

Appendix 8

Geotechnical Planning Review Report



Document Verification

Job title		SECTION 16 PLANNING APPLICATION FOR THE PROPOSED RESIDENTIAL DEVELOPMENT AT NO. 66 DEEP WATER BAY ROAD, SHOUSON HILL, HONG KONG		Job number	
Document title		GEOTECHNICAL PLANNING REVIEW REPORT		DWB66 File reference DWB66/GPRR-01	
Document ref					
Revision	Date	Filename			
0	April 2025		Prepared by	Checked by	Approved by
		Name	Jacky Ip	Thomas Chui	Thomas Chui
		Signature			
		Filename			
			Prepared by	Checked by	Approved by
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		Signature			
		Filename			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

AP	RSE	RGE
Name: Date:	Name: Date:	Name: Date:

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1. Background

C M Wong & Associates Ltd. Was appointed to carry out Geotechnical Planning Review Report (GPRR) for Section 16 Planning Application for the proposed Residential Development at No. 66 Deep Water Bay Road, Shouson Hill, Hong Kong

This GPRR is carried out based on desk study and review of available documentary information and proposed development plan. The geology and site conditions are described. Potential geotechnical constraints are identified in this assessment.

2. The Site and the Existing Geotechnical Features

The site is located at no. 66 Deep Water Bay Road, Shouson Hill. The site is connected to Deep Water Bay road via an access road from the north-east corner of the site. Site photos taken in February 2025 are presented in Appendix A (see Photos 1 to 3). The site location plan is provided in figure no. 1.

According to the available SIS records obtained from Geotechnical Engineering Office (GEO), there are 4 existing geotechnical features located in the vicinity of the site. Existing geotechnical feature no. 11SW-D/C1854 is partly lies within the northwestern of the Site. The existing geotechnical feature no. 11SW-D/C1853 is outside lot and located to the west of the existing access road between Deep Water Bay Road and the subject site. Geotechnical feature nos. 15NW-B/C399 and 11SW-D/CR1868 are located immediately outside and about 5m from the southeastern of the site boundary, respectively. The feature location plan is provided in figure no. 2.

3. Desk Study

Desk study has been carried out to search and review the existing building records, previous ground investigation data and geotechnical study reports kept by the Geotechnical Information Unit (GIU) of Geotechnical Engineering Office (GEO) and the Buildings Department (BD).

3.1 Geological Maps.

The geology of the Study Area is shown on the Hong Kong Geological Survey (HKGS) Map Sheet 11 & 15, 1:20,000 - scale HGM20 series. The local geology of the Study Area is presented in Figure 3 and described below.

The geological maps indicated that majority of area is underlain by “Eutaxitic, crystal-bearing fine ash vitric tuff” (Kra_e) of Ap Lei Chau Formation, Repulse Bay Volcanic Group. With a narrow strip along the northern boundary of the site is underlain by “Undivided, mainly crystal-bearing fine ash vitric tuff” (Kra_fvt) of Ap Lei Chau Formation, Repulse Bay Volcanic Group. No fault or photo lineament has been recorded within or in the vicinity of the site.

3.2 Enhanced Natural Terrain Landslide Inventory

In 1995, the GEO compiled the Natural Terrain Landslide Inventory (NTLI) from an interpretation of high - altitude (8,000ft and above) aerial photographs dated from 1945 to 1994 (King, 1999). In 2007, the GEO produced an Enhanced Natural Terrain Landslide Inventory (ENTLI) using low-altitude (8,000ft and below) aerial photographs to update the NTLI.

In accordance with GEO Report No. 138 (GEO, 2016), landslides are classed as either “Relict” or “Recent”, depending on their appearance in aerial photographs. “Relict” landslides are defined as those where the main scarp is well-defined but vegetation has re-established on the scar on the earliest set of available aerial photographs. “Recent” landslides are defined as having occurred within the timespan of the aerial photograph coverage. These are typically identified as having a light tone on the aerial photographs and are bare of vegetation.

The ENTLI has recorded none relict / recent landslides within and in the vicinity of the Site.

3.3 Large Landslide Inventory

The Large Landslide Inventory was compiled by Scott Wilson Ltd. under Agreement No. CE39/98 “Specialist API Services for the Natural Terrain Landslide Study” (1999a and 1999b). According to the Large Landslide Inventory, there are no features recorded within and in the vicinity of the Site.

3.4 Reported Landslide Incidents

There were two previous incidents located about the location of feature 11SW-D/C1853 before site formation for the access road for the previous development of the site.

Incident no. 33/11SW-D recorded in a landslide on 17 June 1983. The landslide located the access road to the site about 60m from the northern boundary. The inspection was carried out on 12 July 1983. The description of failure was “Shallow soil slip due to poor drainage”. The depth of failure was 1.5m and for a breath of 5.5m. The debris was removed prior to inspection.

Incident no. 34/11SW-D recorded in a landslide on 17 June 1983. The landslide located the access road to the site about 70m from the northern boundary. The inspection was carried out on 12 July 1983. The description of failure was also “Shallow soil slip due to poor drainage”. The depth of failure was 1.5m and for a breath of 2.5m. The debris was removed prior to inspection.

The incident reports were provided in appendix B.

3.5 Natural Terrain Hazard studies

A Stage 2 (H) report no. S2(H)R 20/2013 was prepared by Fugro (Hong Kong) Limited in August 2013 to a study area 11SW-D/SA12 – Shouson Hill, Hong Kong Island (East). The study area included the natural slope to the north of the subject site and named as Study Area NHC1 and no potential hazard is identified to the natural slope above the subject site. A Stage 3 (H) report no. S3(H)R 019/2013 was prepared by Fugro (Hong Kong) Limited in January 2014 to the same study area as the aforementioned stage 2 (H) report to design of the necessary mitigation works. And no proposed mitigation works required for the natural slope above the subject site. Extract of the Stage 2 (H) and Stage 3 (H) report is provided in appendix B.

The subject site is located below natural terrain and meets the alert criteria for a Natural Terrain Hazard Study (NTHS). A NTHS will be carried out in detail design stage, the study will carry out a review including but not limited to a desk study, detailed aerial photograph interpretation and site reconnaissance to ascertain that the findings of the previous study are still valid and applicable to the proposed development. Mitigation measures such as flexible barrier may be proposed if found necessary after the study.

3.6 Buildings Department (BD) Records.

BD reference 3/3018/87 contains the footings plan for the existing buildings at no. 66 Deep Water Bay Road. The buildings were supported by strip footings with 1m thick and they were founded on Grade III or better rock with bearing capacity of 3000kPa.

BD reference 6/3018/87 contains the site formation plans for the existing development and the access road to the site. The sections in the site formation plans indicated the northern portion of the site was formed by cutting into rock. Extract of the BD record is provided in appendix C.

3.7 GIU records

GIU reference no. 15555 contains GI record for Borehole BH2 to BH10 carried out for the existing development of subject site. A summary of finding of these existing boreholes is as follows:

Borehole Identification	Sub-soil Profile			
	Fill (mPD)	CDG (mPD)	C to HDG (mPD)	Grade III Rock (mPD)
BH-2	+83.11 to +82.44 (concrete & brick)	-	+82.44 to +78.66	+78.66 (Cat 1(c) Rock Head)
BH-3	+84.66 to +83.69	+83.69 to 81.10	-	+81.10 (Cat 1(c) Rock Head)
BH-4	+91.08 to +91.08	-	-	+90.08 (Cat 1(c) Rock Head)
BH-5	-	-	-	+101.20 (Cat 1(c) Rock Head)
BH-6	+92.38 to +91.78	-	-	+91.78 (Cat 1(c) Rock Head)
BH-7	+106.20 to +106.00	-	+106.00 to +104.20	+104.20 (Cat 1(c) Rock Head)
BH-8	+93.07 to +92.72	-	-	+92.72 (Cat 1(c) Rock Head)
BH-9	+85.38 to +85.08	-	+85.08 to +78.38	+78.38 (Cat 1(c) Rock Head)

BH-10	-	+71.48 to 68.58	-	+68.58 (Cat 1(c) Rock Head)
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The existing GI location plan is provided in figure 4. And borehole logs for these existing drillholes are provided in Appendix D.

4. Impacts of proposed works on existing Geotechnical Features

Feature no. 11SW-D/C1854

Feature no. 11SW-D/C1854 is located at the northern side of the site. Sub-division no. 2 of the feature lie within the site while sub-division no. 1 of the feature is immediately outside the site. According to the SIS record, the slope has a maximum height about 10m with 65m long measured along its toe, and the average slope gradient is about 70 degrees to the horizontal. BD record indicated the feature was formed during site formation of the existing development of the site.

Feature no. 15NW-B/C399

Feature no. 15NW-B/C399 is located immediate outside the south-eastern boundary. According to the SIS record, the slope has a maximum height about 4m with 25m long measured along its toe, and the average slope gradient is about 40 degrees to the horizontal.

Feature no. 15NW-B/C1853

Feature no. 15NW-B/C1853 is located about 5m to the north of the northern lot boundary and it is at the west of the access road leading to Deep Water Bay road. According to the SIS record, the slope has a maximum height about 20m with 88m long measured along its toe, and the average slope gradient is about 41 degrees to the horizontal.

Feature no. 11SW-D/CR1868

Feature no. 11SW-D/CR1868 is located about 5m away from the south-eastern site boundary. According to the SIS record, the slope portion has a maximum height about 9.4m with 121m long measured along its toe, and the average slope gradient is about 64 degrees to the horizontal. And the wall portion has a maximum height of about 1.8m with a length of about 7.6m.

Impacts of proposed works on existing Geotechnical Features

The proposed development consists of construction for two 3-storey houses with a basement. The schematic geotechnical works for the proposed development are discussed below (Figure no. 5 to 9):-

The schematic geotechnical works consists of foundation works with mini-piles and raft footings, ELS with temporary rock/soil cut slope and pipe pile wall, and construction of retaining wall. Detail site formation proposal shall be submitted to Buildings Department for approval.

Since Feature no. 11SW-D/C1854 is partly located within the application site, the stability on the geotechnical feature shall be assessed in detail under a separate submission. Site formation works / slope upgrading works such as installation of rock dowel/soil nails works will be proposed in the site formation design / slope upgrading design submission if the stability of such geotechnical feature cannot fulfil the current engineering standards.

Feature no. 15NW-B/C399 is located immediate outside the south-eastern boundary. The proposed works in the development will be designed such that the effect to this feature will be insignificant.

Since Feature no. 11SW-D/C1853 is located outside lot, adjoining to the access road. The feature is formed under the site formation work of the access road during the previous development of the subject site. The maintenance responsible of the feature lies with the subject lot. The stability on this geotechnical feature shall be assessed in detail under a separate submission. Site formation works / slope upgrading works such as installation of rock dowel/soil nails works will be proposed in the site formation design / slope upgrading design submission if the stability of such geotechnical feature cannot fulfil the current engineering standards.

Since Feature no. 11SW-D/CR1868 is located outside the subject site and located about 5m to the south-eastern boundary of the site. The feature is located within lot RBL 667 &Ext. and the maintenance responsibility lies with lot RBL 667 &Ext. There is no checking record for this feature. The proposed works in the development will be designed such that the effect to this feature will be insignificant.

Temporary working platform may be required to facility the foundation work and ELS construction works. The design of the temporary working platform (if any) will be such that the effect to the slopes in the vicinity of the site will be insignificant.

5. Conclusion

Based on the above discussion, it can be concluded that the proposed residential development is considered to be feasible from geotechnical point of view. The existing feature within site shall be upgraded to the current engineering standards if the stability of such geotechnical features are found below standards. For features located outside the site, the proposed works in the development will be designed such that the effect to outside site features will be insignificant.

It is essential to search and review the background information of existing building, geotechnical feature and underground services within and in the vicinity of the site. Site investigation is proposed to reveal/confirm the subsoils and the ground regime within and in the vicinity of the site as well as to determine the engineering properties of subsoils and rock. The ground investigation field works should be preceded under supervision of suitably qualified engineers and technically competent persons conforming the requirements specified in the "Code of Practice for Site Supervision 2009" published by the BD.

For safety and cost effective, the foundation design and slope/retaining wall stability assessment and excavation planning as well as the design of geotechnical structure should be based on geological horizons inferred from the ground investigation results, groundwater table interpreted from the piezometer / standpipe monitoring records and geotechnical parameters determined and adopted by field and laboratory testing.

The subject site is located below steep natural terrain and meets the alert criteria for a Natural Terrain Hazard Study (NTHS). A NTHS will be carried out in detail design stage.

A comprehensive precautionary monitoring program including settlement markers, tilting, vibration check points as well as groundwater observation wells shall be implemented to ensure demolition of foundation of existing buildings and substructure construction being carried out safety and soundly.

FIGURES



Figure 1



Legend:
 The Application Site

PROJECT
SECTION 16 PLANNING APPLICATION
FOR THE PROPOSED RESIDENTIAL
DEVELOPMENT AT NO. 66 DEEP WATER
BAY ROAD, SHOUSON HILL, HONG KONG

DRG. TITLE	DRG. NO
SITE LOCATION PLAN	FIG-01
SCALE 1:5000 IN A3	DATE MAY 2025

CMA C M WONG & ASSOCIATES LTD
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E-mail: cmwal@cmwal.com

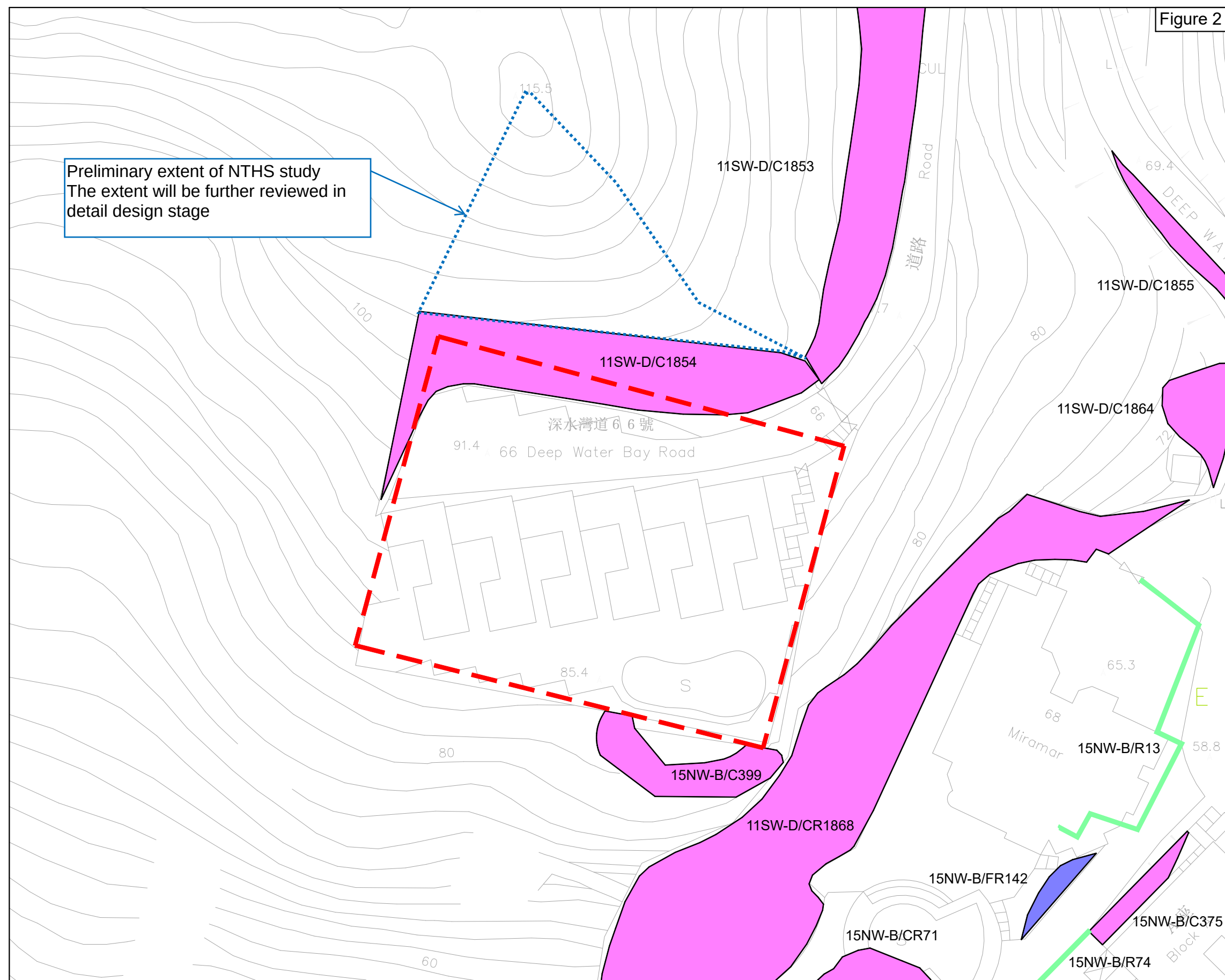


Figure 2



Legend:



The Application Site

Existing Geological Feature



Fill Slope



Cut Slope



Retaining Wall

PROJECT

SECTION 16 PLANNING APPLICATION
FOR THE PROPOSED RESIDENTIAL
DEVELOPMENT AT NO. 66 DEEP WATER
BAY ROAD, SHOUSON HILL, HONG KONG

DRG. TITLE
FEATURES LOCATION PLAN

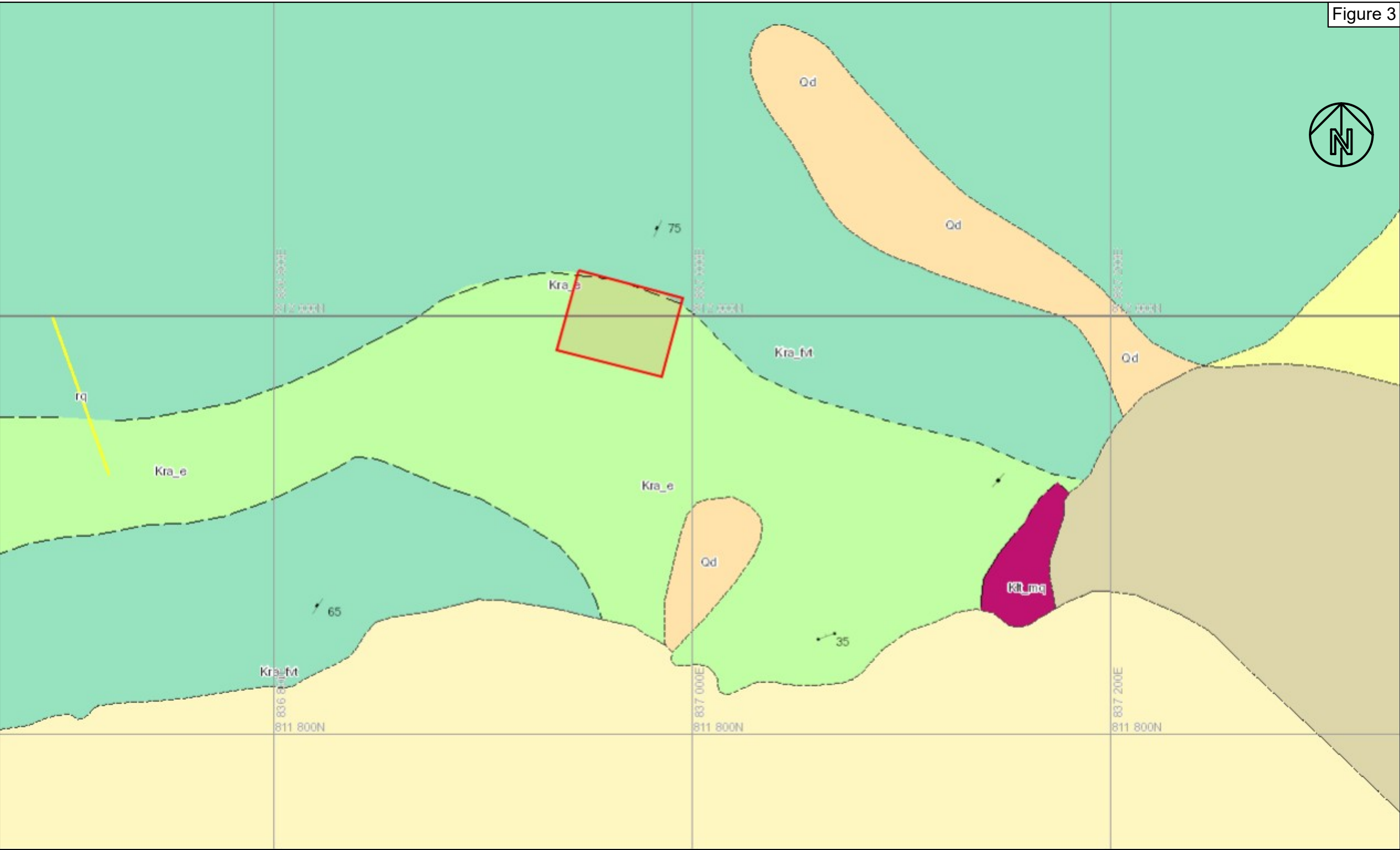
DRG. NO	FIG-02
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SCALE	1:500 IN A3
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DATE	MAY 2025
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Legend:

The Application Site

Hong Kong Geological Survey Sheet 11 and 15
Solid and superficial geology (2010 & 2012)

Qd Colluvium (Silt, and gravel with boulders)

Klt_m Porphyritic fine- to medium-grained quartz monzonite, Tei Tong Tsui Quartz Monzonite, Lion rock suit

Kra_e Eutaxitic, crystal-bearing fine ash vitric tuff, Ap Lei Chau Formation, Repulse Bay Volcanic Group

Kra_ft Undivided, mainly crystal-bearing fine ash vitric tuff, Ap Lei Chau Formation, Repulse Bay Volcanic Group

PROJECT	
DRG. TITLE	DRG. NO
GEOLOGICAL MAP	FIG-03
SCALE 1:2000 IN A3	DATE MAY 2025
CMA C M WONG & ASSOCIATES LTD TEL: (852) 2522 1068 E-mail: cmwal@cmwal.com	

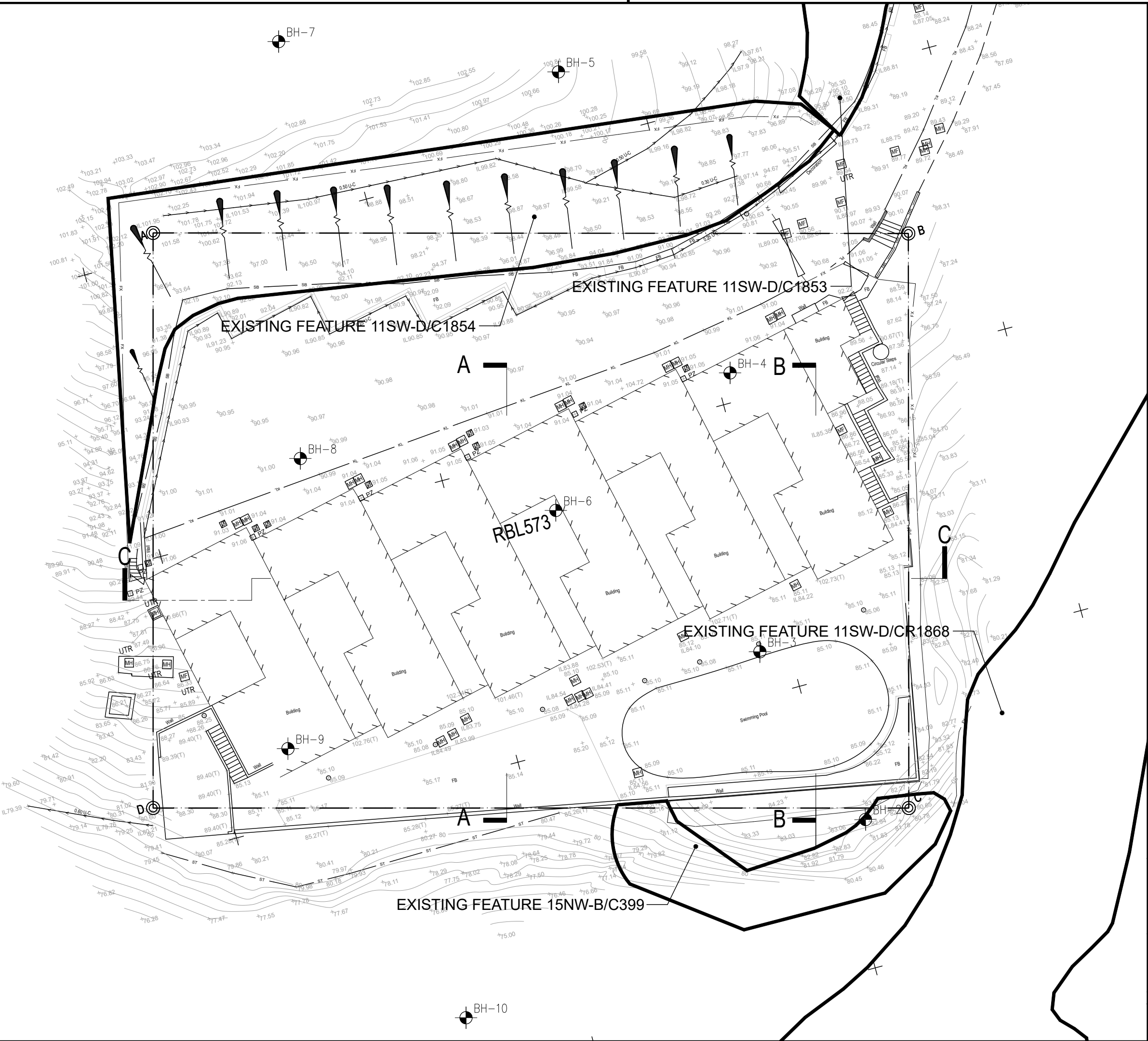
Legend:



THE APPLICATION SITE



EXISTING BOREHOLE
GIU REPORT NO. 15554



PROJECT
SECTION 16 PLANNING APPLICATION
FOR THE PROPOSED RESIDENTIAL
DEVELOPMENT AT NO. 66 DEEP
WATER BAY ROAD, SHOUSON HILL,
HONG KONG

DRG. TITLE
EXISTING BOREHOLE
LOCATION PLAN

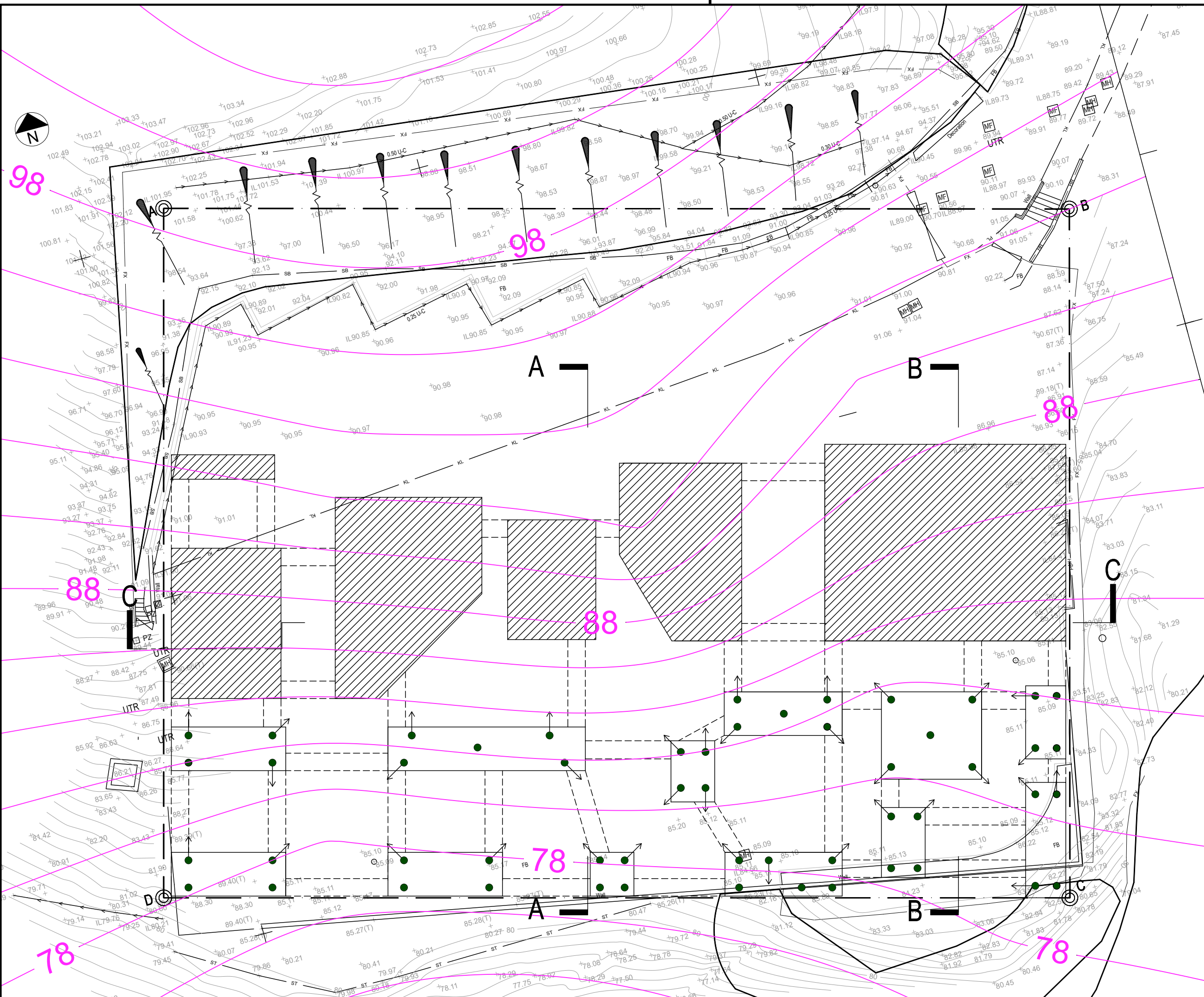
DRG. NO

FIG-04

SCALE 1:250 IN A3

DATE MAY 2025

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Legend:

- THE APPLICATION SITE
- PRELIMINARY CONTOUR LEVEL OF CATEGORY I(C) ROCK
- PROPOSED FOOTING
- PROPOSED PILE CAP
- PROPOSED TIE BEAM
- PROPOSED MINI PILE

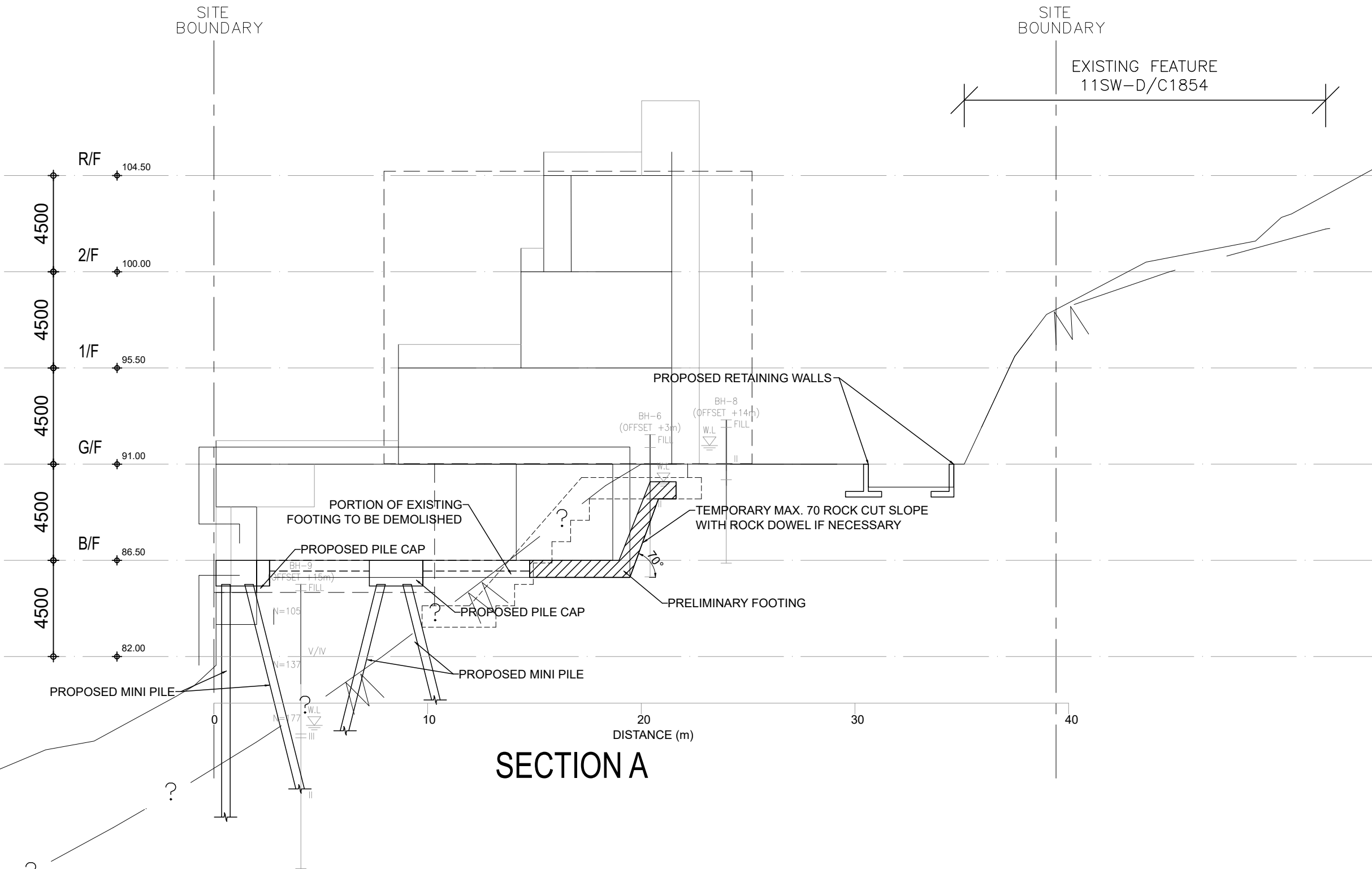
NOTE:
THE FOUNDATION/SITE FORMATION/ELS WORKS SHOWN ARE PRELIMINARY, SUBJECT TO GI RESULTS AND DETAIL DESIGN.

PROJECT	
SECTION 16 PLANNING APPLICATION FOR THE PROPOSED RESIDENTIAL DEVELOPMENT AT NO. 66 DEEP WATER BAY ROAD, SHOUSON HILL, HONG KONG	
DRG. TITLE	DRG. NO
PRELIMINARY FOUNDATION PLAN AND PRELIMINARY ROCKHEAD CONTOUR	FIG-05
SCALE	DATE
1:200 IN A3	MAY 2025

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- Legend:
- SITE BOUNDARY
 - ? -? M? - PRELIMINARY CONTOUR LEVEL OF CATEGORY 1(C) ROCK
 - [Hatched Box] PROPOSED FOOTING
 - [Empty Box] PROPOSED PILE CAP
 - [Dashed Box] PROPOSED TIE BEAM
 - [Brick Pattern Box] PROPOSED SCREEN WALL

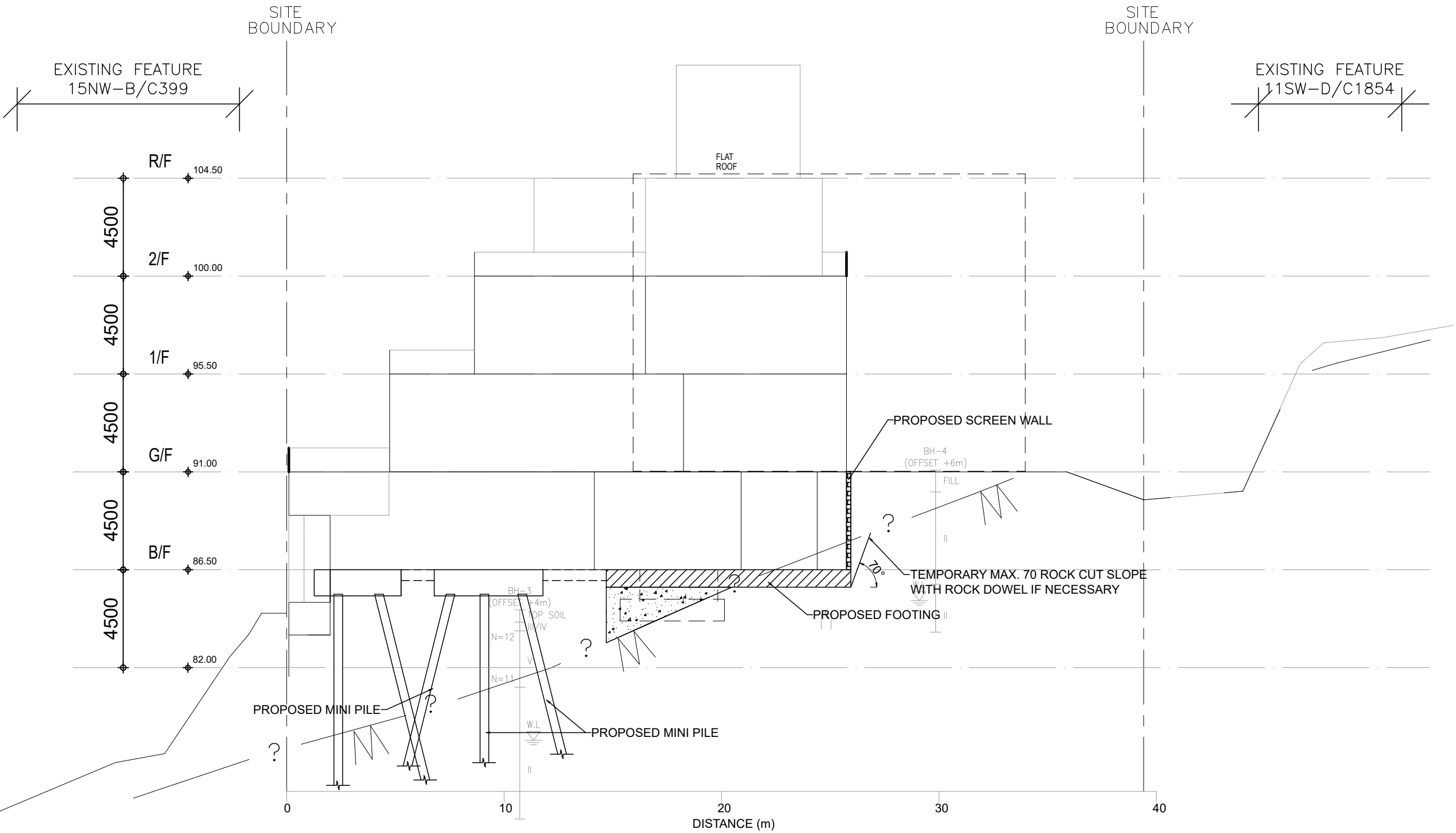


SECTION A

NOTE:
THE FOUNDATION/SITE FORMATION/ELS WORKS SHOWN ARE PRELIMINARY,
SUBJECT TO GI RESULTS AND DETAIL DESIGN.

PROJECT SECTION 16 PLANNING APPLICATION FOR THE PROPOSED RESIDENTIAL DEVELOPMENT AT NO. 66 DEEP WATER BAY ROAD, SHOUSON HILL, HONG KONG			
DRG. TITLE SCHEMATIC SECTION A-A		DRG. NO FIG-07	
SCALE	1:200 IN A3	DATE	MAY 2025
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- Legend:
- SITE BOUNDARY
 - PRELIMINARY ROCKHEAD PROFILE
 - PROPOSED FOOTING
 - PROPOSED PILE CAP
 - PROPOSED TIE BEAM
 - PROPOSED SCREEN WALL



SECTION B

NOTE:
THE FOUNDATION/SITE FORMATION/ELS WORKS SHOWN ARE PRELIMINARY,
SUBJECT TO GI RESULTS AND DETAIL DESIGN.

PROJECT			
SECTION 16 PLANNING APPLICATION FOR THE PROPOSED RESIDENTIAL DEVELOPMENT AT NO. 66 DEEP WATER BAY ROAD, SHOUSON HILL, HONG KONG			
DRG. TITLE		DRG. NO	
SCHEMATIC SECTION B-B		FIG-08	
SCALE	1:200 IN A3	DATE	MAY 2025

Legend:

SITE BOUNDARY

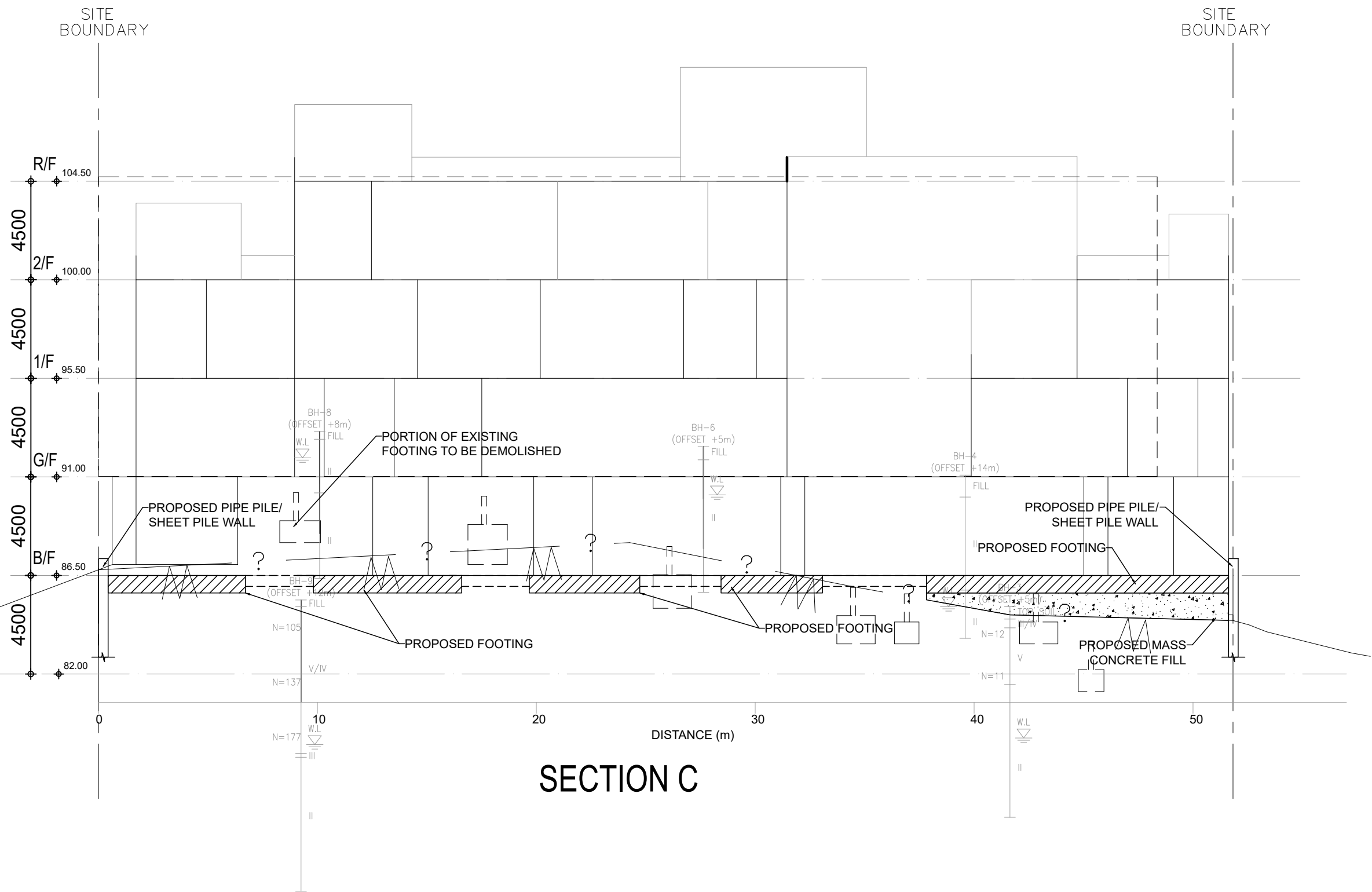
PRELIMINARY CONTOUR LEVEL OF CATEGORY 1(C) ROCK

PROPOSED FOOTING

PROPOSED PILE CAP

PROPOSED TIE BEAM

PROPOSED MASS CONCRETE FILL



NOTE:
THE FOUNDATION/SITE FORMATION/ELS WORKS SHOWN ARE PRELIMINARY,
SUBJECT TO GI RESULTS AND DETAIL DESIGN.

PROJECT

SECTION 16 PLANNING APPLICATION
FOR THE PROPOSED RESIDENTIAL
DEVELOPMENT AT NO. 66 DEEP
WATER BAY ROAD, SHOUSON HILL,
HONG KONG

DRG. TITLE

SCHEMATIC SECTION
C-C

DRG. NO

FIG-09

SCALE

1:200 IN A3

DATE

MAY 2025

CMA

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Appendix A : Site Photographs

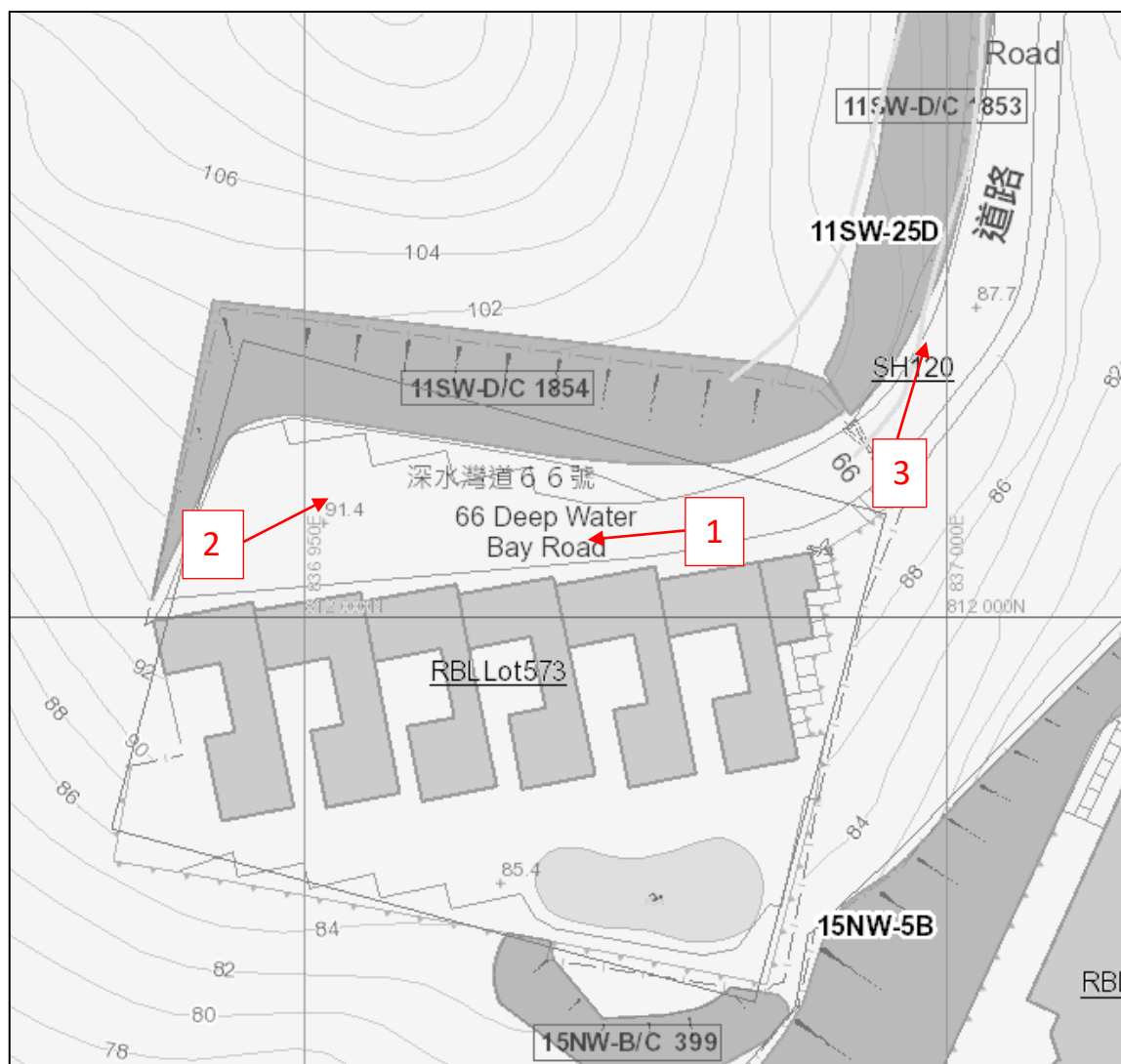


Photo Location Plan

Legend:



Photo location and direction



Photo 1: General View of site



Photo 2: General view of Feature 11SW-D/C1854



Photo 3: General view of the access road

Appendix B :
SIMAR and SIS records for
existing features, and extract of
previous GEO studies

Slope Maintenance Responsibility Report

(11SW-D/C1853)



ESTATE MANAGEMENT SECTION
LANDS DEPARTMENT

List of Slope Maintenance Responsibility Area(s)

1	11SW-D/C1853		Sub-Division	Not Applicable
	Location	Slope falls in Government land, adjoining access road to RBL573 near spot level 81.3		
	Responsible Lot/Party	RBL 573	Maintenance Agent	Not Applicable
	Remarks	Not Applicable		

- End of Report -

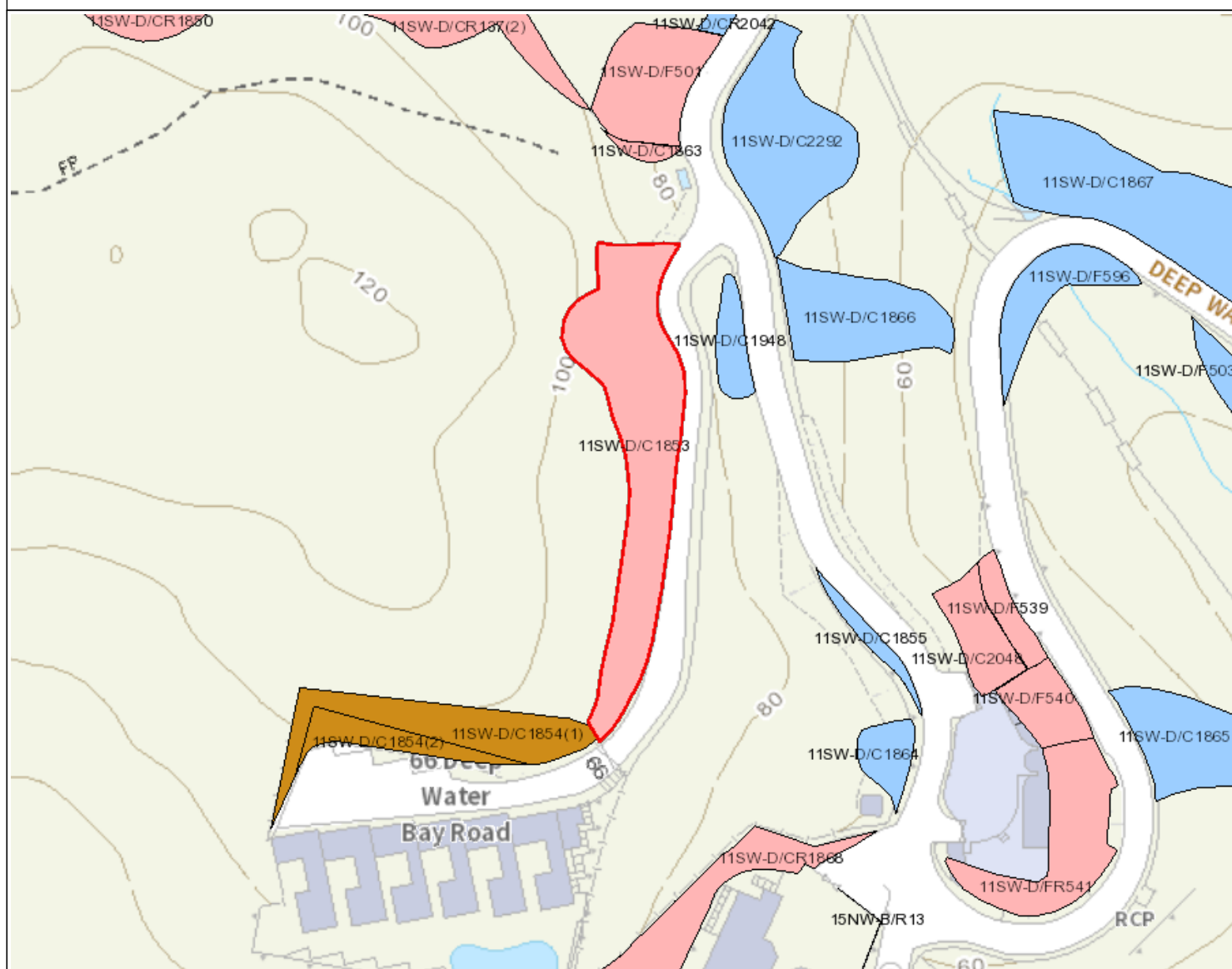
Notes:

- (i) The location plan in Annex is for identification purposes of slope(s) only.
- (ii) The slope(s) as listed in the Slope Maintenance Responsibility Report may not be shown on the location plan in Annex.

