (HK) PTY LTD

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A Campbell Brothers Limited Company

**Batch:** HK38474  
**Sub Batch:** 2  
**Date of Issue:** 02/09/2005  
**Client:** INTER PACIFIC LIMITED  
**Client Reference:** LAI KING HILL ROAD

## CERTIFICATE OF ANALYSIS



		SAMPLE IDENTIFICATION										
		Laboratory I.D.	7									
		Date Sampled	16/08/2005									
		T7										
METHOD	ANALYSIS DESCRIPTION	UNIT	LOR	T7								
EA-002	pH Value @ 25°C		0.1	7.3								
EA-010	Conductivity @ 25°C	uS/cm	1	22								
EA-020	Salinity	mg/kg	1	<1								
ED-045	Chloride	mg/kg	1	28								
EK-055A	Ammonia as N	mg/kg	0.01	44.5								
EP-026	Chemical Oxygen Demand	mg/kg	2	4440								

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**Batch:** HK38474  
**Sub Batch:** 2  
**Date of Issue:** 02/09/2005  
**Client:** INTER PACIFIC LIMITED  
**Client Reference:** LAI KING HILL ROAD

## QUALITY CONTROL REPORT



				SAMPLE IDENTIFICATION															
				Laboratory I.D.	200	201													
				Date Sampled															
METHOD	ANALYSIS DESCRIPTION	UNIT	LOR	BLANK	LCS % REC														
				CHECKS AND SPIKES															
EA-002	pH Value @ 25°C		0.1	—	—														
EA-010	Conductivity @ 25°C	uS/cm	1	<1	100%														
EA-020	Salinity	mg/kg	1	—	—														
ED-045	Chloride	mg/kg	1	<1	100%														
EK-055A	Ammonia as N	mg/kg	0.01	<0.01	100%														
EP-026	Chemical Oxygen Demand	mg/kg	2	—	92%														

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CERTIFICATE OF ANALYSIS

<b>CONTACT:</b>	MR ALLEN CHENG	<b>Batch:</b>	HK38474
<b>CLIENT:</b>	INTER PACIFIC LIMITED	<b>Sub Batch:</b>	3
<b>ADDRESS:</b>	FLAT B 11/F KIU FU COMM BLDG NO 300 LOCKHART ROAD WANCHAI HONG KONG	<b>LABORATORY:</b>	HONG KONG
<b>ORDER No.:</b>	50205/LKHR/GI-1	<b>DATE RECEIVED:</b>	16/08/2005
<b>PROJECT:</b>	LAI KING HILL ROAD	<b>DATE OF ISSUE:</b>	26/08/2005
		<b>SAMPLE TYPE:</b>	SOIL
		<b>No. of SAMPLES:</b>	1

COMMENTS

Sample analysed on an as received basis. Results reported on an as received basis.  
Soil sample was leached with 1:10 soil/water extract.

NOTES

This is the Final Report and supersedes any preliminary report with this batch number.  
Results apply to sample(s) as submitted. All pages of this report have been checked and approved for release.

ISSUING LABORATORY: HONG KONG

**Address**

ALS Technichem (HK) Pty Ltd  
11/F  
Chung Shun Knitting Centre  
1-3 Wing Yip Street  
Kwai Chung  
HONG KONG

**Phone:** 852-2610 1044  
**Fax:** 852-2610 2021  
**Email:** hongkong@alsenviro.com

Ivan S H Leung  
Supervisor - Microbiology & Ecotoxicology

**Other ALS Environmental Laboratories**

<b>AUSTRALIA</b>	<b>AMERICAS</b>
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Abbreviations: % SPK REC denotes percentage spike recovery  
CHK denotes duplicate check sample  
LOR denotes limit of reporting  
LCS % REC denotes Laboratory Control Sample percentage recovery

**Batch:** HK38474  
**Sub Batch:** 3  
**Date of Issue:** 26/08/2005  
**Client:** INTER PACIFIC LIMITED  
**Client Reference:** LAI KING HILL ROAD

## CERTIFICATE OF ANALYSIS



		SAMPLE IDENTIFICATION							
		Laboratory I.D.	7						
		Date Sampled	16/08/2005						
		UNIT	LOR	T7					
METHOD	ANALYSIS DESCRIPTION	UNIT	LOR	<3.0					
EM-002	<i>E. coli</i>	MPN/ml	3	<3.0					

**Note :**

MPN' most probable number, '<'=less than, 'ND'=Not Detected  
 MFM' = membrane filtration method, 'cfu' = colony forming unit, '<1 ' = Not Detected

**Sampling Method :** Sample was collected by client.  
**Conditions of Sample(s) Received :** Sample, in plastic bottles labelled sterile, was received in a cool condition.

