Appendix 9

GEOTECHNICAL PLANNING REVIEW REPORT

ARUP

The Hong Kong Jockey Club

Proposed Place of Recreation, Sports or Culture (Public Riding School) with Ancillary Facilities at Government Land in D.D. 233, The Restored Landfill Site (TKOL II/III) in TKO Area 105, Tseung Kwan O (GLA TSK-500 (Part))

Geotechnical Planning Review Report

Reference: REP-004-02

Rev 2| 30 January 2026

This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 304521

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1. Introduction

1.1 Project Description

1.1.1 This Geotechnical Planning Review Report is prepared in support of the Section 16 ("**S16**") Planning Application to allow for the development of a Public Riding School with ancillary facilities (e.g. utility trench) (collectively as the "**PRS**") at Government Land in D.D. 233, The Restored Landfill Site (TKOL II/III) in TKO Area 105, New Territories ("**TKOL II/III**") for the HKJC Public Riding Schools Limited (the "**Applicant**"). The Application Site comprises of three (3) existing platforms and land required for the provision of ancillary utility trench connecting to the three (3) platforms (collectively as the "**Application Site**") within TKOL II/III. The PRS aligns with the Government's policy objectives in fostering more public participation in the community through wider visibility and popularity of horse riding, supporting equestrian as an elite sport, and maintaining Hong Kong as a centre for major international sports events.

1.1.2 The Application Site is predominately zoned "Open Space" ("**O**") on the Approved Tseung Kwan O Outline Zoning Plan No. S/TKO/32 ("**Approved OZP**"), whilst a strip of area at the north is zoned "Green Belt" ("**GB**") and a minor portion abutting Chun Sing Street is zoned "Other Specified Uses" annotated "Industrial Estate" ("**OU(Industrial Estate)**") on the Approved OZP. The PRS with ancillary facilities ('Horse Riding School' subsumed under 'Place of Recreation, Sports or Culture' use) is a Column 2 use under the "O", "GB" and "OU(Industrial Estate)" zones that may be permitted with or without conditions on Application under S16 of the Town Planning Ordinance ("**TPO**"). There are no plot ratio ("**PR**"), building height ("**BH**"), and site coverage ("**SC**") restrictions imposed on the "O", "GB" and "OU(Industrial Estate)" zones of the Approved OZP. While a portion of TKOL II/III falls within the Clear Water Bay Country Park ("**CWBCP**"), the Application Site does not involve any areas falling within the Country Park Boundary.

1.1.3 The PRS is located on three (3) platforms, namely the Lower Platform (i.e. Reception and Hospitality Lounges) (approx.+6.0mPD), Middle Platform (i.e. Pony Paddock & Pavilion I)(approx. +40.0mPD) and Upper Platform (i.e. Horse Paddock & Pavilion II) (approx.140.0mPD), with a proposed total GFA of approx. 9,000m^2 and a proposed building height of 4.8m to 7.7m. An ancillary utility trench connecting to the three (3) platforms is also proposed to accommodate various essential utilities services in support of the PRS operations.

1.2 Purpose of this Report

1.2.1 The location of the Application Site and the indicative scheme for the proposed development is shown in **Figure 1.1** and **Figure 1.2** respectively.

1.2.2 This Geotechnical Planning Review Report provides the following assessment to support the planning application for the PRS:

- Summary of the available geotechnical information for the Application Site;
- Initial review of the geotechnical issues relating to the proposed development; and
- Proposed works and the corresponding impact on the existing slope features.

2. Site Description

2.1 TKOL II/III

2.1.1 TKOL II/III has a total area of about 40 hectares with the large level difference from approx. +5mPD up to approx. +140mPD. There are three relatively flat platforms (namely Upper Platform, Middle Platform and Lower Platform) at the elevation of approx. +140mPD, +40mPD and +6mPD respectively with about 43,700 m^2 which can be utilized for the PRS. The location of TKOL II/III is shown in **Figure 2.1**.

2.2 The Application Site

2.2.1 For the S16 application purpose, the Application Site in this report comprises of three (3) existing platforms and land required for the provision of ancillary utility trench connecting to the three (3) platforms within TKOL II/III. The extent of the Application Site is also shown in **Figure 2.1**.

2.2.2 The Application Site is surrounded by a number of existing registered man-made features, namely Feature Nos. 12SW-A/F67, 12SW-A/F68, 12SW-A/F69, 12SW-A/F70, 12SW-A/F72, 12SW-A/F73, 12SW-A/F74, 12SW-A/F96, 12SW-A/C203, 12SW-A/C227, and 12SW-A/C228.

3. Geotechnical Review

3.1 Previous Natural Terrain Hazard Studies and Geotechnical Assessment

3.1.1 Two different studies were carried by EPD and HKJC separately in 2003/2004 and 2023 respectively for geotechnical review / natural terrain hazard study for any potential afteruse development. The aforementioned studies have been summarized in **Table 3-1** below and enclosed in **Appendix A**, **Appendix B** and **Appendix C** for reference.

Table 3-1 Summary of Previous Studies

Report Date	Report Title	Prepared By	Appendix No.
February 2003	Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development – Natural Terrain Hazard Assessment Report [Report No. 382311/NTHA/Revised Issue 2]	Binnie Black & Veatch Hong Kong Limited (under EPD)	Appendix A
January 2004	Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development – Final Geotechnical Assessment Report [Report No. 382311/FGAP/ Issue 1]	Binnie Black & Veatch Hong Kong Limited (under EPD)	Appendix B
January 2023	Natural Terrain Hazard Study Report for the Proposed Development of New Public riding School at the Restored Tseung Kwan O Stage II/III Landfill (TKOL II/III)	Modern Consulting Engineers Limited (under HKJC)	Appendix C

3.2 Desk Study

3.2.1 A desk study has been carried out to support the geotechnical appraisal. The desk study included a review of the general site history through aerial photograph interpretation (API); the checking of the condition and engineering status of the existing registered man-made features within and adjacent to the Application Site; gathering and review of existing ground investigation (GI) records; and a review of topographic conditions to determine the need (or otherwise) for further assessment of natural terrain hazards. The API refer to the previous study carried out by Modern Consulting Engineers Limited in January 2023 (Modern, 2023) is extracted and enclosed in **Appendix D** for natural terrain hazard assessment. All salient geological features, hydrology, change of land use, past instability, ground condition and any potential geological or landslide problems have been identified and documented within this.

3.3 Published Geology

3.3.1 The Application Site is covered by the following geological publication and references:-

- Hong Kong Geological Survey Sheet 12 (1:20,000) “Solid and Superficial Geology for Hong Kong and Kowloon (1989);
- Hong Kong Geological Survey Memoir No. 4 (1990);
- Geological Area Studies Programme VII – Clear Water Bay (1988);

- The Pre-Quaternary Geology of Hong Kong, with the 1:100 000 Geological Map of Hong Kong (2000); and
- The Quaternary Geology of Hong Kong (2000).

3.4 Solid and Structural Geology

3.4.1 The published 1:20,000 scale solid and superficial map sheet no. 12 (GEO, 1989), and the published 1:100,000 scale geological map indicate that the solid geology of the Upper Platform is dominated by the Trachydacite lava of the Ta Miu Wan Member of the Clear Water Bay Formation (Jmw), with the minor northeastern-most portion falls within the fine ash Tuff of the Clear Water Bay Formation (fa). Whilst for the Middle and Lower Platform, only limited extent of solid geology of tuffaceous mudstone, siltstone and breccia of Jurassic Mang Kung Uk Formation (JMK) are recorded near the boundary.

3.4.2 The major structural features recorded in the published geological maps consist of three (3) nos. of NW-SE trending faults situated to the southeast of TKOL II/III. A NE-SW trending fault is also recorded around 25m to the southwest of the Middle Platform. Fractured fault materials and deepening of rockhead could be encountered near the recorded faults.

3.5 Superficial Geology

3.5.1 According to the published 1:20,000 scale geological map, extensive quaternary marine mud (QHH) with fill is recorded at the Lower Platform, with minor extent of marine sand (ms) is recorded at the northern tip of the Lower Platform. The Middle Platform is situated within a variety of quaternary superficial deposits, consisting of alluvium (Qa), beach deposits (Qb), marine sand (ms) and debris flow deposits (Qd). Whilst only a minor portion of the Upper Platform consists of superficial deposits of debris flow deposits (Qd).

3.5.2 In addition to the published geology, as the Application Site was used for landfill purpose from 1988 to 1994; majority of the Application Site was underlain by the waste fill materials, comprising mixed domestic, commercial, construction and special wastes. A capping layer had been constructed on top of the landfills after the completion of the operation of the landfill in 1994.

3.6 Existing Ground Investigation Data

3.6.1 Existing Ground Investigation (GI) information for the proposed works' boundary has been retrieved from the Geotechnical Information Unit (GIU), Geotechnical Engineering Office (GEO) of CEDD. The previous investigations conducted in the vicinity of TKOL II/III are summarized in **Table 3-1** below and shown in **Figure 3.2**.

GIU Ref.	Year	Contractor	Report Title
05396	1984	Gammon (Hong Kong) Limited	Junk Bay Controlled Tip, Stages II & III, Phase I & II Site Investigation Report
05553	1984	Gammon (Hong Kong) Limited	Junk Bay Controlled Tip Stage II Site Investigation Report
05554	1984	Gammon (Hong Kong) Limited	Junk Bay Controlled Tip Stage I Site Investigation Report
06641	1985	Gammon (Hong Kong) Limited	Junk Bay Controlled Additional Marine Site Investigation Report
12800	1990	Lam Geotechnics Limited	Junk Bay Landfill Stage II & III Site Investigation Report
18164	1993	Enpack (Hong Kong) Limited	Tseung Kwan O Landfill Stage II/III Slope Monitoring Works Final Report

GIU Ref.	Year	Contractor	Report Title
21370	1996	Geotechnics & Concrete Engineering (Hong Kong) LTD.	Restoration of Tseung Kwan O Landfills Provision of Monitoring Holes in Tseung Kwan O Stage II/III Landfill Ground Investigation Report
24046	1991	Gammon (Hong Kong) Limited	Project No. 5021 Dr Tseung Kwan O Landfill Stage III Phase I Geotechnical Submission - Borrow Area

3.6.2 Most of the GIs were completed prior to the construction of the TKOL II/III. As the TKOL II/III was carried out later than most of the exiting ground investigation, only limited GIs provides information on waste fill and capping fill thicknesses.

3.6.3 TKOL II/III was modelled by GI information extracted from GIU and supplemented by the as-built drawing nos. STG2/STE/DRW/001, 011 and 012/R and NDD/6235 to 6242 of the landfill site enclosed in **Appendix E**. From the information available, the landfill comprises approximately 1.35m thick fill capping layer overlaying the waste body. For the northeast part of TKOL II/III, the waste fill is mainly underlain by Completely/Highly Decomposed Volcanic rocks (C/HDV); while the southwest part of TKOL II/III, due to the historical reclamation works, marine mud and alluvium with limited thickness may be found below the waste fill.

3.7 Existing Man-made Features

3.7.1.1 A total of 5 nos registered man-made features that overlap or are in close proximity with the Application Site are recorded in the GEO Slope Information System (SIS). A summary of the feature registration numbers, responsible maintenance parties and current study status retrieved from the Landslip Prevention Measures Information System (LPMIS) for these features are provided in **Table 3-2**. The feature extent and locations are presented in **Figure 3.3.**

Table 3-3 Summary of Existing Features

Existing Feature	Maintenance	Maximum Height (m)	Length (m)	Average Angle (degree)
12SW-A/F67	EPD	32	440	20
12SW-A/F68	EPD	28	396	25
12SW-A/F70	EPD	20	210	20
12SW-A/F73	EPD	30	145	25
12SW-A/F96	EPD	8	200	35

The detail descriptions of the registered features are presented as follows:

3.7.2 Feature No. 12SW-A/F67

The feature is a southwestern-facing soil fill slope, located in the western portion of TKOL II/III. The slope portion is about 32m high with a slope angle of 20°.

The northern portion of the feature is overlapping with the Application Site at the lower platform. The southern portion of the feature is overlapping with the Application Site at the middle platform.

3.7.3 Feature No. 12SW-A/F68

The feature is a southwestern-facing soil fill slope, located in the western portion of TKOL II/III. The slope portion is about 28m high with a slope angle of 25°.

The southern portion of the feature is overlapping with the Application Site at the middle platform.

3.7.4 Feature No. 12SW-A/F70

The feature is a southwestern-facing soil fill slope, located in the western portion of TKOL II/III. The slope portion is about 20m high with a slope angle of 20°.

The southern portion of the feature is overlapping with the Application Site at the middle platform.

3.7.5 Feature No. 12SW-A/F73

The feature is a southwestern-facing soil cut slope, located in the eastern portion of TKOL II/III. The slope portion is about 30m high with a slope angle of 20°.

The northern portion of the feature is overlapping with the Application Site at the upper platform.

3.7.6 Feature No. 12SW-A/F96

The feature is a northeastern-facing soil fill slope, located in the eastern portion of TKOL II/III. The slope portion is about 8m high with a slope angle of 35°.

The feature is located along the edge of the Application Site at the middle platform.

3.8 Stage 2 Study Report

3.8.1 The GIU did not contain the record of any Stage 2 Study Report covering the features around TKOL II/III area likely due to Stage 2 Studies have not been carried out for those features as they were previously under the maintenance responsibility of the EPD.

4. Natural Terrain Hazard Study

4.1 Overview

4.1.1 The Natural Terrain Hazard Study (NTHS) has been looked at extensively in the previous studies that were done by Binnie Black & Veatch Hong Kong Limited (B&V) under EPD in 2003/2004 and Modern Consulting Engineers Limited (Modern) under HKJC in 2023. The NTHS was initially investigated by B&V in 2003 with a production of NTHS report (**Appendix A**); then in 2004, the NTHS was reviewed again by B&V in a Geotechnical Assessment Report (**Appendix B**), where a passive mitigation measure so called 'no-build zone' was introduced.

4.1.2 Subsequently in 2023, the NTHS done by B&V, as well as the proposed 'no-build zone', for the Upper Platform area was further reviewed and validated by Modern. The corresponding reports can be found in **Appendix C**. The report was approved by GEO and the approval memo dated 18 May 2023 is enclosed in **Appendix F**.

4.1.3 The three reports mentioned above covered the engineering geological assessment, natural terrain hazard review, natural terrain hazard assessment and hazard mitigation strategy in accordance with GEO SPR 1/2002 and GEO Report No. 138 (2nd Edition) respectively.

4.1.4 It should be noted that as discussed in Section 2.2 of the previous NTHS report by Modern in 2023, a natural terrain hazard screening had been carried out following the "In-principle Objection Criteria" and the "Alert Criteria" according to the GEO Report No. 138 2nd Edition, for the three (3) platforms (Lower Platform, Middle Platform and Upper Platform) at the PRS.

4.1.5 The screening result indicated that the measured angular elevations from the natural terrain catchments to the Lower and Middle Platforms range between 16^{o} and 18^{o}, which did not satisfy the alert criteria. As a result, the natural terrain hazard study is considered not required for these two (2) platforms. This screen result is considered to be still valid taking into account the current proposed development layout and location at Lower and Middle Platform.

4.2 Natural Terrain Hazard Assessment

4.2.1 The Design Event Approach (DEA) has been promulgated in both of the above-mentioned NTHS reports. This comprises the standard method for the assessment of natural terrain hazards and involves the classification of catchments as either Level 1 catchments suitable for the application of prescriptive mitigation measures or Level 2 catchments requiring measures to be designed through the determination of a Design Event volume, and the debris mobility modelling has been carried out to simulate the design event and the potential natural terrain hazard.

4.3 Natural Terrain Hazard Mitigation Strategy

4.3.1 Following the Geotechnical Assessment Report that were done by B&V in 2004, a 'no-build zone' was established for the Site as passive natural terrain hazard mitigation measure and was defined as one meter further away from the calculated debris run-distances, outside which no development will be affected by any potential natural terrain hazard. The proposed extent of the 'no-build zone' by B&V in 2004 can be found in **Figure 1.2**.

4.3.2 The NTHS report by Morden in 2023 had reviewed and validated this "No-build Zone" for the Upper Platform only, which was considered to be reasonable since the Middle and lower Platforms will not be affected by natural terrain hazard based on the initial screening.

4.3.3 Additionally, at the time of writing this report, a preliminary review on the previous studies has been carried out. The initial findings suggest that the 'no-build zone' was established in a reasonably conservative manner and is considered still valid for the purpose of current assessment.

4.3.4 As indicated in **Figure 1.2,** the entire Middle and Lower Platforms are located outside the 'no-build zone' and will not be affected by natural terrain hazard. However, it should be noted the 'no-build zone' encroaches slightly into the Upper Platform in the north and part of the proposed EVA/Driveway, ancillary E&M facillities, and wash box facilities located within the 'no-build zone'. The need to relocate or mitigate the EVA (e.g. concrete retaining wall), ancillary E&M facillities and wash box facilities shall be further reviewed at the later stage of the project, taking into account the GEO Report No. 138 (2nd Edition) requirement and the operational need of the project.

4.3.5 Additional, two (2) boulders within natural terrain area have also been recommended to be removed or in-situ stabilized as a precautionary measure based on the previous studies. This requirement should also be reviewed at the later stage.

5. Proposed Geotechnical Works

5.1 General

5.1.1 The Application Site area comprises three relatively flat platforms (namely Upper Platform, Middle Platform and Lower Platform) and are surrounded by mainly natural terrain and several registered features, where the slope angles range between 20 and 35 degrees. Minimal site formation works are expected within the three platforms as they have already been formed with fairly flat areas as part of the landfill site construction works.

5.1.2 The proposed excavation works will be limited to a depth of 500mm as requested by EPD to protect the LLDPE layer which forms part of the landfill site capping layer.

5.1.3 As extracted from the Technical Information Kit for TKOL II/III by EPD **(Appendix G)**, the planned development loads at the three platforms have been limited to 50kPa for Upper and Lower Platforms and 40kPa for Middle Platform for the purpose of protecting the underground restoration facilities. In order to maximise the development potential of the three platforms, the current proposed master layout plan will lead to maximum design load up to the load limit as set up by EPD.

5.1.4 In view of the excavation depth constraints and the gentle sloping ground at the platforms, stepped raft foundations may be considered as the foundation type to suit the existing topography and limit the excavation depth. Nevertheless, to further control the magnitude of the total development load to be below 50/40kPa, stepped raft foundations are likely to be upgraded into stepped cellular raft foundations, which comprises flat upper (suspended) slab and stepped bottom (ground bearing) slab with two-way interlocking vertical structural elements (concrete walls). This could effectively limit the thickness of the raft, keep the weight of the foundation to a minimum and helps to form flat areas for the superstructures.

5.1.5 Furthermore, utilities trenches have been proposed at the landfill slope surface to accommodate proposed essential utilities in supporting the operation of PRS. A typical section of the utility trench can be found in Figure 5.1. The total weight of the utility trench is considered to be less than 5kPa, which is quite manageable from the slope stability point of view. The details of the utility trench shall be further studies at the later stage of the project.

5.2 Impact on Existing Features

5.2.1 The load limits as mentioned in **Section 5.1.3** have been used to check the impact on stability of the existing man-made features affecting or being affected by the Application Site, including Feature nos.: 12SW-A/F 67, 12SW-A/F 68, 12SW-A/F 70, 12SW-A/F 73 and 12SW-A/F96.

5.2.2 The required factor of safety (FoS) of those concerned features affecting or being affecting by the Application Site is determined based on the "Consequence-to-life" and "Economic Consequence" categories in accordance with the guidelines provided in GEO TGN No. 15 and WBTC No. 13/1999. A FoS of up to 1.4 was found to be required for all the above-mentioned features affecting or being affecting by the Application Site.

5.2.3 The preliminary stability assessment suggested the FoS of the existing features nos. 12SW-A/F 67, 12SW-A/F 68, 12SW-A/F 70, 12SW-A/F 73 and 12SW-A/F96 affecting or being affecting by the Application Site are up to the required value of 1.4 and is considered to be satisfactory to the current standard. A sensitivity of the slope stability check for increased development load from 40kPa to 50kPa for Middle Platform also suggested the FoS of all features affecting or being affecting Middle Platform is still up the required standard of 1.4. The potential of adopting a higher load of 50kPa for the development in Middle Platform will be investigated in detail at a later stage of the project.

6. Conclusion and Recommendation

6.1 Conclusion and Recommendation

6.1.1 A geotechnical planning review has been conducted for the HKJC Public Riding School (PRS) at the three platforms and the land required for the provision of ancillary utility trench connecting to the platforms to accommodate proposed essential utilities in supporting the operation of PRS within the restored landfill site (TKOL II/III) in Tseung Kwan O that may affect, or be affected by, natural terrain of man-made slopes or retaining wall features in accordance to GEO Advice Note for Planning Application under Towen Planning Ordinance (Cap. 131). The Indicative Scheme of the Development Site comprises various structures and stables spread across three platforms.

6.1.2 The review has been carried out based on the findings of desk studies, aerial photo interpretation (API) and site inspection of TKOL II/III and the adjacent natural terrain catchments. TKOL II/III is located at the toe of the few catchments.

6.1.3 The Natural Terrain Hazard Study covered the engineering geological assessment, natural terrain hazard review, natural terrain hazard assessment and hazard mitigation strategy has been carried out for TKOL II/III, which indicates there is potential natural terrain hazard at the natural terrain catchments overlooking TKOL II/III. The 'no-build zone' has thus been delineated for TKOL II/III, with localised in-situ stabilization of boulders.

6.1.4 Schematic plans of PRS development have been proposed. The structures are proposed on the platforms and will adopt a stepped-raft foundation to follow the elevation of the terrain and limit excavation depth to within 500mm.

6.1.5 The planned development load at the three platforms has been limited to 50kPa for Upper and Lower Platforms and 40kPa for Middle Platform. However, the preliminary slope stability assessment suggested the FoS of the existing landfill slopes are still satisfactory even with 50kPa load at all the platforms. The potential of adopting a higher load (50kPa) at Middle Platform will be explored in detail at the later stage of the project.

6.1.6 In conclusion, the proposed redevelopment is considered to be feasible from the geotechnical perspective.

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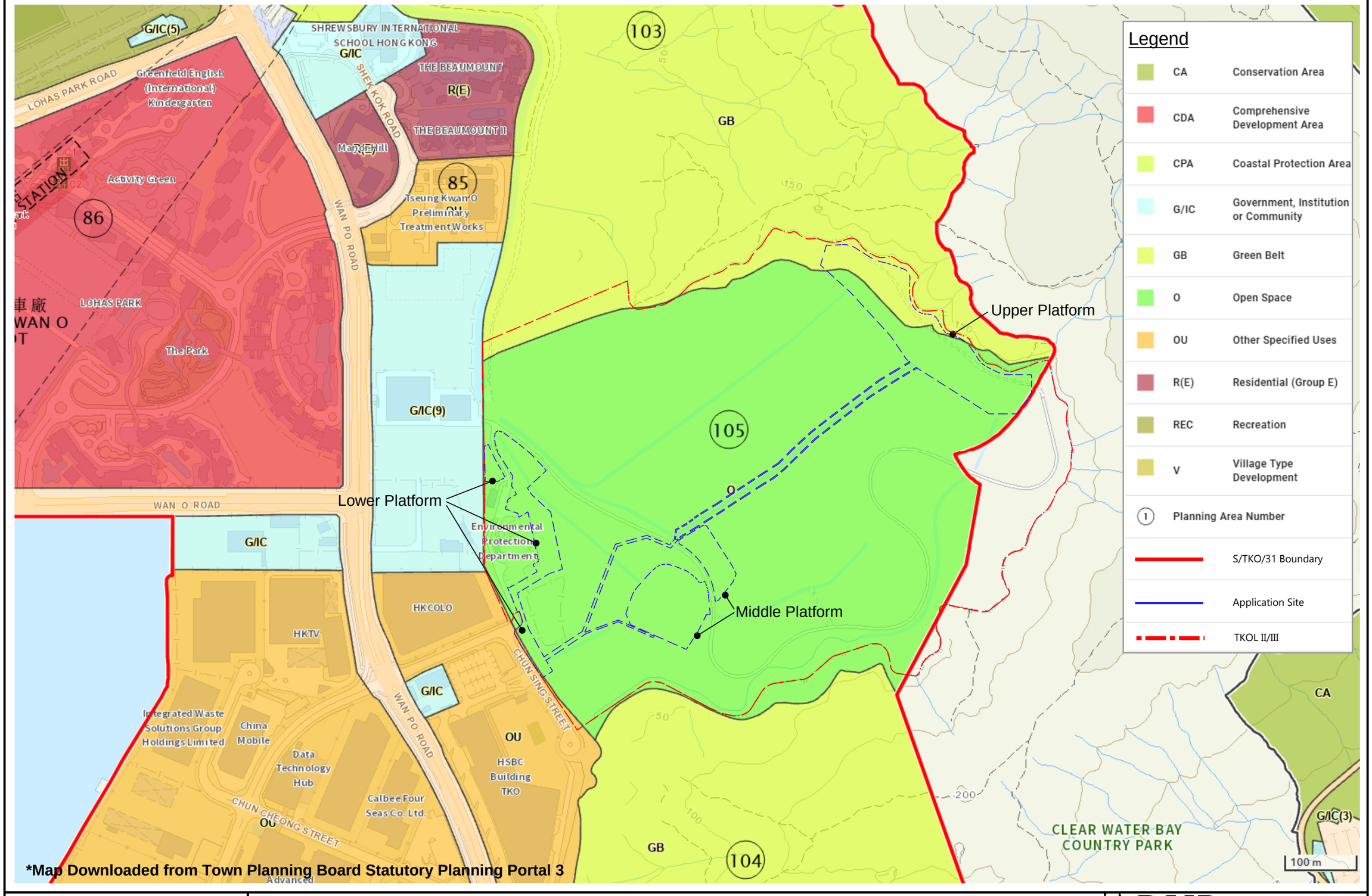
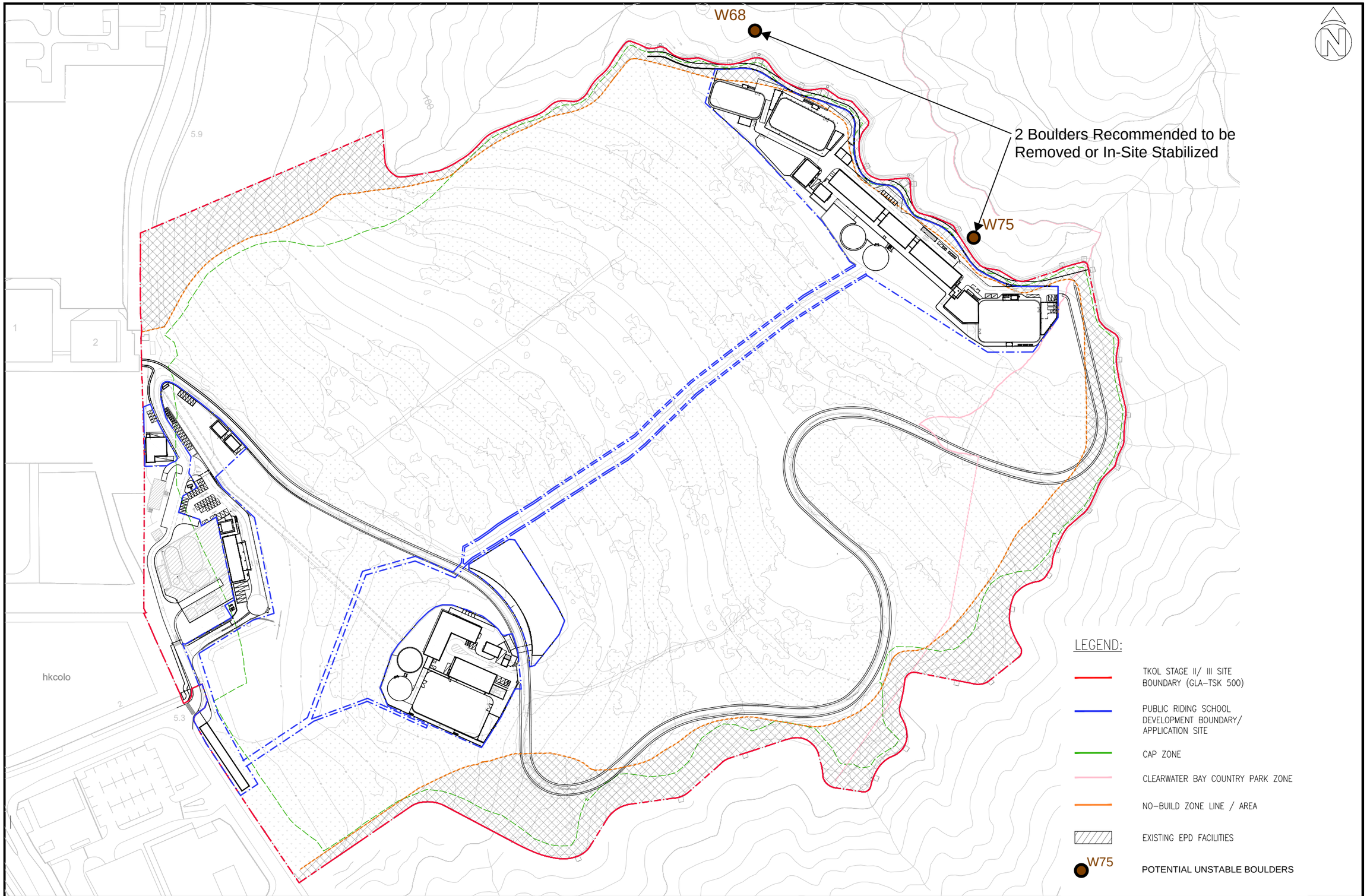
Figures



*Map Downloaded from Town Planning Board Statutory Planning Portal 3

Job Title **Proposed Place of Recreation, Sports or Culture (Public Riding School) with Ancillary Facilities at Government Land in D.D. 233, The Restored Landfill Site (TKOL II/III) in TKO Area 105, Tseung Kwan O (GLA TSK-500 (Part))**	Drawing Title **Location Plan with S/TKO/31**	ARUP Scale As Shown Drawn by: WT Date July 25 Checked: MX Approved: JL Job No. **304521** Figure No. **FIGURE 1.1**



Job Title

Proposed Place of Recreation, Sports or Culture (Public Riding School) with Ancillary Facilities at Government Land in D.D. 233, The Restored Landfill Site (TKOL II/III) in TKO Area 105, Tseung Kwan O (GLA TSK-500 (Part))

Drawing Title

Indicative Scheme of the Proposed Amendment (Master Layout Plan)

ARUP

Scale 1:3000 (A3)

Drawn by: WT Date July 25 Checked: MX Approved: JL

Job No. **304521**

Figure No. **FIGURE 1.2**

Job Title

Proposed Place of Recreation, Sports or Culture (Public Riding School) with Ancillary Facilities at Government Land in D.D. 233, The Restored Landfill Site (TKOL II/III) in TKO Area 105, Tseung Kwan O (GLA TSK-500 (Part))

Drawing Title

Site Location Plan

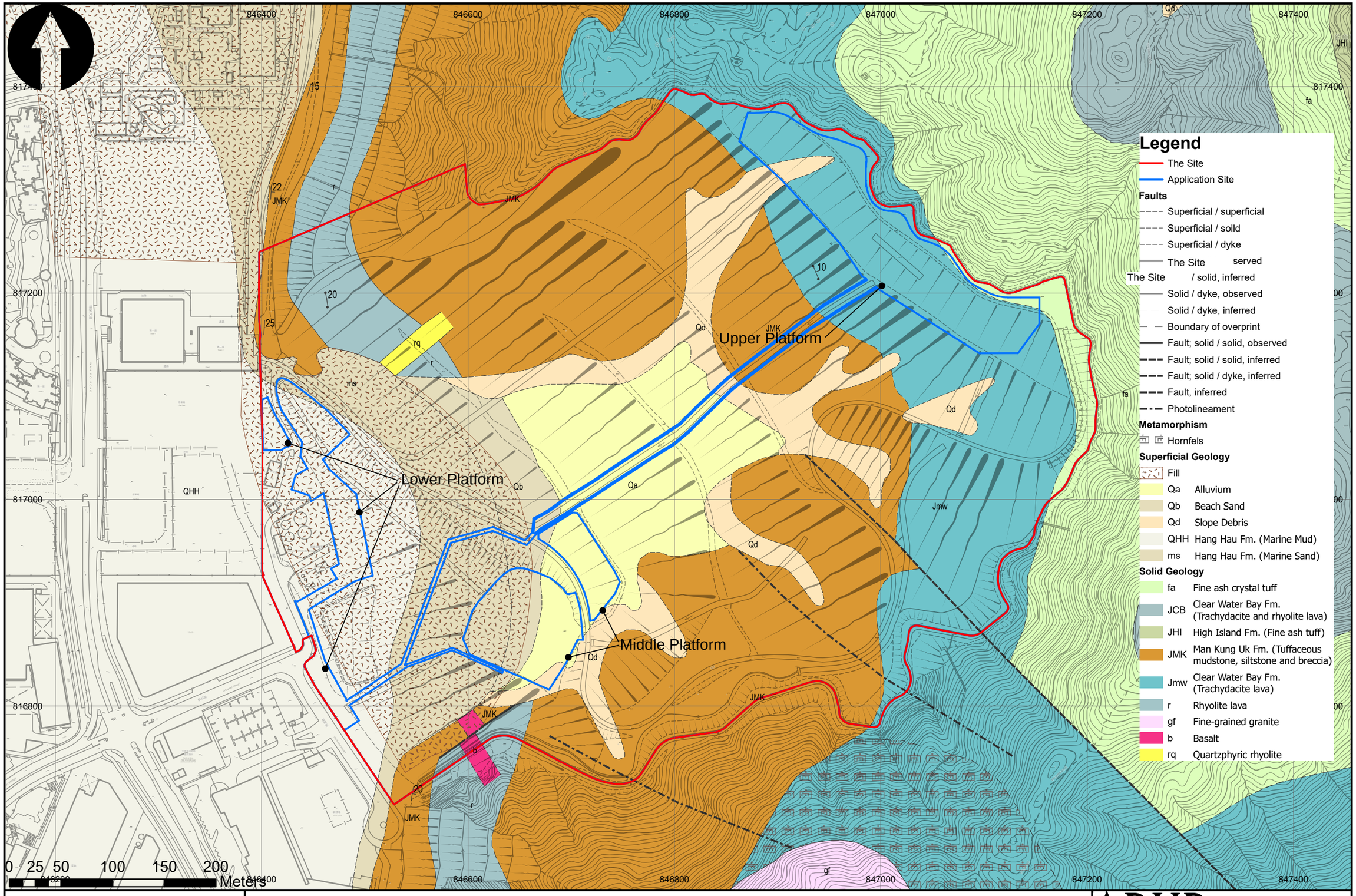
ARUP

Scale 1:3000 (A3)

Drawn by: WT Date July 25 Checked: MX Approved: JL

Job No. **304521**

Figure No. **FIGURE 2.1**



Job Title

Proposed Place of Recreation, Sports or Culture (Public Riding School) with Ancillary Facilities at Government Land in D.D. 233, The Restored Landfill Site (TKOL II/III) in TKO Area 105, Tseung Kwan O (GLA TSK-500 (Part))

Drawing Title

Part Plan of Geological Map Sheet 12

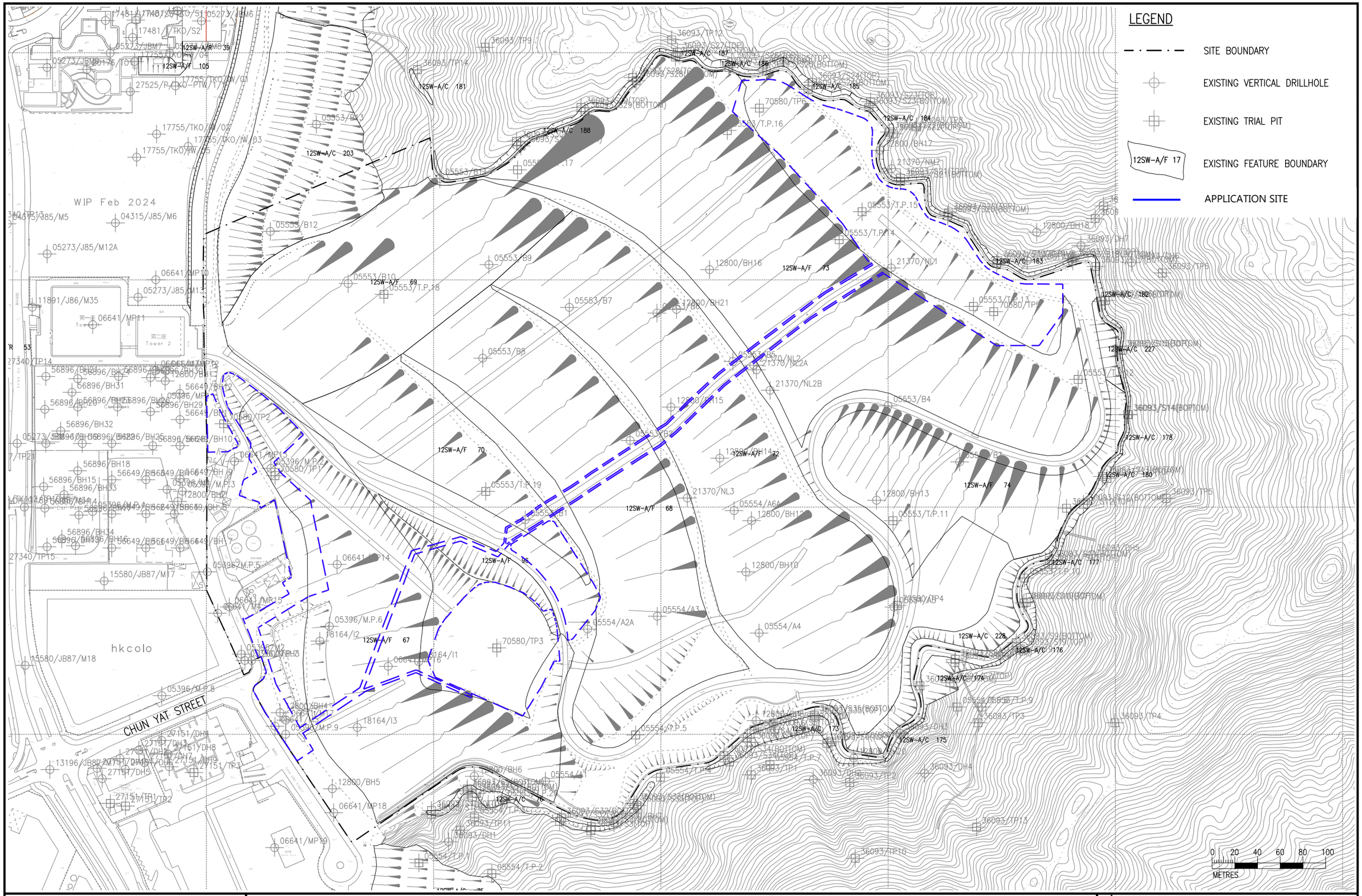
ARUP

Scale As Shown

Drawn by: WT Date May 25 Checked: MX Approved: JL

Job No. **304521**

Figure No. **FIGURE 3.1**



Job Title

Proposed Place of Recreation, Sports or Culture (Public Riding School) with Ancillary Facilities at Government Land in D.D. 233, The Restored Landfill Site (TKOL II/III) in TKO Area 105, Tseung Kwan O (GLA TSK-500 (Part))

Drawing Title

Existing GI Location

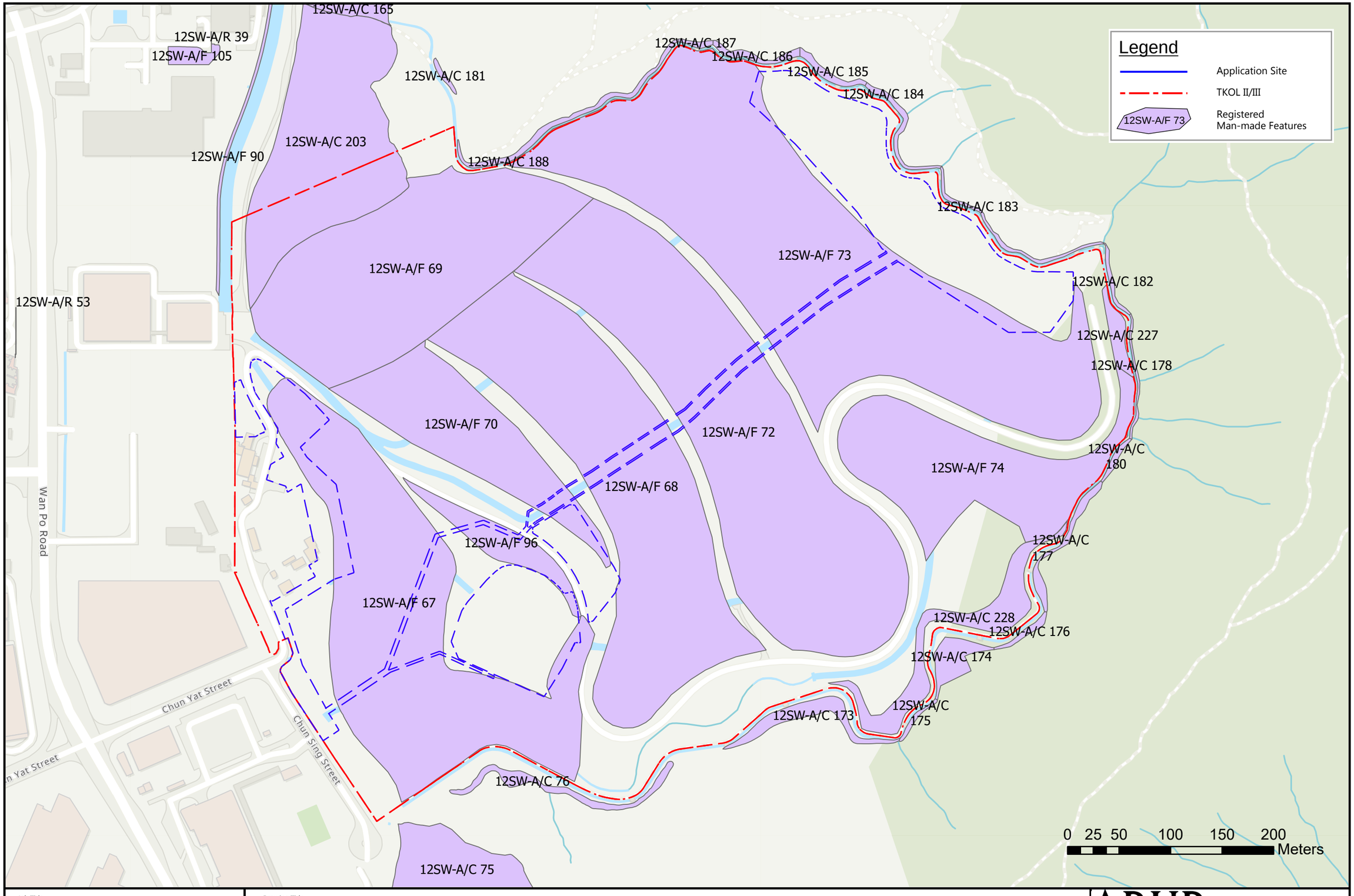
ARUP

Scale As Shown

Drawn by: WT Date July 25 Checked: MX Approved: JL

Job No. **304521**

Figure No. **FIGURE 3.2**



Job Title

Proposed Place of Recreation, Sports or Culture (Public Riding School) with Ancillary Facilities at Government Land in D.D. 233, The Restored Landfill Site (TKOL II/III) in TKO Area 105, Tseung Kwan O (GLA TSK-500 (Part))

Drawing Title

Adjacent Registered Man-made Features

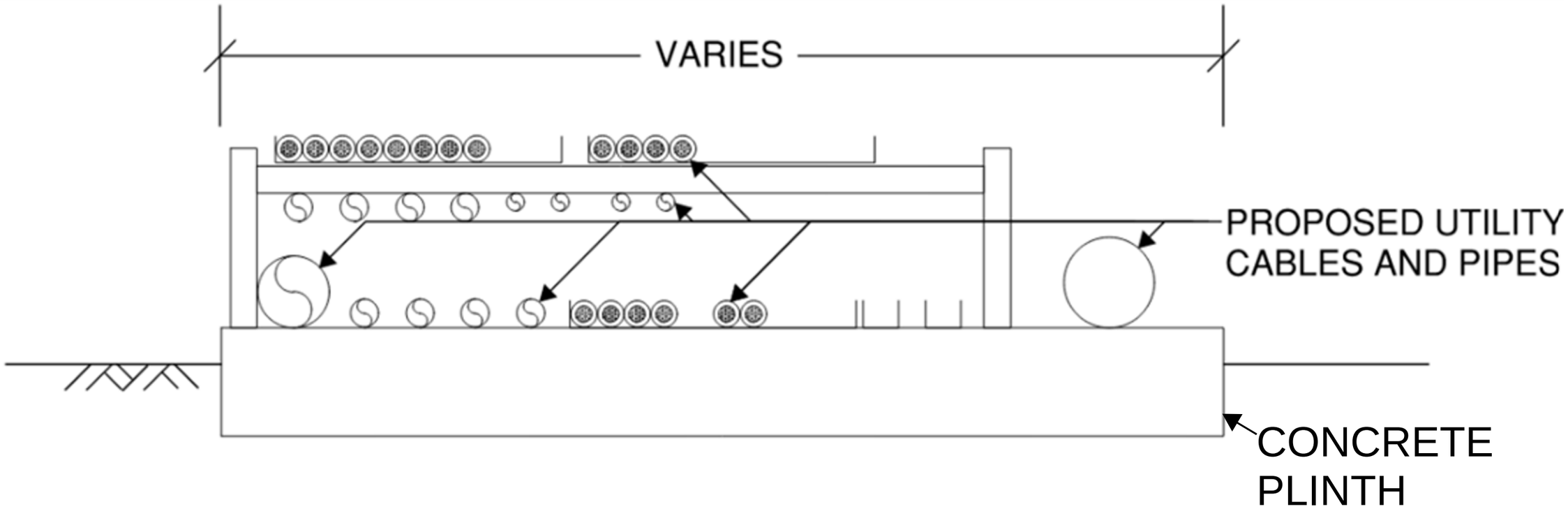
ARUP

Scale As Shown

Drawn by: WT Date July 25 Checked: MX Approved: JL

Job No. **304521**

Figure No. **FIGURE 3.3**



Job Title

Proposed Place of Recreation, Sports or Culture (Public Riding School) with Ancillary Facilities at Government Land in D.D. 233, The Restored Landfill Site (TKOL II/III) in TKO Area 105, Tseung Kwan O (GLA TSK-500 (Part))

Drawing Title

Typical Section of Proposed Utility Trench

ARUP

Scale As Shown

Drawn by: WT Date July 25 Checked: MX Approved: JL

Job No. **304521**

Figure No. **FIGURE 5.1**

Appendix A

Previous NTHS Report 2003

Agreement No. FD 01-052
Geotechnical Review and Site Investigation Works
For Tseung Kwan O Landfill Stage II/III
Afteruse Development

Natural Terrain Hazard Assessment Report

[Report No. 382311/NTHA/Revised Issue 2]

Report Authorized For Issue By:	..... For and on Behalf of Black & Veatch Hong Kong Ltd.

Black & Veatch Hong Kong Ltd.
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February 2003

SUMMARY

The Hong Kong Environmental Protection Department (EPD) launched in 1996 a Landfill Restoration Programme (LRP) for 13 closed landfills. Tseung Kwan O Landfill Stage II/III is one of the 13 closed landfills. In October 2001, the EPD appointed Binnie Black & Veatch Hong Kong Ltd (BBVHKL) to study the geotechnical feasibility of the park.

This report provides a study of the natural terrain that could impact on the landfill site. The objective of the natural terrain hazard assessment is to identify, determine and quantify any natural hazards that could affect the proposed works and also, where necessary, to propose conceptual designs for appropriate mitigation measures.

The API in association with the NTLI Database and site walkover confirmed that there is evidence of relict and recent landsliding within several of the catchments within the study area.

Based on assessment results, it is considered that channelised debris flows, boulder falls and open hillslope landslides all form potential hazards. Mitigation measures for both types of landslides and boulder falls have been determined on a catchment by catchment basis and includes a ramp-up barrier such as an earth bund proposed along the toe of the slope and stabilisation/preventive measures of several boulders. In addition, where barriers are not required, a restricted zone, isolated by fencing be incorporated along the toe of the natural terrain.

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Checked	John Hall	pp Tony Chen	Feb 2003
Reviewed	Tony Chen	Tony Chen	Feb 2003

1. INTRODUCTION

1.1 Background

The Hong Kong Environmental Protection Department (EPD) launched in 1996 a Landfill Restoration Programme (LRP) for 13 closed landfills. Tseung Kwan O Landfill II/III is one of the 13 closed landfills.

The restoration works for TKO II/III were completed in 1999 and the landfill is considered safe and environmentally acceptable for afteruse. At present, there are several afteruse proposals for the landfill being explored, including an option to develop the landfill into a recreational facility with a material recycling facility for educational purposes (the Park).

In October 2001, the Environmental Protection Department appointed Binnie Black & Veatch Hong Kong Ltd. (BBVHKL) to study the geotechnical feasibility of the park.

1.2 Purpose of Report

The purpose of this report is to provide a study of the natural terrain that could impact on the landfill site. The report includes a summary of background information reviewed in the Preliminary Geotechnical Assessment report (December 2001) and a more detailed review of the Aerial Photograph Interpretation (API). The objective of the natural terrain hazard assessment is to identify, determine and quantify any natural hazards that could affect the proposed works and also, where necessary, to propose conceptual designs for appropriate mitigation measures.

2. THE SITE

2.1 Site Description

Tseung Kwan O Landfill Stage II/III (TKO II/III) is located near Tseung Kwan O Bay, as shown in Figure 1, and was formed by infilling of the Tai Chik Sha Valley. The area was formerly a west facing, bowl shaped valley overlooking Tai Chik Sha Wan and a small embayment to Tseung Kwan O Bay. Only a small part of the landfill extends over the original seabed.

The landfill operations in Stage II/III filled the northern side of the valley at Tai Chik Sha, to the top platform level of 140mPD. The landfill profile now dips at a gradient of approximately 1 in 3 to the west from the top of the platform at the valley head to 5mPD at the toe, over a horizontal distance of about 750m. The site comprises several waste slopes and is bounded by a series of cut slopes, and beyond these cuttings, natural terrain as shown in Figure 2.

3. BACKGROUND INFORMATION

3.1 General

This section summarises the findings of the preliminary geotechnical assessment report for the proposed site.

3.2 Site Geology

The Geological Map Sheet No. 12, Solid and Superficial Geology (Scale 1:20 000, GCO, 1989) indicates that the site comprises tuffs, ash and lavas of Upper Jurassic age (Figure 3). The original landform, prior to the construction and operation of the landfill, was a basin enclosed by hills on three sides with a bay on the shore to the west of the site boundary. To the sides of the valley are volcanic rocks of the Repulse Bay Formation, weathered in places to form decomposed volcanic material and covered in part by superficial deposits. The valley floor consists of alluvium, comprising clays, silts and sands. Existing boreholes located around the site show that the volcanic tuff is fractured and jointed. A summary of the existing borehole records is presented in Appendix A.

GASP Report VII for the Clear Water Bay area (GCO, 1988) discusses the site during its pre-operation condition and relevant maps are shown in Appendix A. It reveals that the site is classified as having predominantly extreme geotechnical limitations, requiring a very high engineering cost and very intensive site investigation. Localised areas of moderate to high geotechnical limitations requiring a normal to high engineering cost and normal to intensive site investigation situated in the western portion of the site. The central region of the site is identified as zones of colluvium surrounded by zones of general instability associated with predominantly insitu terrain. Slopes on insitu terrain generally steeper than 30° occur in the westernmost region of the site. The two rock types (Repulse Bay Formation) of banded acid lavas, some welded tuffs in the east and pyroclastic rocks in the west usually produces a thin soil horizon followed downwards by sandy completely weathered material overlying less weathered, locally strongly jointed rock below an average depth of 11m. Several geological photolineaments cut the site, trending approximately East-West, North-South, and NW-SE.

3.3 Site Hydrogeology

The steep hillsides and relatively high permeability of the superficial deposits indicates that the groundwater regime must be highly transient, responding not only to seasonal variation in infiltration but also to rainfall events. Limited groundwater monitoring data indicates that, prior to the restoration of the landfill, the ground water level was below 122mPD.

The basal leachate collection systems (Ref. 16 & 17) on the back face of the formation slopes are on natural ground. Hence the exterior sub-surface water regime is intimately connected with that of the leachate regime.

A sub-soil water abstraction system (Ref. 18) has been installed as part of the restoration works. This system is designed to limit the amount of groundwater infiltration from the surrounding hillsides into the waste mass, to control leachate generation. The annual design review undertaken in May 2001 indicates that the measured leachate levels were within the design expectations (Ref 19).

3.4 Previous and Recent Ground Investigation

3.4.1 Previous Ground Investigation (Pre-2002)

Previous ground investigation (predominantly carried out in 1988-89) within the landfill site (Figure 4 and Appendix A) reveals that the ground conditions; at the base of the terrain (in the west) consists of several layers of fill (sand, gravel & rock fill) overlying superficial deposits, marine and alluvial deposits, which in turn overlie insitu soil. Midslope, rockhead was generally encountered between +17.32 and +39.43mPD overlain by insitu soil and in one drillhole (12800/BH13) 0.60m of alluvial sand. At the crest of the terrain (in the east), rockhead was encountered between +107.38 and +162.36 below 2.0-5.0m thickness of soil.

3.4.2 Recent Ground Investigation (2002)

Ground investigation has been carried out on the natural terrain (see Figure 4 and Appendix A), and the findings are discussed below.

In the north-west, trial pits reveal that 0.5 to 1.30m of colluvium (generally of silty fine to coarse sand with fine to coarse gravel and cobble sized rock fragments) overlies completely to highly decomposed rhyolite with bedrock encountered in TP14 at 1.65m below ground level.

In the northern region, drillholes reveal that the ground conditions comprise of superficial deposits of fill, completely to highly/moderately decomposed rock (12m in thickness), and rockhead at between 152 and 157mPD (at 1.22m and 13.65m below ground level). Trial pits reveal 0.1 to 1.5m of colluvium (silty fine sand to sandy silt) overlying insitu soil and bedrock. Rock types encountered are of fine ash tuff and trachydacite lava.

In the easternmost region, drillhole DH5 reveals fill and topsoil overlying completely to highly/moderately decomposed tuff and rockhead encountered at 135.64mPD (5.13m depth). Trial pits further upslope reveal topsoil and colluvium (silty fine to coarse sand with gravel and boulder sized rock fragments) up to 1.2m thick overlying bedrock.

In the southernmost area, drillhole DH3 at the toe of the natural terrain comprises of 2.6m fill (for the construction of the catchwater channel), completely to highly decomposed trachydacite lava and rockhead at 79.91mPD (7.55m depth). Drillholes further upslope reveal 1.5m of colluvium, insitu soil up to 14m in thickness and rockhead at 118.11mPD (8.40m depth). Trial pits reveal topsoil and colluvium up to 1.65m thickness over highly to moderately decomposed trachydacite lava and tuffaceous breccia. Further upslope, colluvium (0.1 to 0.90m thickness) overlies moderately decomposed rock.

In the south-westernmost, drillhole DH1 and trial pit TP11 reveals up to 1.0m colluvium overlying insitu soil (rhyolite).

Concealed open joints were observed in trial pit TP4 situated near the crest of Catchment No. 6A and indicates the presence of potential instability.

A summary of the groundwater monitoring records from the ground investigation works reveal groundwater levels of 147mPD (6m bgl) and 155.33mPD (15.40m bgl) in the north, 132.16mPD

(8.61m bgl) in the east, 118.51 (8.0m bgl), 98.26 (15.10m bgl) and 79.51mPD (7.95m bgl) in the southern region, and 27.09mPD (14.60m bgl) in the southwest.

3.5 Natural Terrain Landslide Inventory and Large Landslide Database

The Catalogue of Natural Slope Landslides (NTLI) and Large Landslide Database of the area (see Figure 6 and Appendix C) have been examined.

No landslides are recorded in the Large Landslide Database for this area.

The NTLI records 13 landslides on the natural terrain above the landfill area. Eight of these have been verified by API. Ten of these are on the southern slopes. And three on the eastern slopes. Ground slope angles across the landslide heads of between 18° to 45° were measured and the landslide scars are all less than 20m in width.

4. AERIAL PHOTOGRAPH INTERPRETATION (API)

4.1 Introduction

Table 4.1 lists the aerial photographs obtained from the Geotechnical Engineering Office, which comprise high and low flight and partially enlarged photography and cover the entire project area. A summary of the features observed is contained in Appendix B, and a recent aerial photograph is illustrated in Figure 5 (Part Print – AP No. CN17111, Year 1997). The serial numbers of the photographs inspected are listed in Table 4.1.

4.2 Geomorphology

The ridgelines that form the watershed to this catchment can be generally likened to the rim of a bowl tilted in a north westerly direction. The ridgeline rises from the capped landfill level in the south west, to a high of around 230mPD in the east, before descending back to landfill level in the north west (see Figure 5).

The exception to this simplistic analogy is a sub-catchment in the north east which extends back beyond the general peripheral rim, to a peak at around 330mPD.

The capped surface of the landfill that fills the bowl slopes down in a south westerly direction, intercepting the mainly first order drainage lines at what would have been their mid-sections.

The natural terrain that the streams drain is generally steep (around 30° or steeper) with just isolated patches and ridge sections that fall to shallower angles of between 20° to 30°. Natural slopes in the north and south were found to be predominantly similar with slope angles between 17° and 43° (see Appendix D for the Natural Terrain Hazard Map and Sections 1-3 in Appendix E). However, localised areas of slope angles up to 48° can be identified in the natural slopes in the south.