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Search Criteria: 11SW-D/C1853

Location Plan



Legend

- Slope Area(s)
- - - - - Search Location
- Slope(s) Maintained by Government
- Slope(s) Maintained by Private Party/Parties
- Slope(s) Maintained by Government and Private Party/Parties



ESTATE MANAGEMENT SECTION
LANDS DEPARTMENT

This Plan is **NOT TO SCALE** and intended for **IDENTIFICATION** only. All information shown on this plan **MUST** be verified by field survey.

Printed on: 25/02/2025

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Search Criteria: 11SW-D/C1853

BASIC INFORMATION

Location: ACCESS ROAD TO NO. 66 DEEP WATER BAY ROAD.
Registration Date: 16-03-1998
Ranking Score (NPRS): 0 (LPMit)
Date of Formation: post-1977
Date of Construction/ Modification: N/A
Data Source: SIRST
Approximate Coordinates: Easting : 837001 Northing : 812055

CONSEQUENCE-TO-LIFE CATEGORY

Facility at Crest: Undeveloped green belt
Distance of Facility from Crest (m): 0
Facility at Toe: Road/footpath with low traffic density
Distance of Facility from Toe (m): 0
Consequence-to-life Category: 3
Remarks: N/A

SLOPE PART

(1) Max. Height (m): 20 Length (m): 88 Average Angle (deg): 41

WALL PART

N/A

MAINTENANCE RESPONSIBILITY

(1) Sub Div.: 0 Maintenance Type: Private Party: RBL 573 Agent: N/A Land Cat.: 5a Reason Code: 44 MR Endorsement Date: 04-08-1998

DETAILS OF SLOPE / RETAINING WALL

Date of Inspection: 22-10-1996
Data Source: SIRST
Slope Part Drainage: (1) Position: Stepped Size(mm): 251
Wall Part Drainage: N/A

SLOPE PART

Slope Part (1)
Surface Protection (%): Bare: 50 Vegetated: 40 Chunam: 10 Shotcrete: 0 Other Cover: 0
Material Description: Material type: Rock Geology: N/A
Berm: No. of Berms: N/A Min. Berm Width (m): N/A
Weepholes: Size (mm): 40 Spacing (m): 1.2

WALL PART

N/A

SERVICES

N/A

CHECKING STATUS INFORMATION

N/A

BACKGROUND INFORMATION

GIU Cell Ref.: 11SW25D8
Map Sheet Reference (1:1000): 11SW-25D
Aerial Photos: A14542 (1988), A14543 (1988)
Nearest Rainguage Station (Station Number): Gramtham Hospital, Wong Chuk Hang Road(H24)
Data Collected On: 22-10-1996
Date of Construction, Subsequent Modification and Demolition: Modification: Constructed Before: 1988 After: 1986
Related Reports/Files or Documents: File/Report: DLC/BC Ref. No.: SHX 120
File/Report: DLC/BC Ref. No.: SHX 120
File/Report: Development Ref. No.: 3747/46/100B
File/Report: Development Ref. No.: 3747/46/100B
Remarks: No file no in incident card, Incident no. 33/11SW-D.
Follow Up Actions: N/A
DH-Order (To Be Confirmed with Buildings Department): None
Advisory Letter (To Be Confirmed with Buildings Department): None

ENHANCED MAINTENANCE INFORMATION

From Maintenance Department: (Last Updated Date: 19/02/2025)

eLPMIS

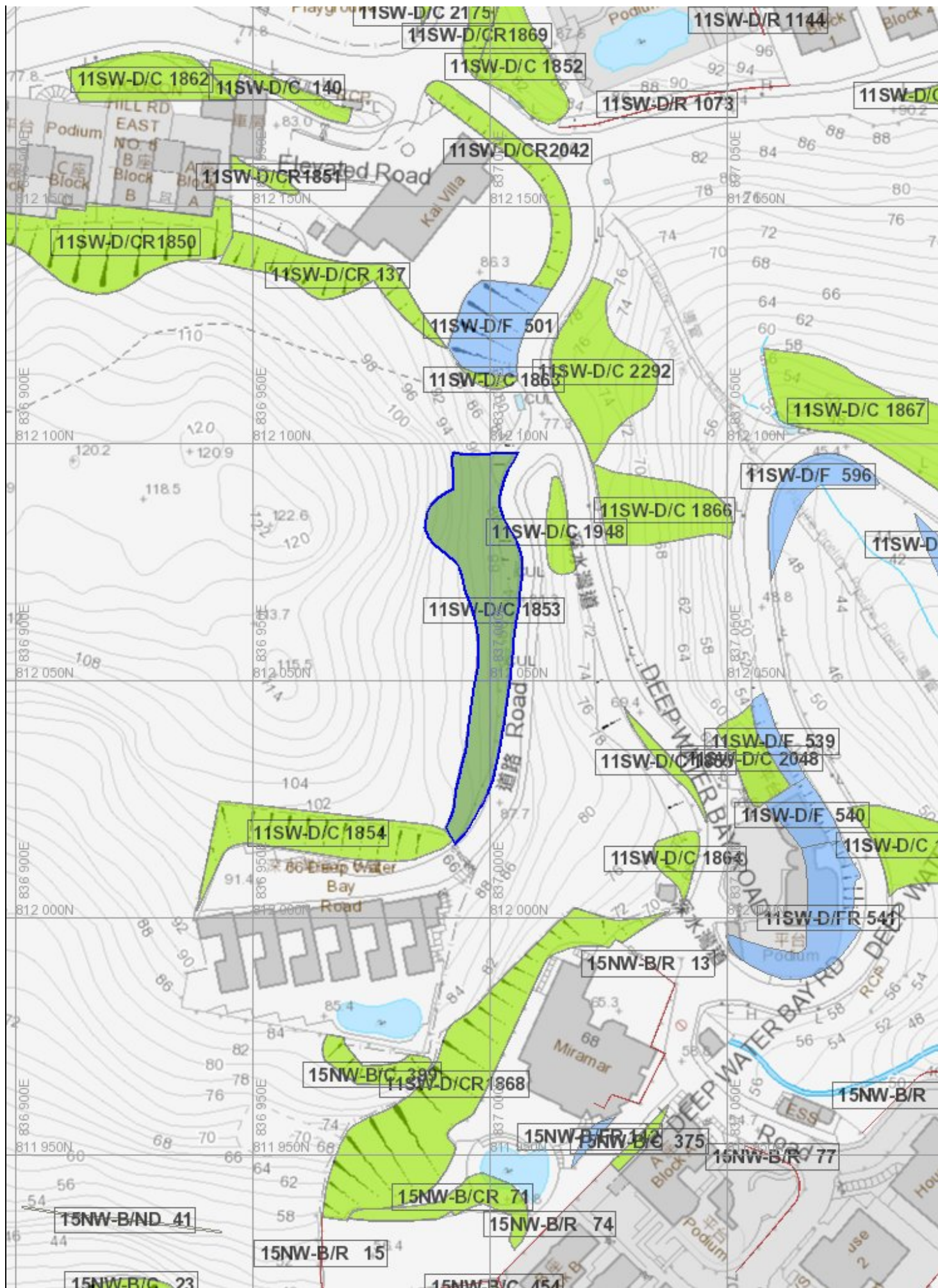


PHOTO



GENERAL VIEW

11SW-D/C1853



Slope Maintenance Responsibility Report

(15NW-B/C399)



ESTATE MANAGEMENT SECTION
LANDS DEPARTMENT

List of Slope Maintenance Responsibility Area(s)

1	15NW-B/C399		Sub-Division	Not Applicable
	Location	ON GOVERNMENT LAND TO THE SOUTH OF RBL573		
	Responsible Lot/Party	Lands Department	Maintenance Agent	Lands Department
	Remarks	For enquiries about the maintenance of this slope / sub-division of the slope, please contact the Maintenance Agent directly.		

- End of Report -

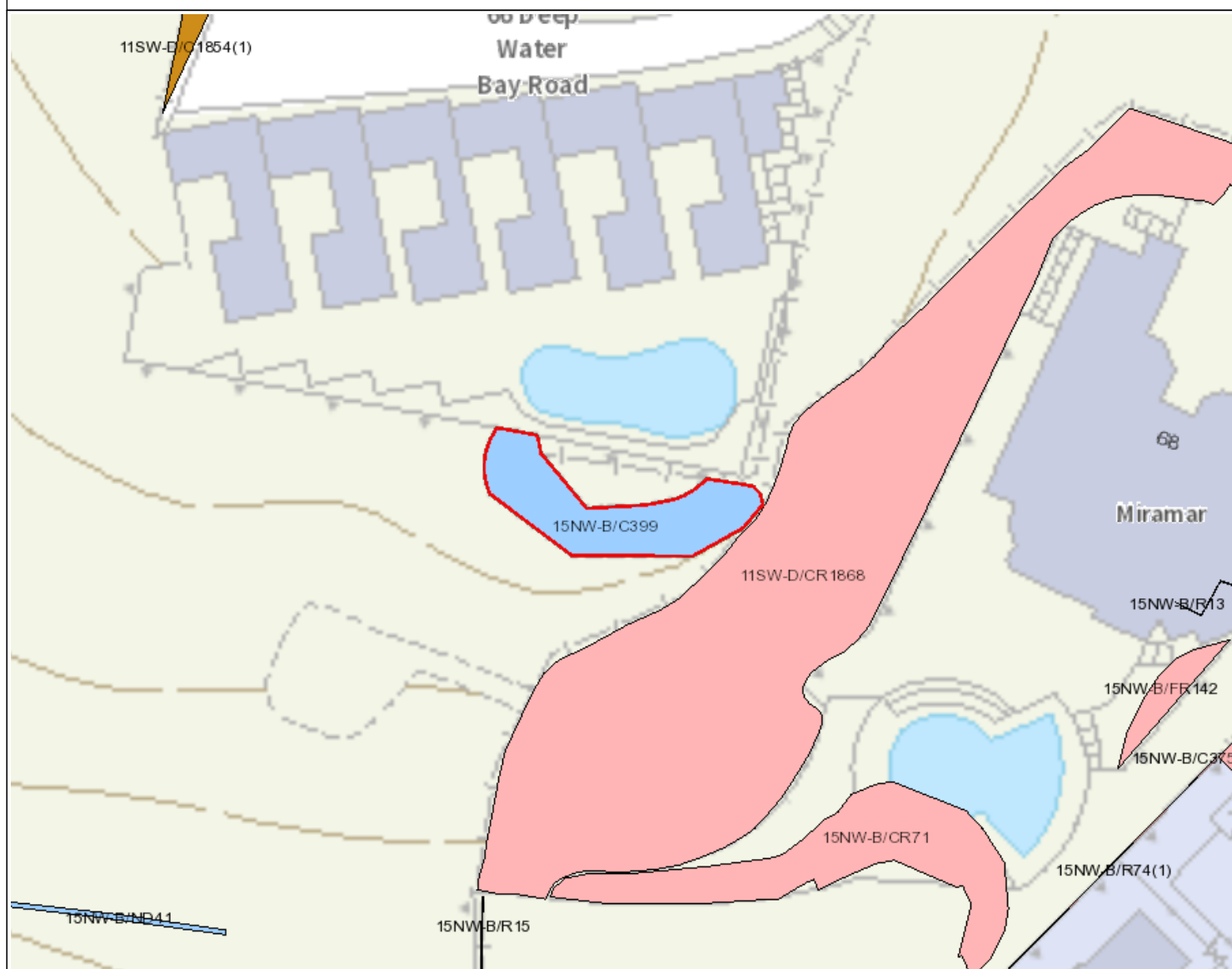
Notes:

- (i) The location plan in Annex is for identification purposes of slope(s) only.
- (ii) The slope(s) as listed in the Slope Maintenance Responsibility Report may not be shown on the location plan in Annex.

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Search Criteria: 15NW-B/C399

Location Plan



Legend

- Slope Area(s)
- - - - - Search Location
- Slope(s) Maintained by Government
- Slope(s) Maintained by Private Party/Parties
- Slope(s) Maintained by Government and Private Party/Parties



ESTATE MANAGEMENT SECTION
LANDS DEPARTMENT

This Plan is **NOT TO SCALE** and intended for **IDENTIFICATION** only. All information shown on this plan **MUST** be verified by field survey.

Printed on: 25/02/2025

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Search Criteria: 15NW-B/C399

BASIC INFORMATION

Location: South of the Swimming Pool of 66 Deep Water Bay Rd.
Registration Date: 22-10-2003
Ranking Score (NPRS): 0 (EI)
Date of Formation: post-1977
Date of Construction/ Modification: N/A
Data Source: Basic data interpreted from API techniques
Approximate Coordinates: Easting : 836975 Northing : 811967

CONSEQUENCE-TO-LIFE CATEGORY

Facility at Crest: Densely-used open area/facilities
Distance of Facility from Crest (m): 2
Facility at Toe: Undeveloped green belt
Distance of Facility from Toe (m): 2
Consequence-to-life Category: 2
Remarks: N/A

SLOPE PART

(1) Max. Height (m): 4 Length (m): 25 Average Angle (deg): 40

WALL PART

N/A

MAINTENANCE RESPONSIBILITY

(1) Sub Div.: 0 Maintenance Type: Government Party: Lands D Agent: Lands D Land Cat.: 5b(vi) Reason Code: 62 MR Endorsement
Date: 25-11-2004

DETAILS OF SLOPE / RETAINING WALL

Date of Inspection: 05-12-2003
Data Source: Basic data interpreted from API techniques
Slope Part Drainage: N/A
Wall Part Drainage: N/A

SLOPE PART

Slope Part (1)
Surface Protection (%): Bare: 0 Vegetated: 0 Chunam: 0 Shotcrete: 0 Other Cover: 100
Material Description: Material type: N/A Geology: N/A
Berm: No. of Berms: N/A Min. Berm Width (m): N/A
Weepholes: Size (mm): N/A Spacing (m): N/A



WALL PART

N/A

SERVICES

N/A

CHECKING STATUS INFORMATION

N/A

BACKGROUND INFORMATION

GIU Cell Ref.:	N/A
Map Sheet Reference (1:1000):	15NW- 5B
Aerial Photos:	N/A
Nearest Rainguage Station (Station Number):	N/A(N/A)
Data Collected On:	05-12-2003
Date of Construction, Subsequent Modification and Demolition:	N/A
Related Reports/Files or Documents:	N/A
Remarks:	N/A
Follow Up Actions:	N/A
DH-Order (To Be Confirmed with Buildings Department):	None
Advisory Letter (To Be Confirmed with Buildings Department):	None

ENHANCED MAINTENANCE INFORMATION

From Maintenance Department: (Last Updated Date: 19/02/2025)

eLPMIS



PHOTO

N/A



Slope Maintenance Responsibility Report

(11SW-D/C1854)



ESTATE MANAGEMENT SECTION
LANDS DEPARTMENT

List of Slope Maintenance Responsibility Area(s)

1	11SW-D/C1854		Sub-Division	1
	Location	Within and to the north of RBL 573		
	Responsible Lot/Party	Lands Department	Maintenance Agent	Lands Department
	Remarks	For enquiries about the maintenance of this slope / sub-division of the slope, please contact the Maintenance Agent directly.		
2	11SW-D/C1854		Sub-Division	2
	Location	Within and to the north of RBL 573		
	Responsible Lot/Party	RBL 573	Maintenance Agent	Not Applicable
	Remarks	Not Applicable		

- End of Report -

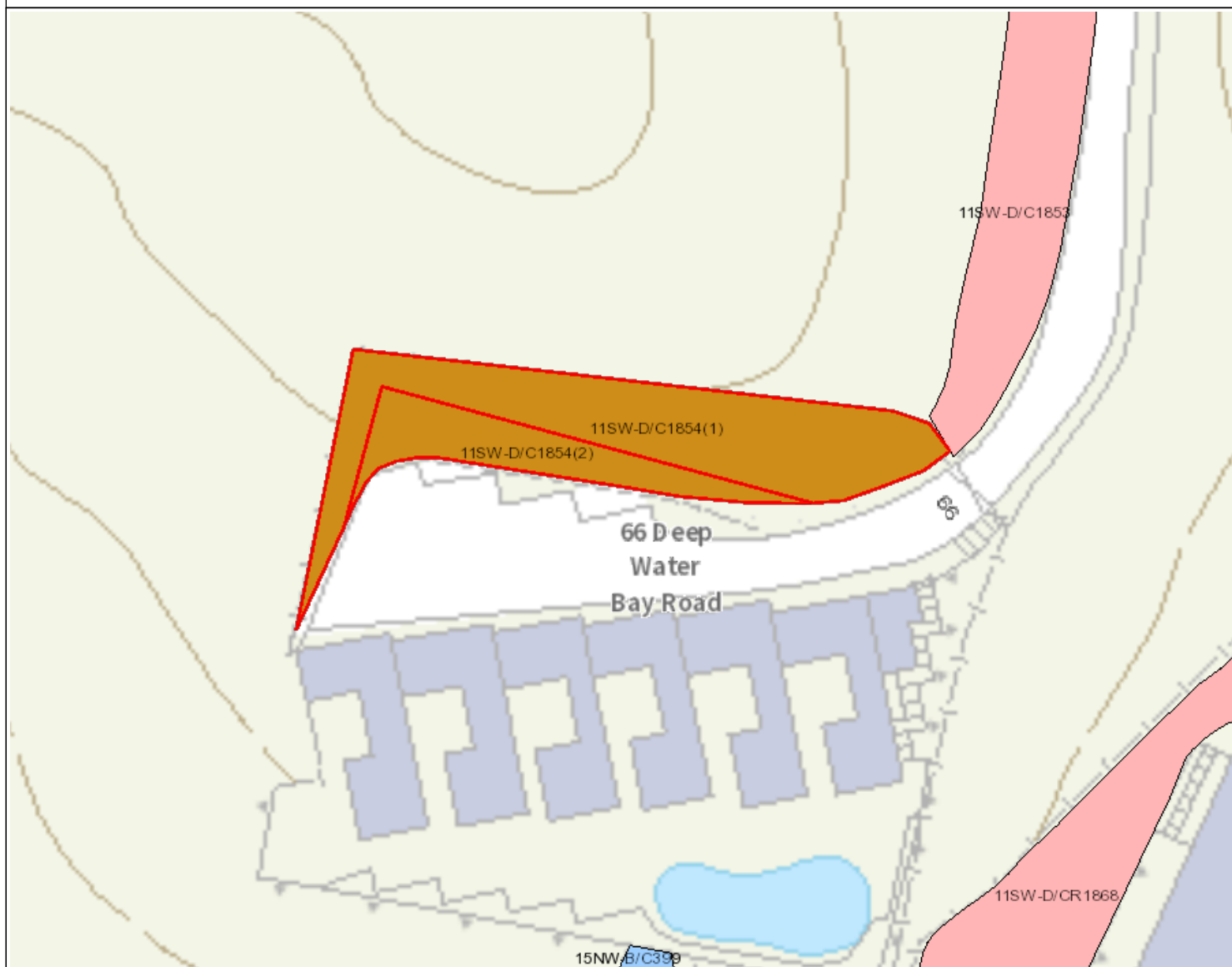
Notes:

- (i) The location plan in Annex is for identification purposes of slope(s) only.
- (ii) The slope(s) as listed in the Slope Maintenance Responsibility Report may not be shown on the location plan in Annex.

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Search Criteria: 11SW-D/C1854

Location Plan



Legend

- Slope Area(s)
- - - - Search Location
- Slope(s) Maintained by Government
- Slope(s) Maintained by Private Party/Parties
- Slope(s) Maintained by Government and Private Party/Parties



ESTATE MANAGEMENT SECTION
LANDS DEPARTMENT

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Search Criteria: 11SW-D/C1854

BASIC INFORMATION

Location:	66 Deep Water Bay Road, Hong Kong
Registration Date:	16-03-1998
Ranking Score (NPRS):	9 (LPMit)
Date of Formation:	post-1977
Date of Construction/ Modification:	N/A
Data Source:	Project Office
Approximate Coordinates:	Easting : 836967 Northing : 812013

CONSEQUENCE-TO-LIFE CATEGORY

Facility at Crest:	Undeveloped green belt
Distance of Facility from Crest (m):	0
Facility at Toe:	Open car park
Distance of Facility from Toe (m):	0
Consequence-to-life Category:	2
Remarks:	N/A

SLOPE PART

(1) Max. Height (m): 10 Length (m): 65 Average Angle (deg): 70

WALL PART

N/A

MAINTENANCE RESPONSIBILITY

(1) Sub Div.: 1	Maintenance Type: Mixed	Party: Lands D	Agent: Lands D	Land Cat.: 1,5a,5b(vi),7	Reason Code: 62	MR Endorsement
Date: 02-11-1999						
(2) Sub Div.: 2	Maintenance Type: Mixed	Party: RBL 573	Agent: N/A	Land Cat.: 1,5a,5b(vi),7	Reason Code: 1,44,46	MR Endorsement
Date: 02-11-1999						

DETAILS OF SLOPE / RETAINING WALL

Date of Inspection:	16-11-2018		
Data Source:	Project Office		
Slope Part Drainage:	(1)	Position: Crest	Size(mm): 300
	(2)	Position: Toe	Size(mm): 275
Wall Part Drainage:	(1)	Position: Crest	Size(mm): 225

SLOPE PART

**Slope Part (1)**

Surface Protection (%): Bare: 100 Vegetated: 0 Chunam: 0 Shotcrete: 0 Other Cover: 0
Material Description: Material type: Rock Geology: N/A
Berm: No. of Berms: N/A Min. Berm Width (m): N/A
Weepholes: Size (mm): N/A Spacing (m): N/A

WALL PART

N/A

SERVICES

N/A

CHECKING STATUS INFORMATION

Tagmark: 9259_1_1 Part: 1 Checking Status: No checking records Checking Certificate No.: N/A

BACKGROUND INFORMATION

GIU Cell Ref.: 11SW25D7
Map Sheet Reference (1:1000): 11SW-25D
Aerial Photos: A14542 (1988), A14543 (1988)
Nearest Rainguage Station (Station Number): Gramtham Hospital, Wong Chuk Hang Road(H24)
Data Collected On: 16-11-2018
Date of Construction, Subsequent Modification and Demolition: Modification: Constructed Before: N/A After: 1988
Related Reports/Files or Documents: File/Report: DLC/BC Ref. No.: RBL 573
File/Report: DLC/BC Ref. No.: RBL 573
File/Report: Development Ref. No.: GCI 3/4/20/5/82,
File/Report: Development Ref. No.: GCI 3/4/20/5/82,
File/Report: Development Ref. No.: GCI 3/4/30/8/87
File/Report: Development Ref. No.: GCI 3/4/30/8/87
Remarks: N/A
Follow Up Actions: N/A
DH-Order (To Be Confirmed with Buildings Department): None
Advisory Letter (To Be Confirmed with Buildings Department): None

ENHANCED MAINTENANCE INFORMATION

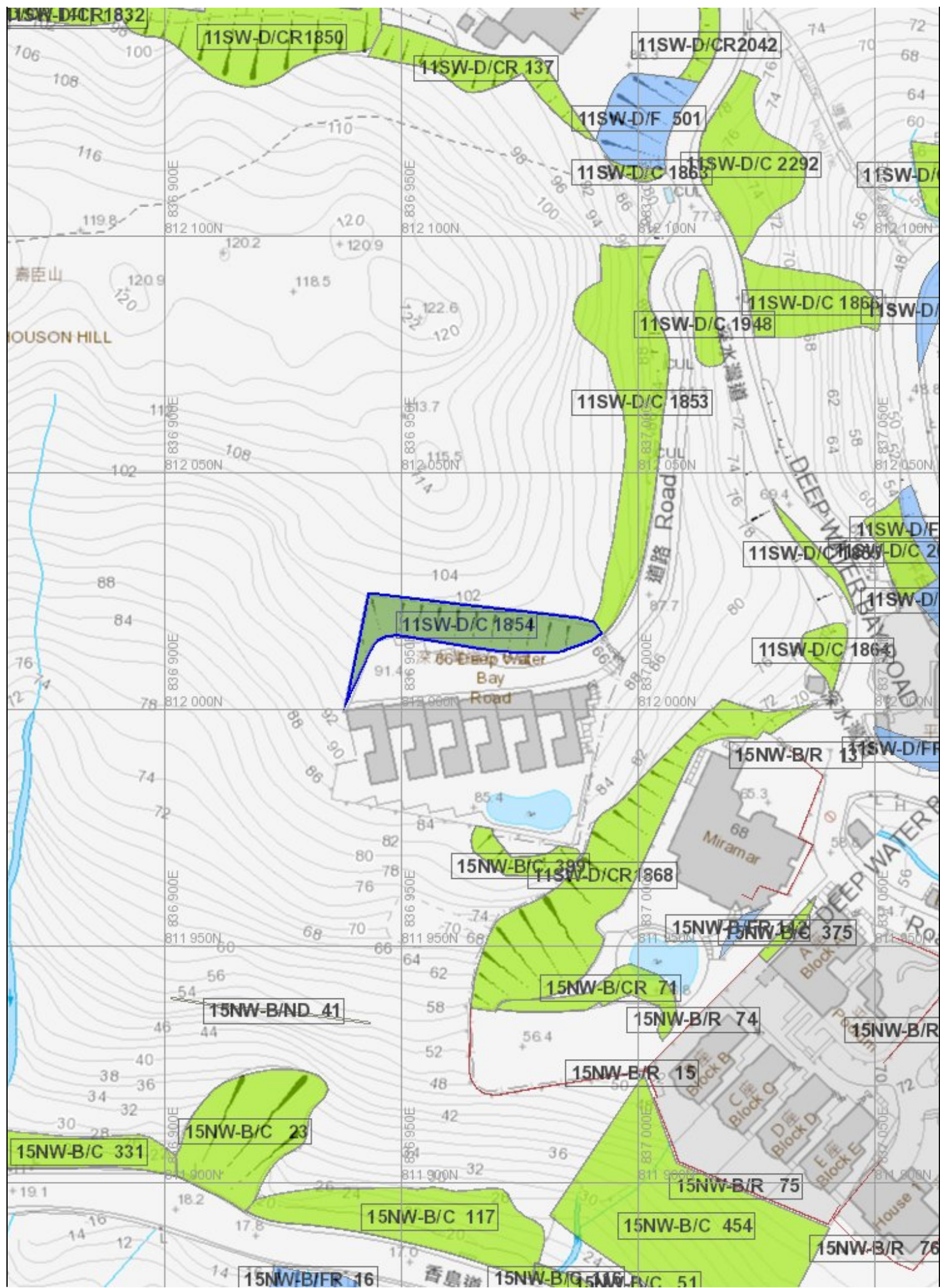
From Maintenance Department: (Last Updated Date: 19/02/2025)



eLPMIS

PHOTO





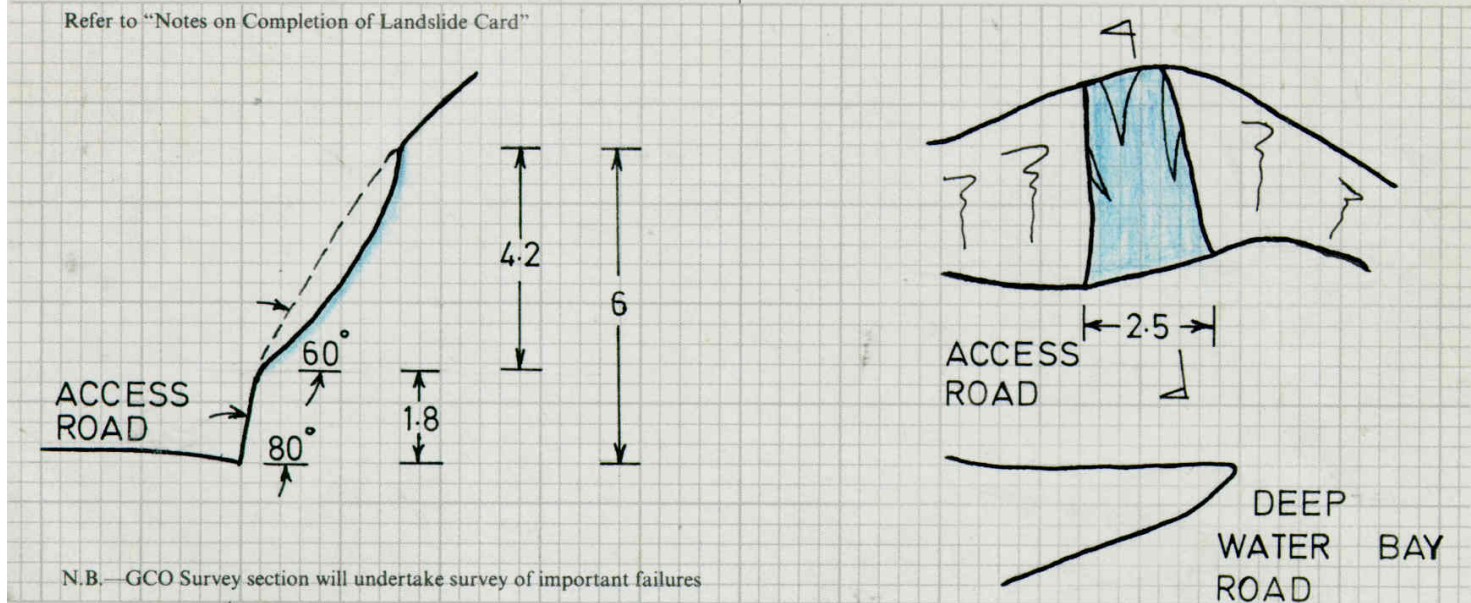
	2 Inspected by W. K. LAI	3 Failure Number 34/11 SW-D					
	4 Ownership Private	5 Lot No. RBL 573					
	6 Location Access road to 66 Deep Water Bay Rd.	7 Active Construction Site Yes/No					
	8 Failure: 17.6.83						
9 Inspected: 10 30 / 12.7.83		10 File No.					
Retaining Wall	Natural	Cut	Fill	Chunam/Concrete	Grass	Trees/Bushes	Stone Pitching
11	12	13	14	20	21	22	23
Possible Cause				Rainfall in preceding			
Ground Water	Infiltration	Pipe Failure	Excavation	15 days	1 day	1 hour	
30	31	32	33	40	41	42	
Material				60 Remaining Danger			
D.V.	D.G.	Soil	Rock	Colluvium	Continuing Erosion		
50	51	52	53	54	71 Joint controlled		
70 Description of Failure Shallow soil slip due to poor drainage.				80 Back Analysis Yes/No			

G11 Cell: 11-SW-25D-8-11



Detail of Failure		105 C.S.	106 I.S.	107 Vol. Slip	108 Vol. Debris	109 $\bar{c}$	110 $\bar{\phi}$
90 Cut height 6	91 breadth 2.5			92 angle 60°	93 depth 1.5	94 scarp distance 0	
95 failure height 4.2	96 toe height 1.8	101 debris breadth	102 debris angle	103 debris max. thickness	104 debris length		

Section 1: 200	Plan 1: 200
-------------------	----------------



water conditions (show on drawing) PWD BOO 114	water seeping from				154 fluidity of debris Debris removed prior to inspection.
	drain	main	debris	scarp (give depth BGL)	
	150	151	152	153	

1981

2 Inspected by
W. K. LAI

3 Failure Number
33/11 SW-D

4 Ownership
Private

5 Lot No. RBL 573

6 Location
Access to 66
Deep Water Bay Rd.

7 Active Construction Site. ☒ Yes ☐ No

8 Failure: 17.6.83 9 Inspected: 10 30/12.7.83

10 File No.

Retaining Wall	Natural	Cut	Fill	Chunam/Concrete	Grass	Trees/Bushes	Stone Pitching
11	12	13	14	20	21	22	23
		☒		☒			

Possible Cause

Ground Water	Infiltration	Channel Failure	Excavation	15 days	1 day	1 hour
30	31	32	33	40	41	42
	☒	☒		17	255	

Rainfall in preceding

Material

D.V.	D.G.	Soil	Rock	Colluvium
50	51	52	53	54
☒		☒		

60 Remaining Danger

Continuing Erosion

70 Description of Failure
Shallow soil slip due to poor drainage.

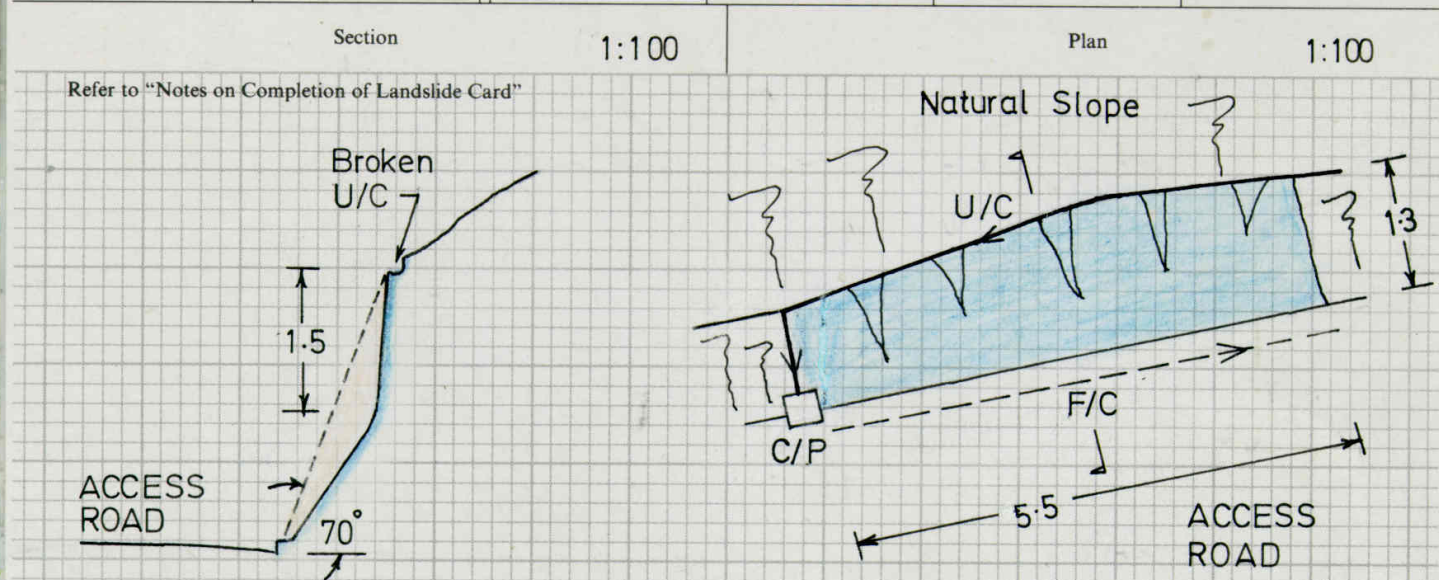
71 Joint controlled

80 Back Analysis
Yes/No

GIU call: 11-SW-25D-R-11



Detail of Failure		105 C.S.	106 I.S.	107 Vol. Slip	108 Vol. Debris	109 $\bar{c}$.	110 $\bar{\sigma}$		
90 Cut height	3	91 breadth:	5.5	92 angle:	70°	93 depth:	1.5	94 scarp distance:	0
95 failure height	3	96 toe height	0	101 debris breadth	102 debris angle	103 debris max. thickness	104 debris length		



N.B.—GCO Survey section will undertake survey of important failures

water conditions (show on drawing) PWD BOO 114	water seeping from				154 fluidity of debris Debris removed prior to inspection.
	drain	main	debris	scarp (give depth BGL)	
	150	151	152	153	1981

**STUDY AREA NO. 11SW-D/SA12
Shouson Hill,
Hong Kong Island (East)**

Fugro (Hong Kong) Limited

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**Landslip Preventive Measure Division 3
Geotechnical Engineering Office
Civil Engineering and Development Department**

August 2013

FOREWORD

This report presents the findings and recommendations of a Natural Terrain Hazard Study (NTHS) for the Study Area 11SW-D/SA12 - Shouson Hill, Hong Kong Island (East). The purposes of this study are to evaluate the hazards arising from the natural terrain and make recommendations for mitigation works.

Originally, the NTHS was carried out based on the Design Event Approach with reference to GEO Report No. 138, including detailed desk study, aerial photograph interpretation, detailed engineering geological field mapping, dynamic debris mobility analysis, natural terrain hazard assessment, design event determination and the formulation of hazard mitigation strategies. Subsequently it has been revised to incorporate the interim guidelines of the Enhanced Approach to NTHS distributed by GEO in mid April. The work was undertaken and compiled by Fugro (Hong Kong) Ltd. on behalf of the Geotechnical Engineering Office (GEO) of the Civil Engineering and Development Department (CEDD), under Agreement No. CE 16/2011 (GE) - Landslip Prevention and Mitigation Works, Package B, Investigation, Design, and Construction.

The findings of the NTHS show that natural terrain hazards including open hillslope landslides and boulder fall have the potential to affect facilities at the toe of the Study Area. Hazard mitigation works were recommended for 7 of the 8 hillside catchments within the Study Area and following assessment using the Enhanced Approach the extent of mitigation has been significantly reduced. The remaining catchment is within a private lot.

Signed



Y C Koo

Director

Fugro (Hong Kong) Limited

Date

30 August 2013

Agreement No. CE 16/2011(GE)
LPMitP, 2011, Package B, Landslip
Prevention and Mitigation Works,
Hong Kong Island (East) -
Investigation, Design and Construction

1 Introduction

1.1 General

Fugro (Hong Kong) Limited (FHK) was appointed by the Geotechnical Engineering Office (GEO) of the Civil Engineering and Development Department (CEDD) under Agreement No. CE 16/2011 (GE) to undertake a Stage 2 (H) Study for the Study Area 11SW-D/SA12 - Shouson Hill, Hong Kong Island (which consists of 8 hillside catchments).

This report covers the Stage 2 (H) Study for Study Area 11SW-D/SA12 - Shouson Hill, Hong Kong Island.

1.2 Scope

Originally the scope of the Study was defined in Clause 6.2 (iii) of the Brief of Agreement CE16/2011 (GE) and was a Natural Terrain Hazard Study (NTHS) following the Design Event Approach (Ng et. al., 2003), and design option assessment of mitigation measures and schematic design option of the recommended mitigation measures. In accordance with the brief a Working Paper on Desk Study (DSWP), formed a Natural Terrain Hazard Review (NTHR) as defined in Ng et al. (2003) was submitted on 17 July 2012 (Fugro, 2012).

A NTHS consists of two components, a Natural Terrain Hazard Review (NTHR) and a Natural Terrain Hazard Assessment (NTHA) (Ng et al., 2003). The NTHA includes detailed field mapping and ground investigation to evaluate and, where necessary, revise the preliminary models and develop a site specific hazard model for design purposes. This report contains the results of the NTHS including field mapping and on-going site-specific, project ground investigation.

In April 2013, the GEO issued interim guidelines for the Enhanced Approach to the Design Event Approach.

Using the Enhanced Approach, design options for mitigation are assessed and schematic designs of the options are included to mitigate the identified hazards. Three options of mitigation have been chosen. Option 1 involves the installation of soil nails to stabilize potential landslide sources. Option 2 involve the construction of check dams/ rigid barriers. Option 3 involves the installation of flexible barriers. In-situ stabilization measures and rock fall barriers will be installed to mitigate against potential rock and boulder fall in all three options.

1.3 Methodology

The DSWP summarised the key desk study information and used aerial photograph interpretation (API) and site reconnaissance to generate a conceptual engineering geological

model, based on which the ground investigation (GI) was designed. This also formed the basis of the initial assessment of the landslide design event and mitigation strategy.

The conceptual engineering geological model was evaluated and revised following the initial phase of engineering geological mapping. The results of the field mapping allowed an initial hazard model to be developed. The hazard model formed the basis for the debris mobility assessment and preliminary mitigation design.

The Enhanced Approach for dealing with natural terrain under LPMitP was adopted as far as possible in this study. This approach enhances the application of the React-To-Known-Hazard principle and a Credible Design Event (CE) replaces the previous system which used a Conservative Event and a Worst Credible Event Scenarios.

2 Description of the Site

2.1 General

Study Area **11SW-D/SA12 – Shouson Hill** is located in the southwestern part of Hong Kong Island just to the north of Deep Water Bay and is essentially natural terrain. The Study Area is a horse-shoe shaped area and about 3.6 ha in size. It encompasses the steep hillsides to the north, northwest, west, southwest, east and southeast of the east-west trending ridgeline which forms the summit of Shouson Hill (**Figure 1**).

The area has been divided into 8 Natural Hillside Catchments (NHC1-8).

- a) NHC 1 – An area of southeast facing terrain bounded by the eastern north-south trending ridgeline section of Shouson Hill ranging from 122 mPD to 116 mPD elevation and descending to about 70 mPD on Deep Water Bay Road. The area is about 0.64 ha in size. The development of the Miramar and Deep Water Bay Road are the main facilities-at-risk. The catchment is designated as 11SW-D/OH44a;
- b) NHC 2 – An area of northerly facing moderately steep hillside sloping from the east-west trending ridgeline at an elevation of about 120 mPD to Kai Villa and Blocks A & B of 8 Shouson Hill Rd East. The area is about approximately 0.43 ha in size. The catchment is designated as 11SW-D/OH44b;
- c) NHC 3 – This is a relatively small area (about 0.16 ha) of north facing terrain down slope from the east-west striking ridgeline (120 mPD) to the platform (90 mPD) for Blocks C & D of 8 Shouson Hill Rd East and Houses 25 & 26 of Las Pinadas. The catchment is designated as 11SW-D/OH44;

- d) NHC 4 – This is northward sloping terrain about 125 m long down slope from the summit of Shouson Hill (148 mPD) to the platform of Las Pinadas at an elevation of about 94 mPD. The area is approximately 0.79 ha in size and extends around the northwest spurline up slope of the platform for Bello Horizonte (ground level of about 107 mPD). The catchment is designated as 11SW-D/OH45a;
- e) NHC 5 – This is a small westward-facing catchment between the summit of Shouson Hill (148 mPD) and the swimming pool platform and Block 6 of the US Consulate Staff Quarters at about 102 mPD. The catchment is designated as 11SW-D/OH45;
- f) NHC 6- This is a small area (0.1 ha) of westerly sloping essentially anthropogenic terrain at the western end of the Study Area. Part of the platform (101 mPD) for Blocks 2-5 of the US Consulate Staff Quarters forms the crest of the catchment and the platform for Pak Villa (73 mPD) lies down slope. The catchment is designated as 11SW-D/DF28a and is excluded from the NTHS;
- g) NHC 7 – This is an area of about 0.44 ha of western facing catchment bounded by the summit of Shouson Hill at the crest (148 mPD) and part of the platform for the swimming pool, garage and shelter at Pak Villa and the public road at about 70 mPD. The catchment is designated as 11SW-D/DF28; and
- h) NHC 8 – This is the largest of the NHCs occupying about 0.79 ha of southwesterly facing terrain. It also has the summit of Shouson Hill at the crest of the catchment (148 mPD) and at the base a public road (73 mPD) and the platform for Flamaglo at about 69 mPD. The catchment is designated as 11SW-D/DF28b.

The Study Area is dominated by the imposing rounded summit and ridge/spurlines of Shouson Hill and relatively steep slopes falling to cut/fill slopes and platforms, from an elevation of about 148 mPD to about 68 mPD. There is evidence of considerable old military and other anthropogenic activity which has disturbed the terrain especially around the summit and western slopes. Much of the general Study Area is quite steeply sloping and is covered by dense, almost impenetrable vegetation. Some areas of steep rock face and outcrop also occur. The Working Paper initially identified about 28 ephemeral drainage lines, however, subsequent detailed field work and integrated API indicates that only 2 could be considered as having potential for channelised debris flows and 5 considered as topographic depressions with potential for topographic depression failures.

2.2 Facilities

There are a numerous substantial residential buildings and cut and fill slope features near the toe of the Study Area. At the crest, there are old military ruins with an artillery ramp leading up to it from the toe of the western part of Study Area. The locations of registered slope features are shown on **Figure 5**.

3 Desk Study

3.1 Published Geology

The area of Shouson Hill is characterized by jointed fine ash, vitric tuffs of the Upper Jurassic Ap Lei Chau Formation (JAC). The regional geology, as shown on the 1:20 000 scale Geological Map Sheet 11-HGM 20, is reproduced in **Figure 2**. Generally, this unit is overlain by the coarse ash vitric tuffs of the Tai Mo Shan Formation (JTM) and underlain by the fine ash tuffs, breccia and tuffites of Shing Mun Formation (JSM). The published geological map shows a Quartzphyritic rhyolite dyke striking north-northwest in the southwest of the area. The general geology is also described by Sewell et al. (2000).

The regional Geotechnical Area Studies Programme Report for Hong Kong & Kowloon (GCO, 1987) also covers the area at a scale of 1:20 000. The Physical Constraints Map (PCM) identified the major constraints as steep in-situ terrain with general instability occurring on part of the northern side of Shouson Hill (Study Area) and zones of general instability associated with steeply sloping colluvium on the southern side (i.e., high and extreme geotechnical limitations, respectively).

3.2 Landslide Inventories

3.2.1 Enhanced Natural Terrain Landslide Inventory (ENTLI)

In 1995, GEO compiled the Natural Terrain Landslide Inventory (NTLI), from the interpretation of high-altitude aerial photographs dating from 1945 to 1994 (Evans *et al*, 1997; King, 1999). In 2004, GEO initiated an update of the NTLI using low-altitude (8,000 ft and below) aerial photographs and produced an Enhanced Natural Terrain Landslide Inventory (ENTLI). The ENTLI continues to be updated as new landslides occur.

According to the ENTLI database, four recent natural terrain landslide features 11SWD0661E, 11SWD0662E, 11SWD0692E and 11SWD0694E were recorded within the Study Area (MGS, 2007; updated by FSWJV in 2009) (**Figure 3** and **Table 1**). The recent failures were recorded in 1967, 1967, 1972 and 1972 respectively and were classified as open hillslope landslides. In addition, two relict landslide features 11SWD0005E and 11SWD0008E were identified using aerial photographs taken in 1963.

3.2.2 Large Landslide Inventory

The Large Landslide Inventory was compiled by Scott Wilson Ltd. under Agreement No. CE39/98 “Specialist API Services for the Natural Terrain Landslide Study” (1999a and 1999b). According to the Large Landslide Inventory, there are no features recorded within the Study Area.

3.2.3 Landslide Incidents

According to the GEO landslide database (as of 2010), there are numerous landslide incidents reported to GEO in the general area of Shouson Hill affecting a range of man-made features (**Figure 3** and **Table 2**) since records commenced in 1982. However, only three incidents (HK2006/9/712, 33/11SW-D and 34/11SW-D) occur in the Study Area, associated with man-made features 11SW-D/C1948 and 11SW-D/C1853 on Deep Water Bay Road. Two other incidents (HK1993/9/25 & HK2008/6/147) are also relatively small failures associated with cut slope feature no. 11SW-D/C669 below NHC 8 and the cut slope of feature no. 11SW-D/CR141 behind Las Pinadas below NHC 4, respectively.

3.3 Territory-wide QRA of Boulder Fall Hazards

A reconnaissance level (regional scale) boulder study formed part of a preliminary study for GEO under Stage 1 of the Phase III Study of the “Hong Kong Special Administrative Region-wide Quantitative Risk Assessment (QRA) of Boulder Fall Hazards” (MGS, 1999). This work produced a “boulder field inventory” based on API techniques. This inventory was prepared by Water Resources Consulting Services as sub-consultants to MGS. The inventory (Emery, 1998) contains 12,017 polygons showing individual boulder fields. Each polygon was classified in relation to four attributes:

- a) percentage of the polygon area covered by boulders;
- b) boulder type;
- c) boulder size; and
- d) boulder shape.

Seven QRA Boulder Inventory polygons intersect the Study Area (S11_28, S11_29, S11_31, S15_656, S15_657, S11_U and S15_U), and only 5 contain reference to boulders with the others relating to areas that already underwent urban development (**Figure 4** and **Table 3**).

Polygon S11_28 covers parts of the south-western section of the area in NHC 7 & 8, S15_655 parts of the adjoining Sheet 15; S11_31 adjoins the toe NHC 1 & 2. These polygons are classified as land surface obscured by vegetation.

Polygon S11_29 occupies much of the area and together with S15-657 (on Sheet 15) is classified as cliff or rock outcrop with 100% rounded boulders greater than 5 m in size. During field reconnaissance there was no evidence of large 5 m boulders or large detachable blocks of outcrop.

3.4 Associated Man-made Slopes

The locations of the existing registered slopes and retaining walls are listed in **Table 4** and are shown in **Figure 5**. Twenty registered features are located at the boundary of the Study Area, of which nine are cut slopes, three are fill slopes, one is retaining wall and seven are cut and retaining wall features. The engineered slopes are generally associated with construction of roads and site formation for residential buildings.

Stage 2 Studies have been completed for 11SW-D/C1863, 11SW-D/CR137, 11SW-D/CR141, 11SW-D/CR148, 11SW-D/CR1850 and 15NW-B/C197, and advisory letters were recommended for 11SW-D/CR141, 11SW-D/CR1850 and 15NW-B/C197 and Dangerous Hillside (DH) orders were recommended for 11SW-D/C1853 (mid-slope of NHC1), 11SW-D/CR137 (downslope of NHC2) and 11SW-D/CR141 (downslope of NHC4). Stage 2 Study for 11SW-D/CR1868 was terminated as the feature was found to be up to standard by previous study accepted by GEO or previously upgraded. No Stage 2 or Stage 3 Study was conducted for the remainder of the registered features.

The maintenance agents and responsibility parties for these registered slopes are also given in **Table 4**.

3.5 Previous Ground Investigation Data

Limited geotechnical ground investigation data is available within the Study Area (Figure 6). Ground investigation data is available for locations north, east and south-east of the Study Area dating from 1982. A summary of ground investigation records obtained from the Geotechnical Information Unit (GIU) library that are relevant to the Study Area is included in Table 5A for reports:

- a) GIU Reports Ref. 4278 (1982), 15554 (1987), 18871 (1988), 19026 (1985), 24863 (1993), 24865 (1991) and 24868 (1991).

A single borehole is located within the north-western lower hillslopes of the Study Area (18871/DH7). Heavily to completely decomposed saprolite 7.3 m thick was recorded above rock head. The solid geology for this drillhole was classified as volcanic.

Two drillholes occur within the central northern lower hillslopes of the Study Area (18871/DH6 & DH13). Heavily to completely decomposed saprolite between 10 and 15.1 m thick were recorded. The solid geology for these drillholes is classified as volcanic.

Three boreholes occur near the eastern Study Area boundary (19026/BH1, BH2 & BH3). Fill between 0.1 and 1.9 m thick and saprolite between 2.5 and 5.4 m in thickness were recorded. The solid geology for these drillholes is classified as volcanic tuff.

Three drillholes occur near the south-eastern boundary of the Study Area (15554/BH1, BH5 & BH7). Saprolite between 2 and 2.3 m thick was recorded within GI stations 15554/BH1 & BH7. Rock head was encountered at the surface of 15554/BH5. The solid geology for these drillholes is classified as volcanic.

Groundwater data relevant to the Study Area was limited to a single GIU report (15554). A summary of the groundwater data from three boreholes located within the Study Area and seven near the south-eastern boundary is included in Table 5B. The depth of the measured groundwater head for three boreholes within the Study Area (15554/BH1, BH5 & BH7) ranged from 2.90 m to 3.78 m below ground level.

3.6 Geotechnical Area Studies

The Geotechnical Area Studies (GAS) Programme produced one report of relevance to the Study Area is GAS Programme Report I – Hong Kong and Kowloon (GASP I), a regional 1:20 000 scale study (GCO, 1987). The regional assessment presents information on the physical and resources of the area in the form of a systematic land inventory and relevant aspects are described below. Extracts of the Terrain Classification Map (TCM; **Figure 7A**), Physical Constraints Map (PCM; **Figure 7B**), Geotechnical Land Use Map (GLUM; **Figure 7C**) and Engineering Geology Map (EGM; **Figure 7D**) are presented. There is no 1:2 500 scale GAS District Report covering any part of the Study Area or nearby in the district.

As indicated in the TCM (GCO, 1987) (**Figure 7A**), the western and easternmost slopes of the Study Area are characterised by convex side slopes ranging from 15° to 30°. Most of the northern and western facing slopes in the central portion of the Study Area are convex to planar side slopes sloping at 30° to 40°. The slopes to the south of the Study Area are 15° to 30° sloping colluvial footslopes (drainage plains) with evidence of instability.

The PCM (GCO, 1987) (**Figure 7B**) highlights that the central slopes of the Study Area are predominantly insitu terrain, while the slopes near the eastern and western boundaries occur in areas without any major physical constraints. The southern slopes of Shouson Hill, in comparison are colluvial in nature with zones of run off concentration and general instability.