**Sample Receiving Time :** 16/08/2005 11:00  
**Test Starting Time :** 17/08/2005 15:15  
**Testing Period:** 17-22/08/2005

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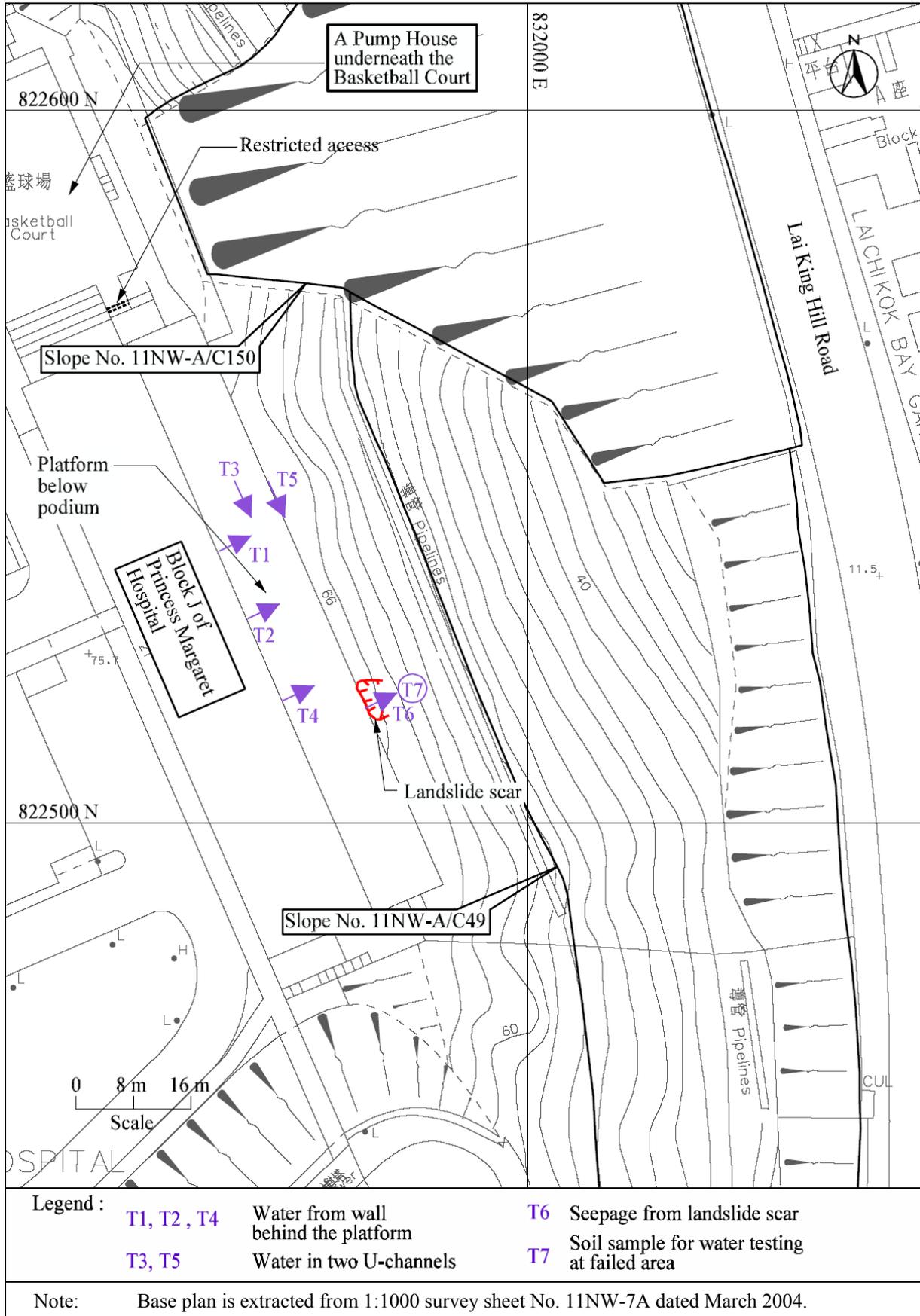


Figure B1 - Locations of Water Sampling for Laboratory Test

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

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電話: (852) 2762 5346  
傳真: (852) 2714 0275  
電子郵件: [wmcheung@cedd.gov.hk](mailto:wmcheung@cedd.gov.hk)

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### 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.

### 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.

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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.

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TGN 1 Technical Guidance Documents