The choice of slope angle classes used in the Natural Terrain Hazard Map (see Appendix D) is based on the work of Hungr et al (1984, 1987) and Franks (1998). These are 0 - 7°, 8°-17°, 18°-

29° and 30°+ respectively. These ranges have been chosen on the basis of GEO Report No. 57 which states that the formation of debris deposition fan starts on < 8° slopes for channelised failure, < 18° slopes for non-channelised failure, < 30° slopes for openhill landslide; and >30° slopes for landslide initiation to occur. The slope angles were measured automatically from the 2m contour interval on the 1:1,000 scale maps using ArcGIS.

4.3 Structural Geology

The geological map shows a NW-SE trending fault cutting the south-western area of the site with several geological photolineaments trending approximately East-West, North-South and NW-SE which are also identified from the API (see Figure 5).

Fracture Trace Analysis of the landfill site carried out in 2001 to identify potential extraction well locations, also identified a number of distinct structural features trending in orientations identical to those seen in the API. These are likely to exert primary control over the hydrological and hydrogeological regimes within the landfill catchment.

4.4 Hydrology/Hydrogeology

Streams are relatively steep and stream sections (Sections 4-4 to 13-13 included in Appendix E) reveal that streams in the northern and southern regions of the site were generally found to be predominantly between 14° and 42°.

The 9 catchments that make up the study area are discussed below;

Catchment Nos. 1 to 3 in the North

The stream lines within these catchments can be classified as ephemeral and are poorly developed and dry. There is no API evidence for extensive sub-surface piping nor any springs or seepage lines.

Catchment No. 4

The south-west flowing stream lines which run centrally along the catchment are well developed and can be classified as perennial. Stream sections reveal stream angles of between 14° and 42°. The mid-point and the lower reaches of the streams were observed to be densely vegetated and site inspection also observed boulders of approximately 0.5m diameter in size along the stream course. Water flow and seepage are observed at the toe of the natural terrain.

Catchment Nos. 5, 6A and 6B

The stream lines within these catchments are poorly developed and dry and can be classified as ephemeral. Stream sections (6-6 and 13-13) reveal stream angles of between 22° and 41°. There is no API evidence for extensive sub-surface piping nor any springs or seepage lines.

Catchment No. 7

The ephemeral drain paths are observed to be densely vegetated within the study catchment. Stream sections (7-7 to 9-9) reveal stream angles of between 20° and 35°. Site inspection also

observed boulders of approximately 0.5m diameter in size along the stream course. There is no API evidence for extensive sub-surface piping nor any springs or seepage lines.

Catchment Nos. 8 and 9

The ephemeral drain paths are observed to be densely vegetated within the study catchment. Stream sections (10-10 to 12-12) reveal stream angles of between 29° and 32°. Site inspection also observed boulders of approximately 0.5m diameter in size along the drainage line in the west (adjacent to drillhole DH1). There is no API evidence for extensive sub-surface piping nor any springs or seepage lines.

4.4.1 Discussion

The majority of the drainage lines were found to be dry with no API evidence for extensive sub-surface piping nor any springs or seepage lines. The exception is within Catchment No. 4 along Stream sections 4-4 and 5-5 where constant water flow was observed during the site inspections and seepage on adjacent cut slopes.

4.5 Natural Terrain Hazards

Based on API, the Catalogue of Natural Slope Landslides and Landslide Database of the area, a total of twenty-two landslides have been identified of which 20 occurred prior to 1975. The landslides have been numbered for easy reference on the API and Engineering Geology Maps (contained in Appendix B and I) and an inventory is included as Table 6.2. One landslide in the south occurred in 1997 and had an estimated volume of around 100m^3. The debris trail extended for approximately 40m into an adjacent drainage line.

Rock failure occurred in 2000 on the formed slope, 12SW-A/C175, in the southern region of the site which was later cleared and the surface covered with shotcrete.

Some boulders and boulder fields are observed mainly within Catchment Nos. 2 and 4 which may pose boulder fall hazards to the proposed development. Detailed assessment is discussed in Section 7.

4.6 Conclusions

The API indicates that there is evidence of relict and recent landslides, and boulders within the natural terrain of the study area. Landslides and rockfalls pose a potential threat to the landfill afteruse development. The results identified by the API is presented in the API Map in Appendix B.

5 SITE RECONNAISSANCE

5.1 Natural Terrain

Field inspections were carried out by BBV's geotechnical engineer and geologist in November 2001 and July 2002. The general views of the natural terrain are shown in Plates 1 to 6 in Appendix F. The locations of the photographs taken during the inspections are shown in Figure 7.

During the inspection (field traverses are shown in Figure 7), most of the natural slopes were covered by vegetation. No fresh or recent landslide scars were identified except the one identified in the 1997 aerial photographs. However, based upon API and NTLI information, and this site inspection, the southern slopes in Catchment Nos. 6A, 6B, 7 to 9 appear historically unstable as indicated by relict landslide scars in this area.

Boulder fields were observed mainly at the eastern and northern slopes, some of which pose long term potential risk to the landfill afteruse development. Boulder stabilisation measures, as recommended in a boulder survey in 1998, had been carried out in most of the boulder-field areas within Catchment Nos 3, 4, 8 and 9 (see Plates 9 and 11 in Appendix F). However, a detailed boulder survey carried out for this assessment revealed that several boulders in Catchments 2 and 4 require stabilisation measures.

Boulders, on average 0.5m in diameter, were observed along drainage channels in Catchment No. 4 and 9 (see Plates 13 and 14) and 7 and because of their relatively small size, these boulders are not considered to be a major concern.

The inspection observed colluvial deposits in Catchment 4 which consists of silty fine to coarse sand to silty clay with fine to coarse gravel and occasional boulder sized rock fragments.

Constant water flow was observed at the toe of the natural slope (along streams of Sections 4-4 and 5-5) in the north-westernmost area of the site indicating a high ground water level as recorded in the ground investigation works.

No distressed ground or tension cracks have been observed on most of the natural slopes during site inspection. However, open joints up to 20mm wide were found in trial pit TP4 located in Catchment No. 6A. At this location, the slope angle is >30°.

6 NATURAL TERRAIN HAZARD STUDIES

6.1 General

The Design Event Approach, as promulgated by GEO SPR 1/2002 has been used to assess the natural terrain hazards and mitigation. The procedure is outlined below and relevant tables are included in Appendix E.

The facility type and group has been assessed. Group 1 facilities exist along the north-eastern edge of the landfill platform (beneath catchments 3 and 4) and beneath part of catchment 9.

Elsewhere Group 3 facilities have been assumed, which includes open space and lightly trafficked roads.

The 20°, 25° and 30° angular elevation trace was superimposed onto the landfill platform beneath the surrounding natural terrain to determine the proximity of the facilities to possible natural terrain hazards, as shown in Appendix E.

The susceptibility of the hillside to failure (susceptibility classes A-D, Table 4 in Appendix E) was determined on a catchment by catchment basis (see Landslide Susceptibility Map in Appendix E) to determine the relative likelihood of a natural terrain hazard being produced by each catchment (see Natural Terrain Hazard Map in Appendix D).

The Consequence Class has been assessed in accordance with Table 3 (Appendix E) depending on the facility group and proximity as described above.

The design event, Conservative Event (CE), for the majority of the catchments have been determined in accordance with Table 2 in Appendix E.

6.2. Design Landslides

As mentioned above and in accordance with SPR 1/2002, "Conservative Event" (CE) landslides have needed to be modelled.

Referring to Hong Kong GEO Reports (Nos. 35, 43, 54, 59, 70, 97 and 105) containing rainfall and landslides occurrence between 1992-1998, a total of 355 natural slope landslides were reported (Table 6.1). The size distribution chart accompanying the table shows that the majority of landslides are less than 300m^3 (95%).

All recorded landslides on the site from the Catalogue of Natural Slope Landslides and Landslide Database and from API are presented in Table 6.2. The landslides have been numbered for easy reference on the API Map (contained in Appendix B). Based on site inspection and from ground investigation information, the average thickness of the original landslide debris would be between 1.0 and 1.5m. The estimation of landslide source volumes is presented in Table 6.2. The size distribution histogram and accumulative frequency chart accompanying the table shows that the largest historical landslide volume in the area is not greater then 200m^3 and that up to 95% have volumes of <185m^3. Thus, it is considered that the source volume of 240m^3 (the mean between site specific and GEO reported landslides) assumed for CE events is appropriate.

6.2.1 Channelised Debris Flow Landslides Study

In order to ascertain appropriate run-out volumes for each individual potential landslide, long sections along each relevant drainage line have been prepared and are included in Appendix E. From this information, and assuming the source landslide all occur near to the ridgeline of each catchment, entrainment values have been added to the original source volume pro-rata with the length of colluvium identified along the stream channel. The rate of erosion has been considered as 2.3 m^3/m for CE landslides.

The estimation of the failure debris discharge, velocity and run-out has been carried out in accordance with GEO Report No. 104. The calculation of the debris discharge, debris velocity

and run-out distances, for all catchments considered as possible sources for CE landslides are included in Table G1 in Appendix G.

Each catchment considered is discussed in turn below, starting from the most westerly catchment and working around the landfill in an anti-clockwise direction. Reference should also be made to Tables 6.3 and 6.4 and also the Landslide Susceptibility Map (contained in Appendix E) which shows the individual catchments.

Catchment 1

There are records of two relict landslides recorded from NTLI and API information within Catchment 1 in the north-west. However, these are found to affect the area to the north of the study area only, and not the landfill platform.

Catchment 2

There are no records of relict landslides within Catchment 2 which would affect the landfill site and therefore it is considered that this catchment is of low susceptibility (Class D). Furthermore, the small size of this catchment limits the size of debris flow that could be developed. Consequently no further study of channelised debris flows are considered necessary in this area.

Catchment 3

Catchment 3 does not have any evidence of recent or relict landsliding. There is however the potential for landsliding given the presence of locally steep (greater than 30°) soil slopes. Hence the catchment has been designated Susceptibility Class C. The facility at the toe has been designated Group 1, and is deemed to be moderately close (20 to 25° angular elevation). This gives a Consequence Class of III, which according to Table 2 of SPR 1/2002, requires a CE landslide to be allowed for.

Calculations show that 697m^3 of debris could discharge onto the platform, with a theoretical run-out distance of 36m.

Catchment 4

There are records of relict landslides both within and in the relevant vicinity of the catchment and is thus classified as Susceptibility Class C (i.e. the natural terrain is moderately susceptible to the type of failure under consideration, with a notional annual probability of occurrence within the order of 1/100 to 1/1000). The Facility Grouping of 1, together with the proximity of "Moderately Close" based on Table 3, with an angular elevation from the natural terrain of 25°-30°, gives a Consequence Class of II. Thus a "Conservative Event" as the design event has been adopted.

The calculated volume of debris of 3756m^3 could be deposited along the stream section considered and thus mitigation measures will not be required. However, the lowermost reaches of the stream is found to have slope angles of 21°, and therefore mitigation measures are recommended for potential mid-slope failures. The calculations show that for a run-out volume of 552m^3, an expected run-out distance of 31m is possible.

Catchments 5

There are no records of relict landslides within this catchment from NTLI and API information. However, catchments on either side are deemed Class C, and it is therefore considered that this catchment is of moderate susceptibility (Class C) also. On this basis, a CE channelised debris flow has been modelled and gives a total run-out volume of 697m^3, and a run-out distance of 35.48m.

Catchment 6A

There are records of relict landslides within the catchment and is thus classified as Susceptibility Class C (i.e. the natural terrain is moderately susceptible to the type of failure under consideration, with a notional annual probability of occurrence within the order of 1/100 to 1/1000). The Facility Grouping of 3, together with the proximity of "Moderately Close" based on Table 3, with an angular elevation from the natural terrain of 25°-30°, gives a Consequence Class of III. Thus a "Conservative Event" as the design event will be adopted.

Calculations taking into account an entry channel slope angle of 41° shows that for a final run-out volume of 550m^3, an expected run-out distance of 45m is estimated from the slope toe.

Catchment 6B

There are records of relict landslides within the catchment and thus the existing access road is classified as Susceptibility Class C (i.e. the natural terrain is moderately susceptible to the type of failure under consideration, with a notional annual probability of occurrence within the order of 1/100 to 1/1000). The Facility Grouping of 3, together with the proximity of "Moderately Close" based on Table 3, with an angular elevation from the natural terrain of 25°-30°, gives a Consequence Class of III. Thus a "Conservative Event" as the design event will be adopted.

Calculations taking into account an entry channel slope angle of 32° estimates that for a final run-out volume of 550m^3, an expected run-out distance of 53.48m is estimated.

Catchment 7

There are records of relict and recent landslides within the catchment and thus the existing access road is classified as Susceptibility Class B (i.e. the natural terrain is highly susceptible to the type of failure under consideration, with a notional annual probability of occurrence in the order of 1/10 or higher). The Facility Grouping of 3, together with the proximity of "Moderately Close" based on Table 3, with an angular elevation from the natural terrain of 25°-30°, gives a Consequence Class of III. Thus a "Conservative Event" as the design event will be adopted.

Calculations taking into account an entry channel slope angle of 32° estimates that for a final run-out volume of 628m^3, an expected run-out distance of 53.48m from the slope toe is estimated.

Catchment 8

Records indicate the presence of a relict landslide within the catchment and is thus classified as Susceptibility Class C (i.e. the natural terrain is moderately susceptible to the type of failure under consideration, with a notional annual probability of occurrence within the order of 1/100 to

1/1000). The Facility Grouping of 3, together with the proximity of "Moderately Close" based on Table 3, with an angular elevation from the natural terrain of <25°, gives a Consequence Class of III. Thus a "Conservative Event" as the design event will be adopted.

Calculations taking into account an entry channel slope angle of 32° estimates that for a final run-out volume of 655m^3, an expected run-out distance of 53.48m is estimated from the slope toe.

Catchment 9

There are records of recent landslides within and in the vicinity of the catchment and is thus classified as Susceptibility Class B (i.e. the natural terrain is highly susceptible to the type of failure under consideration, with a notional annual probability of occurrence within the order of 1/10 to 1/100). The Facility Grouping of 3 for the access road, together with the proximity of "Moderately Close" based on Table 3, with an angular elevation from the natural terrain of 25°-30°, gives a Consequence Class of III. Thus a "Conservative Event" as the design event will be adopted. In addition, the Facility Grouping of 1 for the proposed recycling facility, together with the proximity of "Far", with an angular elevation from the natural terrain of <25°, gives a Consequence Class of III, and thus a "Conservative Event" is also adopted.

The calculations have taken into account an entry channel slope angle of 31° and shows that for a final run-out volume of 701m^3, an expected run-out distance of 109.37m is estimated from the toe of the slope. This could theoretically impact on the proposed recycling facility proposed in the Conceptual Design layout (Figure 9).

6.2.2 Open Hillslope Landslides

Areas of the proposed development that are considered vulnerable to zones of potential open hillslope failure, are those that lie directly downslope from a natural slope steeper than 30°, with no intervening depositional area (a slope of 17° or less). Based on the Natural Terrain hazard Map (Appendix D) this affects much of the proposed platform particularly where such steep ground occurs directly above cut slopes.

The landslide source volume of 240 m^3 for conservative events used in the case of channelised debris flow landslides is assumed. The estimation of the failure debris run-out has been carried out in accordance with SPR1/2002 and calculations are summarised in Table G2 in Appendix G.

Where open hillslope failures are considered possible, and have been required to be modelled, it has been assumed that the entire volume of debris from the design landslide is deposited on the platform below with an angle of reach of 20°. This is deemed a conservative angle of reach based on the works of Franks (1996), which suggests that the relationship between angle of reach and landslide volume is given by:

$\theta = 38.256 - 6.0244 \times \log V$

Where: θ = angle of reach, and
V = landslide volume (m^3)

This gives a theoretical angle of reach of 24.0° for CE landslides.

Run-out distances for individual open hillslope landslides are given in Appendix G. The calculations assume that CE size landslides have a width of 10m, based on the average width of natural terrain landslides quoted in the Mid-Levels Study, which give debris volumes per metre width of landslide of $24m^3$.

Each catchment considered is discussed in turn below, working around the landfill in an anti-clockwise direction from the west.

Catchment 1

As previously discussed, this catchment, cannot affect the landfill platform due to its orientation, and has therefore not been considered further as part of this study.

Catchment 2

There are no records of relict or recent landslides in Catchment 2 indicating a low susceptibility to landsliding. This fact together with the catchment's small area and low elevation indicates that no further open hillslope consideration need be given to this catchment.

Catchment 3

Calculations show that $240m^3$ of debris from a CE sized landslide could discharge onto the platform, with a theoretical run-out distance of 11.84m.

Catchment 4

Calculations show that for a CE run-out volume of $24m^3/m$, an expected run-out distance of 12.06m is estimated from the slope toe.

per m^2

Catchment 5

Calculations show that $240m^3$ of debris from a CE sized landslide could discharge onto the platform, with a theoretical run-out distance of 12.01m.

Catchment 6A

Calculations show that for a CE run-out volume of $24m^3/m$, an expected run-out distance of 15.08m is estimated from the slope toe.

Catchment 6B

Calculations show that for a CE run-out volume of $24m^3/m$, an expected run-out distance of 15.64m is estimated from the slope toe.

Catchment 7

Calculations show that for a CE run-out volume of $24m^3/m$, an expected run-out distance of 14.66m is estimated from the slope toe.

Catchment 8

Calculations show that for a run-out volume of $24m^3/m$, an expected run-out distance of 14.97m is estimated from the slope toe.

Catchment 9

Calculations show that for a run-out volume of $24m^3/m$, an expected run-out distance of 22.38m is estimated from the slope toe.

The findings of the open hillslope hazard assessment are summarised in Table 6.6.

7 ASSESSMENT OF ROCK/BOULDER FALLS

7.1 General

The objectives of the boulder study has been to identify all boulders which pose a threat to the development area and to propose appropriate remedial measures to reduce the risk to an acceptable level.

7.2 Boulder Study

The site survey of the hillsides involved the inspection of all boulders within the catchment area above the development. Where active erosion, typified by an absence of vegetation, is evident and therefore providing a potential failure trigger mechanism, the boulder has been classed as having low stability. Where active erosion is not ongoing, typified by stable vegetation, boulders are classed as having a high stability. The boulder study has been carried out on site and the results are included below.

Each of the low stability boulders has then been classified in terms of shape, potential failure mechanism and risk to the development. In particular, it is judged whether the likely trajectory of the boulder would result in its reaching or stopping before the development. The former case would be deemed high risk, the latter low risk. All high-risk boulders have been recommended for preventive works.

Based on the past design submission for Contract No. EP/SP/29/95, Tseung Kwan O Landfills Restoration Contract, Stage II/III Boulder Stabilisation (prepared by Swire BFI & BCL in 1998), boulders with size $>2m^3$ were considered to be of low or intermediate stability and at risk of falling/sliding to the landfill. The summary made in this report presented that there are more than 500 boulders exposed in the hillside above the Stage II/III landfill site. Approximately 400 were of sufficient size to warrant close inspection and classification.

Of these, 75 boulders have been rated as having low or intermediate stability and therefore classified as high risk. Of these, 38 boulders were rated as low stability and therefore recommended for stabilisation works. During site inspection carried out in November 2001, it was seen that the boulder stabilisation works proposed in 1998 had been carried out (see Plates 10 and 12) and no stability problems were observed.

However, site inspection carried out in July 2002 revealed the presence of two potentially high-risk boulders in Catchment Nos. 2 and 4 (see Plates. 9 and 11). The boulders of medium stability category have been classified on the basis of shape, potential failure mode, and recommended preventive works. The results of the study are summarised in Table 7.1 and the mitigation measures described in the following section.

7.3 Rock Fall Study

The only location where rockfalls are considered a possibility is in Catchment 4 where numerous rock outcrops occur within the 80m high natural terrain, which slopes at an angle of between 23° to 32° (predominantly <30°).

Empirical studies of rockfall have been carried out by several authors. The most commonly quoted reference is the work done by Ritchie (1963) for the Washington State Highway Commission in the United States. Ritchie's work involved the use of slow-motion cameras to record hundreds of full-scale rockfall tests. Most of the study involved hard basaltic rocks and natural or excavated slopes of varying ages. Ritchie observed that the prevalent modes of rockfall motion were as follows:

- rolling on slopes at less than 45°,
- bouncing on slopes in the range of 45°-75°;
- falling on slopes steeper than 75°.

The natural slopes above the proposed site is generally at angles between 23° to 32° (predominantly <30°) and covered by vegetation. Given that the friction angle between boulder and slope surface would have greater than 30° (i.e. slope angle predominantly < friction angle) boulder movement triggered by erosion or thermal effects are unlikely to occur.

Site inspection reveals that previous stabilization measures have been carried out within this catchment. Consequently, no further boulder study is considered necessary.

8 MITIGATION MEASURES

8.1 Introduction

Mitigation measures generally fall into one of the three categories: the slowing down by means of absorbing energy; to divert by redirection; and to stop by means of a barrier. The effects of the first are hard to determine and these measures are normally utilised as a factor of safety rather than a designed feature. The effects of the second and third are easier to determine once the size, velocity and direction of the debris flow have been determined as recommended by GEO Report No. 104.

8.2 Proposed Mitigation Measures

The proposed conceptual mitigation measures are designed to isolate the natural slopes from the proposed development and to adequately protect the development from landslide debris. The measures proposed have taken into account isolated boulders in catchments 2 and 4, and channelised debris flows and open hillslope landslide failures elsewhere.

The options of either a retaining structure or a ramp-up barrier or bund have been considered as mitigation measures for this site. However, it is considered that the construction of a retaining structure would result in disturbance of the landfill capping system. In addition, the ramp-up barrier (earth bund) is considered to be the most cost-effective, and environmentally acceptable.

Calculations show that all channelised debris flows could be contained within a 2.5m high earth bund located approximately 14m distance from the drainage line entry point onto the landfill waste slopes. Similarly, all open hillslope failures could be contained within a 2.5m high earth bund located approximately 3m from the edge of the platform. Calculations showing the heights and distances for the bund is given in Appendix G, and are summarised in Table G2.

Consequently it is proposed to construct a 2.5m high earth bund at a minimum distance of 3m from the platform edge, or 14m from a drainage line entry point (or projected entry point) onto the platform, whichever is the greater, around the site. Given the low susceptibility of Catchment 2, it is considered that the bund could be omitted around this part of the platform, although a 4m sterile zone isolated by fencing could be considered as a precaution.

The general arrangement is shown in the Mitigation Strategy Map in Appendix H.

If this option is to be adopted, several factors need to be considered, including:

- Access to the catchwater within the isolated sterile zone for maintenance
- Realigning the existing assess road where it encroaches within the bund/ sterile zone

With regard to access to the catchwater, this could be achieved by breaks in the bund at strategic locations, or else ramps over the top at intervals.

Previous boulder stabilisation works had been carried out. However, site inspection revealed that two potentially high-risk boulders in Catchment Nos. 2 and 4 require stabilising/preventive measures. It is recommended that Boulder D1 be removed and dentition be carried out on Boulder D2. Removal and breaking up of boulder D1 should be by splitting using pneumatic percussive drilling using either dynamic or chemical means. Care should be taken to avoid dislodging the boulder during splitting. The removal of Boulder D2 would affect the stability of the surrounding boulders and thus dentition has been considered the best stabilising measure.

In all cases, environmental acceptability with respect to visual impact of the proposed measures needs to be considered, and specialist landscaping advice sought.

9 CONCLUSIONS

The API in association with the NTLI Database and site walkover confirmed that there is evidence of relict and recent landsliding within several of the catchments within the study area. No distressed ground and tension cracks are observed during the site inspection. However, concealed open joints were observed in trial pit TP4 situated near the crest of Catchment No. 6A and indicates the presence of potential instability.

Based on assessment results, it is considered that channelised debris flows, boulder falls and open hillslope landslides all form potential hazards.

Landslide source volumes have been estimated from a statistical appraisal of site specific relict and recent landslide scars, and a comparison with regional landslide data. A landslide source volume of 240m^3 has been determined as a conservative size.

Mitigation measures for both types of landslides and boulder falls have been determined on a catchment by catchment basis. A ramp-up barrier such as an earth bund, is proposed along the toe of the slope where potential hazards have been identified and boulders require stabilisation/preventive measures. In addition, it is recommended that where barriers are not required, a restricted zone, isolated by fencing be incorporated along the toe of the natural terrain.

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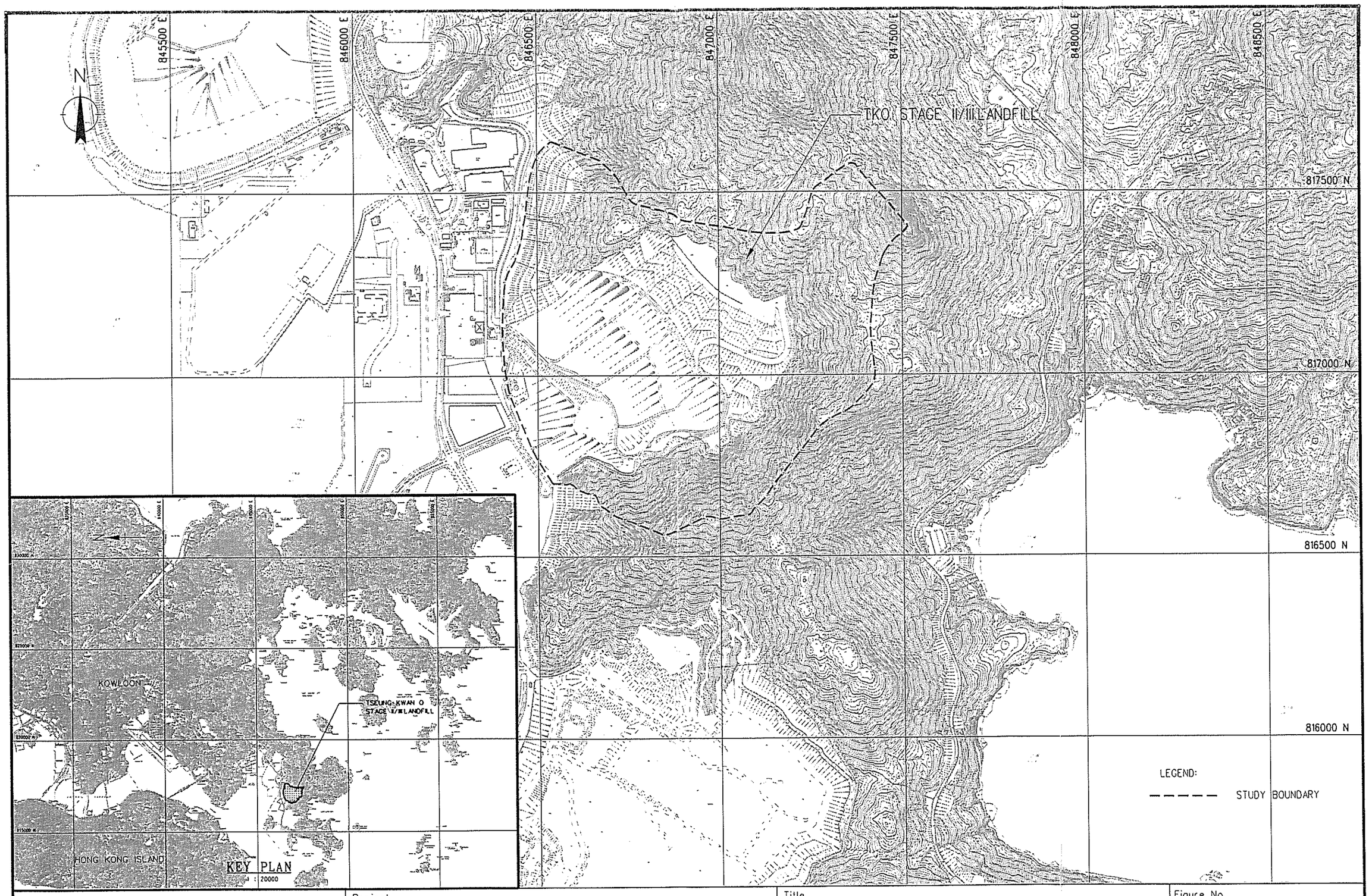
19. Binnie Black & Veatch HK Limited, June 2001, Tseung Kwan O Landfills Restoration Contract. Slope Design Annual Review Report.

End of Text

FIGURES



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Engineers and Scientists

Project	Tseung Kwan O Stage II/III Landfill Afteruse Development
Prepared By:	SMO
Checked By:	KWK
Title	SITE LOCATION PLAN
Figure No.	1
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12SW-A/C178

12SW-A/C180

12SW-A/C177

12SW-A/C176

12SW-A/C174

12SW-A/C175

12SW-A/C173

PART 'I'

12SW-A/C76

12SW-A/C183

PART 'II'

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12SW-A/C185

12SW-A/C186

12SW-A/C187

12SW-A/C188

12SW-A/C181

PART 'I'

PART 'D'

12SW-A/C165

12SW-A/C203

PART 'D'

12SW-A/F74

12SW-A/F73

12SW-A/F72

PART 'B'

12SW-A/F68

12SW-A/F70

12SW-A/F69

12SW-A/F67

PART 'G'

PART 'H'

ENTRANCE 'C'

LEGEND:

- LANDFILL BOUNDARY
- STUDY BOUNDARY
- GEO REGISTERED FILL SLOPE
- GEO REGISTERED CUT SLOPE

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.
2. ALL LEVELS ARE IN METRES ABOVE PRINCIPAL DATUM.
3. ALL DIMENSIONS ARE TYPICAL AND TO BE CONFIRMED AT DETAILED DESIGN.

Approved

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Contract no.

Contract
GEOTECHNICAL REVIEW AND SITE INVESTIGATION WORKS FOR TSEUNG KWAN O STAGE II/III AFTERUSE DEVELOPMENT

Figure Title

TSEUNG KWAN O STAGE II/III LANDFILL GEO REGISTERED SLOPES

Figure no.	Scale
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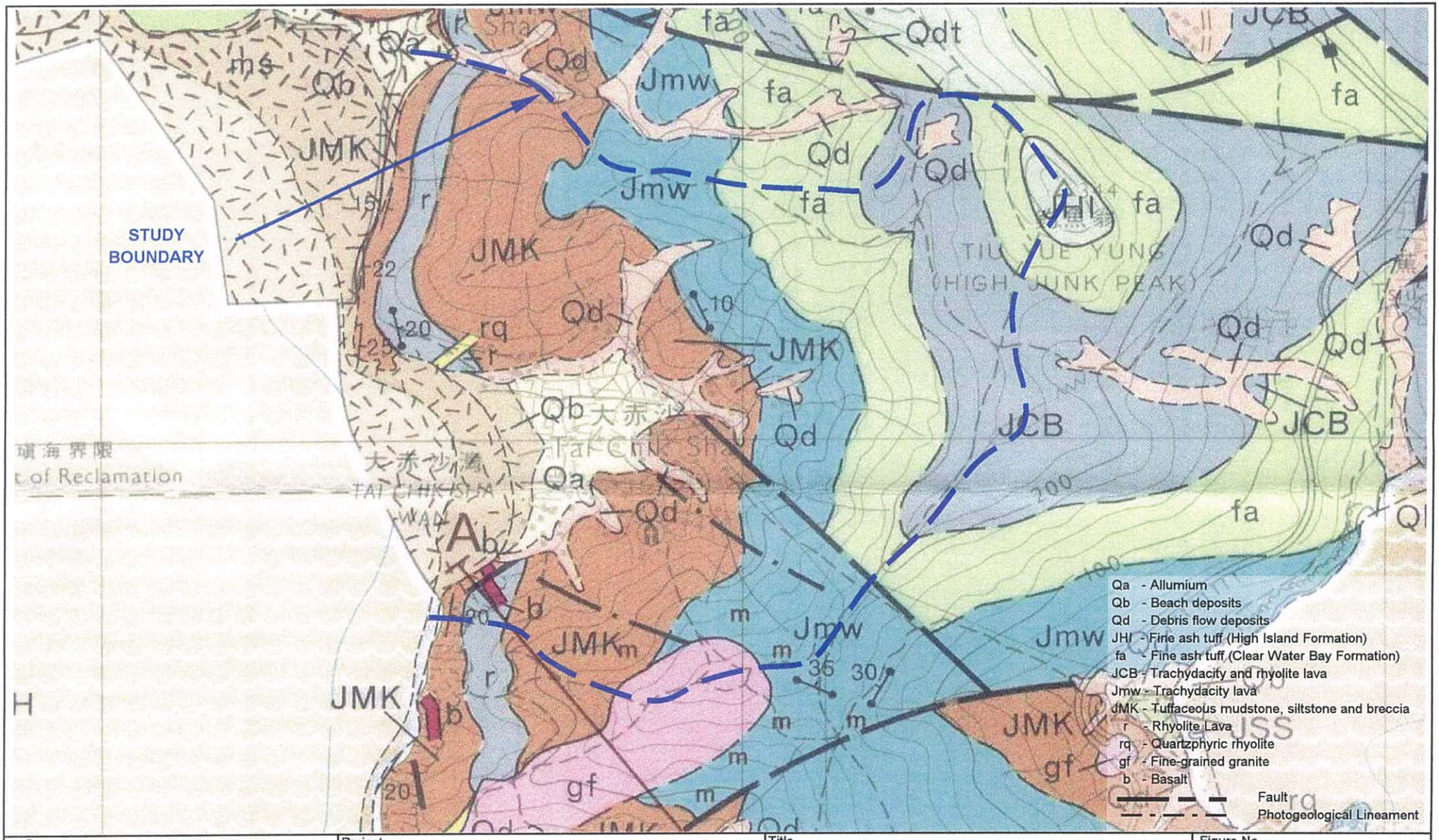

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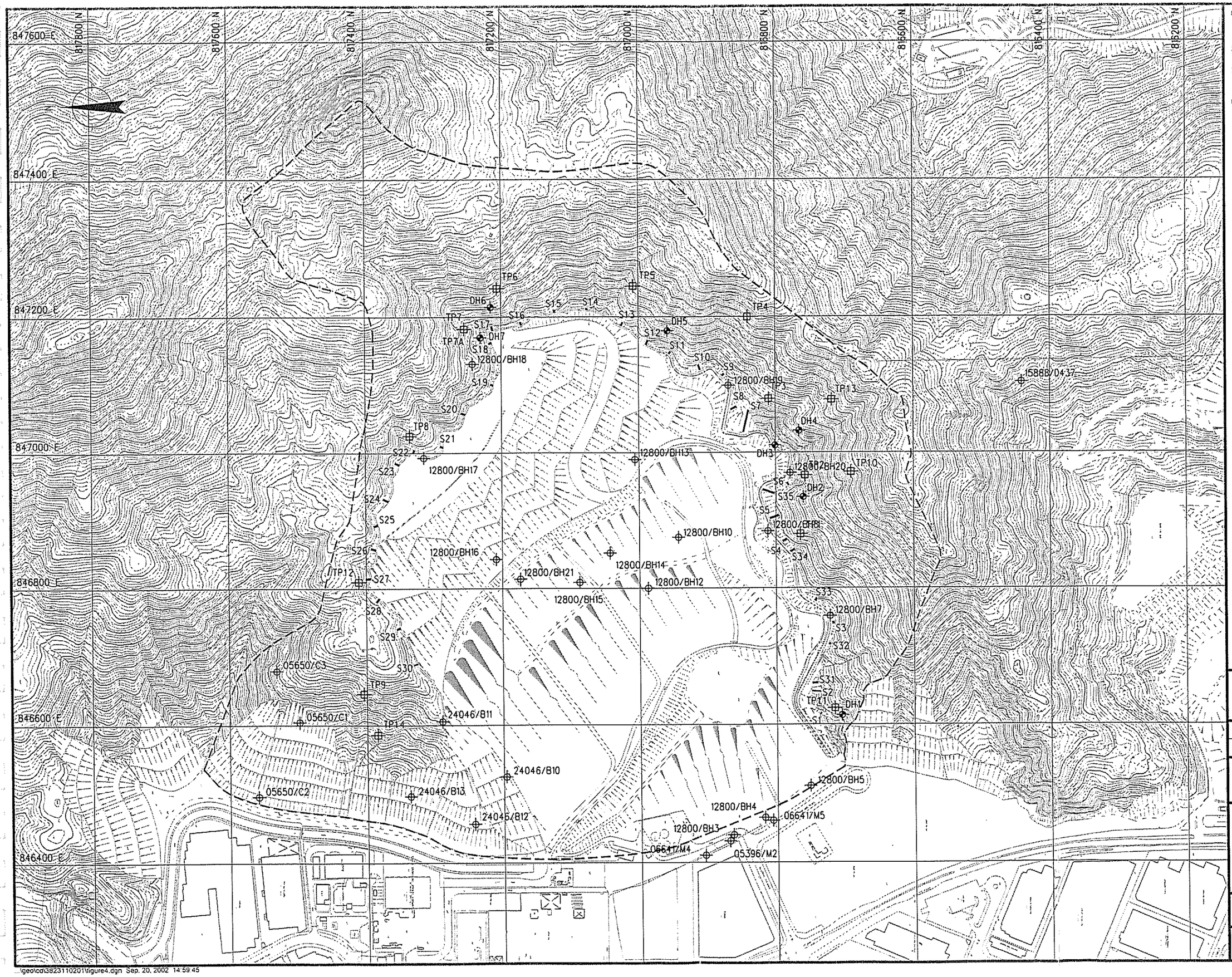

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3. ALL DIMENSIONS ARE TYPICAL AND TO BE CONFIRMED AT DETAILED DESIGN.

LEGENDS:

- EXISTING DRILLHOLES
- RECENT TRIALPITS
- DH1 — RECENT DRILLHOLES
- S1 — RECENT SLOPE STRIPPING
- STUDY BOUNDARY

Approved

ORIGINAL SIGNED BY C. DUTTON

CAD ref. MAIN : FIGURE-4.DGN
XREF : B12SW06B.D, B12SW01B.D, B12SW02A,B,C,D & B12SW07A,B,C,D.DGN

Contract no. FD01-052

Contract
GEOTECHNICAL REVIEW AND SITE INVESTIGATION WORKS FOR TSEUNG KWAN O STAGE II/III AFTERUSE DEVELOPMENT

Figure Title
LOCATION PLAN OF EXISTING AND RECENT GI

Figure no. 4

Scale 1 : 5000

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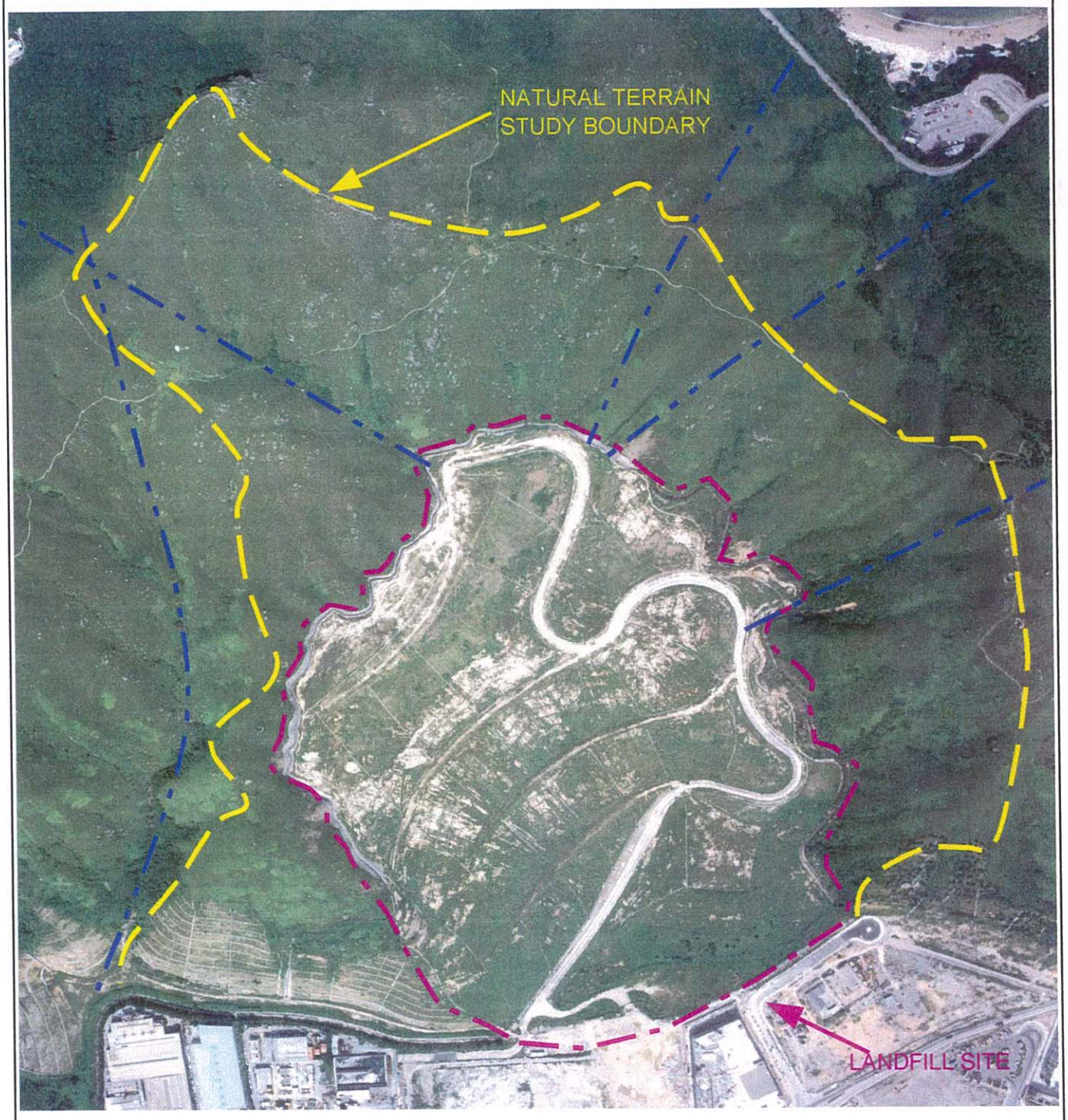

LEGEND:

Photogeological Lineament

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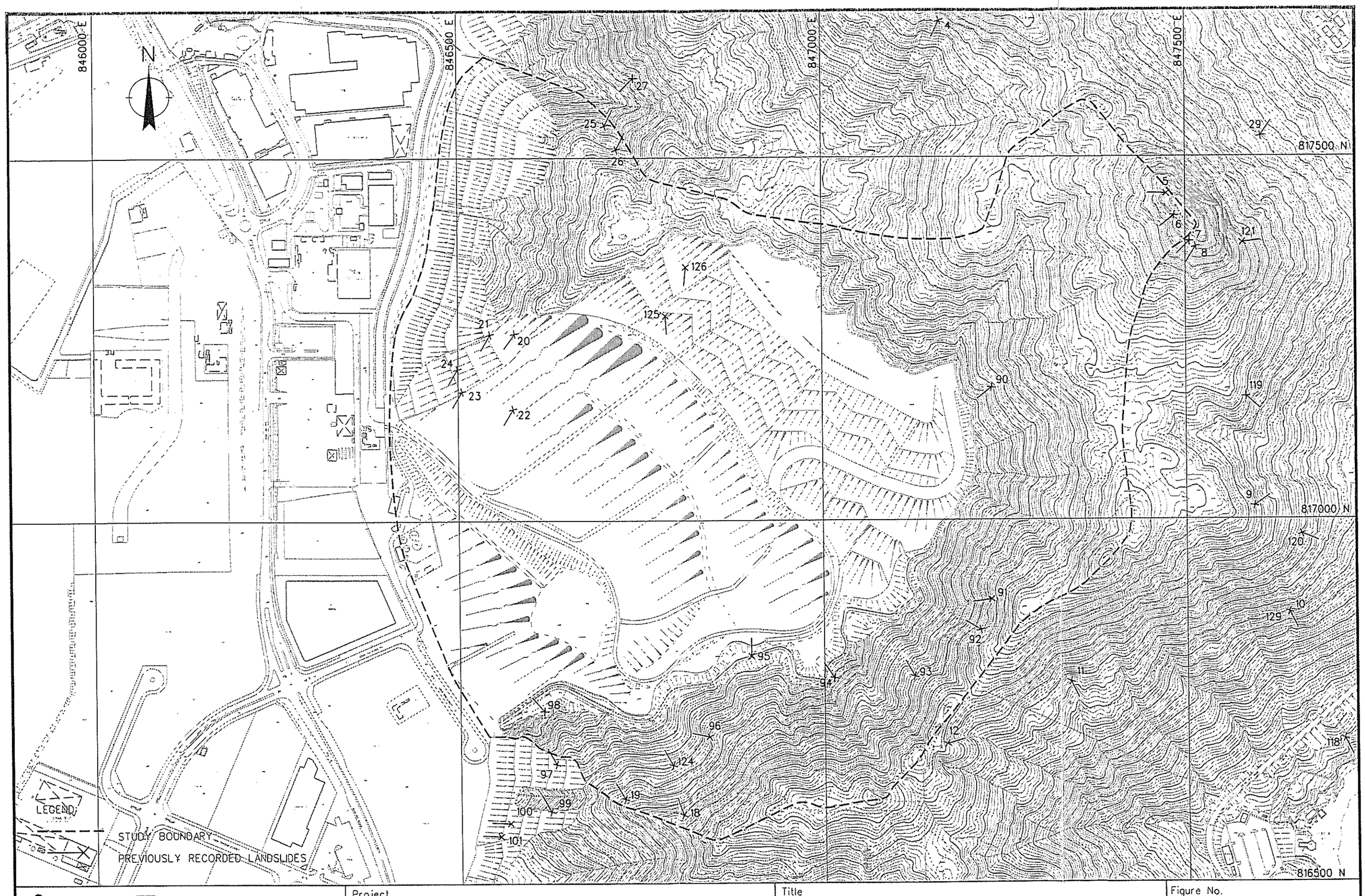

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Project	Tseung Kwan O Stage II/III Landfill Afteruse Development
Prepared By:	SMO
Checked By:	KWK
Title	NATURAL TERRAIN LANDSLIDE INVENTORY MAP
Figure No.	6
Scale	1 : 5000

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NOTES:

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2. ALL LEVELS ARE IN METRES ABOVE PRINCIPAL DATUM.
3. ALL DIMENSIONS ARE TYPICAL AND TO BE CONFIRMED AT DETAILED DESIGN.

LEGENDS:

- (1) CATCHMENT NOS.
- CATCHMENT BOUNDARY
- (1) PHOTO NO.
- FIELD TRAVERSES
- NATURAL TERRAIN BOUNDARY

Approved

ORIGINAL SIGNED BY C. DUTTON

CAD ref. MAIN : FIGURE-7.DGN
XREF : B12SW06B.D, B12SW01B.D, B12SW02A,B,C,D & B12SW07A,B,C,D.DGN

Contract no. F001-052

Contract
GEOTECHNICAL REVIEW AND SITE INVESTIGATION WORKS FOR TSEUNG KWAN O STAGE II/III AFTERUSE DEVELOPMENT

Figure Title

FIELD INSPECTION TRAVERSE AND LOCATIONS OF PHOTOGRAPHS FOR NATURAL SLOPES

Figure no. 7

Scale 1 : 5000

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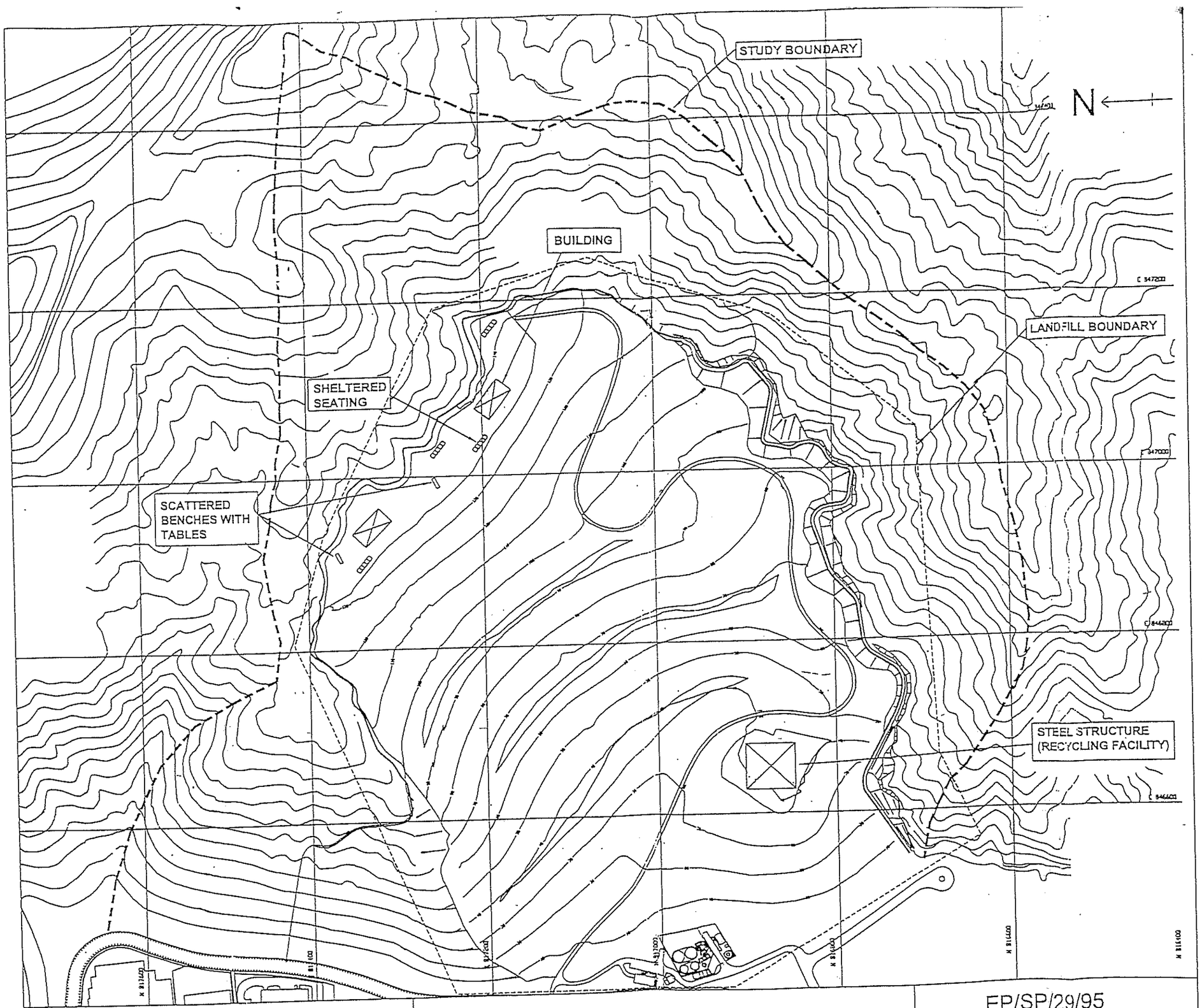


ENVIRONMENTAL PROTECTION DEPARTMENT
THE GOVERNMENT OF THE HONG KONG SPECIAL ADMINISTRATIVE REGION

FIGURE 8 - Tseung Kwan O Landfill Stage II/III
Conceptual Design

EP/SP/29/95

2001-29D.DWG

20 JULY 2001

TABLES

Table 4.1 Summary of Aerial Photographs

Level of Photograph	Photo No. (Year)
High-Flight	Y00432-3 (1945), Y12906-8 (1964), 8038-9 (1973), 9709-10 (1974), A01724-A01725 (1985), CN16263-CN16264 (1996), CN18613-CN18615 (1997) and CN25715-CN25715 (1999).
Low-Flight	Y08353-4 (1963), Y13343-4 (1967), 9303-9305 (1974), 14973-14974 (1976), 30720 (1980), 44300 (1982), 47500-47501 (1983), A07542-A07543 (1986), A07375-A07376 (1986), A10847-A10848 (1987), A14141 (1988), A16794-A16796 (1989), A20554-A20555 (1990), A25266-A25267 (1991), A32763-A32764 (1992), A37384-A37386 (1993), A38017-A38019 (1994), CN10018-CN10020 (1995), CN14306-CN14307 (1996) CN17111-CN17112 (1997), CN21382-CN21383 (1998) A48421-A48423 (1998) and A49687-A49688 (1999).

Table 6.1 No. of Natural Slope Landslide reports for the period 1992 - 1998

Year	No. of Natural Slope Landslide Reported	No. of Landslide Volume < 50m^3	List of Landslide Volume > 50m^3					
1992	51	49	200	300				
1993	94	83	65	450	94	422	72	245
			450	500	84	300	750	
1994	59	55	500	200	100	55		
1995	26	23	95	50	100			
1996	9	9						
1997	88	70	400	150	2000	750	500	200
			100	100	170	150	78	80
			100	150	500	750	3000	100
1998	28	19	<100	560	150	225	50	300
			900	80	60			
(total)	**355**	**308**						

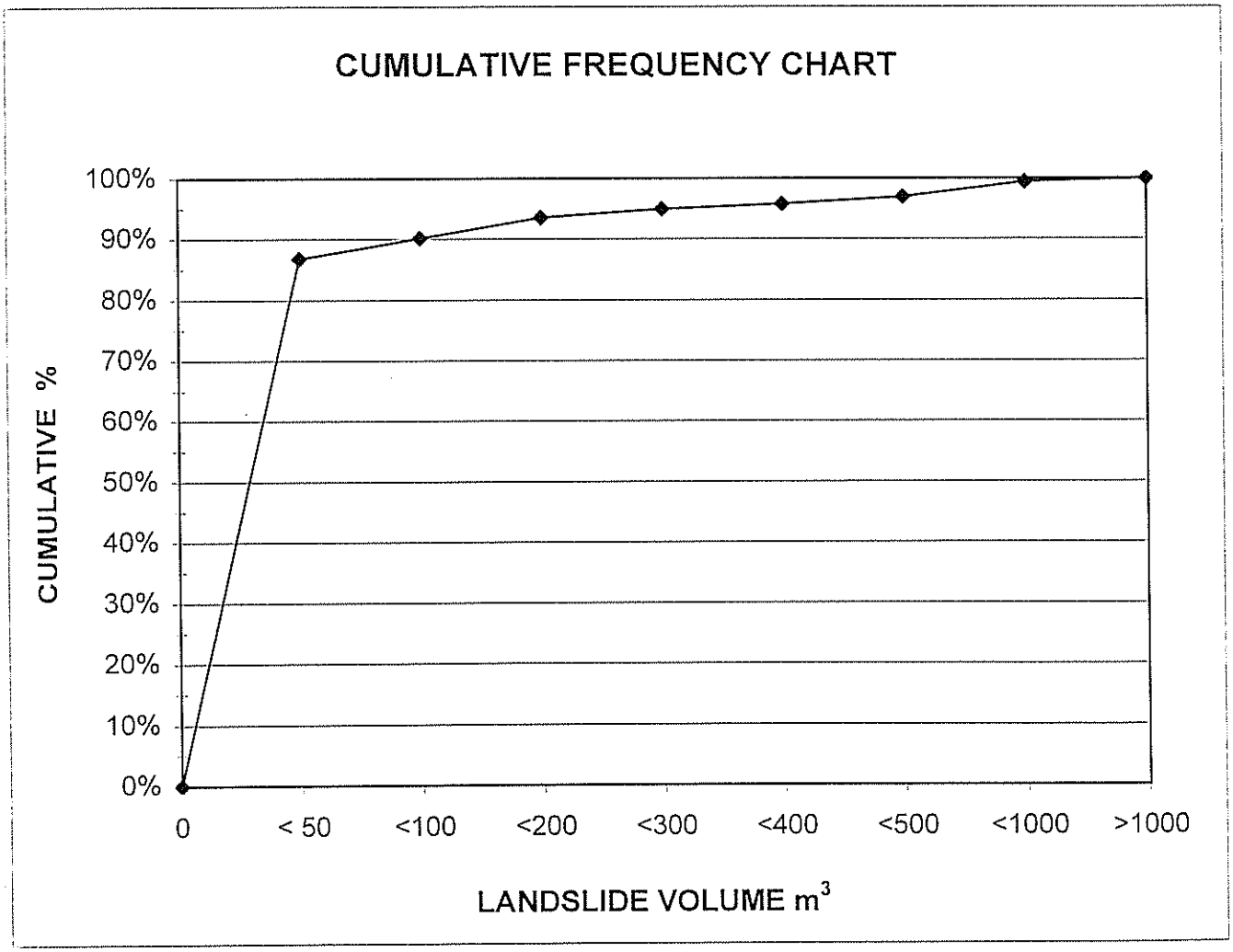


Table 6.2 Inventory of Landslide Scars (to be continued)

Landslide No	Estimate slip scar volume (m^3) (See Note 2)	Width (m) (See Note 1)	From API	From NTLI	Remarks
1	132.3	9 (3.5)		1945, 1964	NTLI Tag No. 97
2	50	7 (1.7)		1945, 1964	NTLI Tag No. 98
3	72	12 (1.0)	Yes	1945	NTLI Tag No. 19
4	90	15 (1.0)	Yes	1945	NTLI Tag No. 18
5	54	10 (1.0)		1974, 1975	NTLI Tag No. 124
6	92.4	13 (1.0)	Yes	1964, 1973	NTLI Tag No. 96
7	72.9	9 (1.5)	Yes		
8	162	15 (1.5)	Yes		
9	60	10	Yes - 1997		
10	163.8	13 (1.5)	Yes		
11	129.6	12 (1.5)	Yes		
12	50.4	8 (1.5)	Yes - 2000		Rock slope failure
13	176.4	14 (1.5)	Yes	1945, 1964	NTLI Tag No. 93
14	72.6	11 (1.0)	Yes		
15	135	15 (1.0)	Yes	1945, 1964	NTLI Tag No. 92
16	108	15 (1.0)	Yes	1945, 1964	NTLI Tag No. 91
17	108	12 (1.5)		1945, 1964	NTLI Tag No. 90
18	135	15 (1.0)	Yes		
19	168	20 (1.0)	Yes		
20	86.4	12 (1.0)	Yes	1945	NTLI Tag No. 6
21	100.8	14 (1.0)	Yes	1945	NTLI Tag No. 5
22	48	10 (1.0)		1945, 1964	NTLI Tag No. 94

Notes:

1 The width refers to the maximum width of the scar, assuming a roughly circular plan area (thickness of colluvium from GI information or 1.5 for WCE and 1.0 for CE).