The GLUM (GCO, 1987) is relevant because it highlights in four classes (low-extreme) the degree of geotechnical limitations associated with the terrain and is based directly on the slope gradient, terrain, erosion and instability attributes recorded in the TCM. A summary of the TCM attributes are presented in **Table 6**. At the commencement of the GAS Programme, every TCM unit was rated from low to extreme geotechnical limitations (I-IV) in relation to their anticipated susceptibility to slope instability. This information is of benefit because the GLUM system was originally designed, in the parlance of 1979, as a Landslide Hazard or Landslide Susceptibility Map, and therefore provides some regional context. Neither of these terms was acceptable due to socio-economic concerns at the time.

The GLUM (**Figure 7C**) indicates that the eastern, south-eastern, and western portions of the Study Area are predominantly GLUM Class III terrain, which have high geotechnical limitations which equate to substantial hazards. The southern slopes to the south of Study Area are classified as GLUM Class IV, with extreme geotechnical limitations and quite major hazards.

The EGM (GCO, 1987); (**Figure 7D**) illustrates that the Study Area is predominantly pyroclastic in nature. The EGM is of historical interest, because although the colluvial mapping was specifically updated, the solid geology was wholly derived from Allen & Stephens (1971). This mapping was at 1:50 000 scale and is replaced by the current 1:20 000 scale regional geology map (HGM 20 Sheet 11) (GCO, 1986). The regional EGM's also were a benchmark in relating weathering, material characteristics and engineering comments to basic lithology in a regional context.

3.7 Site History

The site history dates from the earliest available aerial photography in 1949 and a summary of the observations is presented together, with the detailed API Report including 14 annotated aerial photograph plates and one oblique photograph in **Appendix A**.

Natural ephemeral drainage lines, intermittent bedrock, some precipitous rock faces, relatively thin recent and relict colluvium, recent/relict landslide features, and considerable evidence of old and recent anthropogenic activity are observed. Old anthropogenic features include military ruins from World War II and ruins from the 1880s. There is also evidence of old agricultural terracing and associated practices. Recent anthropogenic activity include the construction of cut and fill slopes in association with the construction of Shouson Hill Road, Shouson Hill Road East, and Deep Water Bay Road, and fill platforms in association with private developments west, north and east of the Study Area.

In 1949 much of the area around Shouson Hill had been developed and the current-day road system and many of the associated cut and fill slopes were in place. Evidence of old military and other anthropogenic activity is widespread in these photographs and clearly pre-date 1949. Numerous cut and fill platforms are associated with residential development of predominantly bungalow-style garden compounds. By 1963, some re-development is occurring on the lower terrain with site formation affecting existing cut and fill slopes with many new features being created. The natural terrain on Shouson Hill is relatively un-vegetated and considerable information relating to the geomorphology, geology and terrain conditions are observable.

In the 1967 aerial photographs, some instability is apparent on the western and northern facing slopes of the Study Area with at least 4 landslips indicated in **Figure 11**, of which the northern facing failure (L8) has been removed by site formation between 1973 and 1978. These events were probably associated with the intense rainstorm in June 1966. In 1972, at least two of five failures appear to be natural failures and appear to have been re-activated possibly with the mid year rainstorms of 1972 that resulted in the Po Shan and Sau Mau Ping landslide disasters.

Much of the instability associated with the general Shouson Hill area occurred on man-made features, with many landslide incidents reported. However, the failures on the natural terrain in the Study Area were generally prior to 1980. Since that time, and particularly over the last decade, the vegetation density has progressively increased in a dramatic manner across the area. Today, the vegetation is almost impenetrable except on areas of outcrop or exposed weathered saprolite.

During the late 1970s, 1980s and 1990s considerable re-development of the residential buildings occurred with larger multi-storied blocks, such as Las Pinadas and Flamaglo constructed.

3.8 Utilities Information

According to the following, there are no current or planned utilities in the Study Area: Drainage Services Department, Water Supplies Department, Transport Department, CLP Power/ Hong Kong Electric, Hong Kong & China Gas, PCCW-HKT Telephone Ltd, Wharf New T & T, Hong Kong Cable TV, Hutchison Global Communications Ltd, New World Telephone and Hong Kong Broadband Network.

3.9 Land Status

The Study Area is predominantly on unallocated government land (Figure 8). The southwestern and western catchments of the Study Area (NHC8, 7 & 6) are bound by cut slopes no. 15NW-B/C197, 11SW-D/C669, 11SW-D/CR148, 11SW-D/C869 of government and private responsibilities (**Table 4**). The whole of Catchment NHC6 is within the Private Lot/Sandwich Lots while Private Lot/Sandwich Lots are also present within the other two catchments.

The northwestern catchments of the Study Area (NHC5 & 4) are bound by cut and fill slopes no. 11SW-D/C860, 11SW-D/CR878, 11SW-D/CR141, 11SW-D/CR1832, 11SW-D/R429 and 11SW-D/F211 of government and private responsibilities. Private Lot/Sandwich Lots are also present within each of these catchments.

The north and northeastern catchments of the Study Area (NHC3 & NHC2) are bound by cut and fill slopes no. 11SW-D/C1863, 11SW-D/CR137, 11SW-D/CR1850, and 11SW-D/F501 of private responsibilities. Private Lot/Sandwich Lots are also present within each of these catchments. Catchment NHC2 also has areas of Overlapping Lot/ Stratum Lots and Licensed Areas. The DLO of Lands Department has confirmed that the lease modifications for RBL766SA and RBL245 SA SS.1 affecting the eastern section of Catchment NHC2 were withdrawn (**Appendix H**).

The southeastern catchment of the Study Area (NHC1) contains and is bound by cut slopes no. 11SW-D/C1948, 11SW-D/C1853, 11SW-D/C1854, 11SW-D/C1864, 11SW-D/C1868 and 15NW-B/C399 of government and private responsibilities. Private

Lot/Sandwich Lot, Overlapping Lot/Stratum lot and Licensed Area of land also occur within this catchment.

3.10 Aerial Photograph Interpretation

In 1949, the Study Area was covered by sparse vegetation and consisted of ridgelines, hillcrests, rock cliffs, and side slopes. The Study Area and its surroundings have been substantially disturbed by man with military fortifications at the crest and a series of cut slopes along the northern, western, and eastern toes, associated with the construction of private developments, Shouson Hill Road, Shouson Hill Road East and Deep Water Bay Road. Two relict landslides are apparent in the 1963 aerial photographs, one at the northern portion of NHC8 and one at midslope of NHC3. Four possible natural terrain landslides are apparent in the 1967 aerial photographs, and six in the 1972 aerial photographs. Additional possible natural terrain landslides were apparent within the vicinity of the Study Area in the 1984, 1985, 1986, 1995, and 2009 aerial photographs (Appendix A).

From the 1949 to 2000 aerial photographs, evidence of anthropogenic features such as military fortifications, paths and construction of private developments were apparent throughout and around the Study Area, which eventually became masked by increasingly dense vegetation.

3.11 Conceptual Model

The desk study indicated that the Study Area is underlain by fine ash vitric tuff with some quartzphyric rhyolite in the western catchments. The terrain is predominantly in-situ with recent colluvium along the drainage lines particularly in the western and southwestern catchments. Some evidence of relict colluvium exists along parts of the spurlines and upper slopes. Some surface erosion and slope wash is evident. There is also evidence of some landslide debris associated with the recent ENTLI features.

Thirteen recent landslides are observed by API in and around the Study Area, with some probably associated with anthropogenic activity and man-made slope failures. Two relict landslide depressions were recorded in the ENTLI. Based on the field mapping and the hillshade model generated from LIDAR data, it is evident that the terrain has been modified by old anthropogenic terracing as well as military-associated activities.

Based on the initial findings of the Desk Study Working Paper (Fugro, 2012) open hillslope landslides (OHL), channelized debris flows (CDF) and rock/ boulder fall were assessed as potential hazards that may affect the facilities. These hazards have been confirmed during the study with additional topographic depression failures (TDF). Preliminary landslide source volumes of 120 m³ and 250 m³ for OHL and CDF were proposed for the worst credible design event (WCE) and these have been reduced and refined to the Credible Event (CE) based on the enhanced approach for dealing with Natural Terrain under LPMitP and to the terrain conditions during the study, with verification by both detailed field mapping and project ground investigation. TDF was not yet introduced at the time of submission of the

working paper in which the preliminary landslide source volumes were stated and had been treated as CDFs.

4 Engineering Geological Assessment

4.1 General

The geomorphology was mapped based on the system of Savigear (1965) and GEO Technical Guidance Note No. 22 (GEO, 2004). Superficial geology and geomorphology were mapped based on aerial photograph interpretation (API), detailed field mapping, interpretation of LiDAR data, and consideration of previous and project ground investigation (GI) data.

Field reconnaissance was carried out in early May 2012, while detailed mapping was carried out from December 2013 to April 2013. The site conditions within the area were observed including slope gradients, superficial geology, possible landslide scars, hydrological conditions, and anthropogenic alteration. Pervasive man-made ground disturbance of the area was apparent.

The Study Area was densely vegetated making access to most of the site difficult. Temporary ladders and associated vegetation clearance during ground investigation provided access. (**Plates 1 to 5**). **Plate 14** shows a view across Island Road – Area C towards the summit of Shouson Hill.

Anthropogenic features were observed within the Study Area including possible old agricultural terraces, graves and rubble walls (**Plates 6 to 10**), hewn blocks, remnants of concrete structures, small boulders and concrete detritus (**Plates 11 to 13**), concrete U-shaped drainage channels, trenches (**Plates 15 & 16**) and registered slope features within the lower hillslope locations of the Study Area (**Plates 17 to 20**).

In particular, Catchment NHC 6 consists of essentially man-made cut and fill slopes (**Plate 5**), related to old and more recent site formation associated with the construction of cut and fill platforms above it.

Project Ground Investigation was carried out with the purpose of further developing and refining the engineering geological model (**Plates 21 to 23**). Rock outcrop mainly observed as rock cliffs were located near and on the hillcrests, and side slopes of the Study Area (**Plates 24 to 29**) found in NHCs 1, 2, 4, 5 and 7 with slope angles ranging from 35° to 60° (**Figure 10**). Boulders found within the Study Area are generally less than 0.5 m and no more than 1 m. Further observations on solid geology can be found in **Section 4.2.2**.

Landslide scars (**Plates 30 & 32**) as well as colluvium of varying thicknesses, ranging from 0.5 m to 1.5 m (**Plates 31 to 34**) were observed.

The superficial geology and geomorphology map compiled from integrated API and detailed field mapping is shown in **Figure 10**. Detailed field mapping records and field traverses (with plate orientations) (**Figure C1**) are indicated in **Appendix C**.

Ephemeral drainage lines and topographic depressions were observed from API and detailed field mapping (**Figures 10 and 13, Plates 35 to 41**). They are located on the northern and western portion (i.e. Hillside Catchments NHC 2, 3, 4, 5, 7 and 8) of the Study Area. The drainage lines were dry during field observations, partly due to mapping during the dry season, with cobbles and boulders of sizes 0.1 m to 0.3 m normally occurring within them. Further hydrogeology observations can be found in **Section 4.2.4**.

4.2 Engineering Geology

4.2.1 Project Ground Investigation

Site-specific, project ground investigation (GI) was planned after the initial engineering geological model was developed during desk study and API. This included a total of nine trial pits and six drillholes with piezometers. Contractors' GI logs were checked and revised as necessary, by the consultant's engineering geologists and revisions have been incorporated in the logs, reproduced in **Appendix B**. (Field Work Report (VIBRO, GE/2011/06)). Trial pits were sited to provide a maximum indication of superficial deposits. **Table 7A** summarises the GI findings and **Table 7B** summarises rock joint measurements (stereonet diagrams of the data in **Appendix C**).

The maximum depth of colluvium recorded was about 1.7 m (DH6) underlain by saprolite with recorded thicknesses ranging from 0.9 m to 14.07 m (DH4, where saprolite was encountered from 1 m below ground level till the end of the drillhole). No residual soil was encountered from GI. Colluvium was underlain by bedrock in TP5 and DH3. Rockhead was encountered in the drillholes between 2.3 m and 5.3 m below ground surface except DH4, DH5 and DH6 where no rockhead was encountered. The solid geology for the saprolite was classified as fine ash vitric tuff.

4.2.2 Solid Geology

According to the 1:20 000 geological map (**Figure 2**; GCO, 1986; HGMO, 2006), the Study Area is predominately composed of fine ash vitric tuff of the Ap Lei Chau Formation, undivided (JAC). A dyke of Quartzphyric Rhyolite is also trending northwest-southeast across the western part (in NHC 6, 7 and 8) of the Study Area.

Outcrop occurs on and near the ridgeline, and rock cliff and slopes are found in NHCs 1, 2, 4, 5 and 7 with slope angles ranging from 35° to 60° (**Plates 24 to 29**). They are generally of Grades III and higher, with the majority of the joints striking NW-SE and NE-SW. Basic rock mass information is contained in **Appendix F**.

4.2.3 Superficial Geology

Considering the results of superficial geology and geomorphology mapping based on integrated API (**Appendix A**), field mapping (**Appendix C**) and LiDAR data, the Engineering Geological and Geomorphological Map is presented in **Figure 10**.

The superficial materials generally include concrete detritus, fill, recent and relict colluvium and residual soil/ saprolite. More specific descriptions follow:

Concrete Detritus

Concrete detritus is found in small pockets at the toe of Hillside Catchments NHC 5 and NHC 8, and at the crests of Hillside Catchments NHC 4, 5 and 7. The concrete relicts could be the remnants of the anthropogenic activities of the military site active dating back to the late 1800s. The blocks are generally angular and < 1 m in length. Furthermore an old concrete artillery ramp trending northwest-southeast and the ruins of two concrete military fortifications occur at the crest of Hillside Catchments NHC 4, 5, 7, and 8.

Fill

Fill generally occurs on the eastern part of the Study Area, specifically on the toe of Hillside Catchments NHC 1 and 2, where it ranges from 0.1 to 1.9 m thick as revealed by boreholes BH1 to BH3 from previous ground investigation (GIU Report No. 19026). Observations from the 1963 aerial photographs indicated that extensive activities of cutting, filling and formation of cut platforms are ongoing on the toe of Hillside Catchments NHC 1 and 2 and also extensively in 6 and 7. API evidence is compelling and information from previous ground investigation also indicates the existence of fill in these areas. A veneer of fill is likely located at the western summit in association with the old military features.

Colluvium

Colluvium, mostly thin, of recent age covers most parts of the Study Area. Colluvium of less than a metre thick is generally found on the open hill slopes; colluvium of less than 1.5 m thick is generally found in the northern part of the Study Area (i.e. in the swale terrain of Hillside Catchments NHC 2, 3 and 4); colluvium of up to 2 m thick is generally found in the western part of the Study Area (i.e. in the swale areas of Hillside Catchments NHC 5, 7 and 8). The colluvium is generally fine grained sandy, silty clay with some angular gravels and cobbles. There is also evidence of some relict colluvium mostly on the upper slopes and spurlines. Relict colluvium also occurs near the toe of NHC8.

Residual Soil/Saprolite

Residual soil/ saprolite are found predominantly on the open hill slopes and spurlines of Hillside Catchments NHC4, 3, 2 and NHC1. These materials are normally thin (< 0.5 m, for example TP5 has no saprolite over bedrock) over shallow rock on the spurlines and upper terrain. They appear to be thick on areas of deeper weathering on the summit located adjacent to rock outcrop, with TP3 revealing saprolite of 1.8 m near the summit.

4.2.4 Hydrogeology

Two ephemeral drainage lines and five topographic depressions were observed from API and detailed field mapping. They are located on the northern and western portion (i.e.

Hillside Catchments NHC 2, 3, 4, 5, 7 and 8) of the Study Area. The drainage lines were dry during field observations, partly due to mapping during the dry season.

Little evidence of groundwater or seepage was apparent, except associated with a basin-like area on the broad summit ridgeline which may act as a recharge area for the underlying rock units.

Figure 10 shows the two key ephemeral drainage lines and the five topographic depressions where topographic depression failures may occur. The criteria for entrainment are assessed based on the channelization ratios (depth/ width) of the channel and the size of the catchment area. It is found that sufficiently large channelization ratios (about 0.2 and above) exist in the drainage lines. The average channelization ratios for DL 7.1 and 8.2 are both 0.4.

Angular to subangular cobbles and sometimes boulders normally occur in the drainage lines, with sizes varying from 0.1 m to 0.3 m in diameter.

4.2.5 Anthropogenic Modification

Almost the entire Study Area has undergone some sort of anthropogenic modification, including slope cutting, artificial filling, constructing of concrete structures, terracing, trash disposal and shotcreting. Parts of the site were used by the military dating back to the late 1800s. The site was disturbed during World War II with substantial evidence of battle field conflict. Anthropogenic features such as two ruined military fortifications, trenches, an old artillery ramp trending northwest and a footpath/ trench trending east are in the Study Area.

4.3 Instability

The Landslide Inventory was compiled from API and, where possible, confirmed by fieldwork (**Figure 11, Table 8**). Two relict landslides occur within the Study Area and are recorded in the ENTLI. There were 13 recent landslides in the Study Area, of which 10 can be seen in 1967 and 1972 aerial photographs, and six are recorded in the ENTLI. Information on the 15 landslide features identified within an area of about 3.6 ha including and nearby the Study Area is included in the Landslide Inventory (**Table 8**). The Landslide Inventory also includes information on the hazard type, certainty of observations and possible association with anthropogenic activity. Many of the recent landslides identified have occurred in “quasi-natural” hillsides composed of residual soil, fill platforms and/or colluvium affected by old and recent anthropogenic activity.

Based on the available data, two relict ENTLI landslide features were identified within the Study Area. These occurred in the upper slopes of the Study Area, one facing north at the top of topographic depression in catchment NHC 3 and the other facing southwest on an open hillslope in catchment NHC8.

One relict landslide (L2) within catchment NHC 3 was confirmed in the field, with an estimated volume of 150 m³ making it the largest relict landslide. Relict landslide L1 located on an open hill slope in the midslopes of catchment NHC8 had an estimated volume of 40 m³.

The ENTLI recorded six recent landslides within the nearby terrain and a further 6 were identified during the Desk Study and further API. The largest of these was first evident in 1972 and had a source volume of about 100 m^3 (L3) and was located on the midslopes of a westerly oriented natural hill slope in catchment NHC7. The debris associated with L3 did not appear to runout to the cut slope at the toe of the hillside.

The next largest recent landslide was L5 (1967) located midslope in catchment NHC7, about 14 m southwest of L3, with an estimated source volume of 90 m^3 . The debris of L5 deposited into the debris of L3 about 16 m below the headscar of L5. For all recent in **Table 8** ($n=13$) the average adopted source volume is $41 \pm 37 \text{ m}^3$ with a median of 30 m^3 indicating a skewed population. This non-uniform distribution is probably due to the small sample size or could indicate differences in the magnitude and frequency of landslides, such that the order of magnitude difference in the largest source volume indicated an order of magnitude difference in frequency; however this is inconclusive.

The landslide source area dimensions (width and length) were identified from API and ground experience and where possible field mapping and then transferred to GIS. Depths range from 0.5 to 2.0 m based on field work and the results of the further API. Given the inaccuracies in the topographic base map for the area some features do not appear to be shown to map scale. The landslide source volumes were calculated using the approach recommended by Cruden and Varnes (1996), where a hemispherical failure surface is assumed ($\text{Landslide Volume} = 1/6 (\pi) \times W_r \times L_r \times D_r$). The calculated volumes were compared to API estimated volumes which indicated reasonable agreement. Adopted volumes were rounded to the nearest 5 m^3 if $<100 \text{ m}^3$ and to the nearest 10 m^3 if $>100 \text{ m}^3$.

4.4 Engineering Geomorphology

Whilst the regional geomorphological information together with the available GASP data provides a broad framework to consider the Study Area in its regional context and allows some insight into of the evolution of terrain units. It is insufficient to enable the identification of more site specific geomorphological processes which influence landslide hazards at this time. Consequently, engineering geomorphological mapping was undertaken. The objective of the mapping is to identify associations between surface forms, near-surface materials and geomorphological processes. The terrain is subdivided into land units and smaller land elements (Cooke & Doornkamp, 1990). The units are primarily a function of the age of the landscape, whereas the land facets and elements more closely reflect differing geomorphological processes which shaped the large-scale surface form. This methodology follows the approach of TGN 22 (GEO, 2004) in that it utilizes a combination of morphological, morphographical, morphogenetic and morphochronological mapping.

4.4.1 Terrain Units

The Study Area has been classified into four primary terrain units (**Figure 12**) based on the interpretation of surface material, form and geomorphological process to develop a conceptual engineering geological/geomorphological model. The descriptions follow:

- a) **Terrain Unit 1 (TU1)** predominantly consists of intermittent bedrock and saprolite on the ridgeline. Areas of shallow relict/ recent colluvium (< 1 m) along spurlines and ridgelines also occur. The central north-eastern and south-western ridgelines have gently sloping flanks, generally between 5° and 15° in gradient and planar-convex in form. Central north-western ridgelines hillcrests have quite steeply sloping flanks, generally steeper than 30° and planar convex in form. Some spurlines have similar characteristics;
- b) **Terrain Unit 2 (TU2)** consists of extensive and numerous areas of steeply sloping rock cliff to gently sloping outcrop. Typical slopes are planar-convex in nature with slope gradients typically 30 to 40°;
- c) **Terrain Unit 3 (TU3)** predominantly consists of side slopes which are generally characterised by thin colluvium (<1 m) and slope wash. The central north-eastern side slopes are generally between 5° and 15° in gradient and are planar-convex in form. The eastern and north-western side slopes are generally between 15° and 30° with some slopes steeper than 30°; and
- d) **Terrain Unit 4 (TU4)** consists of colluvial swales. These areas are characterised by colluvium generally between 1.5 m and 2 m thick and sometimes landslide debris. This terrain unit is generally characterised by convex breaks-in-slope between 15° and 30° in gradient.

4.4.2 Geological Model

Structural geology poses a major control in determining the locations of exposed head scars of the recent landslides. Most of the major landslides L3, L4, L5 and L6 (**Figure 11**), both observed in API and field verified, are found in the western and southwestern hill slopes of the Study Area (catchments NHC5, NHC7 and NHC8). Exposed rock outcrop and boulders, which have the potential to impose rock fall and boulder fall hazards, are also found in these parts of the Study Area. This can be supported by the apparent strike of structural discontinuity (**Figure 10**), where majority of the joints indicate a northwest-southeast trending direction, with some northeast-southwest trending too. The intrusive rock quartzophyric rhyolite (rq) illustrated in the published regional geological map (scale 1:20,000) (**Figure 2**) also trends in a northwest-southeast direction.

Anthropogenic factor could also impose a control in determining the locations of the boulders found in NHC5 and 7 since the part of the Study Area over at the peak of catchments NHC4, NHC5 and NHC7 has been heavily modified dating back to the 1800s.

Geomorphologically, the slope lengths over at the western catchments of the Study Area are longer than those in the northern and eastern part of the Study Area. Therefore source volumes of potential landslides are greater in the western catchments than the rest of the catchments. Also, the terrains at the western part of the Study Area is more similar to the terrain south of the Study Area geomorphologically (i.e. long slope lengths with some incised channels) and thus their source volumes of a similar magnitude.

Evidence in the project ground investigation in NHCs 5, 7 and 8 (such as TP1, TP2, TP3, DH4, DH5 and DH6 logs) also indicate that the colluvium thickness are generally not greater than 2 m.

4.5 Immediate and Obvious Dangers

No immediate and obvious dangers were observed during the study, either in the field, API, or in desk study.

5 Hazard Assessment

5.1 “React-to-Known” Criteria

Each catchment was assessed as to whether they meet the criteria for React-to-Known-Hazard under the Enhanced Approach. In all catchments (except NHC6 which is excluded from the NTHS), although there are no immediate and obvious dangers observed, there exist evidence supporting the possibility that a dangerous situation could develop. Past persistent landslides and strong geological evidence are the dominant factors.

For Natural Hillside Catchment NHC1, there are no past persistent landslides or newly emerged hazardous situation. However, there is strong geological evidence indicating a dangerous situation could develop, where exposed jointed rock outcrop with daylighting joints near the crest of this catchment poses rock fall hazards (**Figure 10**).

For Natural Hillside Catchment NHC2, there are no past persistent landslides or newly emerged hazardous situation. However, there is strong geological evidence indicating a dangerous situation could develop, where jointed bedrock with daylighting joints near the crest poses rock fall hazards (**Figure 10**). There is also clear evidence from geomorphology which indicates a dangerous situation could develop. Topographic depression failures can be generated in this catchment with source volume of 70 m^3 . Open hillslope landslides can also occur with source volume of 50 m^3 (**Figures 10 and 13**).

For Natural Hillside Catchment NHC3, there are no past persistent landslides or newly emerged hazardous situation. However, there is clear evidence from geomorphology which indicates a dangerous situation could develop, where topographic depression failures can be generated in this catchment with source volume of 70 m^3 . Open hillslope landslides can also occur with source volume of 50 m^3 (**Figures 10 and 13**).

For Natural Hillside Catchment NHC4, there are no past persistent landslides or newly emerged hazardous situation. However, there is strong geological evidence indicating a

dangerous situation could develop, where jointed bedrock with daylighting joints found near the hillside of the north-facing slope poses rock fall hazards. Boulders, possibly related to past anthropogenic activities, found near the crest of NHC4 pose boulder fall hazards. There is also clear evidence from geomorphology which indicates a dangerous situation could develop, where topographic depression failures can be generated in this catchment with source volume of 70 m^3 . Open hillslope landslides can also be generated in this catchment with source volume of 50 m^3 (**Figures 10 and 13**).

For Natural Hillside Catchment NHC5, there is no newly emerged hazardous situation. However, there are past persistent landslides and strong geological evidence indicating a dangerous situation could develop. There are two recent landslides (L4 and L6, of estimated landslide volume about 10 m^3 and 50 m^3) which are observed in 1967 and 1972 aerial photographs respectively (**Figure 11**). In the field, there is clear evidence from geomorphology that these two past landslides are located in terrain where topographic depression failures and open hillslope landslides are possible respectively (**Figure 13**). Topographic depression failures and open hillslope landslides can be generated in this catchment with source volumes of 100 m^3 and 50 m^3 respectively. Jointed bedrock with daylighting joints found along the hillside in this catchment poses rock fall hazards (**Figure 10**). Boulders found near the crest of NHC5, possibly related to past anthropogenic activities, also pose boulder fall hazards.

Natural Hillside Catchment NHC6 is entirely anthropogenic and is not included in the NTHS.

For Natural Hillside Catchment NHC7, there is no newly emerged hazardous situation. However, there are past persistent landslides and strong geological evidence indicating a dangerous situation could develop. There are two large recent landslides (L3 and L5, of estimated landslide volume about 100 m^3 and 90 m^3) which are observed in 1972 and 1967 aerial photographs respectively in this catchment (**Figure 11**). In the field, there is clear evidence from geomorphology that these landslides are located in terrain where channelized debris flows are possible (**Figure 13**). Channelised debris flows can be generated in this catchment with source volume of 100 m^3 . Debris deposits are evident within the swale containing DL7.1. Open hillslope landslides can also occur with source volume of 50 m^3 . Jointed bedrock with daylighting joints found along the hillside in this catchment poses rock fall hazards (**Figure 10**). Boulders, possibly related to past anthropogenic activities, are found near the crest of NHC7 and pose boulder fall hazards.

For Natural Hillside Catchment NHC8, there are no past persistent landslides or newly emerged hazardous situation. However, there is strong geological evidence indicating a dangerous situation could develop. There is clear evidence from geomorphology which indicates a dangerous situation could develop, where channelized debris flows and topographic depression failures can be generated in this catchment with source volume of 100 m^3 . Open hillslope landslides can also occur with source volume of 50 m^3 (**Figures 10 and 13**). Debris deposits are evident within the swale containing DL8.2.

A summary of the discussed criteria for React-to-Known-Hazard under the Enhanced Approach is shown in **Table 9**.

5.2 Hazard Types

5.2.1 Open Hillslope Landslide

Open Hillslope Landslide (OHL) hazards are slope failures where the landslide debris remains wholly on the open hillside and is not channelised along a stream course. Based on the engineering geological and geomorphological mapping of the Study Area, it is considered that such hazard could affect down slope facilities. The type of potential OHL under consideration includes shallow translational slides, shallow slumps, shallow debris avalanche, and shallow debris spreads. Due to pervasive disturbance of parts of the Study Area as a former military site, some potential landslides may be considered within the framework of “disturbed hillside failures – Type A or B” (Ng et al, 2003). OHL hazards mainly originate from Hazard Zone 1 as shown in **Figure 13**.

5.2.2 Topographic Depression Failure

Topographic Depression Failure (TDF) hazards are slope failures where landslide debris are somewhat confined within a topographic depression but without significant channelisation effects. The entrainment potential of TDF is lower than that of CDF in general and largely dependent on the presence of entrainable materials within the topographic depression. Topographic depressions were identified in the northern and southwestern portions (Hillside Catchments NHC 2, 3, 4, 5 and 8) of the Study Area during field mapping and API. CDF hazards mainly originate from Hazard Zone 3 as shown in **Figure 13**.

The entrainment potential of TDF is lower than CDF in general, hence an entrainment depth of 0.1 m is adopted for TDFs in the Study Area.

5.2.3 Channelised Debris Flow

Channelised debris flows (CDF) occur when saturated landslide debris becomes confined within a steeply inclined, incised stream channel. These types of failures are typically extremely mobile and landslide volumes can exceed that of the source area due to entrainment of material within the stream bed and channel sides. Some channelized areas or incised ephemeral drainage lines were identified in the western portions (Hillside Catchments NHC 7 and 8) of the Study Area during field mapping and API. There is also evidence of previous CDFs in NHC 7. CDF hazards mainly originate from Hazard Zone 3 as shown in **Figure 13**. Therefore, it is considered that the susceptibility to such landslides is high.

The entrainment depth was determined based on GI and field mapping. It is bounded on the upper by GI colluvium depth ranging from 0.7m to 1.7m in NHCs 7 and 8, and on the lower by field observations of entrainable material within the drainage lines. Field estimates of entrainment depths range from 0.1m to 0.3m with an overall average of 0.2m. It is sufficient for our purposes to assume an erosion depth of 0.2m on average along all drainage lines.

5.2.4 Deep Seated Landslide

No obvious deep-seated landslide hazards were observed in the field nor was there obvious evidence of such hazards found within available desk study information.

5.2.5 Rock Fall

Significant steep rock cliffs, intermittent bedrock exposures, and other obvious, potential rock fall sources were identified over the crests and open hill slopes of Hillside Catchments NHC 1, 2, 4, 5 and 7. There is a potential rock fall hazard with a block size of up to 2 m in diameter in Hillside Catchment NHC 4 and a block size of up to 1 m in diameter in the other Hillside Catchments. Rock fall hazards mainly originate from Hazard Zones 4 and 5 as shown in **Figure 13**.

5.2.6 Boulder Fall

Boulder fall may occur when there are partially-completely exhumed or precariously perched boulders on slopes generally greater than 20° and may be triggered by rainfall and associated slope movements. Boulders, including exhumed corestones, were observed on Hillside catchments NHC 4, 5 and 7. The block sizes of the boulders are up to 1 m in diameter. Boulder fall hazard locations are shown in **Figure 13**.

5.2.7 Multiple Failures

More than one landslide may occur in a catchment during an intense rainstorm and these are termed “multiple failures.” In some cases, it may be possible to assess whether two or more landslides occurred in a catchment during the same storm, however there are limitations and conclusions are highly interpretive with respect to the timing of landslide initiation. No evidence of recent, multiple failures was identified in the same year. Relict failures cannot be assessed in this regard, since there is no aerial photograph record for the time period in which these may have occurred, apart from the baseline of 1963.

5.2.8 Hazards Arising from Man-Made Ground

Hazards arising from man-made ground were assessed with regards to the risk they pose to the existing developments. While no significant hazards were found in the other catchments, it is recommended to assess NHC6 separately as a disturbed terrain due to the heavy anthropogenic disturbances involved in the construction of the buildings above and below.

5.3 Enhanced Approach for Dealing with Natural Terrain under LPMitP

Based on the Enhanced Approach for Dealing with Natural Terrain under LPMitP, a “Credible Event” (CE) is adopted for all catchments except for NHC 6 (**Table 9**).

A Credible Event (CE) is one that occurs within a reasonable design period of about 50 to 100 years, and should be less in source volume than a “conservative event”. It is primarily assessed from recent landslides and “drainage line” incision due to recurrent debris flows for OHL, TDF and CDF and strong geological evidence for boulder/ rock fall.

For comparison, a conservative event is defined in Ng et al, (2003) as “a reasonably safe but not overly cautious estimate of the hazard that may affect the site, with a notional return period in the order of 100 years, and is generally based on the largest historical landslide over the past 50 to 100 years in the catchment and its vicinity as appropriate.”

A Worst Credible Event (WCE) is defined in Ng et al. (2003) as “a very conservative estimate, such that the occurrence of a more severe event is sufficiently unlikely. Its notional return period is in the order of 1,000 years, which indicates an order of magnitude difference compared with that of a ‘conservative event’. It generally corresponds to the largest credible landslide based on interpretation of historical landslide date, geomorphological evidence in the catchment and its vicinity as appropriate, and any other relevant evidence from similar terrain in Hong Kong.”

5.4 Design Event Source Volumes

The stability of materials on the hillsides within the area is influenced by the geology, geomorphology, landslide history, and anthropogenic modification. Analysis of these factors along with the relevant desk study data allowed for a preliminary, conservative assessment of natural and quasi-natural terrain hazards in the Study Area. **Figure 13** shows the locations of the categorised hazards and associated Credible Event (CE) source volumes. The hazards presented by potential instability of the slopes include open hillslope landslides (OHL) topographic depression failure (TDF), channelised debris flow (CDF) and rock boulder fall hazard.

The largest (recent) landslide depression has an adopted volume of about 100 m³. A CE source volume of 100 m³ is adopted for modelling in Hazard Zone 3 (swales in Catchments 5, 7 & 8). A CE source volume of 70 m³ is adopted for modelling in Hazard Zone 2 (swales in Catchments 2, 3 & 4) while 50 m³ is adopted for modelling in Hazard Zone 1.

5.5 Design Event Modelling

Debris mobility modelling to evaluate landslide run out was undertaken using DAN-W, developed by O. Hungr Geotechnical Research Inc. to model the post-failure motion of rapid landslides. Twelve landslide scenarios were modelled in total, with four Open Hillslope Landslide (OHL), five Topographic Depression Failure (TDF) and three Channelised Debris

Flow (CDF) scenarios (**Appendix D**). Credible Event (CE) scenarios were simulated for each hazard zone. Hazard Zone 1 had a 50 m³ source volume, Hazard Zone 2 had a 70 m³ source volume and Hazard Zone 3 had a 100 m³ source volume.

The results of the analysis indicate that anticipated debris velocities at the observation point (Location of Proposed Mitigation Works) vary from 0 m/s (where the modelled debris flow does not reach the observation point) to about 12 m/s. A more detailed summary of the results is located in **Appendix D** and **Table D1**.

5.6 Hazard Model

The stability of materials on the hill slopes within the Study Area is influenced by the geology, geomorphology, landslide susceptibility, and anthropogenic modification. Assessment of the engineering geology and geomorphology of the area allowed for the development of a detailed observational model of the Study Area. An assessment of natural, quasi-natural and anthropogenic terrain hazards is provided with hazard zonation and associated hazard types and magnitudes presented in **Figure 13**.

Hazard Zone 1 (HZ1) consists of much of the western, northern, and eastern side slopes of Study Area. It is composed of colluvium (<1 m) and is a potential open hillslope landslide (OHL) source area. Two recent landslide features were recorded in HZ1.

Hazard Zone 2 (HZ2) is present in topographic depressions in catchments NHC2, NHC3 and NHC4 on the northern portion of the Study Area. HZ2 is composed of colluvium (<1.5 m) and has potential topographic depression failure (TDF) hazards occurring in catchments with pronounced topographic depressions but without a well-defined drainage channel. One relict and one recent landslide feature are recorded in HZ2.

Hazard Zone 3 (HZ3) is present on the midslopes of the western portion of the Study Area and consisting of colluvial swales (<2 m). The zone is drained by incised channels DL7.1 and DL8.2. HZ3 has potential topographic depression failure (TDF) and channelized debris flow (CDF) hazards. One relict and three recent landslide features are recorded in HZ3.

Hazard Zone 4 (HZ4) consists of potential rock fall hazards. It is present along the upper side slope of the western portion and eastern, upper side slope portions of the Study Area, where cliffs and bedrock occur. The rock fall volume is up to a block size of 1 m in diameter for this hazard zone.

Hazard Zone 5 (HZ5) consists of potential rock fall hazards from the toe to crest of the northern portion of the Study Area where cliffs and bedrock occurs. The rock fall volume is up to a block size of 2 m in diameter for this hazard zone.

There is potential for boulder fall hazards to occur in the western portion of catchments NHC4, NHC5 and NHC7. Boulders of not more than 1m in diameter occur near the crests of these catchments.

No obvious deep-seated landslide hazards were observed in the field, nor was there any obvious evidence of such hazards found within available desk study information.

5.7 Risk

Considering the presence of recent landslides in the Study Area, hazard modelling results, desk study and field mapping, there is a potential risk of future landslides. Mitigation structures will reduce landslide risk to facilities below the Study Area.

5.8 Limitations

The hazard model and associated assessment of relative risk has been primarily developed from API, field mapping, which were enhanced by use of LiDAR data. Project ground investigation (GI) reduced uncertainties in the Engineering Geology Geomorphology (EGG) and hazard models.

6 Mitigation Strategy

6.1 Hazards to be Mitigated

CDF, OHL and TDF hazards have the potential to affect facilities at the toe of the Study Area (refer to **Figure 13**).

Typically one of two approaches can be taken for the mitigation of the hazards, with the selection of the preferred approach largely dependent on the magnitude of the hazard, the landslide velocity and the extent of the affected area. These options include:

- a) Stabilization at Source – in-situ stabilization of the potential landslide source areas through the installation of soil nails or similar measures; and
- b) Debris Containment– depending on the magnitude of the particular landslide event, debris can be prevented from impacting facilities to be protected through provision of flexible barriers / rigid concrete barriers.

Rock and boulder falls have the potential to affect some of the facilities at the toe of catchments NHC 1, 2, 4, 5, and 7. Rock fall mitigation approaches typically include one or a combination of the following:

- a) Stabilization at Source – in-situ stabilization of the potential rock fall source areas through the installation of rock bolts or similar measures; and

- b) Flexible barriers – depending on the magnitude of the particular rock fall event, rock blocks can be prevented from impacting facilities to be protected through provision of flexible barriers.

6.2 Possible Hazard Mitigation Strategies

Brief details of three possible hazard mitigation schemes (**Figures 14A, 14B, 14C**) are summarized below. Further details of these schemes, including cost estimates and detailed reviews of the constructability and environmental impact and other factors are included in **Appendix E**. Mitigation works were only proposed on Government Lands only in order to avoid potential conflicts with Private Lots. The Design Event volumes to be mitigated are taken as the source plus entrainment volumes.

The facilities-at-risk mostly includes residential buildings, moderately used roads, and substantial structures including a garage. Thus, hazard mitigation works are required for the Study Area. The various mitigation options considered for the Study Area include:

Option	Mitigation works for OHL / TDF	Mitigation works for CDF	Mitigation works for RF
1	Soil Nails	Soil Nails	In-situ stabilization measures and rock fall barrier
2	Rigid Barrier	Rigid Barrier	
3	Flexible Barrier	Flexible Barrier	

Option 1 refers to the installation of soil nails in areas targeted to provide an adequate factor of safety against failure of the top 2m of the regolith with information on the soil and groundwater from current ground investigation works. In-situ stabilization measures and rock fall barrier are proposed to mitigate rock fall and boulder fall at NHC 1, 2, 4, 5, and 7.

Option 2 refers to the installation of rigid barriers along the toe of most catchments and in-situ stabilization measures and rock fall barriers at the southern end of NHC1 and central northern end of NHC4. The rigid barriers are designated to catch the landslide and rock fall debris with slight wing walls to retain and train debris.

Option 3 refers to the construction of flexible barriers and in-situ stabilization measures and rock fall barriers at the toe of most catchments to mitigate potential landslide and rock fall hazards.

The above mitigation options were discussed in the GEO Design Review Committee (DRC) meeting on 15 August 2013. During the meeting, the DRC endorsed Option 1 as the preferred option with in-situ stabilization measures to be constructed on the hillside slopes to mitigate rock fall and boulder fall hazards. To optimize the design, the flexible barrier was deleted.

6.3 Preliminary Landscape Design

To alleviate the visual impact due to the proposed hazard mitigation works, landscaping treatments are proposed for each of the mitigation schemes. Preliminary landscape design for each of the mitigation schemes are given in **Appendix E**.

7 Conclusions and Recommendations

A Natural Terrain Hazard Study (NTHS) using the Design Event approach was performed for the Study Area 11SW-D/SA12, at Shouson Hill (a total of eight hillside catchments). The hazard models for the assessment were developed based on the findings of detailed desk study, API integrated with geological and geomorphological field mapping, ground investigation findings, and a synthesis of the data and analysis into a detailed observational model that forms the basis of the hazard assessment.

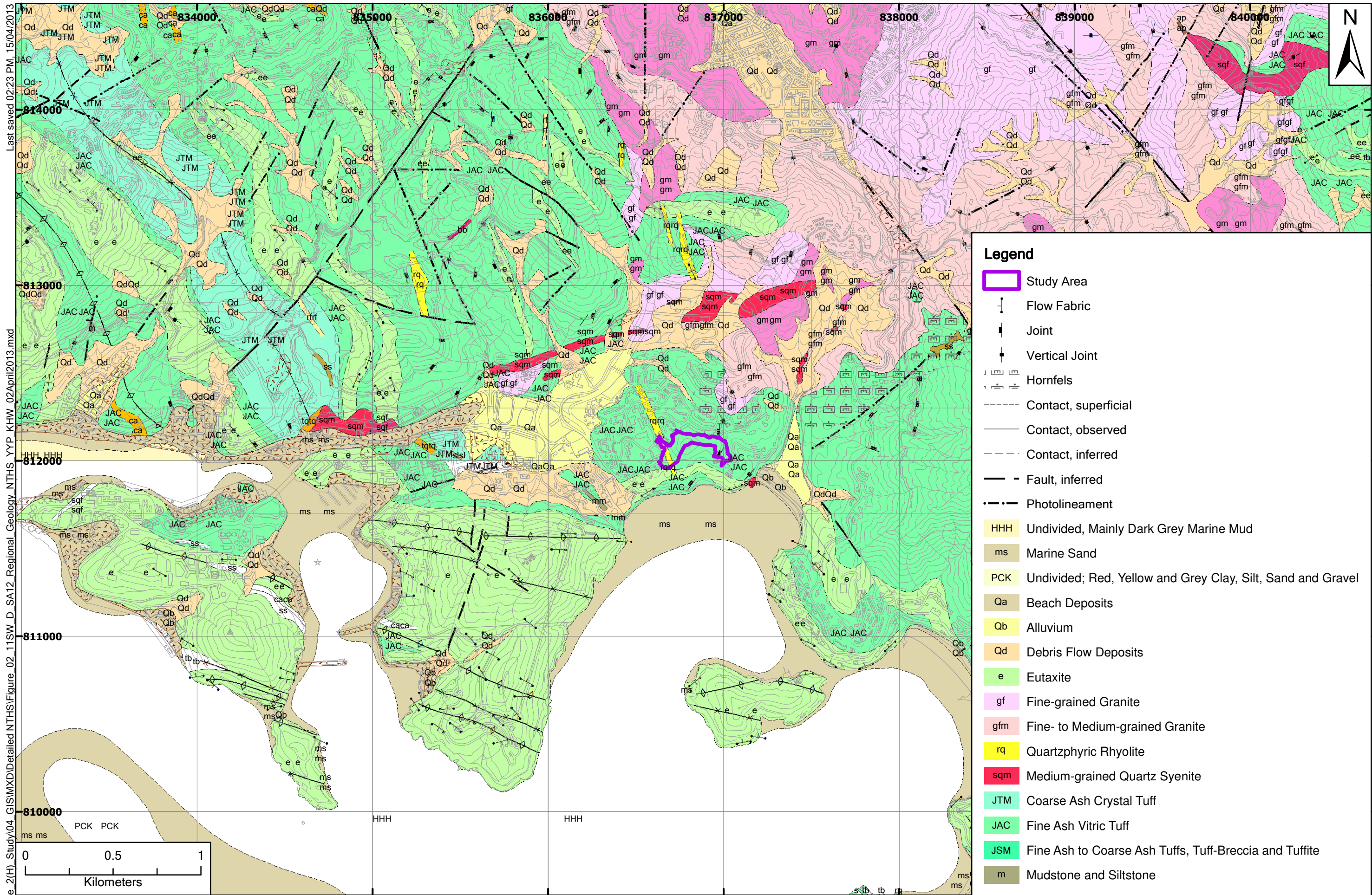
The NTHS identified five hazard zones and related Design Event volumes. The hazards include Open Hillslope Landslide (OHL), Topographic Depression Failure (TDF), Channelised Debris Flow (CDF), Rock Fall and Boulder Fall. The hazard zones are: HZ1 (OHL) with a source volume of 50 m³; HZ2 (TDF) with a source volume of 70 m³ (and entrainment depth of 0.1 m); HZ3 (CDF/TDF) with a source volume of 100 m³ (and entrainment depth of 0.2 m), and two Rock Fall HZ's of 1m diameter (HZ4) and 2m diameter (HZ5) as well as 3 Boulder Fall source areas of 1 m diameter boulders. All the estimated potential landslide source volumes were Credible Event (CE).

Considering the findings of the NTHS, hazard mitigation works are recommended for seven of the eight the hillside catchments to address the Credible Event (CE) magnitudes and hazard types.

8 References

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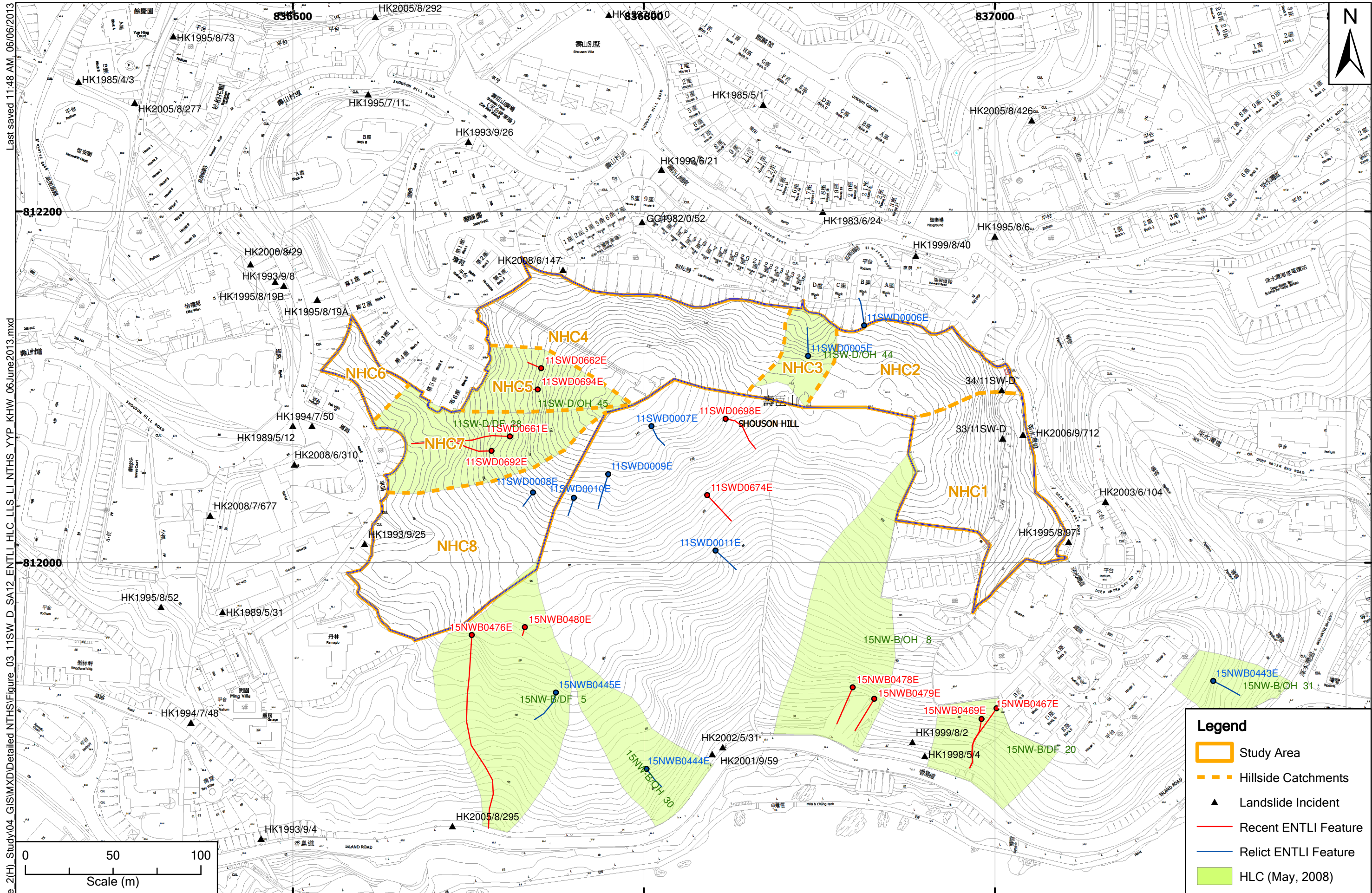


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Job Title
Agreement No. CE 16/2011 (GE)
Landslip Prevention and Mitigation Programme,
2011, Package B,
Landslip Prevention and Mitigation Works,
Hong Kong Island (East) -
Investigation, Design and Construction

Drawing Title
**Natural Terrain Hazard Study for
Study Area 11SW-D/SA12 - Shouson Hill
Regional Geology**
Note: Notional & Extracted from 1:20,000 Scale Geological Mapsheet 11 - HGM20 and 15 - HGM20. Topographic base map is 1:20,000 scale (2002), 10 m contour intervals; mapsheets 11 and 15.

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Job No. 110441	Figure No. 02	



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Drawing Title

**Natural Terrain Hazard Study for
Study Area 11SW-D/SA12 - Shouson Hill
ENTLI, HLC, Large Landslide & Landslide Incidents**

Note: Topographic base map is 1:1,000 scale (2010), 2 m contour intervals; mapsheets 11SW: 25c and 25d, 15NW:5a and 5b. LiDAR - derived contours (2m) shown in Study Area.

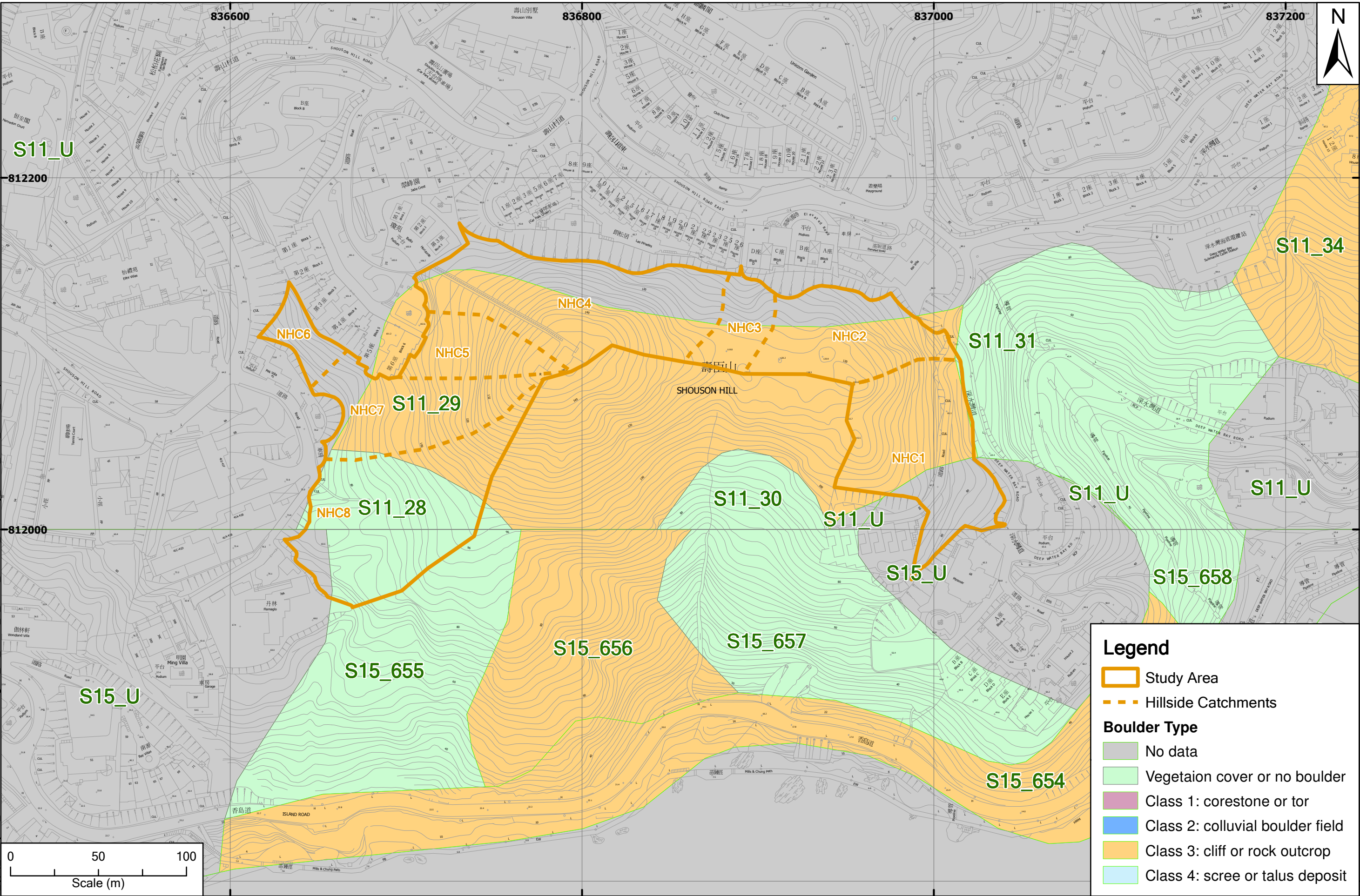
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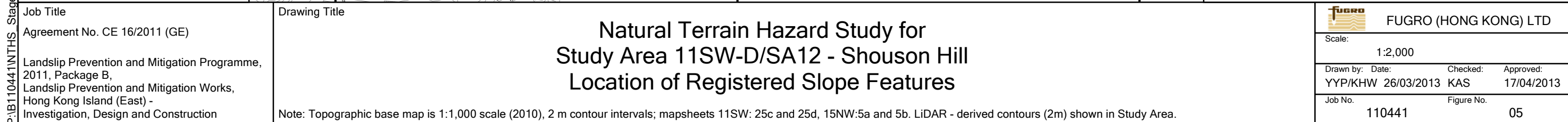
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Figure No. 03

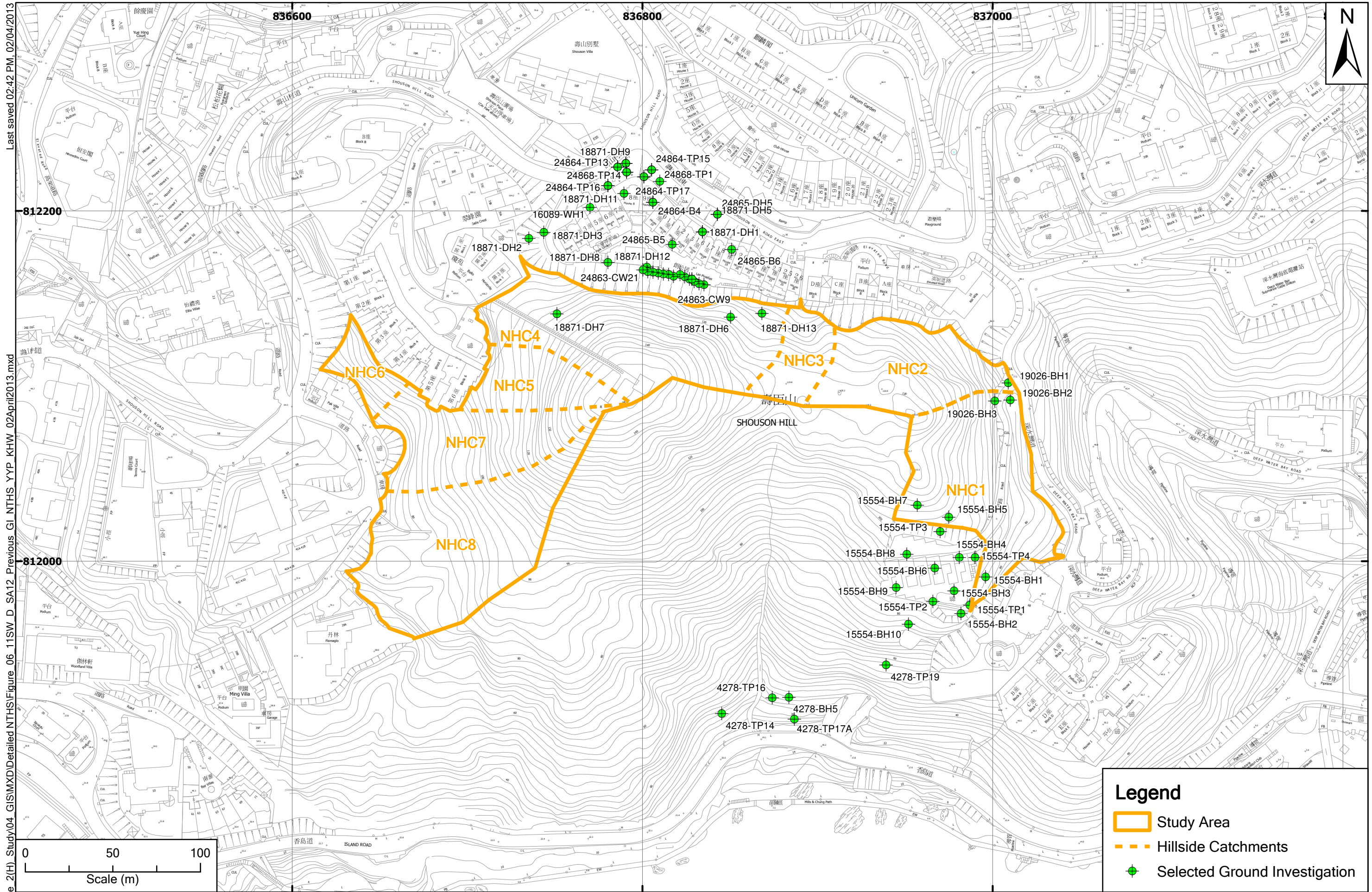


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Drawing Title
**Natural Terrain Hazard Study for
Study Area 11SW-D/SA12 - Shouson Hill
Boulder Inventory**
Note: Topographic base map is 1:1,000 scale (2010), 2 m contour intervals; mapsheets 11SW: 25c and 25d, 15NW:5a and 5b.

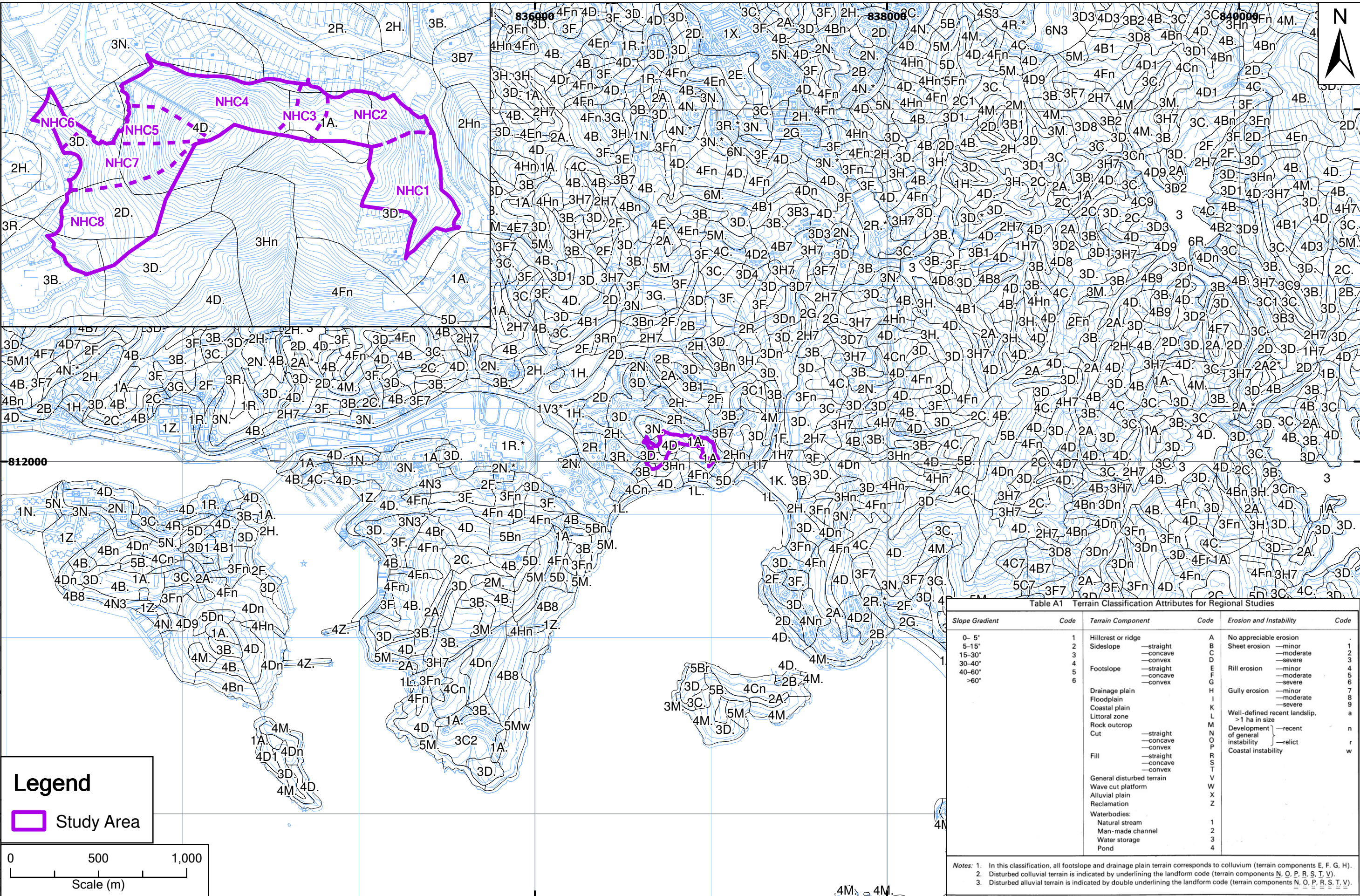
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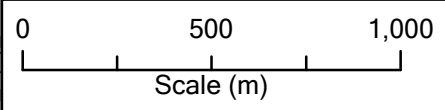
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 Study Area



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Drawing Title

**Natural Terrain Hazard Study for
Study Area 11SW-D/SA12 - Shouson Hill
Regional - Terrain Classification Map - GASP I**

Note: Topographic base map is 1:20,000 scale (2002), 10 m contour intervals; mapsheets 11_2002.dgn and 15_2002.dgn. Inset 1:1,000 scale (2010), 2m contour intervals; mapsheets 11SW: 25c, 25d; 15NW: 5a, 5b.

Table A1 Terrain Classification Attributes for Regional Studies					
Slope Gradient	Code	Terrain Component	Code	Erosion and Instability	Code
0-5°	1	Hillcrest or ridge	A	No appreciable erosion	.
5-15°	2	Sideslope	B	Sheet erosion	—minor
15-30°	3	—straight	C	—moderate	2
30-40°	4	—concave	D	—severe	3
40-60°	5	Footslope	E	Rill erosion	—minor
>60°	6	—straight	F	—moderate	4
		—concave	G	—severe	5
		—convex	H	Gully erosion	—minor
		Drainage plain	I	—moderate	6
		Floodplain	J	—severe	7
		Coastal plain	K	Well-defined recent landslip,	a
		Littoral zone	L	>1 ha in size	
		Rock outcrop	M	Development of general	n
		Cut	N	instability	—recent
		—straight	O	—relict	r
		—concave	P	Coastal instability	w
		—convex	Q		
		Fill	R		
		—straight	S		
		—concave	T		
		—convex	U		
		General disturbed terrain	V		
		Wave cut platform	W		
		Alluvial plain	X		
		Reclamation	Z		
		Waterbodies:			
		Natural stream	1		
		Man-made channel	2		
		Water storage	3		
		Pond	4		

Notes: 1. In this classification, all footslope and drainage plain terrain corresponds to colluvium (terrain components E, F, G, H).
2. Disturbed colluvial terrain is indicated by underlining the landform code (terrain components N, O, P, R, S, T, V).
3. Disturbed alluvial terrain is indicated by double underlining the landform code (terrain components N, O, P, R, S, T, V).

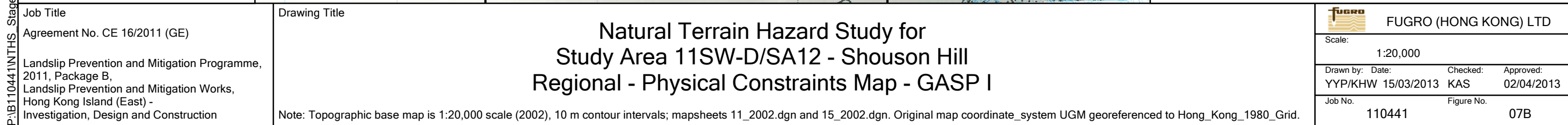


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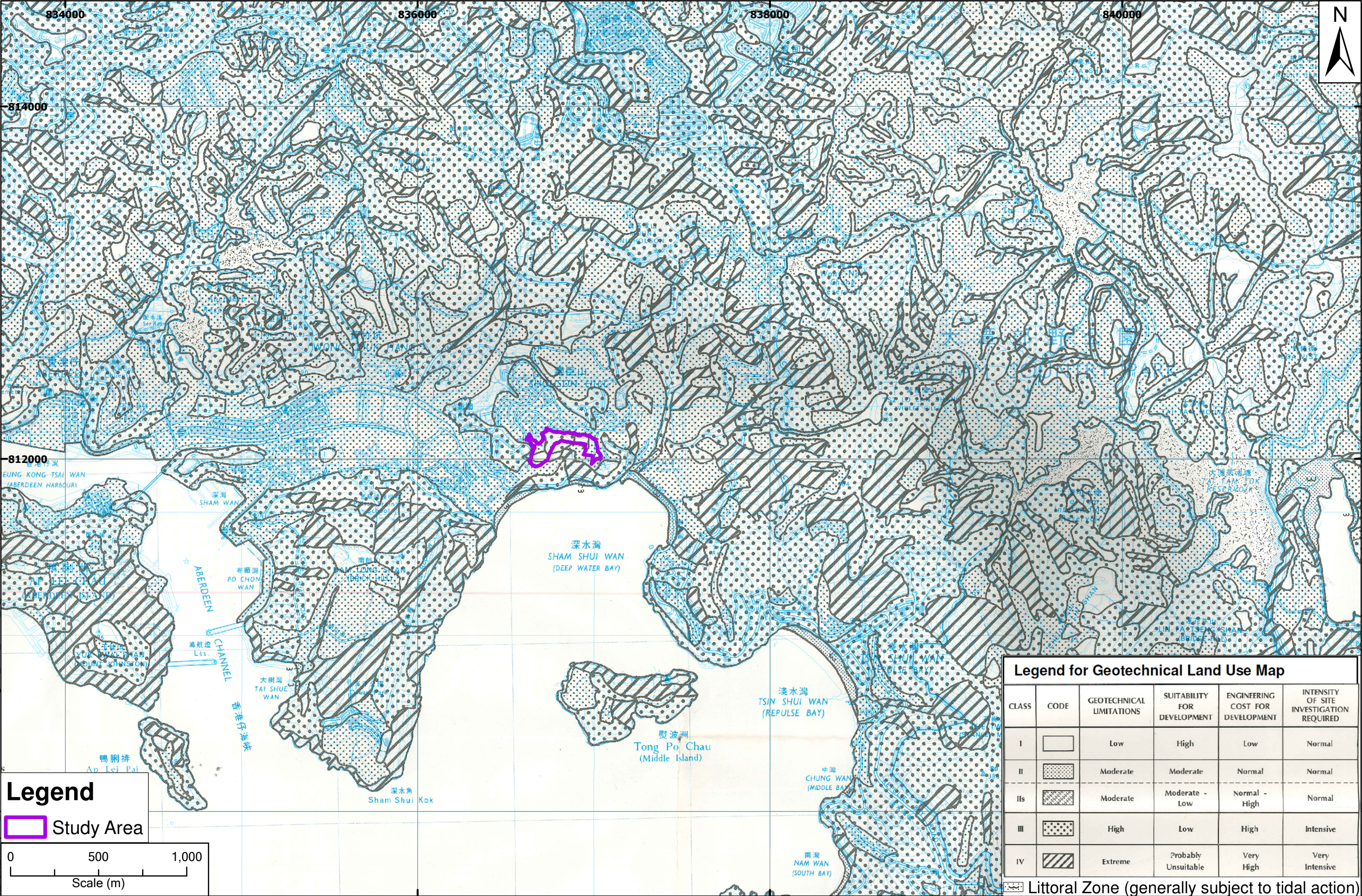
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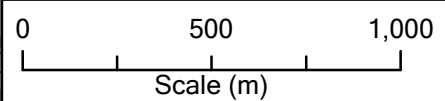


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Legend
 Study Area



Legend for Geotechnical Land Use Map					
CLASS	CODE	GEOTECHNICAL LIMITATIONS	SUITABILITY FOR DEVELOPMENT	ENGINEERING COST FOR DEVELOPMENT	INTENSITY OF SITE INVESTIGATION REQUIRED
I		Low	High	Low	Normal
II		Moderate	Moderate	Normal	Normal
IIs		Moderate	Moderate - Low	Normal - High	Normal
III		High	Low	High	Intensive
IV		Extreme	Probably Unsuitable	Very High	Very Intensive

Littoral Zone (generally subject to tidal action)

Job Title
Agreement No. CE 16/2011 (GE)
Landslip Prevention and Mitigation Programme, 2011, Package B,
Landslip Prevention and Mitigation Works,
Hong Kong Island (East) -
Investigation, Design and Construction

Drawing Title
**Natural Terrain Hazard Study for
Study Area 11SW-D/SA12 - Shouson Hill**
Regional - Geotechnical Limitations associated with the Terrain (Geotechnical Land Use Map) - GASP I
Note: Topographic base map is 1:20,000 scale (2002), 10 m contour intervals; mapsheets 11_2002.dgn and 15_2002.dgn. Original map coordinate system UGM georeferenced to Hong_Kong_1980_Grid.

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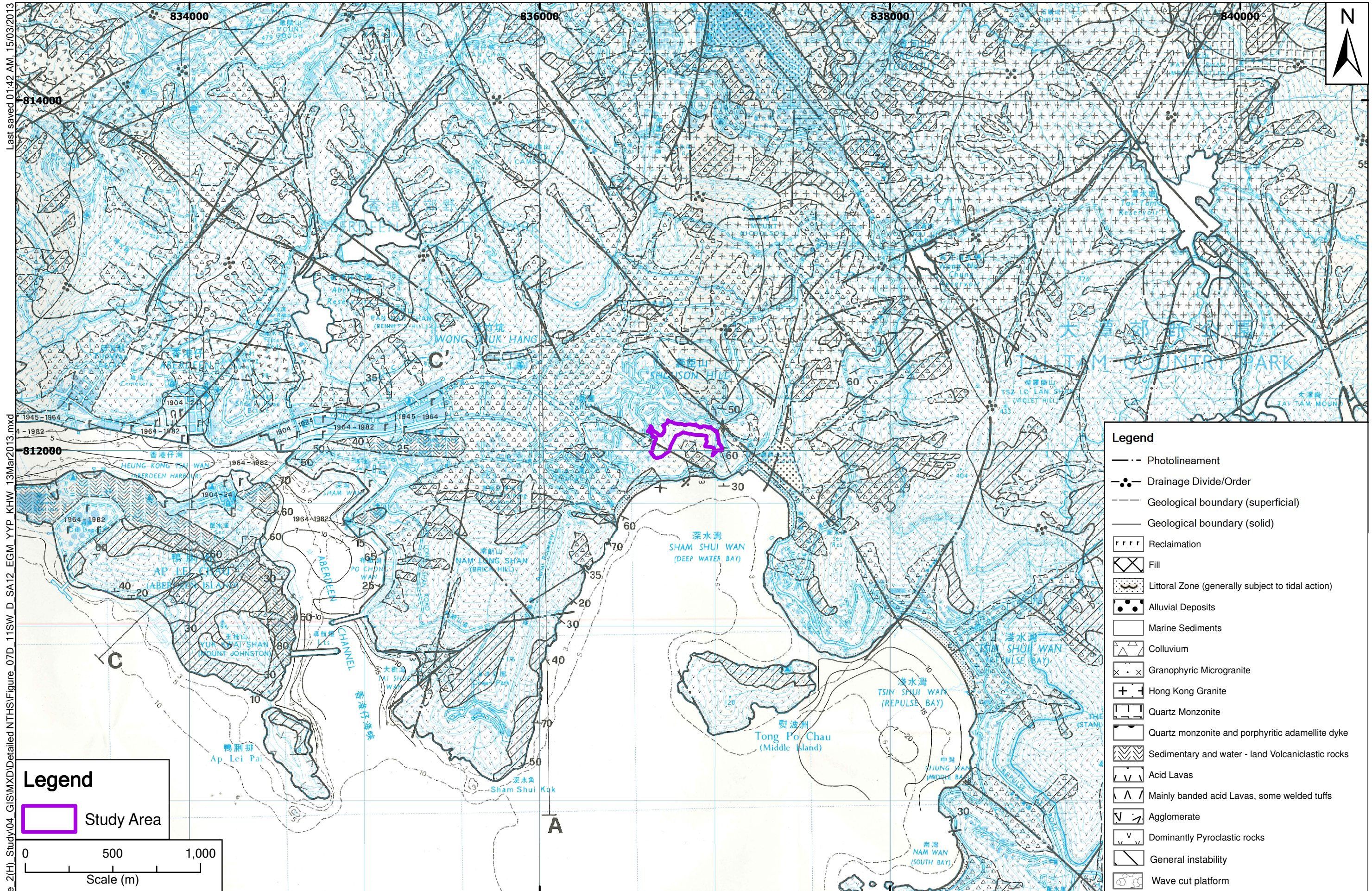
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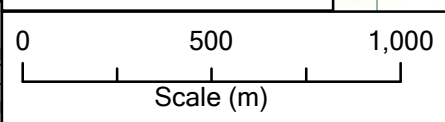
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Figure No. 07C



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Study Area



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Agreement No. CE 16/2011 (GE)

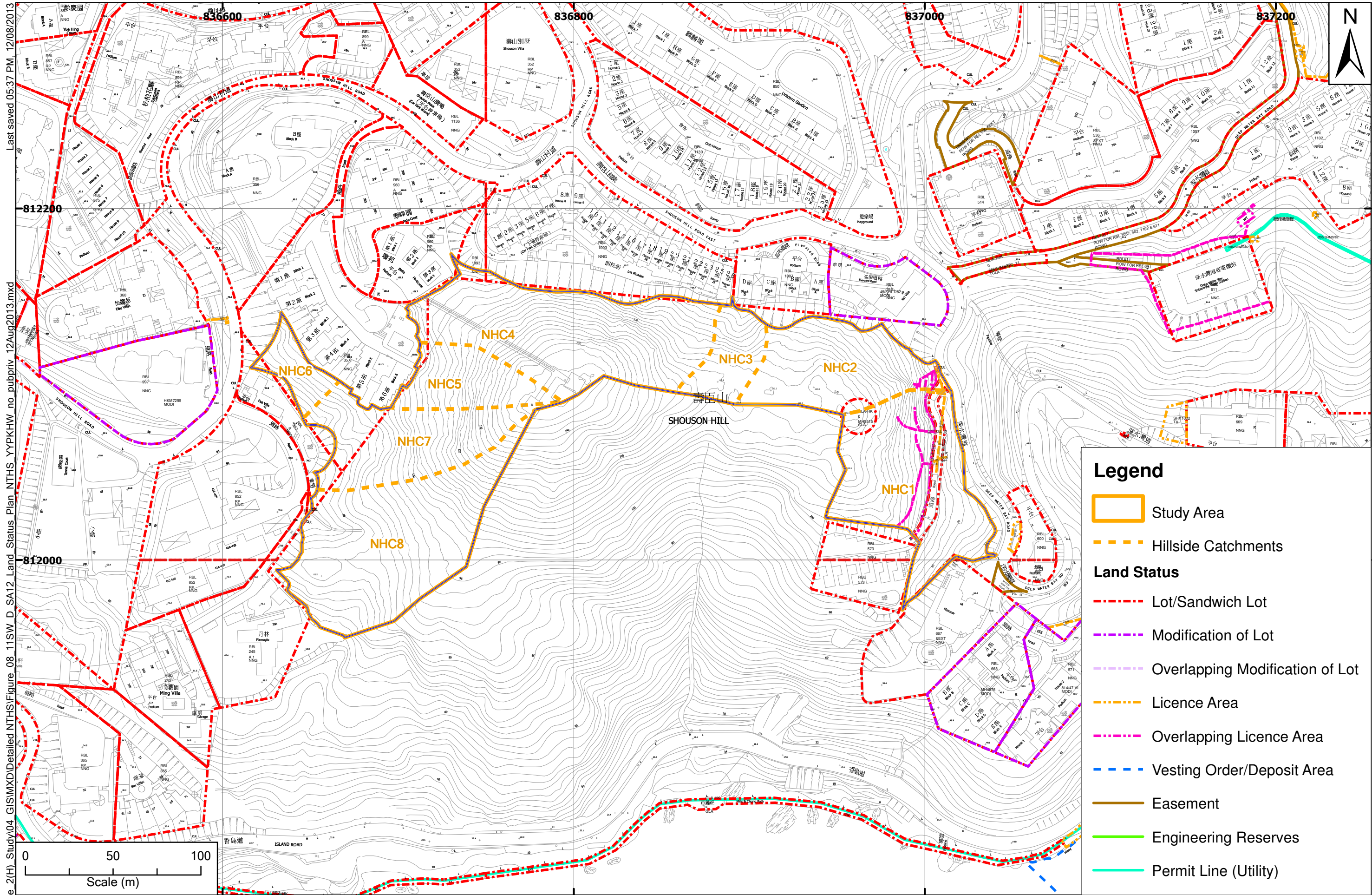
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Drawing Title

**Natural Terrain Hazard Study for
Study Area 11SW-D/SA12 - Shouson Hill
Regional - Engineering Geology Map - GASP I**

Note: Topographic base map is 1:20,000 scale (2002), 10 m contour intervals; mapsheets 11_2002.dgn and 15_2005.dgn. Original map coordinate_system UGM georeferenced to Hong_Kong_1980_Grid.

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		Approved: 02/04/2013
Job No. 110441	Figure No. 07D	

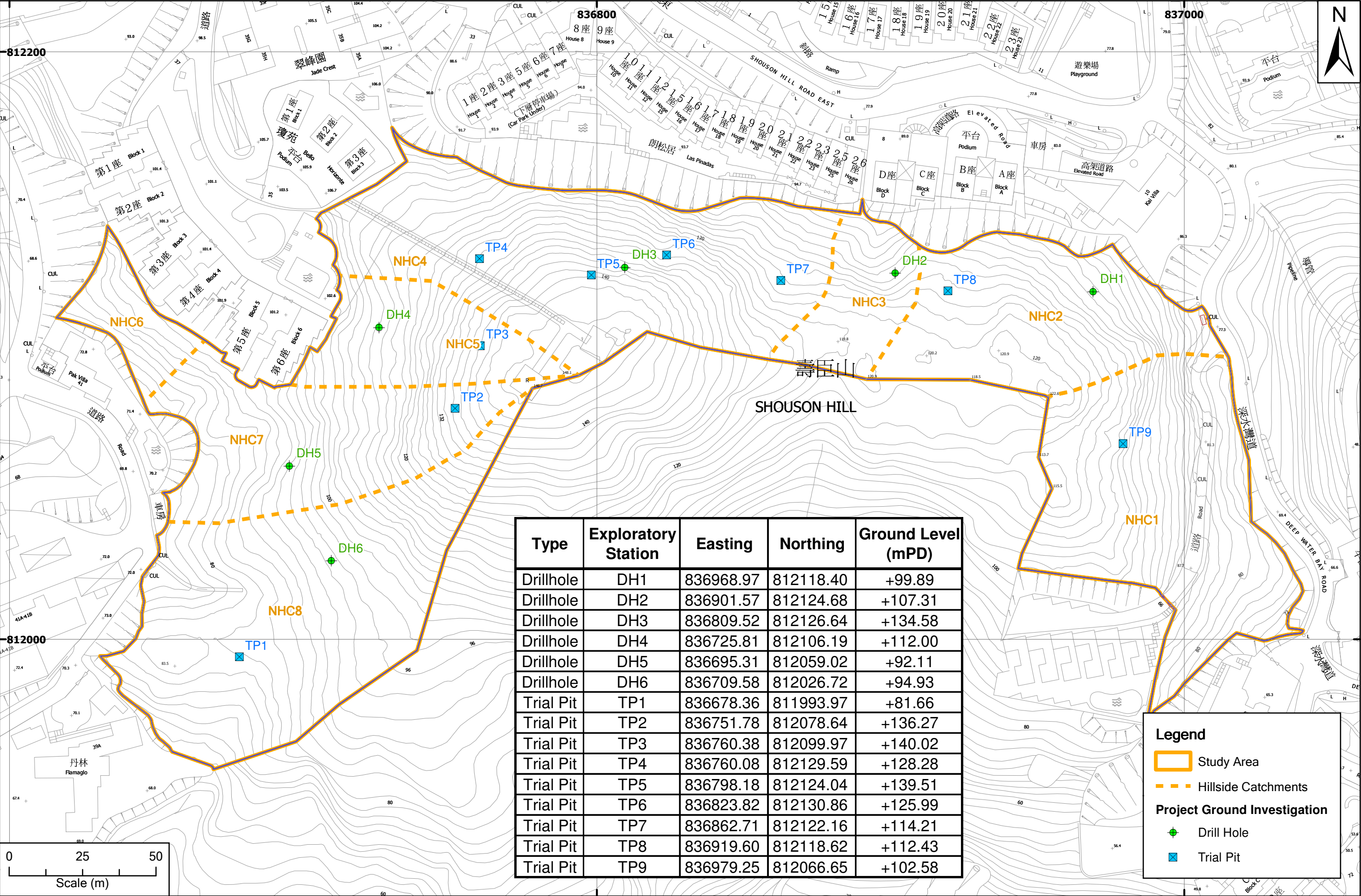


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P:\B110441\NTHS Stage 2(H) Study\04 GISMXDDetailedNTHS\Figure 08 11SW D SA12 Land Status Plan NTHS YYPKHW no pubpriv 12Aug2013.mxd

Job Title
Agreement No. CE 16/2011 (GE)
Landslip Prevention and Mitigation Programme,
2011, Package B,
Landslip Prevention and Mitigation Works,
Hong Kong Island (East) -
Investigation, Design and Construction

Drawing Title
**Natural Terrain Hazard Study for
Study Area 11SW-D/SA12 - Shouson Hill
Land Status Plan**
Note: Topographic base map is 1:1,000 scale (2010), 2 m contour intervals; mapsheets 11SW: 25c and 25d, 15NW:5a and 5b. LiDAR - derived contours (2m) shown in Study Area.

 FUGRO (HONG KONG) LTD		
Scale: 1:2,000		
Drawn by: YYP/KHW	Date: 12/08/2013	Checked: KAS Approved: 12/08/2013
Job No. 110441	Figure No. 08	



Type	Exploratory Station	Easting	Northing	Ground Level (mPD)
Drillhole	DH1	836968.97	812118.40	+99.89
Drillhole	DH2	836901.57	812124.68	+107.31
Drillhole	DH3	836809.52	812126.64	+134.58
Drillhole	DH4	836725.81	812106.19	+112.00
Drillhole	DH5	836695.31	812059.02	+92.11
Drillhole	DH6	836709.58	812026.72	+94.93
Trial Pit	TP1	836678.36	811993.97	+81.66
Trial Pit	TP2	836751.78	812078.64	+136.27
Trial Pit	TP3	836760.38	812099.97	+140.02
Trial Pit	TP4	836760.08	812129.59	+128.28
Trial Pit	TP5	836798.18	812124.04	+139.51
Trial Pit	TP6	836823.82	812130.86	+125.99
Trial Pit	TP7	836862.71	812122.16	+114.21
Trial Pit	TP8	836919.60	812118.62	+112.43
Trial Pit	TP9	836979.25	812066.65	+102.58

Legend

Study Area

Hillside Catchments

Project Ground Investigation

Drill Hole

Trial Pit

Job Title
Agreement No. CE 16/2011 (GE)

Landslip Prevention and Mitigation Programme,
2011, Package B,
Landslip Prevention and Mitigation Works,
Hong Kong Island (East) -
Investigation, Design and Construction

Drawing Title

Natural Terrain Hazard Study for Study Area 11SW-D/SA12 - Shouson Hill Project Ground Investigation Stations

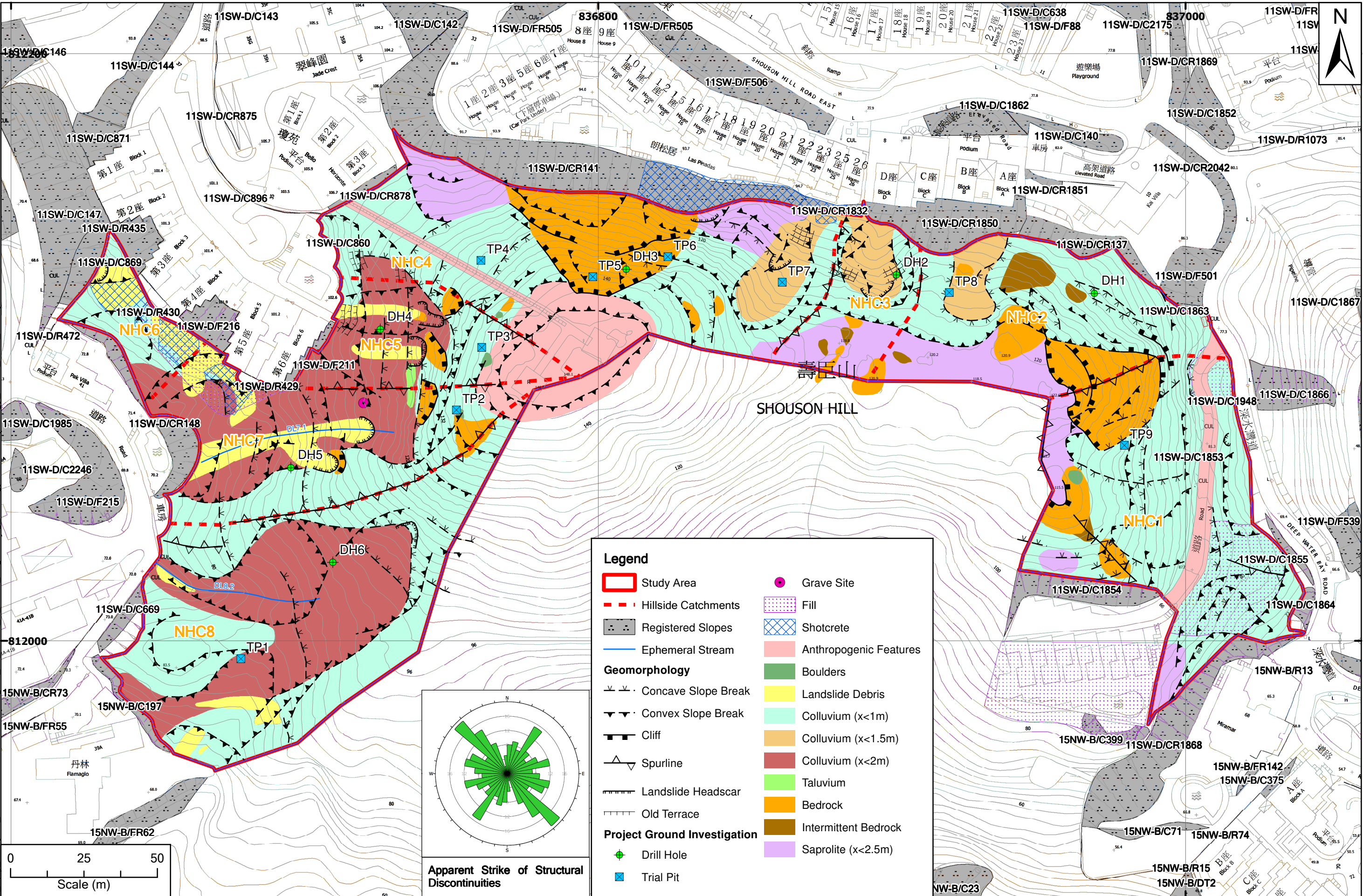
Note: Topographic base map is 1:1,000 scale (2010), 2 m contour intervals; mapsheets 11SW: 25c and 25d, 15NW:5a and 5b. LiDAR - derived contours (2m) shown in Study Area

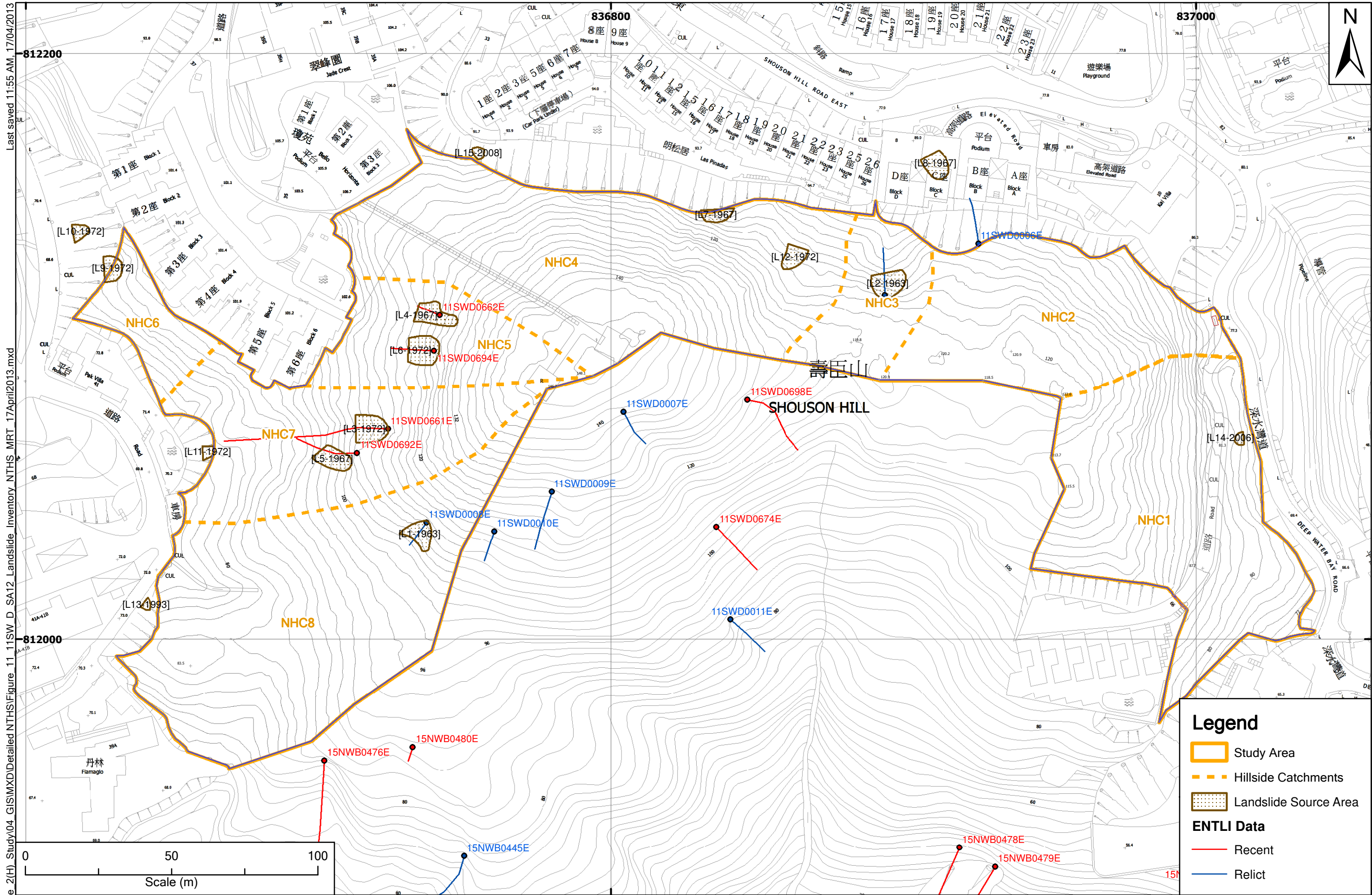
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Drawn by:	Date:	Checked:	Approved:
KHW	28/05/2013	KAS	28/05/2013

Job No.	Figure No.
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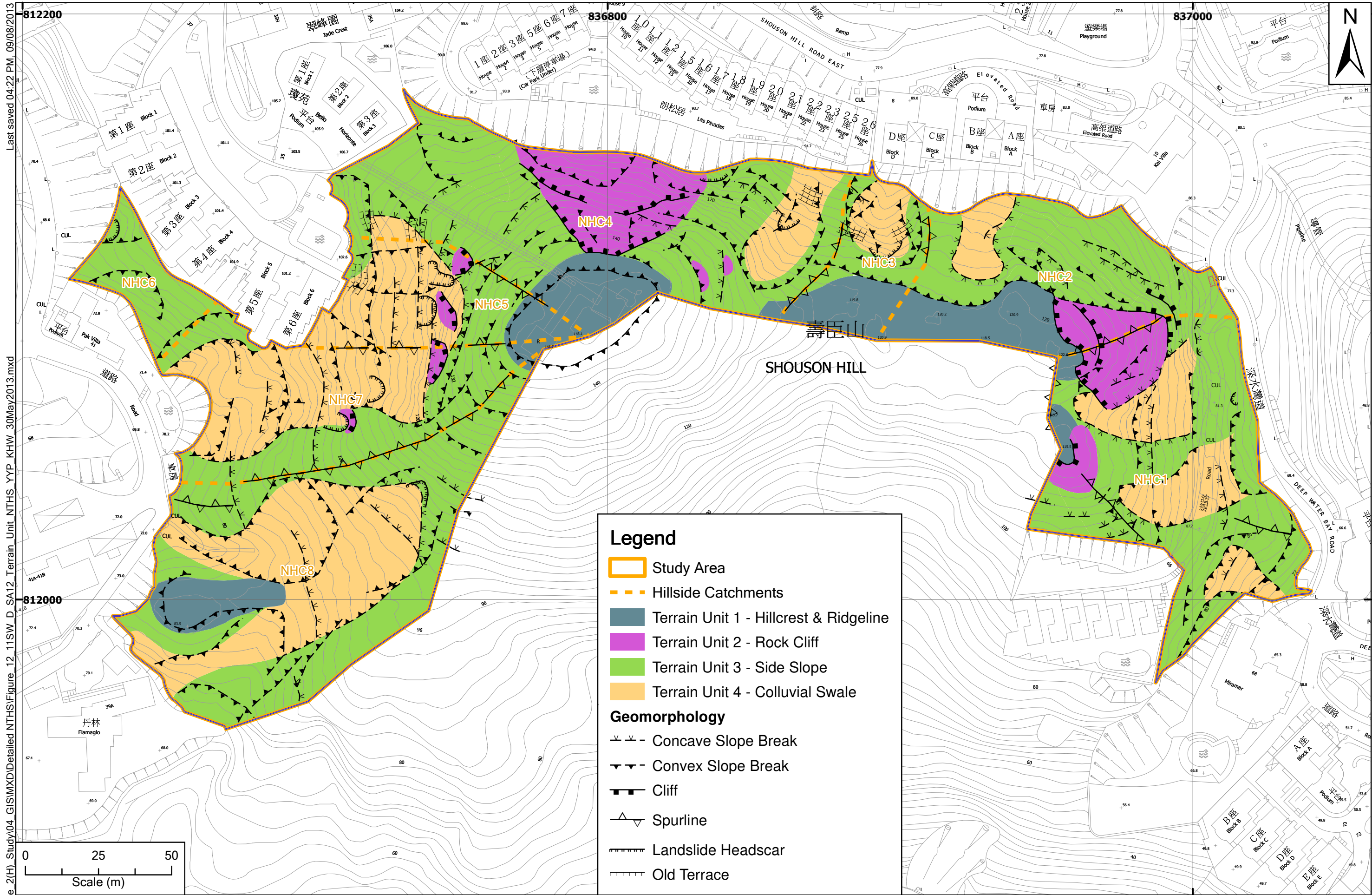


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P:\B110441\NTHS Stage 2(H) Study\04 GISMXDDetailed\NTHS\Figure 11 11SW D SA12 Landslide Inventory NTHS.MRT 17April2013.mxd

Job Title
Agreement No. CE 16/2011 (GE)
Landslip Prevention and Mitigation Programme,
2011, Package B,
Landslip Prevention and Mitigation Works,
Hong Kong Island (East) -
Investigation, Design and Construction

Drawing Title
**Natural Terrain Hazard Study for
Study Area 11SW-D/SA12 - Shouson Hill
Landslide Inventory Map**
Note: Topographic base map is 1:1,000 scale (2010), 2 m contour intervals; mapsheets 11SW: 25c and 25d, 15NW:5a and 5b. LiDAR - derived contours (2m) shown in Study Area

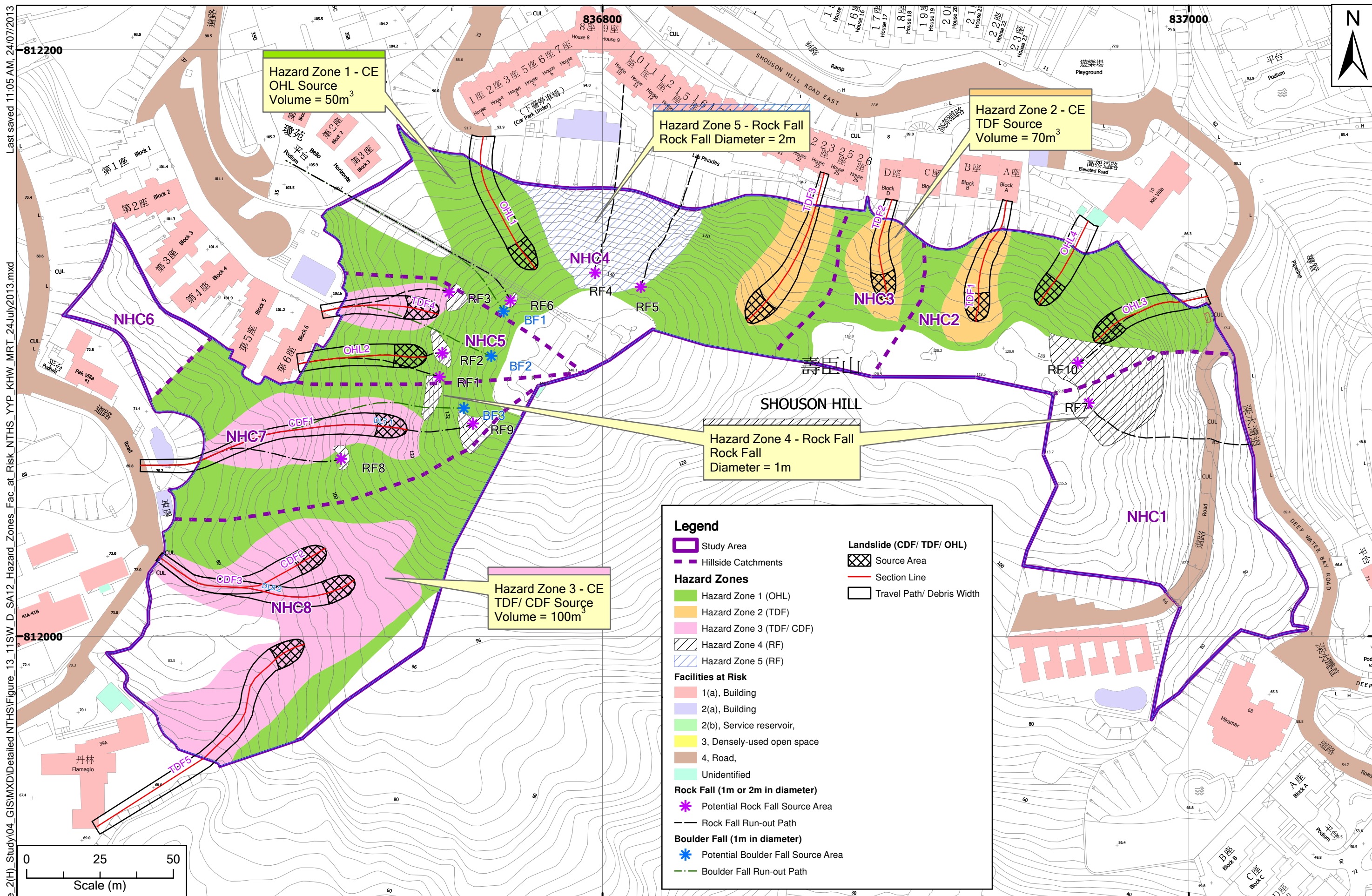
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YYP/KHW
Checked: KAS
Approved: 17/04/2013
Job No. 110441
Figure No. 11



Job Title
Agreement No. CE 16/2011 (GE)
Landslip Prevention and Mitigation Programme,
2011, Package B,
Landslip Prevention and Mitigation Works,
Hong Kong Island (East) -
Investigation, Design and Construction

Drawing Title
**Natural Terrain Hazard Study for
Study Area 11SW-D/SA12 - Shouson Hill
Terrain Unit Map**
Note: Topographic base map is 1:1,000 scale (2010), 2 m contour intervals; mapsheets 11SW: 25c and 25d, 15NW:5a and 5b. LiDAR - derived contours (2m) shown in Study Area.