2 Circular slip surface is assumed for the source volume estimation (i.e. 60% of W x L x D).

Table 6.2 Inventory of Landslide Scars (continued)

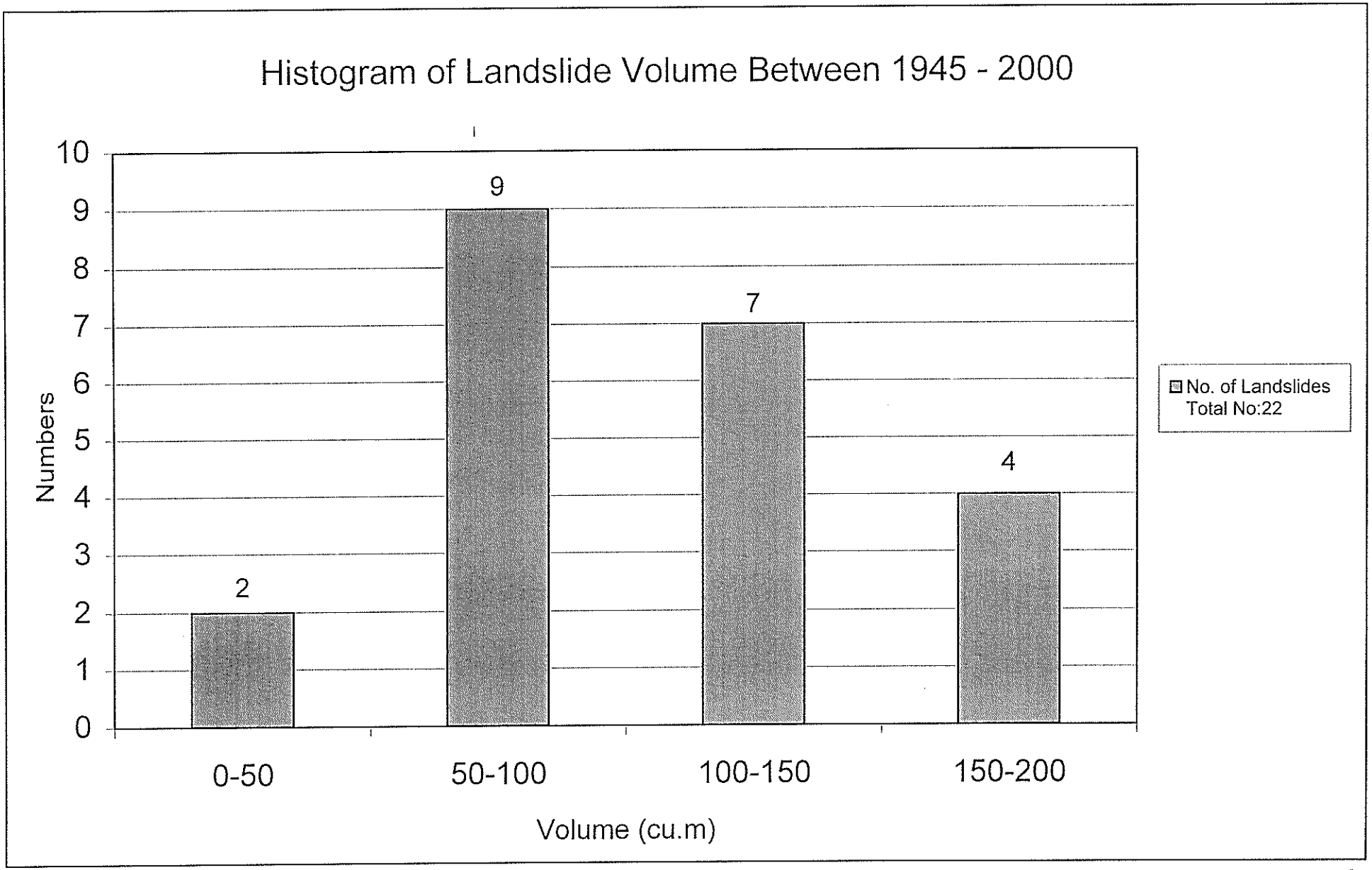


Table 6.2 Inventory of Landslide Scars (continued)

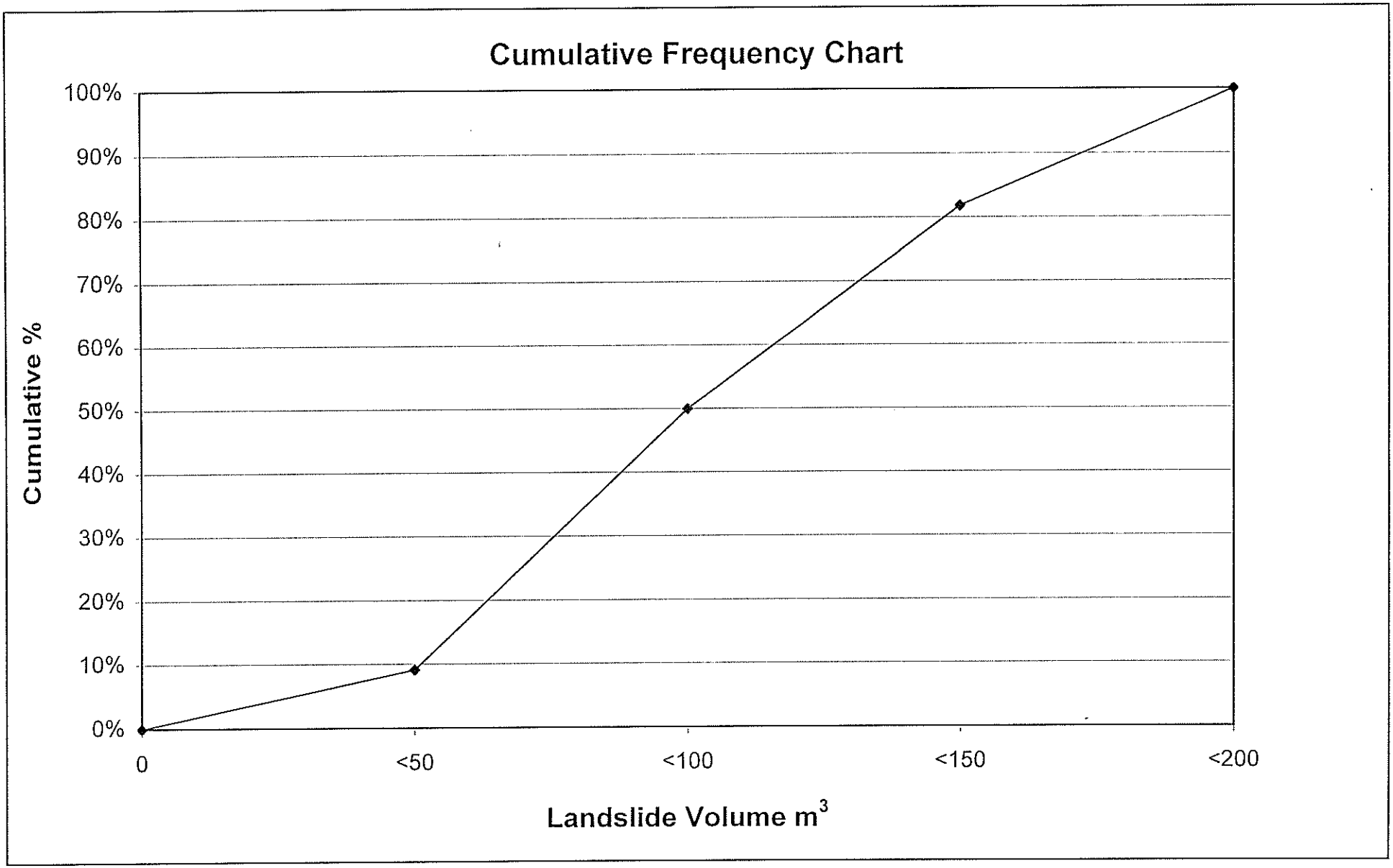


Table 6.3 Design Requirements Summary Table

Catchment	Facility	Facility Group [1]	Consequence Class [3]	Susceptibility Class [4]	Design Requirements [2]
1	Built-up area	3	II - Moderately close	X	N
2	Formed slope	3	II - Very close	D	N
3	Temporary offices	1	II - Moderately close	C	CE
4	Access Road	1	II - Moderately close	C	CE
5	Access Road	3	III - Moderately close	C	CE
6A	Access Road	3	III - Moderately close	C	CE
6B	Access Road	3	III - Moderately close	C	CE
7	Access Road	3	III - Moderately close	B	CE
8	Access Road	3	III - Moderately close	C	CE
9	Access Road	3	III - Moderately close	B	CE
	Steel Structure	1	III-Far	B	CE

Note: (1) Please refer to Table 1
(2) Please refer to Table 2
(3) Please refer to Table 3
(4) Please refer to Table 4
X Does not affect landfill platform

Table 6.4 Estimation of Channelised Debris Flow Volume for Each Catchment

Catchment No.	Susceptibility Class	Design Landslide Event	Upper Drainage Line Angle (degrees)	Lower Drainage Line Angle (degrees)	Source Volume (m^3)	9% Deposition of Initial Volume from Main Scrap	Length of Drainage Line (m)	Possible Length of Erosion (i.e.Colluvium in Drainage Line & gradient >20°) (m)	Designed Erosion Rate (m^3/m)	Entrainment Volume (m^3)	Run-out Volume (m^3)	Trail Width (m)	Thickness of Deposition (m)	Length of Deposition (streambed gradient <20°) (m)	Total Volume of Deposition on Channel (m^3)	Final Run-out Volume (m^3)	Expected Run-out Distance (m)
3	C	CE	28	5	240	22	208	208	2.3	478.4	697	6	3.22	0	0	**697**	36.05
4 (Case 2)	C	CE	36	5	240	22	145	145	2.3	333.5	552	6	2.96	0	0	**552**	31.06
5	C	CE	29	5	240	22	208	208	2.3	478.4	697	6	3.27	0	0	**697**	35.48
6A	C	CE	41	10	240	22	144	144	2.3	331.2	550	6	2.02	0	0	**550**	45.34
6B	C	CE	32	10	240	22	144	144	2.3	331.2	550	6	1.71	0	0	**550**	53.48
7	B	CE	32	10	240	22	178	178	2.3	409.4	628	6	1.96	0	0	**628**	53.48
8	C	CE	32	10	240	22	190	190	2.3	437	655	6	2.04	0	0	**655**	53.48
9	B	CE	31	15	240	21.6	210	210	2.3	483	701	6	1.07	0	0	**701**	109.37

Note:

1. Refer to Table 9, GEO Report No. 57, of channelised failure:
   % deposition of initial volume from main scrap = **9%**
   Erosion Rate = **2.3 m^3/m (CE)**
   Trail width = **6m** (CE)
   Thickness of deposition should be read in conjunction with summary table of debris flow calculation in Appendix I
2. N/A = Not Applicable because out of project area.

Table 6.5
Summary Table for Channelised Debris Flows

Catchment No.	Design Landslide Event	Entry Channel Slope Angle (°)	Final Run-Out Volume (m^3)	Expected Run-Out Distance (m)
3	CE	56	697	36.05
4 (Case 1)	CE	42	0	-
4 (Case 2)	CE	36	552	31.06
5	CE	29	697	35.48
6A	CE	41	550	45.34
6B	CE	32	550	53.48
7	WCE	32	1,197	81.85
8	CE	32	655	53.48
9	CE	31	701	109.37

Table 6.6
Summary Table for Open Hillslope Landslides

Catchment No.	Design Landslide Event	Slope Angle (°) at Slope Toe	Final Run-Out Volume (m^3/m)	Expected Run-Out Distance (m)
3	CE	56	24	11.84
4	CE	60	24	12.06
5	CE	59	24	12.01
6A	CE	57	24	15.08
6B	CE	70	24	15.64
7	WCE	50	30	16.39
8	CE	55	24	14.97
9	CE	60	24	22.38

Table 7.1
Summary of Boulder Survey

Boulder No.	Size (m^3)	Catchment No.	Shape	Stability Rating (1)	Risk Rating (2)	Potential failure Mechanism (3)	Stabilisation/ Preventive Works
1	2.88	2	Cubic-subrounded	M	H	R	Removal
2	1.44	4	Cubic-subangular	M	H	T	Dentition

Notes: (1) M-Medium
(2) H-High
(3) R- Rolling
T-Toppling

APPENDICES

APPENDIX A

Summary of GASP Report VII and Existing Borehole Records

GASP Report VII

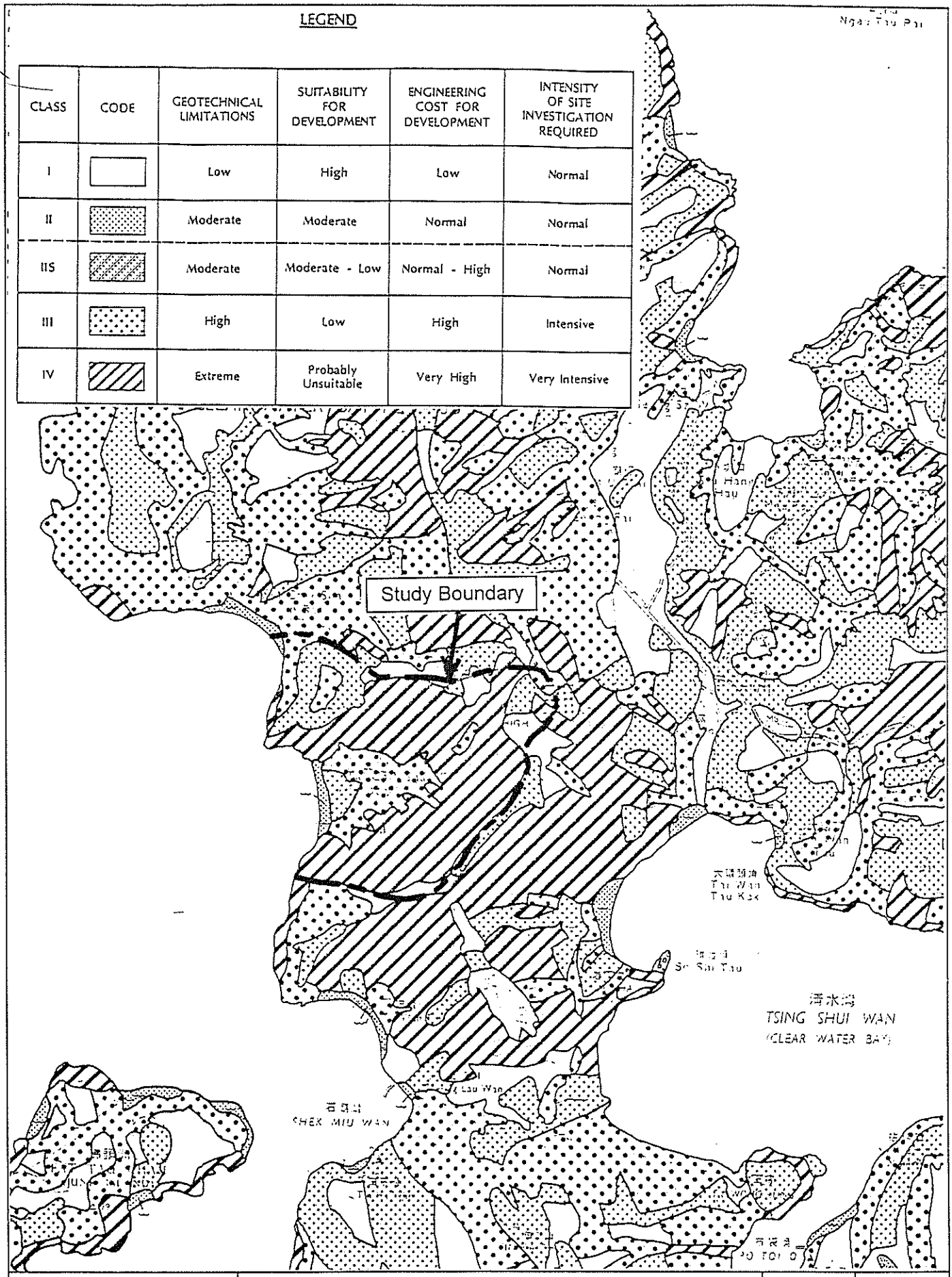
The Geotechnical Area Studies Programme (GASP) Report VII for the Clear Water Bay area (1988), issued by the Geotechnical Engineering Office, has been consulted and relevant information is summarised below with relevant maps shown as Figures B1 to B3. It should be noted that this information only discusses the site during its pre-operation condition.

Maps (Figure No.)	Remarks
GLUM (Figure A1)	1. The site is classified as having predominantly extreme geotechnical limitations, probably unsuitable for development requiring a very high engineering cost and very intensive site investigation. Localised areas of moderate to high geotechnical limitations are situated in the western portion of the site which require a normal to high engineering cost and normal to intensive site investigation.
Physical Constraints Map (Figure A2)	1. The central region of the site is identified as zones of colluvium which are subject to overland flow and periodic inundation with evidence of unusual groundwater regime. The majority of the site surrounding this central region is identified as zones of general instability associated with predominantly insitu terrain. 2. Localised zones of general instability associated with predominantly colluvial terrain is situated in the southern portion of the site and slopes on insitu terrain which are generally steeper than 30° occur in the westernmost region of the site.
Engineering Geology Map (Figure A3)	1. The site is shown to be located on the Repulse Bay Formation of mainly banded acid lavas, some welded tuffs in the east and dominantly pyroclastic rocks in the west. The two rock types usually produces a thin (<1m) soil horizon followed downwards by yellowish brown sandy completely weathered material overlying less weathered, locally strongly jointed rock below an average depth of 11m. The stability of the weathered material and of highly jointed rock masses may be suspect, especially during or immediately after prolonged rainfall. Failures are quite common and rapid surface run-off predicted. There are few opportunities for creation of platforms with usable sites small and fragmented. 2. The central region of the site is located in colluvium which occur as independent deposits of a unique age such that one deposit overlies another. The older deposits may be subject to severe weathering. The depth of such weathering may be in the order of 10m or more. This material has moved in the geologic past and is prone to reactivation if not carefully treated by such measures as low batter angles, drainage and surface protection, especially when saturated. Has low to moderate bearing capacity characteristics and should always be drained. Voids may cause settlement of roads, services and buildings.

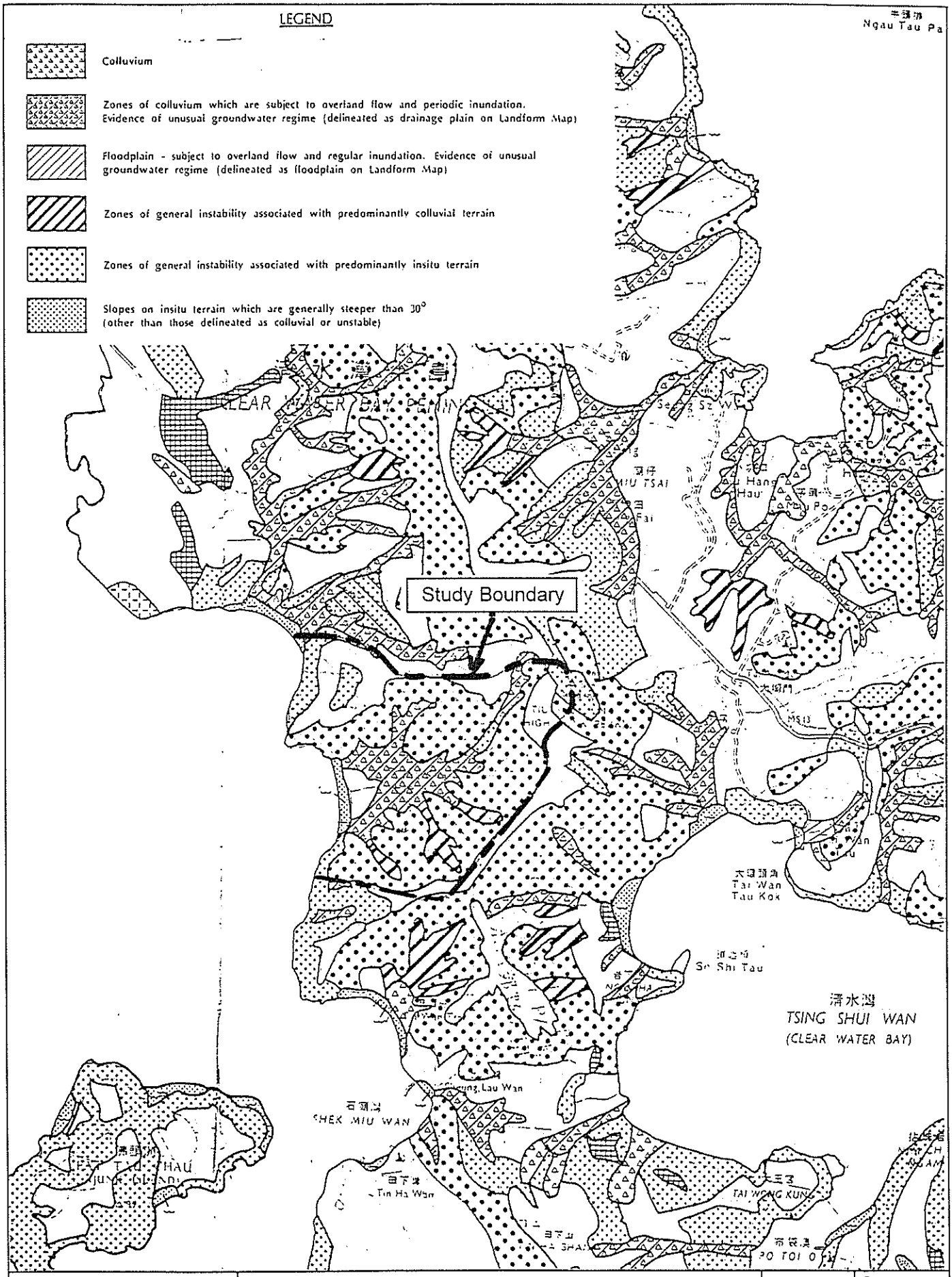
	3. In the southernmost tip of the site, granophyric microgranite occurs which weathers to produce a clayey silty sand with corestones. Depths of weathering in excess of 20m can occur. Weathered material may be unstable if undercut. Joints control stability in any rock cutting. 4. Several geological photolineaments cut the site, trending approximately East-West, North-South and NW-SE.

LEGEND

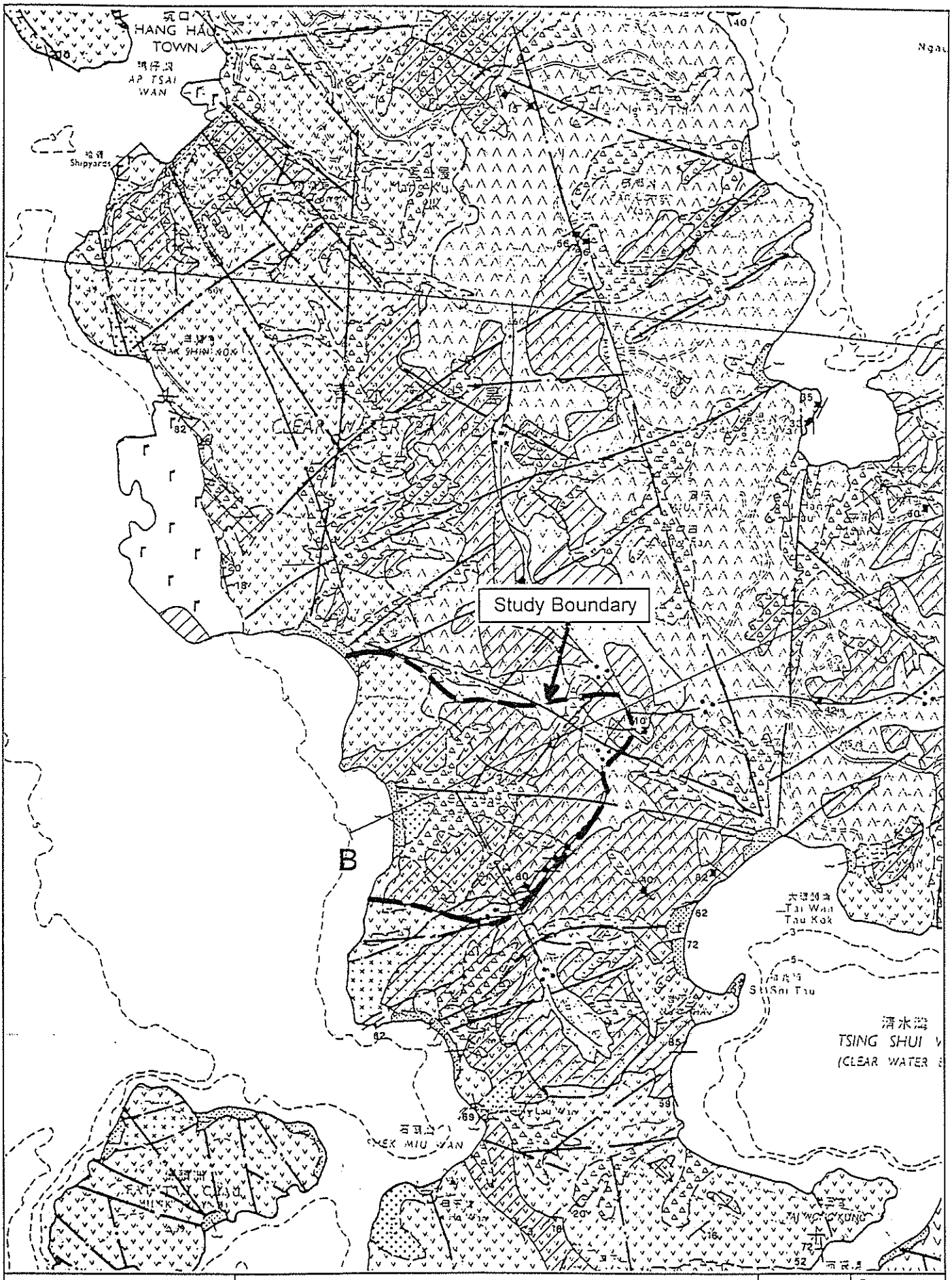
CLASS	CODE	GEOTECHNICAL LIMITATIONS	SUITABILITY FOR DEVELOPMENT	ENGINEERING COST FOR DEVELOPMENT	INTENSITY OF SITE INVESTIGATION REQUIRED
I		Low	High	Low	Normal
II		Moderate	Moderate	Normal	Normal
IIS		Moderate	Moderate - Low	Normal - High	Normal
III		High	Low	High	Intensive
IV		Extreme	Probably Unsuitable	Very High	Very Intensive



Binnie	Project: Tseung Kwan O Stage II/III Landfill Afteruse Development	Prepared by: SMO	Date: Nov 01
Figure No: A1	Title: Geotechnical Land Use Map	Scale: 1:20 000	



Binnie	Project: Tseung Kwan O Stage II/III Landfill Afteruse Development	Prepared by: SMO	Date: Nov 01
Figure No: A2	Title: Physical Constraints Map	Scale: 1:20 000	



Binnie	Project: Tseung Kwan O Stage II/III Landfill Afteruse Development	Prepared by: SMO	Date: Nov 01
Figure No: A3a	Title: Engineering Geology Map	Scale: 1:20 000	

Map unit	Weathering and Soil Development	Engineering Comment (Stability, Foundation, Hydrogeology)	Material Uses and Excavation Characteristics
RECLAMATION / FILL	These materials placed by man have no soil (pedogenic) or weathering profile but may contain weathered rocks or be underlain by natural superficial deposits and/or a pre-existing weathered profile.	Few problems if properly compacted. Old fill slopes may be poorly compacted and subject to failure. Steep excavations require support. High groundwater requires special drainage. Low bearing pressures can be accepted directly, high loads need raft, spread or piled foundations. Settlement problems minor except in sanitary landfill which may have associated leachate and gas problems.	These areas, when properly formed, provide platforms with high development potential. Care should be taken in excavation of sanitary landfill when biodegradation is incomplete.
LITTORAL DEPOSITS	Nil	Materials are usually saturated and saline. Raised beaches may be leached by rainwater but may remain saline at depth. Groundwater extraction may induce incursion of saline water. Poor grading characteristics—low fines. Low bearing pressures can be accepted directly, moderate and high loads need raft, spread or piled foundations.	Main development potential is as beaches for recreational purposes. Excavation of these materials is usually prohibited.
ALLUVIAL DEPOSITS	In subaerial locations very minor development of soil horizon. Relict deposits may be more weathered. Very old deposits may contain completely weathered boulders.	Locally low-lying terrain may be subject to flooding. Materials are usually saturated and of a low density – clay layers are normally consolidated. Buried channels may pose local problems of high water flows into tunnels or excavations. Steep excavations require support. Groundwater may be saline if adjacent to coast. Incursion of saline groundwater following abstraction of fresh groundwater may occur. Low bearing pressures can be accepted directly, moderate and high loads need raft, spread or piled foundations.	Land deposits easily excavated. Marine deposits often form reasonable hydraulic fill. Excavation by cutter, suction or bucket dredger.
COLLUVIUM: VOLCANIC DERIVED / GRANITIC DERIVED / MIXED	Colluvium can occur as independent deposits of a unique age such that one deposit overlies another. The older deposits may be subject to severe weathering and may be completely decomposed to a mottled, coloured sandy silt or clayey silt similar to the insitu residual deposits of their parent materials. The depth of such weathering may be in the order of 10 m or more.	This material has moved in its geologic past and is prone to reactivation if not carefully treated by such measures as low batter angles, drainage, and surface protection, especially when saturated. Has low to moderate bearing capacity characteristics but should always be carefully drained because it may be susceptible to failure when wet. Voids may cause settlement of roads, services and buildings. Tunnelling probably difficult. Site investigation likely to be difficult and expensive.	May be used for borrow due to its ease of excavation by machine, broad grading characteristics and relative ease of access on hillsides. Some stream fill bouldery deposits will be of limited use. Large boulders may require blasting or splitting.
SEDIMENTARY VOLCANICLASTIC AND EXTRUSIVE IGNEOUS ROCKS / REPULSE BAY FORMATION: SEDIMENTARY AND WATER-LAID VOLCANICLASTIC ROCKS	Shallow to moderately deep, reddish to brown, fine, sandy to silty clay, i.e. residual soil sometimes with ferruginous gravel and weathered rock fragments, overlying completely to highly weathered rock which grades into less weathered strongly jointed volcanic rock at depths from 5–20 m.	The sediments are bedded and fissile and weather relatively rapidly to a grey silt when exposed. Some stability problems may arise. Groundwater regime may be controlled by the bedded character of the rock.	Can be scraped and ripped when weathered. Fresh rock will need pneumatic machines or blasting. Due to highly variable properties and presence of chert bands, this material would not make a good source of aggregate but is well suited for filling.
ACID LAVAS	Rock usually develops a thin (< 1 m) soil horizon and a thin (< 10 m) weathered zone before passing rapidly into moderately to slightly weathered bedrock.	Stability of weathered material and also of highly jointed rock masses may be suspect, especially during or immediately after prolonged heavy rainfall. Failures are quite common, especially in over-steepened slopes. Rapid surface runoff is common. Stability of rock slopes controlled by relatively closely spaced discontinuities in moderately weathered to fresh rock mass. —Few opportunities for creation of platforms: usable sites may be small and fragmented. —Access route selection hampered by terrain. —Tunnelling probably easier than in granitoids. Deep weathering and close jointing should be anticipated near structural geological lineaments.	Very hard and abrasive when fresh, will require blasting which may result in brittle fracture. Inadvisable for aggregate unless tested for silica/cement reaction.
MAINLY BANDED ACID LAVAS, SOME WELDED TUFFS / AGGLOMERATE / DOMINANTLY PYROCLASTIC ROCKS	Rock usually produces a thin (< 1 m) soil horizon, followed downwards, especially on lower slopes, by yellowish brown sandy completely weathered material overlying less weathered, locally strongly jointed rock below an average depth of 11 m. On steep, high slopes considerable rock exposure occurs, with thin soil or weathering cover.		Material can be used for fill if it is weathered locally. It is possible to quarry, although very hard and not generally favoured. Coarse crystal tuff horizons may provide good aggregate.
INSTRUSIVE IGNEOUS ROCKS (PLUTONIC): GRANOPHYRIC MICROGRANIT	Weathers to produce a clayey silty sand with corestones. Depth of weathering similar to other granites. Fresh rock outcrops in stream beds on occasions.	Weathered material may be unstable if undercut. Joints control stability in any rock cutting.	Weathered material could be machine excavated for use as fill. Fresh rock will require blasting.

General instability

Binnie	Project: Tseung Kwan O Stage II/III Landfill Afteruse Development	Prepared by: SMO	Date: Nov 01
Figure No: A3b	Title: Engineering Geology Map	Scale: 1:20 000	

Existing Borehole Records and GI Information

27 boreholes drilled in and adjacent to the proposed works area have been reviewed. Drillhole locations are shown in Figure 8. In general, the information indicates that the ground conditions at or near the area could be of 9 types of stratification. Materials encountered in the boreholes are summarised below:

Soil/Rock Types	Thickness (m) / (basal) mPD	SPT 'N' value	Descriptions
Fill (Landfill)	12.0- 18.0 / -6.54 to -10.15		Landfill material of layers of gravel, sand and rock fill.
Fill	1.15 / +18.75		Cobble, gravel with silty Sand.
Topsoil	0.7-1.0	10	Loose, reddish pink & brown, silty Sand to clayey sandy Silt with gravel & cobbles.
Colluvium	0.5-1.50	20	Soft, brownish red sandy silty Clay with gravel & cobbles of volcanic.
Marine Deposit	4.0-6.0 / -9.85 to –11.5		Very soft, greenish grey Silt/Clay to clayey silty Sand with shell fragments.
Alluvium	0.60-6.8 (at base; -13.21 to -16.65 and midslope +32.9)	43 – 90	At base of terrain – stiff, greenish yellow silty Clay. At midslope, 0.60m silty Sand with cobbles.
C-HDV PW 30 – 50	0.44 – 15.6 / At base; 11-16/ +8.9 to –29.85; 0.45-15.6/ +23.5 to +39.43; 4.53-8.8/ +70.10 to +88.90; 0.44 / +107.38	8 – 209	Dense to very dense, yellowish and reddish brown, grey, silty to clayey SAND to fine sandy clayey Silt with some gravel (completely to highly decomposed volcanic).
M/HDV	1.0-3.5/ -30.85 to – 31.51; 6.6/+21.0; 1.0/+58.26; 2.9-5.3/ +78.48 - +81.1; 2.62/+133.68		Moderately weak to moderately strong, light purple & brown, grey fine to medium grained Volcanic.
Rockhead	+7.4 – +25.1; +31.35 - +39.43; +57.26 - +88.90; +107.38; +133.68 - +162.36 (mPD)		Moderately strong to very strong, grey, moderately to slightly decomposed (M-SD) fine to medium grained Volcanic with closely to very widely spaced joints.

Recent Borehole Records and GI Information

7 boreholes drilled and 14 trial pits excavated on the natural slopes surrounding the proposed development have been reviewed. Drillhole locations are shown in Figure 4. In general, the information indicates that the ground conditions at or near the area could be of 8 types of stratification. Materials encountered in the boreholes are summarised below:

Soil/Rock Types	Thickness (m) / (basal) mPD	SPT 'N' value	Descriptions
Fill	0.5 –2.59 / +84.87, +139.77, +152.68		Firm, greyish brown, sandy silt to silty fine to coarse Sand with gravel.
Topsoil	0.5 / +140.27		Firm, grey, silty fine to medium Sand with gravel.
Colluvium	1.0 / +40.69; 1.50 / +112.36 to +125.01	8	Soft to firm, yellowish to greyish brown, sandy Silt/Clay and silty fine to coarse Sand with gravel, cobbles & boulder sized volcanic.
Residual Soil	1.0 / +38.19, +111.86, +169.73		Firm, yellowish brown, sandy clayey Silt.
C-HD Rhyolite PW 30 – 50	>11.60 / +26.59 (SW)	42 - >100	Rhyolite; brown, dappled red and white, silty fine to coarse Sand to fine to coarse Gravel
C-HD Trachydacite Lava/Tuff PW 30 – 50	0.12 – 4.3 / +107.56 to +124.89; 1.30 / +138.47; 0.72 / +151.96; 7.60 / +162.13	17 - 67	Firm to very stiff, yellowish brown and light grey, sandy Silt to silty clayey fine to coarse Sand or fine to coarse Gravel sized rock fragments.
M/HD Trachydacite Lava/Tuff	4.96 – 9.53 / 79.91 to 98.03; 6.8 / +118.11; 2.83 /+135.64; 5.05/+157.08;		Moderately weak to moderately strong, light brown, dappled white and red, Trachydacite Lava; greenish grey fine ash Tuff.
Rockhead	7.55 bgl / 79.91; 8.40 bgl / +118.11; 5.13 bgl / +135.64; 1.22 to 13.65 bgl / +151.96 to +157.08		Moderately strong to very strong, grey, stripped dark grey, moderately to slightly decomposed (M-SD) Trachydacite Lava/Tuff with closely to medium spaced joints.

GEOTECHNICS & CONCRETE ENGG. (H.K.) LTD.

GROUND INVESTIGATION DEPARTMENT

HOLE NO. DH1

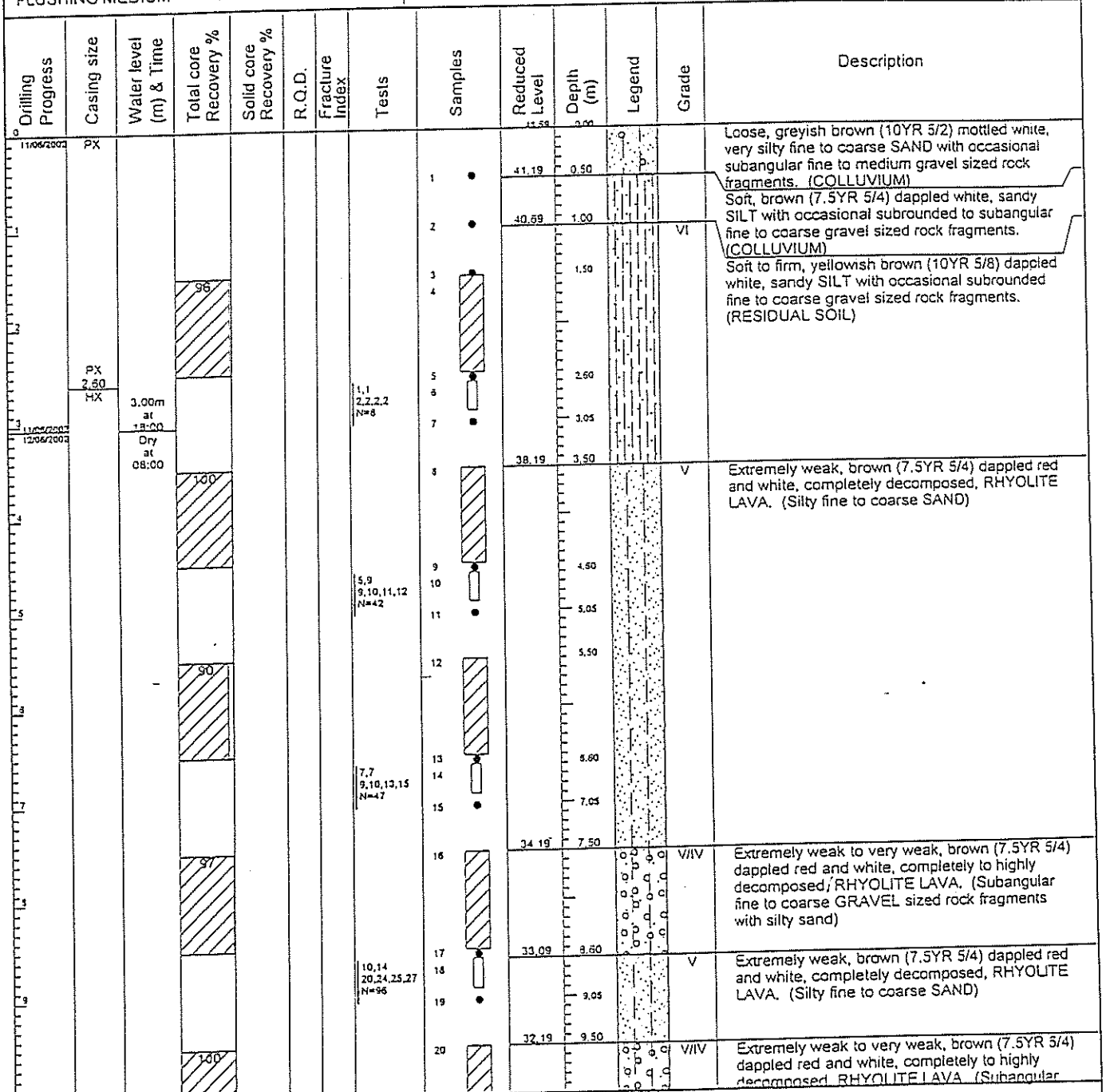
SHEET 1 of 2

DRILLHOLE RECORD

CONTRACT NO. GE/2001/13

PROJECT Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

METHOD	Rotary Cored	CO-ORDINATES E 846613.47 N 816705.21	Works Order No. GE/2001/13.10
MACHINE & No.	DR86		DATE from 11/06/2002 to 13/06/2002
FLUSHING MEDIUM	Air-Foam	ORIENTATION Vertical	GROUND LEVEL 41.69 mPD



- SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U76 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE
- PISTON SAMPLE
- WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- IMPRESSION PACKER TEST
- IN-SITU VANE SHEAR TEST
- PACKER TEST

LOGGED K.L. Lo

DATE 14/06/2002

CHECKED Tom Lo

DATE 17/06/2002

REMARKS
1. Standpipe was installed at 15.10m depth.

GEOTECHNICS & CONCRETE ENGG. (H.K.) LTD.

GROUND INVESTIGATION DEPARTMENT

HOLE NO. DH1

SHEET 2 of 2

DRILLHOLE RECORD

CONTRACT NO. GE/2001/13

PROJECT Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

METHOD	Rotary Cored	CO-ORDINATES E 846613.47 N 816705.21	Works Order No. GE/2001/13.10
MACHINE & No.	DR86		DATE from 11/06/2002 to 13/06/2002
FLUSHING MEDIUM	Air-Foam	ORIENTATION Vertical	GROUND LEVEL 41.69 mPD

Drilling Progress	Casing size	Water level (m) & Time	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
10	HX												fine to coarse GRAVEL sized rock fragments with silty sand)
							8,15 17,17,22,31 N=87	21 22 23	31.09	10.60		V	Extremely weak, brown (7.5YR 5/4) dappled red and white, completely decomposed, RHYOLITE LAVA. (Silty fine to coarse SAND)
11		10.50m at 18:00							30.19	11.05 11.50			
12/06/2002 13/06/2002		10.96m at 08:00	0					24	29.69	11.80 12.00		V/IV	Extremely weak to very weak, brown (7.5YR 5/4) dappled red and white, completely to highly decomposed, RHYOLITE LAVA. (Subangular fine to coarse GRAVEL sized rock fragments with silty sand)
12			80					25				V	Extremely weak, brown (7.5YR 5/4) locally dappled white, completely decomposed, RHYOLITE LAVA. (Very stiff, sandy SILT)
13								26		13.00 13.10			
							24,26/75mm 73,27/11mm (100blS/86mm)	27 28		13.34			
	HX 14.00								27.89	13.80		V	Extremely weak, brown (7.5YR 5/4) dappled white, completely decomposed, RHYOLITE LAVA. (Silty fine to coarse SAND)
14			97					29					
15		13.50m at 18:00					A	30	26.59	15.10			Hole completed at 15.10m.
16													
17													
18													
19													
20													

- SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U76 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE
- PISTON SAMPLE
- WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- IMPRESSION PACKER TEST
- IN-SITU VANE SHEAR TEST
- PACKER TEST

LOGGED K.L. Lo

DATE 14/06/2002

CHECKED Tom Lo

DATE 17/06/2002

REMARKS

GEOTECHNICS & CONCRETE ENGG. (H.K.) LTD.

GROUND INVESTIGATION DEPARTMENT

HOLE NO. DH2

SHEET 1 of 3

DRILLHOLE RECORD

CONTRACT NO. GE/2001/13

PROJECT Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

METHOD	Rotary Cored	CO-ORDINATES E 846934.31 N 816760.17	Works Order No. GE/2001/13.10
MACHINE & No.	DR129		DATE from 07/06/2002 to 10/06/2002
FLUSHING MEDIUM	Air-Foam	ORIENTATION Vertical	GROUND LEVEL 113.36 mPD

Drilling Progress	Casing size	Water level (m) & Time	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
07/06/2002	PX							1		0.50			Firm to stiff, brown (7.5YR 5/4) dappled red and white, sandy SILT with occasional subangular to subrounded fine to coarse gravel sized rock fragments. (COLLUVIUM)
								2	112.36	1.00		VI	Firm, brown (7.5YR 5/4) dappled white and red, sandy SILT. (RESIDUAL SOIL)
								3	111.86	1.50		V	Extremely weak, yellowish brown (10YR 5/8) dappled white and red, completely decomposed, TRACHYDACITE LAVA. (Firm, sandy SILT)
	PX 2.00 HX		92					4					
								5	110.76	2.60			
							3,5 5,6,10,13 N=34	6				V	Extremely weak, light grey (7.5YR 7/1) dappled white and streaked red, completely decomposed, TRACHYDACITE LAVA. (Stiff, slightly sandy SILT)
								7	109.86	3.50			
			100					8				V/IV	Extremely weak to very weak, brown (7.5YR 5/4) dappled grey, white and red, completely to highly decomposed, TRACHYDACITE LAVA. (Subangular fine to coarse GRAVEL sized rock fragments with silty sand)
			95					9					
								10		4.10			
07/06/2002		Dry at 18:00											
08/06/2002		Dry at 08:00						11	108.16	5.20			
	HX 5.80						13,11 9,15,28,35 N=87	12				V/IV	Extremely weak to very weak, reddish brown (5YR 5/4) dappled white, completely to highly decomposed, TRACHYDACITE LAVA. (Silty SAND with some subangular fine to medium gravel sized rock fragments)
			91	26	19	NI		13	107.58	5.65 5.80			
						10.5	T2IQ1					IV	
						NI						III	Weak, brown dappled white and red, highly decomposed, TRACHYDACITE LAVA. Joints are closely spaced, rough undulating and rough stepped, narrow, iron and manganese oxide stained, dipping at 40° to 50° and 60° to 70°, highly fractured. From 6.14m to 6.33m : Moderately strong and moderately decomposed.
			97	0	0		T2IQ1			6.50		IV	
			100	0	0		T2IQ1		106.01	7.35			
							T2IQ1		105.86	7.50		V/IV	Extremely weak to very weak, brown (7.5YR 5/4) dappled white, completely to highly decomposed, TRACHYDACITE LAVA. (Silty SAND with some subangular fine to coarse gravel sized rock fragments)
			30	19	0				105.39	7.97		III/IV	
						NR			105.23			V/IV	
						8.7				8.30		III/IV	
			90	90	0		T2IQ1						Moderately weak to weak, brown dappled white and red, moderately to highly decomposed, TRACHYDACITE LAVA. Joints are closely spaced, rough undulating and rough stepped, very narrow, iron and manganese oxide stained, kaolin infilled (<1mm thick), dipping at 20° to 30° and 60° to 70°, locally highly fractured. From 7.97m to 8.13m : No core recovered,
			98	98	0		T2IQ1			8.80			
							T2IQ1		103.86	9.50		IV	
			34	0	0	NI	T2IQ1		103.63	9.73		V/IV	
			92	38	0					9.85		IV	

- SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U76 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE
- PISTON SAMPLE
- WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- IMPRESSION PACKER TEST
- IN-SITU VANE SHEAR TEST
- PACKER TEST

LOGGED K.L. Lo

DATE 11/06/2002

CHECKED Tom Lo

DATE 12/06/2002

REMARKS
1. Standpipe was installed at 15.33m depth.

GEOTECHNICS & CONCRETE ENGG. (H.K.) LTD.

GROUND INVESTIGATION DEPARTMENT

HOLE NO. DH2

SHEET 2 of 3

DRILLHOLE RECORD

CONTRACT NO. GE/2001/13

PROJECT Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

METHOD	Rotary Cored	CO-ORDINATES E 846934.31 N 816760.17	Works Order No. GE/2001/13.10
MACHINE & No.	DR129		DATE from 07/06/2002 to 10/06/2002
FLUSHING MEDIUM	Air-Foam	ORIENTATION Vertical	GROUND LEVEL 113.36 mPD

Drilling Progress	Casing size	Water level (m) & Time	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
10										10.00		III	assumed to be completely to highly decomposed trachydacite lava. From 8.30m to 8.45m : A subvertical joint dipping at 80° to 90°. From 9.40m to 9.50m : Weak and highly decomposed.
11			100	37	25	8.9		T2101		10.70		IV III/IV	Extremely weak to very weak, brown (7.5YR 5/4) dappled white and red, completely to highly decomposed, TRACHYDACITE LAVA. (Silty fine to coarse SAND with some subangular fine to medium gravel sized rock fragments)
			88	36	29	NI		T2101		11.35			
12						NR		T2101	101.40	11.96		V/IV	Moderately weak to weak, brown (7.5YR 5/4) dappled red and white, moderately to highly decomposed, TRACHYDACITE LAVA. Joints are closely spaced, rough undulating and rough stepped, very narrow, iron and manganese oxide stained, kaolin infilled (<1mm), dipping at 20° to 30° and 60° to 70°, locally highly fractured. From 9.73m to 10.00m : Weak and highly decomposed. From 10.00m to 10.20m : Moderately strong and moderately decomposed. From 10.00m to 10.20m : A subvertical joint dipping at 80° to 90°. From 10.20m to 10.30m : Weak and highly decomposed. From 10.30m to 10.45m : Moderately strong and moderately decomposed. From 10.45m to 10.57m : Weak and highly decomposed.
			96	78	56	1.9		T2101	101.05	12.31		II	
13		Dry at 18:00	98	52	46	12.5		T2101	100.51	12.45		III/IV	
9/6/2002						NI				12.85		IV	
10/6/2002		Dry at 08:00	95	78	32	8.0		T2101		13.40		III/IV	
14			80	51	20	NI			99.22	14.00 14.14		IV	
						NR			98.92	14.44		V/IV	
						9.0			98.82	14.54		III/IV	
15		Dry at 18:00					A	T2101	98.03	15.33		III	No core recovered, assumed to be completely to highly decomposed TRACHYDACITE LAVA.
10/6/2002													Strong, grey mottled white and black slightly decomposed, TRACHYDACITE LAVA. Joints are medium spaced, rough stepped, very narrow to extremely narrow, iron and manganese oxide stained, dipping at 40° to 50° and 60° to 70°.
16													Moderately weak, reddish brown dappled white, moderately to highly decomposed, TRACHYDACITE LAVA. Joints are closely spaced, rough undulating, very narrow, iron and manganese oxide stained, kaolin infilled (<1mm), dipping at 20° to 30° and 40° to 50°. From 13.17m to 13.50m : Weak and highly decomposed. From 14.00m to 14.14m : Weak and highly decomposed. From 14.14m to 14.44m : No core recovered, assumed to be completely to highly decomposed trachydacite lava.
17													
18													
19													Moderately strong, purplish brown, moderately decomposed, TRACHYDACITE LAVA. Joints are closely spaced, rough undulating and rough stepped, very narrow, iron and manganese oxide stained, dipping at 20° to 30°
20													

- SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U75 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE
- PISTON SAMPLE
- WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- IMPRESSION PACKER TEST
- IN-SITU VANE SHEAR TEST
- PACKER TEST

LOGGED K.L. Lo

DATE 11/06/2002

CHECKED Tom Lo

DATE 12/06/2002

REMARKS

GEOTECHNICS & CONCRETE ENGG. (H.K.) LTD.

GROUND INVESTIGATION DEPARTMENT

HOLE NO. DH2

SHEET 3 of 3

DRILLHOLE RECORD

CONTRACT NO. GE/2001/13

PROJECT Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage I/III Afteruse Development Ground Investigation

METHOD	Rotary Cored	CO-ORDINATES E 846934.31 N 816760.17	Works Order No. GE/2001/13.10
MACHINE & No.	DR129		DATE from 07/06/2002 to 10/06/2002
FLUSHING MEDIUM	Air-Foam	ORIENTATION Vertical	GROUND LEVEL 113.36 mPD

Drilling Progress	Casing size	Water level (m) & Time	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
										20.00			40° to 50° and 60° to 70°. Hole completed at 15.33m.

20 21 22 23 24 25 26 27 28 29 30

- SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U75 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE
- PISTON SAMPLE
- WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- IMPRESSION PACKER TEST
- IN-SITU VANE SHEAR TEST
- PACKER TEST

LOGGED K.L. Lo

DATE 11/06/2002

CHECKED Tom Lo

DATE 12/06/2002

REMARKS

GEOTECHNICS & CONCRETE ENGG. (H.K.) LTD.

GROUND INVESTIGATION DEPARTMENT

HOLE NO. DH3

SHEET 1 of 2

DRILLHOLE RECORD

CONTRACT NO. GE/2001/13

PROJECT Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

METHOD	Rotary Cored	CO-ORDINATES E 847010.71 N 816800.79	Works Order No. GE/2001/13.10
MACHINE & No.	DR89		DATE from 01/06/2002 to 05/06/2002
FLUSHING MEDIUM	Air-Foam	ORIENTATION Vertical	GROUND LEVEL 87.46 mPD

Drilling Progress	Casing size	Water level (m) & Time	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
01/06/2002	PX							1	86.96	0.50			Greyish brown (10YR 5/2) dappled white, silty fine to coarse SAND with some subangular to angular fine to coarse gravel sized rock fragments and occasional rootlets. (FILL)
								2	86.46	1.00			Brown (7.5YR 5/4), silty fine to coarse SAND with much subangular to angular fine to coarse gravel sized rock fragments. (FILL)
			100					3	85.96	1.50			Stiff, brown (7.5YR 5/4), sandy SILT with some subangular fine to medium gravel sized rock fragments. (FILL)
	PX 1.90							4					
	HX		100					5	85.56	1.90			Greyish brown (10YR 5/2) mottled white, very silty fine to coarse SAND with much subangular fine to coarse gravel sized rock fragments. (FILL)
								T2101	84.87	2.59			Grey (7.5YR 6/1) dappled pink, subangular BOULDER sized of no fine concrete with some subangular fine to coarse gravel sized no fine concrete fragments. (NO FINE CONCRETE)
		Dry at 18:00	100	0	0	NI				2.75		III	
01/06/2002 03/06/2002		Dry at 08:00	100	11	0			T2101				III/IV	Moderately weak, greenish grey streaked red and dappled white, moderately to highly decomposed, TRACHYDACITE LAVA.
			70	0	0			T2101		3.40			Joints are closely spaced, rough undulating, narrow, iron and manganese oxide stained, dipping at 40° to 50° and 50° to 60°, highly fractured.
						NR		T2101	83.78	3.68			From 2.59m to 2.75m : Moderately strong and moderately decomposed.
			100	100	96	7.5		T2101	83.56	3.90		III/IV	From 3.58m to 3.68m : With silty fine to coarse SAND matrix.
			90	80	0	NI		T2101		4.25		III	No core recovered, assumed to be completely to highly decomposed TRACHYDACITE.
	HX 4.75					6.0				4.75		III/IV	
			100	74	62			T2101	81.85	5.61		III/IV	Moderately strong, greenish grey streaked red and dappled brown, moderately decomposed, TRACHYDACITE LAVA.
						>20							Joints are medium spaced locally closely spaced, rough undulating and rough stepped, narrow to very narrow, iron and manganese oxide stained, dipping at 30° to 40°, 40° to 50° and 70° to 80°.
						4.3							
						NI			81.35	6.11		IV	
		Dry at 18:00				12.0							
04/06/2002						NI		T2101		6.47		III	From 4.33m to 4.41m : Moderately weak and moderately to highly decomposed.
		Dry at 08:00	100	67	56	4.0							From 5.25m to 5.35m : A subvertical joint dipping at 80° to 90°.
			100	93	69			T2101					
						NI			79.91	7.55		III/IV	Moderately weak, brown dappled light yellow, moderately to highly decomposed, TRACHYDACITE LAVA.
			100	100	77	15.0						III	Joints are closely spaced, rough stepped and rough undulating, narrow to very narrow, iron and manganese oxide stained, dipping at 20° to 30° and 50° to 60°.
						8.6							
						1.4		T2101				II	
												III	Weak, brown (7.5Y 5/4), highly decomposed, TRACHYDACITE LAVA. (Angular fine to coarse GRAVEL sized rock fragments with silty fine to coarse sand)
			100	100	100					9.10			
								T2101				II	Moderately strong, grey, striped dark and light grey dappled brown, moderately decomposed, TRACHYDACITE LAVA.
													Joints are closely spaced locally medium

- SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U75 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE
- PISTON SAMPLE
- WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- IMPRESSION PACKER TEST
- IN-SITU VANE SHEAR TEST
- PACKER TEST

LOGGED K.L. Lo

DATE 07/06/2002

CHECKED Tom Lo

DATE 08/06/2002

REMARKS

1. The original core run from 1.90m to 2.75m was divided into two segments (1.90m to 2.59m and 2.59m to 2.75m), due to the existence of no fine concrete and moderately decomposed trachydacite lava simultaneously.
2. Standpipe was installed at 12.50m depth.

GEOTECHNICS & CONCRETE ENGG. (H.K.) LTD.

GROUND INVESTIGATION DEPARTMENT

HOLE NO. DH3

SHEET 2 of 2

DRILLHOLE RECORD

CONTRACT NO. GE/2001/13

PROJECT Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

METHOD	Rotary Cored	CO-ORDINATES E 847010.71 N 816800.79	Works Order No. GE/2001/13.10
MACHINE & No.	DR89		DATE from 01/06/2002 to 05/06/2002
FLUSHING MEDIUM	Air-Foam	ORIENTATION Vertical	GROUND LEVEL 87.46 mPD

Drilling Progress	Casing size	Water level (m) & Time	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
10										10.00			spaced, rough undulating and rough stepped, very narrow, iron and manganese oxide stained, dipping at 10° to 20°, 20° to 30° and 40° to 50°. From 7.45m to 7.55m : Moderately weak, brown, moderately to highly decomposed.
			100	95	77	8.7		T2IO1		10.46		III	Moderately strong, grey stripped dark grey and light grey, dappled brown, moderately decomposed, TRACHYDACITE LAVA. Joints are medium spaced locally closely spaced, rough undulating and rough stepped, very narrow to extremely narrow, iron and manganese oxide stained, soil infilling (<5mm thick), dipping at 20° to 30°, 40° to 50° and 60° to 70°. From 8.33m to 8.96m : Strong and slightly decomposed. From 9.12m to 9.60m : An incipient vertical joint. From 9.60m to 10.18m : Strong and slightly decomposed. From 11.13m to 11.82m : Strong and slightly decomposed. Hole completed at 12.66m.
11						3.7							
		8.00m at 13:00						T2IO1				II	
04/06/2002										11.90			
05/06/2002		9.20m at 08:00	100	84	51	10.0						III	
		8.50m at				2.6	B	T2IO1	74.80	12.66			
05/06/2002													
13													
14													
15													
16													
17													
18													
19													
20													

- SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U76 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE
- PISTON SAMPLE
- WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- IMPRESSION PACKER TEST
- IN-SITU VANE SHEAR TEST
- PACKER TEST

LOGGED K.L. Lo

DATE 07/06/2002

CHECKED Tom Lo

DATE 08/06/2002

REMARKS

GEOTECHNICS & CONCRETE ENGG. (H.K.) LTD.

GROUND INVESTIGATION DEPARTMENT

HOLE NO. DH4

SHEET 1 of 2

DRILLHOLE RECORD

CONTRACT NO. GE/2001/13

PROJECT Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

METHOD	Rotary Cored	CO-ORDINATES E 847032.27 N 816765.57	Works Order No. GE/2001/13.10
MACHINE & No.	DR87		DATE from 08/06/2002 to 12/06/2002
FLUSHING MEDIUM	Air-Foam	ORIENTATION Vertical	GROUND LEVEL 126.51 mPD

Drilling Progress	Casing size	Water level (m) & Time	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
08/06/2002	PX							1	126.01	0.50			Dense, brown (10YR 4/3), silty fine to coarse SAND with much angular to subangular fine to coarse gravel sized rock fragments. (COLLUVIUM)
								2	125.51	1.00			Light yellowish brown (10YR 5/6), silty fine to coarse SAND with much angular to subangular fine to coarse gravel sized rock fragments. (COLLUVIUM)
	PX 1.50							3	125.01	1.50		V/IV	Red (5R 5/6), silty fine to coarse SAND with some angular to subangular fine to coarse gravel sized rock fragments. (COLLUVIUM)
	HX		86	0	0	NI		4 T2101	124.89	1.62		IV/III	Extremely weak, weak red (5R 4/2) mottled white, completely to highly decomposed, TRACHYDACITE LAVA. (Silty clayey fine to coarse SAND with much subangular to angular fine to coarse gravel sized rock fragments)
			95	0	0			T2101		2.20			Strong, yellowish brown, locally dappled grey and white, slightly decomposed, TRACHYDACITE LAVA.
			100	73	31	14.6		T2101		2.40		III/IV	Joints are very closely to closely spaced, rough planar and rough undulating, very narrow, iron and manganese oxide stained with clay coating (<1mm), dipping at 15° to 25°, locally 80° to 90°.
		3.50m at 18:00	100	80	55	>20		T2101		3.15		II	From 1.62m to 2.40m : Moderately weak to moderately strong and highly to moderately decomposed.
08/06/2002 10/06/2002		3.10m at 08:00	100	90	77	7.8		T2101		3.70			From 2.40m to 3.05m : Moderately strong to moderately weak and moderately to highly decomposed.
								T2101					From 4.54m to 4.78m : Subvertical joint.
			100	56	38	>20		T2101		5.16		III/II	From 5.28m to 5.61m : An 80° to 90° joint.
						11.1		T2101					From 5.28m to 6.00m : Moderately strong to strong, moderately to slightly decomposed.
	HX 6.50					NI		T2101				IV/III	From 6.00m to 6.50m : Moderately weak to moderately strong and highly to moderately decomposed.
			99	26	11			T2101		6.50		III/IV	From 6.50m to 8.40m : Moderately strong to moderately weak and moderately to highly decomposed.
10/06/2002 11/06/2002		7.20m at 18:00				16.1		T2101					
		6.50m at 08:00	98	27	13			T2101		7.38			
						NI		T2101					
						>20		T2101	118.11	8.40			
			100	93	82	8.3		T2101				II	Strong, light greenish grey striped light grey, slightly decomposed, TRACHYDACITE LAVA. Joints are closely spaced, locally medium spaced and very closely spaced, rough planar and rough undulating, very narrow, iron and manganese oxide stained, dipping at 15° to 25°, locally 80° to 90°.
						7.3		T2101					
			100	100	87			T2101		9.40			

- SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U76 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE
- PISTON SAMPLE
- WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- IMPRESSION PACKER TEST
- IN-SITU VANE SHEAR TEST
- PACKER TEST

LOGGED K.L. Lo

DATE 13/06/2002

CHECKED Tom Lo

DATE 14/06/2002

REMARKS
1. Standpipe was installed at 13.63m depth.

GEOTECHNICS & CONCRETE ENGG. (H.K.) LTD.

GROUND INVESTIGATION DEPARTMENT

HOLE NO. DH4

SHEET 2 of 2

DRILLHOLE RECORD

CONTRACT NO. GE/2001/13

PROJECT Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

METHOD	Rotary Cored	CO-ORDINATES E 847032.27 N 816765.57	Works Order No. GE/2001/13.10
MACHINE & No.	DR87		DATE from 08/06/2002 to 12/06/2002
FLUSHING MEDIUM	Air-Foam	ORIENTATION Vertical	GROUND LEVEL 126.51 mPD

Drilling Progress	Casing size	Water level (m) & Time	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
10										10.00			From 9.90m to 10.25m : Silicified.
11/06/2002		7.90m at 18:00				2.2		T2101					
12/06/2002 11		10.80m at 08:00	100	96	88	4.0				10.80			From 10.80m to 10.96m : Silicified.
								T2101					From 11.57m to 11.78m : An 80° to 90° joint.
12			100	100	89					12.22			
						2.5		T2101					
13						7.0							
12/06/2002		10.50m at 18:00					A		112.88	13.63			Hole completed at 13.63m.
14													
15													
16													
17													
18													
19													
20													

- SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U76 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE
- PISTON SAMPLE
- WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- IMPRESSION PACKER TEST
- IN-SITU VANE SHEAR TEST
- PACKER TEST

LOGGED K.L. Lo

DATE 13/06/2002

CHECKED Tom Lo

DATE 14/06/2002

REMARKS

GEOTECHNICS & CONCRETE ENGG. (H.K.) LTD.

GROUND INVESTIGATION DEPARTMENT

HOLE NO. DH5

SHEET 1 of 2

DRILLHOLE RECORD

CONTRACT NO. GE/2001/13

PROJECT Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

METHOD	Rotary Cored	CO-ORDINATES E 847179.35 N 816958.22	Works Order No. GE/2001/13.10
MACHINE & No.	DR129		DATE from 03/06/2002 to 03/06/2002
FLUSHING MEDIUM	Air-Foam	ORIENTATION Vertical	GROUND LEVEL 140.77 mPD

Drilling Progress	Casing size	Water level (m) & Time	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
01/06/2002	PX							1	140.27	0.50			Firm, dark brownish grey (2.5Y 3/2), sandy SILT with occasional rootlets, subrounded to subangular fine to medium gravel sized quartz and rock fragments. (TOP SOIL)
								2	139.77	1.00		V	Firm, greyish brown (10YR 5/2) dappled white, sandy SILT with occasional subrounded to subangular fine to medium gravel sized rock fragments. (FILL)
			70					3 4	139.27	1.50		V	Extremely weak, yellowish brown (10YR 5/8) spotted and dappled white, completely decomposed, fine ash TUFF. (Silty fine to coarse SAND with some subangular fine to medium gravel sized rock fragments)
	PX 2.30							5	138.47	2.30		III/IV	Extremely weak to very weak, brown (7.5YR 5/4), dappled light grey and black, completely decomposed, fine ash TUFF. (Subangular fine to coarse GRAVEL sized rock fragments with silty sand)
		Dry at 18:00	100	76	46	NI 6.9		T2IO1					Moderately weak to moderately strong, greenish grey, streaked red, dappled brown, moderately to highly decomposed, fine ash TUFF.
31/05/2002 03/06/2002		Dry at 08:00	94	5	0	NI		T2IO1		3.35			Joints are closely spaced, rough undulating and rough stepped, narrow to very narrow, iron oxide and manganese oxide stained, dipping at 40° to 50°, 60° to 70° and 70° to 80°.
						NR			136.54	4.23		V/IV	From 3.45m to 3.55m : A subvertical joint dipping at 80° to 90°.
			100	41	33	NI		T2IO1	136.37	4.40		III/IV	From 4.23m to 4.40m : No core recovered, assumed to be completely to highly decomposed tuff.
			100	76	48	14.8		T2IO1	135.64	4.98 5.13		III	From 4.68m to 4.98m : A subvertical joint dipping at 80° to 90°.
			97	86	81	NI 1.5		T2IO1		5.40		III/II	Strong to moderately strong, greenish grey dappled brown, slightly to moderately decomposed, fine ash TUFF.
			100	89	85	10.0 2.6		T2IO1		6.38		III	Joints are medium spaced, locally closely spaced, rough undulating and rough stepped, very narrow to extremely narrow, iron and manganese oxide stained, dipping at 20° to 30°, 40° to 50° and 70° to 80°.
									133.44	7.33		II	From 5.13m to 5.30m : A incipient subvertical joint dipping at 80° to 90°.
			100	100	85	12.0 3.5		T2IO1		8.37		III II	From 5.13m to 5.50m : Moderately strong and moderately decomposed. From 6.85m to 7.33m : Moderately strong and moderately decomposed. Strong, greenish grey spotted black, stripped dark green, dappled brown, slightly decomposed, dappled brown, slightly decomposed, fine ash TUFF. Joints are medium spaced locally closely spaced, rough undulating and rough stepped, extremely narrow, iron and manganese oxide stained, dipping at 20° to 30° and 40° to 50°. From 7.33m to 8.82m : With chlorite vein (<1mm thick), closely spaced, dipping at 40° to 50° and 70° to 80°. From 8.93m to 9.18m : Moderately strong and
										9.93			

- SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U76 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE
- PISTON SAMPLE
- WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- IMPRESSION PACKER TEST
- IN-SITU VANE SHEAR TEST
- PACKER TEST

LOGGED K.L. Lo

DATE 04/06/2002

CHECKED Tom Lo

DATE 05/06/2002

REMARKS
1. Standpipe was installed at 10.93m depth.

GEOTECHNICS & CONCRETE ENGG. (H.K.) LTD.

GROUND INVESTIGATION DEPARTMENT

HOLE NO. DH5

SHEET 2 of 2

DRILLHOLE RECORD

CONTRACT NO. GE/2001/13

PROJECT Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

METHOD	Rotary Cored	CO-ORDINATES E 847179.35 N 816958.22	Works Order No. GE/2001/13.10
MACHINE & No.	DR129		DATE from 03/06/2002 to 03/06/2002
FLUSHING MEDIUM	Air-Foam	ORIENTATION Vertical	GROUND LEVEL 140.77 mPD

Drilling Progress	Casing size	Water level (m) & Time	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
03/06/2002		Dry at 18:00	100	100	95		A	T2:101	129.84	10.93			moderately decomposed.
													Hole completed at 10.93m.

- SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U76 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE
- PISTON SAMPLE
- WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- IMPRESSION PACKER TEST
- IN-SITU VANE SHEAR TEST
- PACKER TEST

LOGGED K.L. Lo

DATE 04/06/2002

CHECKED Tom Lo

DATE 05/06/2002

REMARKS

GEOTECHNICS & CONCRETE ENGG. (H.K.) LTD.

GROUND INVESTIGATION DEPARTMENT

HOLE NO. DH6

SHEET 1 of 2

DRILLHOLE RECORD

CONTRACT NO. GE/2001/13

PROJECT Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

METHOD	Rotary Cored	CO-ORDINATES E 847214.42 N 817215.18	Works Order No. GE/2001/13.10
MACHINE & No.	DR86		DATE from 04/06/2002 to 07/06/2002
FLUSHING MEDIUM	Air-Foam	ORIENTATION Vertical	GROUND LEVEL 170.73 mPD

Drilling Progress	Casing size	Water level (m) & Time	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
04/06/2002	PX							1		0.50		VI	Firm, yellowish brown (10YR 5/8), slightly sandy SILT. (RESIDUAL SOIL)
								2	169.73	1.00		V	Extremely weak, light yellowish brown (2.5Y 6/4) dappled white, completely decomposed, fine ash crystal TUFF. (Firm to stiff, sandy SILT)
	PX 1.50	1.20m at 18:00						3		1.50			
05/06/2002	HX	Dry at 08:00	90					4					
								5	168.13	2.60		V	Extremely weak, pale brown (10YR 6/3) dappled yellow and white, completely decomposed, fine ash crystal TUFF. (Silty fine to coarse SAND)
							1,3 5,3,4,5 N=17	6		3.05			
								7		3.50			
			100					8					
								9	166.13	4.60		V	Extremely weak, light brownish grey (10YR 6/2), completely decomposed, fine ash crystal TUFF. (Silty fine to coarse SAND)
							3,6 6,7,7,8 N=28	10		5.05			
								11	165.23	5.50		V	Extremely weak, yellowish brown (10YR 5/8), completely decomposed, fine ash crystal TUFF. (Silty fine to coarse SAND with occasional subangular fine to medium gravel sized rock fragments)
			100					12		6.60			
								13					
							4,5 10,13,13,15 N=51	14		7.05			
								15	163.23	7.50		V/IV	Extremely weak to very weak, grey (7.5YR 6/1) dappled brown, completely to highly decomposed, fine ash crystal TUFF. (Subangular fine to coarse GRAVEL with silty sand)
			100					16					
	HX 8.60	5.50m at 18:00						17	162.13	8.60		III/IV	Moderately weak, brownish grey spotted white, moderately to highly decomposed, fine ash crystal TUFF. Joints are closely to very closely spaced, rough undulating and rough stepped, narrow, iron and manganese oxide stained, dipping at 10° to 20°, 40° to 50° and 70° to 80°. From 8.90m to 9.08m : A subvertical joint
08/06/2002		Dry at 08:00	100	44	11	11.8 NI		T2101				IV	
												III/IV	
			100	41	0	20.0 NI		T2101		9.51		IV	
												III/IV	

- SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U75 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE
- PISTON SAMPLE
- WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- IMPRESSION PACKER TEST
- IN-SITU VANE SHEAR TEST
- PACKER TEST

LOGGED K.L. Lo

DATE 08/06/2002

CHECKED Tom Lo

DATE 10/06/2002

REMARKS
1. Standpipe was installed at 16.53m depth.

GEOTECHNICS & CONCRETE ENGG. (H.K.) LTD.

GROUND INVESTIGATION DEPARTMENT

HOLE NO. DH6

SHEET 2 of 2

DRILLHOLE RECORD

CONTRACT NO. GE/2001/13

PROJECT Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

METHOD	Rotary Cored	CO-ORDINATES E 847214.42 N 817215.18	Works Order No. GE/2001/13.10
MACHINE & No.	DR86		DATE from 04/06/2002 to 07/06/2002
FLUSHING MEDIUM	Air-Foam	ORIENTATION Vertical	GROUND LEVEL 170.73 mPD

Drilling Progress	Casing size	Water level (m) & Time	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
						15.0			160.53	10.20		IV	dipping at 80° to 90°. From 9.08m to 9.20m : Weak and highly decomposed. From 9.44m to 9.53m : Weak and highly decomposed. From 9.95m to 10.10m : Weak and highly decomposed.
			100	66	46	NI						III/IV	
						10.0		T2101				III	
						4.4				11.50		III/IV	Moderately strong, brown grey spotted white, moderately decomposed, fine ash TUFF. Joints are closely spaced, rough undulating and rough stepped, very narrow, iron and manganese oxide stained, dipping at 20° to 30°, 40° to 50° and 70° to 80°. From 10.55m to 11.00m : Moderately weak and moderately to highly decomposed. From 11.50m to 12.12m : A subvertical joint dipping at 80° to 90°. From 11.80m to 12.40m : Moderately weak and moderately to highly decomposed. From 12.45m to 13.05m : A subvertical joint dipping at 80° to 90°.
			100	84	44							III	
						4.0		T2101				III/IV	
												III	
			100	74	40	11.1				13.08		III/IV	
								T2101	157.08	13.65		III	From 13.08m to 13.65m : Moderately weak and moderately to highly decomposed.
		Dry at 18:00				NI							Moderately strong, brown grey spotted white, moderately decomposed, fine ash crystal TUFF. Joints are closely spaced, locally medium and very closely spaced, rough undulating and rough stepped, very narrow, iron and manganese oxide stained, dipping at 20° to 30°, 40° to 50° and 60° to 70°.
06/06/2002						13.5				14.52			
07/06/2002		Dry at 08:00	100	80	48								
						>20		T2101	155.27	15.46		II	Moderately strong, brownish grey spotted white, moderately decomposed, coarse ash crystal TUFF. Joints are closely spaced, locally medium and very closely spaced, rough undulating and rough stepped, very narrow, iron and manganese oxide stained, dipping at 20° to 30°, 40° to 50° and 60° to 70°. From 15.46m to 15.68m : Strong and slightly decomposed. From 16.43m to 16.53m : A subvertical joint dipping at 80° to 90°. Hole completed at 16.53m.
						2.9				15.95		III	
						>20							
			100	90	86	11.8		T2101	154.20	16.53			
07/06/2002		Dry at 18:00											

- SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U75 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE
- PISTON SAMPLE
- WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- IMPRESSION PACKER TEST
- IN-SITU VANE SHEAR TEST
- PACKER TEST

LOGGED K.L. Lo

DATE 08/06/2002

CHECKED Tom Lo

DATE 10/06/2002

REMARKS

GEOTECHNICS & CONCRETE ENGG. (H.K.) LTD.

GROUND INVESTIGATION DEPARTMENT

HOLE NO. DH7

SHEET 1 of 1

DRILLHOLE RECORD

CONTRACT NO. GE/2001/13

PROJECT Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

METHOD	Rotary Cored	CO-ORDINATES E 847169.93 N 817230.31	Works Order No. GE/2001/13.10
MACHINE & No.	DR86		DATE from 30/05/2002 to 31/05/2002
FLUSHING MEDIUM	Air-Foam	ORIENTATION Vertical	GROUND LEVEL 153.18 mPD

Drilling Progress	Casing size	Water level (m) & Time	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples	Reduced Level	Depth (m)	Legend	Grade	Description
0 30/05/2002	HX								153.18	0.00			
									152.68	0.50		V	Dark greyish brown (10YR 4/2) dappled yellowish brown and locally white, slightly silty fine to coarse SAND with much angular to subangular fine to coarse gravel sized rock fragments and occasional rootlets. (FILL)
	HX 1.22							INSPECTION PIT	152.18	1.00		IV/V	Extremely weak, yellowish brown (10YR 5/8) mottled white, locally dappled dark brown, completely decomposed, fine ash TUFF. (Silty fine to coarse SAND with some subangular fine to medium gravel sized quartz fragments)
									151.96	1.22		III	Very weak to weak, grey (7.5YR 6/1) dappled brown, highly to completely decomposed, fine ash TUFF. (Angular to subangular fine to coarse GRAVEL with some cobble sized rock fragments)
30/05/2002 31/05/2002		0.80m at 18:00	100	50	23	NI 12.3		T2IO1		1.96			Strong to moderately strong, greenish grey spotted white and dappled yellowish brown and dark brown, slightly to moderately decomposed, fine ash TUFF. Joints are closely to medium spaced, locally widely and very closely spaced, smooth planar and smooth undulating, extremely narrow to very narrow, iron and manganese oxide stained, dipping at 5° to 15°, 20° to 30°, 55° to 65° and 70° to 80°. From 1.22m to 1.27m : Moderately weak and moderately decomposed. From 1.27m to 3.74m : Moderately strong and moderately decomposed. From 3.26m to 3.59m : An 80° to 90° joint.
		Dry at 08:00	95	83	68			T2IO1					
			100	86	86	3.7		T2IO1		3.26		II/III	
			100	100	100	1.0		T2IO1		4.09			
			100	99	89	6.1		T2IO1		5.58			
7 31/05/2002		Dry at 18:00							146.16	7.02			Hole completed at 7.02m.
10													

- SMALL DISTURBED SAMPLE
- LARGE DISTURBED SAMPLE
- SPT LINER SAMPLE
- U76 UNDISTURBED SAMPLE
- U100 UNDISTURBED SAMPLE
- MAZIER SAMPLE
- PISTON SAMPLE
- WATER SAMPLE
- PIEZOMETER TIP
- STANDPIPE
- STANDARD PENETRATION TEST
- PERMEABILITY TEST
- IMPRESSION PACKER TEST
- IN-SITU VANE SHEAR TEST
- PACKER TEST

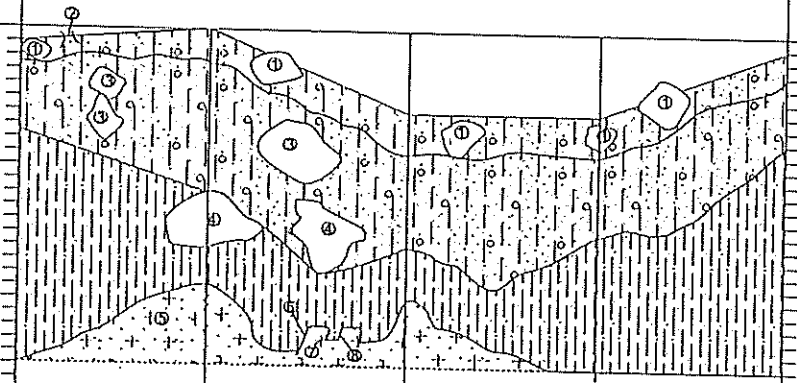
LOGGED K.L. Lo

DATE 01/06/2002

CHECKED Tom Lo

DATE 03/06/2002

REMARKS
1. Standpipe was installed at 7.02m depth.

Samples & Test	Depth (m)	Sketch	Depth (m)	Legend	Description	Grade
1, 2, 3, 4, 5	0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0		0.30, 0.5, 0.80, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0		Loose, dry, dark grey (10YR 4/1), organic, silty fine to coarse SAND with much angular fine to coarse gravel and cobble sized quartz and rock fragments and occasional boulder sized moderately decomposed tuff fragments, also with much plant rootlets. (TOP SOIL)	
					Dense, dry, brown (7.5YR 4/4) dappled red and dark grey, very silty fine to coarse SAND with much angular to subangular fine to coarse gravel and cobble sized quartz and rock fragments, also occasional boulder sized moderately decomposed tuff fragments. (COLLUVIUM)	V
					Extremely weak, dry, light grey (10YR 7/2) dappled white and yellowish brown, completely decomposed, TUFFACEOUS BRECCIA. (Stiff to very stiff, sandy SILT with occasional angular fine gravel sized quartz and rock fragments)	
					Trial pit terminated at 2.50m depth.	

① Boulders sized moderately decomposed tuff fragments of maximum size 0.20m x 0.25m.
② Tree trunk of diameter 200mm.
③ Boulder sized moderately decomposed tuff fragments of maximum size 0.35m x 0.41m.
④ Weak and highly decomposed Tuffaceous Breccia.
⑤ Moderately strong, brown dappled white, moderately decomposed, Tuffaceous Breccia. Joints are closely spaced, rough planar, extremely narrow to very narrow, iron oxide stained.
⑥ 152°/82°
⑦ 147°/80°
⑧ 347°/77°

FACE A: 1.50 m FACE B: 1.50 m FACE C: 1.50 m FACE D: 1.50 m

Notes:
1. Small disturbed samples were taken at 0.50m, 1.00m and 1.50m depths.
2. Undisturbed vertical samples (U100) were taken at 1.00m and 2.00m depths.

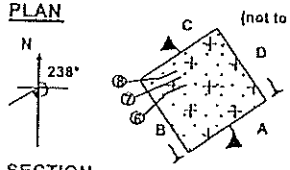
SYMBOLS

- Small Disturbed Sample
- Large Disturbed Sample
- Undisturbed Vertical Sample
- Undisturbed Horizontal Sample
- Block Sample
- In-situ Density Test
- Water Sample
- Water Seepage

REMARKS

Ground Water
No Groundwater
Plant Used
Hand dug
Shoring
Timber shoring over full height
Stability
Stable
Depth at pit centre
2.00m
Others
Nil

PLAN (not to scale)



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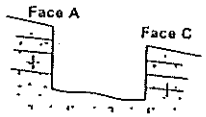


Contract No. :	GE/2001/13	
Works Order No.	: GE/2001/13.10	
Co-ordinates	:	
E 846879.71	N 816764.24	
Ground Level	: 99.76	mPD
Logged by	: K.L. Lo	
Date logged	: 03/07/2002	
Checked by	: Tom Lo	
Date Checked	: 04/07/2002	

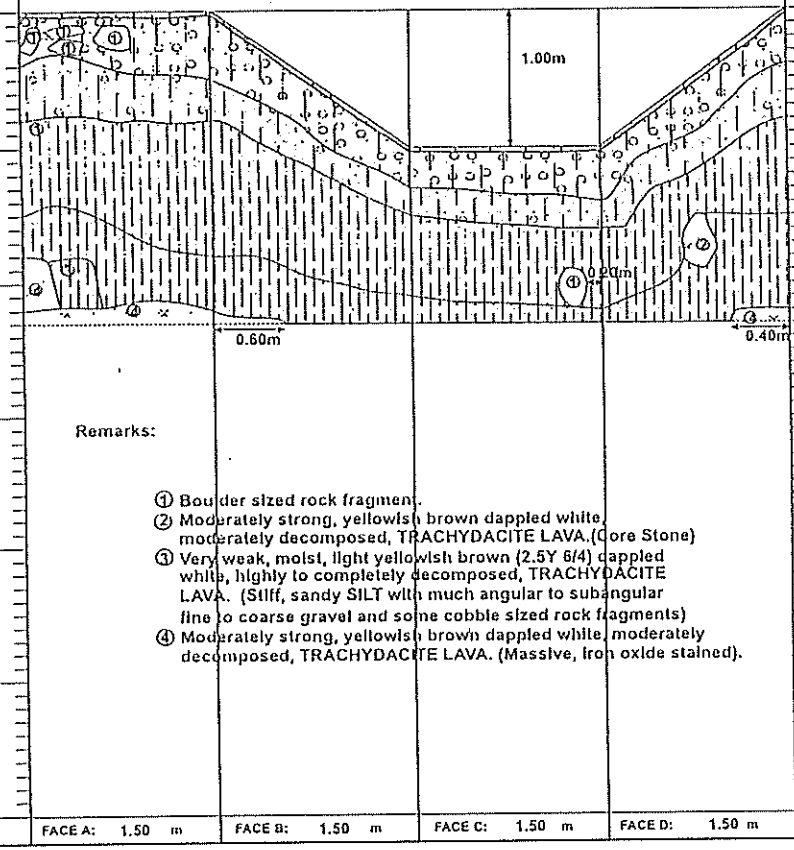
PROJECT

Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

Sheet	1	of	1		
Date excavated	24/06/2002	to	02/07/2002		
Date Reinstated	23/07/2002	to	23/07/2002		

TRIAL PIT NO.
TP1

GEOTECHNICS & CONCRETE ENGG. (HONG KONG) LIMITED
GROUND INVESTIGATION DEPARTMENT

Samples & Test	Depth (m)	Sketch	Depth (m)	Legend	Description	Grade
1 2 3 4	0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0		0.03 0.40 0.5 0.80 1.0 1.5 2.0 2.30 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0		Loose, dry, dark brown (7.5YR 3/2), slightly silty fine to coarse SAND with occasional subangular fine to medium gravel sized quartz and rock fragments and some rootlets. (TOP SOIL) Loose, dry, organic, brownish grey (10YR 6/2), subangular to subrounded fine to coarse GRAVEL with much cobble and some boulder of maximum size 300m x 150mm sized moderately decomposed tuff and some matrix of loose, brown, silty fine to coarse sand and some plant rootlets and wood fragments. (COLLUVIUM) Loose, moist, dark brownish grey (2.5Y 3/2), silty fine to coarse SAND with some subangular to subrounded fine to coarse gravel sized rock fragments and some plant rootlets. (COLLUVIUM) Firm, moist, yellowish brown (10YR 5/8) dappled grey and white, sandy SILT with much angular to subangular fine to coarse gravel and occasional cobble and boulder of maximum size 0.20m x 0.15m sized rock fragments and occasional plant rootlets. (COLLUVIUM) Extremely weak, moist, light reddish brown (5YR 6/4) dappled white, completely decomposed, TRACHYDACITE LAVA. (Stiff, slightly sandy SILT with occasional angular to subangular fine to medium gravel sized quartz and rock fragments) Trial pit terminated at 2.30m depth.	V

Remarks:

① Boulder sized rock fragment.
② Moderately strong, yellowish brown dappled white, moderately decomposed, TRACHYDACITE LAVA.(Core Stone)
③ Very weak, moist, light yellowish brown (2.5Y 6/4) dappled white, highly to completely decomposed, TRACHYDACITE LAVA. (Stiff, sandy SILT with much angular to subangular fine to coarse gravel and some cobble sized rock fragments)
④ Moderately strong, yellowish brown dappled white, moderately decomposed, TRACHYDACITE LAVA. (Massive, iron oxide stained).

Notes:
1. Small disturbed samples were taken at 0.50m, 1.00m and 1.50m depths.
2. Undisturbed vertical sample (U100) was taken at 1.00m depth.

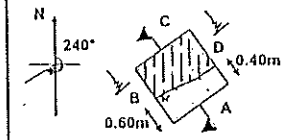
SYMBOLS

- Small Disturbed Sample
- Large Disturbed Sample
- Undisturbed Vertical Sample
- Undisturbed Horizontal Sample
- Block Sample
- Insitu Density Test
- Water Sample
- Water Seepage

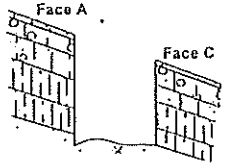
REMARKS

Ground Water
No Groundwater
Plant Used
Hand dug
Shoring
Timber shoring over full height
Stability
Stable
Depth at pit centre
1.80m
Others
Nil

PLAN (not to scale)



SECTION



Contract No. :	GE/2001/13	
Works Order No.	: GE/2001/13.10	
Co-ordinates	:	
E 846966.44	N 816757.58	
Ground Level	: 103.24	mPD
Logged by	: K.L. Lo	
Date logged	: 03/07/2002	
Checked by	: Tom Lo	
Date Checked	: 04/07/2002	

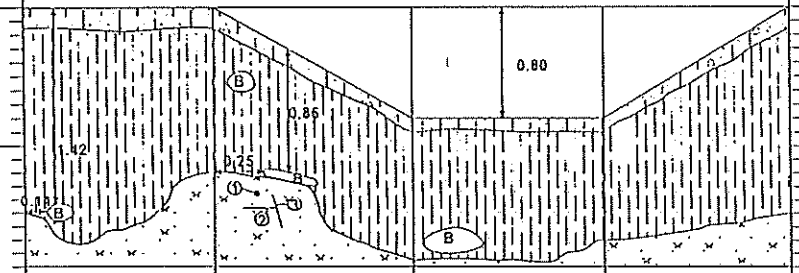
PROJECT

Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

Sheet	1	of	1		
Date excavated	25/06/2002	to	02/07/2002		
Date Reinstated	22/07/2002	to	22/07/2002		

TRIAL PIT NO.
TP2

GEOTECHNICS & CONCRETE ENGG. (HONG KONG) LIMITED
GROUND INVESTIGATION DEPARTMENT

Samples & Test	Depth (m)	Sketch	Depth (m)	Legend	Description	Grade
1, 2, 3, 4	0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0		0.15, 0.5, 1.0, 1.5, 1.90, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0		Loose, dry, dark greyish brown (10YR 4/2), slightly silty fine to coarse SAND with some angular to subangular fine to coarse gravels sized rock fragments and much rootlets. (TOP SOIL) Stiff, moist, yellowish brown (10YR 5/8) mottled white and dappled dark brown, sandy SILT with much subangualr to subrounded fine to coarse gravel and cobble and occasional boulder of maximum size 0.50m x 0.15m sized rock fragments. (COLLUVIUM) Moderately strong, light grey spotted white and pink, dappled yellowish brown, moderately decomposed, TRACHYDACITE LAVA. Joints are closely spaced, smooth planar and smooth undulating, iron oxide stained, dipping at 20° to 30° and 70° to 80°. Trial pit terminated at 1.90m depth.	III

FACE A: 1.50 m FACE B: 1.50 m FACE C: 1.50 m FACE D: 1.50 m

Remarks:

B: Boulder sized rock fragments.
① 285°/22°
② 004°/70°
③ 070°/80°

Notes:
1. Small disturbed samples were taken at 0.50m, 1.00m and 1.50m depths.
2. Undisturbed vertical sample (U100) was taken at 1.00m depth.

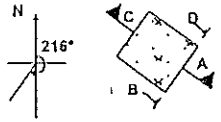
SYMBOLS

- Small Disturbed Sample
- Large Disturbed Sample
- Undisturbed Vertical Sample
- Undisturbed Horizontal Sample
- Block Sample
- Insitu Density Test
- Water Sample
- Water Seepage

REMARKS

Ground Water
No Groundwater
Plant Used
Hand dug
Shoring
No shoring
Stability
Stable
Depth at pit centre
1.50m
Others
Nil

PLAN (not to scale)



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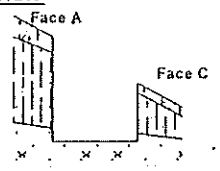


Contract No. :	GE/2001/13	
Works Order No.	: GE/2001/13.10	
Co-ordinates	:	
E 847079.36	N 816810.10	
Ground Level	: 130.90	mPD
Logged by	: K.L. Lo	
Date logged	: 05/07/2002	
Checked by	: Tom Lo	
Date Checked	: 06/07/2002	

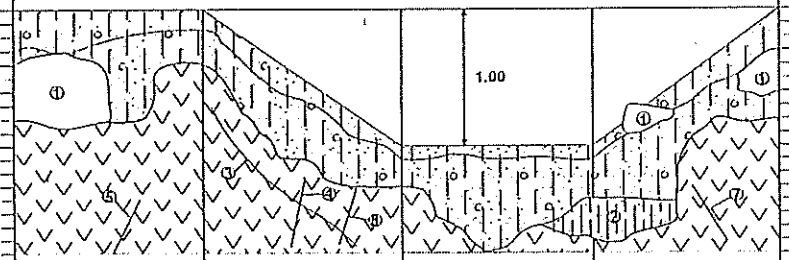
PROJECT

Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

Sheet	1	of	1	
Date excavated	03/07/2002	to	04/07/2002	
Date Reinstated	26/07/2002	to	26/07/2002	

TRIAL PIT NO.
TP3

GEOTECHNICS & CONCRETE ENGG. (HONG KONG) LIMITED
GROUND INVESTIGATION DEPARTMENT

Samples & Test	Depth (m)	Sketch	Depth (m)	Legend	Description	Grade
1 0.50 2 1.00	0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0	 ① Boulders sized moderately decomposed tuff of maximum size 700mm x 420mm. ② Extremely weak, dry, yellowish brown (10YR 5/8) mottled white, completely decomposed, fine ash TUFF. (Very stiff, sandy SILT) ③ 276°/78° ④ 171°/78° ⑤ 092°/86° ⑥ 257°/70° ⑦ 298°/85° ⑧ 165°/62° FACE A: 1.50 m FACE B: 1.50 m FACE C: 1.50 m FACE D: 1.50 m	0.30 0.5 0.80 1.0 1.5 1.80 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0		Loose, dry, dark greyish brown (10YR 4/2), organic, slightly silty fine to coarse SAND with much angular to subangular fine to coarse gravel and some cobble sized quartz and rock fragments and with much plant rootlets. (TOP SOIL) Loose, dry, brown (10YR 4/3) dappled grey, silty fine to coarse SAND with much angular to subangular fine to coarse gravel and some cobble and occasional boulders sized moderately decomposed tuff fragments. (COLLUVIUM) Moderately strong, light grey dappled yellowish brown and mottled white and pink, moderately decomposed, fine ash TUFF. Joints are closely to medium spaced, smooth planar and rough undulating, extremely narrow to very narrow, occasionally narrow, iron and manganese oxide stained, soil of silty fine to coarse sand (<1mm) infilled. Trial pit terminated at 1.80m depth. Note: 1. Small disturbed samples were taken at 0.50m and 1.00m depths.	III

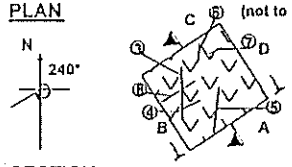
SYMBOLS

- Small Disturbed Sample
- Large Disturbed Sample
- Undisturbed Vertical Sample
- Undisturbed Horizontal Sample
- Block Sample
- Insitu Density Test
- Water Sample
- Water Seepage

REMARKS

Ground Water
No Groundwater
Plant Used
Hand dug
Shoring
No shoring
Stability
Stable
Depth at pit centre
1.30m
Others
Nil

PLAN (not to scale)



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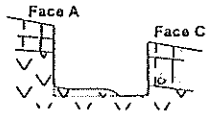


Contract No. :	GE/2001/13	
Works Order No.	: GE/2001/13.10	
Co-ordinates	:	
E 847199.76	N 816840.44	
Ground Level	: 183.03	mPD
Logged by	: K.L. Lo	
Date logged	: 29/06/2002	
Checked by	: Tom Lo	
Date Checked	: 02/07/2002	

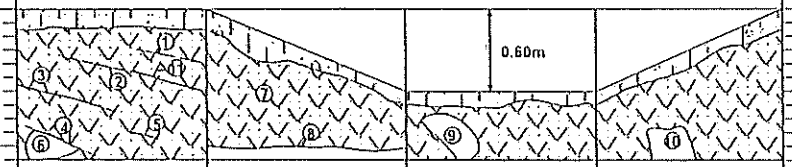
PROJECT

Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

Sheet	1 of 1		
Date excavated	24/06/2002	to	28/06/2002
Date Reinstated	23/07/2002	to	23/07/2002

TRIAL PIT NO.
TP4

GEOTECHNICS & CONCRETE ENGG. (HONG KONG) LIMITED
GROUND INVESTIGATION DEPARTMENT

Samples & Test	Depth (m)	Sketch	Depth (m)	Legend	Description	Grade
1	0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0		0.15, 1.10		Loose, dry, dark grey (10YR 4/1), organic, silty fine to coarse SAND with much angular to subangular fine to coarse gravel sized quartz and rock fragments, and occasional cobbles sized moderately decomposed tuff fragments, and also with much plant rootlets. (TOP SOIL) Moderately strong, brownish grey, moderately decomposed, fine ash TUFF. Joints are closely spaced, smooth planar and rough undulating, extremely narrow, iron and manganese oxide stained. Trial pit terminated at 1.10m depth. Note: 1. Small disturbed sample was taken at 0.50m depth.	III

	Dip Direction/Dip angle		Staining
1	155°/53°	smooth planar	Iron and manganese oxide
2	165°/56°	smooth planar	Iron and manganese oxide
3	152°/66°	smooth planar	Iron and manganese oxide
4	154°/70°	smooth planar	Iron and manganese oxide
5	148°/78°	rough undulating	Iron and manganese oxide
6	357°/29°	rough undulating	Iron and manganese oxide
7	045°/52°	rough planar	Iron oxide
8	054°/82°	rough undulating	Iron and manganese oxide
9	043°/50°	rough undulating	Iron and manganese oxide
10	220°/40°	rough undulating	Iron and manganese oxide

FACE A: 1.50 m FACE B: 1.50 m FACE C: 1.50 m FACE D: 1.50 m

SYMBOLS

- Small Disturbed Sample
- Large Disturbed Sample
- Undisturbed Vertical Sample
- Undisturbed Horizontal Sample
- Block Sample
- Insitu Density Test
- Water Sample
- Water Seepage

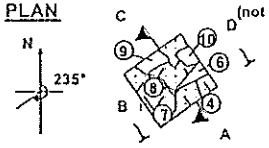
REMARKS

Ground Water
No Groundwater
Plant Used
Hand dug
Shoring
No shoring

Stability
Stable

Depth at pit centre
0.60m
Others
Nil

PLAN (not to scale)



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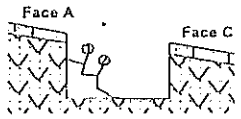


Contract No.	:	GE/2001/13
Works Order No.	:	GE/2001/13.10
Co-ordinates	:	
E 847244.97	N 817007.61	
Ground Level	:	163.51 mPD
Logged by	:	K.L. Lo
Date logged	:	03/07/2002
Checked by	:	Tom Lo
Date Checked	:	04/07/2002

PROJECT

Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

Sheet	1	of	1		
Date excavated	20/06/2002	to	02/07/2002		
Date Reinstated	24/07/2002	to	24/07/2002		

TRIAL PIT NO.
TP5

GEOTECHNICS & CONCRETE ENGG. (HONG KONG) LIMITED
GROUND INVESTIGATION DEPARTMENT

Samples & Test	Depth (m)	Sketch	Depth (m)	Legend	Description	Grade
1, 2, 3, 4, 5, 6, 7, 8, 9	0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0	0.30m; Ⓑ Boulder sized of moderately decomposed rock fragments of maximum size 0.42m x 0.12m. Ⓒ Corestone of moderately decomposed, fine ash TUFF. FACE A: 1.50 m FACE B: 1.50 m FACE C: 1.50 m FACE D: 1.50 m	0.30, 0.80, 3.15		Soft, dry, very dark greyish brown (10YR 3/2), sandy SILT with some subangular fine to coarse gravel and occasional boulder sized rock fragments and with some rootlets. (COLLUVIUM) Loose, moist, yellowish brown (10YR 5/4) mottled light yellowish brown and white, very silty fine to coarse SAND with some subangular fine to coarse gravel and occasional boulder sized rock fragments and with occasional rootlets. (COLLUVIUM) Stiff, moist, yellowish brown (10YR 5/6) mottled pink and light yellowish brown, sandy SILT with occasional subangular fine gravel sized rock fragments and with some subrounded to rounded pocket of completely decomposed fine ash tuff of maximum size 0.50m x 0.40m. (RESIDUAL SOIL) Extremely weak, yellowish brown (10YR 5/6) mottled pink and white, completely decomposed, fine ash TUFF. (Silty fine to coarse SAND with occasional fine gravel sized rock fragments) Extremely weak to very weak, light grey (5Y 7/2) mottled yellowish brown and pink, completely to highly decomposed, fine ash TUFF. (Silty fine to coarse SAND with some angular fine gravel sized rock fragments) Trial pit terminated at maximum depth 3.15m.	VI V V/IV

Notes:
1. Small disturbed samples were taken at 0.50m, 1.00m, 1.50m, 2.00m, 2.50m and 3.00m depths.
2. Undisturbed vertical samples (U100) were taken at 1.00m, 2.00m and 3.00m (0% recovery) depths.

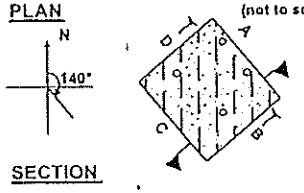
SYMBOLS

- Small Disturbed Sample
- Large Disturbed Sample
- Undisturbed Vertical Sample
- Undisturbed Horizontal Sample
- Block Sample
- Insitu Density Test
- Water Sample
- Water Seepage

REMARKS

Ground Water
No Groundwater
Plant Used
Hand dug
Shoring
Timber shoring over full height
Stability
Stable
Depth at pit centre
3.00m
Others
Nil

PLAN (not to scale)



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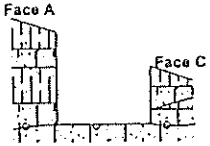


Contract No.	:	GE/2001/13
Works Order No.	:	GE/2001/13.10
Co-ordinates	:	
E 847241.54	N 817206.07	
Ground Level	:	182.69 mPD
Logged by	:	K.L. Lo
Date logged	:	13/06/2002
Checked by	:	Tom Lo
Date Checked	:	14/06/2002

PROJECT

Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

Sheet	1	of	1	
Date excavated	10/06/2002	to	12/06/2002	
Date Reinstated	05/07/2002	to	05/07/2002	

TRIAL PIT NO.
TP6

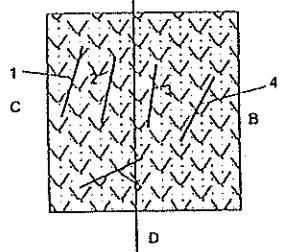
GEOTECHNICS & CONCRETE ENGG. (HONG KONG) LIMITED
GROUND INVESTIGATION DEPARTMENT

Samples & Test	Depth (m)	Sketch	Depth (m)	Legend	Description	Grade
1	0.5	0.85m	0.20		Firm, dry, dark grey (2.5Y 4/1), sandy SILT with some subangular fine to coarse gravel and occasional cobble sized rock fragments and some rootlets. (COLLUVIUM)	
	1.0		0.40		Stiff, moist, light brown (10YR 5/3) spotted white, slightly sandy CLAY with much subangular fine to coarse gravel and occasional cobble and boulder of maximum size 400mm sized rock fragments and with occasional rootlets. (COLLUVIUM)	
	1.5		0.5		Trial pit terminated at 0.40m depth.	
	2.0		1.0			
	2.5		1.5			
	3.0		2.0			
	3.5		2.5			
	4.0		3.0			
	4.5		3.5			
	5.0		4.0			
	5.5		4.5			
	6.0		5.0			
			5.5			
			6.0			

① Moderately strong, light brownish grey mottled yellowish brown and black, moderately decomposed lapilli bearing, fine ash TUFF.

② Boulder sized moderately decomposed tuff.

Top View



Joint Number	Dip Direction/ Dip Angle
1	248°/076°
2	248°/078°
3	250°/080°
4	302°/068°
5	295°/076°

FACE A: 1.50 m FACE B: 1.50 m FACE C: 1.50 m FACE D: 1.50 m

Note:
1. Large disturbed sample was taken at 0.30m depth.

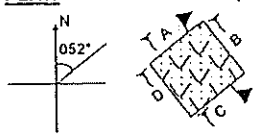
SYMBOLS

- Small Disturbed Sample
- Large Disturbed Sample
- Undisturbed Vertical Sample
- Undisturbed Horizontal Sample
- Block Sample
- Insitu Density Test
- Water Sample
- Water Seepage

REMARKS

Ground Water
No Groundwater
Plant Used
Hand dug
Shoring
No shoring
Stability
Stable
Depth at pit centre
0.40m
Others
Nil

PLAN (not to scale)



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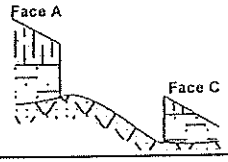


Contract No. :	GE/2001/13	
Works Order No.	: GE/2001/13.10	
Co-ordinates	:	
E 847182.48	N 817253.88	
Ground Level	: 164.99	mPD
Logged by	: K.L. Lo	
Date logged	: 07/06/2002	
Checked by	: Tom Lo	
Date Checked	: 08/06/2002	

PROJECT

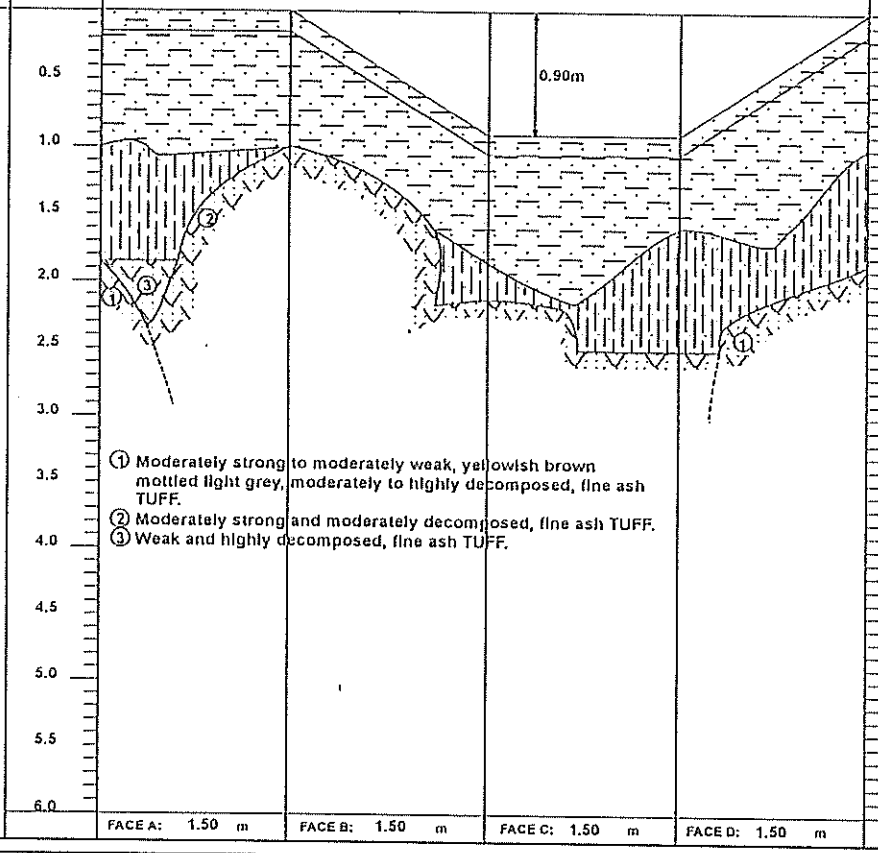
Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

Sheet	1	of	1	
Date excavated	06/06/2002	to	06/06/2002	
Date Reinstated	03/07/2002	to	03/07/2002	

TRIAL PIT NO.
TP7

GEOTECHNICS & CONCRETE ENGG. (HONG KONG) LIMITED
GROUND INVESTIGATION DEPARTMENT

Samples & Test	Depth (m)	Sketch	Depth (m)	Legend	Description	Grade
1, 2, 3, 4, 5	0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0	0.90m	0.15, 1.00, 1.85		Firm, dry, dark grey (2.5Y 4/1), slightly sandy CLAY with some subangular fine to coarse gravel and occasional cobble sized rock fragments and with some rootlets. (COLLUVIUM) Firm, moist, light brown (10YR 5/3) spotted white, slightly sandy CLAY with much subangular fine to coarse gravel and cobble sized rock fragments and with occasional rootlets. (COLLUVIUM) Weak to very weak, yellowish brown (10YR 5/4) mottled light grey, highly to completely decomposed, fine ash TUFF. (Stiff, sandy SILT with much subangular fine to coarse gravel sized rock fragments) Trial pit terminated at 1.85m depth.	IV/V



Notes:
1. Small disturbed samples were taken at 0.50m, 1.00m and 1.50m depths.
2. Undisturbed vertical sample (U100) samples were taken at 1.00m depth.
3. Large disturbed sample was taken at 1.80m depths.

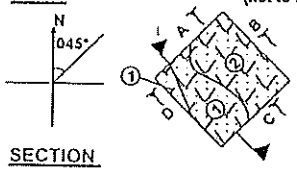
SYMBOLS

- Small Disturbed Sample
- Large Disturbed Sample
- Undisturbed Vertical Sample
- Undisturbed Horizontal Sample
- Block Sample
- Insitu Density Test
- Water Sample
- Water Seepage

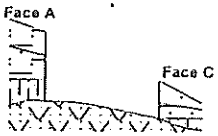
REMARKS

Ground Water
No Groundwater
Plant Used
Hand dug
Shoring
Timber shoring over full height
Stability
Stable
Depth at pit centre
1.30m
Others
Nil

PLAN (not to scale)



SECTION



Contract No. :	GE/2001/13	
Works Order No.	: GE/2001/13.10	
Co-ordinates	:	
E 847189.84	N 817265.01	
Ground Level	: 166.88	mPD
Logged by	: K.L. Lo	
Date logged	: 11/06/2002	
Checked by	: Tom Lo	
Date Checked	: 12/06/2002	

PROJECT

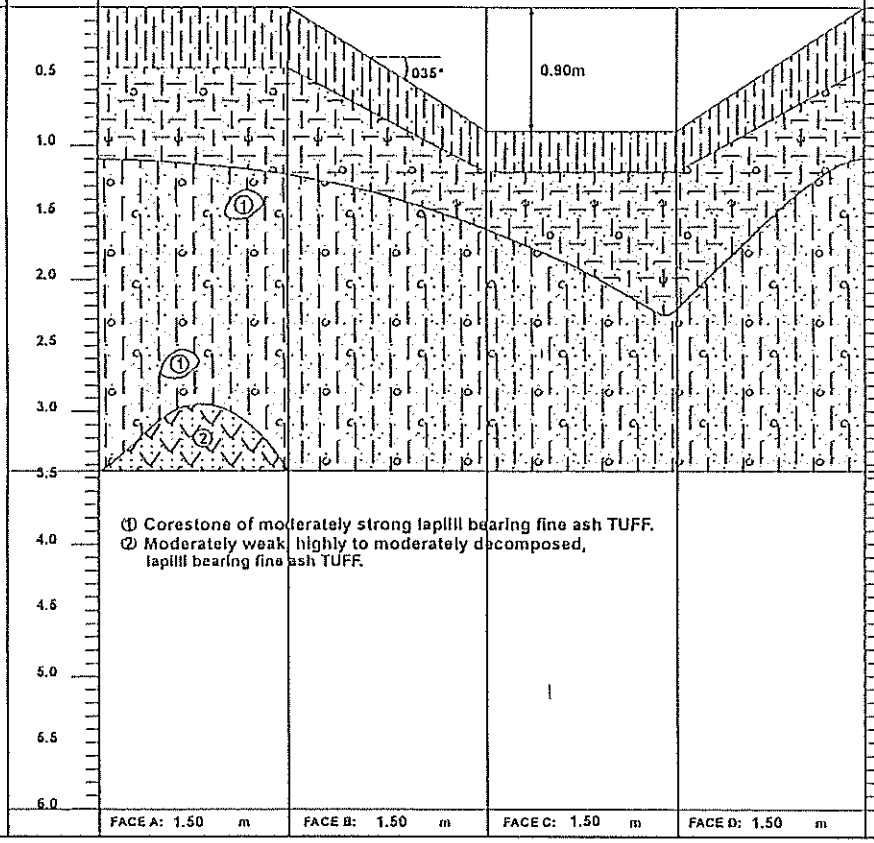
Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

Sheet	1	of	1	
Date excavated	10/06/2002	to	10/06/2002	
Date Reinstated	03/07/2002	to	03/07/2002	

TRIAL PIT NO.
TP7A

GEOTECHNICS & CONCRETE ENGG. (HONG KONG) LIMITED
GROUND INVESTIGATION DEPARTMENT

Samples & Test	Depth (m)	Sketch	Depth (m)	Legend	Description	Grade
					Stiff, dry, dark grey (2.5Y 4/1) sandy SILT with some subangular fine to coarse gravel and occasional cobble sized rock fragment and some rootlets. (COLLUVIUM)	
					Firm, moist, dark greyish brown (10YR 4/2) sandy SILT/CLAY with some subangular fine to coarse gravel and cobble sized rock fragments and some rootlets. (COLLUVIUM)	
					Weak to extremely weak, dry, olive grey (5Y 5/2) mottled yellowish brown and brown, highly to completely decomposed, lapilli bearing fine ash TUFF. (Silty fine to medium SAND with occasional subangular fine gravel and occasional boulder of maximum size 300mm sized rock fragment.	IV/V
					Trial pit terminated at 3.45m depth.	



Notes:
1. Small disturbed samples were taken at 0.50m, 1.00m, 1.50m, 2.00m, 2.50m and 3.00m depths.
2. Undisturbed vertical samples (U100) were taken at 1.00m and 2.00m depths.
3. Large disturbed samples was taken at 3.00m depth.