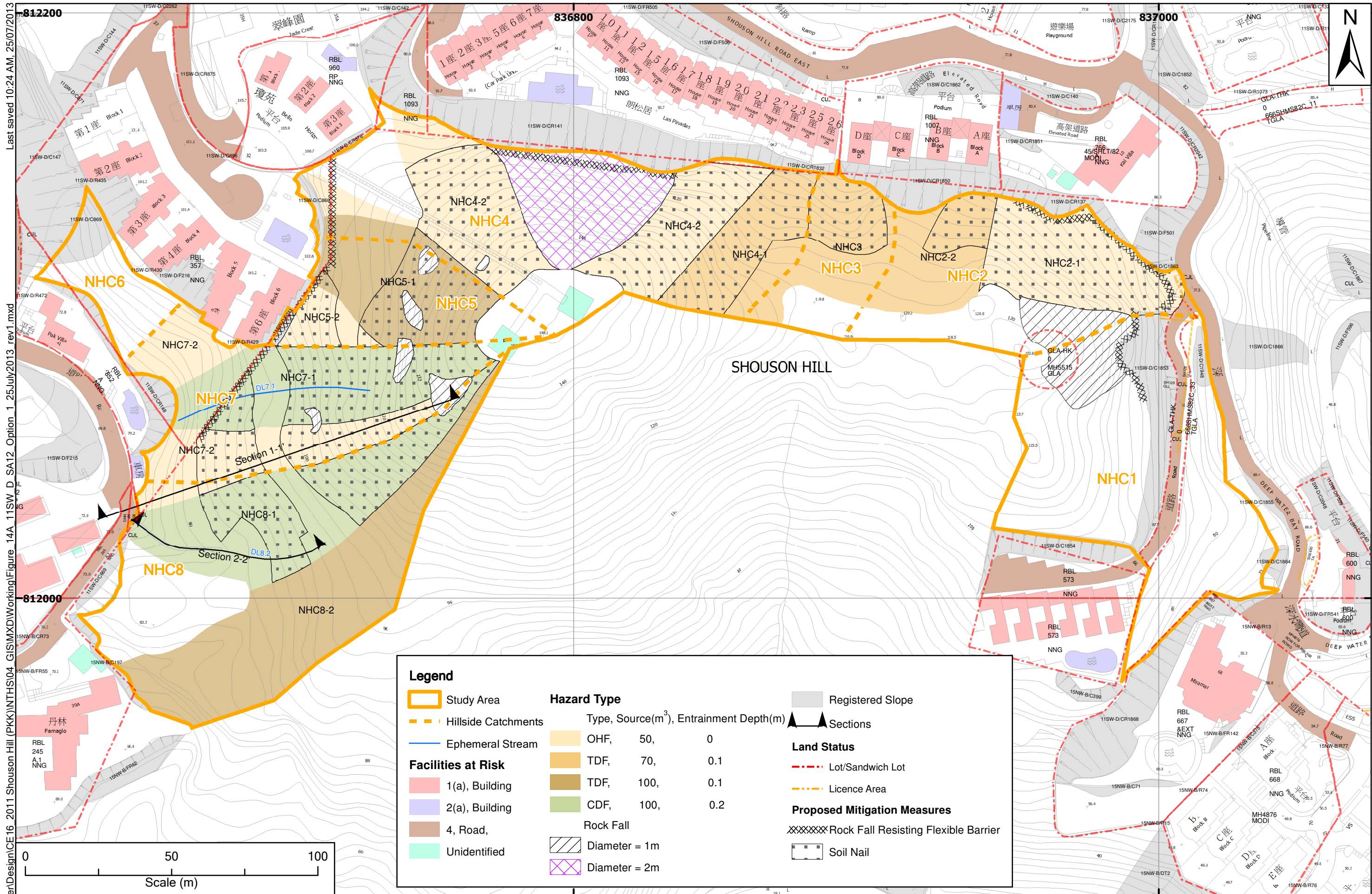
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Drawn by: Date: 09/08/2013
Checked: KAS
Approved: 09/08/2013
Job No. 110441
Figure No. 12



Job Title	
Agreement No. CE 16/2011 (GE)	
Landslip Prevention and Mitigation Programme, 2011, Package B, Landslip Prevention and Mitigation Works, Hong Kong Island (East) - Investigation, Design and Construction	

Drawing Title	Natural Terrain Hazard Study for Study Area 11SW-D/SA12 - Shouson Hill Hazard Zones and Facilities-at-Risk Note: Topographic base map is 1:1,000 scale (2010), 2 m contour intervals; mapsheets 11SW: 25c and 25d, 15NW:5a and 5b. LiDAR - derived contours (2m) shown in Study Area.
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Drawn by: YYP/KHW Date: 24/07/2013	Checked: KAS Approved: 24/07/2013
Job No. 110441	Figure No. 13



Job Title
Agreement No. CE 16/2011 (GE)

Landslip Prevention and Mitigation Programme,
2011, Package B,
Landslip Prevention and Mitigation Works,
Hong Kong Island (East) -
Investigation, Design and Construction

Drawing Title

Study Area 11SW-D/SA12
Shouson Hill
Preliminary Mitigation Design Option 1

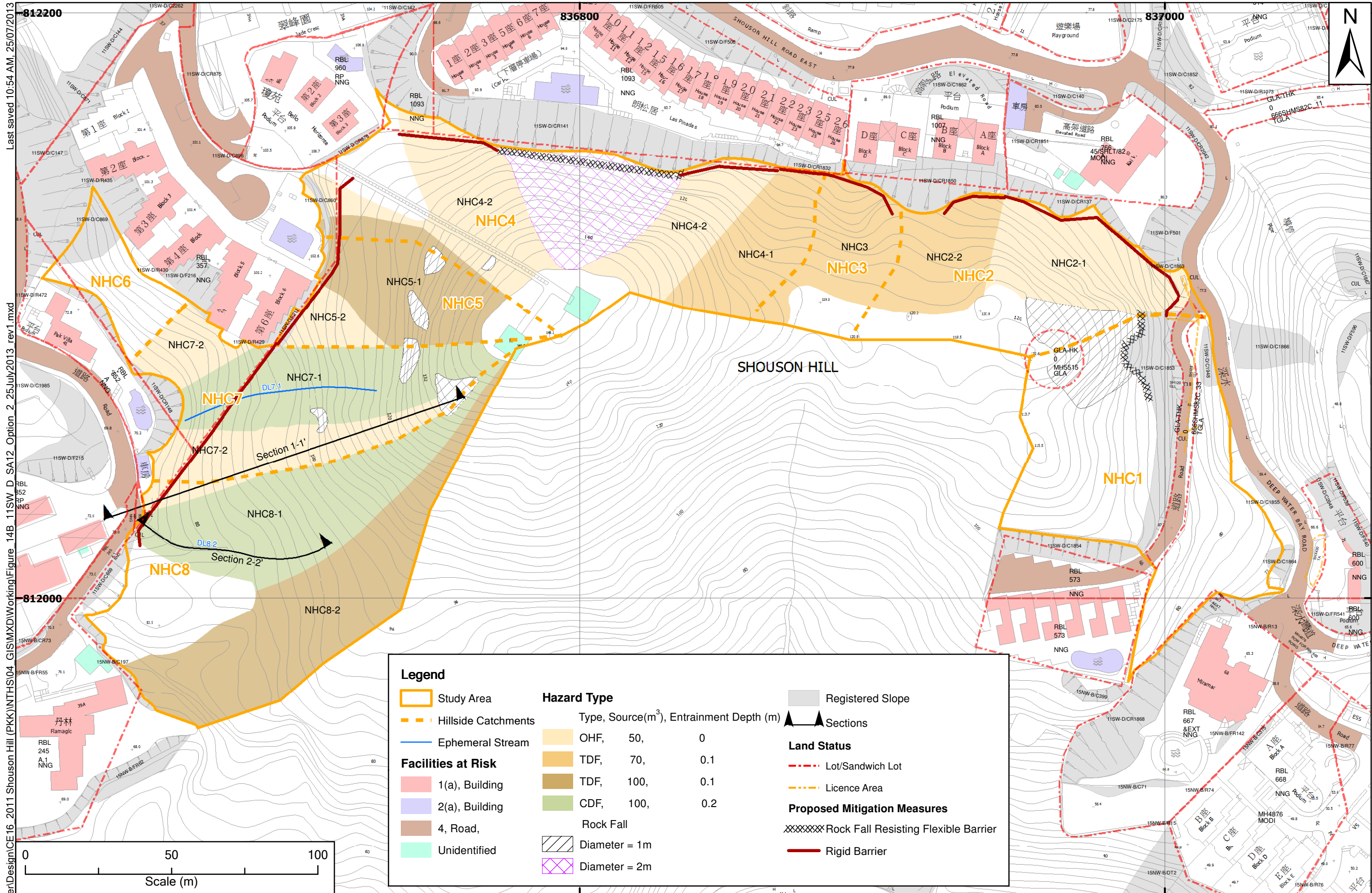
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FUGRO (HONG KONG) LTD

Scale: 1:1,200

Drawn by: P.J.Y. Date: 25/07/2013
Checked: P.K.K. Date: 25/07/2013
Approved: [Signature] Date: 25/07/2013

Job No. 110441
Figure No. 14A



Job Title
Agreement No. CE 16/2011 (GE)

Landslip Prevention and Mitigation Programme,
2011, Package B,
Landslip Prevention and Mitigation Works,
Hong Kong Island (East) -
Investigation, Design and Construction

Drawing Title

Study Area 11SW-D/SA12
Shouson Hill
Preliminary Mitigation Design Option 2

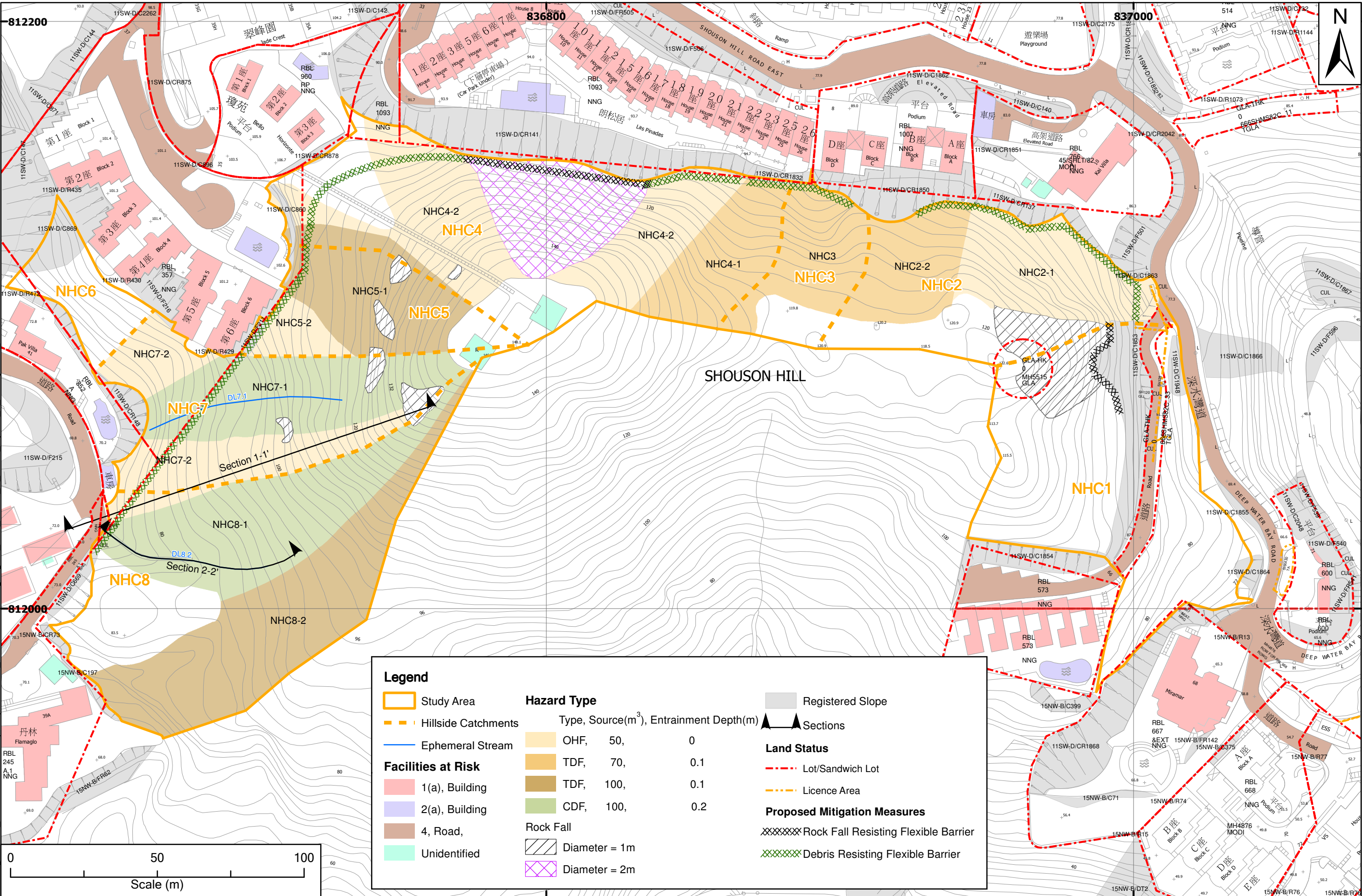
Note: Topographic base map is 1:1,000 scale (2010), 2 m contour intervals; mapsheets 11SW: 25c and 25d, 15NW:5a and 5b.

FUGRO (HONG KONG) LTD

Scale:
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PJY 25/07/2013 PKK 25/07/2013

Job No. Figure No.
110441 14B



Job Title
Agreement No. CE 16/2011 (GE)

Landslip Prevention and Mitigation Programme,
2011, Package B,
Landslip Prevention and Mitigation Works,
Hong Kong Island (East) -
Investigation, Design and Construction

Drawing Title

Study Area 11SW-D/SA12
Shouson Hill
Preliminary Mitigation Design Option 3

Note: Topographic base map is 1:1,000 scale (2010), 2 m contour intervals; mapsheets 11SW: 25c and 25d, 15NW:5a and 5b.

FUGRO (HONG KONG) LTD

Scale:
1:1,200

Drawn by: Date: Checked: Approved:
PJY 25/07/2013 PKK 25/07/2013

Job No. Figure No.
110441 14C

**STUDY AREA NO. 11SW-D/SA12
(HILLSIDE CATCHMENT NOS.
11SW-D/OH44a, 11SW-D/OH44b, 11SW-D/OH44,
11SW-D/OH45a, 11SW-D/OH45, 11SW-D/DF28a,
11SW-D/DF28, 11SW-D/DF28b)
SHOUSON HILL, HONG KONG ISLAND
(EAST)**

Fugro (Hong Kong) Limited

This report has been prepared for the sole and specific use of the Government of the Hong Kong Special Administrative Region. Any other persons who use any information contained in it do so at their own risk.

**January 2014
LPM Division 3
Geotechnical Engineering Office
Civil Engineering and Development Department**

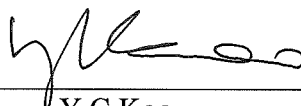
Foreword

This report presents the design of the proposed natural terrain hazard (NTH) mitigation works for Study Area No. 11SW-D/SA12, which is a natural hillside at Shouson Hill, Hong Kong Island (East).

The desk study, aerial photograph interpretation, site inspection, ground investigation supervision, stability analysis, design of NTH mitigation works and compilation of this report were carried out by Fugro (Hong Kong) Limited (FHK) on behalf of the Geotechnical Engineering Office, Civil Engineering and Development Department under Agreement No. CE 16/2011 (GE) - Landslip Prevention and Mitigation Programme, 2011, Package B, Landslip Prevention and Mitigation Works, Hong Kong Island (East) - Investigation, Design, and Construction.

Based on the findings of S2(H) Study under the same Agreement, it was concluded that mitigation works should be carried out to mitigate the landslide risk of the area. Following the recommendation of the S2(H) Study, a design of the necessary mitigation works was carried out by FHK and is presented in this report.

Proposed mitigation works comprising the installation of soil nails and in-situ rock / boulder stabilization measures at the study area. No new maintenance access and landscape measures are required for the mitigation works.



Y C Koo
Project Director

1 Introduction

Fugro (Hong Kong) Limited (FHK) was appointed by the Geotechnical Engineering Office (GEO) of the Civil Engineering and Development Department (CEDD) under Agreement No. CE 16/2011 (GE) to undertake a Natural Terrain Hazard Study (NTHS) for the Study Area 11SW-D/SA12 – Shouson Hill, Hong Kong Island.

A Stage 2(H) Report (S2(H)R 20/2013) was prepared in June 2013, which presented the findings of a review of the potential hazards arising from natural terrain areas within this Study Area. The location and extent of the Study Area are presented in Figure 1.1.

The S2(H) Study was carried out based on Design Event Approach and Enhanced Approach to examine the natural terrain landslide hazard affecting the existing developments and to formulate suitable hazard mitigation strategy to mitigate the risks. The S2(H) Report provided background information including: desk study, aerial photograph interpretation and engineering geological mapping, and findings of site-specific ground investigation (GI). The S2(H) Study was discussed at the Geotechnical Checking Panel Meeting No. 6/2013 on 19 April 2013 and the findings and recommendations were endorsed in principle. A revised S2(H) report incorporating the Enhanced Approach in GEO Technical Guidance Note No. 36 (TGN 36) was submitted to the Checking Panel on 27 June 2013 and was endorsed by the panel on 16 August 2013. An abridged version of S2(H) Report was submitted to the GEO in July 2013 for selection of a preferred construction scheme of NTH mitigation works for the Study Area. The abridged version of S2(H) Report was endorsed by the Design Review Committee on 15 August 2013.

This report presents the design of the proposed NTH mitigation works for the Study Area based on the results of desk study, topographical survey, GI fieldwork and laboratory testing.

2 Description of the Study Area

2.1 General Description

Study Area 11SW-D/SA12 is located in the southwestern part of Hong Kong Island just to the north of Deep Water Bay and is essentially natural terrain. It encompasses the steep hillsides to the north, northwest, west, southwest, east and southeast of the east-west trending ridgeline which forms the summit of Shouson Hill. The Study Area is a horse-shoe shaped area of about 3.6 ha in size (Figure 2.1). The Study Area comprises the following eight Natural Hillside Catchments (NHC):

- (i) NHC1: NHC No. 11SW-D/OH44a,
- (ii) NHC2: NHC No. 11SW-D/OH44b,
- (iii) NHC3: NHC No. 11SW-D/OH44,
- (iv) NHC4: NHC No. 11SW-D/OH45a,
- (v) NHC5: NHC No. 11SW-D/OH45,
- (vi) NHC6: NHC No. 11SW-D/DF28a,
- (vii) NHC7: NHC No. 11SW-D/DF28, and
- (viii) NHC8: NHC No. 11SW-D/DF28b.

General views of the Study Area are shown in Figures 2.2 to 2.5 and vantage points of the photos are shown in Figure 2.1.

2.2 Land Status and Land Use

The Study Area is predominantly on unallocated government land. The southwestern and western catchments of the Study Area (NHC8, 7 & 6) are bound by cut slope nos. 15NW-B/C197, 11SW-D/C669, 11SW-D/CR148 and 11SW-D/C869 of government and private responsibilities. The whole of NHC6 is within the Private Lot while Private Lots are also present within the other two catchments. Below toe of NHC8, 7 & 6 and behind crest of NHC6 are residential buildings.

The northwestern catchments of the Study Area (NHC5 & 4) are bound by cut and fill slope nos. 11SW-D/C860, 11SW-D/CR878, 11SW-D/CR141, 11SW-D/CR1832, 11SW-D/R429 and 11SW-D/F211 of government and private responsibilities. Private Lot/Sandwich Lots are also present within each of these catchments. Below toe of NHC5 & 4 are residential buildings.

The northern and northeastern catchments of the Study Area (NHC3 & 2) are bound by cut and fill slope nos. 11SW-D/C1863, 11SW-D/CR137, 11SW-D/CR1850, and 11SW-D/F501 of private responsibilities. Private Lot/Sandwich Lots are also present within each of these catchments. Below toe of NHC3 & 2 are residential buildings.

The southeastern catchment of the Study Area (NHC1) contains and is bound by cut slope nos. 11SW-D/C1948, 11SW-D/C1853, 11SW-D/C1854, 11SW-D/C1864, 11SW-D/C1868 and 15NW-B/C399 of government and private responsibilities. There are private lots and licensed lands within this catchment. Below toe of NHC1 is Deep Water Bay Road.

3 Geology

All available published geological information for the site has been reviewed in the desk study, including the relevant 1:20,000-scale geological map (Sheets 11 and 15 HGM20, GEO, 1992) & 1:100,000-scale map sheets published by the Hong Kong Geological Survey (Sewell et al, 2000), as well as the accompanying geological memoirs, the relevant reports and maps prepared for the Geotechnical Area Studies Programme (GASP, GCO, 1988) and Boulder Field Inventory. A Regional Geology of the Study Area is shown in Figure 3.1.

According to the 1:20,000-scale geological map, the Study Area is predominately composed of fine ash vitric tuff of the Ap Lei Chau Formation, undivided (JAC). A dyke of Quartzphyric Rhyolite is also trending northwest-southeast across the western part (in NHC 6, 7 and 8) of the Study Area. Outcrop occurs on and near the ridgeline, and rock cliff and slopes are found in NHCs 1, 2, 4, 5 and 7 with slope angles ranging from 35° to 60°. They are generally of Grades III and better, with the majority of the joints striking NW-SE and NE-SW.

To acquire site specific geological information for the NTH Study and design of necessary mitigation works, ground investigation (GI) works were carried out at selected locations to acquire basic geological information on this Study Area.

4 Ground Investigation Works

4.1 Previous Ground Investigation Information

Limited existing geotechnical ground investigation data is available within the Study Area. Ground investigation data is available for locations north, east and south-east of the Study Area dating from 1982.

The locations of the previous GI works are shown in Figure 4.1 and the results are summarized in Appendix A.

4.2 Site-Specific Ground Investigation

A site-specific GI fieldwork was carried out between January 2013 and April 2013 by Vibro (H.K.) Ltd. under Contract No. GE/2011/06 and comprised six drillholes (DH1 to DH6) and nine trial pits (TP1 to TP9).

Locations of the GI stations are also shown in Figure 4.1. Results of the GI are summarised in Appendix A. One set of the final GI reports was filed in the GIU of CEDD.

4.3 Geological Condition

Based on the available GI information, the maximum depth of colluvium was about 1.7 m (DH6) underlain by saprolite with thickness ranging from 0.9 m to 14.07 m (DH4, where saprolite was encountered from 1 m below ground level till the end of the drillhole). No residual soil was encountered in all GI stations. Colluvium was underlain by bedrock in TP5 and DH3. Rockhead was encountered in the drillholes between 2.3 m and 5.3 m below ground surface except DH4, DH5 and DH6 where no rockhead was encountered down to a depth of 15 m. The solid geology for the saprolite was classified as fine ash vitric tuff. Evidence in the project ground investigation in NHCs 5, 7 and 8 (such as TP1, TP2, TP3, DH4, DH5 and DH6 logs) also indicate that colluvium is generally less than 2 m in thickness. Sub-surface materials found in the GI are summarised below:

Colluvium (COLL) Firm, light brown, sandy SILT with some angular to sub-angular fine to medium gravel sized highly decomposed and moderately decomposed rock fragments.

Completely Decomposed Tuff (CDT) Extremely weak, light grey, completely decomposed fine ash vitric TUFF (Slightly sandy SILT with occasional subangular fine gravel).

Highly Decomposed Tuff (HDT) Very weak to weak, light grey, dappled light brown and brown, highly decomposed fine ash vitric TUFF (Slightly sandy silty angular COBBLES with some angular to subangular fine to coarse gravel).

Moderately Decomposed Tuff (MDT) Moderately strong, locally strong, grey, dappled light grey and light brown, moderately decomposed fine ash vitric TUFF.

Based on the desk study information and previous / current GI, the Study Area mainly comprises a layer of colluvium (COLL) with thickness up to 2 m and overlying completely to highly decomposed Tuff (C/HDT) and then bedrock. The rockhead level within the Study Area varies from 140mPD near crest of NHC4, where exposed rock face can be noted, to about 3m and 5m below toe of NHCs 2 and 8 respectively. The inferred geological profiles of eleven design sections of the Study Area are shown in Figures 4.2 to 4.12.

4.4 Groundwater Condition

Based on site inspections to the Study Area carried out in the wet season of 2013, there was no seepage observed at the accessible locations of the Study Area including the main drainage lines of the Study Area. The groundwater level monitoring records taken between March 2013 and April 2013 indicated that the Study Area is generally under dry condition.

To cater for potential rise of groundwater levels during heavy rainfalls, a groundwater table at about 2 m above the bedrock and a perched water table at about 1m above the base of colluvium were adopted in the design of mitigation measures.

The adopted design groundwater tables for a 10-year return period rainfall at the design sections are also shown in Figures 4.2 and 4.12. A summary of the groundwater level monitoring records is provided in Appendix B.

5 Laboratory Testing

To determine the shear strength parameters of various soil materials encountered in the Study Area for the design of mitigation measures, laboratory tests were carried out on selected soil samples collected in the GI works. Following laboratory tests had been undertaken for the soil samples:

- (i) Multi-stage Consolidated Undrained Triaxial Compression Tests;
- (ii) Atterberg Limits Determination;

(iii) Particle Size Distribution Analysis; and

(iv) Moisture Content Determination.

The laboratory tests were carried out by Gammon Construction Limited under Contract No. GE/2013/09. The laboratory test results are summarized in Appendix A. A copy of the final laboratory testing report on the Study Area was filed in GIU of CEDD.

6 Parameters for Analysis

The shear strength parameters of COLL and C/HDT were derived from plotting of the p' - q data of the triaxial compression test results. The adopted parameters are summarized in the table below and the p' - q plots are presented in Appendix C.

Material Type	Effective Cohesion c' (kPa)	Effective Friction Angle, ϕ' (°)	Bulk Unit Weight γ (kN/m ³)
COLL	1	36	19
C/HDT	5	36	19

7 Enhanced Approach for Dealing with Natural Terrain under LPMitP

The Design Event Approach outlined in GEO Report No. 138 and the Enhanced Approach for Dealing with Natural Terrain Studies outlined in TGN 36 were adopted for the S2(H) Study. The potential natural terrain hazards affecting the facilities below the hillsides as identified during the Study are shown on the Hazard Map in Figure 7.1.

The Design Event requirements for the catchments have been assessed in accordance with TGN 36. The S2(H) Study identified five hazard types and related Design Event volumes. The hazards include Open Hillslope Landslide (OHL), Topographic Depression Failure (TDF), Channelised Debris Flow (CDF), Rock Fall (RF) and Boulder Fall (BF). All the estimated potential landslide source volumes were Design Event.

As mentioned in section 2.2, Natural Hillside Catchment NHC6 is within Private Lot No. RBL 357. No works will be proposed inside the lot and hence NHC6 is excluded from the S2(H) Study and this study report. Each catchment was assessed as to whether they meet the criteria for React-to-Known-Hazard under the Enhanced Approach. In all catchments (except NHC6), although there are no immediate and obvious dangers observed, there exist evidence supporting the possibility that a dangerous situation could develop. Past persistent landslides and strong geological evidence are the dominant factors. A summary of the discussed criteria for React-to-Known-Hazard under the Enhanced Approach is shown in the following table.

Natural Hillside Catchment	Criteria for React-to-Known-Hazard under Enhanced Approach			React-to-Known Hazard	Design Event
	Past Persistent Landslides	Strong Geological Evidence	Newly Emerged Hazardous Situation		
NHC1	No	Yes	No	Yes	RF
NHC2	No	Yes	No	Yes	TDF/OHL/RF
NHC3	No	Yes	No	Yes	OHL/TDF
NHC4	No	Yes	No	Yes	OHL/TDF/RF/BF
NHC5	Yes	Yes	No	Yes	OHL/TDF/RF/BF
NHC7	Yes	Yes	No	Yes	CDF/OHL/RF/BF
NHC8	No	Yes	No	Yes	OHL/TDF/CDF

Based on the findings of the S2(H) Study, the estimated design event volumes for OHL, TDF, CDF and RF/BF for each hillside catchment are summarized in the following table and shown in Figure 7.1:

NHC No.	Drainage Line No.	Potential Hazard Type	Design Event Magnitude (m ³)		
			Source	Entrainment	Total
NHC1	-	RF	1m dia.		
NHC2	-	TDF	70	10	80
		OHL	50	-	50
		RF	1m dia.		
NHC3	-	TDF	70	20	90
		OHL	50	-	50
NHC4	-	TDF	70	35	105
		OHL	50	-	50
		RF/BF	2m dia		
NHC5	-	TDF	100	40	140
		OHL	50	-	50
		RF/BF	1m dia		
NHC7	DL7.1	CDF	100	95	195
		OHL	50	-	50
		RF/BF	1m dia		
NHC8	DL8.2	CDF	100	50	150
		TDF	100	5	105
		OHL	50	-	50

The results of the debris mobility assessment and rock/boulder fall analysis indicate the debris from OHL, TDF and CDF and the modeled boulders within the catchments could present risk to the existing facilities (i.e. Buildings and Roads) below the hillslopes. The debris mobility analysis results at the toe of the study area are summarized in the following table and shown in Figure 7.2:

NHC No.	Sub-catchment	Potential Hazard Type	Final Calculated Design Event Volume (m ³)	Debris Impact Velocity at Observation Point (m/s)	
				Proposed Mitigation Site	Facility at Risk
NHC2	NHC2-1	OHL	50	9.0*	9.0*
	NHC2-2	TDF	28	3.7	5.0
NHC3	-	TDF	68	7.5	7.0
NHC4	NHC4-1	TDF	105	8.6	7.0
	NHC4-2	OHL	50	12.0	15.9
NHC5	NHC5-1	TDF	137	9.0	6.5
	NHC5-2	OHL	36	9.0*	6.9
NHC7	NHC7-1	CDF	192	10.0	9.3
	NHC7-2	OHL	-	-	-
NHC8	NHC8-1	CDF	39	4.0	3.2
	NHC8-2	TDF	0	0	0

* Velocity capped at 9 m/s (see TGN 34)

8 Design Option Assessment

An abridged version of Stage 2(H) Report summarizes the key aspects of the Stage 2(H) Report and contains relevant information for evaluating the three proposed options of natural terrain hazard mitigation scheme was submitted for endorsement of the Design Review Committee. Following three design options of the mitigation works were proposed in the Stage 2(H) Report:

- Scheme 1 - installation of soil nails in areas targeted to provide an adequate factor of safety against failure of the top 2m of the regolith based on information on the soil and groundwater acquired from recent GI work. In-situ stabilization measures and rock fall fences are proposed to mitigate rock fall and boulder fall at NHCs 1, 2, 4, 5, and 7.;
- Scheme 2 - installation of rigid barriers along the toe of most catchments and in-situ stabilization measures and rock fall fences at the southern end of NHC1 and central northern end of NHC4. The rigid barriers are designated to catch the landslide and rock fall debris with wing walls at its two sides to retain and train debris; and
- Scheme 3 - construction of flexible barriers and in-situ stabilization measures and rock fall fences at the toe of most catchments to mitigate potential landslide and rock fall hazards.

A GEO Design Review Committee (DRC) Meeting was held on 15 August 2013 to discuss the preferred scheme of mitigation works for the Study Area. Having evaluated the pros and cons of the proposed schemes, including construction problems, environmental impact, cost, construction programme, etc, DRC agreed that the Scheme 1 should be adopted as the preferred option. However, DRC enquired about the necessity of the provision of

flexible barriers along the toe of the hillside, as soil nailing and in-situ stabilization had already proposed to stabilize the landslide source areas and boulder/ rock fall hazard respectively. After discussion, FHK agreed to delete the flexible barriers and optimized the soil nailing and in-situ rock/boulder stabilization measures in the detailed design.

A copy of the extracts of the Abridged Version of Stage 2(H) Report and the minutes of the DRC meeting on 15 August 2013 are given in Appendix D.

9 NTH Mitigation Measures Design

The following NTH mitigation works are recommended:

- (i) Provision of soil nails installation to the natural hillside catchment NHC 2, 3, 4, 5, 7 and 8; and
- (ii) In-situ stabilization measures including rock dowel, concrete buttress and wire mesh are proposed to mitigate rock fall and boulder fall at NHC 1, 2, 4, 5, and 7.

The layout and details of the proposed mitigation works are shown in Figures 9.1 to 9.11 and Drawing Nos. NTHM1230/HC01/03 to NTHM1230/HC01/06.

9.1 Design of Soil Nail

Soil nails installation was proposed to the natural hillside catchment NHC 2, 3, 4, 5, 7 and 8 which are all affecting residential buildings at toe of the Study Area (i.e. Group 1 facility). According to TGN No. 37 where soil nailing is adopted as the mitigation scheme for an OH catchment, an analytical approach should be adopted for the design of soil nails to provide an adequate factor of safety against failure of the top 2m of the regolith, in accordance with the design standards given in the Geotechnical Manual for Slopes (GEO, 1984). As defined in Figure 7.1, all catchments are originally OHL scenarios before it becomes a TDF or CDF hazard and therefore we considered that the requirement of providing adequate factor of safety against failure of the top 2m of the regolith for soil nail design should be applied to all catchments of the Study Area.

It is considered that the residential buildings at the toe of these sub-catchments would be affected by the hazard. Based on Works Bureau Technical Circular No. 13/99 (WB, 1999) and GEO Technical Guidance Note (TGN) No. 15 (GEO, 2007), the consequence-to-life and economic consequence categories of these sub-catchments should be classified as category "1" and category "A" according to Tables 3 and 4 of Appendix A of the Circular respectively. Thus, a minimum factor of safety (FOS) of 1.4 under a 10-year return period rainfall is recommended for the proposed mitigation works at the sub-catchments.

The stability analysis for representative sections at these sub-catchments with soil nails was carried out using computer program SLOPE/W, Version 2007 with the inferred geological model, the assumed groundwater condition and the adopted shear strength parameters as discussed in Sections 4.3 and 4.4. The Morgenstern-Price Method was adopted

to determine the minimum FOS. Calculations of the stability analyses of these sub-catchment with soil nails as mitigation works and designs of soil nails are summarised in the table below and given in Appendix E.

Sub-catchment	Section	Calculated Minimum FOS for a 10-Year Return Period Rainfall	Required FOS
NHC2-1	1-1	1.43	1.4
NHC2-2	2-2	1.44	
NHC3	3-3	1.43	
NHC4-1	4-4	1.42	
NHC4-2	5-5	1.43	
	6-6	1.43	
NHC5-1	7-7	1.45	
NHC5-2	8-8	1.43	
NHC7-1	9-9	1.44	
NHC7-2	10-10	1.42	
NHC8-1	11-11	1.42	

In view of that the Study Area itself is a natural hillside with no high groundwater table noted, the soil at the site would be classified as non-aggressive with guidance given in Section 5.5 of Geoguide 7(GEO, 2008). Based on Table 5.1 of Geoguide 7 (GEO, 2008), Class 2 corrosion protection measures including hot-dip galvanizing and 2mm sacrificial thickness on the radius will be provided to steel reinforcement of soil nails proposed for this Study Area.

9.2 Rock/Boulder Stabilisation Measures

Rock fall / boulder fall hazards were identified in Stage 2(H) Report in the Study Area as presented in Section 7 of this report. In-situ stabilisation measures including dentitions, concrete buttresses, dowelling or removal would be adopted to treat all localised potential unstable boulders and potentially unstable rock blocks that identified in Stage 2(H) Report and as identified on site during the construction of mitigation works at the Study Area by provision of inspection scaffolding. Rock mesh will also be provided to all rock face of the Study Area after stabilisation works.

9.3 Existing Upgraded Man-made Features within Study Area

Twenty registered features are located at the boundary of the Study Area, of which nine are cut slopes, three are fill slopes, one is retaining wall and seven are cut and retaining wall features. The engineered slopes are generally associated with construction of roads and site formation for residential buildings. The locations of the existing registered slopes and

retaining walls in the vicinity of the Study Area are shown in Figure 2.1. Five of them have been checked under previous LPM Stage 2 or Stage 3 studies.

Stage 2 Studies have been completed for 11SW-D/C1863, 11SW-D/CR137, 11SW-D/CR141, 11SW-D/CR148, 11SW-D/CR1850 and 15NW-B/C197, and advisory letters were recommended for 11SW-D/CR141, 11SW-D/CR1850 and 15NW-B/C197 and Dangerous Hillside (DH) orders were recommended for 11SW-D/C1853 (mid-slope of NHC1), 11SW-D/CR137 (downslope of NHC2) and 11SW-D/CR141 (downslope of NHC4). Stage 2 Study for 11SW-D/CR1868 was terminated as the feature was found to be up to standard by previous study accepted by GEO or previously upgraded. No Stage 2 or Stage 3 Study was conducted for the remainder of the registered features.

Installation of soil nail is proposed for the Study Area and hence no additional loading will be added to the existing slopes and retaining walls below the study area. Stability check for existing man-made slopes below the Study Area is considered not necessary.

10 Surface Drainage Measures and Future Maintenance

Since nail heads of proposed soil nails at the Study Area will be recessed and the final slope surface will be reinstated with vegetation, no future maintenance works and drainage channel are considered necessary. No maintenance access and drainage channels shall be proposed to the Study Area.

11 Landscape Design

To enhance the greenery of the Study Area, following landscape works would be carried out as part of the mitigation works:

- (i) Existing mature trees shall be preserved.
- (ii) Hydroseeding with/without biodegradable erosion control mat will be provided to the soil nailed slope surface.

12 Conclusions and Recommendations

Based on the findings of the Stage 2(H) Report carried out for the hillside catchments at Shouson Hill by FHK under Agreement CE 16/2011(GE), it was concluded that suitable mitigation works should be carried out to mitigate the landslide risk associated with the Study Area.

The proposed construction scheme of the mitigation works comprises mainly the provision of soil nails installation and in-situ rock/boulder stabilisation measures. Maintenance access and drainage channel are considered not required for the Study Area. Vegetation cover will be provided to the final surface of the Study Area.

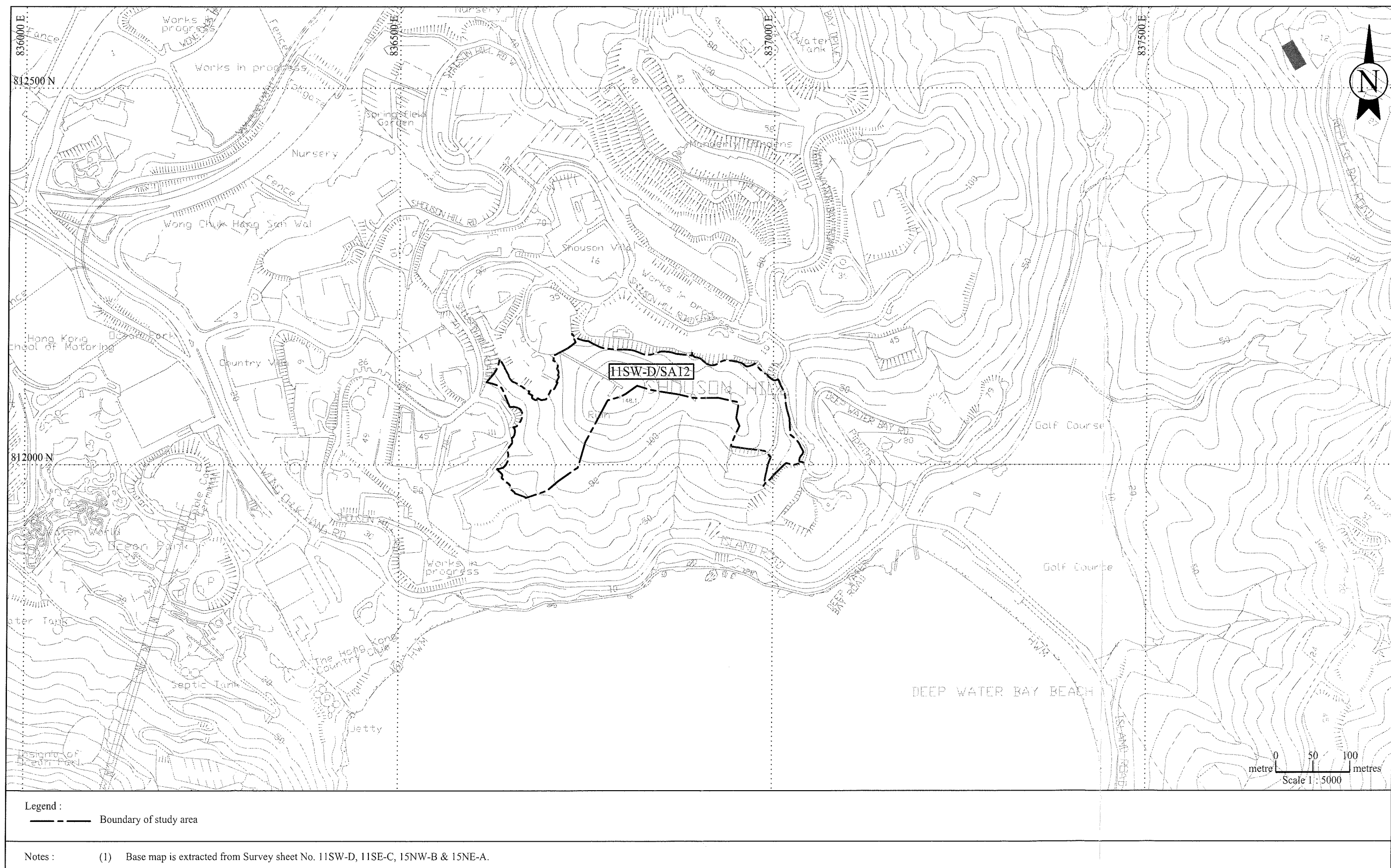


Figure 1.1 Location Plan



Figure 2.2 Plate 1 - General View of the Study Area (Catchment NHC1 to 4) (19 March 2013)



Figure 2.3 Plate 2 - View from NHC 4 towards Its Toe (19 March 2013)

GENERAL NOTES

1. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT DRAWINGS, STANDARD DRAWINGS, THE SPECIFICATIONS AND INSTRUCTIONS ISSUED BY THE ENGINEER.
2. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.
3. ALL LEVELS ARE IN METRES ABOVE PRINCIPAL DATUM (mPD) UNLESS OTHERWISE STATED.
4. ALL MEASUREMENT MUST BE CHECKED ON SITE. DO NOT SCALE FROM THE DRAWINGS.
5. THE CONTRACTOR SHALL REPAIR, MAINTAIN AND REINSTATE ON COMPLETION OF WORKS ALL EXISTING SURFACING COVER, SURFACE DRAINAGE DUCTS, CHANNELS, FENCE, FOOTPATHS, CONCRETE STEPS AND OTHER AFFECTED FACILITIES UNLESS OTHERWISE SPECIFIED ON THE DRAWINGS OR INSTRUCTED BY THE ENGINEER.
6. ANY PROPERTIES, SUCH AS EXISTING FENCING AND PAVEMENT, NEEDED TO BE REMOVED OR RELOCATED FOR CARRYING OUT OF THE WORKS SHALL BE REINSTATED TO THEIR ORIGINAL CONDITIONS, UNLESS OTHERWISE SPECIFIED.
7. STOCKPILING OF MATERIALS OR EQUIPMENT ON THE SLOPE FACE OR CREST IS NOT PERMITTED UNLESS APPROVED BY THE ENGINEER IN WRITING.
8. THE NOTES ON THIS DRAWING ARE THE GENERAL REQUIREMENTS UNLESS OTHERWISE SPECIFIED OR INSTRUCTED BY THE ENGINEER.
9. ANY SOFT SPOTS SHALL BE REMOVED AND ANY VOIDS SHALL BE BACKFILLED WITH CONCRETE OF GRADE 20/20 OR WITH COMPACTED SOIL-CEMENT FILL AS PER GS CLAUSE 7.116 OR WITH COMPACTED SPECIAL FILL AS DIRECTED BY THE ENGINEER.
10. AS INSTRUCTED BY THE ENGINEER, WARNING SIGNS IN ACCORDANCE WITH GEO STANDARD DRAWING NO. R1077 SHALL BE INSTALLED AT LOCATIONS TO BE DETERMINED BY THE ENGINEER ON SITE.

UTILITIES, FENCE/HOARDING AND BOUNDARY OF WORKS SITE :

1. THE PLAN OF UTILITIES HAS BEEN PREPARED FROM INFORMATION PROVIDED BY UTILITIES/SERVICES PROVIDERS. NEITHER THE EMPLOYER NOR HIS AGENTS OR REPRESENTATIVES ACCEPT ANY RESPONSIBILITY WHATSOEVER FOR THE ACCURACY OR SUFFICIENCY OF THE INFORMATION AND THE CONTRACTOR SHALL MAKE SUCH INQUIRES AND INVESTIGATIONS AS ARE REQUIRED FOR HIS OWN USE PRIOR TO COMMENCEMENT OF THE WORKS.
2. PRIOR TO COMMENCEMENT OF THE WORKS, THE CONTRACTOR SHALL CONFIRM THE EXACT LOCATIONS OF THE EXISTING UTILITIES AFFECTING OR BEING AFFECTED BY THE WORKS USING INSPECTION PITS OR OTHER MEANS AS RECOMMENDED BY THE RELEVANT UTILITY/ SERVICES PROVIDERS.
3. THE CONTRACTOR SHALL EXERCISE EXTREME CARE NOT TO DAMAGE ANY EXISTING UTILITIES OR SERVICES WITHIN OR IN THE VICINITY OF THE SITE AND SHALL PROVIDE NECESSARY PROTECTION AND SUPPORT TO THE EXISTING UTILITIES OR SERVICES IN ACCORDANCE WITH THE REQUIREMENTS OF THE RELEVANT UTILITY/ SERVICE PROVIDERS DURING THE EXECUTION OF THE WORKS. SHOULD ANY DAMAGE OCCUR TO THE UTILITIES/ SERVICE DUE TO THE CONTRACTOR'S WORKS, THE CONTRACTOR SHALL BE RESPONSIBLE FOR ANY INCURRED COST RESULTING FROM THE DAMAGE.
4. THE AFFECTED UTILITIES SERVICES (e.g. WATER PIPES AND ELECTRICITY CABLES), IF NECESSARY, SHALL BE TEMPORARILY DIVERTED PRIOR TO COMMENCEMENT OF THE WORKS.
5. THE EXACT BOUNDARY OF THE WORKS SITE AS SHOWN ON THE DRAWING SHALL BE SUBJECT TO THE CONFIRMATION OF THE ENGINEER ON SITE AND/OR PERMISSION FROM THE RELEVANT AUTHORITIES.
6. THE CONTRACTOR SHALL SET OUT THE ALIGNMENT OF PROPOSED HOARDING/FENCE/RAILING ON SITE BASED ON THE INFORMATION PROVIDED. THEIR ALIGNMENT, LAYOUT AND SUPPORT STRUCTURES SHALL BE MODIFIED TO SUIT THE ACTUAL SITE CONDITIONS SUBJECT TO THE AGREEMENT OF THE ENGINEER.
7. ANY WORK TO BE CARRIED OUT WITHIN A RADIUS OF 9m OF A POWER LINE, THE "POWER COMPANY" SHALL BE INFORMED PRIOR TO COMMENCEMENT OF THE WORKS AND THE PROPOSED ACTIVITIES MUST FOLLOW ALL SAFETY PRECAUTIONS IN ACCORDANCE WITH THE CODE OF PRACTICE ON WORKING NEAR ELECTRICITY SUPPLY LINES PREPARED BY EMSD OR OTHER REQUIREMENTS IMPOSED BY THE "POWER COMPANY".
8. AS A GENERAL GUIDE, THE FOLLOWING MINIMUM CLEARANCE SHALL BE OBSERVED AND ADOPTED :
OVERHEAD HT SUPPLY LINE 6m
UNDERGROUND HT CABLE (UP TO 66kV) 1m
9. IT IS IMPERATIVE THAT THE RISK OF DAMAGE TO ELECTRICITY SHALL BE ELIMINATED, i.e. AVOID LIFTING OF ELECTRICITY CABLE OR USE METALLIC BOOM AND TOOLS SUCH AS EXCAVATORS OR SOIL NAIL MACHINES NEAR HT POWER LINES.
10. THE CONTRACTOR SHALL PROPOSE A SAFETY SYSTEM OF WORK IN AGREEMENT WITH THE POWER COMPANY AND THE ENGINEER BEFORE COMMENCEMENT OF WORKS.

ROCK SLOPE AND BOULDERS TREATMENT/ STABILIZATION WORKS :

1. ROCK SLOPE AND BOULDERS TREATMENT/STABILIZATION WORKS INCLUDING SCALING OF ROCK BLOCKS, REMOVAL OF BOULDERS, INSTALLATION OF ROCK DOWELS/BOLTS, CONSTRUCTION OF RELIEF DRAINS AND RAKING DRAINS, CONCRETE BUTTRESSES, SPRAYED CONCRETE, DENTITION AND WIRE MESH PROTECTION SHALL BE CARRIED OUT AS DIRECTED BY THE ENGINEER ON SITE AND IN ACCORDANCE WITH CEDD STANDARD DRAWINGS C2201C, C2202C, C2203/1G, C2204E, C2205D, C2403E AND C2404D.
2. BEFORE CONSTRUCTION, THE POSITIONS OF ROCK SLOPE AND BOULDERS TREATMENT/STABILIZATION WORKS SHALL BE MARKED ON THE SLOPE SURFACE FOR THE ENGINEER'S VERIFICATION AND CONFIRMATION.
3. PRIOR TO BREAKING UP AND REMOVAL OF POTENTIALLY UNSTABLE ROCK FRAGMENTS/PROTRUDING BOULDERS, PROTECTIVE MEASURES SHALL BE PROVIDED TO PREVENT ROCK FRAGMENTS/BOULDERS FROM ROLLING OR SLIDING OUT OF CONTROL.
4. ALL EXCAVATION IN ROCK SHALL USING NON-EXPLOSIVE BREAKING AGENT AND PERCUSSIVE EQUIPMENT SHALL NOT BE USED.
5. THE CONTRACTOR SHALL SUBMIT TO THE ENGINEER FOR APPROVAL A METHOD STATEMENT FOR BREAKING UP AND REMOVAL/TRANSPORTATION OF THE ROCK FRAGMENTS/BOULDERS AT LEAST ONE WEEK PRIOR TO COMMENCEMENT OF WORKS.
6. ALL ROCK DOWELS SHOULD BE INSTALLED NORMAL TO THE POTENTIAL SLIDING PLANE UNLESS SPECIFIED OTHERWISE ON DRAWING OR DIRECTED BY THE ENGINEER ON SITE.
7. ROCK DOWELS SHALL BE 25 mm IN DIAMETER UNLESS OTHERWISE STATED.
8. THE CONTRACTOR SHALL SUBMIT DETAILS OF ROCK DOWEL INSTALLATION INCLUDING METHOD OF GROUTING TO THE ENGINEER FOR APPROVAL AT LEAST ONE WEEK PRIOR TO THE COMMENCEMENT OF WORKS.
9. AT THE TIME OF INSTALLATION, THE STEEL BARS SHALL BE CLEANED AND FREE FROM FITTING, NICKS OR OTHER PHYSICAL DAMAGE, PAINT, GREASE, OIL, SPILT CONCRETE OR GROUT, ADHERING EARTH OR LOOSE RUST, RUST SCALE, LOOSE MILL SCALE AND OTHER DELETERIOUS MATTER.
10. ROCK DOWEL HOLES SHALL BE PROTECTED AGAINST THE ENTRY OF FOREIGN MATTER AFTER DRILLING AND SHALL BE CLEANED OF DRILLING CUT, ETC. USING COMPRESSED AIR BEFORE THE STEEL BAR IS INSERTED.
11. DETAILS OF CONCRETE BUTTRESS SHALL BE IN ACCORDANCE WITH CEDD STANDARD DRAWING NO. C2203/1G.
12. LOCALISED ROCK SCALING OF THE SLOPE SHALL BE UNDERTAKEN TO SUIT THE ALIGNMENT OF THE MASS CONCRETE BUTTRESS AND SHALL BE DIRECTED BY THE ENGINEER ON SITE.
13. THE FOUNDATION FOR THE MASS CONCRETE BUTTRESS SHALL BE EXCAVATED TO A MINIMUM DEPTH OF 300mm IN ROCK OR AS DIRECTED BY THE ENGINEER ON SITE.
14. PRIOR TO CONCRETING, THE ROCK SURFACES SHALL BE CLEANED TO REMOVE MOSS, VEGETATION AND ALL OTHER LOOSE OR DELETERIOUS MATERIALS.
15. PRIOR TO PLACEMENT OF CONCRETE, APPROVAL FROM THE ENGINEER SHALL BE OBTAINED.
16. WIRE MESH SHALL BE PROVIDED TO ALL EXPOSED ROCK SLOPE SURFACE AFTER TREATMENT/STABILIZATION WORKS AS CEDD STANDARD DRAWINGS NO. C2203/1G.

REMOVAL OF EXISTING LOOSE FILL

1. VEGETATION AND TOP SOIL SHALL BE REMOVED TO IDENTIFY THE EXACT EXTENT OF FILL AREA.
2. TRIAL PITS SHALL BE EXCAVATED TO LOCATE THE THICKNESS AS DIRECTED BY THE ENGINEER ON SITE.

SURFACE PROTECTION COVER

1. THE EXACT EXTENT OF SLOPE SURFACE FINISHING SHALL BE CONFIRMED BY THE ENGINEER ON SITE.
2. FOR SOIL SLOPE SURFACES TO BE HYDROSEEDED SHALL BE CARRIED OUT IN ACCORDANCE WITH THE SPECIFICATIONS OR AS INSTRUCTED BY THE ENGINEER ON SITE. THE FIXING DETAILS OF EROSION CONTROL MAT AND WIRE MESH, IF ANY, SHALL BE IN ACCORDANCE WITH CEDD STANDARD DRAWINGS NOS. C2511/1C & C2511/2E.
3. SOIL NAIL HEADS WITHIN THE HYDROSEEDING AREA SHALL BE CONSTRUCTED IN ACCORDANCE WITH CEDD STANDARD DRAWING NO. C2106/4A & C2106/5A.
4. ALL PLANTING MIX SHALL BE PLANTED IN STAGGERED PATTERN.