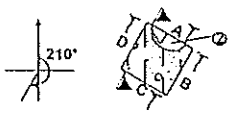
SYMBOLS

- Small Disturbed Sample
- Large Disturbed Sample
- Undisturbed Vertical Sample
- Undisturbed Horizontal Sample
- Block Sample
- Insitu Density Test
- Water Sample
- Water Seepage

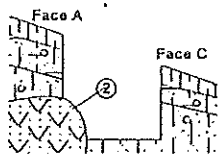
REMARKS

Ground Water
No Groundwater
Plant Used
Hand dug
Shoring
Timber shoring over full height
Stability
Stable
Depth at pit centre
3.00m
Others
Nil

PLAN (not to scale)



SECTION



Contract No. :	GE/2001/13	
Works Order No.	: GE/2001/13.10	
Co-ordinates	:	
E 847025.18	N 817334.69	
Ground Level	: 155.42	mPD
Logged by	: K.L. Lo	
Date logged	: 06/06/2002	
Checked by	: Tom Lo	
Date Checked	: 07/06/2002	

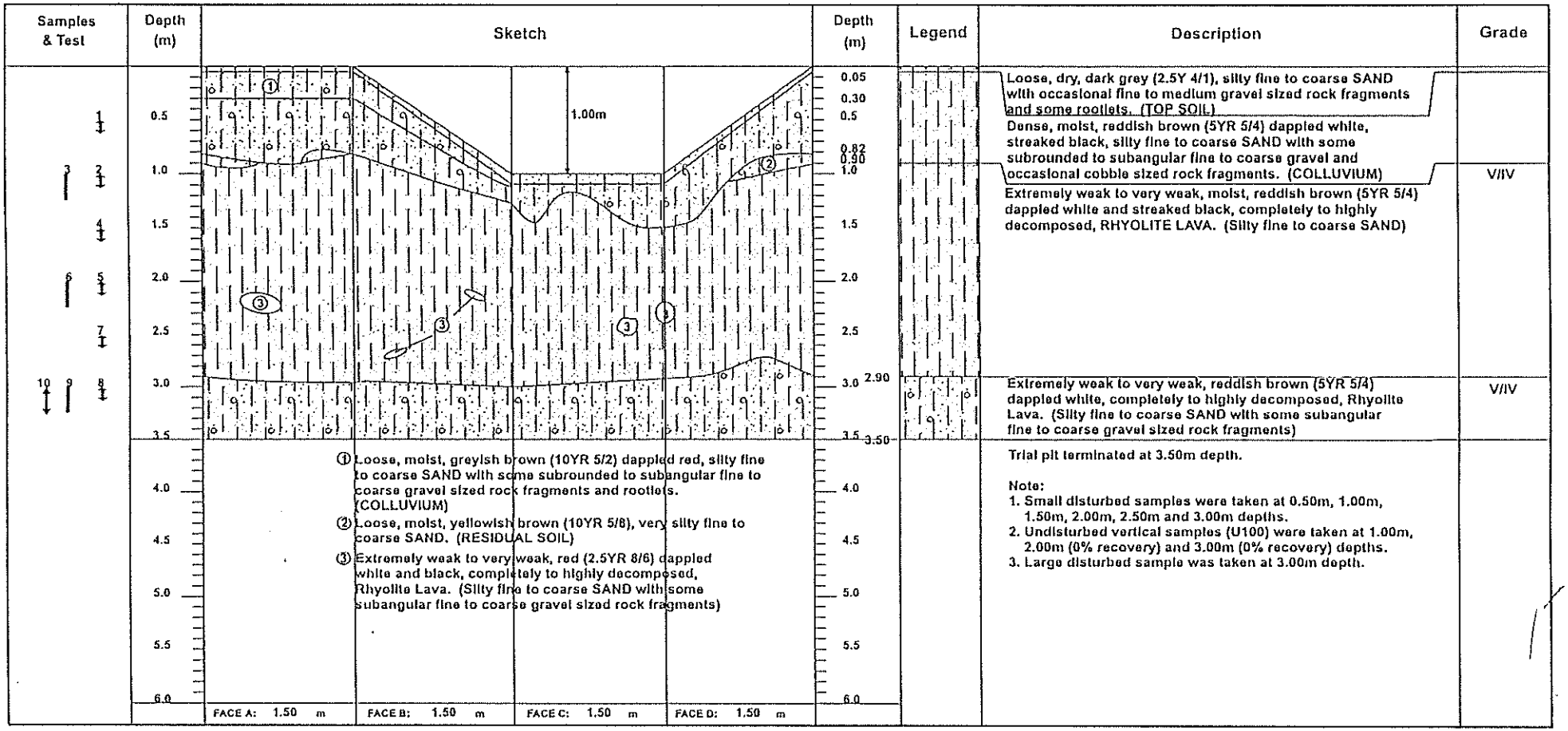
PROJECT

Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

Sheet	1	of	1	
Date excavated	03/06/2002	to	05/06/2002	
Date Reinstated	04/07/2002	to	04/07/2002	

TRIAL PIT NO.
TP8

GEOTECHNICS & CONCRETE ENGG. (HONG KONG) LIMITED
GROUND INVESTIGATION DEPARTMENT



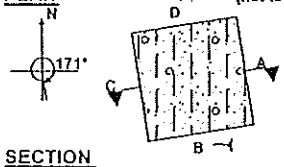
SYMBOLS

- Small Disturbed Sample
- Large Disturbed Sample
- Undisturbed Vertical Sample
- Undisturbed Horizontal Sample
- Block Sample
- Insitu Density Test
- Water Sample
- Water Seepage

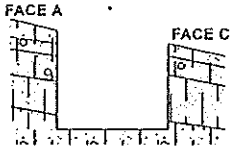
REMARKS

Ground Water
No Groundwater
Plant Used
Hand dug
Shoring
Timber shoring over full height
Stability
Stable
Depth of pit centre
3.00m
Others
Nil

PLAN (not to scale)



SECTION



Contract No. :	GE/2001/13	
Works Order No.	: GE/2001/13.10	
Co-ordinates	:	
E 846645.70	N 817404.81	
Ground Level	: 105.34	mPD
Logged by	: K.L. Lo	
Date logged	: 07/06/2002	
Checked by	: Tom Lo	
Date Checked	: 08/06/2002	

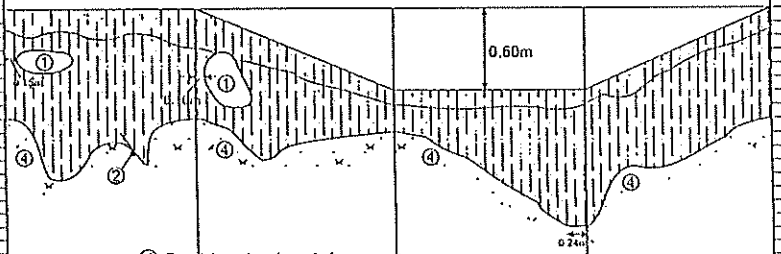
PROJECT

Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

Sheet	1	of	1	
Date excavated	03/06/2002	to	05/06/2002	
Date Reinstated	06/07/2002	to	06/07/2002	

TRIAL PIT NO.
TP9

GEOTECHNICS & CONCRETE ENGG. (HONG KONG) LIMITED
GROUND INVESTIGATION DEPARTMENT

Samples & Test	Depth (m)	Sketch	Depth (m)	Legend	Description	Grade
1 ↕ 3 2 ↕	0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0	 ① Boulder sized rock fragment ② 264/55° ③ 285/28° ④ Moderately strong, grey spotted white and pink, moderately decomposed, TRACHYDACITE LAVA. Joints are closely spaced, rough planar, iron and manganese oxide stained, dipping at 20° to 30°and 50° to 60°. FACE A: 1.50 m FACE B: 1.50 m FACE C: 1.50 m FACE D: 1.50 m	0.15 0.5 0.80 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0		Firm, dry, organic, dark brownish grey (2.5Y 3/2), sandy SILT with occasional angular to subangular fine gravel sized quartz and rock fragments and some plant rootlet. (TOP SOIL) Stiff, dry, yellowish brown (10YR 5/8) dappled grey and white, slightly sandy SILT with some subangular to subrounded fine to coarse gravel and occasional cobble and boulder of maximum size 0.40m x 0.40m sized rock fragments and occasional plant rootlet. (COLLUVIUM) Trial pit terminated at 0.80m depth. Notes: 1. Small disturbed samples were taken at 0.50m and 1.00m depths. 2. Undisturbed vertical samples (U100) was taken at 1.00m depth.	

SYMBOLS

- Small Disturbed Sample
- Large Disturbed Sample
- Undisturbed Vertical Sample
- Undisturbed Horizontal Sample
- Block Sample
- Insitu Density Test
- Water Sample
- Water Seepage

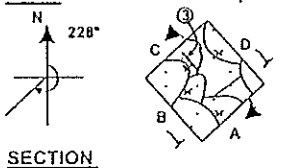
REMARKS

Ground Water
No Groundwater
Plant Used
Hand dug
Shoring
Timber shoring over full height

Stability
Stable

Depth at pit centre
1.20m
Others
Nil

PLAN (not to scale)



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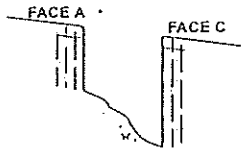


Contract No. :	GE/2001/13	
Works Order No.	: GE/2001/13.10	
Co-ordinates	:	
E 846971.28	N 816690.45	
Ground Level	: 153.75	mPD
Logged by	: K.L. Lo	
Date logged	: 03/07/2002	
Checked by	: Tom Lo	
Date Checked	: 04/07/2002	

PROJECT

Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

Sheet	1	of	1	
Date excavated	27/06/2002	to	02/07/2002	
Date Reinstated	22/07/2002	to	22/07/2002	

TRIAL PIT NO.
TP10

GEOTECHNICS & CONCRETE ENGG. (HONG KONG) LIMITED
GROUND INVESTIGATION DEPARTMENT

Samples & Test	Depth (m)	Sketch	Depth (m)	Legend	Description	Grade
1, 2, 3, 4, 5, 6, 7, 8	0.5, 0.90, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0	0.95m; FACE A: 1.50 m; FACE B: 1.50 m; FACE C: 1.50 m; FACE D: 1.50 m	0.20, 0.5, 0.90, 1.0, 1.5, 2.0, 2.5, 3.0, 3.40, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0		Stiff, dry, very dark greyish brown (10YR 3/2), sandy SILT with some subangular fine to coarse gravel sized rock fragments. (COLLUVIUM) Firm to stiff, moist, yellowish brown (10YR 5/4), sandy SILT with much angular to subangular fine to coarse gravel and occasional cobble sized rock and quartz fragments and with some rootlets. (COLLUVIUM) Weak to extremely weak, yellowish brown (10YR 5/6) mottled pink and white, highly to completely decomposed, Rhyolite Lava. (Sandy SILT with some angular fine to medium gravel sized rock fragments) Trial pit terminated at 3.40m depth. Notes: 1. Small disturbed samples were taken at 1.00m, 1.50m, 2.00m, 2.50m and 3.00m depths. 2. Undisturbed vertical samples (U100) were taken at 1.00m , 2.00m and 3.00m depths.	IV/V

SYMBOLS

- Small Disturbed Sample
- Large Disturbed Sample
- Undisturbed Vertical Sample
- Undisturbed Horizontal Sample
- Block Sample
- Insitu Density Test
- Water Sample
- Water Seepage

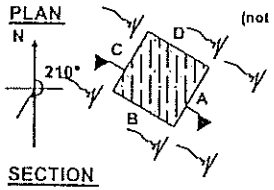
REMARKS

Ground Water
No Groundwater
Plant Used
Hand dug
Shoring
Timber shoring over full height

Stability
Stable

Depth at pit centre
3.00m
Others
Nil

PLAN (not to scale)



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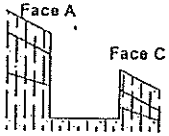


Contract No. :	GE/2001/13	
Works Order No.	: GE/2001/13.10	
Co-ordinates	:	
E 846623.66	N 816715.59	
Ground Level	: 48.21	mPD
Logged by	: K.L. Lo	
Date logged	: 03/07/2002	
Checked by	: Tom Lo	
Date Checked	: 04/07/2002	

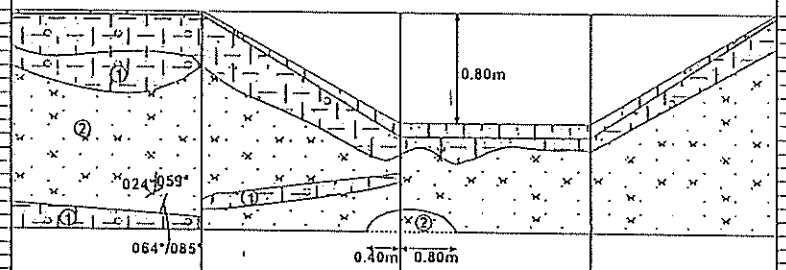
PROJECT

Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

Sheet	1	of	1	
Date excavated	28/06/2002	to	02/07/2002	
Date Reinstated	24/07/2002	to	24/07/2002	

TRIAL PIT NO.
TP11

GEOTECHNICS & CONCRETE ENGG. (HONG KONG) LIMITED
GROUND INVESTIGATION DEPARTMENT

Samples & Test	Depth (m)	Sketch	Depth (m)	Legend	Description	Grade
1	0.5		0.03		Loose, dry, dark grey (2.5Y 4/1), silty fine to coarse SAND with occasional fine to medium gravel sized rock fragments and some rootlets. (TOP SOIL)	
			0.25			IV
2	1.0		0.5		Loose, dry, dark brownish grey (2.5Y 3/2) dappled white and red, silty fine to coarse SAND with some subrounded to subangular fine to coarse gravel sized rock fragments, occasional cobble sized rock fragments. (COLLUVIUM)	
	1.5		1.0			
			1.5		Weak to moderately weak, dry, yellowish brown dappled white, red and black, highly decomposed, highly fractured, TRACHYDACITE LAVA.	
	2.0		1.60		Trial pit terminated at 1.60m.	
	2.5		2.0			
	3.0		2.5			
	3.5		3.0			
	4.0		3.5			
	4.5		4.0			
	5.0		4.5			
	5.5		5.0			
	6.0		5.5			
			6.0			

① Extremely weak to very weak, moist, yellow brown (10YR 5/8), completely to highly decomposed, TRACHYDACITE LAVA. (Silty fine to coarse SAND with some subangular fine to coarse gravel and cobble sized rock fragments)
② Moderately weak, yellowish brown dappled white and streaked black, moderately to highly decomposed, TRACHYDACITE LAVA.

FACE A: 1.50 m | FACE B: 1.50 m | FACE C: 1.50 m | FACE D: 1.50 m

Note:
1. Small disturbed samples were taken at 0.50m and 1.00m depths.

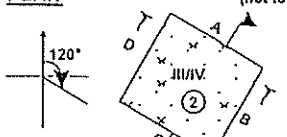
SYMBOLS

- Small Disturbed Sample
- Large Disturbed Sample
- Undisturbed Vertical Sample
- Undisturbed Horizontal Sample
- Block Sample
- Insitu Density Test
- Water Sample
- Water Seepage

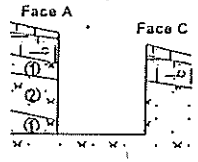
REMARKS

Ground Water
No Groundwater
Plant Used
Hand dug
Shoring
No shoring
Stability
Stable
Depth at pit centre
1.20m
Others
Nil

PLAN (not to scale)



SECTION



Contract No.	:	GE/2001/13
Works Order No.	:	GE/2001/13.10
Co-ordinates	:	
E 846809.76	N 817411.30	
Ground Level	:	135.44 mPD
Logged by	:	K.L. Lo
Date logged	:	07/06/2002
Checked by	:	Tom Lo
Date Checked	:	08/06/2002

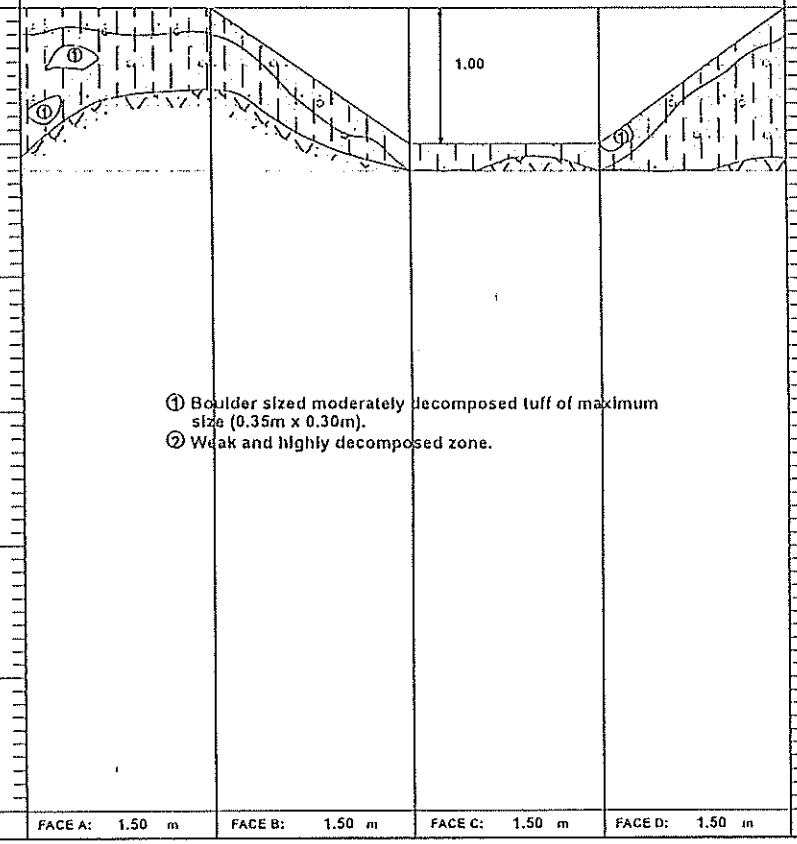
PROJECT

Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

Sheet	1	of	1	
Date excavated	04/06/2002	to	06/06/2002	
Date Reinstated	02/07/2002	to	02/07/2002	

TRIAL PIT NO.
TP12

GEOTECHNICS & CONCRETE ENGG. (HONG KONG) LIMITED
GROUND INVESTIGATION DEPARTMENT

Samples & Test	Depth (m)	Sketch	Depth (m)	Legend	Description	Grade
1 (0.50m), 2 (1.00m)	0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0		0.20, 0.5, 1.0, 1.10, 1.20, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0		Loose, dry, dark grey (10YR 4/1), organic, silty fine to coarse SAND with much angular to subangular fine to medium gravel sized quartz and rock fragments, occasionally cobble sized rock fragments and with much plant rootlets. (TOP SOIL) Loose, dry, yellowish brown (10YR 5/6) dappled dark grey and mottled white, very silty fine to coarse SAND with much angular to subangular fine to coarse gravel sized quartz and rock fragments, some cobble and boulder sized moderately decomposed tuff fragments and occasional plant rootlets. (COLLUVIUM) Moderately strong, grey dappled pink and brown, moderately decomposed, fine ash TUFF with iron and manganese oxide stained on the surface, massive. Trial pit terminated at 1.20m depth.	

Note:
1. Small disturbed samples were taken at 0.50m and 1.00m depths.

SYMBOLS

- Small Disturbed Sample
- Large Disturbed Sample
- Undisturbed Vertical Sample
- Undisturbed Horizontal Sample
- Block Sample
- Insitu Density Test
- Water Sample
- Water Seepage

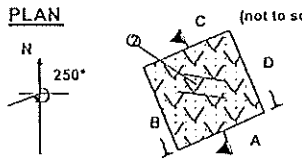
REMARKS

Ground Water
No Groundwater
Plant Used
Hand dug
Shoring
No shoring

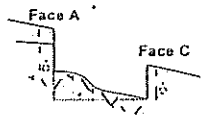
Stability
Stable

Depth at pit centre
0.70m
Others
Nil

PLAN (not to scale)



SECTION



Contract No.	:	GE/2001/13
Works Order No.	:	GE/2001/13.10
Co-ordinates	:	
E 847078.00	N 816718.21	
Ground Level	:	154.28 mPD
Logged by	:	K.L. Lo
Date logged	:	04/07/2002
Checked by	:	Tom Lo
Date Checked	:	05/07/2002

PROJECT

Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

Sheet	1	of	1	
Date excavated	28/06/2002	to	03/07/2002	
Date Reinstated	24/07/2002	to	24/07/2002	

TRIAL PIT NO.
TP13

GEOTECHNICS & CONCRETE ENGG. (HONG KONG) LIMITED
GROUND INVESTIGATION DEPARTMENT

Samples & Test	Depth (m)	Sketch	Depth (m)	Legend	Description	Grade
1, 2, 3, 4, 5	0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0	① Moderately strong, olive mottled black, moderately decomposed, fine grained Rhyolite Lava. ② Boulder sized moderately decomposed Rhyolite Lava. ③ Pocket of completely decomposed Rhyolite Lava. FACE A: 1.50 m FACE B: 1.50 m FACE C: 1.50 m FACE D: 1.50 m	0.20, 0.5, 1.0, 1.40, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0		Stiff, moist, dark grey (2.5Y 4/1), slightly sandy SILT/CLAY with occasional fine to coarse gravel and cobble sized rock fragments. (COLLUVIUM) Stiff, moist, yellowish brown (10YR 5/4) mottled pink, slightly sandy SILT with some angular to subangular fine to coarse gravel and occasional cobble and boulder sized rock fragments (maximum size 350mm) with occasional pockets of completely decomposed Rhyolite Lava (maximum size 150mm). (COLLUVIUM) Trial pit terminated at an average depth of 1.65m. Notes: 1. Small disturbed samples were taken at 0.50m, 1.00m and 1.50m depths. 2. Undisturbed vertical sample (U100) was taken at 1.00m depth. 3. Large disturbed sample was taken at 1.60m depth.	

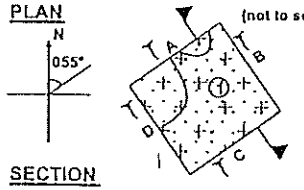
SYMBOLS

- Small Disturbed Sample
- Large Disturbed Sample
- Undisturbed Vertical Sample
- Undisturbed Horizontal Sample
- Block Sample
- In-situ Density Test
- Water Sample
- Water Seepage

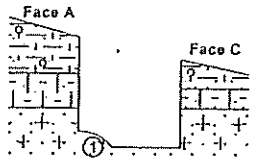
REMARKS

Ground Water
No Groundwater
Plant Used
Hand dug
Shoring
Timber shoring over full height
Stability
Stable
Depth of pit centre
1.65m
Others
Nil

PLAN (not to scale)



SECTION



Contract No. :	GE/2001/13	
Works Order No.	: GE/2001/13.10	
Co-ordinates	:	
E 846585.94	N 817385.05	
Ground Level	: 75.60	mPD
Logged by	: K.L. Lo	
Date logged	: 08/06/2002	
Checked by	: Tom Lo	
Date Checked	: 10/06/2002	

PROJECT

Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development Ground Investigation

Sheet	1	of	1	
Date excavated	06/06/2002	to	07/06/2002	
Date Reinstated	29/06/2002	to	29/06/2002	

TRIAL PIT NO.
TP14

GEOTECHNICS & CONCRETE ENGG. (HONG KONG) LIMITED
GROUND INVESTIGATION DEPARTMENT

APPENDIX B

Aerial Photograph Interpretation And API Map

817500 N
817400 N
817000 N
816800 N
816500 N
847500 E
847255 E
847000 E
846500 E
Natural Terrain Study Boundary
(1945)
(1945 & 1964)
(2000)
(1997)
(1964 & 1973)

Legend

- Landslide scar from API (year of landslide event(s))
- Landslide from NTLI
- Colluvium
- Photogeological lineament
- boulder fields
- Rock outcrops
- drainage line

Revision	Date	Description			Initial
	Design	Check	Drawn	Check	
Initial	SMo	JH	VN	JH	
Date	08/2002	08/2002	08/2002	04/2002	

Approved

AGREEMENT NO. FD01-052

Contract Title

TSEUNG KWAN O STAGE II/III AFTERUSE DEVELOPMENT

Figure Title

AERIAL PHOTO INTERPRETATION MAP

Drawing No.	Scale
APPENDIX B	1:2500

Consultant

Binnie Black & Veatch Hong Kong Limited

API - TSEUNG KWAN O STAGE II/III LANDFILL

Low Flight

Year	Reference No (Scale)	Description
1963	Y08353-4 (3900')	The landfill site is situated in a bowl shaped valley overlooking Tai Chik Sha (TCS) and a small embayment of Tseung Kwan O Bay. The TCS area was originally of a natural hillside surrounded by agricultural fields. The base of the hillside has been terraced for landuse. The slopes are vegetated, being more heavily vegetated in the south, with abundant boulders on hillslopes to the east and south. A number of large boulders can also be identified in the north. A NW-SE trending channel drains the valley. Relict landslide scars are present in the areas to the north-west and and south-west.
1967	Y13343-4 (6250')	Terracing activity on the hillslopes to the north and south and several areas where platforms are formed. Landslips identified on slopes adjacent to drainage paths on the southern slopes in the lower parts of the natural slope. Evidence of erosion along the rdigelines where slight regrowth of vegetation have occurred.
1974	9303-9305 (4000')	Further terracing and platform formation on slopes in the south. Evidence of previous rockfalls in the south and eastern portions of study area. Evidence of further erosion along ridgelines and on lower parts of slopes. Evidence of landslips on lower part of slope in the south and also adjacent to drainage lines in the south-west (identified in NTLI).
1976	14973-74 (5000')	No major changes to the TCS area but terraces to the south are excavated/stripped of vegetation. No changes to natural slope.
1980	30720 (4000')	Further excavation/stripping of vegetation in areas to the south and south-east of TCS to form terraces (probably for the cemetery). Surface of natural slopes to the south cleared of vegetation by hill fires.
1982	44300 (4000')	Vegetation growth on formed terraces and regrowth on previous hill fire areas of natural slope. Adjacent areas surrounding TCS area heavily vegetated.
1983	47500-501 (4000')	No changes to site area. Construction of landfill site (Stage I) further to the north has commenced and platform being formed.
1986	A07542-3 (4000') A07375-6 (4000')	A major portion of the existing agricultural land covered over by vegetation with only faint signs of the terraced landscape. Most of the TCS area heavily vegetated. Platform formed in the area to the west of Siu Chik Sha (to the north of TCS). No changes to natural terrain.
1987	A10847-8	Formation of access to TCS from the Stage I site in

	(4000')	the north and agricultural land has been excavated. Access roads to several parts (in the southern and eastern parts) of the proposed Stage II/III Landfill site have been formed cutting into the base of the natural terrain. Formation of cutslopes commenced in the southern portion of the study area.
1988	A14141 (4000')	Reclaimation for basal platform to the west of TCS commenced with lagoons formed and seawall constructed. Excavation of the TCS area continues and the catchwater channel along the southern perimeter has been formed. Natural terrain becoming heavily vegetated.
1989	A16794-6 (4000')	Reclaimation for basal platform and site formation within landfill site continues. Landfilling apparent at the basal area (in the west) of the site. Formation of cut slope in the southern portion of the study area commences.
1990	A20554-5 (4000')	Site formation into the northern parts of the natural terrain and construction of the catchwater around the northern perimeter has commenced. Landfilling apparent on the centre of the site.
1991	A25266-7 (4000')	Landfill Stage II/III site boundary has been formed and site formation within continues. Cut slope 12SW-A/F67 formed. No changes to natural terrain.
1992	A32763-4 (4000')	Formation of cut slope, 12SW-A/C203, in the north has commenced and other cut slopes continue. Major activity in the northern portion of the site – most probably landfilling. Reclaimation to form platform to the south-west has commenced.
1993	A37384-6 (4000')	Formation of cut slopes continue. Black membrane placed on formed slope 12SW-A/F68. Northernmost portion of the site filled and landfilling apparent in the eastern portion of the site. Formation of cut slopes, 12SW-A/C185 and 12SW-A/C203, to the north have been completed.
1994	A38107-9 (4000')	All cut slopes formed with only minor activity in the eastern portion of the landfill site.
1995	CN10018-20 (3500')	Cut slopes hydroseeded.
1996	CN14306-7 (4000')	Growth of hydroseeding on slopes.
1997	CN17111-2 (4000')	Increase in vegetation at the toe of natural terrain and growth of hydroseeding on cut slopes continue. Evidence of landslip at the southern area of the natural terrain.
1998	CN21382-3 (4000') A48421-3 (4000')	Surfaces of cut slopes covered with white/black membrane layers and then followed by a layer of soil. Landslip covered over by growth of vegetation.
1999	A49687-8 (4000')	Another phase of hydroseeding works emplaced on slope surfaces. Heavily vegetated natural terrain.

High Flight

Year	Reference No (Scale)	Description
1945	Y00432-3 (20,000')	The TCS area was originally of a natural hillside surrounded by agricultural fields. The base of the natural hillside have been terraced for landuse and beyond this, the natural slopes are heavily vegetated.
1964	Y12906-8 (12,500')	Extent of agricultural land increased with terracing along the base of the natural hillsides. Platforms formed for building structures in the north and south.
1973	8038-9 (12,500')	Evidence of a landslide on the slopes to the south (also identified by NTLI) and erosion. Further terracing activity on natural slopes. Platforms previously formed now vegetated.
1974	9709-10 (12,500')	No major changes form previous photograph. Regrowth of vegetation on slope surfaces.
1985	A01724-5 (10,000')	The TCS area was originally of a natural hillside surrounded by agricultural fields. The base of the natural hillside have been terraced for landuse and beyond this, the natural slopes are heavily vegetated.
1996	CN16263-4 (10,000')	Landfill site has been formed with south-west facing hydroseeded cut slopes and catchwater channels along the perimeter.
1997	CN18613-5 (10,000')	No changes to cut slopes with minor formation activity at the base of Slope 12SW-A/F67.
1999	CN25715-6 (8,000')	Growth of hyrodseeding on slope surfaces. Industrial complex constructed at toe of Slope 12SW-A/F67.

APPENDIX C

Catalogue of Natural Slope Landslide And Database

CATALOGUE OF NATURAL SLOPE LANDSLIDES

Map Sheet Report

Map Sheet Reference Number :	12SW-A
Date of Assessment :	5 - 7 February 1996
API Consultant:	G.I.Short API(Consultant)/5 Produced under Agreement No.CE 16/93 for CED
Description of Terrain :	Steep to rolling terrain on volcanic rocks. Vegetation cover is mainly grass.
Land Use :	A mixture of urban and country park.
Extent of Land Modifications :	Approximately 40% of lands has been modified for urban and infrastructure development.
Land Area of Map Sheet :	775 ha
Time Involved :	6.5 hours
No. of Aerial Photo. Sets Examined:	23
Mapping Criteria:	Widths of Landslides Class 1: Landslide less than 20m wide at widest point Class 2: Landslide more than 20m wide at widest point
AP's Showing Recent Landslide activity:	The earliest and complete set of photography flown of the area was in 1945. Very few fresh landslides were observed other than some activity recorded in 1975 and 1992.
Relict Landslips:	Descriptions as per standard. Relict landslides along the coast occurred in soil material.
Years for which Aerial Photographs are not available.	1972 Not flown 1974 One half of area not in GEO collection 1977 Not flown
Years for which Ground Coverage is obscured by Cloud:	
Years and Localities in which Natural Terrain was modified:	Most modifications were in the 1981 and 1994 time periods around Junk Island, Tin Ha and Tai Chik Sha.

1 Natural Terrain Landslide Catalogue, Summary Sheet for Sheet No. 12 SW-A

ID_MAX, Total number of landslides ~~129~~ 130. Unused Numbers between 0 and ID_MAX 0

Aerial Photograph Cover

YEAR	Coverage
1945	FC
1964	FC
1972	NF
1973	FC
1974	PC/NG
1975	FC
1976	FC
1977	NF
1978	FC
1979	FC
1980	FC
1981	FC
1982	FC
1983	FC
1984	FC
1985	FC
1986	FC
1987	FC
1988	FC
1989	FC
1990	FC
1991	FC
1992	FC
1993	FC
1994	FC

Full Aerial Photograph Cover	FC
Partial Aerial Photograph Cover	PC
No Aerial Photograph Cover	NF - Not Flown
	NG - Not in GEO Collection
	NA - Not Available for mapping

List of Aerial Photographs Used

Year	Height (ft)	Photograph Number	Date	Coverage
1945	20 000	Y527-30 Y431-5	11.11.45	A
1964	12 500	Y12906-8 Y12834-6		A
1973	12 500	8037-8	20.12.73	A
1974	12 500	9709-10 9700	21.11.74	B
1975	12 500	12054-6 12066-8	24.12.75	A
1976	12 500	15927-9 15837-9	4.11.76	A
1978	12 500	20762-4	10.1.78	A
1979	10 000	28028-9 28016-8	28.11.79	A
1980	10 000	33425-7	28.11.80	A
1981	10 000	39023-5 39037-8	26.10.81	A
1982	10 000	44464-6 44514-5	10.10.82	A
1983	10 000	51332-3	30.11.83	A
1984	10 000	56488-9	20.10.84	A
1985	10 000	A1714-6 67385-7	7.7.85 1.10.85	A
1986	10 000	A8258-9	21.12.86	A
1987	20 000	A8396-7	5.1.87	A
1988	10 000	A13650-3	4.6.88	A
1989	10 000	A19293-4	20.11.89	A
1990	10 000	A24427-8 A24680-1	3.12.90 4.12.90	A
1991	10 000	A28525-6	21.10.91	A
1992	10 000	A33156-8	11.11.92	A
1993	10 000	CN5341-3 CN5673-4	5.12.93 6.12.93	A
1994	10 000	A39512-4 A39724-6	24.10.94	A

A = full stereoscopic coverage
B = partial stereoscopic coverage

MAP SHEET NUMBER: 12SW - A

TAG NO.	SLOPE	YEAR	COVER	WIDTH	CROSS TAG NO.	LAST YR
0001	18	45	C	1		—
0002	27	45	C	1		—
0003	27	45	C	1		—
0004	30	45	C	2		—
0005	39	45	C	1		—
0006	45	45	C	1		—
0007	39	45	C	1		—
0008	39	45	C	1		—
0009	39	45	C	1		—
0010	39	64	B	1		45
0011	30	45	C	2		—
0012	39	45	C	1		—
0013	39	45	C	1		—
0014	34	45	C	1		—
0015	34	45	C	1		—
0016	45	45	C	2		—
0017	45	45	C	1		—
0018	34	45	C	1		—
0019	34	45	C	1		—
0020	30	45	C	1		—
0021	34	45	C	1		—
0022	27	45	C	1		—
0023	39	45	C	1		—
0024	34	45	C	1		—
0025	39	45	C	1		—
0026	39	45	C	1		—
0027	39	64	C	1		45
0028	39	45	C	1		—
0029	22	45	D	1		—
0030	45	45	C	2		—
0031	39	45	B	2		—

0032	34	45	B	1		-
0033	45	45	B	1		-
0034	39	45	B	1		-
0035	45	45	B	2		-
0036	45	45	B	1		-
0037	45	45	B	1		-
0038	27	45	C	1		-
0039	30	45	C	1		-
0040	34	45	C	1		-
0041	34	45	C	1		-
0042	39	45	C	1		-
0043	34	45	C	2		-
0044	39	45	C	2		-
0045	34	45	C	1		-
0046	34	45	C	1		-
0047	34	45	C	1		-
0048	45	64	C	1		45
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0050	39	45	C	1		-
0051	39	45	C	1		-
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0054	45	45	C	1		-
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0064	45	45	C	2		-

0065	30	45	C	1		—
0066	30	64	C	1		45
0067	45	45	C	2		—
0068	30	45	C	1		—
0069	20	45	C	1		—
0070	15	45	C	2		—
0071	34	45	C	1		—
0072	24	45	C	1		—
0073	20	45	C	1		—
0074	24	45	C	1		—
0075	27	45	C	2		—
0076	34	45	C	1		—
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0079	39	45	C	2		—
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0088	18	45	C	1		—
0089	24	45	C	1		—
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0093	30	64	C	1		45
0094	45	64	C	1		45
0095	30	73	A	1		64
0096	39	73	A	1		64
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0098	45	64	C	1		45

0099	45	64	C	1		45
0100	45	64	C	1		45
0101	45	64	C	1		45
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0118	34	73	A	1		64
0119	39	64	C	1		45
0120	30	64	C	1		45
0121	39	64	C	1		45
0122	34	73	A	1		64
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0124	34	75	A	1		74
0125	30	75	A	1		74
0126	34	75	A	1		74
0127	30	75	A	1		74
0128	39	92	A	1		91
0129	39	92	A	1	10	91
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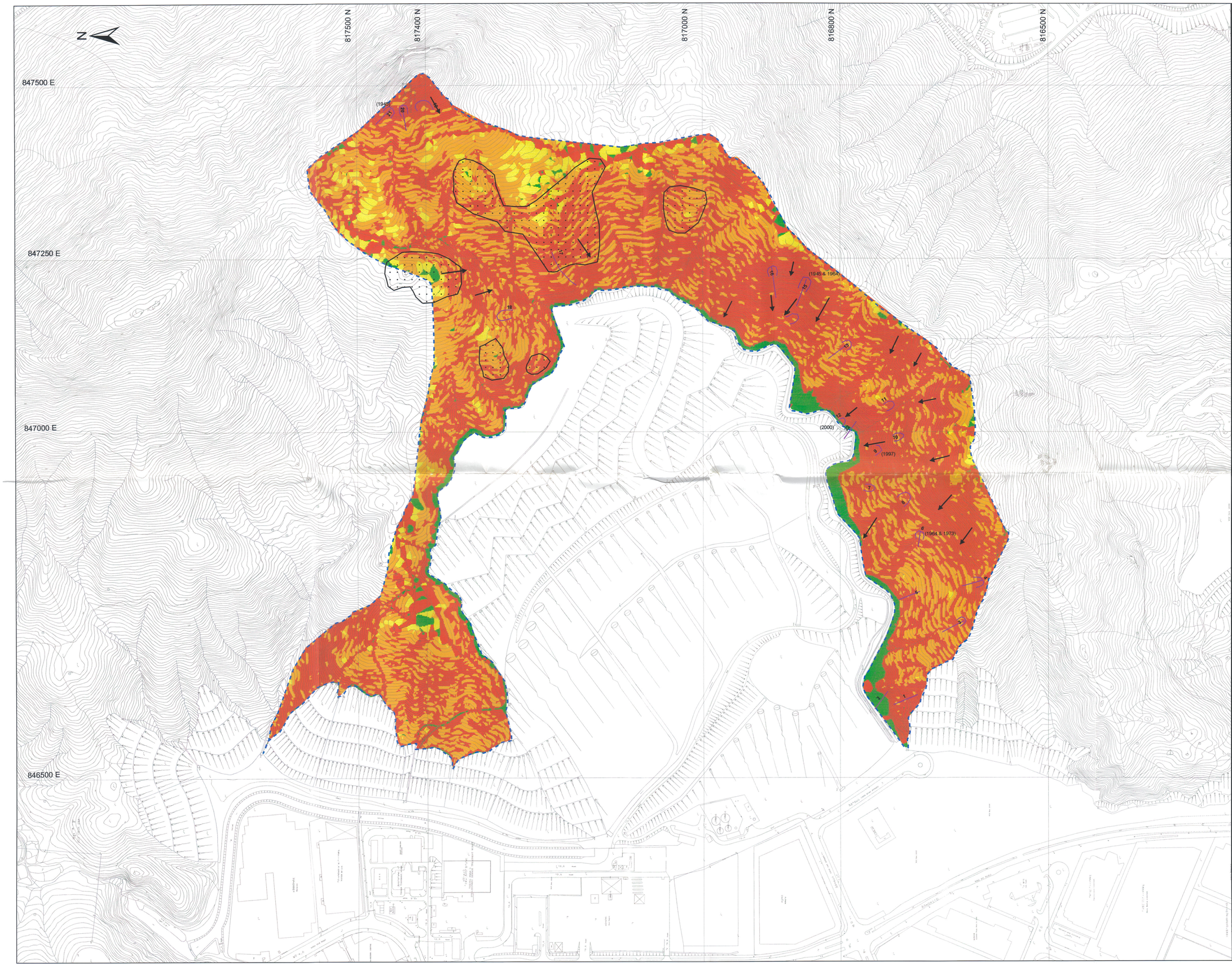
0132						

APPENDIX D

Natural Terrain Hazard Map



Legend

Slope Angle

- 0 - 7 degree
- 8 - 17 degree
- 18 - 29 degree
- > 30 degree

Natural Terrain Study Boundary

Landslide scar from API (year of landslide event(s))

Landslide from NTLI

Potential landslide source and mobility direction

Boundary fields and trajectory direction

Revision	Description			Initial
	Design	Check	Drawn	Check
Initial	SMo	JH	VN	JH
Date	08/2002	08/2002	08/2002	08/2002

Approved

AGREEMENT NO. FD01-052

Contract Title

TSEUNG KWAN O STAGE II/III AFTERUSE DEVELOPMENT

Figure Title

Natural Terrain Hazard Map

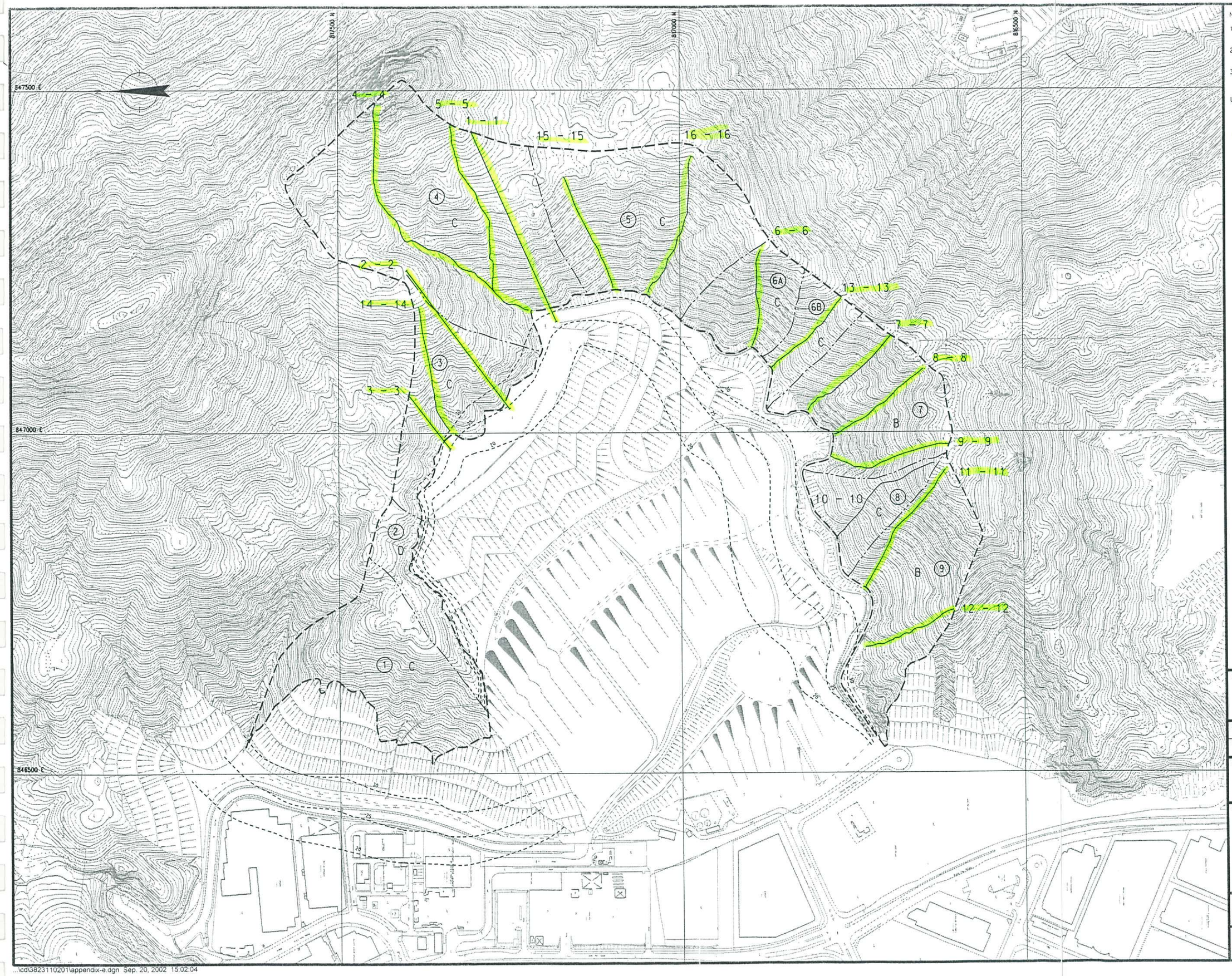
Drawing No.	Scale
APPENDIX D	1:2500

Consultant

Binnie Black & Veatch Hong Kong Limited

APPENDIX E

Landslide Susceptibility Map, Sections and Tables from GEO SPR 1/2002



NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.
2. ALL LEVELS ARE IN METRES ABOVE PRINCIPAL DATUM.
3. ALL DIMENSIONS ARE TYPICAL AND TO BE CONFIRMED AT DETAILED DESIGN.

LEGENDS:

- NATURAL TERRAIN BOUNDARY
- 2-2 STREAM/ CROSS SECTIONS
- (1) CATCHMENT NUMBERS
- CATCHMENT BOUNDARY
- 30 ANGLE OF ELEVATION FROM PLATFORM TO SLOPE
- B SUSCEPTIBILITY CLASSES

Approved

ORIGINAL SIGNED BY C. DUTTON

CAD ref. MAIN : APPENDIX E.DGN
XREF : B12SW06B.D, B12SW01B.D, B12SW02A,B,C,D & B12SW07A,B,C,D.DGN

Contract no. FD01-052

Contract
GEOTECHNICAL REVIEW AND SITE INVESTIGATION WORKS FOR TSEUNG KWAN O STAGE II/III AFTERUSE DEVELOPMENT

Figure Title

LANDSLIDE SUSCEPTIBILITY MAP

Figure no. APPENDIX E

Scale (A3) 1:5000

Binnie Black & Veatch Hong Kong Limited
博威工程顧問有限公司

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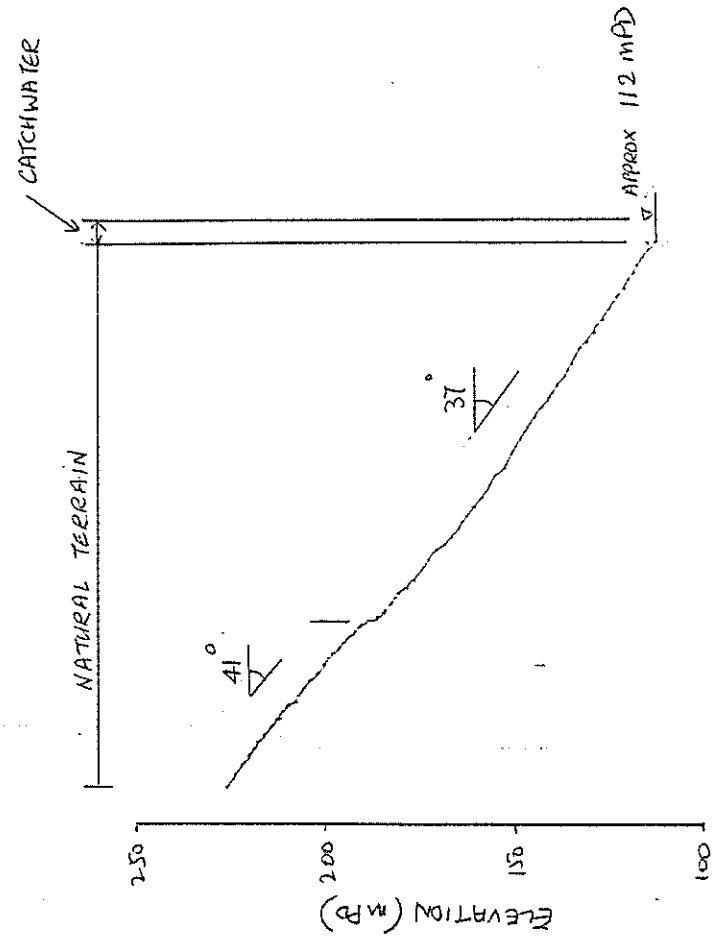

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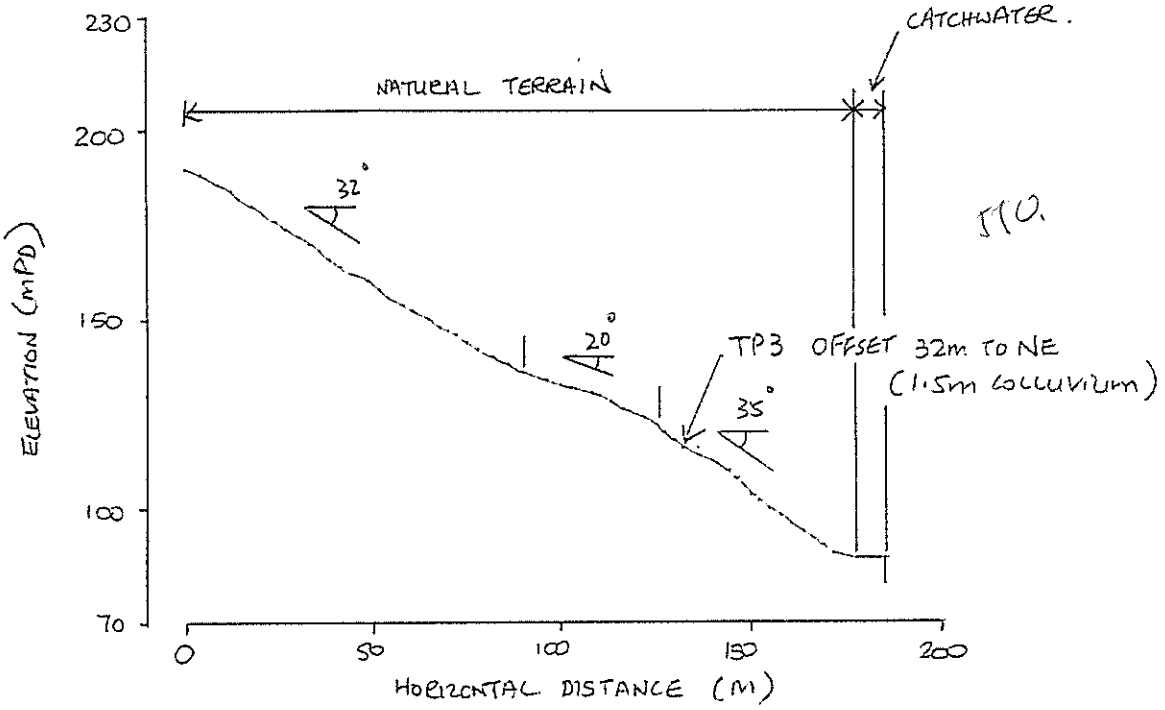
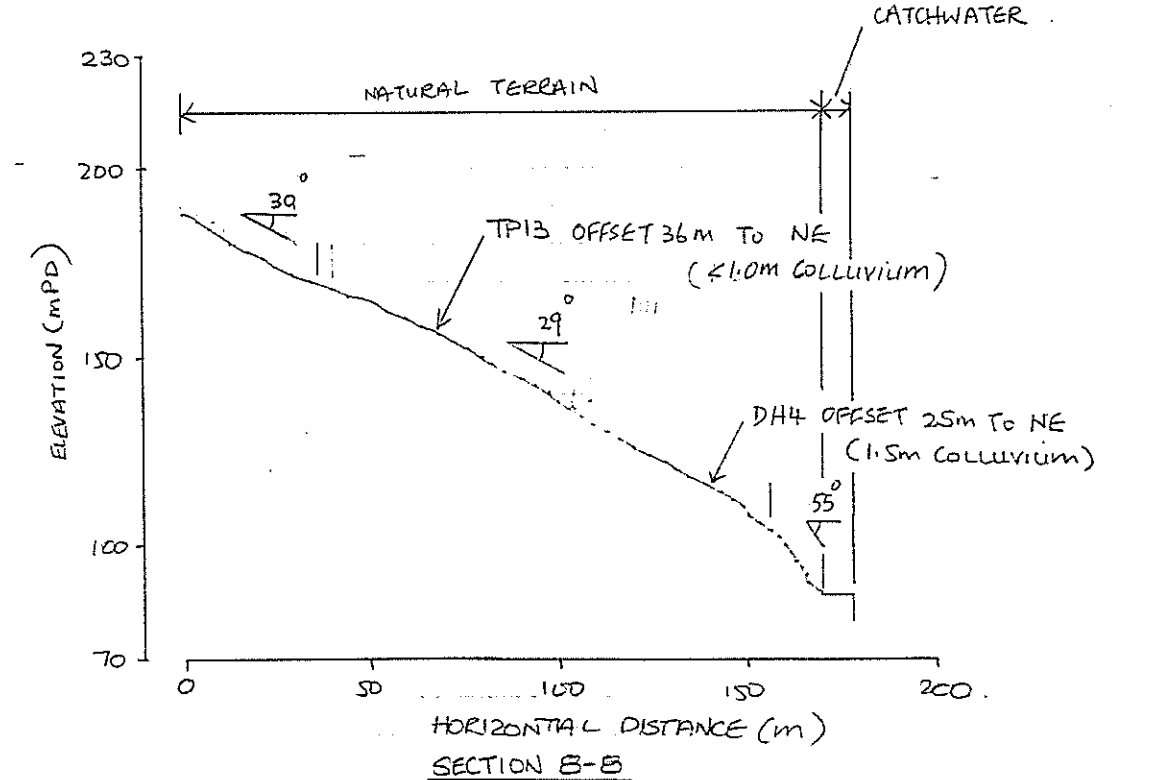


SECTION 7-7



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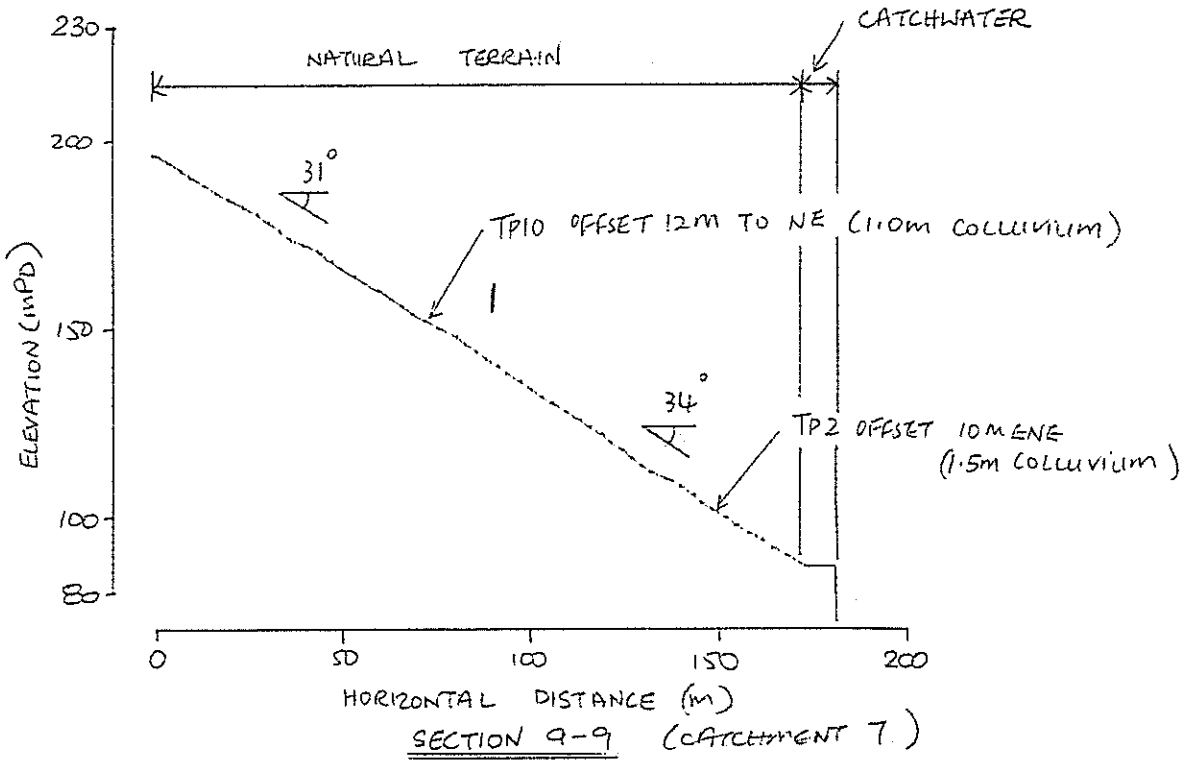

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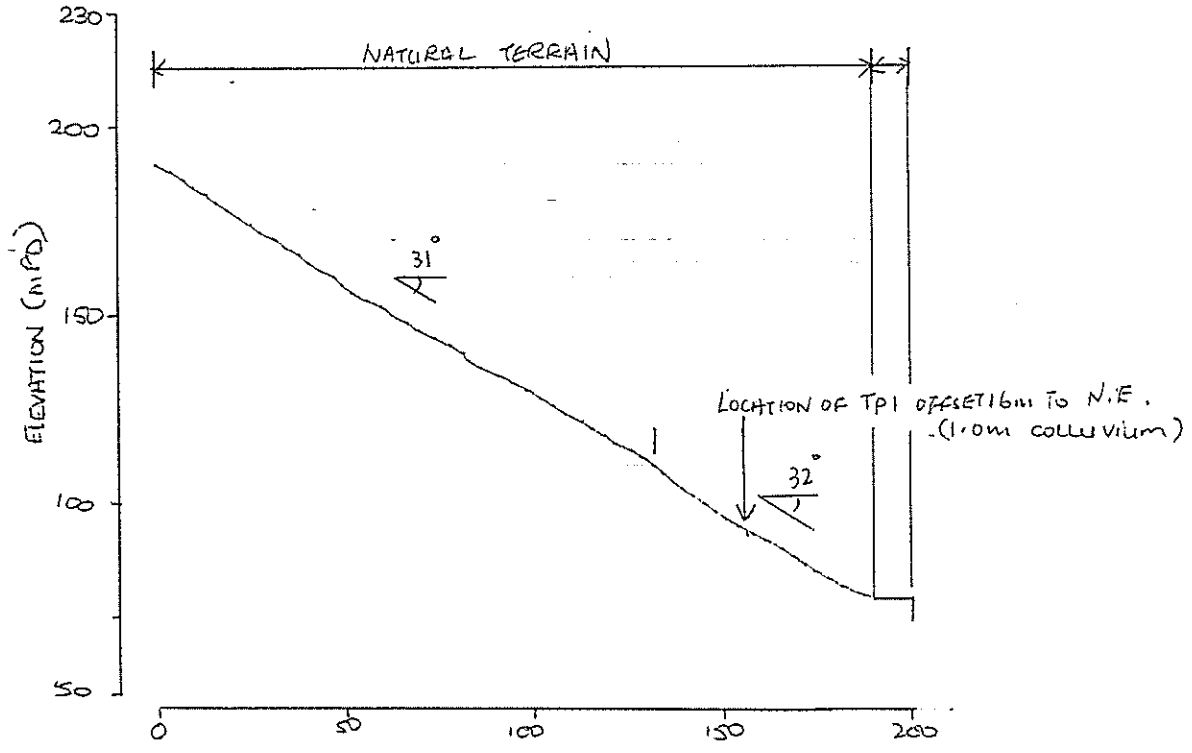

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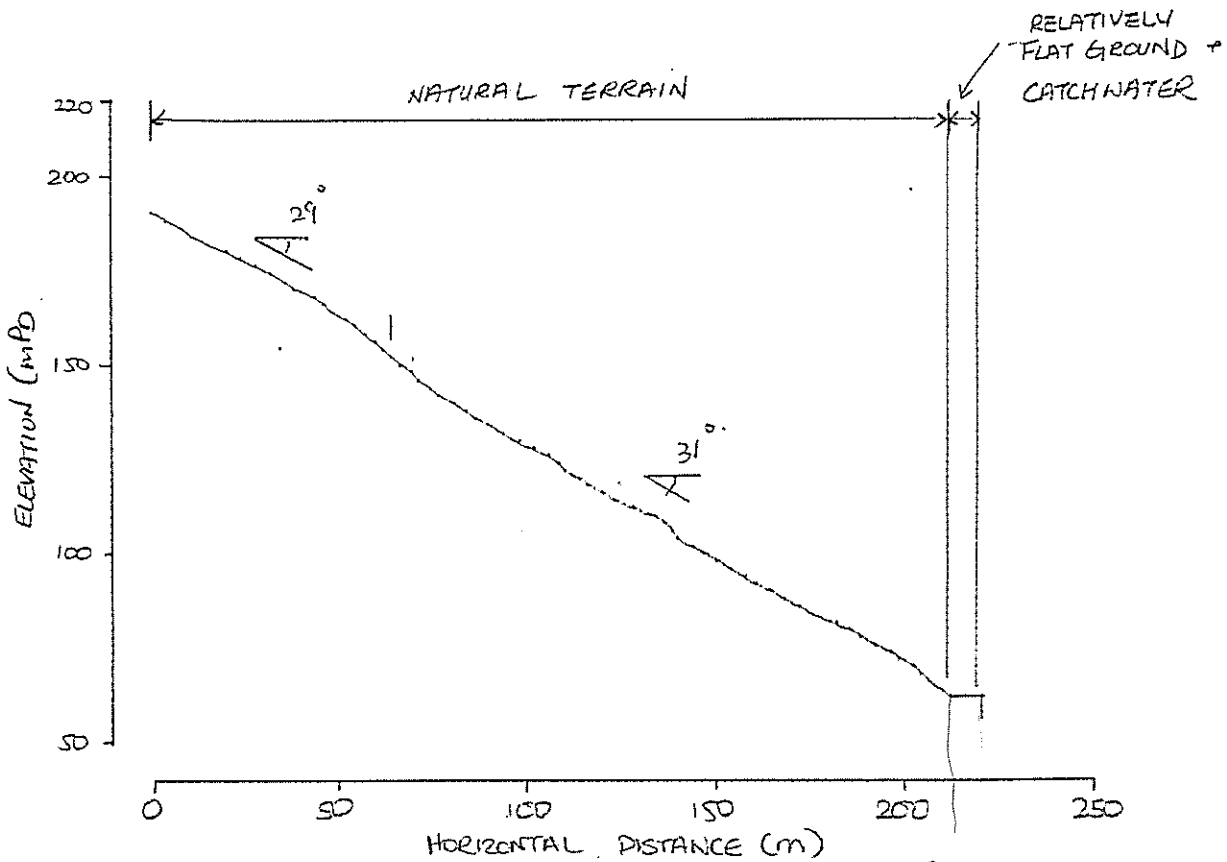

SECTION 11-11

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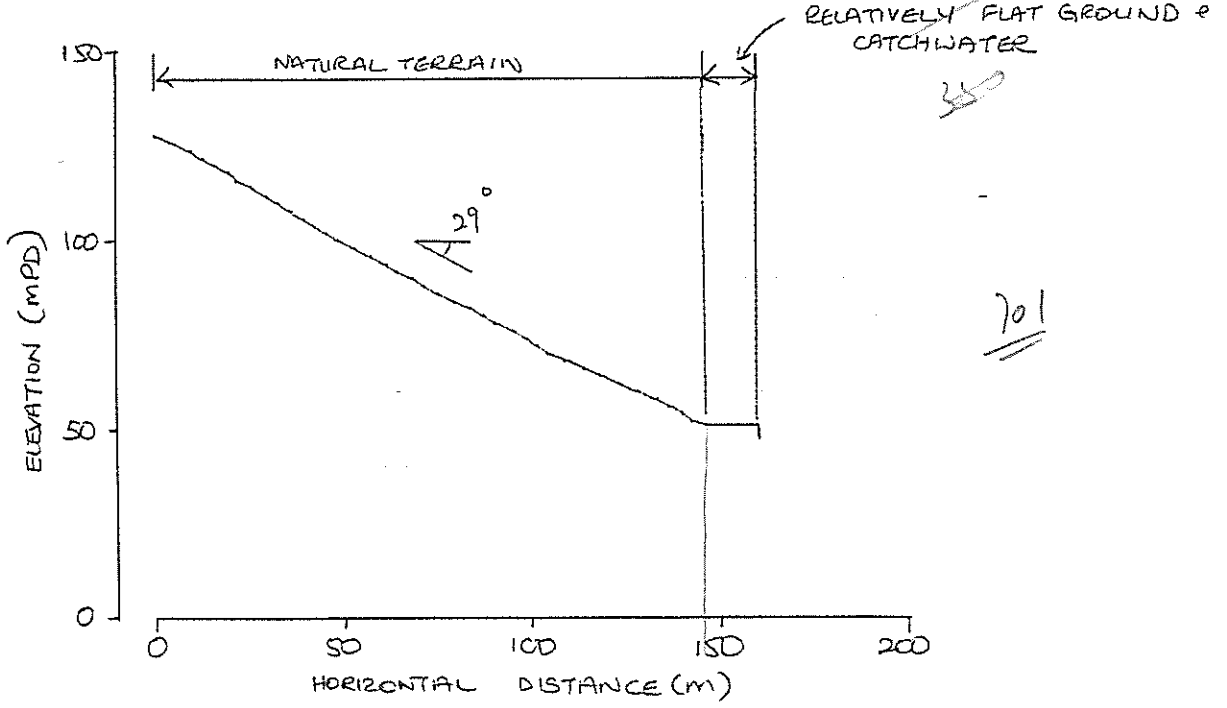

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SECTION 12-12

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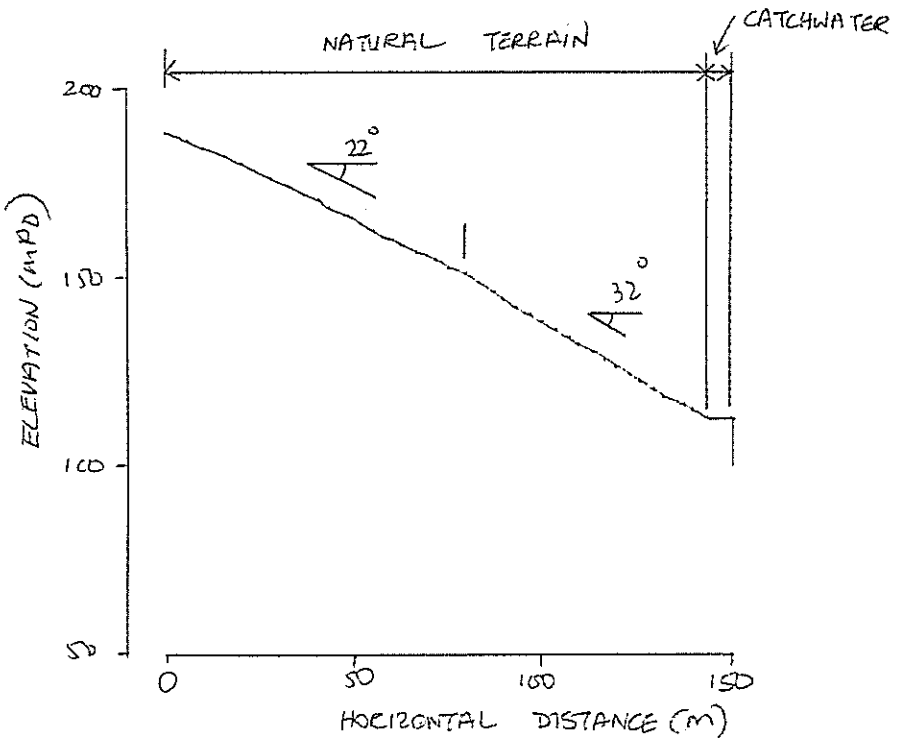

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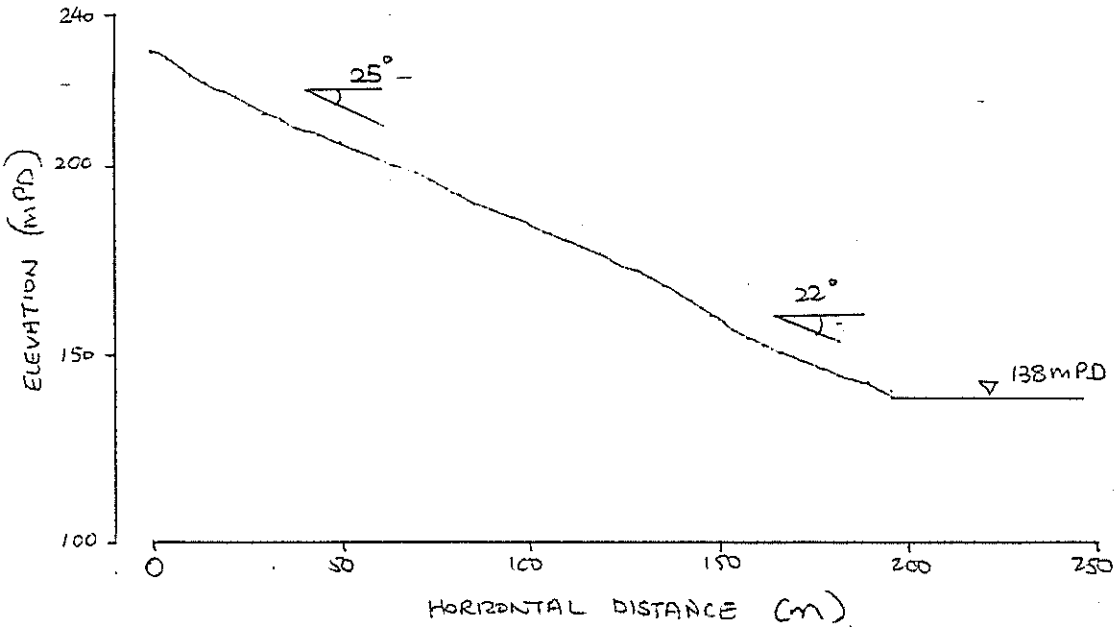

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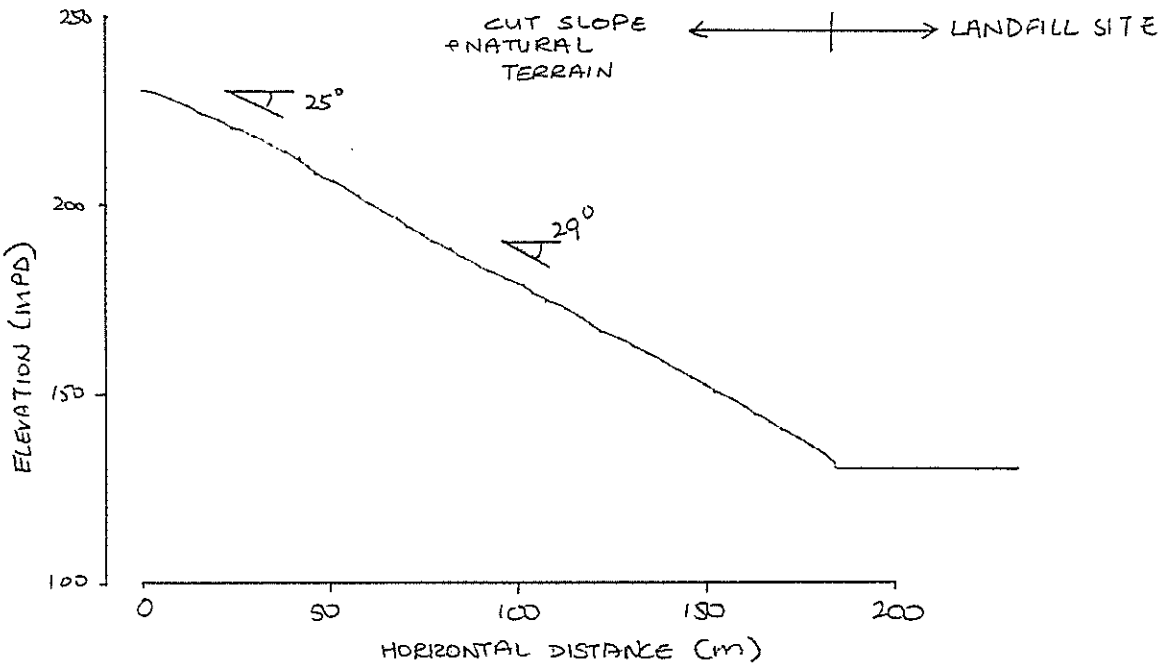

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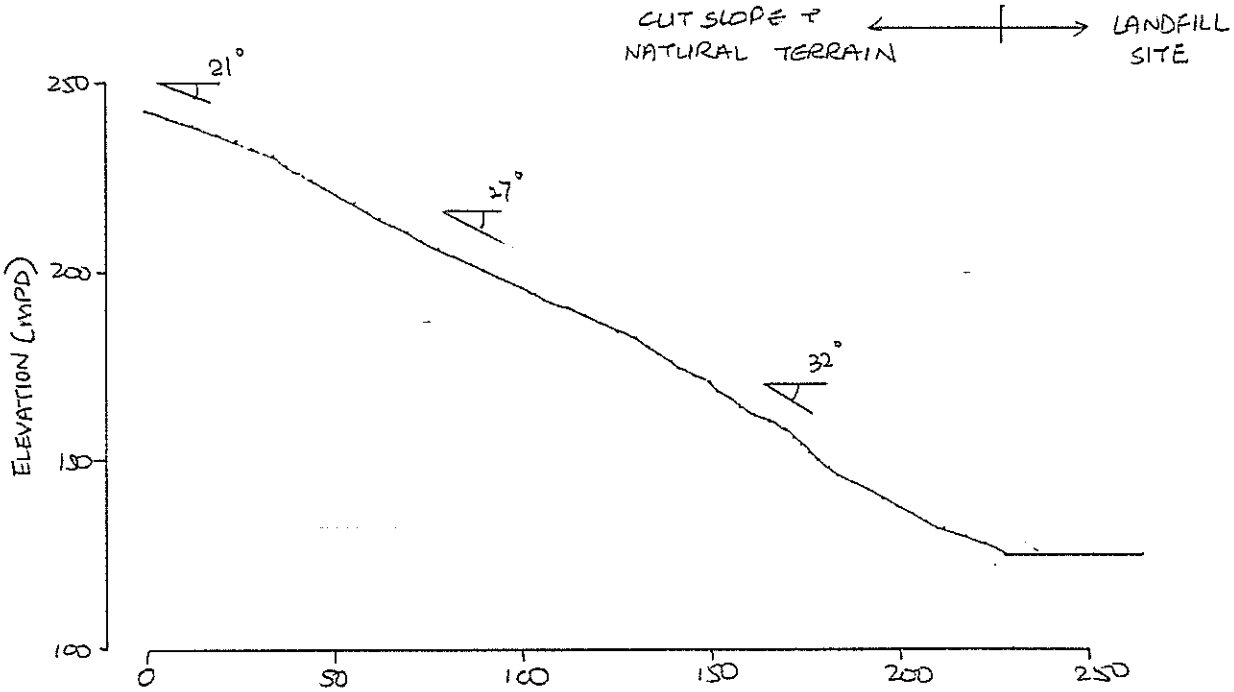

SECTION 16-16

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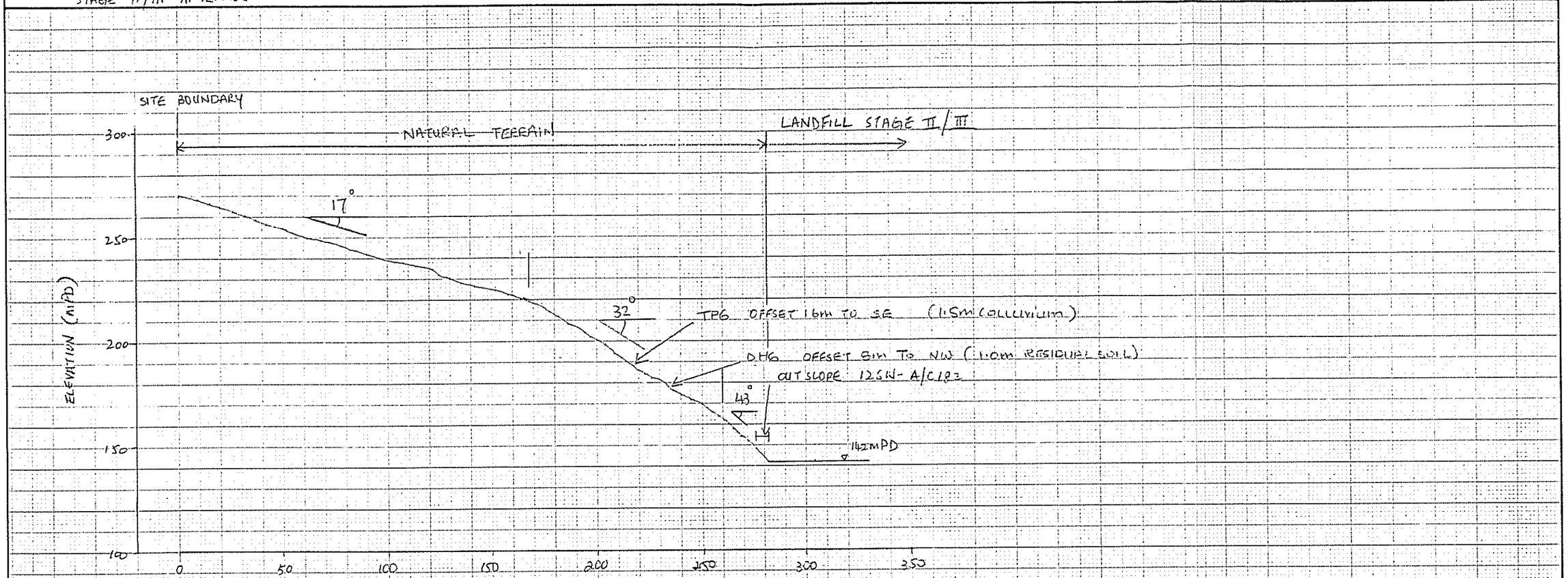
Project AGREEMENT NO. FD 01-052 TSEUNG KWAN O LANDFILL STAGE II/III AFTERUSE Subject SECTION FOR NATURAL SLOPE SECTION 1-1 Job number 382311/0207 Page of



SECTION 1-1

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Date 07/02 Date

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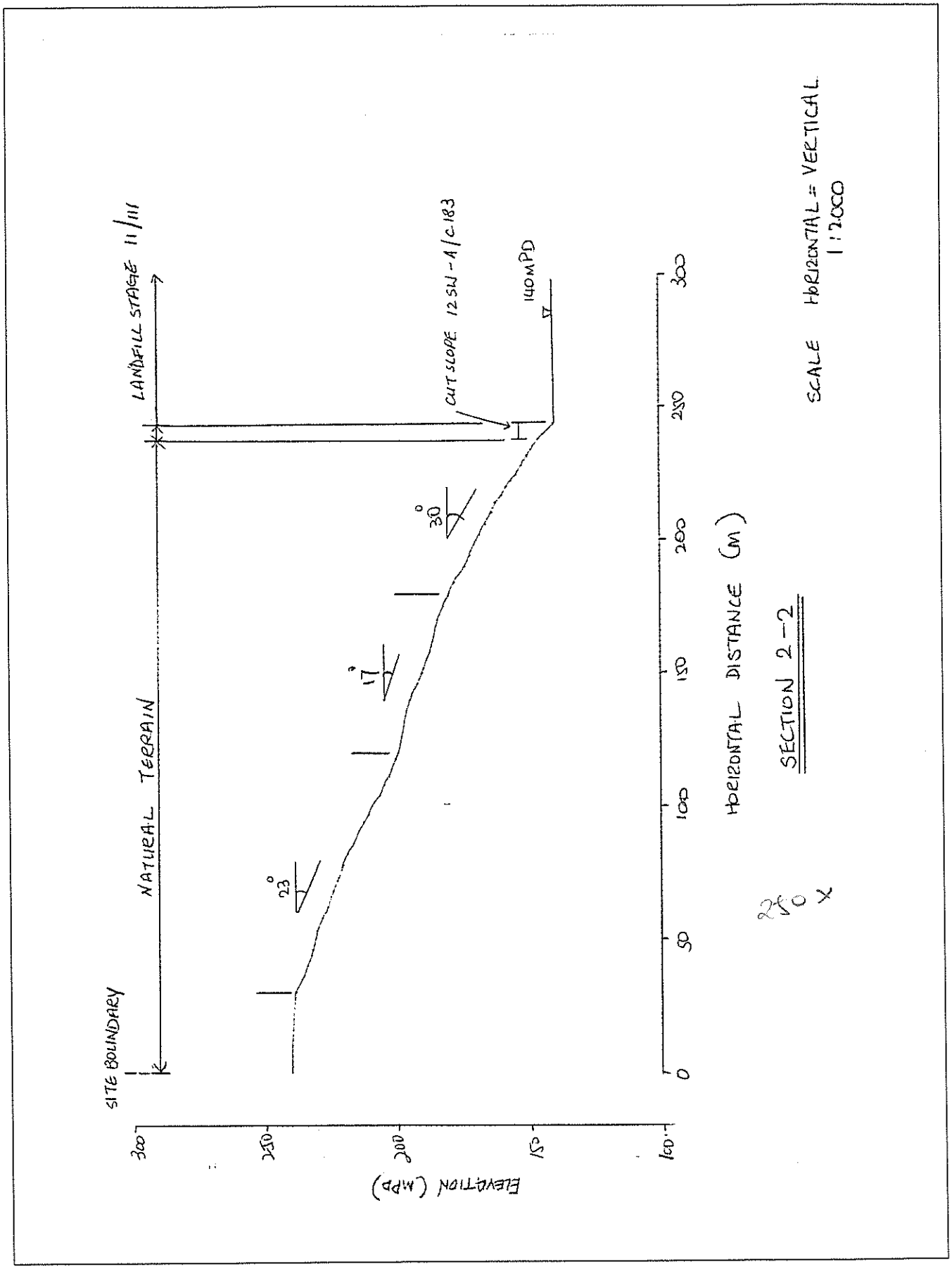
Engineers and Scientists

Project AGREEMENT NO. FD 01-052 TSEUNG KWAN O LANDFILL STAGE II/III AFTERUSE DEVELOPMENT

Subject SECTION FOR NATURAL SLOPE SECTION 2-2 Job number 382311/020 Page of



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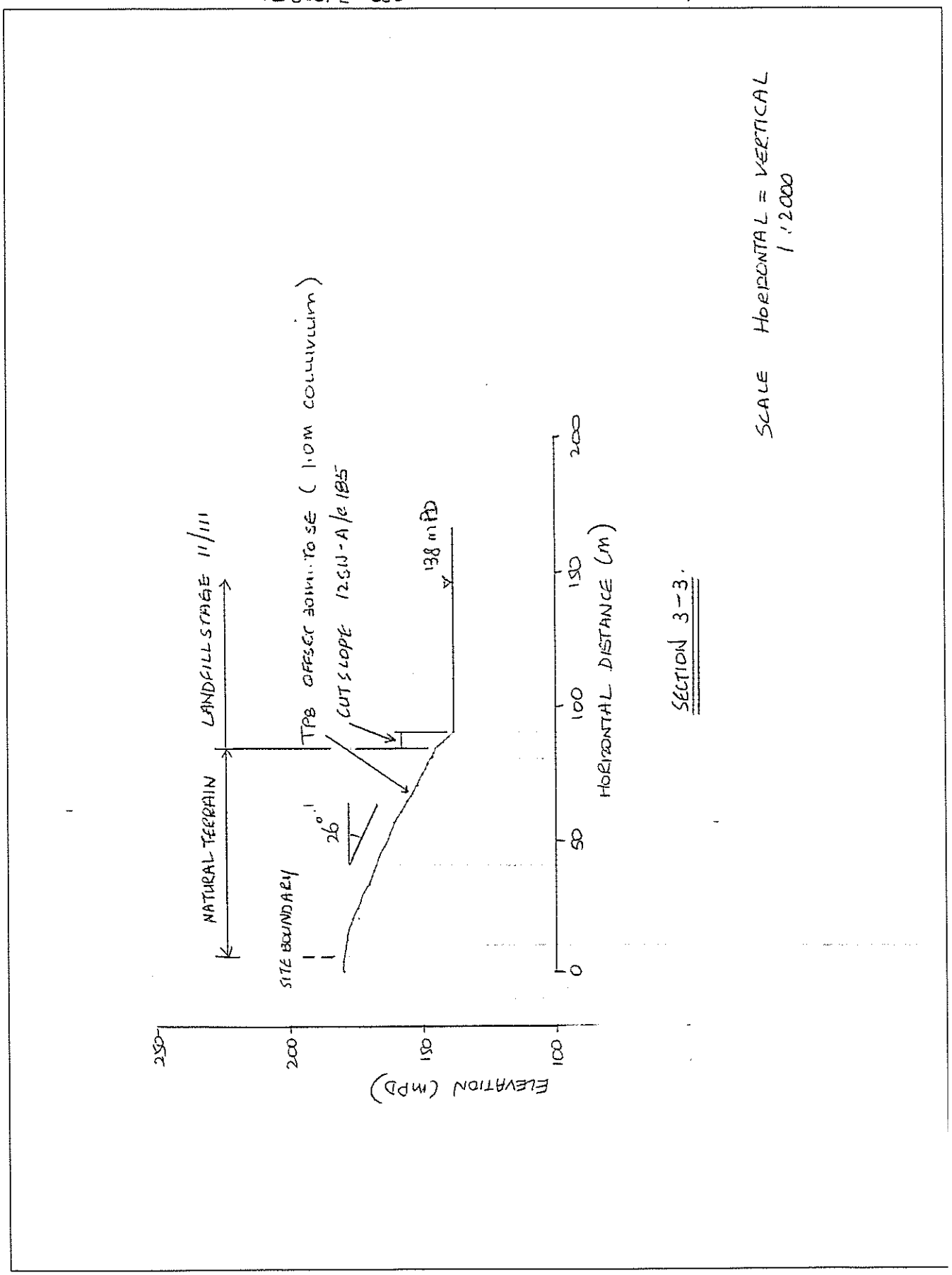
Date 07/02 Date

Project AGREEMENT No. FD 01-052
TSEUNG KWAN O LANDFILL STAGE II/III AFTERUSE

Subject SECTION FOR NATURAL SLOPE SECTION 3-3 Job number 382311/0201 Page of



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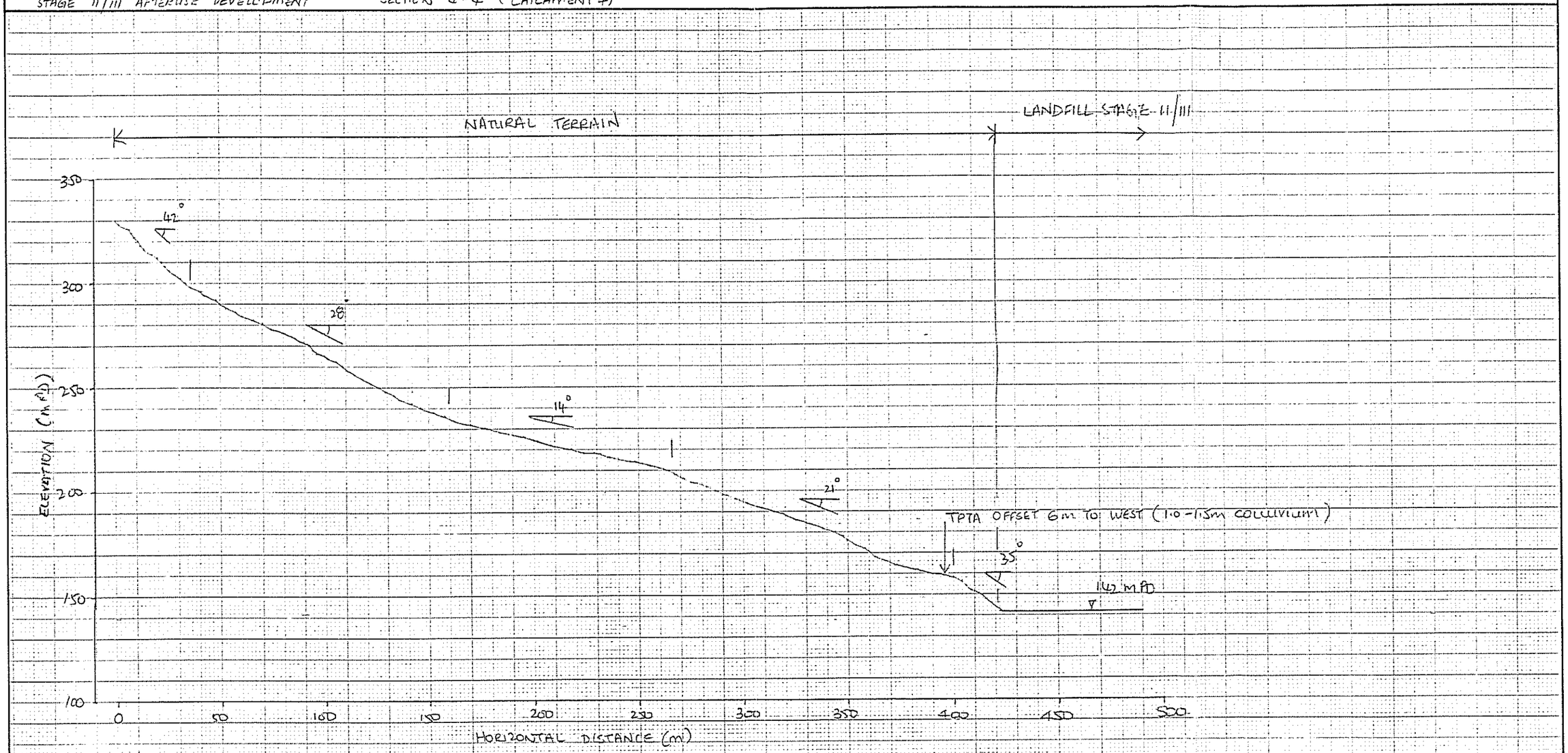
Date 07/02 Date

AGREEMENT No. FD 01-052

Project TSEUNG KWAN O LANDFILL STAGE II/III AFTERUSE DEVELOPMENT Subject STREAM SECTION FOR NATURAL SLOPE SECTION 4-4 (CATCHMENT 4) Job number 38231/0201 Page of



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1 : 2000

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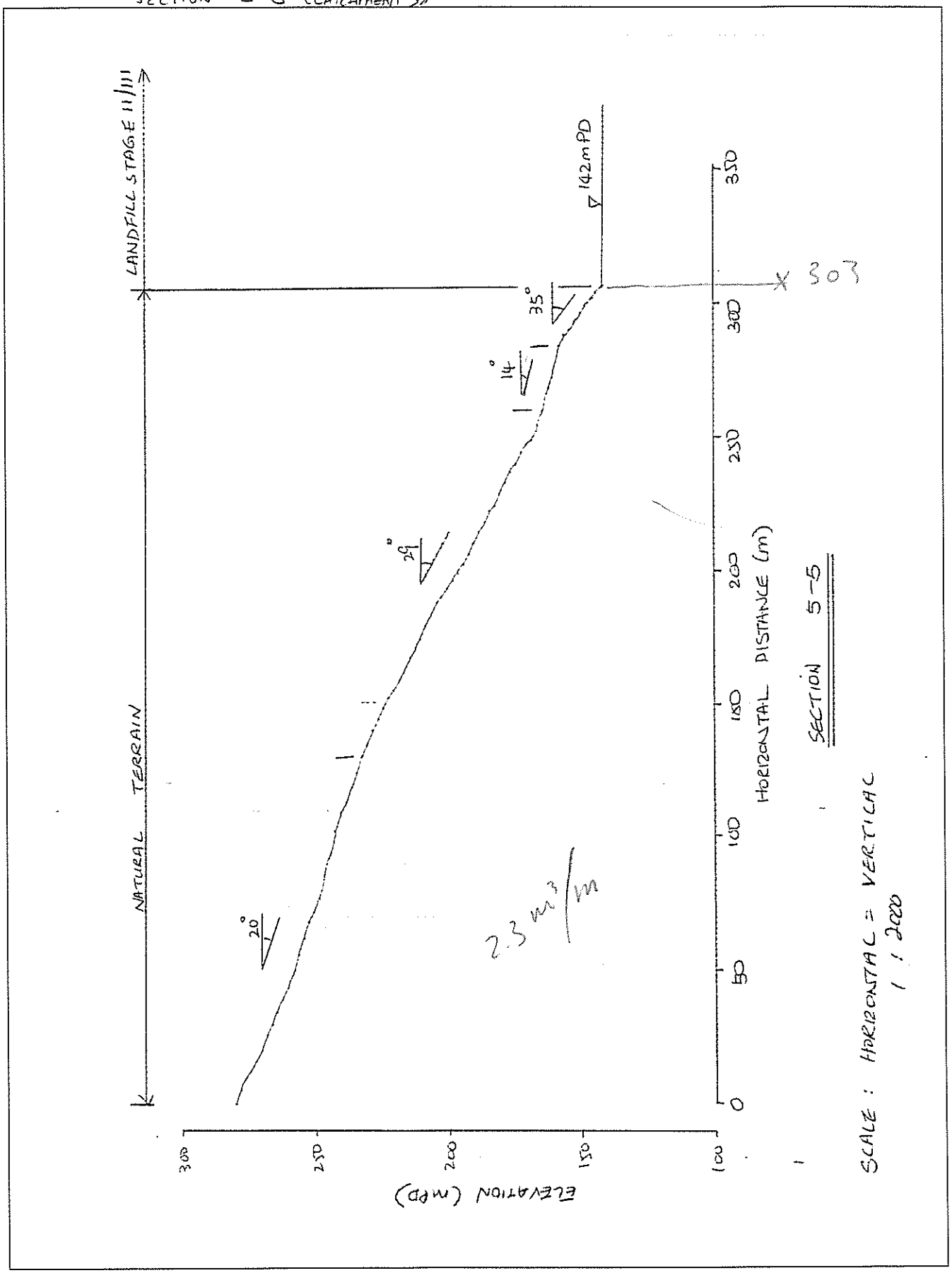
Engineers and Scientists

AGREEMENT NO FD 01-052

Project TSEUNG KWAN O LANDFILL STAGE II/III AFTERUSE DEVELOPMENT

Subject STREAM SECTION FOR NATURAL SLOPE SECTION 5-5 (CATCHMENT 5)

Job number 38231/0201 Page of



Computed by SHO. Checked by Distribution Filed in

Date 07/02 Date

Table 1 – Grouping of Facilities (adapted from Wong, 1998)

Group No.	Facilities
1	(a) Buildings – any residential building, commercial office, store and shop, hotel, factory, school, power station, ambulance depot, market, hospital/polyclinic/ clinic, welfare centre
	(b) Others – bus shelter, railway platform and other sheltered public waiting area – cottage, licensed and squatter area – dangerous goods storage site (e.g. petrol station) – road with very heavy vehicular or pedestrian traffic density
2	(c) Buildings – built-up area (e.g. indoor car park, building within barracks, abattoir, incinerator, indoor games' sport hall, sewage treatment plant, refuse transfer station, church, temple, monastery, civic centre, manned substation)
	(b) Others – road with heavy vehicular or pedestrian traffic density – major infrastructure facility (e.g. railway, tramway, flyover, subway, tunnel portal, service reservoir)
3	– densely-used open space and public waiting area (e.g. densely-used playground, open car park, densely-used sitting out area, horticultural garden) – quarry – road with moderate vehicular or pedestrian traffic density
4	– lightly-used open-air recreation area (e.g. district open space, lightly-used playground, cemetery, columbarium) – non-dangerous goods storage site – road with low vehicular or pedestrian traffic density
5	– remote area (e.g. country park, undeveloped green belt, abandoned quarry) – road with very low vehicular or pedestrian traffic density
Notes : For roads, the Facility Group should be based on Figure A13 (Wong, 1998) taking into account the actual Annual Average Daily Traffic and the number of road lanes. For footpaths alongside roads, it may be assumed that footpaths are within the same group as the adjoining roads, except for Expressways (EX), Urban Trunk Roads (UT) and Rural Trunk Roads (RT). Footpaths alongside EX, UT and RT roads may be taken, by default, as a Group 5 facility, unless dictated otherwise by site-specific conditions.	

Table 2 - Design Requirements for the Design Event Approach

Susceptibility Class (see Table 4)	Consequence Class (see Table 3)			
	I	II	III	IV
A	WCE	WCE	WCE	CE
B	WCE	WCE	CE	CE
C	WCE	CE	CE	N
D	N	N	N	N

Notes :

(1) The recommended minimum design requirements are given in this Table. The designer may adopt a more conservative design or provision of other precautionary/warning measures if considered necessary.

(2) This Table will be applied to each sub-catchment and normally the predominant type of hazard will control the design requirements.

(3) WCE = Adopt a "worst credible event" as the design event.
CE = Adopt a "conservative event" as the design event
N = Further study is not required

Table 3 - Consequence Classes

Proximity	Facility Group	
	1 & 2	3
Very Close (e.g. if angular elevation from the site is ≥ 30°)	I	II
Moderately Close (e.g. if angular elevation from the site is ≥ 25°)	II	III
Far (e.g. if angular elevation from the site is < 25°)	III	IV

Notes :

(1) Facility groups are given in Table 1. Facilities of Groups 4 and 5 normally do not require natural terrain hazard study and hence they are not included in Table 3.

(2) For channelized debris flow, if the worst credible event affecting the site is judged to have a volume exceeding 2000 m^3, the angular elevation given in the above examples should be reduced by 5°.

(3) The examples given above are for general guidance only. Other factors, such as credible debris path, topographical conditions and site-specific historical data, should also be taken into account in assessing the "proximity" of the natural terrain to the site.

(4) This Table is applicable only to sites that require natural terrain hazard study.

Table 4 - Susceptibility Classes

Susceptibility Class	Description
A	The natural terrain is extremely susceptible to the type of failure under consideration, with a notional annual probability of occurrence in the order of 1/10 or higher. For example: there are signs of instability, continued movement, or records of repeated recent failures (say over the past 50 to 100 years as observed from aerial photographs) in the catchment and its relevant vicinity.
B	The natural terrain is highly susceptible to the type of failure under consideration, with a notional annual probability of occurrence within the order of 1/10 to 1/100. For example: there are records of occasional recent failures in the catchment and its relevant vicinity.
C	The natural terrain is moderately susceptible to the type of failure under consideration, with a notional annual probability of occurrence within the order of 1/100 to 1/1000. For example: there are few records of recent failures, but there are indications of relict failures, or geomorphological evidence of potential problems in the catchment and its relevant vicinity, or any other evidence from similar terrain in Hong Kong.
D	The natural terrain is of low susceptibility to the type of failure under consideration, with a notional annual probability of occurrence less than 1/1000. For example: there are no records of recent and relict failures, little geomorphological and other evidence of potential problems in the catchment and its relevant vicinity, and little other evidence from similar terrain in Hong Kong.

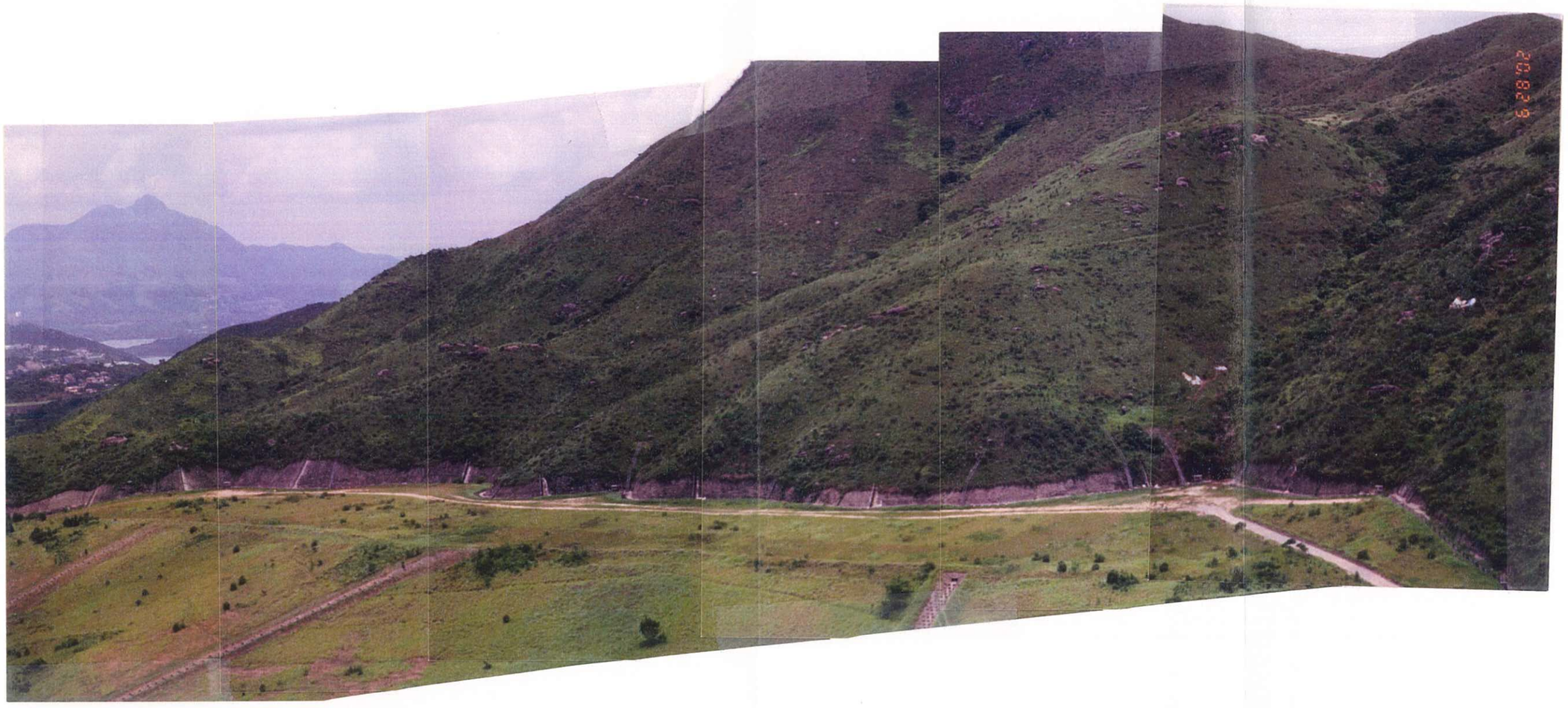
Notes :

(1) In assessing the susceptibility of the hillside to failure, consideration should be taken of the potential effects of changes in environmental factors, e.g. any changes to the overall setting of the terrain such as hill fires and construction upslope, and the relevance of the available historical landslide records.

APPENDIX F

Photographic Plates

Binnie Binnie Black & Veatch Hong Kong Limited Engineers and Scientists	Project Tseung Kwan O Landfill Stage II/III Afteruse Development	Title General View of Catchment Nos. 1 and 2	Plate No. 1
	Prepared By: Smo / Checked By: JH		Scale N.T.S



Binnie Binnie Black & Veatch Hong Kong Limited Engineers and Scientists	Project Tseung Kwan O Landfill Stage II/III Afteruse Development Prepared By: Smo Checked By: JH	Title General View of Catchment Nos. 3 and 4	Plate No. 2 Scale N.T.S

Binnie Black & Veatch Hong Kong Limited Engineers and Scientists	Project Tseung Kwan Landfill O Stage II/III Afteruse Development		Title General View of Catchment No. 5	Plate No. 3
	Prepared By: Smo	Checked By: JH		Scale N.T.S

Binnie Black & Veatch Hong Kong Limited
Engineers and Scientists

Project: Tseung Kwan Landfill O Stage II/III Afteruse Development		Title: General View of Catchment Nos. 6A and 6B	Plate No.: 4
Prepared By: Smo	Checked By: JH		Scale: N.T.S

Binnie Black & Veatch Hong Kong Limited Engineers and Scientists	Project Tseung Kwan Landfill O Stage II/III Afteruse Development Prepared By: Smo Checked By: JH	Title General View of Catchment No. 7	Plate No. 5 Scale N.T.S

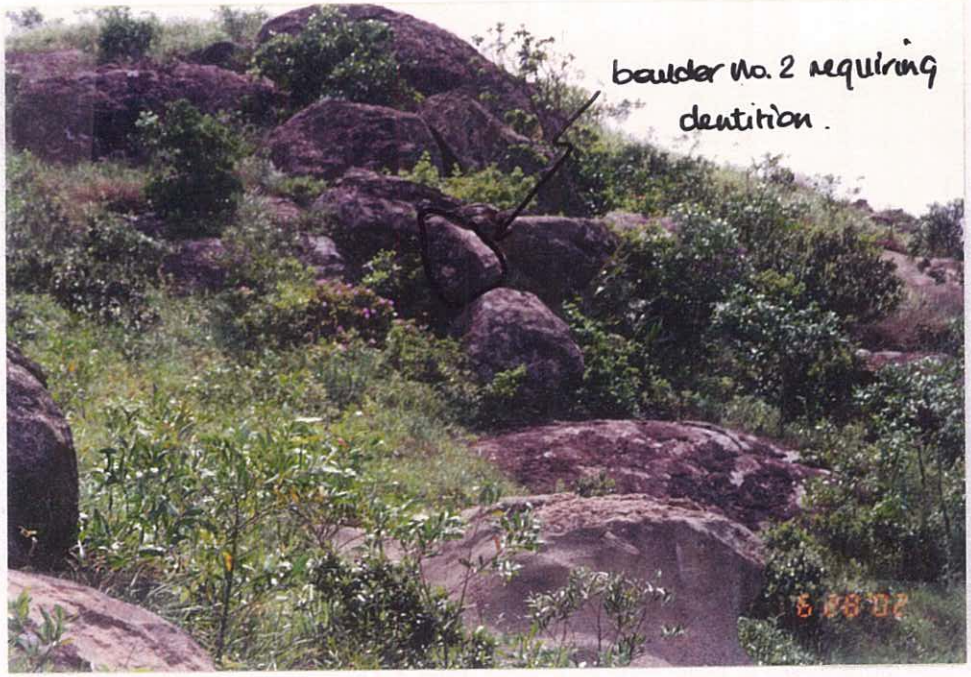
Binnie Black & Veatch Hong Kong Limited Engineers and Scienusts	Project: Tseung Kwan O Landfill Stage II/III Afteruse Development Prepared By: Smo — Checked By: JH	Title: General View of Catchment Nos. 8 and 9	Plate No.: 6 Scale: N.T.S

Binnie Black & Veatch Hong Kong Limited Engineers and Scientists	Project Tseung Kwan O Stage II/III Landfill Afteruse Development Prepared By: MH Checked By: LTC	Title Seepage on Slope No.12SW-A/C182 and 12SW-A/C183	Plate No. 7 Scale N/A

Binnie Black & Veatch Hong Kong Limited Engineers and Scientists	Project Tseung Kwan O Stage II/III Landfill Afteruse Development Prepared By: MH Checked By: LTC	Title Seepage on Slope No.12SW-A/C183	Plate No. 8 Scale N/A

Binnie Black & Veatch Hong Kong Limited Engineers and Scientists	Project: Tseung Kwan Landfill O Stage II/III Afteruse Development Prepared By: Smo — Checked By: JH	Title: Boulder B1 in Catchment No. 2 requiring stabilisation measures	Plate No.: 9 Scale: N.T.S

Binnie Black & Veatch Hong Kong Limited Engineers and Scientists	Project Tseung Kwan Landfill O Stage II/III Afteruse Development Prepared By: Smo Checked By: JH	Title Boulders with stabilisation measures carried out in Catchment No.3	Plate No. 10 Scale N.T.S

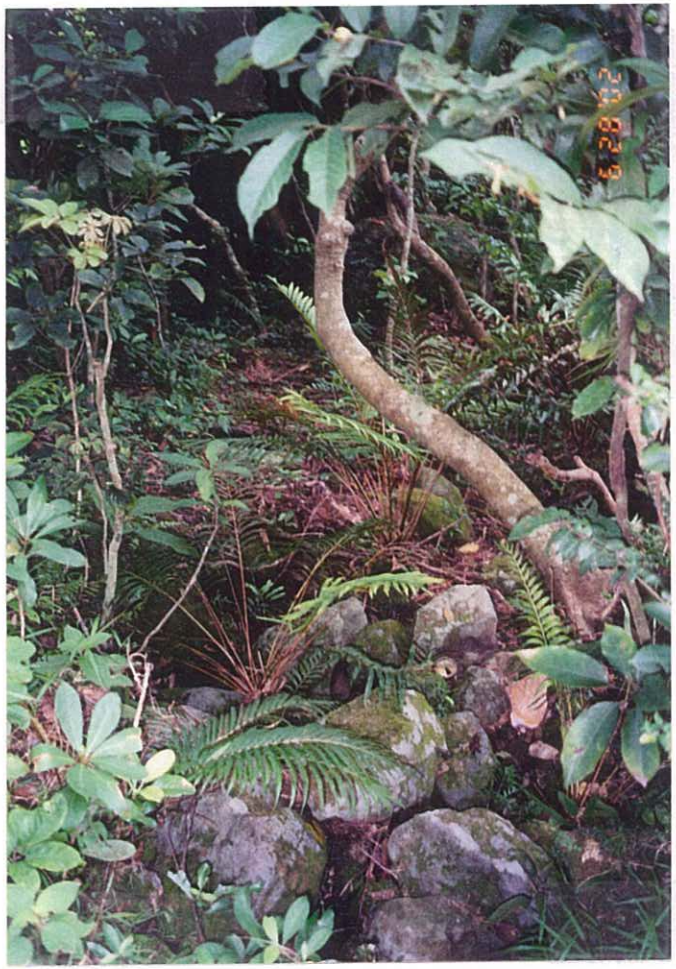


Boulder B2 in Catchment No.4 requiring stabilisation measures

Man-made wall structure on natural slope

Binnie Black & Veatch Hong Kong Limited Engineers and Scientists	Project: Tseung Kwan Landfill O Stage II/III Afteruse Development Prepared By: Smo — Checked By: JH	Title: Boulders and Man-Made structure in Catchement No.4	Plate No.: 11 Scale: N.T.S

Binnie Black & Veatch Hong Kong Limited Engineers and Scientists	Project: Tseung Kwan Landfill O Stage II/III Afteruse Development Prepared By: Smo — Checked By: JH	Title: Boulder Field with stabilisation measures carried out in Catchment No. 4	Plate No.: 12 Scale: N.T.S

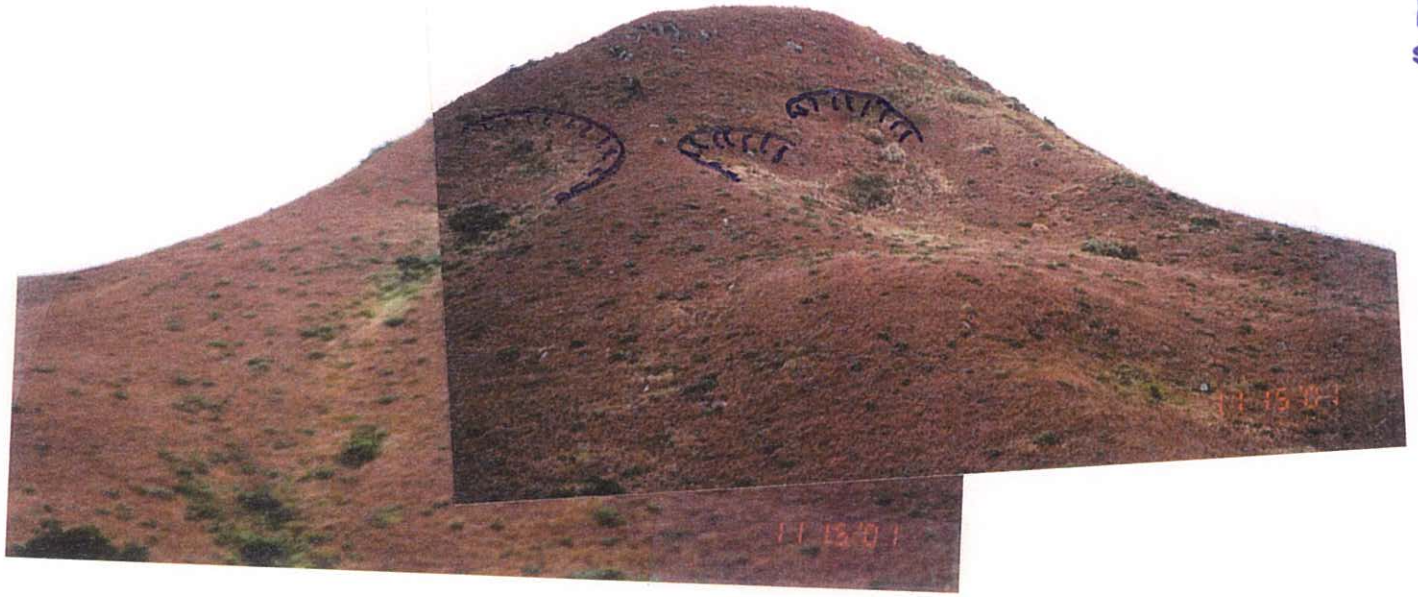


Binnie Black & Veatch Hong Kong Limited Engineers and Scientists	Project: Tseung Kwan Landfill O Stage II/III Afteruse Development Prepared By: Smo — Checked By: JH	Title: General View of drainage channel in Catchment No.4	Plate No.: 13 Scale: N.T.S

Binnie Black & Veatch Hong Kong Limited Engineers and Scientists	Project Tseung Kwan Landfill O Stage II/III Afteruse Development Prepared By: Smo Checked By: JH	Title General View of drainage channel in Catchment No.4	Plate No. 14 Scale N.T.S

Binnie Black & Veatch Hong Kong Limited Engineers and Scientists	Project Tseung Kwan O Stage II/III Landfill Afteruse Development Prepared By: Smo — Checked By: KWK	Title Tor of boulders along the crest of the northern ridge of the study area	Plate No. 15 Scale N/A

Binnie Black & Veatch Hong Kong Limited Engineers and Scientists	Project: Tseung Kwan O Stage II/III Landfill Afteruse Development Prepared By: Smo — Checked By: KWK	Title: Cluster of boulders along the crest of the southern ridge of the study area	Plate No. 16 Scale N/A



Relict landslide scars

Binnie Black & Veatch Hong Kong Limited Engineers and Scientists	Project: Tseung Kwan O Stage II/III Landfill Afteruse Development Prepared By: Smo — Checked By: KWK	Title: Slip scars in the north-east of the study area	Plate No.: 17 Scale: N/A

Binnie Black & Veatch Hong Kong Limited Engineers and Scientists	Project Tseung Kwan O Stage II/III Landfill Afteruse Development		Title Boulders at the toe of the natural slope in the north	Plate No. 18
	Prepared By: Smo	Checked By: KWK		Scale N/A

Binnie Black & Veatch Hong Kong Limited Engineers and Scientists	Project Tseung Kwan O Stage II/III Landfill Afteruse Development	Title Colluvium observed in the north-east	Plate No. 19
	Prepared By: Smo / Checked By: KWK		Scale N/A

APPENDIX G

Run-Out Calculations for Open Hillslope Landslides And Channelised Debris Flows

Table G1 - Summary Table for Channelised Debris Flows

Catchment No.	Design Landslide Event [1]	Entry Channel Slope Angle (°)	Final Run-Out Volume (m^3) [2]	Expected Run-Out Distance (m)
3	CE	28	697	36.05
4 (Case 2)	CE	36	552	31.06
5	CE	29	697	35.48
6A	CE	41	550	45.34
6B	CE	32	550	53.48
7	CE	32	628	53.48
8	CE	32	655	53.48
9	CE	31	701	109.37

Notes: CE - Conservative Event
WCE - Worst Credible Event
[1] - Refer to Table 6.3
[2] - Refer to Table 6.4

DEBRIS FLOW CHARACTERISATION OF DESIGN EVENTS

Location: **Catchment 3 (total landslide volume 697 m^3)**

Design Assumption:

1. The density of the debris has been estimated as follows:
values of 5% carried debris have been quoted, but to be on the safe side 20% will be assumed, and this gives a debris density of (20% of 2000 kg/m^3 and 80% of 1000 kg/m^3) 1200 kg/m^3.

Therefore,				
	unit weight of debris flow (γ_{df})	=	1200	kg/m^3
	unit weight of water (γ_w)	=	1000	kg/m^3
	unit weight of debris solid (γ_{ds})	=	2000	kg/m^3

2. The peak discharge of debris flow has been estimated assuming debris building up behind a temporary dam at a location in the channel, which subsequently fails and produces a wave of debris (Hungr et al. 1984; Frenette *et al.* 1997).

3. The channelised debris flow is assumed and the channel debris yield rate observed in some natural terrian landslides on Lantau Island was estimated to be about 2.3 m^3/m to 3.66 m^3/m (Franks 1998).Therefore, cross-sectional area for this channelised debris is assumed:

X-section area for the channelised debris (A)	=	3.5	m^2
channel width (b)	=	6	m
channel depth (for trapezoid channel, h)	=	1.0	m (base width = 1m is assumed)

4. Estimation of debris velocity, run-out distance, vertical runup distance and debris impact load are based on GEO Report 104, Review of Natural Terrian Landslide Debris-Resisting Barrier Design, GEO, January 2000, by D.O.K. Lo'.