SOIL NAILING WORKS :

1. DIPPING DIRECTION OF SOIL NAILS SHALL BE NORMAL TO THE TOE LINE OF THE SLOPE UNLESS OTHERWISE STATED IN THE DRAWING OR INSTRUCTED BY THE ENGINEER.
2. SOIL NAIL SETTING OUT DATA IS TENTATIVE ONLY. BEFORE SOIL NAIL DRILLING, THE POSITION OF EACH SOIL NAIL SHALL BE MARKED ON THE SLOPE SURFACE FOR THE ENGINEER'S VERIFICATION.
3. LOCATIONS OF SOIL NAILS SHOWN ON THE PLAN ARE INDICATIVE ONLY. EXACT LOCATIONS SHALL BE ADJUSTED TO ACHIEVE A STAGGERED PATTERN WITH RESPECT TO THE ADJOINING ROWS OF SOIL NAILS OR OTHERWISE INSTRUCTED BY THE ENGINEER.
4. DETAILS OF SOIL NAILS AND SOIL NAIL HEADS SHALL BE IN ACCORDANCE WITH CEDD STANDARD DRAWINGS C2106/1I, C2106/2F, C2106/3F, C2106/4A, C2106/5A AND SKETCHES R1043/3B. UNLESS OTHERWISE SPECIFIED IN THE DRAWING OR DIRECTED BY THE ENGINEER.
5. FOR HYDROSEEDING COVER SLOPE, NAIL HEADS SHALL BE RECESSED INTO THE FINAL SLOPE SURFACE TO ALLOW THE INSTALLATION OF SOIL MIX INFILL ON TOP OF THE SOIL NAIL HEADS IN ACCORDANCE WITH THE RELEVANT DRAWING OR TO FLUSH WITH THE WALL FACE.
6. LOCATIONS OF TRIAL NAILS FOR PULL-OUT TEST, IF SO REQUIRED, ARE TENTATIVE ONLY. THE ACTUAL LOCATION OF TRIAL NAILS SHALL BE CONFIRMED BY THE ENGINEER ON SITE.
7. THE BOND LENGTH OF TRIAL NAILS, WHERE ORDERED, SHALL BE 2m UNLESS OTHERWISE SPECIFIED IN THE DRAWINGS OR DIRECTED BY THE ENGINEER.
8. POSITION OF SOIL NAILS SHALL BE ADJUSTED WHERE NECESSARY ON SITE TO AVOID DAMAGE TO EXISTING TREES INCLUDING BRANCHES AND ROOTS OR OTHER UNDERGROUND FACILITIES.
9. SOIL NAILS SHALL BE INSTALLED IN ACCORDANCE WITH THE DETAILS GIVEN IN THE "SOIL NAIL SCHEDULE" OF RELEVANT DRAWINGS UNLESS OTHERWISE INSTRUCTED BY THE ENGINEER.
10. GROUT FOR ALL SOIL NAILS SHALL BE GRADE 30MPa CEMENT GROUT AT 28 DAYS.
11. WITHIN THE IMMEDIATE VICINITY OF BEDROCK OUTCROPS THE NEED FOR SOIL NAIL SHALL BE CONFIRMED BY THE ENGINEER ON SITE.
12. DOUBLE CORROSION PROTECTION, IF SO REQUIRED, SHALL BE PROVIDED TO THOSE SOIL NAILS AND IN ACCORDANCE WITH GEO STANDARD DRAWING NO. R1043/3B.
13. THE CONTRACTOR SHALL PROVIDE RECORDS OF DRILLING FOR ALL TRIAL NAILS AND WORKING SOIL NAILS/ROCK DOWELS, WHERE APPLICABLE.
14. DRILLING RECORDS SHALL INCLUDE THE LOCATION PLAN, LEVELS AND NUMBER OF DRILLHOLES, TIME AND DATE OF DRILLING, WEATHER, OBSERVATION DURING DRILLING, DRILLING RATE IN METRE PER MINUTE AND DESCRIPTION OF THE DRILLED MATERIALS BASED ON THE FLUSHED OUT MATERIALS COLLECTED DURING DRILLING FOR EVERY METRE OF DRILLING OF THE HOLE. WHEN INSTRUCTED, THE FLUSHED OUT MATERIALS SHALL BE COLLECTED IN PLASTIC BAGS WITH LABELS SHOWING THE DATE, DEPTH AND NUMBER OF HOLE OF DRILLING AND KEPT ON SITE IN A PROPER MANNER FOR THE ENGINEER'S EXAMINATION. DRILLING RECORDS SHALL BE PREPARED AND SUBMITTED TO THE ENGINEER WITHIN 24 HOURS AFTER COMPLETION OF DRILLING OF THE HOLES. THE CONTENTS OF THE DRILLING RECORDS SHALL BE PRESENTED IN POINT FORM, GRAPHICAL AND TABLE FORM AS AGREED BY THE ENGINEER.
15. CONCRETE FOR SOIL NAIL HEADS SHALL BE GRADE 30/20 OR SPRAYED CONCRETE, AGREED BY THE ENGINEER, WITH A MINIMUM COMPRESSIVE STRENGTH OF CONCRETE CORES, CONVERTED TO ESTIMATED EQUIVALENT CUBE STRENGTH OF 30 MPa AT 28 DAYS IN ACCORDANCE WITH BS 6089.

THE PROTECTION OF EARTHWORKS AGAINST HEAVY RAINFALL

1. SURFACE WATER FLOWING INTO THE SITE SHALL BE INTERCEPTED AND CONDUITED FROM THE SITE TO AN AGREED DISCHARGE POINT. AT EACH INTERSECTION AND ABRUPT CHANGE IN DIRECTION OF SURFACE DRAINAGE CHANNELS, AN ACCESSIBLE CATCHPIT SHALL BE PROVIDED. ALL DRAINAGE WORKS SHALL BE KEPT CLEAR OF DEBRIS.
2. WHERE PARTIALLY COMPLETED DRAINAGE WORKS DISCHARGE WITHIN THE SITE, A TEMPORARY CONDUIT SHALL BE PROVIDED TO AN ACCEPTABLE DISCHARGE POINT.
3. EARTHWORKS TO FORM THE FINAL FACE SHALL BE FOLLOWED IMMEDIATELY WITH SURFACE PROTECTION AND DRAINAGE WORKS.
4. WHERE TEMPORARY BARE EARTH SLOPE FACES ARE UNAVOIDABLE, THEY SHALL BE PROTECTED WITH SHEETING WELL-SECURED AGAINST WIND. WHERE SLOPE FACES ARE TO BE TEMPORARILY EXPOSED FOR MORE THAN TWO WEEKS, SUITABLE SURFACE PROTECTION WORKS SHALL BE PROVIDED AND AGREED WITH THE ENGINEER.

PROTECTION AND PRESERVATION OF EXISTING

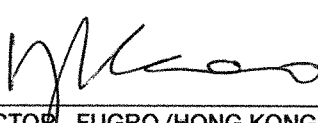
VEGETATION/LANDSCAPE WORKS

1. NO TREES SHALL BE FELLED WITHOUT THE APPROVAL OF THE ENGINEER IN WRITING.
2. ADEQUATE TEMPORARY WORKS SHALL BE PROVIDED TO SUPPORT AND PROTECT EXISTING TREES FROM BEING DAMAGED BY THE SLOPE WORKS IN ACCORDANCE WITH THE SPECIFICATIONS UNLESS OTHERWISE SPECIFIED.
3. WHERE EXISTING SLOPE SURFACE COVER TO BE REMOVED, CARE SHALL BE TAKEN NOT TO DISTURB TREE ROOTS IMMEDIATELY UNDERLYING THE SLOPE SURFACE.
4. AS AGREED OR DIRECTED BY THE ENGINEER, POSITION OF SOIL NAILS, ALIGNMENT OF HOARDING, FENCING, NEW CHANNELS AND MAINTENANCE STAIRWAY/WALKWAY SHALL BE ADJUSTED ON SITE TO AVOID CAUSING DAMAGE TO EXISTING TREES.
5. THE CONTRACTOR SHALL RECORD THE LOCATIONS OF INSPECT, RECORD AND TAKE PHOTOS OF THE CONDITIONS OF THE EXISTING TREES WITHIN THE WORKS SITE. AS DIRECTED BY THE ENGINEER, A REPORT ON THE CONDITIONS OF THE EXISTING TREES, INCLUDING COLOR PHOTOS, PLAN OF LOCATIONS AND BRIEF DESCRIPTIONS OF ANY DEFECTS OR DAMAGE OF TREES OBSERVED SHALL BE SUBMITTED TO THE ENGINEER FOR RECORD AT LEAST 2 WEEKS PRIOR TO COMMENCEMENT OF THE WORKS.
6. THE METALLIC PARTS (SUCH AS HANDRAILING, STEPS AND LOCKABLE GATE) OF THE MAINTENANCE WALKWAY, STEEL AND CONCRETE STAIRCASE SHALL BE PAINTED IN ACCORDANCE WITH SYSTEM D OF GS CLAUSE 18.63. AND THE FINISHING COAT OF THE PAINT SHALL BE 'ANTIQUE' BS 5252F COLOR CODE 10B25, UNLESS SPECIFIED OTHERWISE ON DRAWING.
7. THE FINISHED EXPOSED SOIL SLOPE SURFACE SHALL BE HYDROSEEDED WITH NON-BIODEGRADABLE EROSION CONTROL MAT OR AS DIRECTED BY THE ENGINEER. IF REQUIRED, SHALL BE PROVIDED IN ACCORDANCE WITH CEDD STANDARD DRAWINGS C2511/1C AND C2511/2E OR C2106/4A AND C2106/5A AS APPROPRIATE.

WORKING WITHIN STREAM COURSE

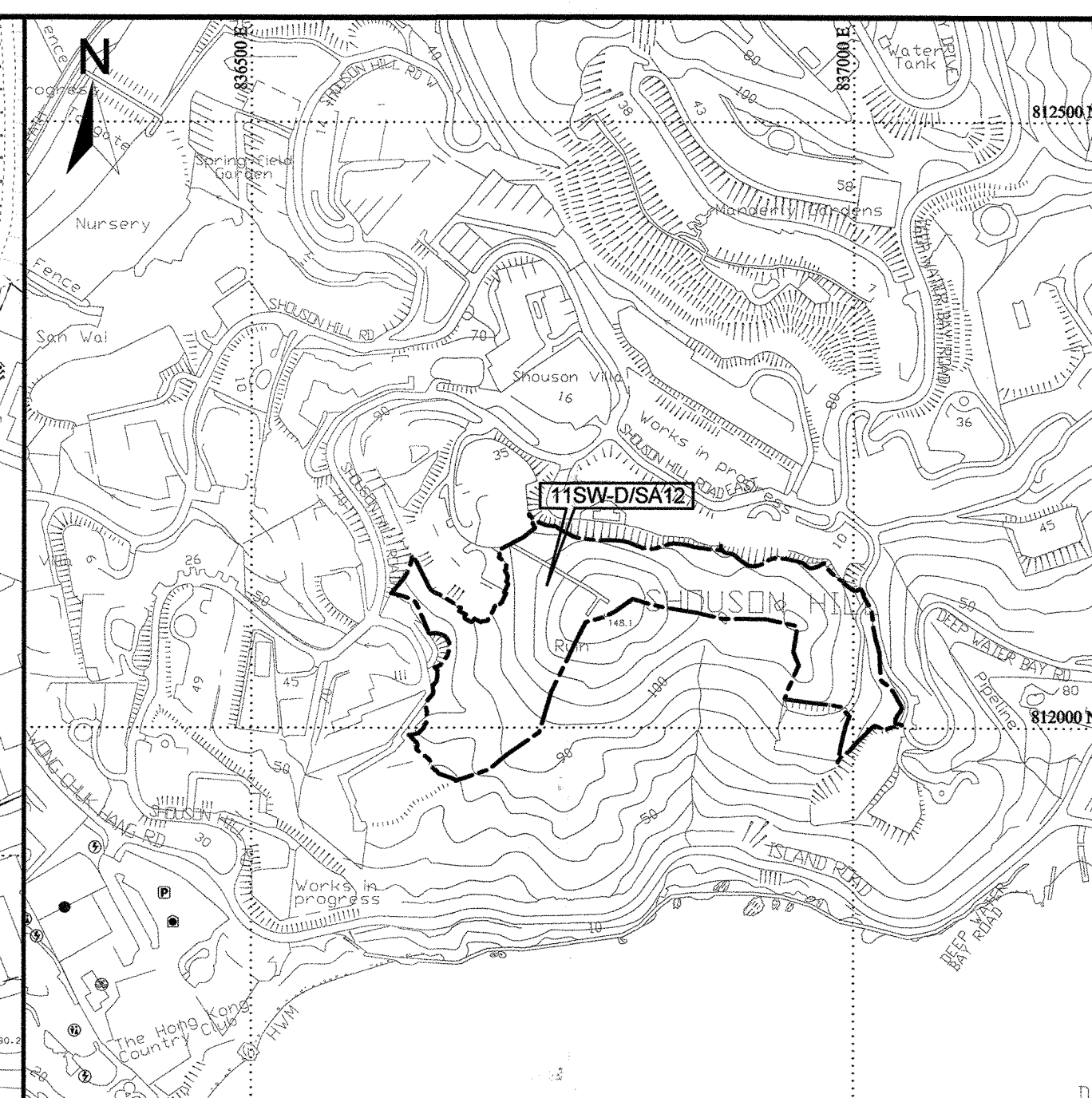
1. A RISK ASSESSMENT SHALL BE CARRIED OUT BY THE CONTRACTOR AND SUBMIT TO THE ENGINEER ON SITE FOR AGREEMENT PRIOR TO COMMENCEMENT OF WORKS WITHIN THE EXISTING STREAM COURSES.
2. THE TIMING OF AND PRECAUTIONARY MEASURES FOR ANY WORKS CARRIED OUT WITHIN THE EXISTING STREAM COURSE(S) SHOULD BE TAKEN INTO THE OUTCOME OF RISK ASSESSMENT.

no.	date	description	designed	checked
		name	date	
designed		Ken	1/2014	
drawn		Heng	1/2014	
checked		AS	1/2014	
approved				


PROJECT DIRECTOR, FUGRO (HONG KONG) LIMITED

project no.		110441 / HC01	
agreement no.		CE 16/2011 (GE)	
contract		CONTRACT NO. GE/2012/30 LANDSLIP PREVENTION AND MITIGATION PROGRAMME, 2011, PACKAGE B, LANDSLIP PREVENTION AND MITIGATION WORKS IN HONG KONG ISLAND (EAST)	
feature no. & location		11SW-D/SA12 SHOUSON HILL	
drawing title			
GENERAL NOTES FOR MITIGATION WORKS			
drawing no.		revision	scale
NTHS1230/HC01/GE/01		-	AS SHOWN
consulting engineer			
		FUGRO (HONG KONG) LIMITED	
office			
LANDSLIP PREVENTIVE MEASURES DIVISION 3 GEOTECHNICAL ENGINEERING OFFICE			
		CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT HONG KONG	
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Status :		P03	

ORIGINAL PAPER SIZE : A1
PLOTTED BY : leonm, 24 Jan 2014 - 12:03pm



KEY PLAN SCALE 1 : 5000 (A1 SIZE)
1 : 10000 (A3 SIZE)

- LEGEND:**
- | | |
|---|--|
|  | BOUNDARY OF STUDY AREA |
|  | HILLSIDE CATCHMENT NO. |
|  | LOT BOUNDARY |
|  | LICENCE BOUNDARY |
|  | REGISTERED MAN-MADE FEATURE BOUNDARY (SIS) |
|  | EXISTING TREE |
|  | EXISTING STREAMLINE |

NOTE :

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT DRAWINGS, STANDARD DRAWINGS, THE SPECIFICATIONS AND INSTRUCTIONS ISSUED BY THE ENGINEER.
2. ALL LEVELS ARE IN METRES ABOVE P.D..
3. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.
4. THE EXACT LOCATION OF THE PROPOSED WORKS SHALL BE CONFIRMED ON SITE BY THE ENGINEER.
5. PRECAUTIONARY MEASURES SHALL BE TAKEN TO PROTECT ADJOINING FACILITIES FROM BEING AFFECTED BY THE WORKS.
6. ALL THE EXISTING SURFACE DRAINAGE SYSTEM OR UNDERGROUND UTILITIES WITHIN THE WORKS AREA/ SITE SHALL BE DIVERTED OR PROTECTED PRIOR TO THE EXECUTION OF THE PROPOSED WORKS TO AVOID ANY DAMAGE.
7. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE DESIGN AND EXECUTION OF ALL TEMPORARY WORKS.
8. NO TREES SHALL BE FELLED WITHOUT APPROVAL IN WRITING BY THE ENGINEER.

no.	date	description					designed/ checked		
		name					date		
designed		Poon					1/2/14		
drawn		Hoi Ck					JAN-2014		
checked		KING					JAN 2014		
approved									

PROJECT DIRECTOR, FUGRO (HONG KONG) LIMITED

project no. 110441 / HC01

agreement no. CE 16/2011 (GE)

contract

CONTRACT NO. GE/2012/30

**LANDSLIP PREVENTION AND MITIGATION
PROGRAMME, 2011, PACKAGE B,
LANDSLIP PREVENTION AND MITIGATION WORKS
IN HONG KONG ISLAND (EAST)**

feature no. & location

11SW-D/SA12
SHOUSON HILL

drawing title

GENERAL LAYOUT PLAN

drawing no.	
NTHS1230/HC01/01	

revision	scale
-	AS SHOWN

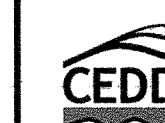
consulting engineer



FUGRO (HONG KONG) LIMITED

office

LANDSLIP PREVENTIVE MEASURES DIVISION 3 GEOTECHNICAL ENGINEERING OFFICE



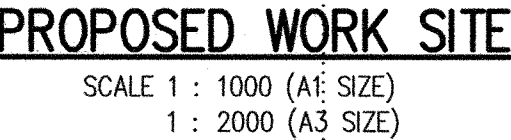
**CIVIL ENGINEERING AND
DEVELOPMENT DEPARTMENT
HONG KONG**

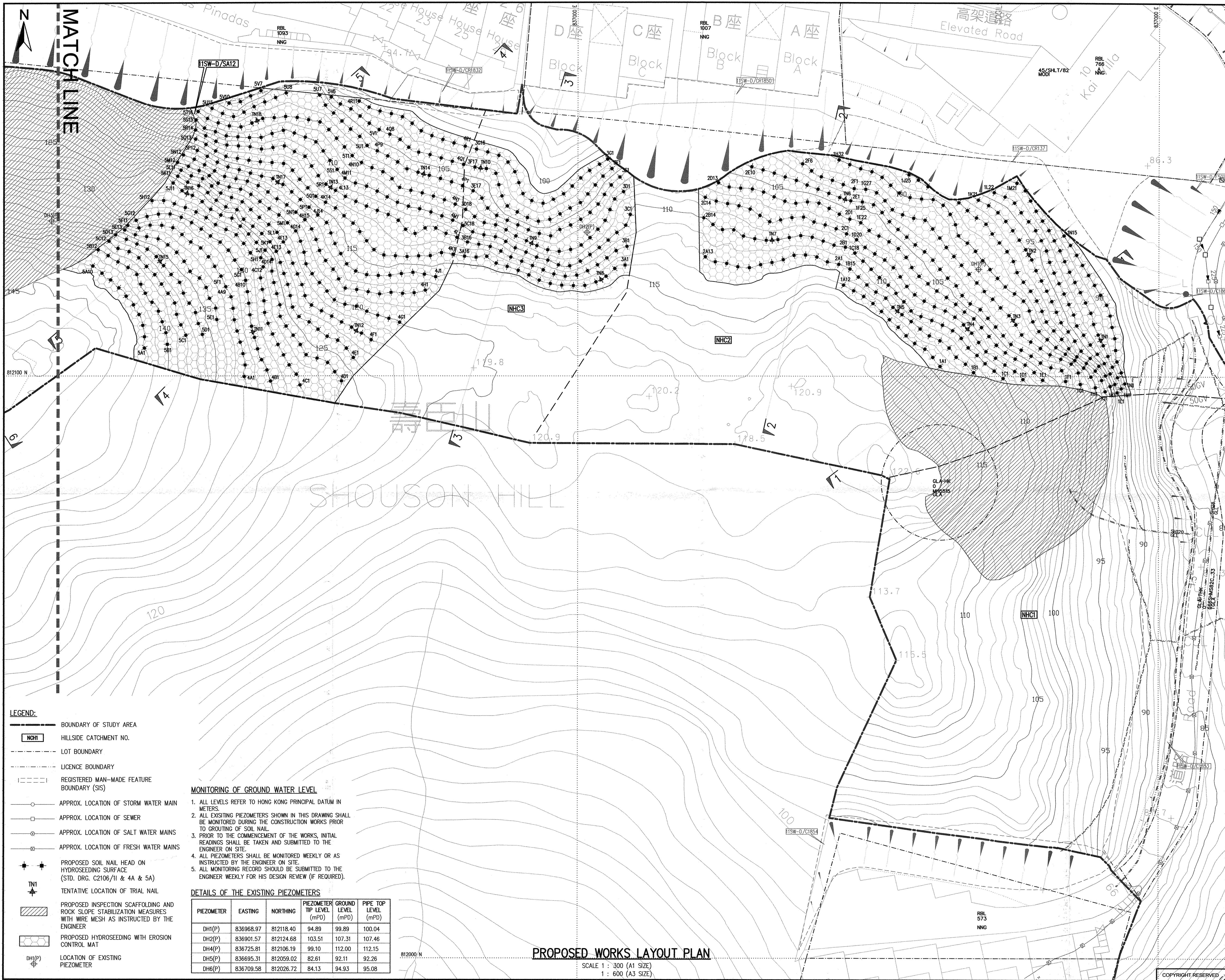
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LOTTED BY : leornn, 24 Jan,2014 - 12:08pm





NOTE :

- THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT DRAWINGS, STANDARD DRAWINGS, THE SPECIFICATIONS AND INSTRUCTIONS ISSUED BY THE ENGINEER.
- ALL LEVELS ARE IN METRES ABOVE P.D..
- ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.
- THE EXACT LOCATION OF THE PROPOSED WORKS SHALL BE CONFIRMED ON SITE BY THE ENGINEER.
- THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE DESIGN AND EXECUTION OF ALL TEMPORARY WORKS.
- PRECAUTIONARY MEASURES SHALL BE TAKEN TO PROTECT ADJOINING FACILITIES FROM BEING AFFECTED BY THE WORKS.
- ALL THE EXISTING SURFACE DRAINAGE SYSTEM OR UNDERGROUND UTILITIES WITHIN THE WORKS AREA/ SITE SHALL BE DIVERTED OR PROTECTED PRIOR TO THE EXECUTION OF THE PROPOSED WORKS TO AVOID ANY DAMAGE.
- FOR SLOPE AREA WITH PROPOSED SOIL NAIL, CONTRACTOR SHALL CARRY OUT A DETAILED BOULDER SURVEY AND THE REPORT SHALL BE SUBMITTED TO THE ENGINEER BEFORE COMMENCEMENT OF SOIL NAIL WORKS. FOR SLOPE AREA WITHOUT ANY PROPOSED WORKS, CONTRACTOR MAY NEED TO PROVIDE ACCESS TO ANY BOULDERS AS OBSERVED ON THE SLOPE AND PROVIDE STABILIZATION WORKS.
- ALL SOIL NAILED SLOPE SURFACE SHALL BE PROTECTED BY BIODEGRADABLE EROSION CONTROL MAT.
- FOR SLOPE AREA WITHOUT ANY PROPOSED WORKS, EXISTING VEGETATION SHALL BE RETAINED AS FAR AS POSSIBLE.

no.	date	description	designed	checked
		name		date
designed		name		date
drawn		name		date
checked		name		date
approved		name		date

PROJECT DIRECTOR, FUGRO (HONG KONG) LIMITED

project no. 110441 / HC01

agreement no. CE 16/2011 (GE)

contract CONTRACT NO. GE/2012/30
LANDSLIP PREVENTION AND MITIGATION PROGRAMME, 2011, PACKAGE B,
LANDSLIP PREVENTION AND MITIGATION WORKS IN HONG KONG ISLAND (EAST)

feature no. & location 11SW-D/SA12
SHOUSON HILL

drawing title PROPOSED WORKS LAYOUT ON HILLSIDE CATCHMENT
(SHEET 1 OF 2)

drawing no. NTHS1230/HC01/03 revision - scale AS SHOWN

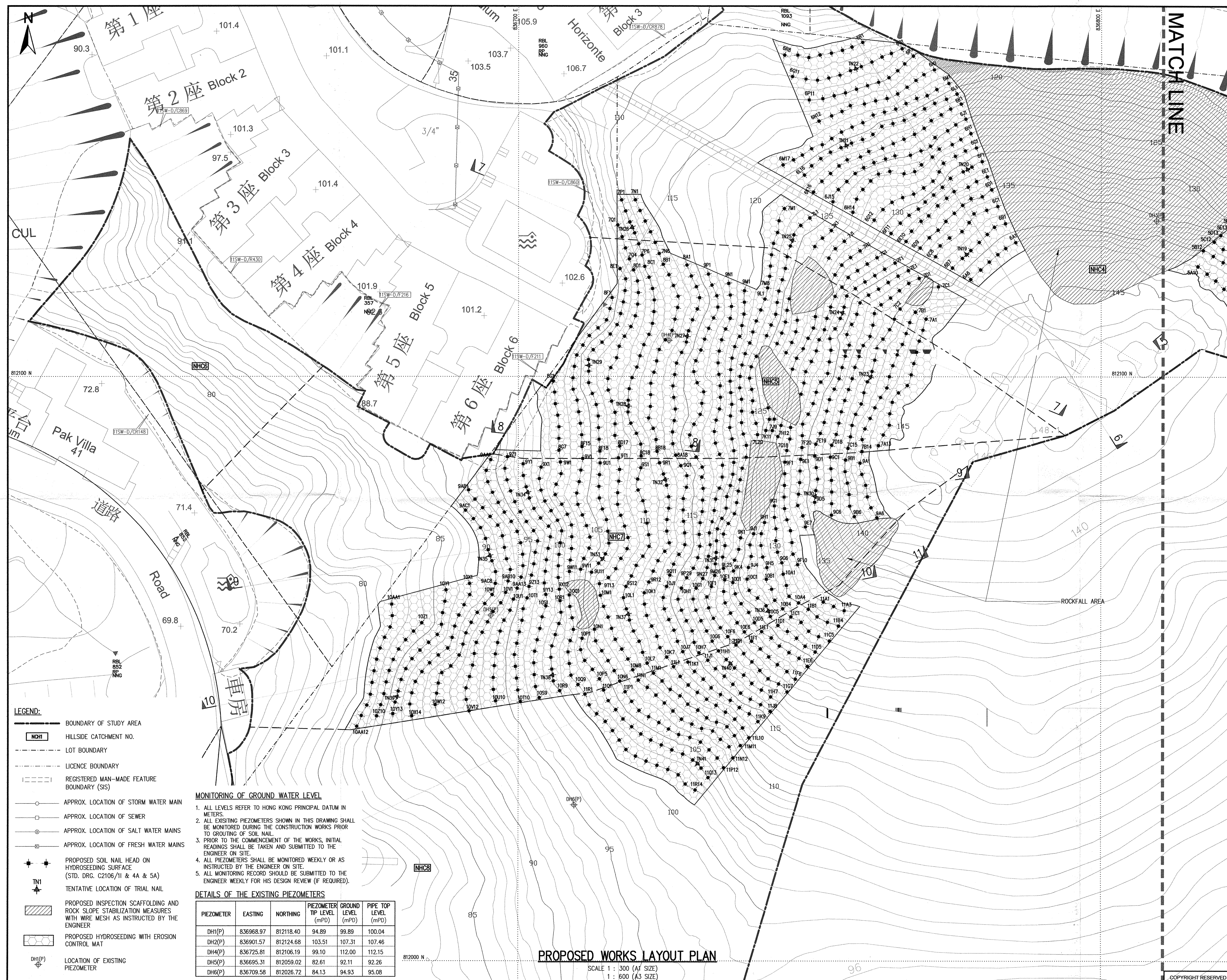
consulting engineer FUGRO (HONG KONG) LIMITED

office LANDSLIP PREVENTIVE MEASURES DIVISION 3
GEOTECHNICAL ENGINEERING OFFICE

CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT HONG KONG

Status : P11

ORIGINAL PAPER SIZE : A1
PLOTTED BY : beam 24 Jan 2014 : 12:05pm



NOTE :

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT DRAWINGS, STANDARD DRAWINGS, THE SPECIFICATIONS AND INSTRUCTIONS ISSUED BY THE ENGINEER.
2. ALL LEVELS ARE IN METRES ABOVE P.D.
3. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.
4. THE EXACT LOCATION OF THE PROPOSED WORKS SHALL BE CONFIRMED ON SITE BY THE ENGINEER.
5. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE DESIGN AND EXECUTION OF ALL TEMPORARY WORKS.
6. PRECAUTIONARY MEASURES SHALL BE TAKEN TO PROTECT ADJOINING FACILITIES FROM BEING AFFECTED BY THE WORKS.
7. ALL THE EXISTING SURFACE DRAINAGE SYSTEM OR UNDERGROUND UTILITIES WITHIN THE WORKS AREA/ SITE SHALL BE DIVERTED OR PROTECTED PRIOR TO THE EXECUTION OF THE PROPOSED WORKS TO AVOID ANY DAMAGE.
8. FOR SLOPE AREA WITH PROPOSED SOIL NAIL, CONTRACTOR SHALL CARRY OUT A DETAILED BOULDER SURVEY AND THE REPORT SHALL BE SUBMITTED TO THE ENGINEER BEFORE COMMENCEMENT OF WORKS FOR SLOPE AREA.
9. WITHOUT ANY PROPOSED WORKS, CONTRACTOR MAY NEED TO PROVIDE ACCESS TO ANY BOULDERS AS OBSERVED ON THE SLOPE AND PROVIDE STABILIZATION WORKS.
10. ALL SOIL NAILED SLOPE SURFACE SHALL BE PROTECTED BY BROADBENGE EROSION CONTROL MATS FOR SLOPE AREA.
11. FOR SLOPE AREA WITHOUT ANY PROPOSED WORKS, EXISTING VEGETATION SHALL BE RETAINED AS FAR AS POSSIBLE.

no.	date	description	designed	checked
designed		name		date
drawn				
checked				
approved				
 PROJECT DIRECTOR, FUGRO (HONG KONG) LIMITED				
project no.		110441 / HC01		
agreement no.		CE 16/2011 (GE)		
contract				
CONTRACT NO. GE/2012/30 LANDSLIP PREVENTION AND MITIGATION PROGRAMME, 2011, PACKAGE B, LANDSLIP PREVENTION AND MITIGATION WORKS IN HONG KONG ISLAND (EAST)				
feature no. & location				
11SW-D/SA12 SHOUSHAN HILL				
drawing title				
PROPOSED WORKS LAYOUT ON HILLSIDE CATCHMENT (SHEET 2 OF 2)				
drawing no.		revision	scale	
NTHS1230/HC01/04		-	AS SHOWN	
consulting engineer				
 FUGRO (HONG KONG) LIMITED				
office				
LANDSLIP PREVENTIVE MEASURES DIVISION 3 GEOTECHNICAL ENGINEERING OFFICE				
 CIVIL ENGINEERING AND DEVELOPMENT AUTHORITY HONG KONG				
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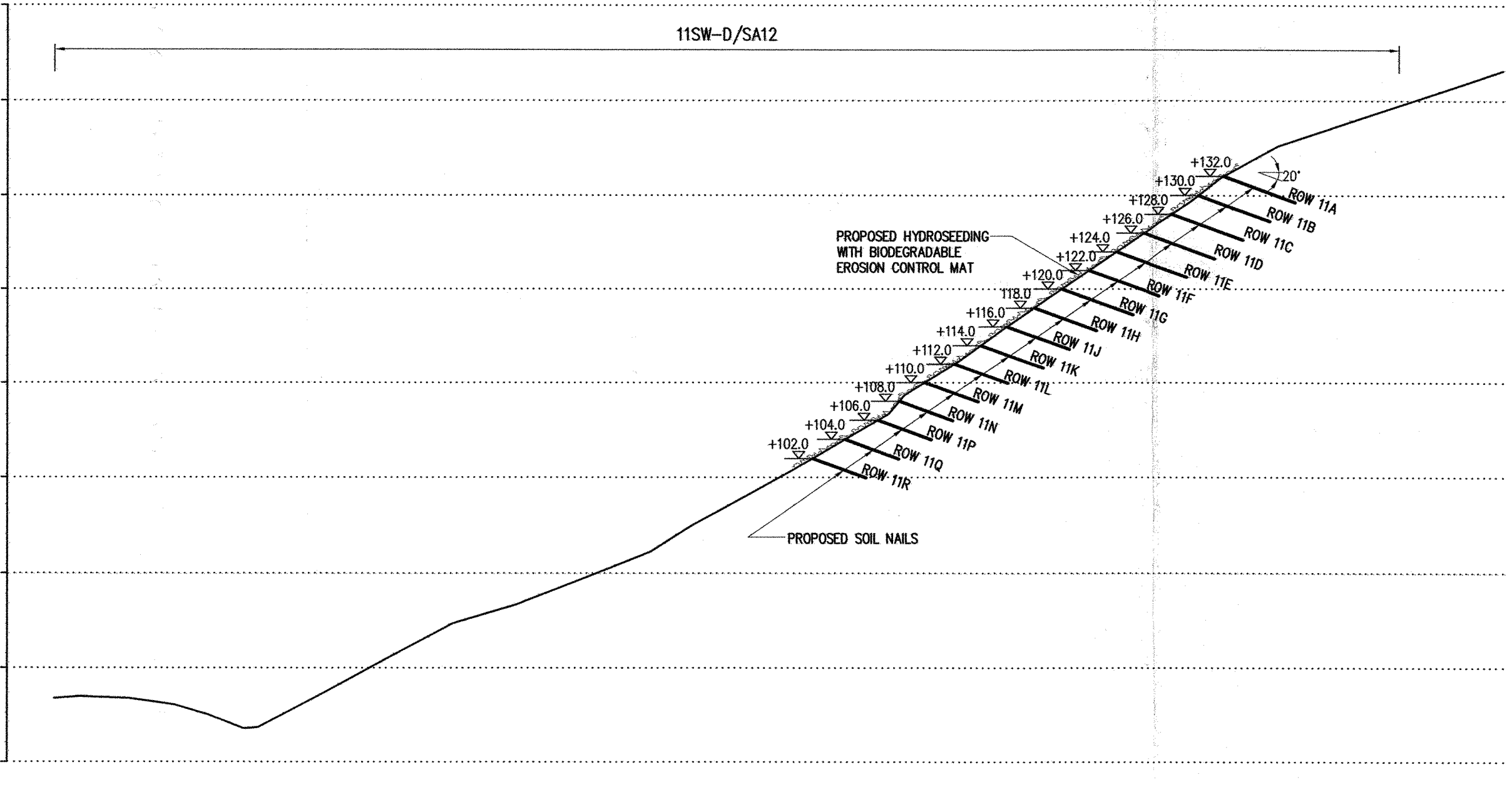
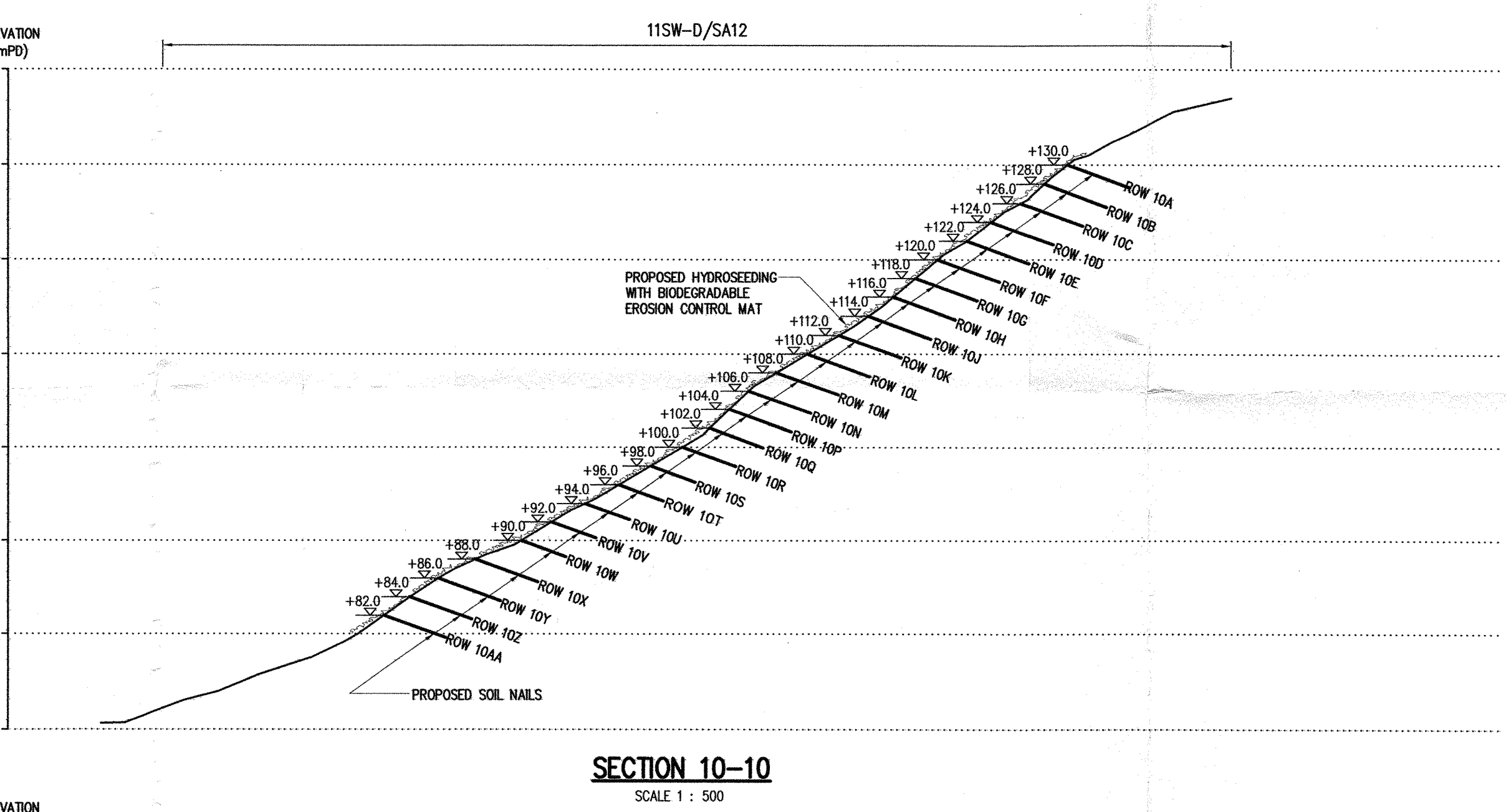
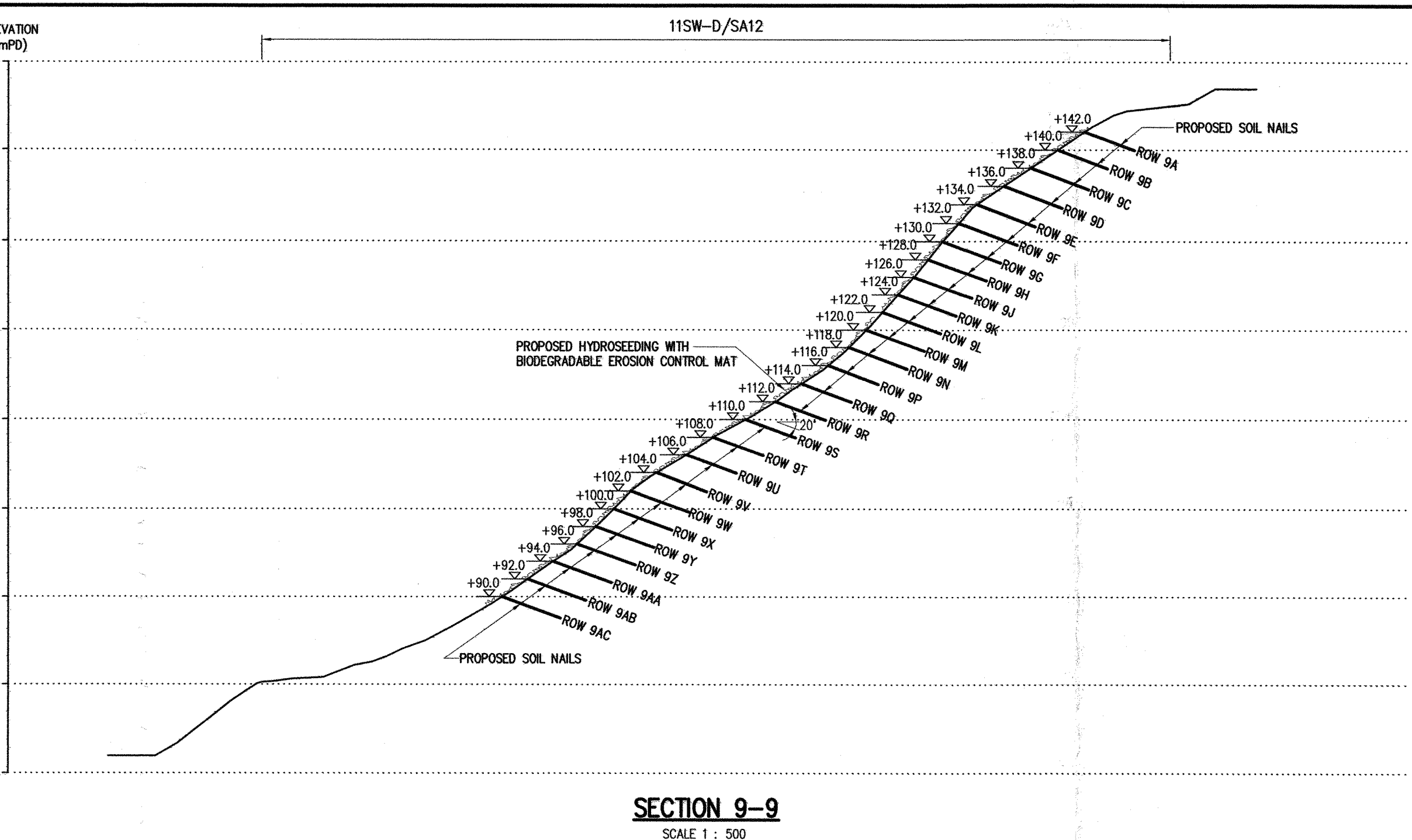
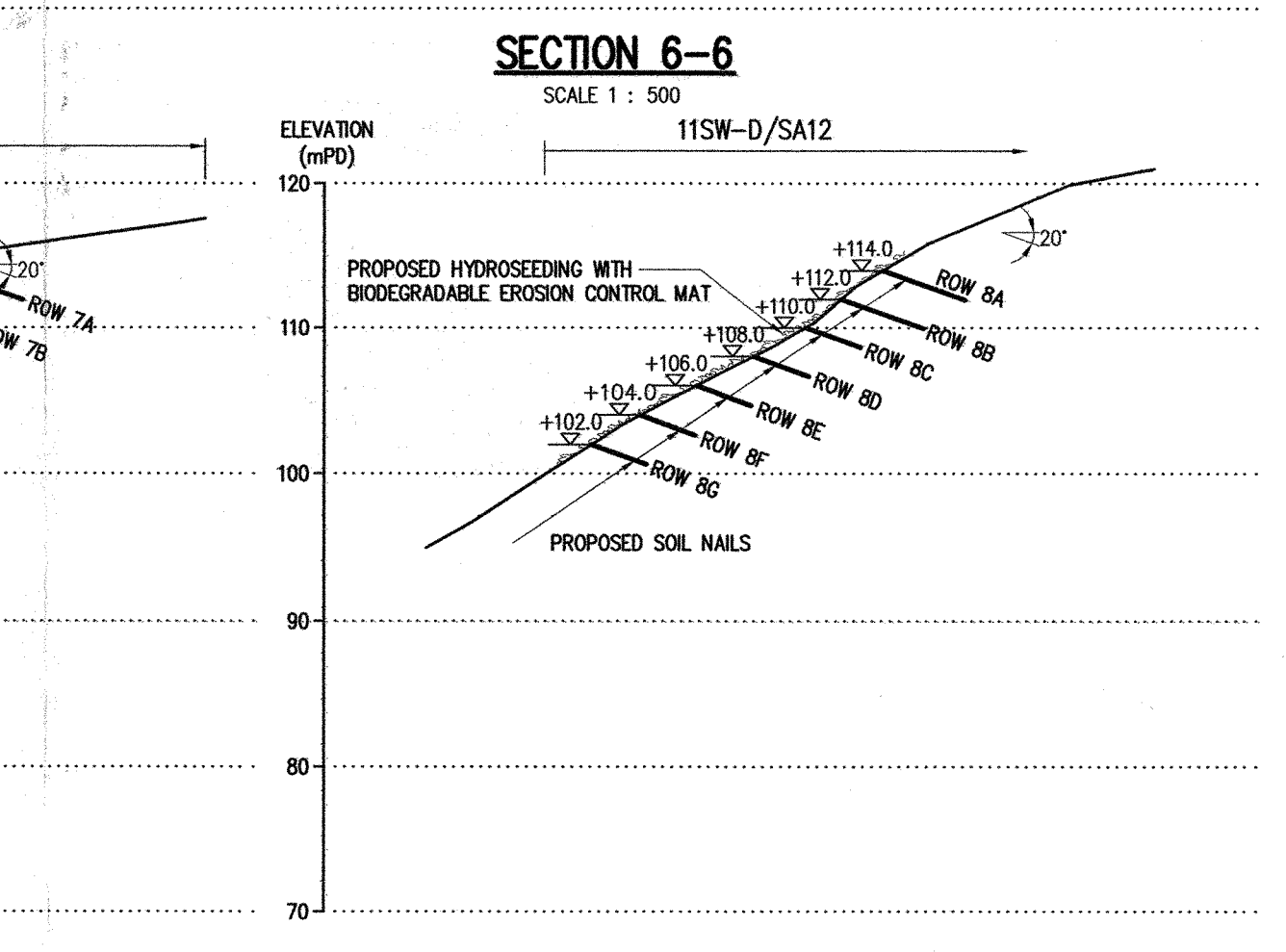
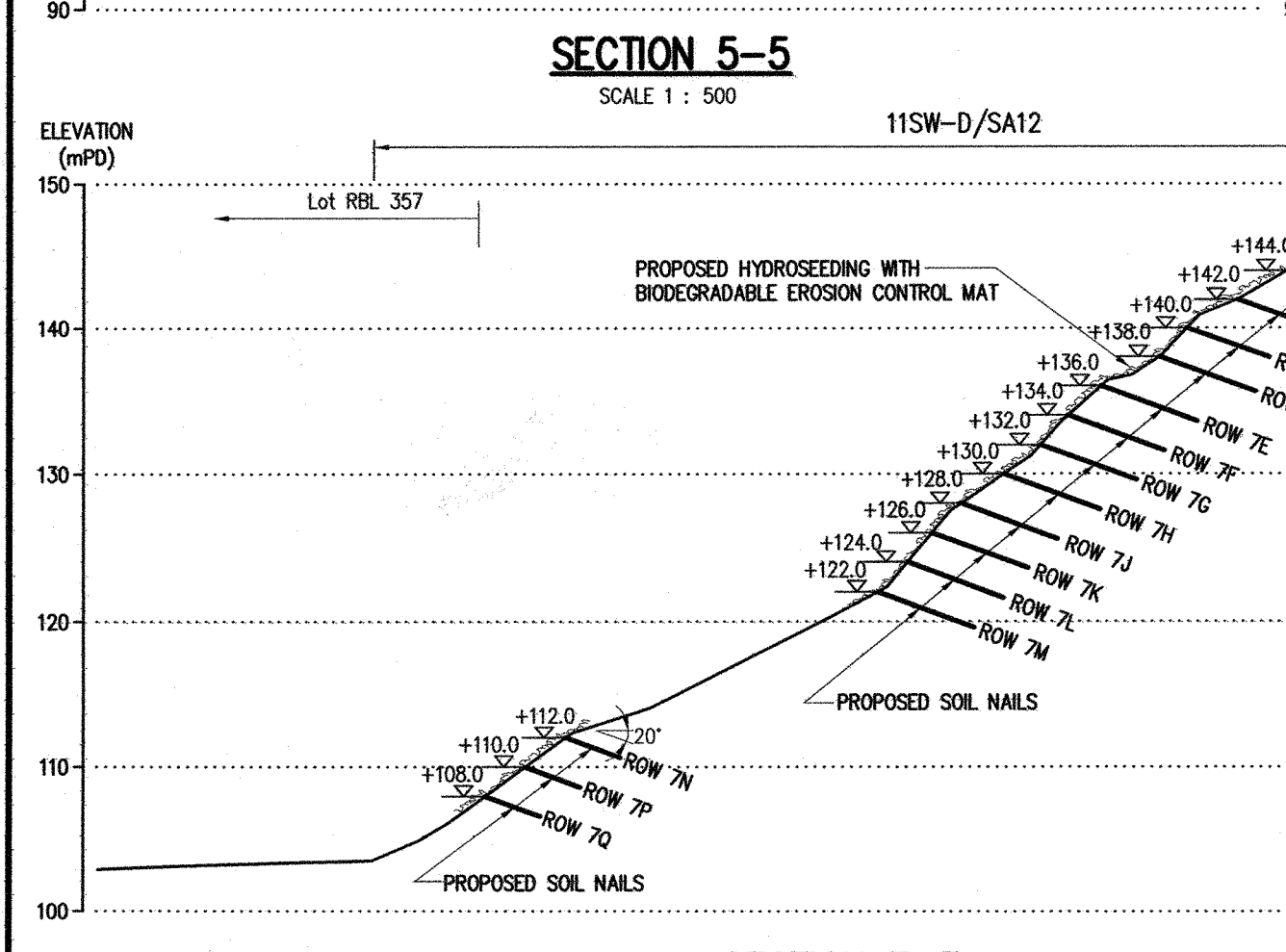
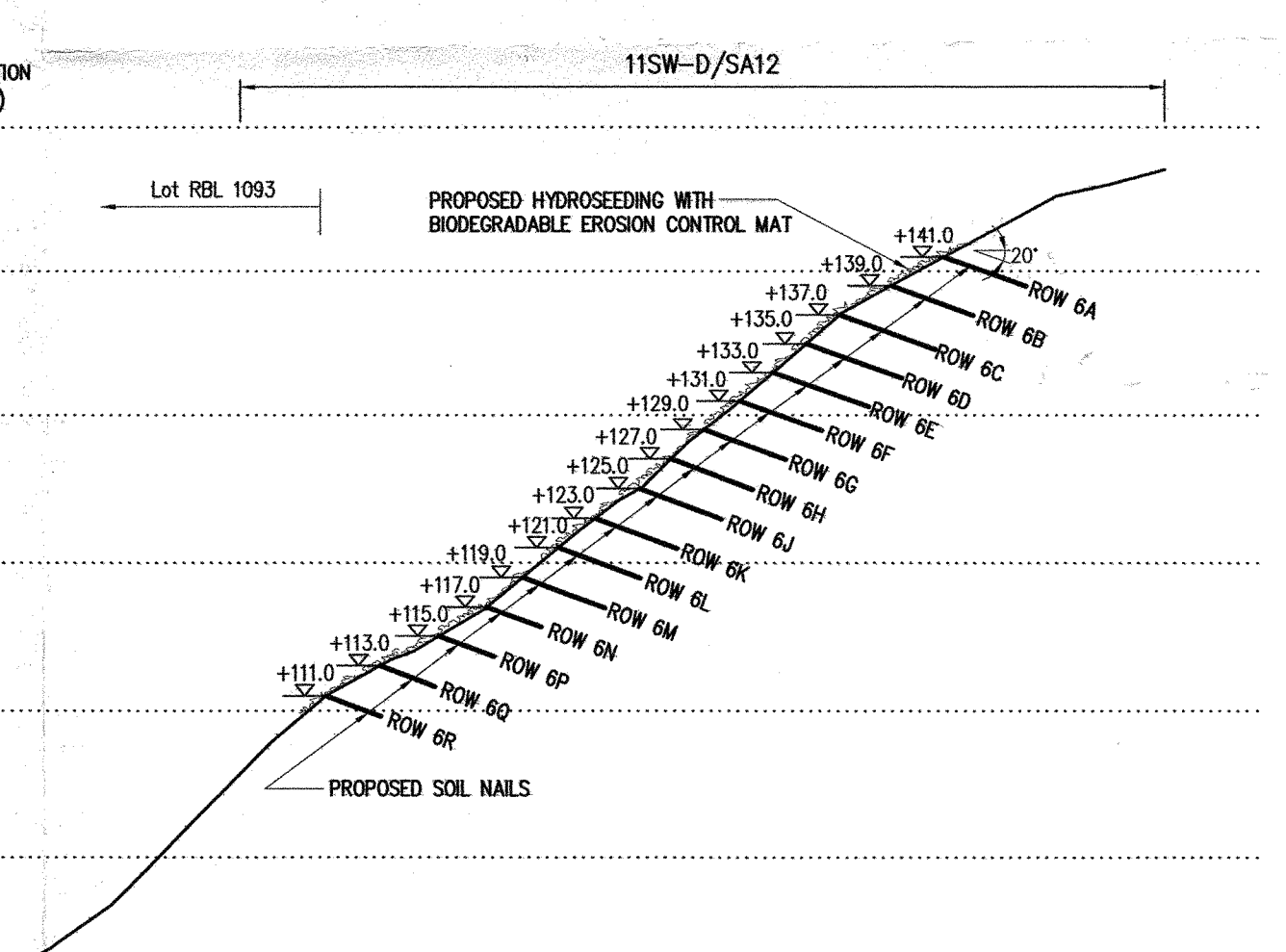
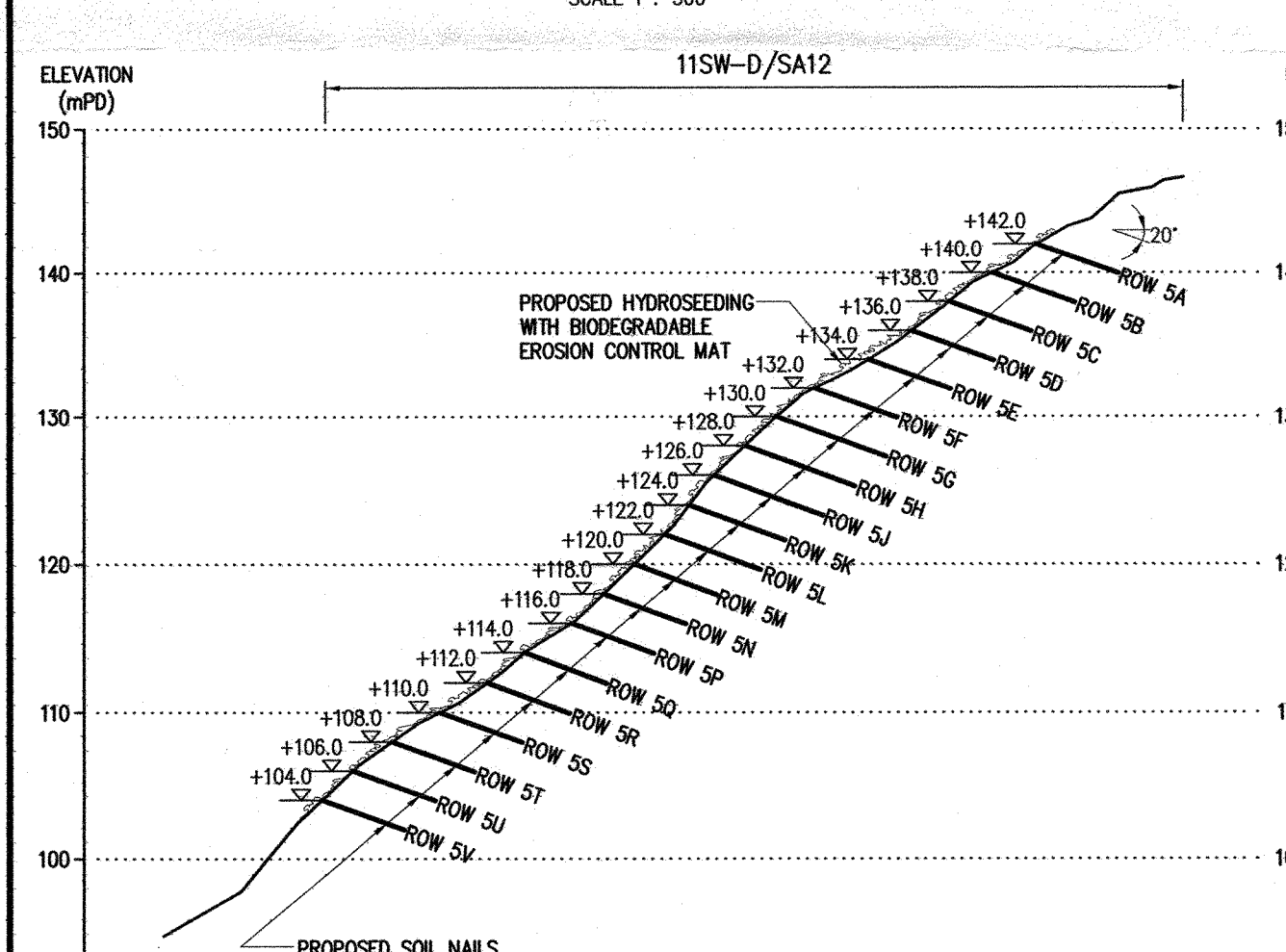
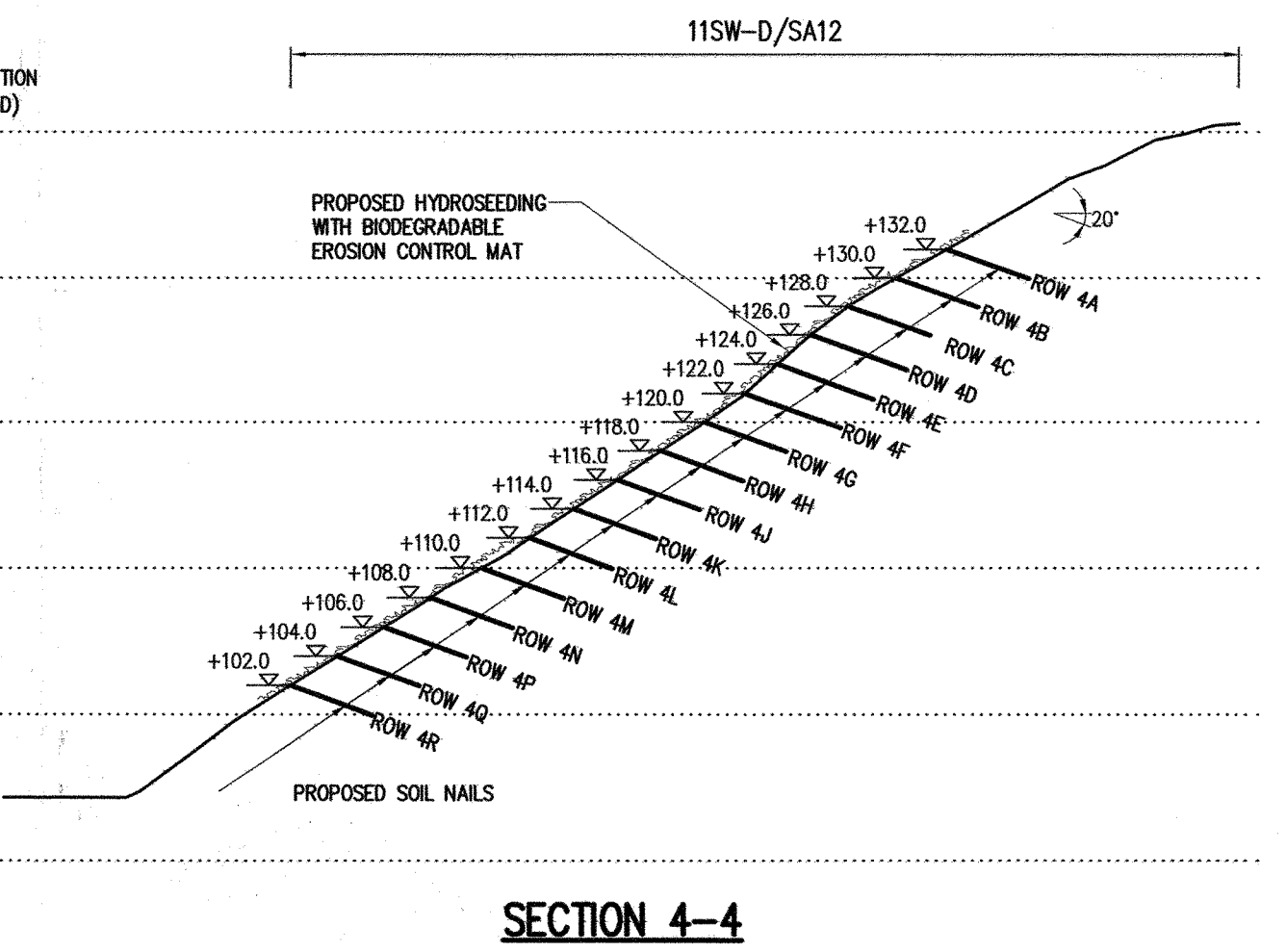
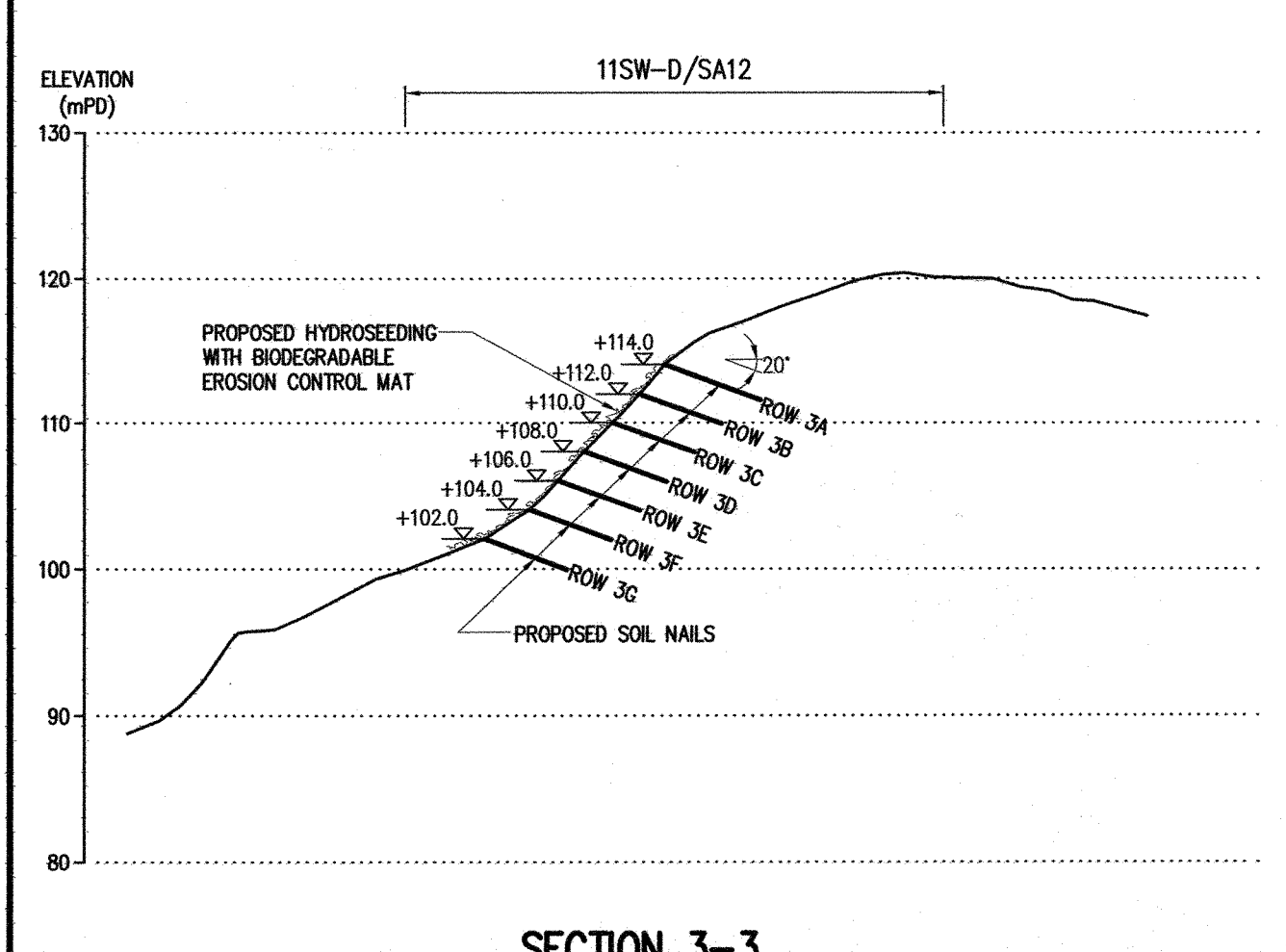
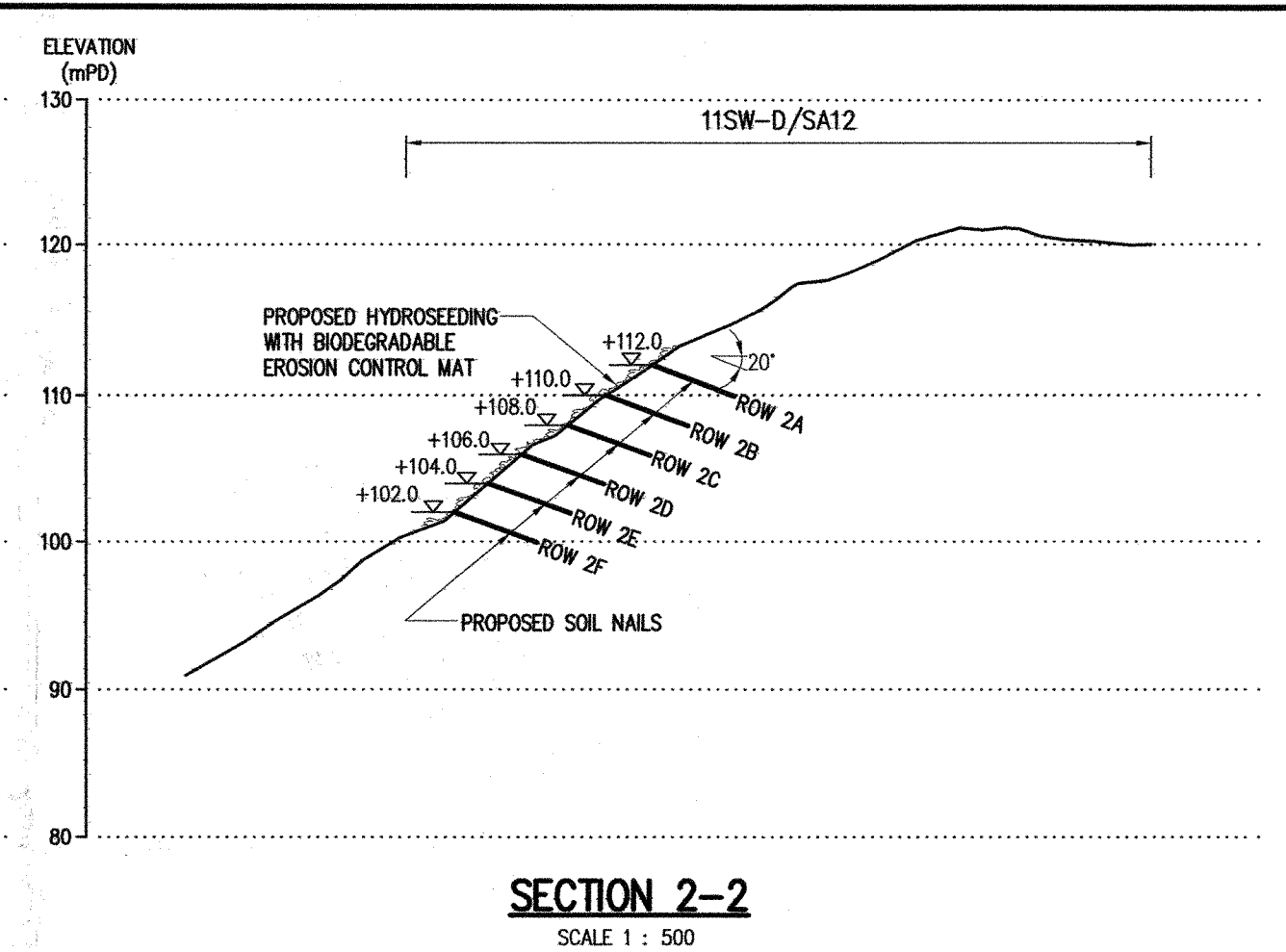
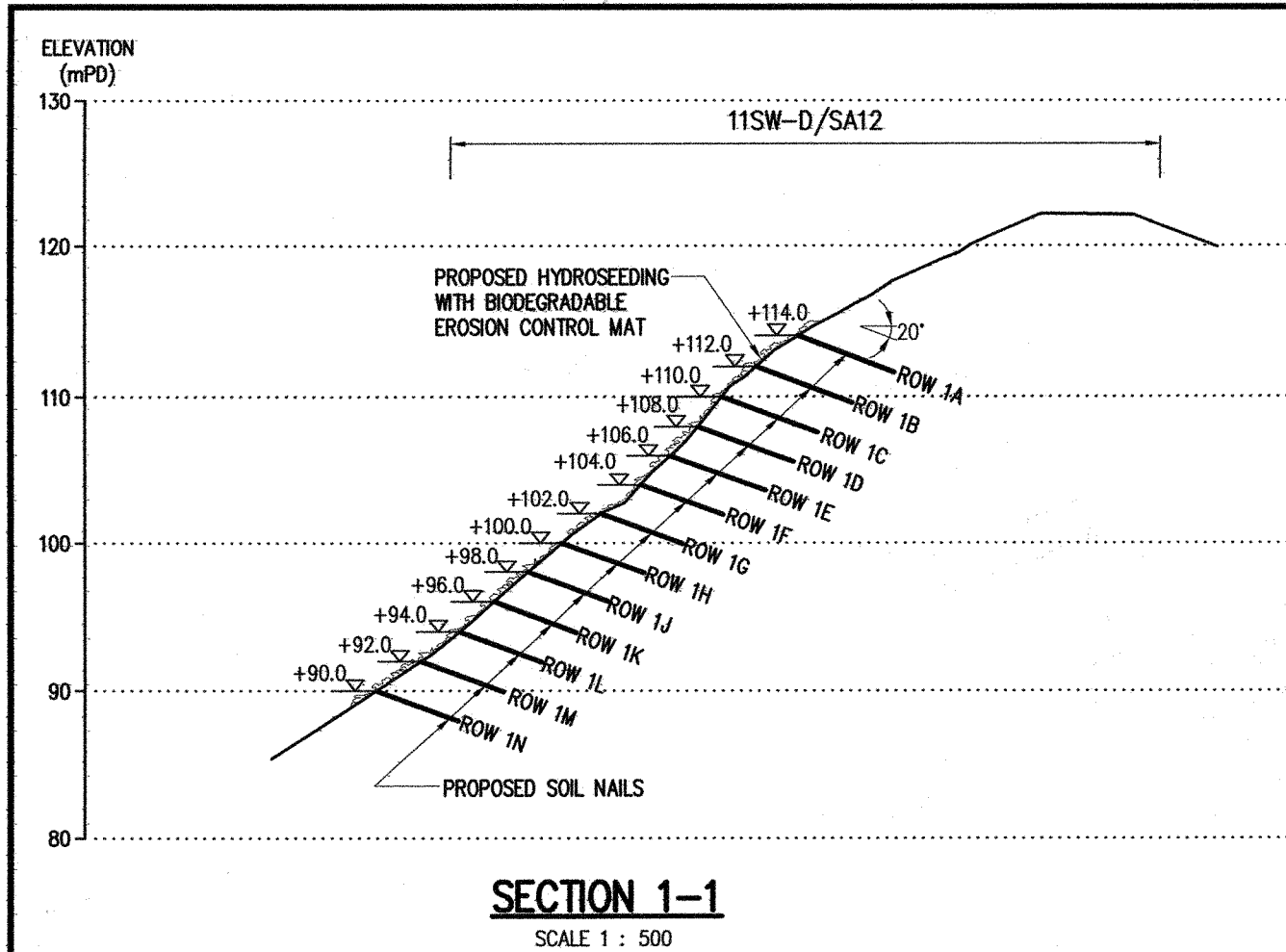
SOIL NAIL SCHEDULE