5. ***Design Parameters***

Flow (channel) Depth	h	=	1.0 m
Gradient of Channel Bed (Table 3, GEO SPR 1/2000)	S	=	15 °
Density of Debris Flow	ρ_{df}	=	1200 kg/m^3
Debris Flow Viscosity (Hungr et al. 1984 recommend)	υ_{df}	=	3 kPa.s
Channel Shape (trapezium) Coefficient	k	=	5
Manning's Channel Roughness Coefficient (natural channel)	n	=	0.04
Coefficient accounting for grain properties & concent. of solids	ξ	=	2.17 $m^{-1/3} s^{-1}$
Gravitational Acceleration	g	=	9.81 m/s^2
Apparent Friction Angle of Debris (debris volume ≥ 400 m^3)	ϕ_a	=	20 °
Entry Channel Slope Angle	θ_{cs}	=	28 °
Assumed Run out Slope Angle	θ_R	=	5 °
Assumed Runup Slope Angle	θ_{up}	=	32 °

1. Determination of Debris Discharge

Apply Hydraulic Theory: $$Q = \sqrt{\frac{g \times A^3}{b}} \quad (m^3/s)$$

given: g = 9.81 m/s^2
A = 3.5 m^2
b = 6 m

$\therefore$ **Q = 8.37 m^3/s** ⇐

2. Determination of Debris Velocity (v)

Calculation is based on Lo (2000), GEO Report 104, Review of Natural Terrain Landslide Debris-Resisting Barrier Design)

(a) Apply Newtonian Laminar Flow:

$$v = \frac{\rho_{df}\, g\, h^2 S}{k \upsilon_{df}} = \mathbf{0.205} \text{ m/s}$$

(b) Apply Newtonian Turbulent Flow:

$$v = \frac{1}{n} h^{2/3} S^{1/2} = \mathbf{12.79} \text{ m/s}$$

(c) Apply Dilatant Flow:

$$v = \xi h^{3/2} S^{1/2} = \mathbf{1.11} \text{ m/s}$$

(d) Empirical:

$$v = k^* h^{2/3} S^{1/5} = \mathbf{7.65} \text{ m/s} \Leftarrow$$ (Du et al. (1987) suggested when h<2.5m, k* =10)

(e) Basic Flow Equation

v = Q / A = **2.39** m/s ⇐ (from above Q = 8.37 m^3/s)

CONCLUSION:

GEO, Report 104, Fig 21, show that slip volume < 2000m^3, the debris max. velocity = 10.5 m/s
From the above, the most likely result of the velocity = **7.65** m/s

3. Determination of Runout Distance (X_L)

(a) Apply Lumped-mass Model:

$$X_L = \frac{v_0^2}{2\,g\cos\theta_R(\tan\varphi_a - \tan\theta_R)}$$

X_L = **19.70** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **10.45** m (when V_0 = **7.65** m/s, Empirical Eq.)

(b) Apply Leading-edge Model:

$$X_L = v_0^2\cos^2(\theta_{cs} - \theta_R)\left[1 + \frac{g\,h\cos\theta_{cs}}{2\,v_0^2}\right]^2 \times \frac{1}{G}$$

where $G = g\,(S_f\cos\theta_R - \sin\theta_R)$
$S_f = \tan\phi_a$ (Hungr & McClung (1987) suggested)

$\Rightarrow$ G = 2.7989
$\therefore$ X_L = **36.05** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **20.43** m (when V_0 = **7.65** m/s, Empirical Eq.)

(c) Apply Constant Rate of Deposition (Van Gassen & Cruden 1989):

$$X_L = \frac{3}{2} \times \frac{v_0^2}{2\,g\cos\theta_R(\tan\varphi_a - \tan\theta_R)}$$

X_L = **29.54** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **15.68** (when V_0 = **7.65** m/s, Empirical Eq.)

Expected max. run-out (X_L) = **36.05** **m** (No mitigation measures taken into account)

4. Determination of Vertical Runup Distance (Δh)

(a) Apply Lumped-mass Model:

$$\Delta h = \frac{v_0^{\,2} \tan \theta_{up}}{2g\left(\tan \phi_a + \tan \theta_{up}\right)}$$

Δh = **3.52** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
Δh = **1.87** m (when V_0 = **7.65** m/s, Empirical Eq.)

(b) Apply Lumped-mass Model Corrected for Momentum Change (Perla et al, 1980):

$$\Delta h = \frac{v_0^{\,2} \cos^2(\theta_{cs} + \theta_{up}) \tan \theta_{up}}{2g\left(\tan \varphi_a + \tan \theta_{up}\right)}$$

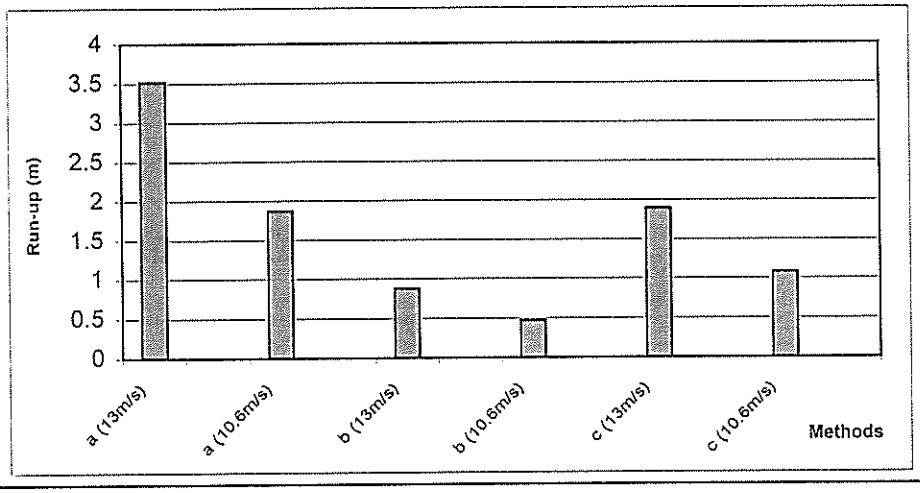
Δh = **0.88** m (when V_0 = **10.5** m/s, GEO Report 104,Fig 21)
Δh = **0.47** m (when V_0 = **7.65** m/s, Empirical Eq.)

(c) Apply Leading-edge Model (Hungr & McClung, 1987; Takahashi & Yoshida, 1979):

$$\Delta h = \frac{v_0^{\,2} \cos^2(\theta_{cs} + \theta_{up}) \tan \theta_{up}}{g\left(\tan \phi_a + \tan \theta_{up}\right)} \left(1 + \frac{gh \cos \theta_{cs}}{2 v_0^{\,2}}\right)^2$$

Δh = **1.90** m (when V_0 = **10.5** m/s, GEO, Report 104, Fig 21)
Δh = **1.08** m (when V_0 = **7.65** m/s, Empirical Eq.)

Run-up (m)						
(Method)-						
a (13m/s)	a (10.6m/s)	b (13m/s)	b (10.6m/s)	c (13m/s)	c (10.6m/s)	Average
3.52	1.87	0.88	0.47	1.9	1.08	**1.62** (m)



DEBRIS FLOW CHARACTERISATION OF DESIGN EVENTS

Location: **Catchment 4 (total landslide volume 552 m^3)**

Design Assumption:

1. The density of the debris has been estimated as follows:
values of 5% carried debris have been quoted, but to be on the safe side 20% will be assumed, and this gives a debris density of (20% of 2000 kg/m^3 and 80% of 1000 kg/m^3) 1200 kg/m^3.

Therefore,	unit weight of debris flow (γ_{df})	=	1200	kg/m^3
	unit weight of water (γ_w)	=	1000	kg/m^3
	unit weight of debris solid (γ_{ds})	=	2000	kg/m^3

2. The peak discharge of debris flow has been estimated assuming debris building up behind a temporary dam at a location in the channel, which subsequently fails and produces a wave of debris (Hungr et al. 1984; Frenette *et al.* 1997).

3. The channelised debris flow is assumed and the channel debris yield rate observed in some natural terrian landslides on Lantau Island was estimated to be about 2.3 m^3/m to 3.66 m^3/m (Franks 1998).Therefore, cross-sectional area for this channelised debris is assumed:

X-section area for the channelised debris (A)	=	3.5	m^2
channel width (b)	=	6	m
channel depth (for trapezoid channel, h)	=	1.0	m (base width = 1m is assumed)

4. Estimation of debris velocity, run-out distance, vertical runup distance and debris impact load are based on GEO Report 104, Review of Natural Terrian Landslide Debris-Resisting Barrier Design, GEO, January 2000, by D.O.K. Lo'.

5. ***Design Parameters***

Flow (channel) Depth	h	=	1.0 m
Gradient of Channel Bed (Table 3, GEO SPR 1/2000)	S	=	15 °
Density of Debris Flow	ρ_{df}	=	1200 kg/m^3
Debris Flow Viscosity (Hungr et al. 1984 recommend)	υ_{df}	=	3 kPa.s
Channel Shape (trapezium) Coefficient	k	=	5
Manning's Channel Roughness Coefficient (natural channel)	n	=	0.04
Coefficient accounting for grain properties & concent. of solids	ξ	=	2.17 $m^{-1/3} s^{-1}$
Gravitational Acceleration	g	=	9.81 m/s^2
Apparent Friction Angle of Debris (debris volume ≥ 400 m^3)	ϕ_a	=	20 °
Entry Channel Slope Angle	θ_{cs}	=	36 °
Assumed Run out Slope Angle	θ_R	=	5 °
Assumed Runup Slope Angle	θ_{up}	=	32 °

1. Determination of Debris Discharge

Apply Hydraulic Theory: $Q = \sqrt{\frac{g \times A^3}{b}}$ (m^3/s)

given:				
	g	=	9.81	m/s^2
	A	=	3.5	m^2
	b	=	6	m

$\therefore$ **Q = 8.37 m^3/s** ⇐

2. Determination of Debris Velocity (v)

Calculation is based on Lo (2000), GEO Report 104, Review of Natural Terrain Landslide Debris-Resisting Barrier Design)

(a) Apply Newtonian Laminar Flow:

$$v = \frac{\rho_{df}\, g\, h^2 S}{k\, \upsilon_{df}} = \mathbf{0.205} \text{ m/s}$$

(b) Apply Newtonian Turbulent Flow:

$$v = \frac{1}{n} h^{2/3} S^{1/2} = \mathbf{12.79} \text{ m/s}$$

(c) Apply Dilatant Flow:

$$v = \xi h^{3/2} S^{1/2} = \mathbf{1.11} \text{ m/s}$$

(d) Empirical:

$$v = k^* h^{2/3} S^{1/5} = \mathbf{7.65} \text{ m/s} \Leftarrow$$

(Du et al. (1987) suggested when h<2.5m, k* =10)

(e) Basic Flow Equation

v = Q / A = **2.39** m/s ⇐ (from above Q = 8.37 m^3/s)

CONCLUSION:

GEO, Report 104, Fig 21, show that slip volume < 2000m^3, the debris max. velocity = 10.5 m/s
From the above, the most likely result of the velocity = **7.65** m/s

3. Determination of Runout Distance (X_L)

(a) Apply Lumped-mass Model:

$$X_L = \frac{v_0^2}{2\,g\cos\theta_R(\tan\varphi_a - \tan\theta_R)}$$

X_L = **19.70** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **10.45** m (when V_0 = **7.65** m/s, Empirical Eq.)

(b) Apply Leading-edge Model:

$$X_L = v_0^2\cos^2(\theta_{cs} - \theta_R)\left[1 + \frac{g\,h\cos\theta_{cs}}{2\,v_0^2}\right]^2 \times \frac{1}{G}$$

where $G = g\,(S_f\cos\theta_R - \sin\theta_R)$
$S_f = \tan\phi_a$ (Hungr & McClung (1987) suggested)

$\Rightarrow$ G = 2.7989
$\therefore$ X_L = **31.06** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **17.51** m (when V_0 = **7.65** m/s, Empirical Eq.)

(c) Apply Constant Rate of Deposition (Van Gassen & Cruden 1989):

$$X_L = \frac{3}{2} \times \frac{v_0^2}{2\,g\cos\theta_R(\tan\varphi_a - \tan\theta_R)}$$

X_L = **29.54** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **15.68** (when V_0 = **7.65** m/s, Empirical Eq.)

Expected max. run-out (X_L) = **31.06** m (No mitigation measures taken into account)

4. Determination of Vertical Runup Distance (Δh)

(a) Apply Lumped-mass Model:

$$\Delta h = \frac{v_0^{\,2} \tan \theta_{up}}{2g\left(\tan \phi_a + \tan \theta_{up}\right)}$$

Δh = **3.52** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
Δh = **1.87** m (when V_0 = **7.65** m/s, Empirical Eq.)

(b) Apply Lumped-mass Model Corrected for Momentum Change (Perla et al, 1980):

$$\Delta h = \frac{v_0^{\,2} \cos^2 (\theta_{cs} + \theta_{up}) \tan \theta_{up}}{2\, g\left(\tan \varphi_a + \tan \theta_{up}\right)}$$

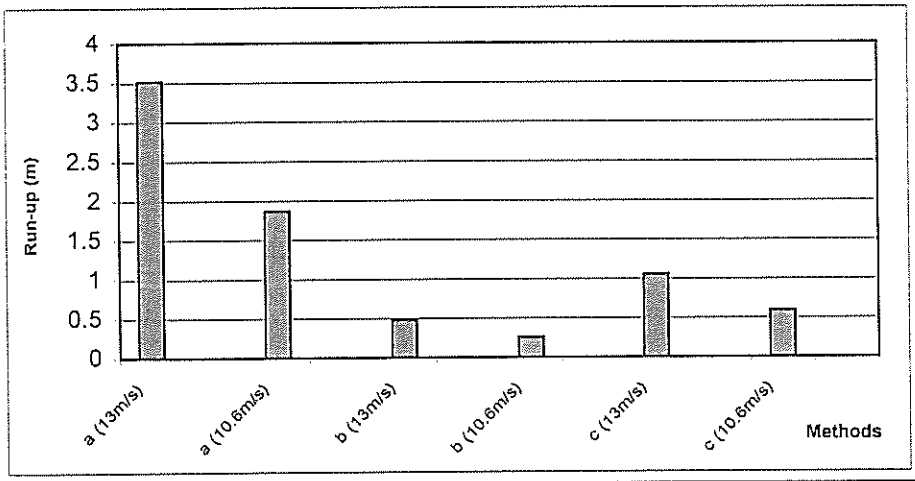
Δh = **0.49** m (when V_0 = **10.5** m/s, GEO Report 104,Fig 21)
Δh = **0.26** m (when V_0 = **7.65** m/s, Empirical Eq.)

(c) Apply Leading-edge Model (Hungr & McClung, 1987; Takahashi & Yoshida, 1979):

$$\Delta h = \frac{v_0^{\,2} \cos^2\left(\theta_{cs} + \theta_{up}\right) \tan \theta_{up}}{g\left(\tan \phi_a + \tan \theta_{up}\right)} \left(1 + \frac{gh \cos \theta_{cs}}{2 v_0^{\,2}}\right)^2$$

Δh = **1.06** m (when V_0 = **10.5** m/s, GEO, Report 104, Fig 21)
Δh = **0.60** m (when V_0 = **7.65** m/s, Empirical Eq.)

Run-up (m)						
(Method)						
a (13m/s)	a (10.6m/s)	b (13m/s)	b (10.6m/s)	c (13m/s)	c (10.6m/s)	Average
3.52	1.87	0.49	0.26	1.06	0.6	**1.3** (m)



DEBRIS FLOW CHARACTERISATION OF DESIGN EVENTS

Location: **Catchment 5 (total landslide volume 697 m^3)**

Design Assumption:

1. The density of the debris has been estimated as follows:
values of 5% carried debris have been quoted, but to be on the safe side 20% will be assumed, and this gives a debris density of (20% of 2000 kg/m^3 and 80% of 1000 kg/m^3) 1200 kg/m^3.

Therefore,	unit weight of debris flow (γ_{df})	=	1200	kg/m^3
	unit weight of water (γ_w)	=	1000	kg/m^3
	unit weight of debris solid (γ_{ds})	=	2000	kg/m^3

2. The peak discharge of debris flow has been estimated assuming debris building up behind a temporary dam at a location in the channel, which subsequently fails and produces a wave of debris (Hungr et al. 1984; Frenette *et al.* 1997).

3. The channelised debris flow is assumed and the channel debris yield rate observed in some natural terrian landslides on Lantau Island was estimated to be about 2.3 m^3/m to 3.66 m^3/m (Franks 1998).Therefore, cross-sectional area for this channelised debris is assumed:

X-section area for the channelised debris (A)	=	3.5	m^2
channel width (b)	=	6	m
channel depth (for trapezoid channel, h)	=	1.0	m (base width = 1m is assumed)

4. Estimation of debris velocity, run-out distance, vertical runup distance and debris impact load are based on GEO Report 104, Review of Natural Terrian Landslide Debris-Resisting Barrier Design, GEO, January 2000, by D.O.K. Lo'.

5. ***Design Parameters***

Flow (channel) Depth	$\underline{h}$	=	1.0 m
Gradient of Channel Bed (Table 3, GEO SPR 1/2000)	S	=	15 °
Density of Debris Flow	ρ_{df}	=	1200 kg/m^3
Debris Flow Viscosity (Hungr et al. 1984 recommend)	υ_{df}	=	3 kPa.s
Channel Shape (trapezium) Coefficient	k	=	5
Manning's Channel Roughness Coefficient (natural channel)	n	=	0.04
Coefficient accounting for grain properties & concent. of solids	ξ	=	2.17 $m^{-1/3} s^{-1}$
Gravitational Acceleration	g	=	9.81 m/s^2
Apparent Friction Angle of Debris (debris volume ≥ 400 m^3)	ϕ_a	=	20 °
Entry Channel Slope Angle	θ_{cs}	=	29 °
Assumed Run out Slope Angle	θ_R	=	5 °
Assumed Runup Slope Angle	θ_{up}	=	32 °

1. Determination of Debris Discharge

Apply Hydraulic Theory: $Q = \sqrt{\frac{g \times A^3}{b}}$ (m^3/s)

given: g = 9.81 m/s^2
A = 3.5 m^2
b = 6 m

$\therefore$ **Q = 8.37 m^3/s** ⇐

2. Determination of Debris Velocity (v)

Calculation is based on Lo (2000), GEO Report 104, Review of Natural Terrain Landslide Debris-Resisting Barrier Design)

(a) Apply Newtonian Laminar Flow:

$$v = \frac{\rho_{df}\, g\, h^2 S}{k\, \upsilon_{df}} = \mathbf{0.205} \text{ m/s}$$

(b) Apply Newtonian Turbulent Flow:

$$v = \frac{1}{n} h^{2/3} S^{1/2} = \mathbf{12.79} \text{ m/s}$$

(c) Apply Dilatant Flow:

$$v = \xi h^{3/2} S^{1/2} = \mathbf{1.11} \text{ m/s}$$

(d) Empirical:

$$v = k^* h^{2/3} S^{1/5} = \mathbf{7.65} \text{ m/s} \Leftarrow$$ (Du et al. (1987) suggested when h<2.5m, k* =10)

(e) Basic Flow Equation

v = Q / A = **2.39** m/s ⇐ (from above Q = 8.37 m^3/s)

CONCLUSION:

GEO, Report 104, Fig 21, show that slip volume < 2000m^3, the debris max. velocity = 10.5 m/s
From the above, the most likely result of the velocity = **7.65** m/s

3. Determination of Runout Distance (X_L)

(a) Apply Lumped-mass Model:

$$X_L = \frac{v_0^2}{2\,g\cos\theta_R(\tan\varphi_a - \tan\theta_R)}$$

X_L = **19.70** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **10.45** m (when V_0 = **7.65** m/s, Empirical Eq.)

(b) Apply Leading-edge Model:

$$X_L = v_0^2\cos^2(\theta_{cs} - \theta_R)\left[1 + \frac{g\,h\cos\theta_{cs}}{2\,v_0^2}\right]^2 \times \frac{1}{G}$$

where $G = g\,(S_f\cos\theta_R - \sin\theta_R)$
$S_f = \tan\phi_a$ (Hungr & McClung (1987) suggested)

$\Rightarrow$ G = 2.7989
$\therefore$ X_L = **35.48** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **20.10** m (when V_0 = **7.65** m/s, Empirical Eq.)

(c) Apply Constant Rate of Deposition (Van Gassen & Cruden 1989):

$$X_L = \frac{3}{2}\times\frac{v_0^2}{2\,g\cos\theta_R(\tan\varphi_a - \tan\theta_R)}$$

X_L = **29.54** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **15.68** (when V_0 = **7.65** m/s, Empirical Eq.)

Expected max. run-out (X_L) = **35.48** **m** (No mitigation measures taken into account)

4. Determination of Vertical Runup Distance (Δh)

(a) Apply Lumped-mass Model:

$$\Delta h = \frac{v_0^{\,2} \tan \theta_{up}}{2g\left(\tan \phi_a + \tan \theta_{up}\right)}$$

Δh = **3.52** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
Δh = **1.87** m (when V_0 = **7.65** m/s, Empirical Eq.)

(b) Apply Lumped-mass Model Corrected for Momentum Change (Perla et al, 1980):

$$\Delta h = \frac{v_0^{\,2} \cos^2 (\theta_{cs} + \theta_{up}) \tan \theta_{up}}{2\, g \left(\tan \varphi_a + \tan \theta_{up}\right)}$$

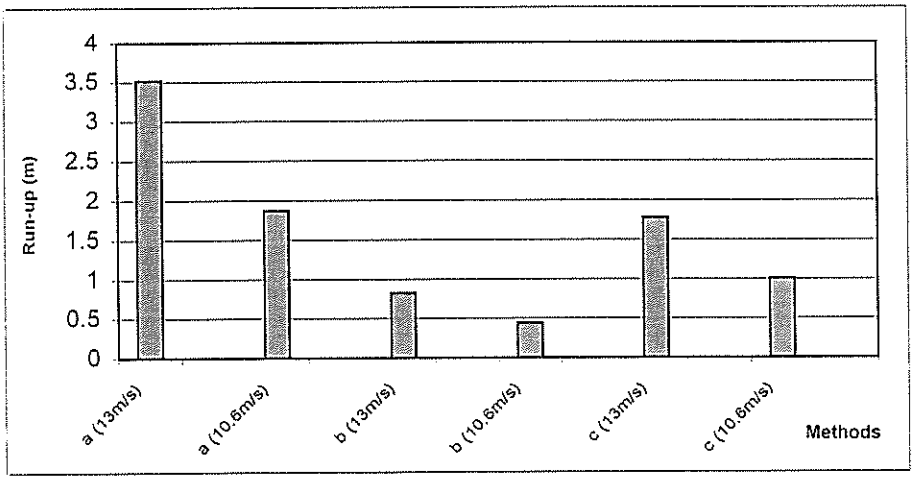
Δh = **0.83** m (when V_0 = **10.5** m/s, GEO Report 104,Fig 21)
Δh = **0.44** m (when V_0 = **7.65** m/s, Empirical Eq.)

(c) Apply Leading-edge Model (Hungr & McClung, 1987; Takahashi & Yoshida, 1979):

$$\Delta h = \frac{v_0^{\,2} \cos^2\left(\theta_{cs} + \theta_{up}\right) \tan \theta_{up}}{g\left(\tan \phi_a + \tan \theta_{up}\right)} \left(1 + \frac{gh \cos \theta_{cs}}{2 v_0^{\,2}}\right)^2$$

Δh = **1.78** m (when V_0 = **10.5** m/s, GEO, Report 104, Fig 21)
Δh = **1.01** m (when V_0 = **7.65** m/s, Empirical Eq.)

Run-up (m)						
(Method)						
a (13m/s)	a (10.6m/s)	b (13m/s)	b (10.6m/s)	c (13m/s)	c (10.6m/s)	Average
3.52	1.87	0.83	0.44	1.78	1.01	**1.575** (m)



DEBRIS FLOW CHARACTERISATION OF DESIGN EVENTS

Location: **Catchment 6A (total landslide volume 550 m^3)**

Design Assumption:

1. The density of the debris has been estimated as follows:
values of 5% carried debris have been quoted, but to be on the safe side 20% will be assumed, and this gives a debris density of (20% of 2000 kg/m^3 and 80% of 1000 kg/m^3) 1200 kg/m^3.

Therefore,	unit weight of debris flow (γ_{df})	=	1200	kg/m^3
	unit weight of water (γ_w)	=	1000	kg/m^3
	unit weight of debris solid (γ_{ds})	=	2000	kg/m^3

2. The peak discharge of debris flow has been estimated assuming debris building up behind a temporary dam at a location in the channel, which subsequently fails and produces a wave of debris (Hungr et al. 1984; Frenette *et al.* 1997).

3. The channelised debris flow is assumed and the channel debris yield rate observed in some natural terrian landslides on Lantau Island was estimated to be about 2.3 m^3/m to 3.66 m^3/m (Franks 1998).Therefore, cross-sectional area for this channelised debris is assumed:

X-section area for the channelised debris (A)	=	3.5	m^2
channel width (b)	=	6	m
channel depth (for trapezoid channel, h)	=	1.0	m (base width = 1m is assumed)

4. Estimation of debris velocity, run-out distance, vertical runup distance and debris impact load are based on GEO Report 104, Review of Natural Terrian Landslide Debris-Resisting Barrier Design, GEO, January 2000, by D.O.K. Lo'.

5. ***Design Parameters***

Flow (channel) Depth	h	=	1.0	m
Gradient of Channel Bed (Table 3, GEO SPR 1/2000)	S	=	15	°
Density of Debris Flow	ρ_{df}	=	1200	kg/m^3
Debris Flow Viscosity (Hungr et al. 1984 recommend)	υ_{df}	=	3	kPa.s
Channel Shape (trapezium) Coefficient	k	=	5	
Manning's Channel Roughness Coefficient (natural channel)	n	=	0.04	
Coefficient accounting for grain properties & concent. of solids	ξ	=	2.17	$m^{-1/2} s^{-1}$
Gravitational Acceleration	g	=	9.81	m/s^2
Apparent Friction Angle of Debris (debris volume ≥ 400 m^3)	ϕ_a	=	20	°
Entry Channel Slope Angle	θ_{cs}	=	41	°
Assumed Run out Slope Angle	θ_R	=	10	°
Assumed Runup Slope Angle	θ_{up}	=	32	°

1. Determination of Debris Discharge

Apply Hydraulic Theory: $Q = \sqrt{\frac{g \times A^3}{b}}$ (m^3/s)

given: g = 9.81 m/s^2
A = 3.5 m^2
b = 6 m

$\therefore$ **Q = 8.37 m^3/s** ⇐

2. Determination of Debris Velocity (v)

Calculation is based on Lo (2000), GEO Report 104, Review of Natural Terrain Landslide Debris-Resisting Barrier Design)

(a) Apply Newtonian Laminar Flow:

$$v = \frac{\rho_{df}\, g\, h^2 S}{k\, \upsilon_{df}} = \mathbf{0.205} \text{ m/s}$$

(b) Apply Newtonian Turbulent Flow:

$$v = \frac{1}{n} h^{2/3} S^{1/2} = \mathbf{12.79} \text{ m/s}$$

(c) Apply Dilatant Flow:

$$v = \xi h^{3/2} S^{1/2} = \mathbf{1.11} \text{ m/s}$$

(d) Empirical:

$$v = k^* h^{2/3} S^{1/5} = \mathbf{7.65} \text{ m/s}$$ ⇐ (Du et al. (1987) suggested when h<2.5m, k* =10)

(e) Basic Flow Equation

v = Q / A = **2.39** m/s ⇐ (from above Q = 8.37 m^3/s)

CONCLUSION:

GEO, Report 104, Fig 21, show that slip volume < 2000m^3, the debris max. velocity = **10.5** m/s
From the above, the most likely result of the velocity = **7.65** m/s

3. Determination of Runout Distance (X_L)

(a) Apply Lumped-mass Model:

$$X_L = \frac{v_0^2}{2\,g\cos\theta_R(\tan\varphi_a - \tan\theta_R)}$$

X_L = **28.88** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **15.33** m (when V_0 = **7.65** m/s, Empirical Eq.)

(b) Apply Leading-edge Model:

$$X_L = v_0^2\cos^2(\theta_{cs} - \theta_R)\left[1 + \frac{g\,h\cos\theta_{cs}}{2\,v_0^2}\right]^2 \times \frac{1}{G}$$

where $G = g\,(S_f\cos\theta_R - \sin\theta_R)$
$S_f = \tan\phi_a$ (Hungr & McClung (1987) suggested)

$\Rightarrow$ G = 1.9086
$\therefore$ X_L = **45.34** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **25.46** m (when V_0 = **7.65** m/s, Empirical Eq.)

(c) Apply Constant Rate of Deposition (Van Gassen & Cruden 1989):

$$X_L = \frac{3}{2} \times \frac{v_0^2}{2\,g\cos\theta_R(\tan\varphi_a - \tan\theta_R)}$$

X_L = **43.32** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **22.99** (when V_0 = **7.65** m/s, Empirical Eq.)

Expected max. run-out (X_L) = **45.34** **m** (No mitigation measures taken into account)

4. Determination of Vertical Runup Distance (Δh)

(a) Apply Lumped-mass Model:

$$\Delta h = \frac{v_0^{\,2} \tan \theta_{up}}{2g\left(\tan \phi_a + \tan \theta_{up}\right)}$$

Δh = **3.52** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
Δh = **1.87** m (when V_0 = **7.65** m/s, Empirical Eq.)

(b) Apply Lumped-mass Model Corrected for Momentum Change (Perla et al, 1980):

$$\Delta h = \frac{v_0^{\,2} \cos^2 (\theta_{cs} + \theta_{up}) \tan \theta_{up}}{2\, g\left(\tan \varphi_a + \tan \theta_{up}\right)}$$

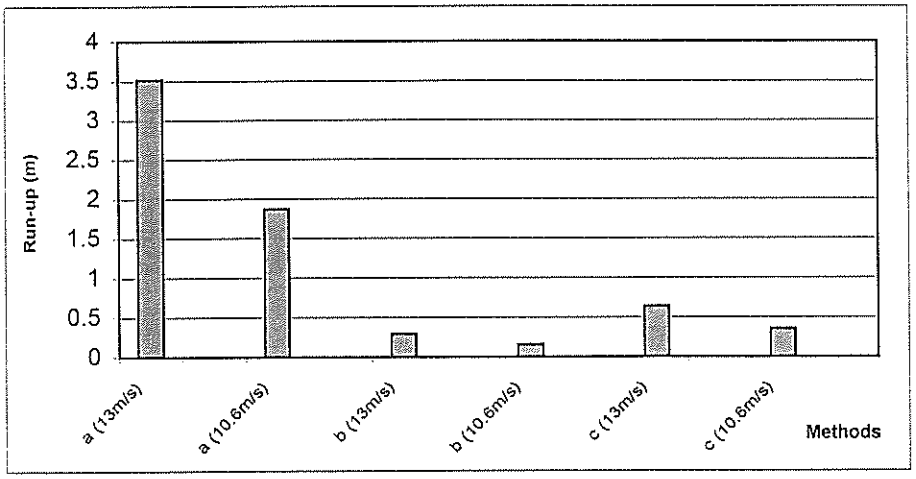
Δh = **0.30** m (when V_0 = **10.5** m/s, GEO Report 104,Fig 21)
Δh = **0.16** m (when V_0 = **7.65** m/s, Empirical Eq.)

(c) Apply Leading-edge Model (Hungr & McClung, 1987; Takahashi & Yoshida, 1979):

$$\Delta h = \frac{v_0^{\,2} \cos^2\left(\theta_{cs} + \theta_{up}\right) \tan \theta_{up}}{g\left(\tan \phi_a + \tan \theta_{up}\right)} \left(1 + \frac{gh \cos \theta_{cs}}{2 v_0^{\,2}}\right)^2$$

Δh = **0.64** m (when V_0 = **10.5** m/s, GEO, Report 104, Fig 21)
Δh = **0.36** m (when V_0 = **7.65** m/s, Empirical Eq.)

Run-up (m)						
(Method)						
a (13m/s)	a (10.6m/s)	b (13m/s)	b (10.6m/s)	c (13m/s)	c (10.6m/s)	Average
3.52	1.87	0.3	0.16	0.64	0.36	**1.14167** (m)



Prepared: SMC Date: Jan 03 Checked: Date:

DEBRIS FLOW CHARACTERISATION OF DESIGN EVENTS

Location: **Catchment 6B (total landslide volume 550 m^3)**

Design Assumption:

1. The density of the debris has been estimated as follows:
values of 5% carried debris have been quoted, but to be on the safe side 20% will be assumed, and this gives a debris density of (20% of 2000 kg/m^3 and 80% of 1000 kg/m^3) 1200 kg/m^3.

Therefore,	unit weight of debris flow (γ_{df})	=	1200	kg/m^3
	unit weight of water (γ_w)	=	1000	kg/m^3
	unit weight of debris solid (γ_{ds})	=	2000	kg/m^3

2. The peak discharge of debris flow has been estimated assuming debris building up behind a temporary dam at a location in the channel, which subsequently fails and produces a wave of debris (Hungr et al. 1984; Frenette *et al.* 1997).

3. The channelised debris flow is assumed and the channel debris yield rate observed in some natural terrian landslides on Lantau Island was estimated to be about 2.3 m^3/m to 3.66 m^3/m (Franks 1998).Therefore, cross-sectional area for this channelised debris is assumed:

X-section area for the channelised debris (A)	=	3.5	m^2
channel width (b)	=	6	m
channel depth (for trapezoid channel, h)	=	1.0	m (base width = 1m is assumed)

4. Estimation of debris velocity, run-out distance, vertical runup distance and debris impact load are based on GEO Report 104, Review of Natural Terrian Landslide Debris-Resisting Barrier Design, GEO, January 2000, by D.O.K. Lo'.

5. ***Design Parameters***

Flow (channel) Depth	h	=	1.0	m
Gradient of Channel Bed (Table 3, GEO SPR 1/2000)	S	=	15	°
Density of Debris Flow	ρ_{df}	=	1200	kg/m^3
Debris Flow Viscosity (Hungr et al. 1984 recommend)	υ_{df}	=	3	kPa.s
Channel Shape (trapezium) Coefficient	k	=	5	
Manning's Channel Roughness Coefficient (natural channel)	n	=	0.04	
Coefficient accounting for grain properties & concent. of solids	ξ	=	2.17	$m^{-1/2} s^{-1}$
Gravitational Acceleration	g	=	9.81	m/s^2
Apparent Friction Angle of Debris (debris volume ≥ 400 m^3)	ϕ_a	=	20	°
Entry Channel Slope Angle	θ_{cs}	=	32	°
Assumed Run out Slope Angle	θ_R	=	10	°
Assumed Runup Slope Angle	θ_{up}	=	32	°

Prepared: SMC Date: Jan 03 Checked: Date:

1. Determination of Debris Discharge

Apply Hydraulic Theory: $Q = \sqrt{\frac{g \times A^3}{b}}$ (m^3/s)

given:				
	g	=	9.81	m/s^2
	A	=	3.5	m^2
	b	=	6	m

$\therefore$ **Q = 8.37 m^3/s** ⇐

2. Determination of Debris Velocity (v)

Calculation is based on Lo (2000), GEO Report 104, Review of Natural Terrain Landslide Debris-Resisting Barrier Design)

(a) Apply Newtonian Laminar Flow:

$$v = \frac{\rho_{df}\, g\, h^2 S}{k\, \upsilon_{df}} = \mathbf{0.205} \text{ m/s}$$

(b) Apply Newtonian Turbulent Flow:

$$v = \frac{1}{n} h^{2/3} S^{1/2} = \mathbf{12.79} \text{ m/s}$$

(c) Apply Dilatant Flow:

$$v = \xi h^{3/2} S^{1/2} = \mathbf{1.11} \text{ m/s}$$

(d) Empirical:

$$v = k^* h^{2/3} S^{1/5} = \mathbf{7.65} \text{ m/s} \Leftarrow$$ (Du et al. (1987) suggested when h<2.5m, k* =10)

(e) Basic Flow Equation

v = Q / A = **2.39** m/s ⇐ (from above Q = 8.37 m^3/s)

CONCLUSION:

GEO, Report 104, Fig 21, show that slip volume < 2000m^3, the debris max. velocity = 10.5 m/s
From the above, the most likely result of the velocity = **7.65** m/s

3. Determination of Runout Distance (X_L)

(a) Apply Lumped-mass Model:

$$X_L = \frac{v_0^2}{2\,g\cos\theta_R(\tan\varphi_a - \tan\theta_R)}$$

X_L = **28.88** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **15.33** m (when V_0 = **7.65** m/s, Empirical Eq.)

(b) Apply Leading-edge Model:

$$X_L = v_0^2\cos^2(\theta_{cs} - \theta_R)\left[1 + \frac{g\,h\cos\theta_{cs}}{2\,v_0^2}\right]^2 \times \frac{1}{G}$$

where $G = g\,(S_f\cos\theta_R - \sin\theta_R)$
$S_f = \tan\phi_a$ (Hungr & McClung (1987) suggested)

$\Rightarrow$ G = 1.9086
$\therefore$ X_L = **53.48** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **30.23** m (when V_0 = **7.65** m/s, Empirical Eq.)

(c) Apply Constant Rate of Deposition (Van Gassen & Cruden 1989):

$$X_L = \frac{3}{2}\times\frac{v_0^2}{2\,g\cos\theta_R(\tan\varphi_a - \tan\theta_R)}$$

X_L = **43.32** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **22.99** (when V_0 = **7.65** m/s, Empirical Eq.)

Expected max. run-out (X_L) = **53.48** **m** (No mitigation measures taken into account)

4. Determination of Vertical Runup Distance (Δh)

(a) Apply Lumped-mass Model:

$$\Delta h = \frac{v_0^{\,2} \tan \theta_{up}}{2g\left(\tan \phi_a + \tan \theta_{up}\right)}$$

Δh = **3.52** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
Δh = **1.87** m (when V_0 = **7.65** m/s, Empirical Eq.)

(b) Apply Lumped-mass Model Corrected for Momentum Change (Perla et al, 1980):

$$\Delta h = \frac{v_0^{\,2} \cos^2 (\theta_{cs} + \theta_{up}) \tan \theta_{up}}{2\,g\left(\tan \varphi_a + \tan \theta_{up}\right)}$$

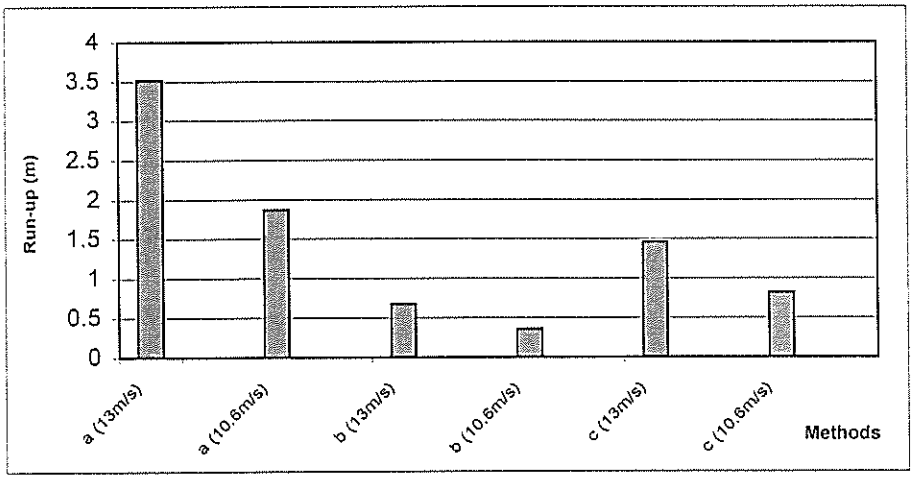
Δh = **0.68** m (when V_0 = **10.5** m/s, GEO Report 104,Fig 21)
Δh = **0.36** m (when V_0 = **7.65** m/s, Empirical Eq.)

(c) Apply Leading-edge Model (Hungr & McClung, 1987; Takahashi & Yoshida, 1979):

$$\Delta h = \frac{v_0^{\,2} \cos^2\left(\theta_{cs} + \theta_{up}\right) \tan \theta_{up}}{g\left(\tan \phi_a + \tan \theta_{up}\right)} \left(1 + \frac{gh \cos \theta_{cs}}{2 v_0^{\,2}}\right)^2$$

Δh = **1.46** m (when V_0 = **10.5** m/s, GEO, Report 104, Fig 21)
Δh = **0.82** m (when V_0 = **7.65** m/s, Empirical Eq.)

Run-up (m)						
(Method)						
a (13m/s)	a (10.6m/s)	b (13m/s)	b (10.6m/s)	c (13m/s)	c (10.6m/s)	**Average**
3.52	1.87	0.68	0.36	1.46	0.82	**1.45167** (m)



DEBRIS FLOW CHARACTERISATION OF DESIGN EVENTS

Location: **Catchment 7 (total landslide volume 628 m^3)**

Design Assumption:

1. The density of the debris has been estimated as follows:
values of 5% carried debris have been quoted, but to be on the safe side 20% will be assumed, and this gives a debris density of (20% of 2000 kg/m^3 and 80% of 1000 kg/m^3) 1200 kg/m^3.

Therefore,	unit weight of debris flow (γ_{df})	=	1200	kg/m^3
	unit weight of water (γ_w)	=	1000	kg/m^3
	unit weight of debris solid (γ_{ds})	=	2000	kg/m^3

2. The peak discharge of debris flow has been estimated assuming debris building up behind a temporary dam at a location in the channel, which subsequently fails and produces a wave of debris (Hungr et al. 1984; Frenette *et al.* 1997).

3. The channelised debris flow is assumed and the channel debris yield rate observed in some natural terrian landslides on Lantau Island was estimated to be about 2.3 m^3/m to 3.66 m^3/m (Franks 1998).Therefore, cross-sectional area for this channelised debris is assumed:

X-section area for the channelised debris (A)	=	3.5	m^2
channel width (b)	=	6	m
channel depth (for trapezoid channel, h)	=	1.0	m (base width = 1m is assumed)

4. Estimation of debris velocity, run-out distance, vertical runup distance and debris impact load are based on GEO Report 104, Review of Natural Terrian Landslide Debris-Resisting Barrier Design, GEO, January 2000, by D.O.K. Lo'.

5. ***Design Parameters***

Flow (channel) Depth	h	=	1.0	m
Gradient of Channel Bed (Table 3, GEO SPR 1/2000)	S	=	15	°
Density of Debris Flow	ρ_{df}	=	1200	kg/m^3
Debris Flow Viscosity (Hungr et al. 1984 recommend)	υ_{df}	=	3	kPa.s
Channel Shape (trapezium) Coefficient	k	=	5	
Manning's Channel Roughness Coefficient (natural channel)	n	=	0.04	
Coefficient accounting for grain properties & concent. of solids	ξ	=	2.17	$m^{-1/3} s^{-1}$
Gravitational Acceleration	g	=	9.81	m/s^2
Apparent Friction Angle of Debris (debris volume ≥ 400 m^3)	ϕ_a	=	20	°
Entry Channel Slope Angle	θ_{cs}	=	32	°
Assumed Run out Slope Angle	θ_R	=	10	°
Assumed Runup Slope Angle	θ_{up}	=	32	°

1. Determination of Debris Discharge

Apply Hydraulic Theory: $Q = \sqrt{\frac{g \times A^3}{b}}$ (m^3/s)

given: g = 9.81 m/s^2
A = 3.5 m^2
b = 6 m

$\therefore$ **Q = 8.37 m^3/s** ⇐

2. Determination of Debris Velocity (v)

Calculation is based on Lo (2000), GEO Report 104, Review of Natural Terrain Landslide Debris-Resisting Barrier Design)

(a) Apply Newtonian Laminar Flow:

$$v = \frac{\rho_{df}\, g\, h^2 S}{k\, \upsilon_{df}} = \mathbf{0.205} \text{ m/s}$$

(b) Apply Newtonian Turbulent Flow:

$$v = \frac{1}{n} h^{2/3} S^{1/2} = \mathbf{12.79} \text{ m/s}$$

(c) Apply Dilatant Flow:

$$v = \xi h^{3/2} S^{1/2} = \mathbf{1.11} \text{ m/s}$$

(d) Empirical:

$$v = k^* h^{2/3} S^{1/5} = \mathbf{7.65} \text{ m/s} \Leftarrow$$ (Du et al. (1987) suggested when h<2.5m, k* =10)

(e) Basic Flow Equation

v = Q / A = **2.39** m/s ⇐ (from above Q = 8.37 m^3/s)

CONCLUSION:

GEO, Report 104, Fig 21, show that slip volume < 2000m^3, the debris max. velocity = **10.5** m/s
From the above, the most likely result of the velocity = **7.65** m/s

3. Determination of Runout Distance (X_L)

(a) Apply Lumped-mass Model:

$$X_L = \frac{v_0^2}{2\,g\cos\theta_R(\tan\varphi_a - \tan\theta_R)}$$

X_L = **28.88** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **15.33** m (when V_0 = **7.65** m/s, Empirical Eq.)

(b) Apply Leading-edge Model:

$$X_L = v_0^2\cos^2(\theta_{cs} - \theta_R)\left[1 + \frac{g\,h\cos\theta_{cs}}{2\,v_0^2}\right]^2 \times \frac{1}{G}$$

where $G = g\,(S_f\cos\theta_R - \sin\theta_R)$
$S_f = \tan\phi_a$ (Hungr & McClung (1987) suggested)

$\Rightarrow$ G = 1.9086
$\therefore$ X_L = **53.48** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **30.23** m (when V_0 = **7.65** m/s, Empirical Eq.)

(c) Apply Constant Rate of Deposition (Van Gassen & Cruden 1989):

$$X_L = \frac{3}{2}\times\frac{v_0^2}{2\,g\cos\theta_R(\tan\varphi_a - \tan\theta_R)}$$

X_L = **43.32** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **22.99** (when V_0 = **7.65** m/s, Empirical Eq.)

Expected max. run-out (X_L) = **53.48** m (No mitigation measures taken into account)

4. Determination of Vertical Runup Distance (Δh)

(a) Apply Lumped-mass Model:

$$\Delta h = \frac{v_0^{\,2} \tan \theta_{up}}{2g\left(\tan \phi_a + \tan \theta_{up}\right)}$$

Δh	=	**3.52**	m	(when V_0	=	**10.5**	m/s, GEO Report 104, Fig 21)
Δh	=	**1.87**	m	(when V_0	=	**7.65**	m/s, Empirical Eq.)

(b) Apply Lumped-mass Model Corrected for Momentum Change (Perla et al, 1980):

$$\Delta h = \frac{v_0^{\,2} \cos^2 (\theta_{cs} + \theta_{up}) \tan \theta_{up}}{2\,g\left(\tan \varphi_a + \tan \theta_{up}\right)}$$

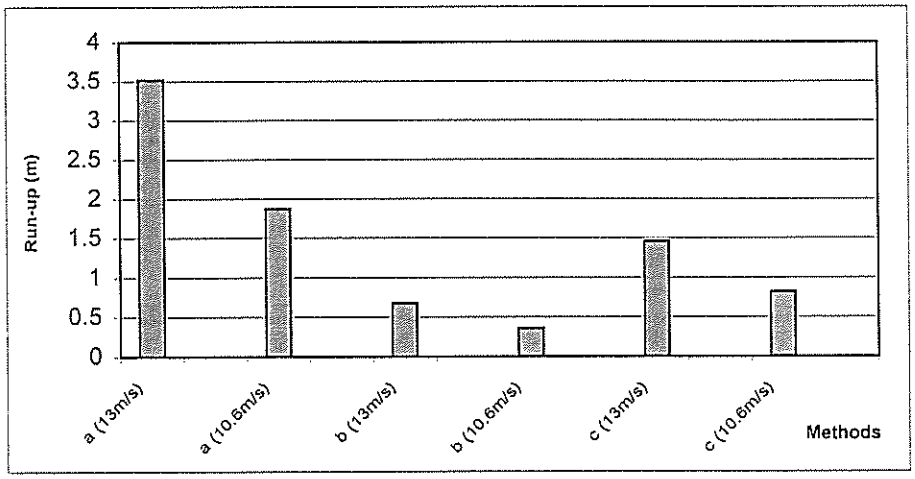
Δh	=	**0.68**	m	(when V_0	=	**10.5**	m/s, GEO Report 104,Fig 21)
Δh	=	**0.36**	m	(when V_0	=	**7.65**	m/s, Empirical Eq.)

(c) Apply Leading-edge Model (Hungr & McClung, 1987; Takahashi & Yoshida, 1979):

$$\Delta h = \frac{v_0^{\,2} \cos^2\left(\theta_{cs} + \theta_{up}\right)\tan \theta_{up}}{g\left(\tan \phi_a + \tan \theta_{up}\right)}\left(1 + \frac{gh\cos\theta_{cs}}{2v_0^{\,2}}\right)^2$$

Δh	=	**1.46**	m	(when V_0	=	**10.5**	m/s, GEO, Report 104, Fig 21)
Δh	=	**0.82**	m	(when V_0	=	**7.65**	m/s, Empirical Eq.)

Run-up (m)						
(Method)						
a (13m/s)	a (10.6m/s)	b (13m/s)	b (10.6m/s)	c (13m/s)	c (10.6m/s)	**Average**
3.52	1.87	0.68	0.36	1.46	0.82	**1.45167** (m)



Prepared: SMO Date: Jun 03 Checked: Date:

DEBRIS FLOW CHARACTERISATION OF DESIGN EVENTS

Location: **Catchment 8 (total landslide volume 655 m^3)**

Design Assumption:

1. The density of the debris has been estimated as follows:
values of 5% carried debris have been quoted, but to be on the safe side 20% will be assumed, and this gives a debris density of (20% of 2000 kg/m^3 and 80% of 1000 kg/m^3) 1200 kg/m^3.

Therefore,	unit weight of debris flow (γ_{df})	=	1200	kg/m^3
	unit weight of water (γ_w)	=	1000	kg/m^3
	unit weight of debris solid (γ_{ds})	=	2000	kg/m^3

2. The peak discharge of debris flow has been estimated assuming debris building up behind a temporary dam at a location in the channel, which subsequently fails and produces a wave of debris (Hungr et al. 1984; Frenette *et al.* 1997).

3. The channelised debris flow is assumed and the channel debris yield rate observed in some natural terrian landslides on Lantau Island was estimated to be about 2.3 m^3/m to 3.66 m^3/m (Franks 1998).Therefore, cross-sectional area for this channelised debris is assumed:

X-section area for the channelised debris (A)	=	3.5	m^2
channel width (b)	=	6	m
channel depth (for trapezoid channel, h)	=	1.0	m (base width = 1m is assumed)

4. Estimation of debris velocity, run-out distance, vertical runup distance and debris impact load are based on GEO Report 104, Review of Natural Terrian Landslide Debris-Resisting Barrier Design, GEO, January 2000, by D.O.K. Lo'.

5. ***Design Parameters***

Flow (channel) Depth	h	=	1.0	m
Gradient of Channel Bed (Table 3, GEO SPR 1/2000)	S	=	15	°
Density of Debris Flow	ρ_{df}	=	1200	kg/m^3
Debris Flow Viscosity (Hungr et al. 1984 recommend)	υ_{df}	=	3	kPa.s
Channel Shape (trapezium) Coefficient	k	=	5	
Manning's Channel Roughness Coefficient (natural channel)	n	=	0.04	
Coefficient accounting for grain properties & concent. of solids	ξ	=	2.17	$m^{-1/2} s^{-1}$
Gravitational Acceleration	g	=	9.81	m/s^2
Apparent Friction Angle of Debris (debris volume ≥ 400 m^3)	ϕ_a	=	20	°
Entry Channel Slope Angle	θ_{cs}	=	32	°
Assumed Run out Slope Angle	θ_R	=	10	°
Assumed Runup Slope Angle	θ_{up}	=	32	°

1. Determination of Debris Discharge

Apply Hydraulic Theory: $Q = \sqrt{\frac{g \times A^3}{b}}$ (m^3/s)

given:				
	g	=	9.81	m/s^2
	A	=	3.5	m^2
	b	=	6	m

$\therefore$ **Q = 8.37 m^3/s** ⇐

2. Determination of Debris Velocity (v)

Calculation is based on Lo (2000), GEO Report 104, Review of Natural Terrain Landslide Debris-Resisting Barrier Design)

(a) Apply Newtonian Laminar Flow:

$$v = \frac{\rho_{df}\, g\, h^2 S}{k\, \upsilon_{df}} = \mathbf{0.205} \text{ m/s}$$

(b) Apply Newtonian Turbulent Flow:

$$v = \frac{1}{n} h^{2/3} S^{1/2} = \mathbf{12.79} \text{ m/s}$$

(c) Apply Dilatant Flow:

$$v = \xi h^{3/2} S^{1/2} = \mathbf{1.11} \text{ m/s}$$

(d) Empirical:

$$v = k^* h^{2/3} S^{1/5} = \mathbf{7.65} \text{ m/s} \Leftarrow$$ (Du et al. (1987) suggested when h<2.5m, k* =10)

(e) Basic Flow Equation

v = Q / A = **2.39** m/s ⇐ (from above Q = 8.37 m^3/s)

CONCLUSION:

GEO, Report 104, Fig 21, show that slip volume < 2000m^3, the debris max. velocity = **10.5** m/s
From the above, the most likely result of the velocity = **7.65** m/s

3. Determination of Runout Distance (X_L)

(a) Apply Lumped-mass Model:

$$X_L = \frac{v_0^2}{2\,g\cos\theta_R(\tan\varphi_a - \tan\theta_R)}$$

X_L	=	**28.88**	m	(when V_0	=	**10.5** m/s, GEO Report 104, Fig 21)
X_L	=	**15.33**	m	(when V_0	=	**7.65** m/s, Empirical Eq.)

(b) Apply Leading-edge Model:

$$X_L = v_0^2\cos^2(\theta_{cs} - \theta_R)\left[1 + \frac{g\,h\cos\theta_{cs}}{2\,v_0^2}\right]^2 \times \frac{1}{G}$$

where $G = g\,(S_f\cos\theta_R - \sin\theta_R)$
$S_f = \tan\phi_a$ (Hungr & McClung (1987) suggested)

$\Rightarrow$ $G =$ 1.9086

$\therefore$ X_L =	**53.48**	m	(when V_0	=	**10.5** m/s, GEO Report 104, Fig 21)
X_L =	**30.23**	m	(when V_0	=	**7.65** m/s, Empirical Eq.)

(c) Apply Constant Rate of Deposition (Van Gassen & Cruden 1989):

$$X_L = \frac{3}{2} \times \frac{v_0^2}{2\,g\cos\theta_R(\tan\varphi_a - \tan\theta_R)}$$

X_L =	**43.32**	m	(when V_0	=	**10.5** m/s, GEO Report 104, Fig 21)
X_L =	**22.99**		(when V_0	=	**7.65** m/s, Empirical Eq.)

Expected max. run-out (X_L) = **53.48** **m** (No mitigation measures taken into account)

4. Determination of Vertical Runup Distance (Δh)

(a) Apply Lumped-mass Model:

$$\Delta h = \frac{v_0^{\,2} \tan \theta_{up}}{2g\left(\tan \phi_a + \tan \theta_{up}\right)}$$

Δh	=	**3.52**	m	(when V_0	= **10.5**	m/s, GEO Report 104, Fig 21)
Δh	=	**1.87**	m	(when V_0	= **7.65**	m/s, Empirical Eq.)

(b) Apply Lumped-mass Model Corrected for Momentum Change (Perla et al, 1980):

$$\Delta h = \frac{v_0^{\,2} \cos^2 (\theta_{cs} + \theta_{up}) \tan \theta_{up}}{2\, g\left(\tan \varphi_a + \tan \theta_{up}\right)}$$

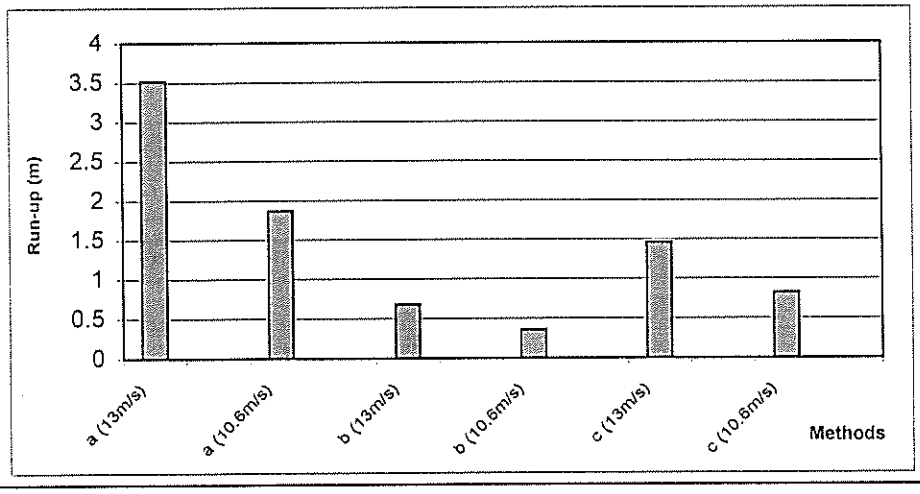
Δh	=	**0.68**	m	(when V_0	= **10.5**	m/s, GEO Report 104,Fig 21)
Δh	=	**0.36**	m	(when V_0	= **7.65**	m/s, Empirical Eq.)

(c) Apply Leading-edge Model (Hungr & McClung, 1987; Takahashi & Yoshida, 1979):

$$\Delta h = \frac{v_0^{\,2} \cos^2\left(\theta_{cs} + \theta_{up}\right) \tan \theta_{up}}{g\left(\tan \phi_a + \tan \theta_{up}\right)} \left(1 + \frac{gh \cos \theta_{cs}}{2 v_0^{\,2}}\right)^2$$

Δh	=	**1.46**	m	(when V_0	= **10.5**	m/s, GEO, Report 104, Fig 21)
Δh	=	**0.82**	m	(when V_0	= **7.65**	m/s, Empirical Eq.)

Run-up (m)						
(Method)						
a (13m/s)	a (10.6m/s)	b (13m/s)	b (10.6m/s)	c (13m/s)	c (10.6m/s)	Average
3.52	1.87	0.68	0.36	1.46	0.82	**1.45167** (m)



Prepared: SMO Date: Jan 03 Checked: Date:

DEBRIS FLOW CHARACTERISATION OF DESIGN EVENTS

Location: **Catchment 9 (total landslide volume 701 m^3)**

Design Assumption:

1. The density of the debris has been estimated as follows:
values of 5% carried debris have been quoted, but to be on the safe side 20% will be assumed, and this gives a debris density of (20% of 2000 kg/m^3 and 80% of 1000 kg/m^3) 1200 kg/m^3.

Therefore,	unit weight of debris flow (γ_{df})	=	1200	kg/m^3
	unit weight of water (γ_w)	=	1000	kg/m^3
	unit weight of debris solid (γ_{ds})	=	2000	kg/m^3

2. The peak discharge of debris flow has been estimated assuming debris building up behind a temporary dam at a location in the channel, which subsequently fails and produces a wave of debris (Hungr et al. 1984; Frenette *et al.* 1997).

3. The channelised debris flow is assumed and the channel debris yield rate observed in some natural terrian landslides on Lantau Island was estimated to be about 2.3 m^3/m to 3.66 m^3/m (Franks 1998).Therefore, cross-sectional area for this channelised debris is assumed:

X-section area for the channelised debris (A)	=	3.5	m^2
channel width (b)	=	6	m
channel depth (for trapezoid channel, h)	=	1.0	m (base width = 1m is assumed)

4. Estimation of debris velocity, run-out distance, vertical runup distance and debris impact load are based on GEO Report 104, Review of Natural Terrian Landslide Debris-Resisting Barrier Design, GEO, January 2000, by D.O.K. Lo'.