SOIL NAIL NO.	NAILS DIAMETER (mm)	TENTATIVE LEVEL (mPD)	TENTATIVE NOS. OF NAILS	TENTATIVE LENGTH OF NAILS (m)	DIPPING ANGLE (DEGREES)	DIPPING DIRECTION (DEGREES)	HORIZONTAL SPACING (m)	DRILLHOLE DIAMETER (mm)	SIZE OF SOIL NAIL HEAD (mm x mm)
1A1-1A12	25	114	12	7	20		2	100	800 x 800
1B1-1B15	25	112	15	7	20		2	100	800 x 800
1C1-1C18	25	110	18	7	20		2	100	800 x 600
1D1-1D20	25	108	20	7	20		2	100	600 x 600
1E1-1E22	25	106	22	7	20		2	100	600 x 600
1F1-1F25	25	104	25	6	20		2	100	600 x 600
1G1-1G27	25	102	27	6	20		2	100	600 x 600
1H1-1H32	25	100	32	6	20		2	100	600 x 600
1J1-1J25	25	98	25	6	20		2	100	600 x 600
1K1-1K21	25	96	21	6	20		2	100	600 x 600
1L1-1L22	25	94	22	6	20		2	100	600 x 600
1M1-1M21	25	92	21	6	20		2	100	600 x 600
1N1-1N15	25	90	15	6	20		2	100	600 x 600
2A1-2A13	25	112	13	6	20		2	100	600 x 600
2B1-2B14	25	110	14	6	20		2	100	600 x 600
2C1-2C14	25	108	14	6	20		2	100	600 x 600
2D1-2D13	25	106	13	6	20		2	100	600 x 600
2E1-2E10	25	104	10	6	20		2	100	600 x 600
2F1-2F6	25	102	6	6	20		2	100	600 x 600
3A1-3A16	25	114	16	7	20		2	100	600 x 600
3B1-3B16	25	112	16	6	20		2	100	600 x 600
3C1-3C18	25	110	18	6	20		2	100	600 x 600
3D1-3D18	25	108	18	6	20		2	100	600 x 600
3E1-3E17	25	106	17	6	20		2	100	600 x 600
3F1-3F17	25	104	17	6	20		2	100	600 x 600
3G1-3G16	25	102	16	6	20		2	100	800 x 800
4A1-4A9	25	132	9	6	20		2	100	600 x 600
4B1-4B10	25	130	10	6	20		2	100	600 x 600
4C1-4C12	25	128	12	6	20		2	100	600 x 600
4D1-4D14	25	126	14	7	20		2	100	600 x 600
4E1-4E13	25	124	13	7	20		2	100	600 x 600
4F1-4F13	25	122	13	7	20		2	100	600 x 600
4G1-4G14	25	120	14	6	20		2	100	600 x 600
4H1-4H15	25	118	15	6	20		2	100	600 x 600
4J1-4J14	25	116	14	6	20		2	100	600 x 600
4K1-4K14	25	114	14	6	20		2	100	600 x 600
4L1-4L13	25	112	13	6	20		2	100	600 x 600
4M1-4M11	25	110	11	6	20		2	100	600 x 600
4N1-4N10	25	108	10	6	20		2	100	600 x 600
4P1-4P9	25	106	9	6	20		2	100	600 x 600
4Q1-4Q8	25	104	8	6	20		2	100	600 x 600
4R1-4R11	25	102	11	6	20		2	100	600 x 600
5A1-5A10	25	142	10	6	20		2	100	600 x 600
5B1-5B12	25	140	12	6	20		2	100	600 x 600
5C1-5C12	25	138	12	6	20		2	100	600 x 600
5D1-5D13	25	136	13	6	20		2	100	600 x 600
5E1-5E13	25	134	13	6	20		2	100	600 x 600
5F1-5F11	25	132	11	6	20		2	100	600 x 600
5G1-5G12	25	130	12	8	20		2	100	600 x 600
5H1-5H12	25	128	12	8	20		2	100	600 x 600
5J1-5J11	25	126	11	8	20		2	100	600 x 600
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5M1-5M12	25	120	12	6	20		2	100	600 x 600
5N1-5N12	25	118	12	6	20		2	100	600 x 600
5P1-5P12	25	116	12	6	20		2	100	600 x 600
5Q1-5Q13	25	114	13	6	20		2	100	600 x 600
5R1-5R14	25	112	14	6	20		2	100	600 x 600
5S1-5S15	25	110	15	6	20		2	100	600 x 600
5T1-5T16	25	108	16	6	20		2	100	600 x 600
5U1-5U15	25	106	15	6	20		2	100	600 x 600
5V1-5V10	25	104	10	6	20		2	100	600 x 600
6A1-6A6	25	141	6	6	20		2	100	600 x 600
6B1-6B7	25	139	7	6	20		2	100	600 x 600
6C1-6C8	25	137	8	7	20		2	100	600 x 600
6D1-6D9	25	135	9	7	20		2	100	600 x 600
6E1-6E10	25	133	10	7	20		2	100	600 x 600
6F1-6F11	25	131	11	6	20		2	100	600 x 600
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6H1-6H14	25	127	14	6	20		2	100	600 x 600
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6M1-6M17	25	119	17	6	20		2	100	600 x 600
6N1-6N12	25	117	12	4	20		2	100	600 x 600
6P1-6P11	25	115	11	4	20		2	100	400 x 400
6Q1-6Q11	25	113	11	4	20		2	100	400 x 400
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7A1-7A13	25	144	13	6	20		2	100	600 x 600
7B1-7B14	25	142	14	6	20		2	100	600 x 600
7C1-7C15	25	140	15	6	20		2	100	600 x 600
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7E1-7E19	25	136	19	7	20		2	100	600 x 600
7F1-7F20	25	134	20	7	20		2	100	600 x 600
7G1-7G18	25	132	18	7	20		2	100	600 x 600
7H1-7H12	25	130	12	7	20		2	100	600 x 600
7J1-7J9	25	128	9	7	20		2	100	600 x 600
7K1-7K11	25	126	11	7	20		2	100	600 x 600
7L1-7L20	25	124	20	7	20		2	100	600 x 600
7M1-7M8	25	122	8	7	20		2	100	600 x 600
7N1-7N6	25	112	6	4	20		2	100	400 x 400
7P1-7P6	25	110	6	4	20		2	100	400 x 400
7Q1-7Q4	25	108	4	4	20		2	100	400 x 400
8A1-8A18	25	114	18	6	20		2	100	600 x 600
8B1-8B18	25	112	18	6	20		2	100	600 x 600
8C1-8C18	25	110	18	4	20		2	100	600 x 600
8D1-8D17	25	108	17	4	20		2	100	600 x 600
8E1-8E18	25	106	18	4	20		2	100	600 x 600
8F1-8F15	25	104	15	4	20		2	100	600 x 600
8G1-8G7	25	102	7	4	20		2	100	600 x 600

NORMAL TO SLOPE FACE

SOIL NAIL SCHEDULE

SOIL NAIL NO.	NAILS DIAMETER (mm)	TENTATIVE LEVEL (mPD)	TENTATIVE NOS. OF NAILS	HORIZONTAL LENGTH OF NAILS (m)	DIPPING ANGLE (DEGREES)	DIPPING DIRECTION (DEGREES)	HORIZONTAL SPACING (m)	DRILLHOLE DIAMETER (mm)	SIZE OF SOIL NAIL HEAD (mm x mm)
9A1-9A6	25	142	6	6	20	NORMAL TO SLOPE FACE	2	100	600 x 600
9B1-9B6	25	138	6	6	20		2	100	600 x 600
9C1-9C6	25	140	6	7	20		2	100	600 x 600
9D1-9D5	25	136	5	7	20		2	100	600 x 600
9E1-9E7	25	134	7	7	20		2	100	600 x 600
9F1-9F10	25	132	10	7	20		2	100	600 x 600
9G1-9G6	25	130	6	7	20		2	100	600 x 600
9H1-9H5	25	128	5	7	20		2	100	600 x 600
9J1-9J4	25	126	4	7	20		2	100	600 x 600
9K1-9K4	25	124	4	7	20		2	100	600 x 600
9L1-9L25	25	122	25	7	20		2	100	600 x 600
9M1-9M26	25	120	26	7	20		2	100	600 x 600
9N1-9N27	25	118	27	7	20		2	100	600 x 600
9P1-9P29	25	116	29	6	20		2	100	600 x 600
9Q1-9Q11	25	114	11	6	20		2	100	600 x 600
9R1-9R12	25	112	12	6	20		2	100	600 x 600
9S1-9S12	25	110	12	6	20		2	100	600 x 600
9T1-9T13	25	108	13	6	20		2	100	600 x 600
9U1-9U11	25	106	11	6	20		2	100	600 x 600
9V1-9V11	25	104	11	6	20		2	100	600 x 600
9W1-9W11	25	102	11	7	20		2	100	600 x 600
9X1-9X12	25	100	12	7	20		2	100	600 x 600
9Y1-9Y13	25	98	13	7	20		2	100	600 x 600
9Z1-9Z13	25	96	13	7	20		2	100	600 x 600
9AA1-9AA13	25	94	13	7	20		2	100	600 x 600
9AB1-9AB10	25	92	10	7	20		2	100	600 x 600
9AC1-9AC8	25	90	8	7	20		2	100	600 x 600
10A1-10A4	25	130	4	7	20		2	100	600 x 600
10B1-10B4	25	128	4	7	20		2	100	600 x 600
10C1-10C5	25	126	5	7	20		2	100	600 x 600
10D1-10D5	25	124	5	7	20		2	100	600 x 600
10E1-10E6	25	122	6	7	20		2	100	600 x 600
10F1-10F6	25	120	6	7	20		2	100	600 x 600
10G1-10G6	25	118	6	7	20		2	100	600 x 600
10H1-10H7	25	116	7	7	20		2	100	600 x 600
10J1-10J7	25	114	7	7	20		2	100	600 x 600
10K1-10K7	25	112	7	7	20		2	100	600 x 600
10L1-10L7	25	110	7	7	20		2	100	600 x 600
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10R1-10R9	25	100	9	6	20		2	100	600 x 600
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10T1-10T10	25	96	10	5	20		2	100	600 x 600
10U1-10U10	25	94	10	5	20		2	100	600 x 600
10V1-10V12	25	92	12	5	20		2	100	600 x 600
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11N1-11N12	25	108	12	6	20	2	100	600 x 600	
11P1-11P12	25	106	12	6	20	2	100	600 x 600	
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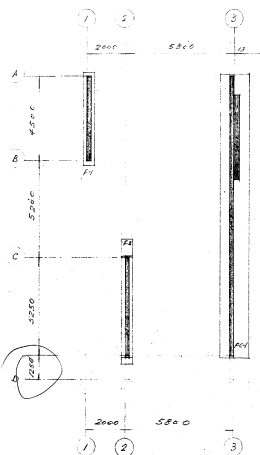
- NOTE :**
1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT DRAWINGS, STANDARD DRAWINGS, SKETCHES, THE SPECIFICATIONS AND INSTRUCTIONS ISSUED BY THE ENGINEER.
 2. ALL LEVELS ARE IN METRES ABOVE P.D..
 3. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.

no.	date	description	designed	checked
		name		date
designed		for		1/2014
drawn		for		JAN-2014
checked		for		JAN-2014
approved				
PROJECT DIRECTOR, FUGRO (HONG KONG) LIMITED				
project no. 110441 / HC01				
agreement no. CE 16/2011 (GE)				
contract CONTRACT NO. GE/2012/30 LANDSLIP PREVENTION AND MITIGATION PROGRAMME, 2011, PACKAGE B, LANDSLIP PREVENTION AND MITIGATION WORKS IN HONG KONG ISLAND (EAST)				
feature no. & location 11SW-D/SA12 SHOUSON HILL				
drawing title SECTIONS				
drawing no. NTHS1230/HC01/06		revision	scale AS SHOWN	
consulting engineer FUGRO (HONG KONG) LIMITED				
office LANDSLIP PREVENTIVE MEASURES DIVISION 3 GEOTECHNICAL ENGINEERING OFFICE				
CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT HONG KONG				
COPYRIGHT RESERVED				
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Status : P02				

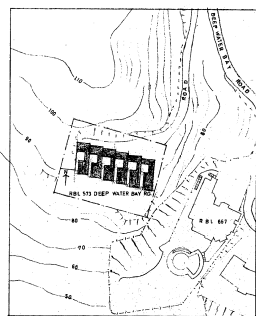
ORIGINAL PAPER SIZE: A1
PLOTTED BY : leon, 24 Jan 2014 - 12:04pm

Appendix C :

Buildings Department Record



FOOTING PLAN (black F)
1/100
(TYPICAL EXCEPT F-3 OF BLOCK A)



BLOCK PLAN 1/1000

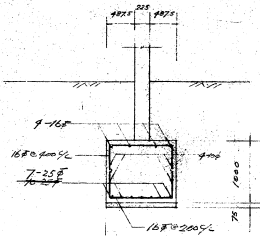
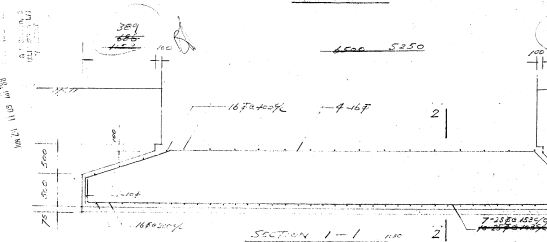
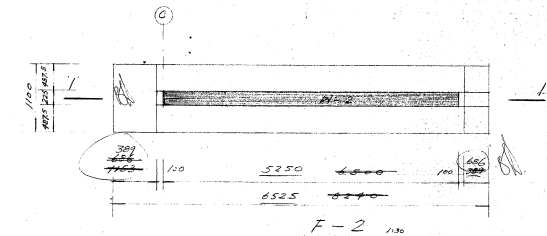
LOADING SCHEDULE

WALL MARK	WALL SIZE	DEAD LOAD		TOTAL LOAD		WIND LOAD			WIND LOAD		
		N _D KN	M _D KNM	N _{TOTL} KN	M _{TOTL} KNM	H _W KN	N _W KN	N _W KNM	H _W KN	N _W KN	M _W KNM
N-1	205 x 900	1332.2	18.0	1332.2	18.0	108.58	1203.74	7.108	38.31	—	277
N-2	205 x 3350	1677.5	17.0	1677.5	17.0	188.69	1726.19	2.951	13.14	—	1562
N-3	205 x 1450	2883.3	21.0	2883.3	21.0	289.27	2448.33	1.870	23.74	—	3797

WALL MARK	WALL SIZE	D+L+N		D+L+N		30 D+N			30 D+N		
		N _{WIND} KN	M _{WIND} KNM	N _{WIND} KN	M _{WIND} KNM	H _W KN	N _{WIND} KN	N _{WIND} KNM	H _W KN	N _{WIND} KN	M _{WIND} KNM
N-1	205 x 900	1332.2	18.0	1332.2	18.0	108.58	1203.74	7.108	38.31	—	277
N-2	205 x 3350	1677.5	17.0	1677.5	17.0	188.69	1726.19	2.951	13.14	—	1562
N-3	205 x 1450	2883.3	21.0	2883.3	21.0	289.27	2448.33	1.870	23.74	—	3797

WALL MARK	WALL SIZE	DEAD LOAD		TOTAL LOAD		WIND LOAD			WIND LOAD		
		N _D KN	M _D KNM	N _{TOTL} KN	M _{TOTL} KNM	H _W KN	N _W KN	N _W KNM	H _W KN	N _W KN	M _W KNM
N-3 + N-1	205 x 900	1332.2	18.0	1332.2	18.0	378.85	2726.19	2.951	288.15	—	277

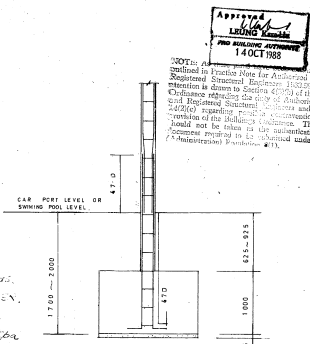
WALL MARK	WALL SIZE	D+L+N		D+L+N		30 D+N			30 D+N		
		N _{WIND} KN	M _{WIND} KNM	N _{WIND} KN	M _{WIND} KNM	H _W KN	N _{WIND} KN	N _{WIND} KNM	H _W KN	N _{WIND} KN	M _{WIND} KNM
N-3 + N-1	205 x 900	1332.2	18.0	1332.2	18.0	378.85	2726.19	2.951	288.15	—	277



SECTION 2-2 1/30

NOTES:

1. CONC. MIX: 1:2:4 (GRADE III) TO BE USED FOR FOOTINGS.
2. COVER TO STEEL: 75mm
3. SAFE BEARING CAPACITY ON ROCK: 3000 KPa (ROCK RECOVERY MORE THAN 50% GRADE III OR BETTER, ROCK WITH NO ADVERSE JOINTS)
4. THE STABILITY OF THE EXISTING SLOPE DOWNHILL OF THE FOOTINGS SHALL BE INVESTIGATED SO AS TO ENSURE THAT THE STABILITY OF THE FOOTINGS WILL NOT BE IMPAIRED. A GEOTECHNICAL REPORT SHALL BE SUBMITTED TO BLD BEFORE THE COMMENCEMENT OF THE SUPERSTRUCTURE.



TYPICAL DETAILS FOR LEVEL BARS

B.O.D. REF. NO. 1304/87
F.S.D. REF. NO.

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1. REVISED 15-6-1988
2. F-2 K.M.F.

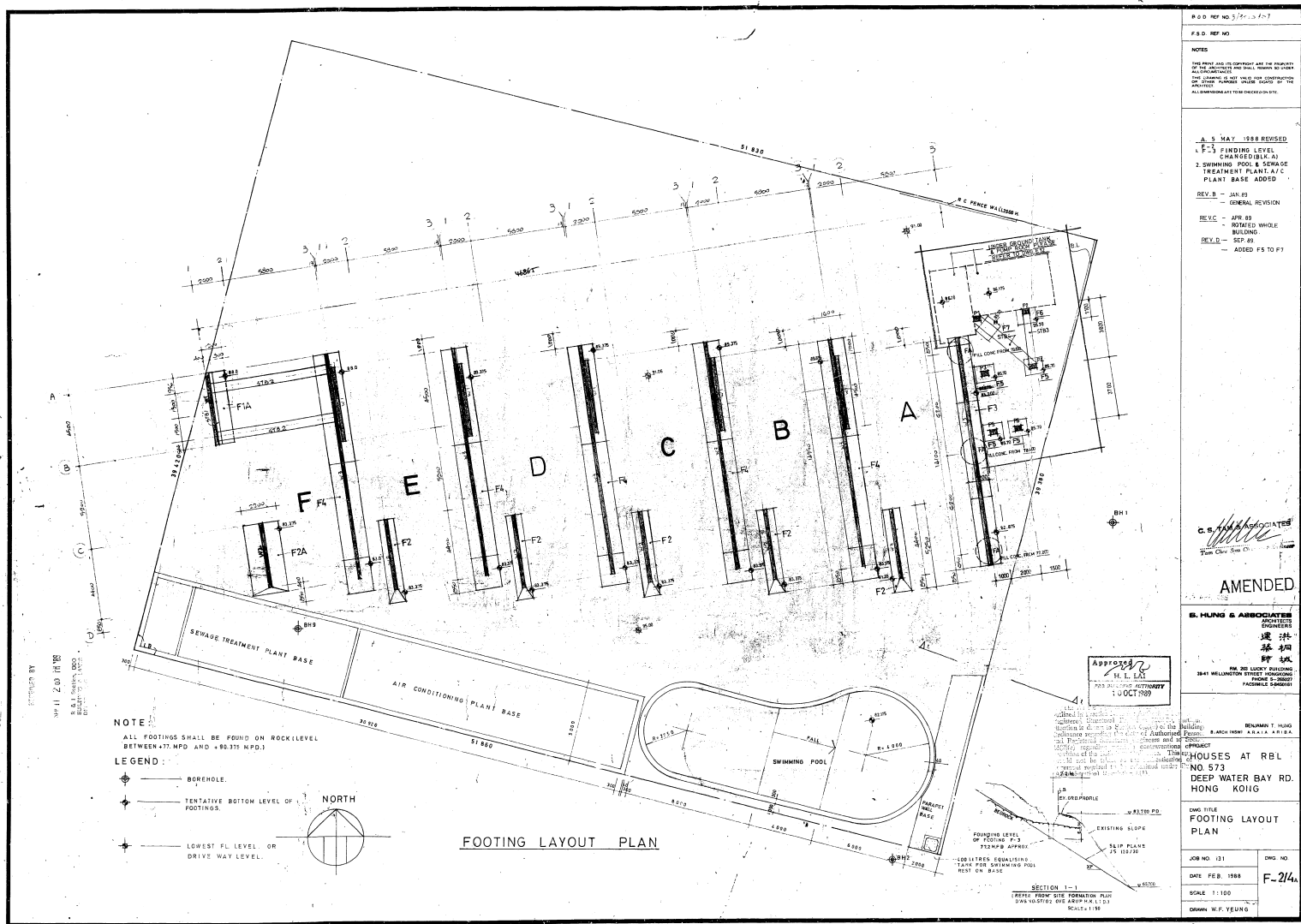
B. HUNG & ASSOCIATES
STRUCTURAL ENGINEERS
140CT1988

PROJECT:
HOUSES AT RBL
NO 573
DEEP WATER BAY RD.
HONG KONG

DWG. TITLE:
LOADING SCHEDULE
FOOTING PLAN &
DETAILS OF F-2

JOB NO. 131
DATE FEB 1988
SCALE 1:30
DRAWN BY F. YEUNG

F-1/4



P.O. REF NO. 3/10/10-7
 F.S.D. REF NO.

NOTES
 THE OWNER AND ITS CONTRACTOR ARE THE RESPONSIBLE FOR THE ACCURACY OF THE DATA, EXCEPT FOR THE DESIGN OF THE BUILDING. THE ENGINEER IS NOT RESPONSIBLE FOR THE CONSTRUCTION OF THE BUILDING. THE ENGINEER IS NOT RESPONSIBLE FOR THE CONSTRUCTION OF THE BUILDING. THE ENGINEER IS NOT RESPONSIBLE FOR THE CONSTRUCTION OF THE BUILDING.

A-3 MAY 1988 REVISED
 F-3 FINDING LEVEL
 1 SWIMMING POOL & SEWAGE TREATMENT PLANT A/C PLANT BASE ADDED

REV. B - JAN 82
 - GENERAL REVISION

REV. C - APR 83
 - ROTATED WHOLE BUILDING

REV. D - SEP 83
 - ADDED F5 TO F7

C.S. HUNG & ASSOCIATES
 ARCHITECTS
 1841 WILMINGTON STREET, HONG KONG

AMENDED

C.S. HUNG & ASSOCIATES
 ARCHITECTS
 1841 WILMINGTON STREET, HONG KONG

APPROVED
 M. L. LAY
 1003 JARDINE CIRCULAR
 10 OCT 1989

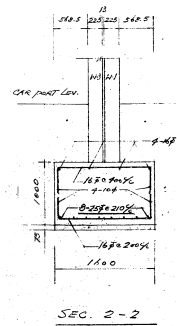
SEALING HOUSES AT RBL NO. 573 DEEP WATER BAY RD. HONG KONG

ENGINEER
 BENJAMIN T. HUNG
 8 ARCH STREET A.R.A. A.R.I.A. A.R.E.A.

DWG. TITLE
 FOOTING LAYOUT PLAN

JOB NO. 131
DATE FEB. 1988
SCALE 1:1000
DRAWN W.F. YEUNG

DWG. NO.
F-214



NOTE: As these plans have been examined and approved by the Building Department, the applicant is advised that the plans are in compliance with the Building Code of the City of New York. The applicant is advised that the plans are in compliance with the Building Code of the City of New York. The applicant is advised that the plans are in compliance with the Building Code of the City of New York.

B. HUNG & ASSOCIATES
ARCHITECTS
ENGINEERS

梁洪
建
桐
猷

RM. 203 LUCKY BUILDING
30-341 WELLINGTON STREET HONGKONG
PHONE 5-28827 FACSIMILE 5-835181

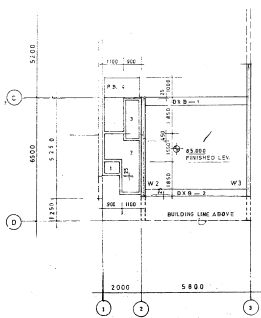
BHUNG

BENJAMIN T. HUNG
B. ARCH (HONG KONG) A.R.A. A.R.C.A.

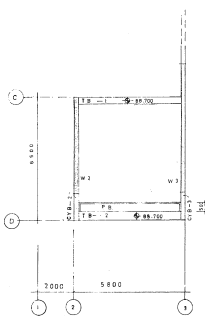
PROJECT
HOUSES AT RBL
NO.573
DEEP WATER BAY RD.
HONG KONG

DWG. TITLE
FOOTING FC-1
DETAILS

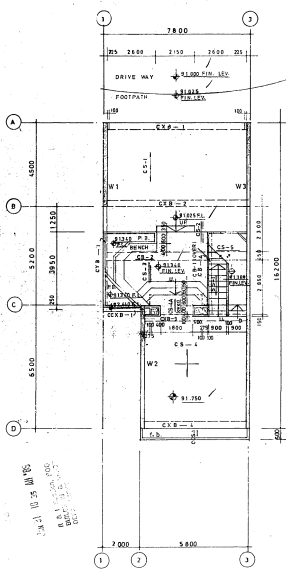
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DATE FEB 1988	
SCALE 1:30	
DRAWN W.F. YEUNG	



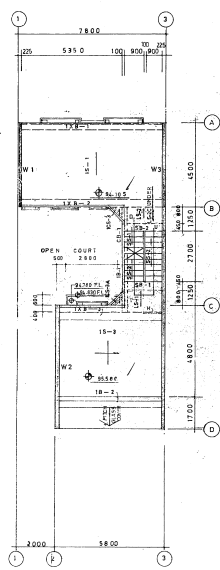
SWIMMING POOL FL. PLAN
BLOCK 8



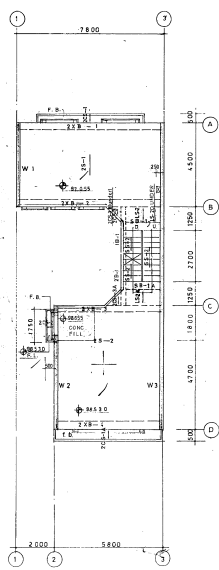
TIE BEAM PLAN



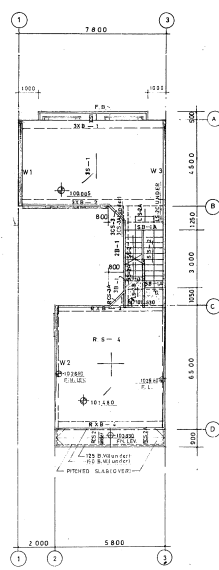
CAR PARK FLOOR PLAN



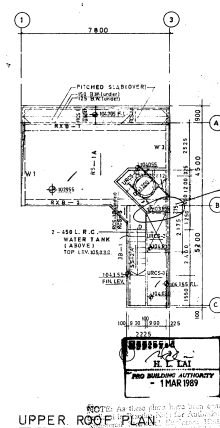
LEVEL 1 FLOOR PLAN



LEVEL 2 FLOOR PLAN

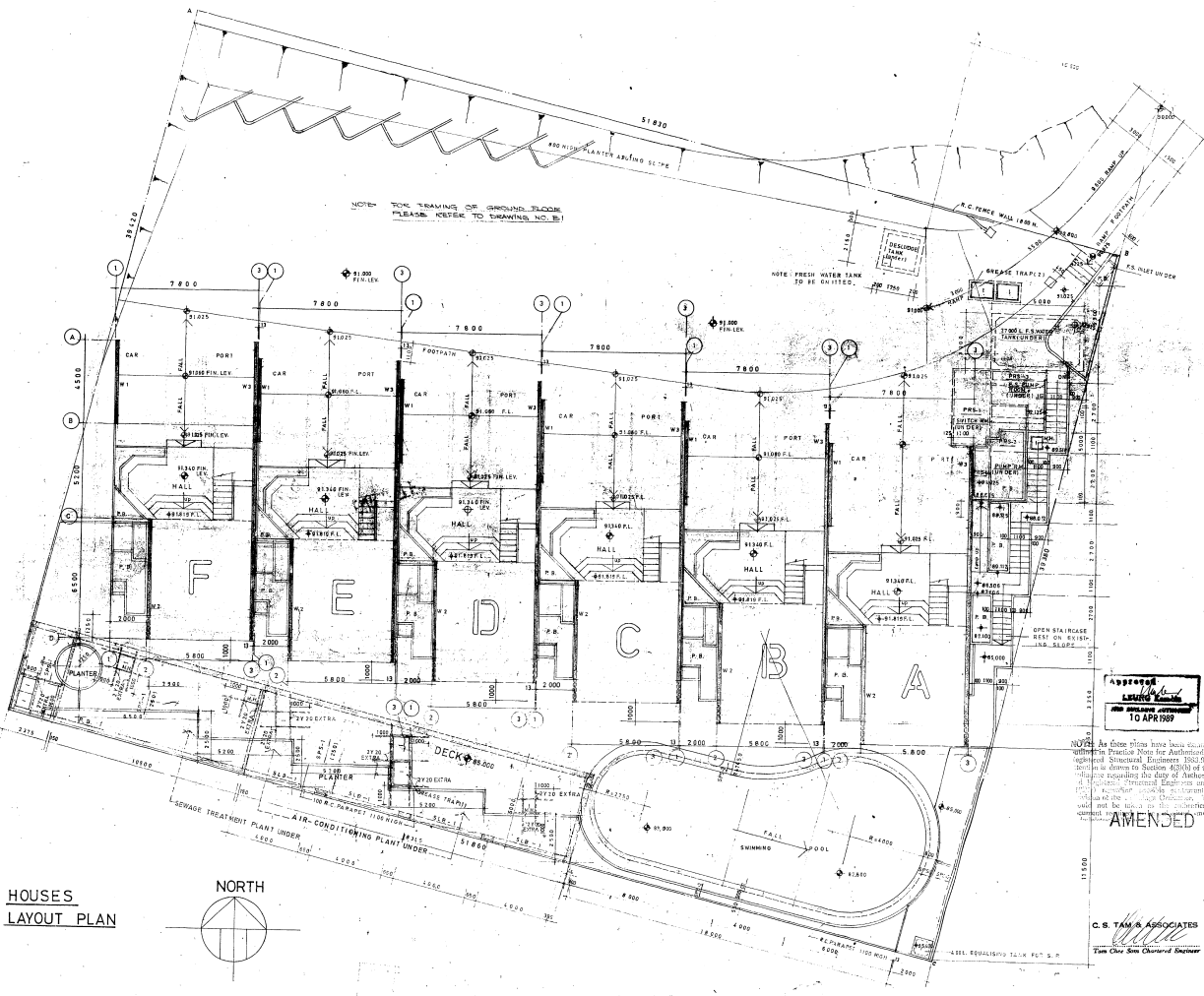


LEVEL 3 FLOOR PLAN

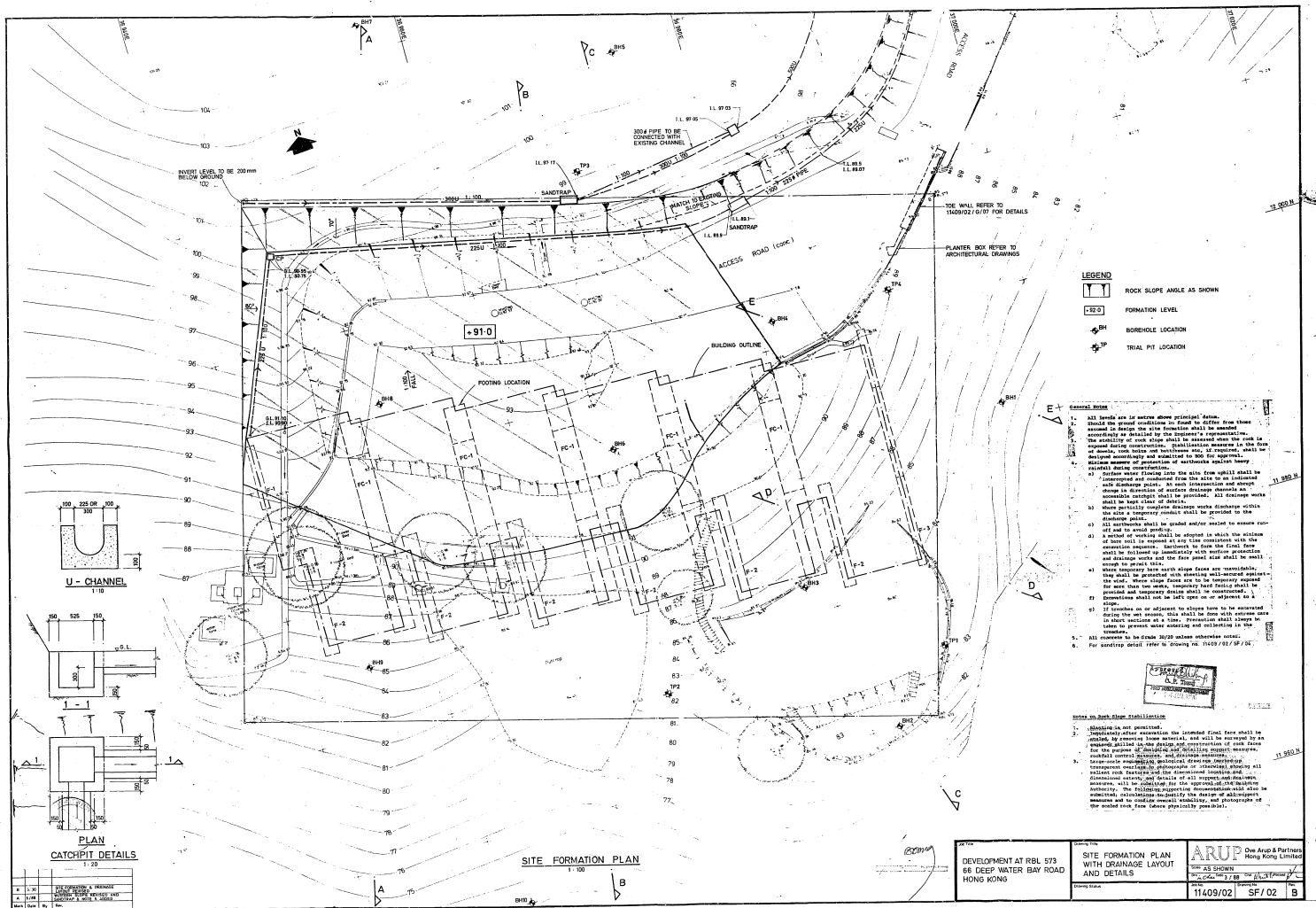


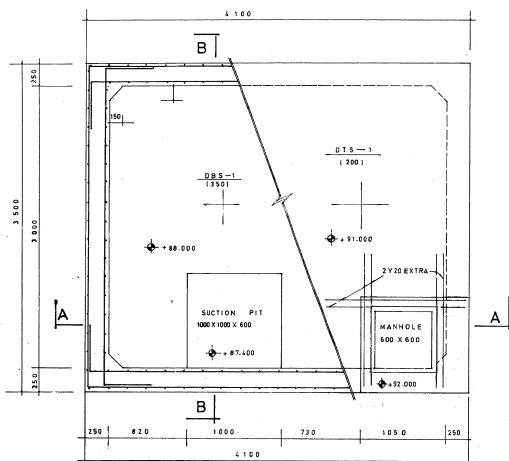
UPPER ROOF PLAN

S.D.D. REF. NO.	
F.S.D. REF. NO.	
NOTES	
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A. REVISED 15 JUNE 1984. 1. URCS-1 ~ URCS-3. 2. SS-24 A.D.D. 3. URCS-1 ~ URCS-10 P-1 P-2 TO BE OMITTED. 4. 2-450L. INSTEAD OF 1-900L. WATER TANK. 5. 1-100L. C.B.S. LOCATION CHANGED. 6. CS 3-55.5 LEV. CHANGED.	
B. REVISED 11 JAN 1989 1. ALL FLOOR LEVEL DECREASED BY 150. 2. IS-2 TO BE OMITTED.	
104055 B/L PLN	
B. HUNG & ASSOCIATES ARCHITECTS ENGINEERS STRUCTURAL BUILDING 100-41 WELLSINGTON STREET HONGKONG TEL. 9-282207-8 5-222208	
PROJECT HOUSES AT RBL NO. 573 DEEP WATER BAY RD HONG KONG	
DWG. TITLE FRAMING PLAN	
JOB NO. 131	DWG. NO.
DATE MAY 87	S-1
SCALE 1:100	
DESIGNER: B. HUNG	

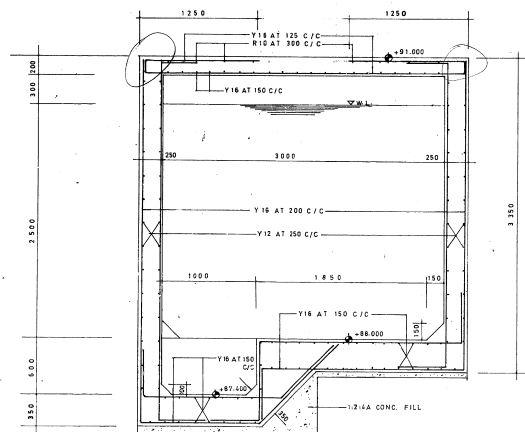


S.D. REF NO. 51	
F.S.D. REF NO.	
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ALL DIMENSIONS ARE TO BE CHECKED ON SITE.	
2. MAY 1988 REVISED "A"	
1. DECK PLAN ADD.	
2. SWIMMING POOL DIMENSION CHANGED.	
3. DESLIPPING PIT ADD.	
4. 37 M. WATER TANK ADD.	
5. PUMP ROOM ADD.	
2. JUNE 1988 REVISED "B"	
1. EQUALISING TANK ADD.	
3. DEC. 1988 REVISED "C"	
1. GREASE TRAPS (11/2) LOCATION.	
11. JAN 1989 REVISED "D"	
1. OPEN STAIRS.	
2. FOOT PATH & DRIVE WAY LEV.	
3. FLOODS LEV.	
5. DESLIPPING TANK.	
6. FRESH WATER TANK OMITTED.	
APPROVED LEUNG KAM TO APR 1989	
B. HUNG & ASSOCIATES ARCHITECTS ENGINEERS 建 洪 林 鋼 許 家	
NO. 208 LUCKY BUILDING 100 HONG KONG STREET HONG KONG PHONE 5-26607 FACSIMILE 5-26627	
AMENDED	
PROJECT HOUSES AT RBL NO. 573 DEEP WATER BAY RD. HONG KONG	
DWG. TITLE HOUSES LAYOUT PLAN	
C.S. TAM & ASSOCIATES Tim Chee Sam Chartered Engineer	
JOB NO. 131	
DATE FEB. 1988	
SCALE 1:100	
DRAWN BY P. YELING	
DWG. NO.	
S-3	
B	
C	



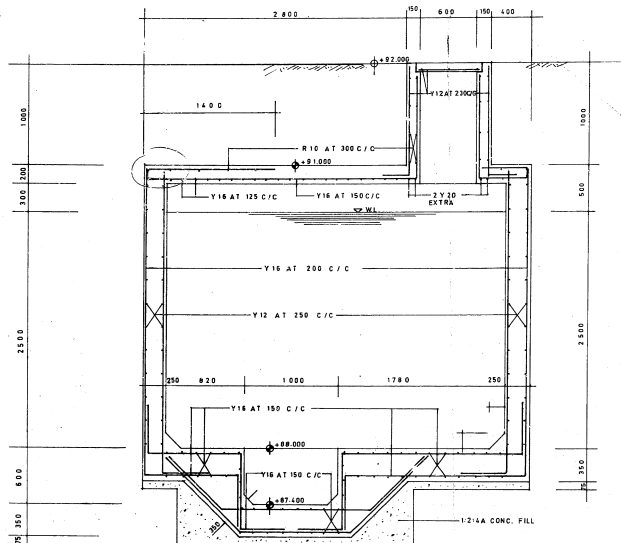


TOP & BOTTOM PLAN
27M WATER TANK
SCALE = 1:20

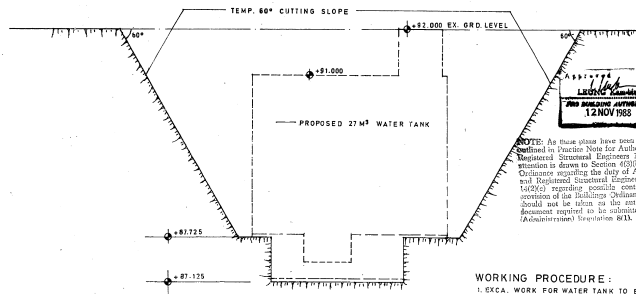


SECTION B - B
SCALE = 1:20

NOTE:
1. CONCRETE MIX FOR WATER TANK TO BE 1:1:2 GRADE (A).
2. COVER TO MAIN REINFORCEMENT—50 MM.



SECTION A - A
SCALE = 1:20



SHORING DETAILS
SCALE = 1:40

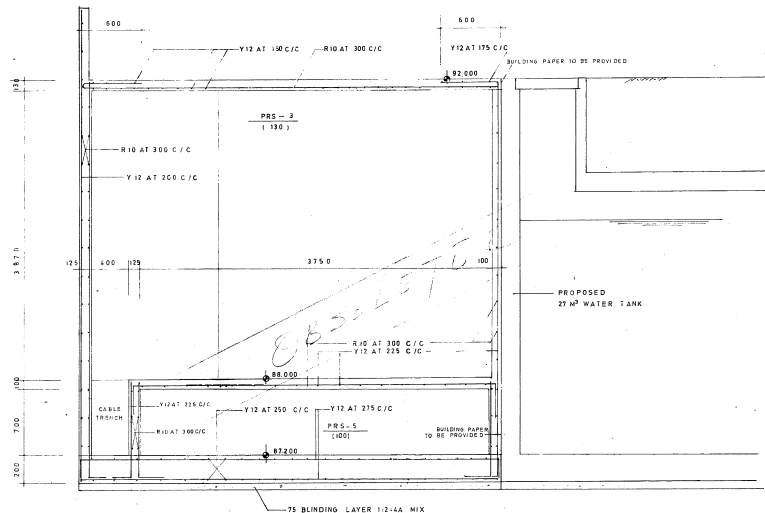
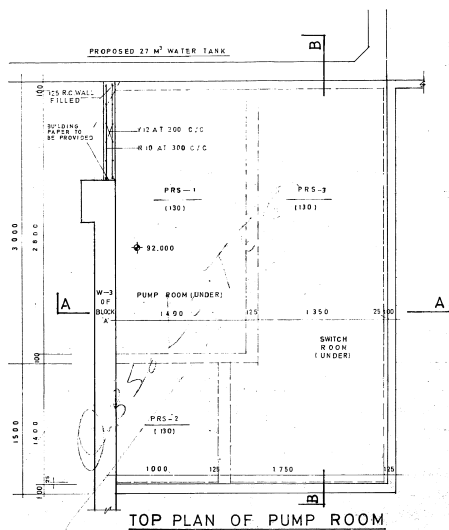
WORKING PROCEDURE:
1. EXCA. WORK FOR WATER TANK TO BE CARRIED OUT WITH A TEMPORARY 60° CUTTING SLOPE.
2. WHEN EXCA. TO THE REQUIRED LEVEL, CONSTRUCT THE WATER TANK IMMEDIATELY.
3. ANY BACK FILLING TO BE COMPACTED TO 95% COMPACTION.
4. AN EXPERIENCED PERSON WILL BE ON SITE TO SUPERVISE THE CONSTRUCTION OF WATER TANK.

R.O.D. REF. NO. 9/20/89
F.S.D. REF. NO.
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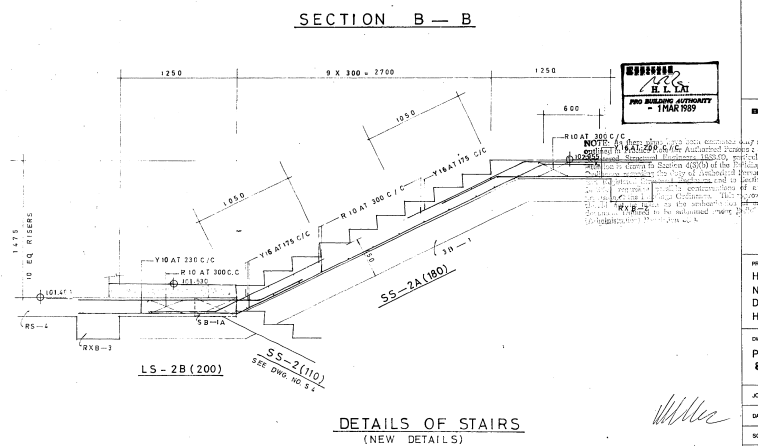
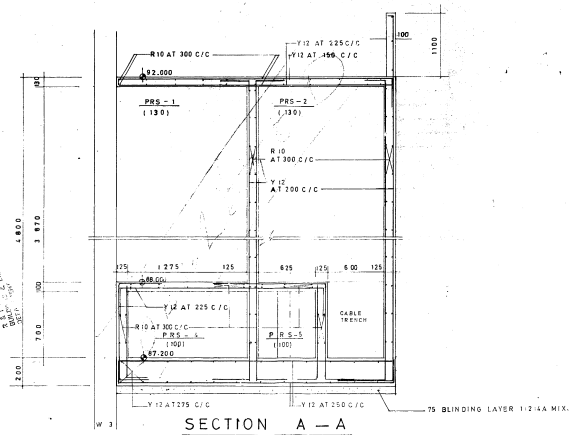
B. HUNG & ASSOCIATES
ARCHITECTS
ENGINEERS
1941 HELLINGTON STREET, WINGLOO, HONG KONG
TEL: 2522 1111
FAX: 2522 1111

ROUSES AT RBL
NO. 573
DEEP WATER BAY RD.
HONG KONG

DWG. TITLE
27M WATER TANK
& SHORING DETAILS
JOB NO. 121
DATE MAR. 1988
SCALE 1:20 1:40
DWG. NO. S 13
DRAWN BY F. YEUNG



NOTE:
CONCRETE MIX FOR PUMP ROOM TO BE 1:2:4



BDD REF NO

FSD REF NO 4

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A. REVISED 27-5-88

NEW STAIRS DETAILS AD

G. REVISED 11-1-89

LEVEL CHANGED.

B. HUNG & ASSOCIATES
ARCHITECTS
ENGINEERS

連洪
孫鋼
師凱

HW. 358 LUCKY BUILDING
29-41 WELLINGTON STREET HONGKONG
PHONE 5-369271
FACSIMILE 5-340511

BDM

BENJAMIN T. HUNG
5 ARCH (HONG KONG) & 5A, B, C, D, E

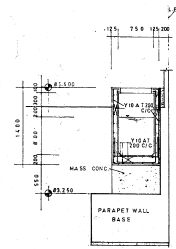
PROJECT
HOUSES AT RBL
NO. 573
DEEP WATER BAY RD
HONG KONG

DWG. TITLE	
PUMP ROOM PLAN & DETAILS	
JOB NO. 133	DWG. NO.
DATE APR. 1988	S14
SCALE 1:20	
DRAWN W.F. YEUNG	

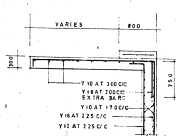
B.O.D. REF. NO. 3/31/87
F.E.D. REF. NO.

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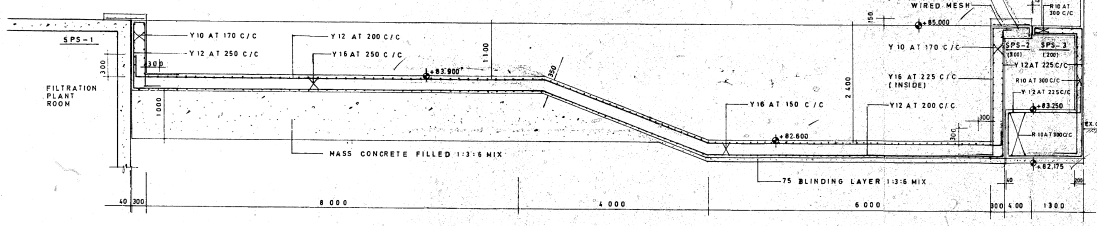
A. R. HUNG & ASSOCIATES
1. EQUALISING TANK FOR



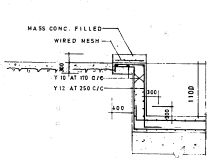
SECTION C - C
(DETAILS OF EQUALISING TANK)



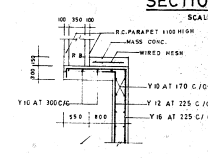
SEC. E - E



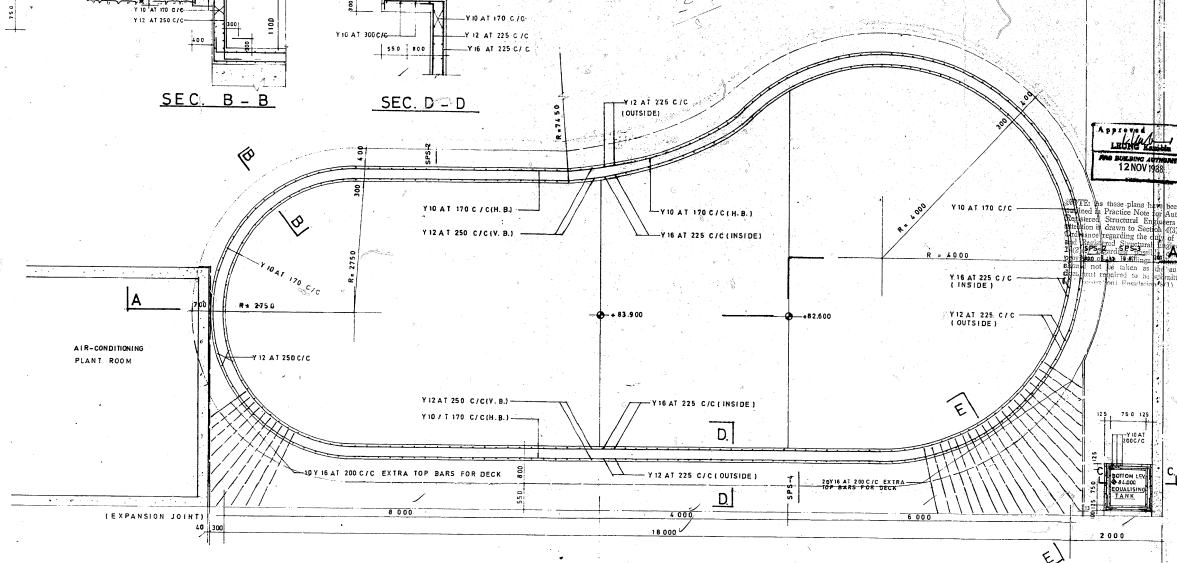
SECTION A - A
SCALE 1:40



SEC. B - B



SEC. D - D



SWIMMING POOL SECTIONAL PLAN
SCALE 1:40

- NOTES:
1. CONCRETE MIX FOR SWIMMING POOL TO BE 1:1:2 (GRADE 1A). REINFORCEMENT: R_{10} - 135 Mpa.
 2. COVER TO STEEL: 50mm FOR POOL ALL & BASE
15mm FOR POOL DECK
 3. ALLOWABLE SOIL BEARING CAPACITY UNDER THE SWIMMING POOL: 100 KN/m².

APPROVED
12 NOV 1988

Non-structural only as shown in Section A-A. Structural Engineer's approval is required for the use of the Building Code of Hong Kong (BCHK) and to Section 10 of the Building Ordinance (BO) and to Section 10 of the Building Ordinance (BO).

B. HUNG & ASSOCIATES
ARCHITECTS
ENGINEERS
28-31 WILKINSON STREET HONG KONG
PHONE 5-38877
FACSIMILE 5-38877

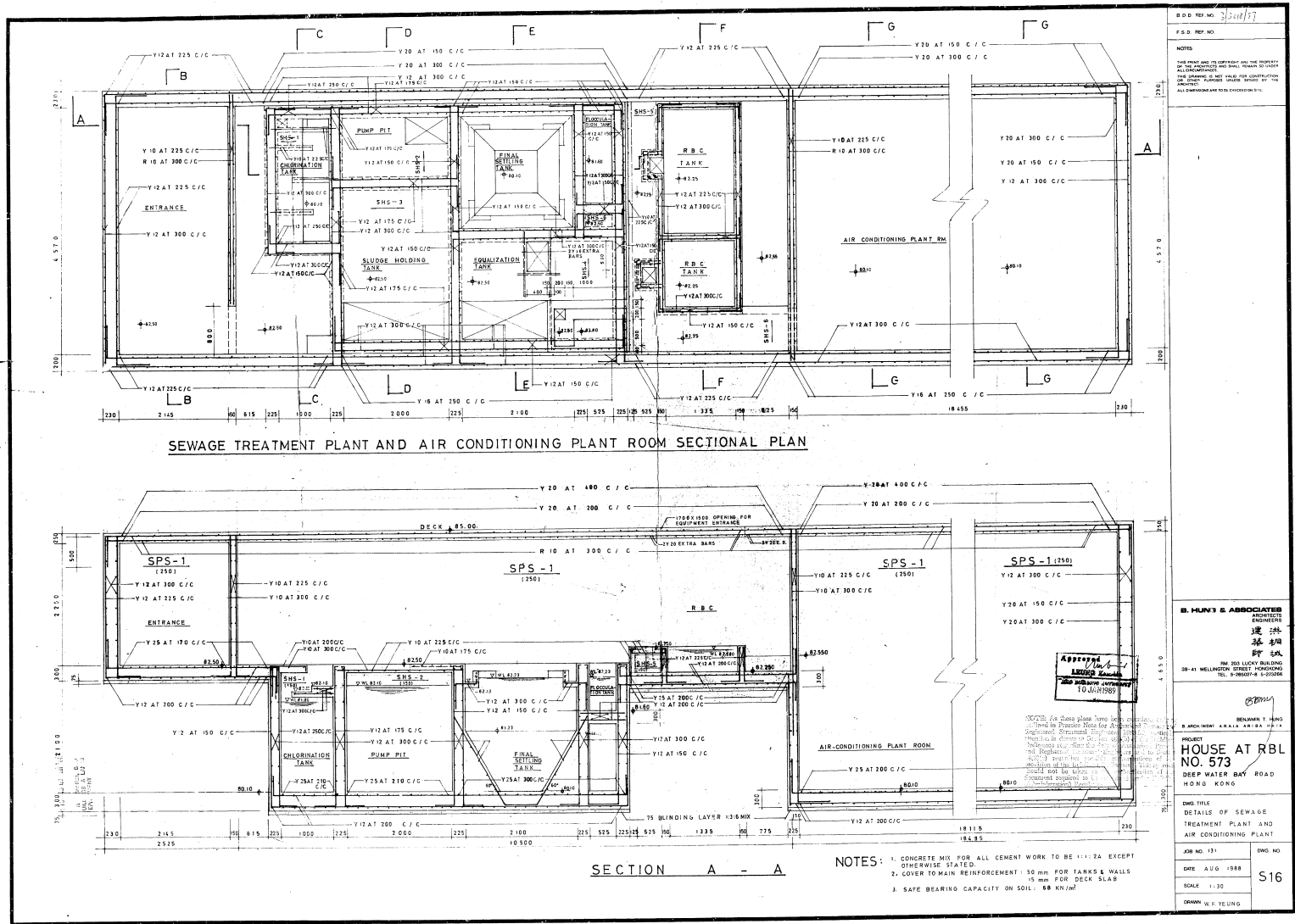
BENJAMIN T. HUNG
K. A. L. HUNG

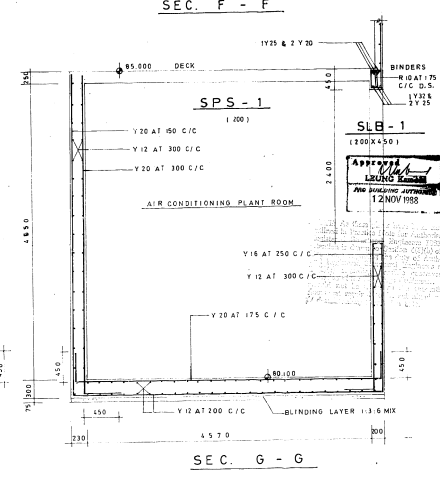
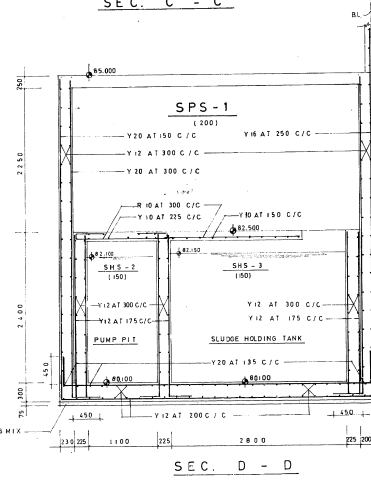
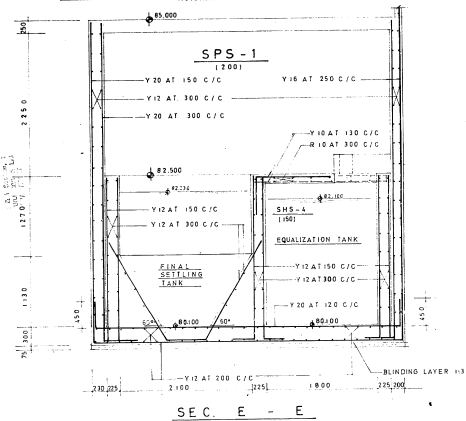
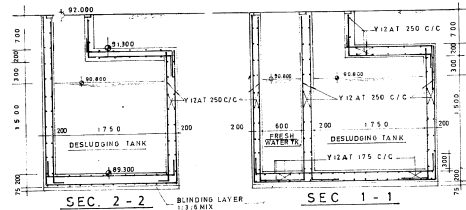
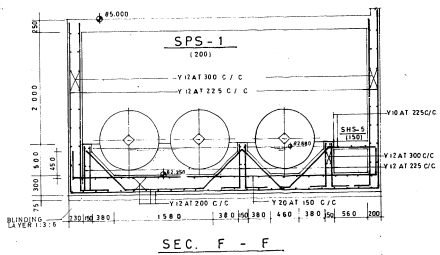
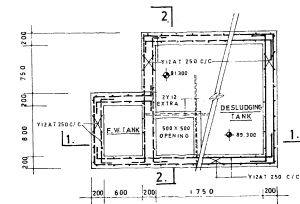
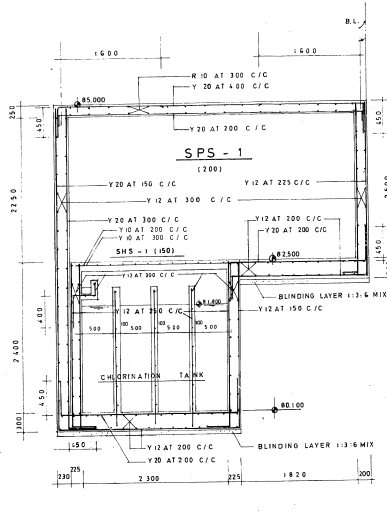
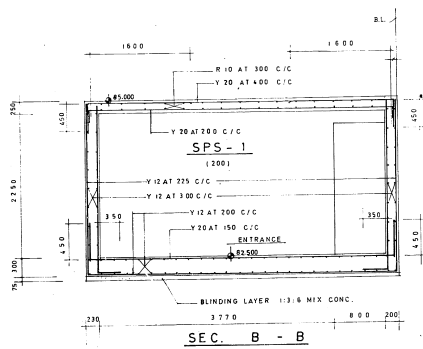
PROJECT:
HOUSES AT RBL
NO. 573
DEEP WATER BAY RD.
HONG KONG

DWG. TITLE
SWIMMING POOL

JOB NO. 131
DATE APR. 1988
SCALE 1:40
DRAWN W. F. YEUNG

S15.





S.D.C. REF. NO. 3/24/87
P.S.D. REF. NO.

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B. HUNG & ASSOCIATES
ENGINEERS
ARCHITECTS
STRUCTURAL ENGINEERS
MECHANICAL ENGINEERS
ELECTRICAL ENGINEERS
12 NOV 1988

PROJECT
HOUSES AT RBL
NO. 573
DEEP WATER BAY
R.D. HONG KONG

DWG. TITLE
DETAILS OF SEWAGE TREAT-
MENT PLANT & A/C PLANT
DETAILS OF DESLEUDGING
TANK

JOB NO. (31)
DATE: AUG. 1988
SCALE: 1:30
DRAWN: W. YEUNG

DWG. NO.
S17

SECTION A - A

SECTION B-B

SECTION C - C

SECTIONAL PLAN OF
GREASE TRAP (1)

SECTION D - D

SECTIONAL PLAN OF
GREASE TRAP (2)

TYPICAL DETAILS OF MANHOLE HANGED UNDER DECK

TYPICAL DETAILS OF MANHOLE

NOTES:

1. CONCRETE MIX FOR GREASE TRAPS AND MANHOLES TO BE USED 1:2:4, EXCEPT OTHERWISE STATED.
2. ALL REINFORCEMENTS TO BE HIGH TENSILE STEEL COMPLYING WITH B.S. 4449.
3. COVER TO MAIN REINF. TO BE 50 mm.
4. LOCATION OF GREASE TRAPS AND MANHOLES TO BE REFER TO DRAINAGE PLANS DWG. NOS. DR-1, DR-2, AND DR-6.

NOTE: As these plans have been cancelled,
I am advised by Practice Note for Authorized Persons
Registered Structural Engineers 1883B, that
attention is drawn to Section 403(6) of the Building
Ordinance regarding the duty of Authorized
Persons Registered Structural Engineers and
Architects to ensure compliance with the provisions
of the Building Ordinance. This approval
should not be taken as the substantiation of any
document required to be submitted under Building

B ARCH INSTRU AGAIN ARCHA

PROJECT

HOUSES AT RBL
NO 573. 66 DEEP
WATER BAY RD.

DWG. TITLE
STRUCTURAL DETAILS FOR
GREASE TRAPS AND MAN-
HOLES

JOB NO. 731	DWG NO.
DATE NOV. 1986	S 18
SCALE 1:20	
DRAWN W. F. YEUNG	

B O D REF NO. 3/200187

F S D REF NO

NOTES

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NEW DRAWING

B. HUNG & ASSOCIATES
ARCHITECTS
ENGINEERS
運洪
慕桐
師城
RM. 205 LUCKY BUILDING
30-41 WELLINGTON STREET HONGKONG
PHONE 5-265027
FACSIMILE 5-0490161

PROJECT
HOUSES AT RBL
NO. 573.66 DEEP
WATER BAY RD.

DWG. TITLE
STRUCTURAL DETAILS FOR
GREASE TRAPS AND MAN-
HOLES

JOB NO. 731	DWG NO.
DATE NOV. 1986	S 18
SCALE 1:20	
DRAWN W. F. YEUNG	

Appendix D :
Available Ground Investigation
Records

DRILLHOLE RECORD

JOB NO. 1007
HOLE NO. BH-2
SHEET 1 of 2
DATE from 21.11.87 to 23.11.87

PROJECT Deep Water Bay Road Development
R.B.L. No. 573, Hong Kong

METHOD Rotary

CO-ORDINATES

MACHINE & NO.

E 836982
N 811970

ROCK COREBIT T2, TNW

HOLE DIA. 114mm

FLUSHING MEDIUM Water

ORIENTATION Vertical

GROUND LEVEL 83.11 mPD

Drilling Progress	Casing depth/size	Water level/time/date	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m.)	Legend	Grade	Zone	Description
21/11	H										0.00				Loose, dark brown, fine to coarse SAND (TOP SOIL)
				50	0				T2	82.63	0.48				GRAVEL sized fragment of moderately to highly decomposed volcanics
								N=33	1	82.44	0.67				Dense, grey, silty fine SAND (Completely Decomposed VOLCANICS)
	2.60 H			0	0				2	80.91	2.20				GRAVEL sized fragment of moderately to highly decomposed volcanics
				40	0				T2	80.51	2.45				Strong, grey, fine grained, Slightly Decomposed VOLCANICS
											2.60				Weathered SEAM of highly decomposed volcanics (NO SAMPLE)
				95	77	53	6				3.00				
				78	56	56	4				3.76				
				0	0						4.00				
				100	100	76	4				4.20				
											4.45				
				100	100	76	4				5.00				
											5.24				
				100	100	95	3				6.00				
											6.79				
21/11 at 18:00				96	96	67	5				7.00				Strong, grey, fine grained, Slightly Decomposed VOLCANICS, closely spaced joints with limonite stains and kooline infilling, dip 60°-70° and 20°-30°
23/11 at 8:00				100	50	50	12				7.80				
				100	100	91	4				8.04				
											8.98				
23/11				100	100	74	5				10.00				

- Small disturbed sample
- Large disturbed sample
- SPT liner sample
- U76 undisturbed sample
- U100 undisturbed sample
- Mazier sample
- P/S Piston sample
- Water sample
- Water Level
- Standard penetration test
- Permeability test
- Piezometer tip
- In-situ vane shear test

LOGGED O.F.Fung
DATE 24.11/87
CHECKED [Signature]
DATE 26.11.87

REMARKS

1. Installed a standpipe to depth 10.20m

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DRILLHOLE RECORD		JOB NO. <u>1007</u>	
		HOLE NO. <u>BH-2</u>	
		SHEET <u>2</u> of <u>2</u>	
		DATE from <u>21.11.87</u> to <u>23.11.87</u>	
PROJECT <u>Deep Water Bay Road Development</u> <u>R.B.L. No. 573, Hong Kong</u>			
METHOD <u>Rotary</u>		CO-ORDINATES	
MACHINE & NO.		E 836982 N 811970 <i>15NW5B1</i>	
FLUSHING MEDIUM <u>Water</u>		ORIENTATION <u>Vertical</u>	
		ROCK COREBIT <u>T2, TNW</u>	
		HOLE DIA. ^H <u>114mm</u>	
		GROUND LEVEL <u>83.11 mPD</u>	

Drilling Progress	Casing depth/size	Water level/time/date	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m.)	Legend	Grade	Zone	Description
23/11		3.20m at 18:00		100	100	74	5		TNW	72.69	10.00 10.42	✓	II		See sheet 1 of 2
											11.00 12.00 13.00 14.00 15.00 16.00 17.00 18.00 19.00 20.00				End of investigation hole at 10.42m
<i>kra</i> <i>e</i>															

• Small disturbed sample • Large disturbed sample ▨ SPT liner sample ■ U76 undisturbed sample ■ U100 undisturbed sample ▨ Mazler sample - P/S Piston sample	▲ Water sample ⊥ Water Level ↓ Standard penetration test ⊞ Permeability test ⊞ Piezometer Up ✓ In-situ vane shear test	LOGGED <u>O.F.Fung</u> DATE <u>24.11.87</u> CHECKED <u>[Signature]</u> DATE <u>26.11.87</u>
REMARKS		

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DRILLHOLE RECORD

JOB NO. 1007
HOLE NO. BH-3
SHEET 1 of 1
DATE from 19.11.87 to 20.11.87

PROJECT Deep Water Bay Road Development
R.B.L. No. 573, Hong Kong

METHOD Rotary

CO-ORDINATES

ROCK COREBIT T2, TNW

MACHINE & NO.

E 836978
N 811983

HOLE DIA. H
114mm

FLUSHING MEDIUM Water

ORIENTATION Vertical

GROUND LEVEL 84.66 mPD

Drilling Progress	Casing depth/size	Water level/time/date	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.O.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m.)	Legend	Grade	Zone	Description
19/11	H										0.00				Loose, dark brown, fine to coarse SAND (TOP SOIL)
				50	6				T2	84.09	0.57				GRAVEL sized fragment of moderately decomposed volcanics with silty sand
								N=12	1	83.69	0.97				
				85					2		2.00				Medium dense, grey and yellowish brown, silty fine to medium SAND
								N=11	3	81.10	3.56				(Completely Decomposed VOLCANICS)
	3.56 H			100	78	54	6		T2		4.04				
				100	91	65	5				5.00				
19/11		1.50m at 18:00		100	100	60	6				5.43				
20/11		2.00m at 8:00		100	100	78	6				6.00				Strong, grey, fine grained, Slightly Decomposed VOLCANICS, closely spaced joints with limonite stains and kaoline infilling, dip 60°-70° and 20°-30°
				100	100	80	6				6.34				
				100	100	78	5				7.00				
											7.84				
											8.00				
											8.43				
											9.00				
20/11		2.50m at 18:00									9.62				
											10.00				End of investigation hole at 9.62m

- Small disturbed sample
- Large disturbed sample
- SPT liner sample
- U76 undisturbed sample
- U100 undisturbed sample
- Mazler sample
- P/S Piston sample
- ▲ Water sample
- ▼ Water Level
- ▼ Standard penetration test
- ▼ Permeability test
- ▲ Piezometer tip
- ▼ In-situ vane shear test

LOGGED O.F.Fung
DATE 23.11.87
CHECKED [Signature]
DATE 25.11.87

REMARKS
1. Installed a standpipe to depth 9.30m

Lam Geotechnics Limited

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DRILLHOLE RECORD

JOB NO. 1007
HOLE NO. BH-4
SHEET 1 of 1
DATE from 22.10.87 to 26.10.87

PROJECT Deep Water Bay Road Development
R.B.L. No. 573, Hong Kong

METHOD Rotary

CO-ORDINATES

E 836981
N 812002

ROCK COREBIT T2, TNW

MACHINE & NO.

HOLE DIA. H to N
114mm to 89mm

FLUSHING MEDIUM Water

ORIENTATION Vertical

GROUND LEVEL 91.08 mPD

Drilling Progress	Casing depth/size	Water level/time/date	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m.)	Legend	Grade	Zone	Description
23/10	H			100	0						0.00				GRAVEL and COBBLE sized fragment of concrete and brick
				92	0						0.50				
23/10	H	1.10 nil at 18:00								90.08	1.00				
24/10	N	2.25 nil at 8:00		97	65	0	*				1.10				
											2.00				
											2.25				
				100	80	49	5				3.00				
											3.20				
				100	81	40	5				4.00				
											4.35				
				100	100	44	8				5.00				
24/10		3.50m at 18:00								85.83	5.25				
26/10		4.05m at 8:00		100	100	63	8				6.00				
											6.45				
				100	100	66	4				7.00				
26/10										83.63	7.45				End of investigation hole at 7.45m
											8.00				
											9.00				
											10.00				

- Small disturbed sample
- Large disturbed sample
- ▨ SPT liner sample
- U76 undisturbed sample
- U100 undisturbed sample
- ▨ Nazler sample
- P/S Piston sample
- ▲ Water sample
- ▼ Water Level
- ▼ Standard penetration test
- ▼ Permeability test
- ▲ Piezometer tip
- ▼ In-situ vane shear test

LOGGED O.F.Fung
DATE 27.10.87
CHECKED
DATE 28.10.87

REMARKS
1. Installed a standpipe at depth 7.30m
2. *: Cannot be determined

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DRILLHOLE RECORD

JOB NO. 1007
HOLE NO. BH-5
SHEET 1 of 1
DATE from 12.11.87 to 20.11.87

PROJECT Deep Water Bay Road Development
R.B.L. No. 573, Hong Kong

METHOD Rotary

CO-ORDINATES

MACHINE & NO.

E 836975
N 812025

ROCK COREBIT T2, TNW

HOLE DIA.

FLUSHING MEDIUM Water

ORIENTATION Vertical

GROUND LEVEL 101.20 mPD

Drilling Progress	Casing depth/size	Water level/time/date	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m.)	Legend	Grade	Zone	Description
17/11				90	0				T2	100.70	0.00	0000	III		GRAVEL sized fragment of moderately decomposed volcanics
				100	72	34	*				0.50	0000			
				98	87	58	7				1.00	V V			
											1.80	V V			
											2.00	V V			
				100	100	84	5				3.00	V V			
											3.20	V			
				100	96	67	9		TNW		4.00	V V	II		Strong, grey, fine grained, Slightly Decomposed VOLCANICS, closely spaced joints with limonite stains, dip 20°-30° and 50°-60°
											4.55	V V			
				100	100	75	7				5.00	V V			
17/11		1.70m at 18:00		100	100	33	4				5.40	V V			
18/11		2.00m at 8:00		100	100	70	7				5.70	V V			
											6.00	V V			
18/11										94.50	6.70	V V			End of investigation hole at 6.70m
											7.00				
											8.00				
											9.00				
											10.00				

- Small disturbed sample
- Large disturbed sample
- ▨ SPT liner sample
- ▨ U76 undisturbed sample
- ▨ U100 undisturbed sample
- ▨ Mozier sample
- P/S Piston sample

- ▲ Water sample
- ≡ Water Level
- ↓ Standard penetration test
- ≡ Permeability test
- ▨ Piezometer tip
- V In-situ vane shear test

LOGGED O.F.Fung

DATE 23.11.87

CHECKED [Signature]

DATE 25.11.87

REMARKS

1. Installed a standpipe to depth 6.50m

2. *: Cannot be determined

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DRILLHOLE RECORD

JOB NO. 1007
HOLE NO. BH-6
SHEET 1 of 1
DATE from 30.10.87 to 6.11.87

PROJECT Deep Water Bay Road Development
R.B.L. No. 573, Hong Kong

METHOD Rotary

CO-ORDINATES

E 836967
N 811996

15NW5B1

ROCK COREBIT T2, TNW

MACHINE & NO.

HOLE DIA. H
114mm

FLUSHING MEDIUM Water

ORIENTATION Vertical

GROUND LEVEL 92.38 mPD

Drilling Progress	Casing depth/size	Water level/time/date	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m.)	Legend	Grade	Zone	Description
30/10	H 0.60 H			83	0				T2	91.78	0.00				GRAVEL and COBBLE sized fragment of concrete
				100	100	100	5				1.00				
				100	100	77	6				1.80				
		1.20m at 18:00		100	100	93	4			89.63	2.75				
30/10		1.40m at 8:00		100	100	86	5				3.00				
31/10		1.30m at 18:00		100	100	93	4				3.70				
		1.40m at 8:00		100	100	100	4				4.00				
31/10		1.20m at 18:00		100	100	100	5				4.70				
2/11		1.20m at 8:00		100	100	75	5				5.00				
2/11		1.50m at 18:00		100	100	100	5				5.43				
3/11		1.20m at 18:00		100	100	75	5				5.65				
4/11		1.70m at 8:00									6.00				
4/11		1.20m at 18:00									6.65				
		1.20m at 18:00									7.00				
											8.00				
											9.00				
											10.00				
• Small disturbed sample ▲ Water sample • Large disturbed sample ▼ Water Level ▨ SPT liner sample ↓ Standard penetration test ■ U76 undisturbed sample ▨ Permeability test ■ U100 undisturbed sample ▲ Piezometer tip ▨ Mazier sample ✓ In-situ vane shear test P/S Piston sample															LOGGED O.F.Fung DATE 7.11.87 CHECKED DATE 9.11.87 REMARKS 1. Installed a standpipe at depth 6.40m

Lam Geotechnics Limited

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DRILLHOLE RECORD				JOB NO. <u>1007</u>
				HOLE NO. <u>BH-7</u>
				SHEET <u>1</u> of <u>1</u>
				DATE from <u>19.11.87</u> to <u>23.11.87</u>
PROJECT <u>Deep Water Bay Road Development</u> <u>R.B.L. No. 573, Hong Kong</u>				
METHOD <u>Rotary</u>		CO-ORDINATES		ROCK COREBIT <u>T2, TNW</u>
MACHINE & NO.		E <u>836957</u> N <u>812032</u> <i>11SW 2507</i>		HOLE DIA. ^H <u>114mm</u>
FLUSHING MEDIUM <u>Water</u>		ORIENTATION <u>Vertical</u>		GROUND LEVEL <u>106.20 mPD</u>

Drilling Progress	Casing depth/size	Water level/time/date	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m.)	Legend	Grade	Zone	Description
20/11	H									06.00	0.20				Loose, brown, fine to coarse SAND (TOP SOIL)
				83	0				T2	05.70	0.50	800	III		GRAVEL sized fragment of moderately to highly decomposed volcanics
				100					1	1.00		x x x x	IV		Very dense, whitish grey, silty fine SAND
	2.00 H								2	04.20	2.00	x x x x	V / IV		(Completely to Highly Decomposed VOLCANICS)
		1.50m at 18:00		87	0					03.80	2.40	0000	III		GRAVEL sized fragment of moderately decomposed volcanics
20/11		2.00m at 8:00		100	50	0	12			2.80		✓			
21/11				100	86	29	10			3.00		✓			
				100						3.80		✓			
				100	89	65	7			4.00		✓			
				100						4.90		✓			
				92	70	28	12		TNW	5.90		✓	II		Strong, grey, fine grained, Slightly Decomposed VOLCANICS, closely spaced joints with limonite stains, dip 20°-30° and 60°-70°
				100	100	70	6			6.85		✓			
				100	100	91	8			7.00		✓			
				100						7.75		✓			
		2.50m at 18:00		100	100	100	3			8.00		✓			
21/11										97.75	8.45	✓			End of investigation hole at 8.45m
										9.00					
										10.00					

- Small disturbed sample
- Large disturbed sample
- ▨ SPT liner sample
- U76 undisturbed sample
- U100 undisturbed sample
- Mazier sample
- P/S Piston sample

- ▲ Water sample
- Y Water Level
- ↓ Standard penetration test
- ⊞ Permeability test
- ▲ Piezometer tip
- ✓ In-situ vane shear test

LOGGED O.F. Fung

DATE 24.11.87

CHECKED [Signature]

DATE 26.11.87

REMARKS

1. Installed a standpipe to depth 8.20m

Lam Geotechnics Limited

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DRILLHOLE RECORD				JOB NO. <u>1007</u>
				HOLE NO. <u>BH-8</u>
				SHEET <u>1</u> of <u>1</u>
				DATE from <u>27.10.87</u> to <u>31.10.87</u>
PROJECT <u>Deep Water Bay Road Development</u> <u>R.B.L. 573, Hong Kong</u>				
METHOD <u>Rotary</u>		CO-ORDINATES E <u>836951</u> N <u>812004</u> <i>11SWRS D7</i>		ROCK COREBIT <u>T2, TNW</u>
MACHINE & NO.				HOLE DIA. <u>H 114mm</u>
FLUSHING MEDIUM <u>Water</u>		ORIENTATION <u>Vertical</u>		GROUND LEVEL <u>93.07 mPD</u>

Drilling Progress	Casing depth/size	Water level/time/date	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.O.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m.)	Legend	Grade	Zone	Description
27/10	H 0.60 H			100	33				T2	92.92	0.15	△△△			CONCRETE SLAB
				100	0					92.72	0.30	○○○			GRAVEL sized fragment of concrete and brick
				100	60	30	8				1.00	✓	✓	II	Strong, light grey, fine grained, Slightly Decomposed VOLCANIC, closely spaced joints with limonite stains, dips mainly 60°-70°, occasionally 20°-30°
				100	100	60	5				1.70	✓	✓	II	
				100	100	60	5				2.00	✓	✓	II	
				100	100	60	5				2.80	✓	✓	II	
27/10 28/10		2.00m at 18:00 1.00m at 8:00		100	100	81	5		TNW	90.27	3.00	✓	✓		Strong, grey, fine grained, Slightly Decomposed VOLCANIC, closely spaced joints with limonite stains, dips mainly 60°-70°, some 20°-30°
				100	100	81	5				4.00	✓	✓	II	
				100	100	65	7				4.30	✓	✓	II	
				100	100	65	7				4.76	✓	✓	II	
28/10 29/10		1.80m at 18:00 1.70m at 8:00		100	92	61	8				5.00	✓	✓		End of investigation hole at 6.70m
				100	42	100	6				6.00	✓	✓		
				100	42	100	6				6.70	✓	✓		
29/10		2.00m at 18:00								86.37	7.00				
											8.00				
											9.00				
											10.00				

- | | |
|---|--|
| <ul style="list-style-type: none"> • Small disturbed sample • Large disturbed sample • SPT liner sample • U76 undisturbed sample • U100 undisturbed sample • Mazler sample P/S Piston sample | <ul style="list-style-type: none"> ▲ Water sample ▼ Water Level ↓ Standard penetration test ⊠ Permeability test ▲ Piezometer tip ✓ In-situ vane shear test |
|---|--|

LOGGED O.F. Fung
 DATE 2.11.87
 CHECKED [Signature]
 DATE 5.11.87

REMARKS
 1. Installed a standpipe at depth 6.50m

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DRILLHOLE RECORD

JOB NO. 1007
HOLE NO. BH-9
SHEET 1 of 2
DATE from 6.11.87 to 11.11.87

PROJECT Deep Water Bay Road Development
R.B.L. No. 573, Hong Kong

METHOD Rotary

CO-ORDINATES

ROCK COREBIT TNW

MACHINE & NO.

E 836945
N 811985

HOLE DIA. H
114mm

FLUSHING MEDIUM Water

ORIENTATION Vertical

GROUND LEVEL 85.38 mPD

Drilling Progress	Casing depth/size	Water level/time/date	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m.)	Legend	Grade	Zone	Description
6/11	H									85.08	0.00				GRAVEL and COBBLE sized fragment (FILL)
6/11		1.00m at 18:00		90				N=105	1		1.00				Very dense, grey and yellow, silty fine SAND relic texture preserve (Completely to Highly Decomposed VOLCANICS)
7/11		nil at 8:00							2		2.00				
									3		3.00				
				100				N=137	4		4.00				
									5		5.00				
									6		6.00				Moderately strong, grey and yellowish brown, fine grained, Moderately Decomposed VOLCANICS with highly decomposed volcanics
				100				N=177			7.00				
7/11		2.00m at 18:00		83	54	39	8			78.38	7.00				Strong, grey, fine grained, Slightly Decomposed VOLCANICS, closely spaced joints with limonite stains, dip 60°-70°, some 10°-30°
8/11		2.50m at 8:00								78.20	7.18				
		2.00m at 18:00		100	100	92	2				7.65				
8/11		2.00m at 18:00									8.00				
10/11		2.75m at 8:00		100	100	68	7				8.75				
10/11				100	100	55	4				9.00				
											9.65				
											10.00				

- Small disturbed sample
- Large disturbed sample
- SPT liner sample
- U76 undisturbed sample
- U100 undisturbed sample
- Mazier sample
- P/S Piston sample
- Water sample
- Water Level
- Standard penetration test
- Permeability test
- Piezometer tip
- In-situ vane shear test

LOGGED O.F.Fung
DATE 12.11.87
CHECKED
DATE 16.11.87

- REMARKS
1. Installed a piezometer at depth 6.80m
 2. *: Cannot be determined

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DRILLHOLE RECORD				JOB NO. <u>1007</u>	
				HOLE NO. <u>BH-9</u>	
				SHEET <u>2</u> of <u>2</u>	
				DATE from <u>6.11.87</u> to <u>11.11.87</u>	
PROJECT <u>Deep Water Bay Road Development</u> <u>R.B.L. No. 573, Hong Kong</u>					
METHOD <u>Rotary</u>		CO-ORDINATES		ROCK COREBIT <u>TNW</u>	
MACHINE & NO.		E <u>836945</u> N <u>811985</u> 15NW5B1		HOLE DIA. <u>H</u> <u>114mm</u>	
FLUSHING MEDIUM <u>Water</u>		ORIENTATION <u>Vertical</u>		GROUND LEVEL <u>85.38 mPD</u>	

Drilling Progress	Casing depth/size	Water level/time/date	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m.)	Legend	Grade	Zone	Description
10/11				100	100	55	4				10.00	✓			Strong, grey, fine grained, Slightly Decomposed VOLCANICS, closely spaced joints with limonite stains, dip 60°-70°, some 10°-30°
											11.05	✓			
10/11		2.20m at 18:00		100	100	88	6		TNW		11.85	✓	II		
11/11		4.50m at 8:00									12.00	✓			
				100	100	90	4				13.00	✓			
11/11										72.08	13.30	✓			End of investigation hole at 13.30m
											14.00				
											15.00				
											16.00				
											17.00				
											18.00				
											19.00				
											20.00				

- Small disturbed sample
- Large disturbed sample
- ▨ SPT liner sample
- U76 undisturbed sample
- U100 undisturbed sample
- ▨ Mazier sample
- P/S Piston sample

- ▲ Water sample
- ▼ Water Level
- ↓ Standard penetration test
- ▨ Permeability test
- ▲ Piezometer tip
- ✓ In-situ vane shear test

LOGGED O.F. Fung

DATE 12.11.87

CHECKED [Signature]

DATE 16.11.87

REMARKS

Krd
vt

Lam Geotechnics Limited

• Office: 2/F., 332 Lockhart Rd., Kai Kwong Comm. Bldg., Hong Kong. • Laboratory: G/F., 218 Wan Chai Rd., Hong Kong.
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DRILLHOLE RECORD				JOB NO. <u>1007</u>
				HOLE NO. <u>BH-10</u>
				SHEET <u>1</u> of <u>1</u>
				DATE from <u>19.11.87</u> to <u>23.11.87</u>
PROJECT <u>Deep Water Bay Road Development</u> <u>R.B.L. No. 573, Hong Kong</u>				
METHOD <u>Rotary</u>		CO-ORDINATES		ROCK COREBIT <u>TNW</u>
MACHINE & NO.		E <u>836952</u> N <u>811964</u> <i>15NW5B1</i>		HOLE DIA. ^H <u>114mm</u>
FLUSHING MEDIUM <u>Water</u>		ORIENTATION <u>Vertical</u>		GROUND LEVEL <u>71.48 mPD</u>

Drilling Progress	Casing depth/size	Water level/time/date	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m.)	Legend	Grade	Zone	Description
19/11	H										0.00				Dense, yellowish brown and grey, silty fine SAND (Completely Decomposed VOLCANIC) <i>15NW5B1</i>
				100					1		1.00	x			
									2		2.00	x			
19/11	H	2.90 at 18:00		90					3	78.36	2.90	x			
20/11		2.00m at 8:00		100	93	22	5				4.00	v			Strong, grey, fine grained, Slightly Decomposed VOLCANIC, closely spaced joints with limonite stains, dip 20°-30° and 60°-70° <i>15NW5B1</i> <i>VT</i>
20/11		3.00m at 18:00		100	100	50	20				4.40	v			
21/11		3.00m at 8:00		100	78	80	3				4.64	v			
				100							5.00	v			
				100	100	90	5				5.95	v			
				100	100	90	4				7.00	v			
				100	100	90	4				7.40	v			
				100	100	90	4				8.00	v			
				100	100	90	4				8.50	v			
21/11		4.00m at 18:00		100	100	100	1				9.02	v			End of investigation hole at 9.02m
											10.00				

- Small disturbed sample
- Large disturbed sample
- SPT liner sample
- U76 undisturbed sample
- U100 undisturbed sample
- Mazier sample
- P/S Piston sample

- ▲ Water sample
- ⌵ Water Level
- ↓ Standard penetration test
- ⊠ Permeability test
- ▲ Piezometer tip
- ✓ In-situ vane shear test

LOGGED O.F.Fung

DATE 24.11.87

CHECKED [Signature]

DATE 27.11.87

REMARKS

1. Installed a standpipe to depth 8.80m with filter aggregates from 2.90m to 9.02m

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