5. ***Design Parameters***

Flow (channel) Depth	h	=	1.0	m
Gradient of Channel Bed (Table 3, GEO SPR 1/2000)	S	=	15	°
Density of Debris Flow	ρ_{df}	=	1200	kg/m^3
Debris Flow Viscosity (Hungr et al. 1984 recommend)	υ_{df}	=	3	kPa.s
Channel Shape (trapezium) Coefficient	k	=	5	
Manning's Channel Roughness Coefficient (natural channel)	n	=	0.04	
Coefficient accounting for grain properties & concent. of solids	ξ	=	2.17	$m^{-½} s^{-1}$
Gravitational Acceleration	g	=	9.81	m/s^2
Apparent Friction Angle of Debris (debris volume ≥ 400 m^3)	ϕ_a	=	20	°
Entry Channel Slope Angle	θ_{cs}	=	31	°
Assumed Run out Slope Angle	θ_R	=	15	°
Assumed Runup Slope Angle	θ_{up}	=	32	°

1. Determination of Debris Discharge

Apply Hydraulic Theory: $Q = \sqrt{\frac{g \times A^3}{b}}$ (m^3/s)

given: g = 9.81 m/s^2
A = 3.5 m^2
b = 6 m

$\therefore$ **Q = 8.37 m^3/s** ⇐

2. Determination of Debris Velocity (v)

Calculation is based on Lo (2000), GEO Report 104, Review of Natural Terrain Landslide Debris-Resisting Barrier Design)

(a) Apply Newtonian Laminar Flow:

$$v = \frac{\rho_{df}\, g\, h^2 S}{k \upsilon_{df}}$$ = **0.205** m/s

(b) Apply Newtonian Turbulent Flow:

$$v = \frac{1}{n} h^{2/3} S^{1/2}$$ = **12.79** m/s

(c) Apply Dilatant Flow:

$$v = \xi h^{3/2} S^{1/2}$$ = **1.11** m/s

(d) Empirical:

$$v = k^* h^{2/3} S^{1/5}$$ = **7.65** m/s ⇐ (Du et al. (1987) suggested when h<2.5m, k* =10)

(e) Basic Flow Equation

v = Q / A = **2.39** m/s ⇐ (from above Q = 8.37 m^3/s)

CONCLUSION:

GEO, Report 104, Fig 21, show that slip volume < 2000m^3, the debris max. velocity = 10.5 m/s
From the above, the most likely result of the velocity = **7.65** m/s

3. Determination of Runout Distance (X_L)

(a) Apply Lumped-mass Model:

$$X_L = \frac{v_0^2}{2g\cos\theta_R(\tan\varphi_a - \tan\theta_R)}$$

X_L = **54.92** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **29.14** m (when V_0 = **7.65** m/s, Empirical Eq.)

(b) Apply Leading-edge Model:

$$X_L = v_0^2 \cos^2(\theta_{cs} - \theta_R)\left[1 + \frac{g\,h\cos\theta_{cs}}{2\,v_0^2}\right]^2 \times \frac{1}{G}$$

where $G = g\,(S_f \cos\theta_R - \sin\theta_R)$
$S_f = \tan\phi_a$ (Hungr & McClung (1987) suggested)

$\Rightarrow$ G = 1.0038
$\therefore$ X_L = **109.37** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **61.87** m (when V_0 = **7.65** m/s, Empirical Eq.)

(c) Apply Constant Rate of Deposition (Van Gassen & Cruden 1989):

$$X_L = \frac{3}{2} \times \frac{v_0^2}{2g\cos\theta_R(\tan\varphi_a - \tan\theta_R)}$$

X_L = **82.37** m (when V_0 = **10.5** m/s, GEO Report 104, Fig 21)
X_L = **43.71** (when V_0 = **7.65** m/s, Empirical Eq.)

Expected max. run-out (X_L) = **109.37** **m** (No mitigation measures taken into account)

4. Determination of Vertical Runup Distance (Δh)

(a) Apply Lumped-mass Model:

$$\Delta h = \frac{v_0^{\,2} \tan \theta_{up}}{2g\left(\tan \phi_a + \tan \theta_{up}\right)}$$

Δh	=	**3.52**	m	(when V_0	=	**10.5**	m/s, GEO Report 104, Fig 21)
Δh	=	**1.87**	m	(when V_0	=	**7.65**	m/s, Empirical Eq.)

(b) Apply Lumped-mass Model Corrected for Momentum Change (Perla et al, 1980):

$$\Delta h = \frac{v_0^{\,2} \cos^2 (\theta_{cs} + \theta_{up}) \tan \theta_{up}}{2\, g\left(\tan \varphi_a + \tan \theta_{up}\right)}$$

Δh	=	**0.72**	m	(when V_0	=	**10.5**	m/s, GEO Report 104,Fig 21)
Δh	=	**0.38**	m	(when V_0	=	**7.65**	m/s, Empirical Eq.)

(c) Apply Leading-edge Model (Hungr & McClung, 1987; Takahashi & Yoshida, 1979):

$$\Delta h = \frac{v_0^{\,2} \cos^2\left(\theta_{cs} + \theta_{up}\right) \tan \theta_{up}}{g\left(\tan \phi_a + \tan \theta_{up}\right)} \left(1 + \frac{gh \cos \theta_{cs}}{2 v_0^{\,2}}\right)^2$$

Δh	=	**1.56**	m	(when V_0	=	**10.5**	m/s, GEO, Report 104, Fig 21)
Δh	=	**0.88**	m	(when V_0	=	**7.65**	m/s, Empirical Eq.)

Run-up (m)						
(Method)						
a (13m/s)	a (10.6m/s)	b (13m/s)	b (10.6m/s)	c (13m/s)	c (10.6m/s)	Average
3.52	1.87	0.72	0.38	1.56	0.88	**1.48833** (m)

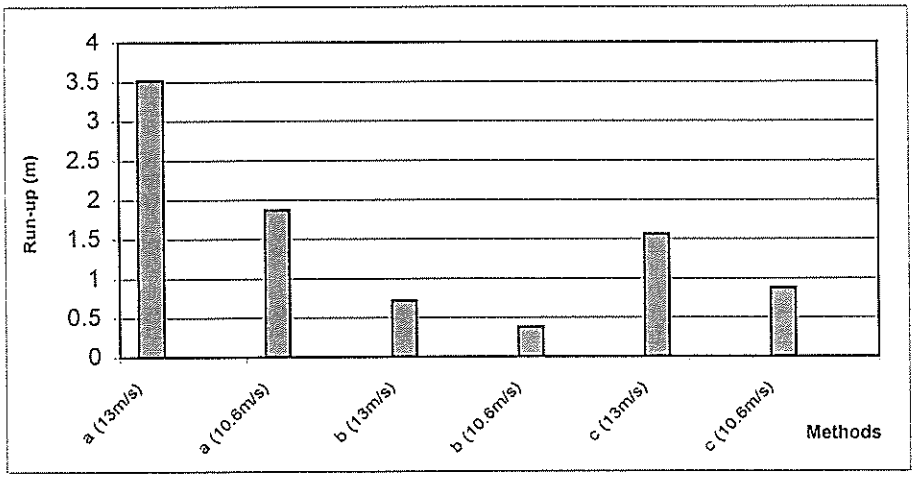


Table G2 - Summary of Calculations

Catchment No.	OPEN HILLSLOPE LANDSLIDES			CHANNELISED DEBRIS FLOWS		
		Capacity of Bund [2]			Capacity of Bund [2]	
	Run-Out Distance (m) [1]	Height (m)	Distance (m)	Run-Out Distance (m) [1]	Height (m)	Distance (m)
3	11.84	2.5	1.7	36.05	2.5	13.2
4	12.06	2.5	2	31.06	2.5	11.5
5	12.01	2.5	1.9	35.48	2.5	13.6
6A	15.08	2.5	1.7	45.34	2.5	11.5
6B	15.64	2.5	2.6	53.48	2.5	12
7	14.66	2.5	1.2	53.48	2.5	11.6
8	14.97	2.5	1.6	53.48	2.5	12.8
9	22.38	2.5	2	109.37	2.5	13.8

Notes : (1) Run-Out Distance of hazards excluding mitigation measures
(2) Height and Distance from slope toe

Conclusions:

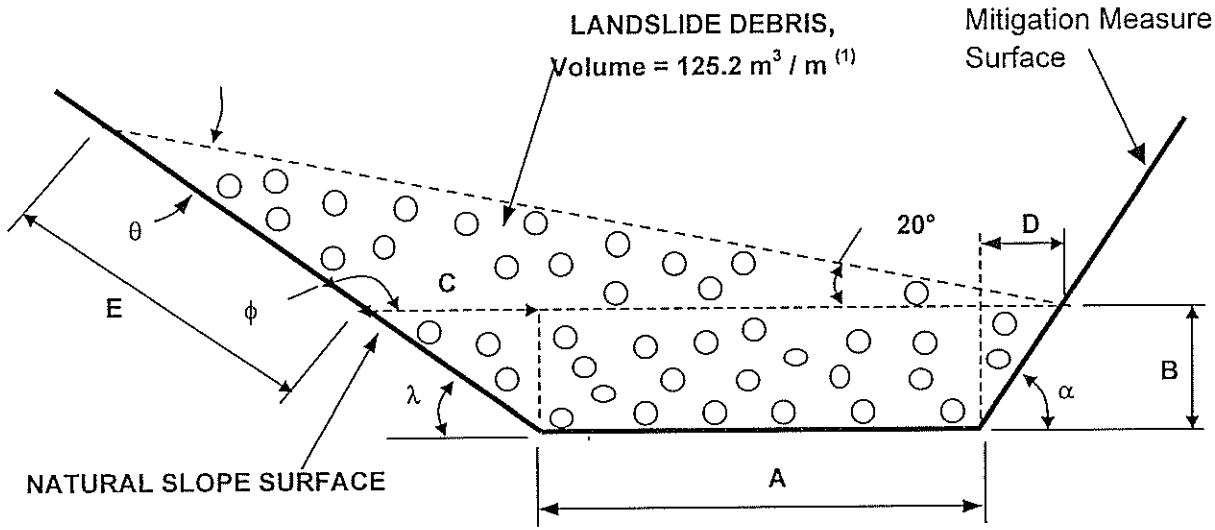
Say 3m

Calculations for Open Hillslope Landslides reveal that mitigation measures in the form of a 2.5 m height barrier should be constructed at minimum distances between 1.2 and 2.6m from the slope toe to contain the landslide debris.
Calculations for Channelised Debris Flows reveal that mitigation measures in the form of a 2.5 m height barrier should be constructed at minimum distances between 11.5 and 13.8m from the drainage mouth to contain the landslide debris.

Say 14m.

3m

Thus, for consistency of construction and to contain both open hillslope landslide and channelised debris flow hazards, the proposed mitigation measure in the form of a ramp-up barrier is recommended at a minimum distance of 4m from the slope toe. Taking into consideration the locations of existing formed slopes at the toe of the natural terrain and channel structures, the exact location of the proposed mitigation measures is shown in the Mitigation Strategy Map in Appendix H.



INPUT DATA

λ	56	°
α	32	°
A	13.2	m
B	2.5	m

CALCULATION

$\theta = \lambda - 20 = 36.00$

$D = B / \tan\alpha = 4.00$

$C = B / \tan\lambda = 1.69$

$H = A + C + D = 18.89$

$\phi = 180 - \lambda = 124.00$

$E = H \sin 20 / \sin\theta = 10.99$

Volume of Basal Trapezoid

$\text{Area}_T = (2A + D + C) \times B / 2$

$= 40.1089 \ m^3$

Volume of Upper Triangle

$\text{Area}_\Delta = E\ H \sin\phi / 2$

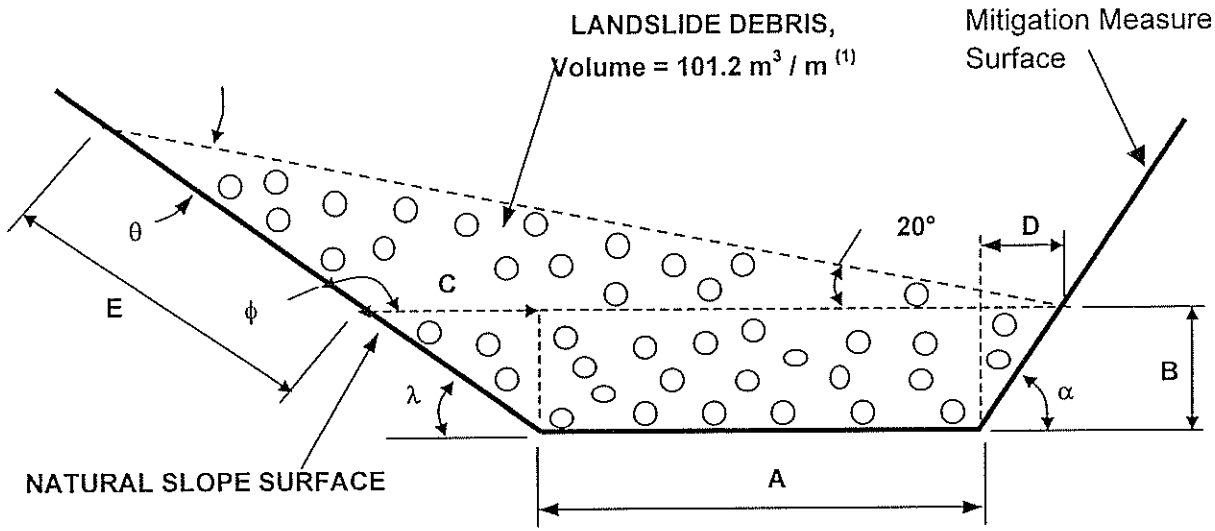
$= 86.04 \ m^3$

Total Volume = $\text{Area}_T + \text{Area}_\Delta$ = 126.15 m^3 / m

(Therefore, a 2.5m barrier of a minimum distance of 13.2m from slope toe will contain CE of 125.2m^3 / m)

Notes: (1) Volume = Final Run-Out Volume / Trail Width (6m)

Subject: Capacity Against Channelised Debris Flow (Catchment 3)	Prepared: Smo	Checked: KWK	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:



INPUT DATA

λ	60	°
α	32	°
A	11.5	m
B	2.5	m

CALCULATION

$\theta = \lambda - 20$ = 40.00

$D = B / \tan\alpha$ = 4.00

$C = B / \tan\lambda$ = 1.44

Volume of Basal Trapezoid

$\text{Area}_T = (2A + D + C) \times B / 2$

= 35.5553 m^3

$H = A + C + D$ = 16.94

$\phi = 180 - \lambda$ = 120.00

$E = H \sin 20 / \sin\theta$ = 9.02

Volume of Upper Triangle

$\text{Area}_\Delta = E\ H \sin\phi / 2$

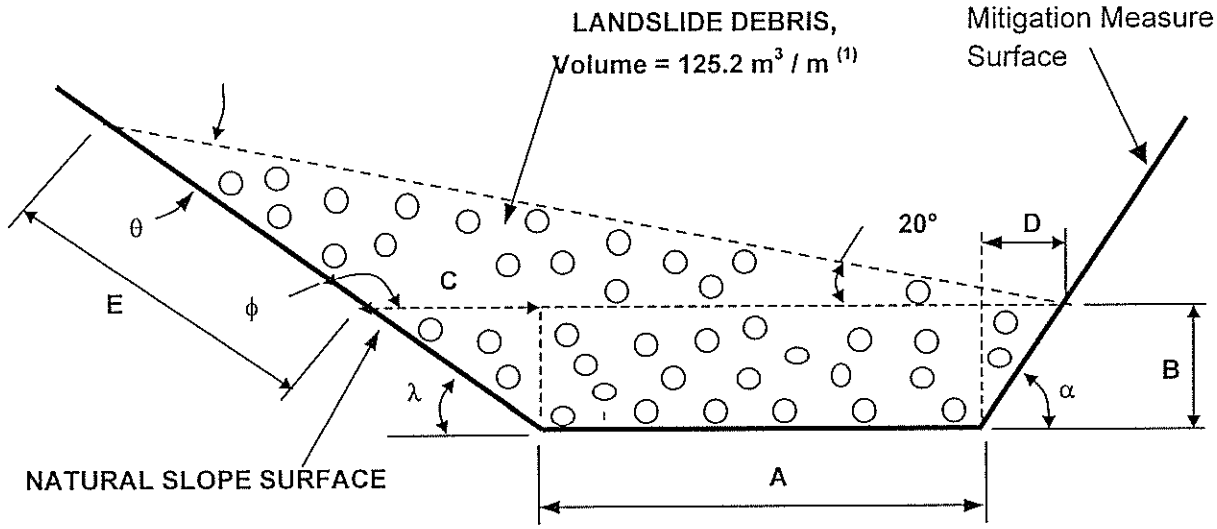
= 66.15 m^3

Total Volume = $\text{Area}_T + \text{Area}_\Delta$ = **101.70** m^3/m

(Therefore, a 2.5m barrier of a minimum distance of 11.5m from slope toe will contain CE of 101.2 m^3 / m)

Notes: (1) Volume = Final Run-Out Volume / Trail Width (6m)

Subject: Capacity Against Channelised Debris Flow (Catchment 4)	Prepared: Smo	Checked: KWK	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:



INPUT DATA

λ	59	°
α	32	°
A	13.6	m
B	2.5	m

CALCULATION

$\theta = \lambda - 20 = 39.00$

$D = B / \tan\alpha = 4.00$

$C = B / \tan\lambda = 1.50$

Volume of Basal Trapezoid

$Area_T = (2A + D + C) \times B / 2$

$= 40.8787 \ m^3$

$H = A + C + D = 19.10$

$\phi = 180 - \lambda = 121.00$

$E = H \sin 20 / \sin\theta = 10.38$

Volume of Upper Triangle

$Area_\Delta = E \ H \sin\phi / 2$

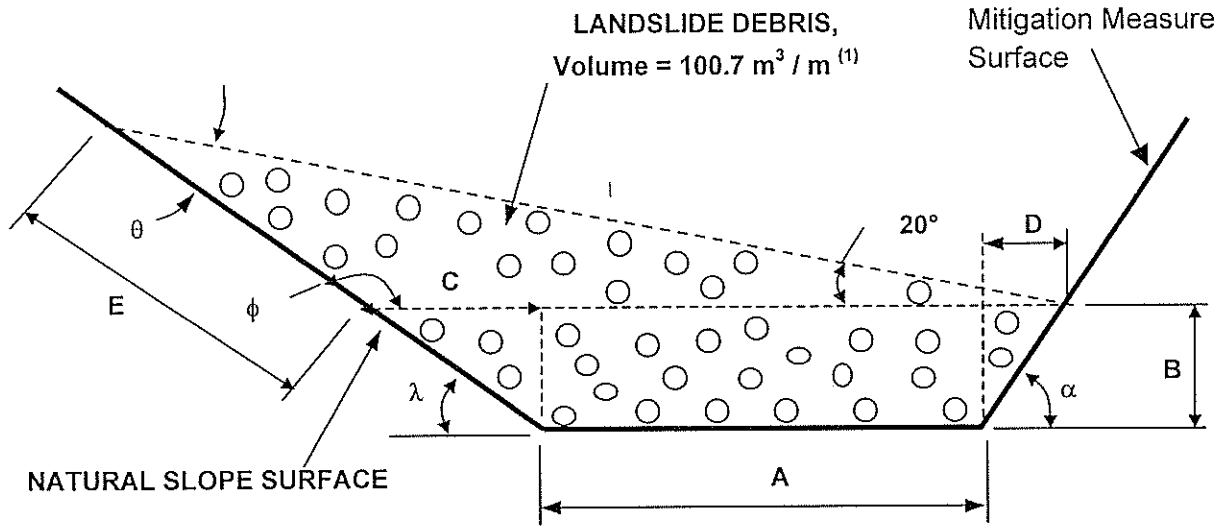
$= 85.00 \ m^3$

Total Volume = $Area_T$ + $Area_\Delta$ = 125.88 m^3 / m

(Therefore, a 2.5m barrier of a minimum distance of 13.6m from slope toe will contain CE of 125.20m^3 / m)

Notes: (1) Volume = Final Run-Out Volume / Trail Width (6m)

Subject: Capacity Against Channelised Debris Flow (Catchment 5)	Prepared: Smo	Checked: KWK	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:



INPUT DATA

λ	60	°
α	32	°
A	11.5	m
B	2.5	m

CALCULATION

$\theta = \lambda - 20$ = 40.00

$D = B / \tan\alpha$ = 4.00

$C = B / \tan\lambda$ = 1.44

Volume of Basal Trapezoid

$Area_T = (2A + D + C) \times B / 2$

= 35.5553 m^3

$H = A + C + D$ = 16.94

$\phi = 180 - \lambda$ = 120.00

$E = H \sin 20 / \sin\theta$ = 9.02

Volume of Upper Triangle

$Area_\Delta = E\ H \sin\phi / 2$

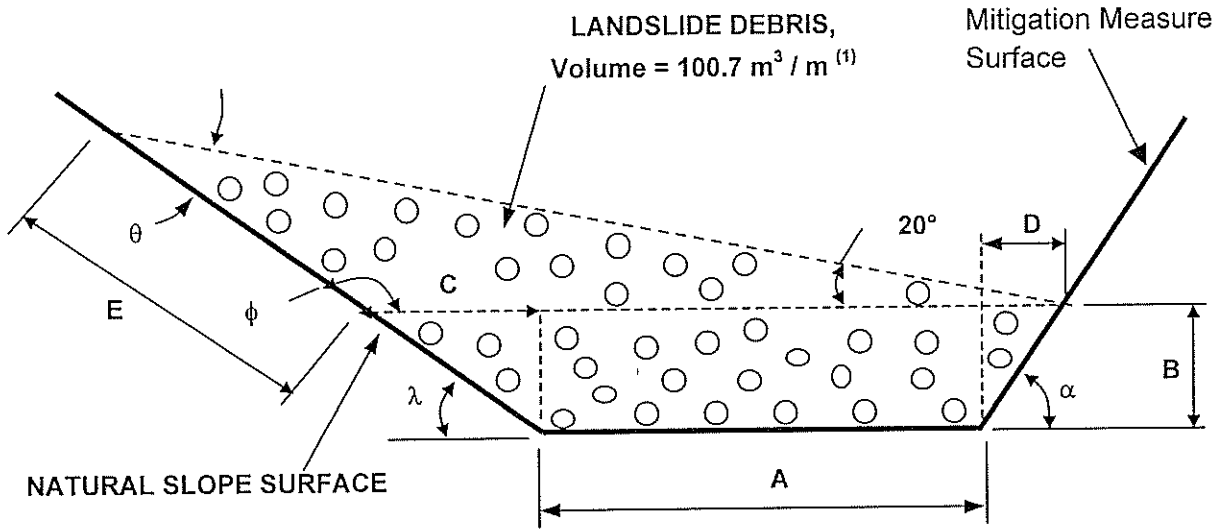
= 66.15 m^3

Total Volume = $Area_T + Area_\Delta$ = **101.70** m^3/m

(Therefore, a 2.5m barrier of a minimum distance of 11.5m from slope toe will contain CE of 100.7m^3 / m)

Notes: (1) Volume = Final Run-Out Volume / Trail Width (6m)

Subject	Prepared	Checked	
Capacity Against Channelised Debris Flow (Catchment 6A)	Smo	KWK	
Project	**Date**	**Scale**	**Figure No.**
Tseung Kwan O Landfill Stage II/III Afteruse Development	Jan-03		



INPUT DATA

λ	65	°
α	32	°
A	12	m
B	2.5	m

CALCULATION

$\theta = \lambda - 20$ = 45.00

$D = B / \tan\alpha$ = 4.00

$C = B / \tan\lambda$ = 1.17

Volume of Basal Trapezoid

$Area_T = (2A + D + C) \times B / 2$

= 36.4583 m^3

$H = A + C + D$ = 17.17

$\phi = 180 - \lambda$ = 115.00

$E = H \sin 20 / \sin\theta$ = 8.30

Volume of Upper Triangle

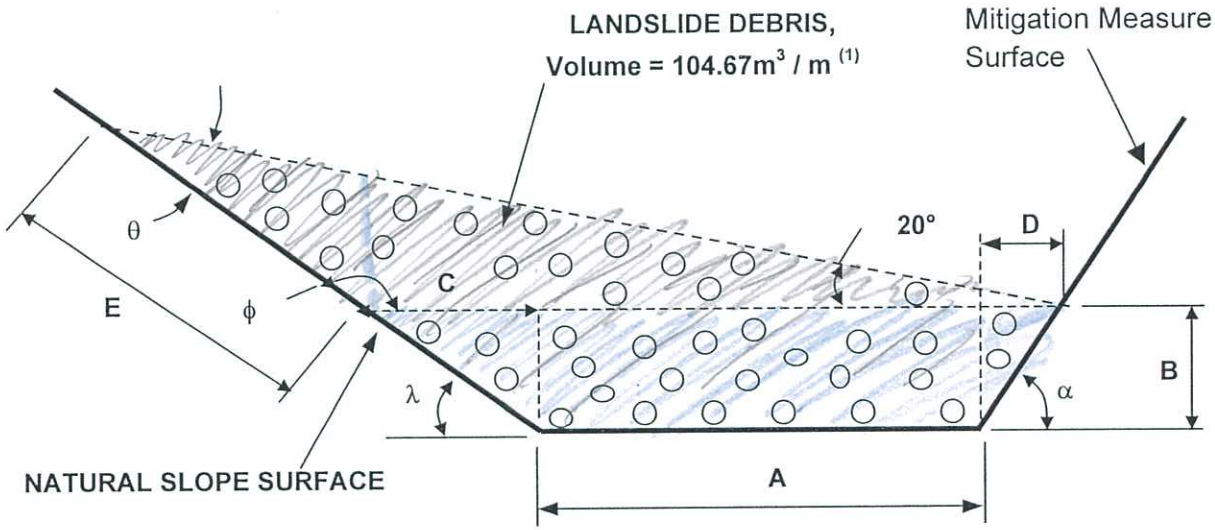
$Area_\Delta = E\ H \sin\phi / 2$

= 64.59 m^3

Total Volume = $Area_T$ + $Area_\Delta$ = **101.05** m^3 / m (Therefore, a 2.5m barrier of a minimum distance of 12m from slope toe will contain CE of 100.7m^3 / m)

Notes: (1) Volume = Final Run-Out Volume / Trail Width (6m)

Subject: Capacity Against Channelised Debris Flow (Catchment 6B)	Prepared: Smo	Checked: KWK	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.



INPUT DATA

λ	58	°
α	32	°
A	11.6	m
B	2.5	m

CALCULATION

$\theta = \lambda - 20 = 38.00$

$D = B / \tan\alpha = 4.00$

$C = B / \tan\lambda = 1.56$

Volume of Basal Trapezoid

$\text{Area}_T = (2A + D + C) \times B / 2$

$= 35.9538 \ m^3$

$H = A + C + D = 17.16$

$\phi = 180 - \lambda = 122.00$

$E = H \sin 20 / \sin\theta = 9.53$

Volume of Upper Triangle

$\text{Area}_\Delta = E\ H \sin\phi / 2$

$= 69.39 \ m^3$

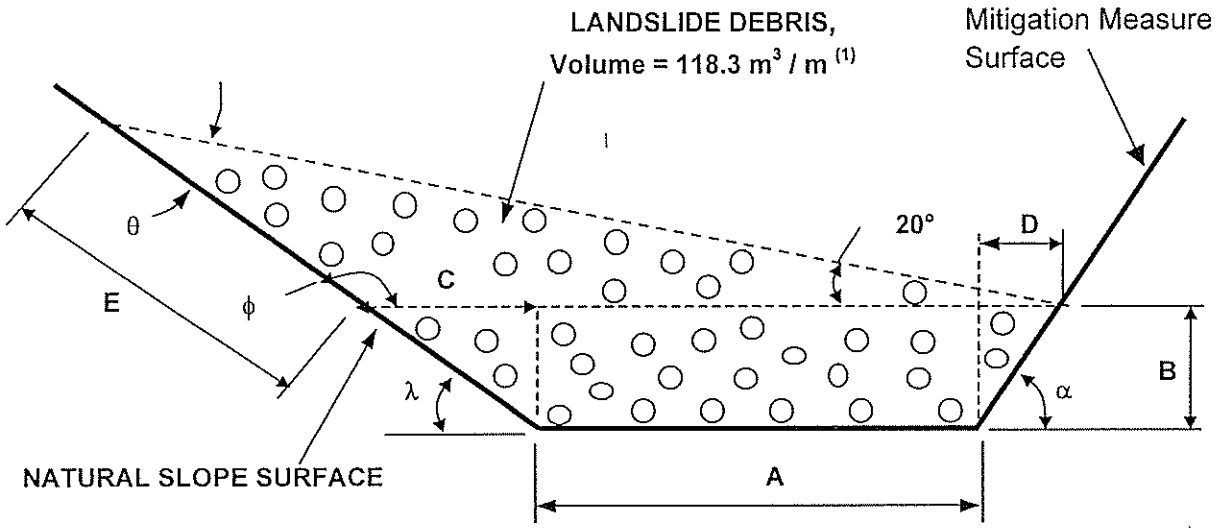
Total Volume = $\text{Area}_T + \text{Area}_\Delta$

= **105.34** m^3 / m

(Therefore, a 2.5m barrier of a minimum distance of 11.6m from slope toe will contain CE of 104.67m^3 / m)

Notes: (1) Volume = Final Run-Out Volume / Trail Width (6m)

Subject	Capacity Against Channelised Debris Flow (Catchment 7)	Prepared Smo	Checked JH	
Project	Tseung Kwan O Landfill Stage II/III Afteruse Development	Date Jan-03	Scale	Figure No.



INPUT DATA

λ	58	°
α	32	°
A	12.8	m
B	2.5	m

CALCULATION

$\theta = \lambda - 20 = 38.00$

$D = B / \tan\alpha = 4.00$

$C = B / \tan\lambda = 1.56$

$H = A + C + D = 18.36$

$\phi = 180 - \lambda = 122.00$

$E = H \sin 20 / \sin\theta = 10.20$

Volume of Basal Trapezoid

$\text{Area}_T = (2A + D + C) \times B / 2$

$= 38.9538 \ m^3$

Volume of Upper Triangle

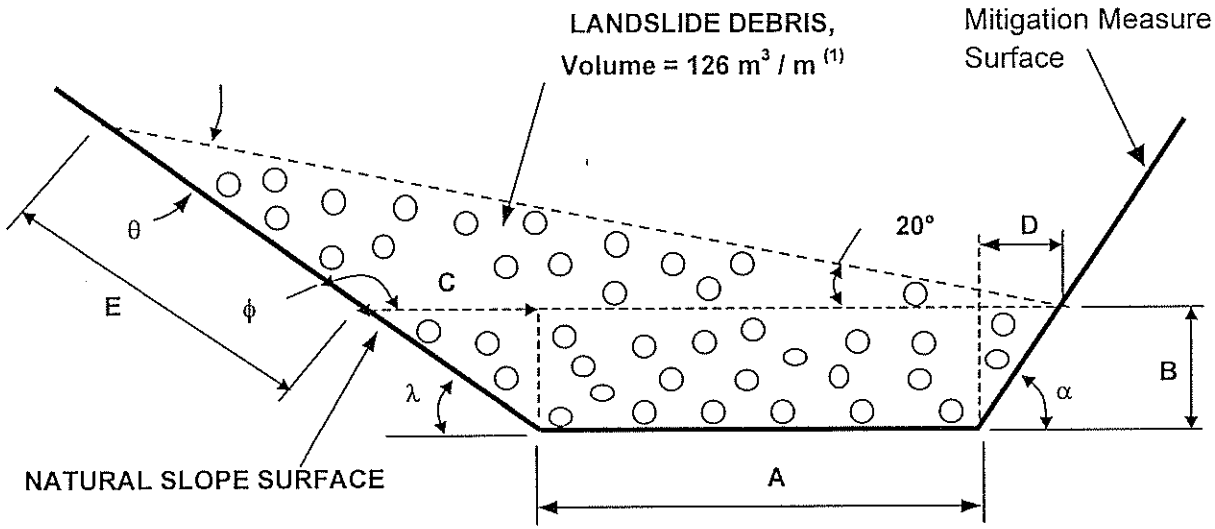
$\text{Area}_\Delta = E\ H \sin\phi / 2$

$= 79.43 \ m^3$

Total Volume = $\text{Area}_T + \text{Area}_\Delta$ = 118.38 m^3 / m (Therefore, a 2.5m barrier of a minimum distance of 12.8m from slope toe will contain CE of 118.3m^3 / m)

Notes: (1) Volume = Final Run-Out Volume / Trail Width (6m)

Subject	Prepared	Checked	
Capacity Against Channelised Debris Flow (Catchment 8)	Smo	KWK	
Project	**Date**	**Scale**	**Figure No.**
Tseung Kwan O Landfill Stage II/III Afteruse Development	Jan-03		



INPUT DATA

λ	60	°
α	32	°
A	13.8	m
B	2.5	m

CALCULATION

$\theta = \lambda - 20 = 40.00$

$D = B / \tan\alpha = 4.00$

$C = B / \tan\lambda = 1.44$

$H = A + C + D = 19.24$

$\phi = 180 - \lambda = 120.00$

$E = H \sin 20 / \sin\theta = 10.24$

Volume of Basal Trapezoid

$\text{Area}_T = (2A + D + C) \times B / 2$

$= 41.3053 \ m^3$

Volume of Upper Triangle

$\text{Area}_\Delta = E\ H \sin\phi / 2$

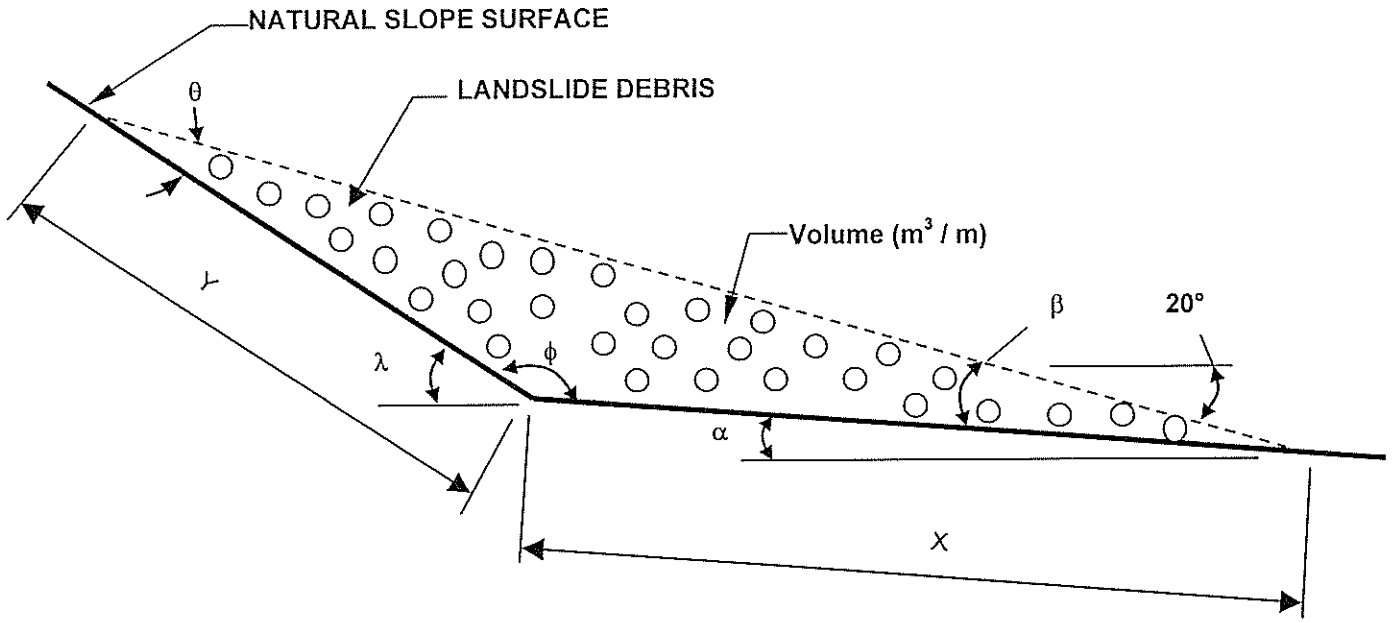
$= 85.33 \ m^3$

Total Volume = $\text{Area}_T + \text{Area}_\Delta$ = 126.63 m^3 / m

(Therefore, a 2.5m barrier of a minimum distance of 13.8m from slope toe will contain CE of 126m^3 / m)

Notes: (1) Volume = Final Run-Out Volume / Trail Width (6m)

Subject	Prepared	Checked	
Capacity Against Channelised Debris Flow (Catchment 9)	Smo	KWK	
Project	**Date**	**Scale**	**Figure No.**
Tseung Kwan O Landfill Stage II/III Afteruse Development	Jan-03		



INPUT DATA

Volume (1)	=	**24** m^3 / m
α	=	**5** °
λ	=	**56** °

CALCULATION

$\phi = 180 - 56 + 5 = \mathbf{129}$

$\beta = 20 - \alpha = \mathbf{15}$

$\theta = \lambda - 20 = \mathbf{36}$

Volume = ½ X Y sin ϕ *(1)*

$$\frac{\sin\beta}{Y} = \frac{\sin\theta}{X} \Rightarrow Y = \frac{X \sin\beta}{\sin\theta} \qquad (2)$$

sub (2) into (1)

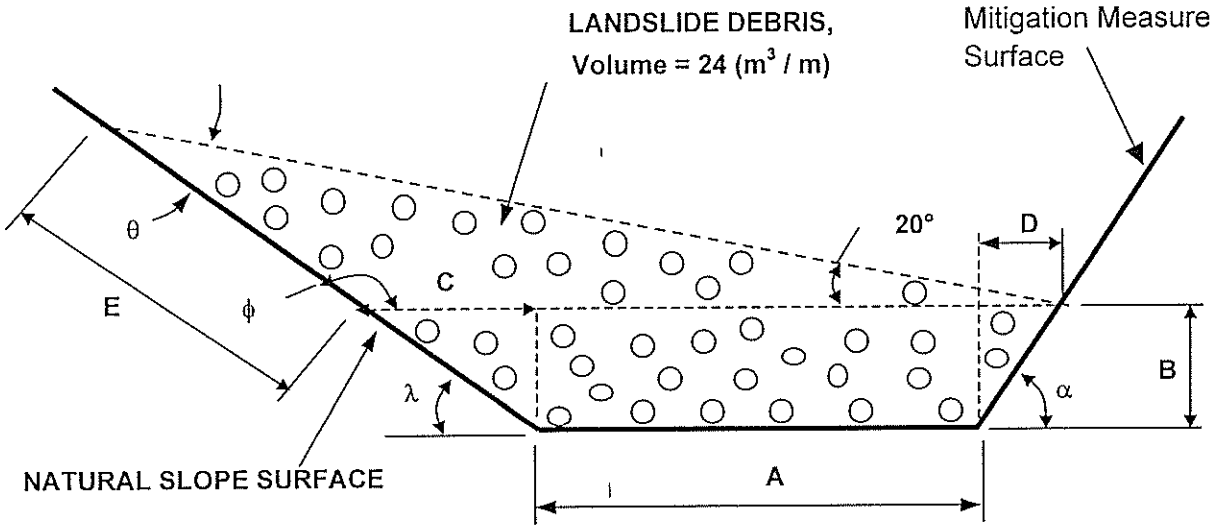
$$\text{Volume} = \frac{1}{2} \times \frac{X \sin\beta}{\sin\theta} \times \sin\phi$$

$$X^2 = \frac{2 \times 24 \times \sin 36}{\sin 15 \times \sin 129}$$

$$X = \underline{11.84} \text{ m}$$

Notes: (1) Volume = Source Volume/10 m (Average figure taken from Mid-Level Studies)

Subject: OPEN HILLSLOPE LANDSLIDE RUN-OUT CALCULATION (Catchment 3)	Prepared: Smo	Checked: JH	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:



INPUT DATA

λ	56	°
α	32	°
A	1.7	m
B	2.5	m

CALCULATION

$\theta = \lambda - 20$ = 36.00

$D = B / \tan\alpha$ = 4.00

$C = B / \tan\lambda$ = 1.69

$H = A + C + D$ = 7.39

$\phi = 180 - \lambda$ = 124.00

$E = H \sin 20 / \sin\theta$ = 4.30

Volume of Basal Trapezoid

$\text{Area}_T = (2A + D + C) \times B / 2$

= 11.3589 m^3

Volume of Upper Triangle

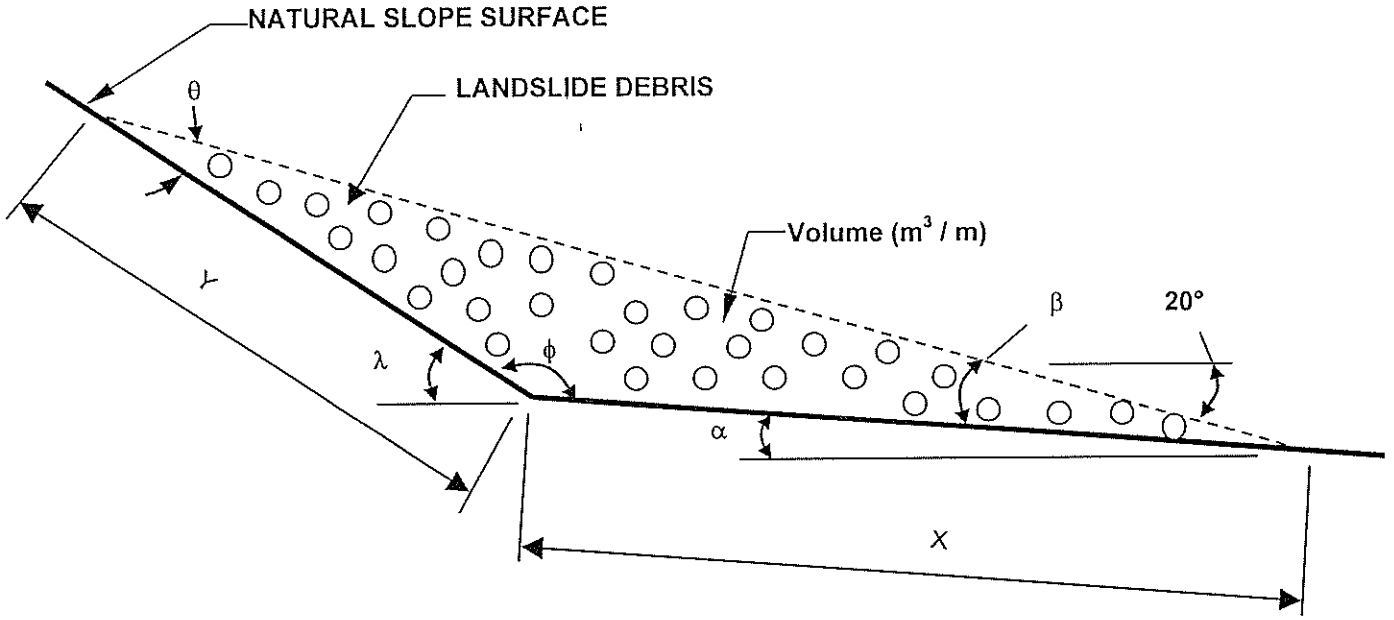
$\text{Area}_\Delta = E\ H \sin\phi / 2$

= 13.16 m^3

Total Volume = $\text{Area}_T + \text{Area}_\Delta$ = **24.52** m^3/m

(Therefore, a 2.5m height barrier of a minimum distance of 1.7m from slope toe will contain 24m^3 / m)

Subject: CAPACITY AGAINST OPEN HILLSLOPE LANDSLIDE (Catchment 3)	Prepared: Smo	Checked: KWK	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:



INPUT DATA

Volume [1]	=	24 m^3 / m
α	=	5 °
λ	=	60 °

CALCULATION

$\phi = 180 - 60 + 5 = 125$

$\beta = 20 - \alpha = 15$

$\theta = \lambda - 20 = 40$

Volume $= \frac{1}{2} X Y \sin \phi$ *(1)*

$$\frac{\sin \beta}{Y} = \frac{\sin \theta}{X} \Rightarrow Y = \frac{X \sin \beta}{\sin \theta} \quad (2)$$

sub (2) into (1)

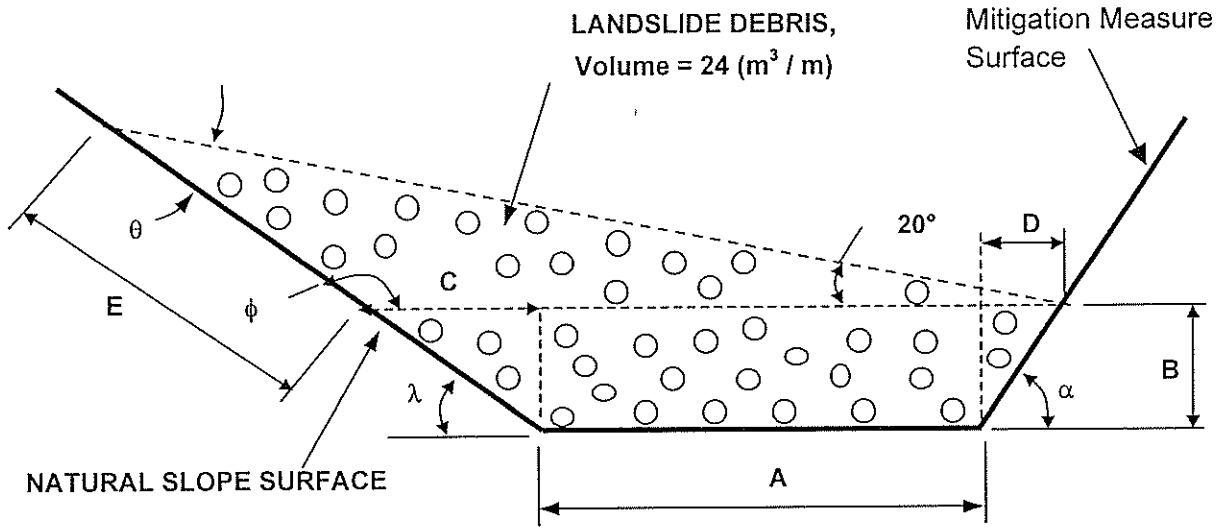
$$\text{Volume} = \frac{1}{2} \times \frac{X \sin \beta}{\sin \theta} \times \sin \phi$$

$$X^2 = \frac{2 \times 24 \times \sin 40}{\sin 15 \times \sin 125}$$

$$X = \underline{12.06} \text{ m}$$

Notes: (1) Volume = Source Volume/10 m (Average figure taken from Mid-Level Studies)

Subject: OPEN HILLSLOPE LANDSLIDE RUN-OUT CALCULATION (Catchment 4)	Prepared: Smo	Checked: JH	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:



INPUT DATA

λ	60	°
α	32	°
A	2	m
B	2.5	m

CALCULATION

$\theta = \lambda - 20$ = 40.00

$D = B / \tan \alpha$ = 4.00

$C = B / \tan \lambda$ = 1.44

Volume of Basal Trapezoid

$\text{Area}_T = (2A + D + C) \times B / 2$

= 11.8053 m^3

$H = A + C + D$ = 7.44

$\phi = 180 - \lambda$ = 120.00

$E = H \sin 20 / \sin \theta$ = 3.96

Volume of Upper Triangle

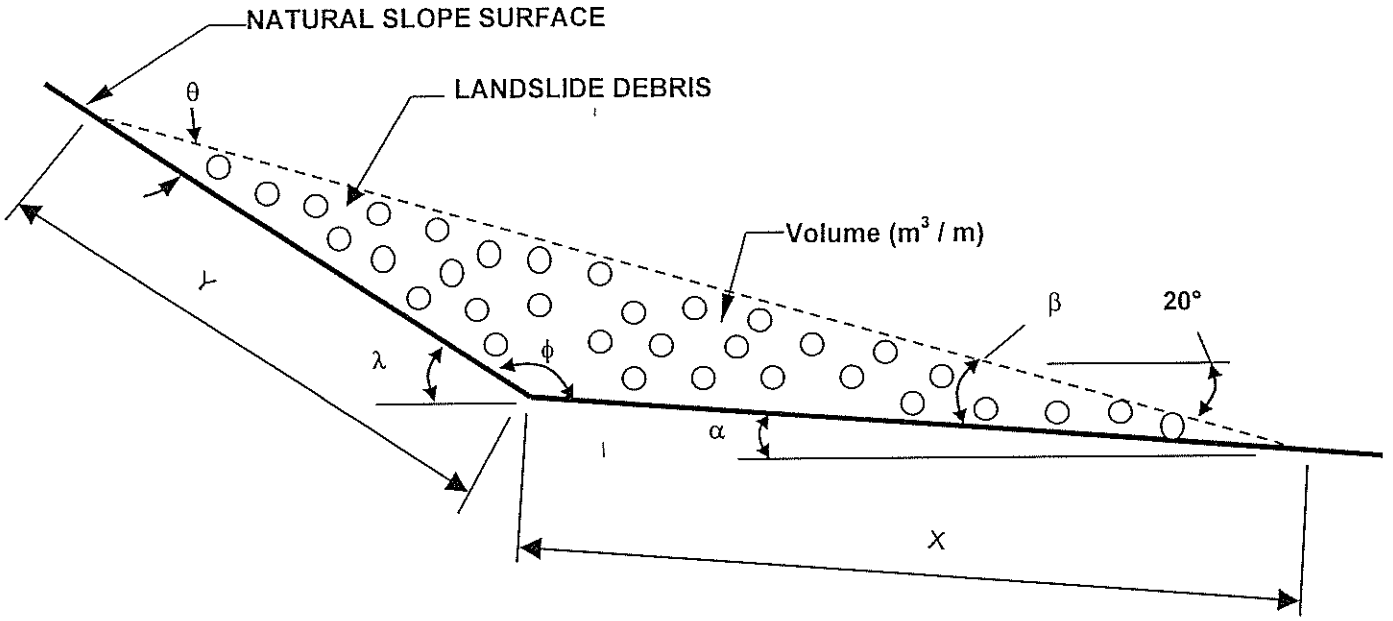
$\text{Area}_\Delta = E\ H \sin \phi / 2$

= 12.77 m^3

Total Volume = $\text{Area}_T + \text{Area}_\Delta$ = **24.57** m^3 / m

(Therefore, a 2.5m height barrier of a minimum distance of 2.0m from slope toe will contain 24m^3 / m)

Subject: CAPACITY AGAINST OPEN HILLSLOPE LANDSLIDE (Catchment 4)	Prepared: Smo	Checked: KWK	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:



INPUT DATA

Volume (1)	=	24 m^3 / m
α	=	5 °
λ	=	59 °

CALCULATION

$\phi = 180 - 59 + 5 = 126$

$\beta = 20 - \alpha = 15$

$\theta = \lambda - 20 = 39$

Volume $= \frac{1}{2} X Y \sin\phi$ *(1)*

$$\frac{\sin\beta}{Y} = \frac{\sin\theta}{X} \Rightarrow Y = \frac{X \sin\beta}{\sin\theta} \quad (2)$$

sub (2) into (1)

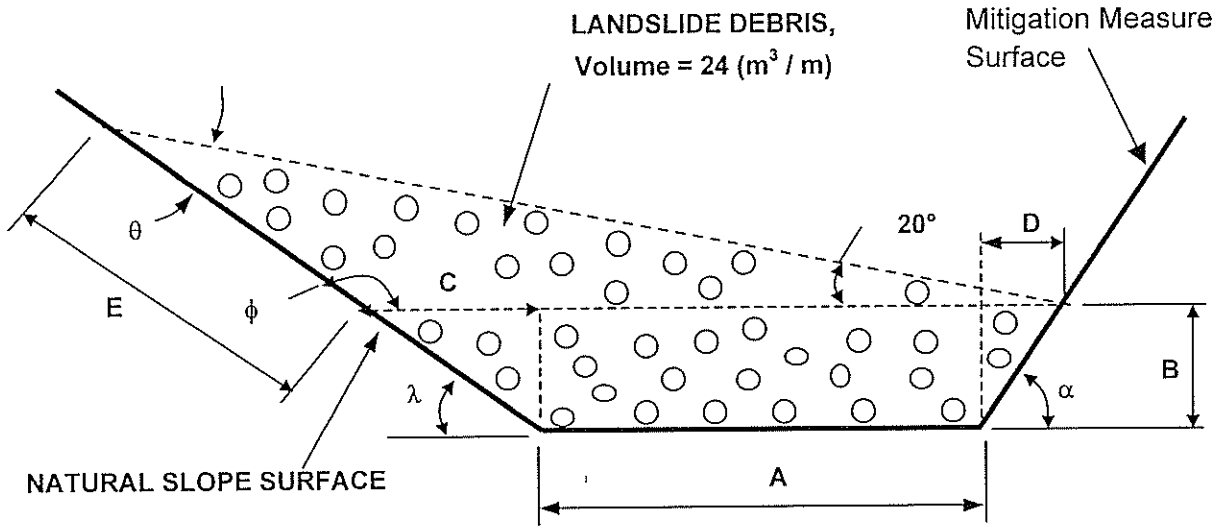
$$\text{Volume} = \frac{1}{2} \times \frac{X \sin\beta}{\sin\theta} \times \sin\phi$$

$$X^2 = \frac{2 \times 24 \times \sin 39}{\sin 15 \times \sin 126}$$

$$X = \underline{12.01} \text{ m}$$

Notes: (1) Volume = Source Volume/10 m (Average figure taken from Mid-Level Studies)

Subject: OPEN HILLSLOPE LANDSLIDE RUN-OUT CALCULATION (Catchment 5)	Prepared: Smo	Checked: JH	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:



INPUT DATA

λ	59	°
α	32	°
A	1.9	m
B	2.5	m

CALCULATION

$\theta = \lambda - 20$ = 39.00

$D = B / \tan \alpha$ = 4.00

$C = B / \tan \lambda$ = 1.50

Volume of Basal Trapezoid

$Area_T = (2A + D + C) \times B / 2$

= 11.6287 m^3

$H = A + C + D$ = 7.40

$\phi = 180 - \lambda$ = 121.00

$E = H \sin 20 / \sin \theta$ = 4.02

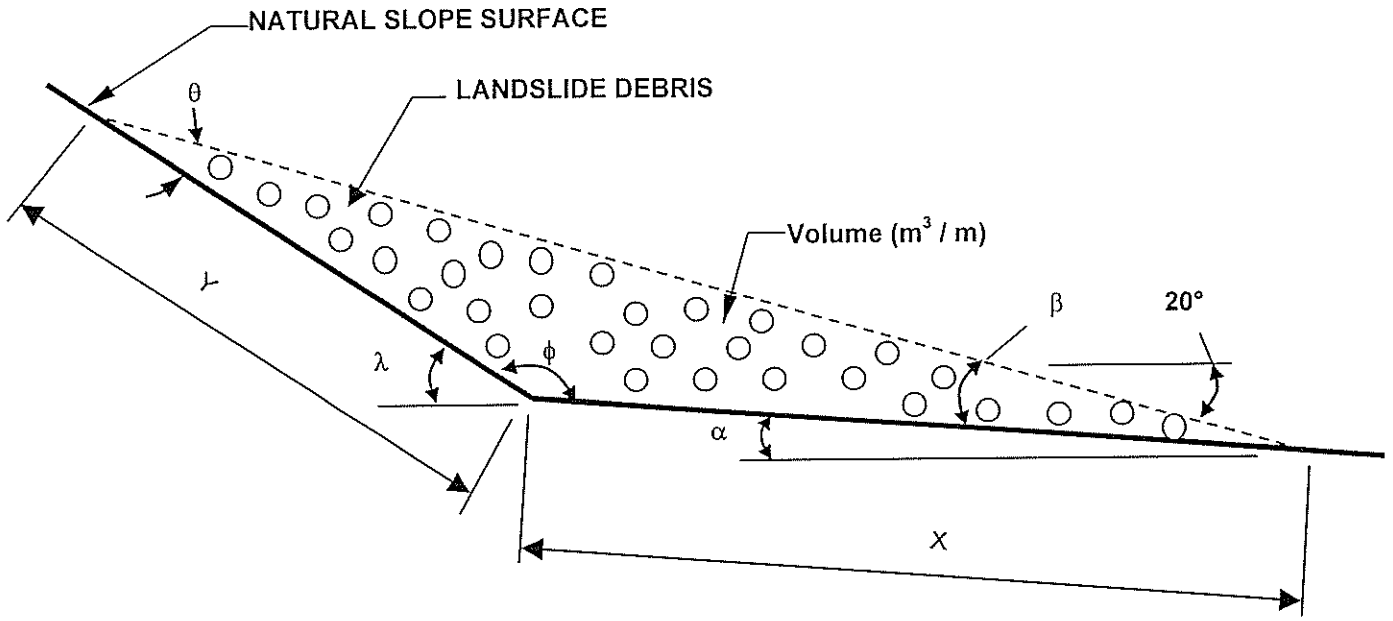
Volume of Upper Triangle

$Area_\Delta = E H \sin \phi / 2$

= 12.77 m^3

Total Volume = $Area_T + Area_\Delta$ = **24.39** m^3 / m (Therefore, a barrier of a minimum distance of 1.9m from slope toe will contain 24m^3 / m)

Subject: CAPACITY AGAINST OPEN HILLSLOPE LANDSLIDE (Catchment 5)	Prepared: Smo	Checked: KWK	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:



INPUT DATA

Volume [(1)]	=	**24** m^3 / m
α	=	**10** °
λ	=	**57** °

CALCULATION

$\phi = 180 - 57 + 10 =$ **133**

$\beta = 20 - \alpha =$ **10**

$\theta = \lambda - 20 =$ **37**

Volume $= \frac{1}{2} X Y \sin \phi$ *(1)*

$$\frac{\sin \beta}{Y} = \frac{\sin \theta}{X} \Rightarrow Y = \frac{X \sin \beta}{\sin \theta} \quad (2)$$

sub (2) into (1)

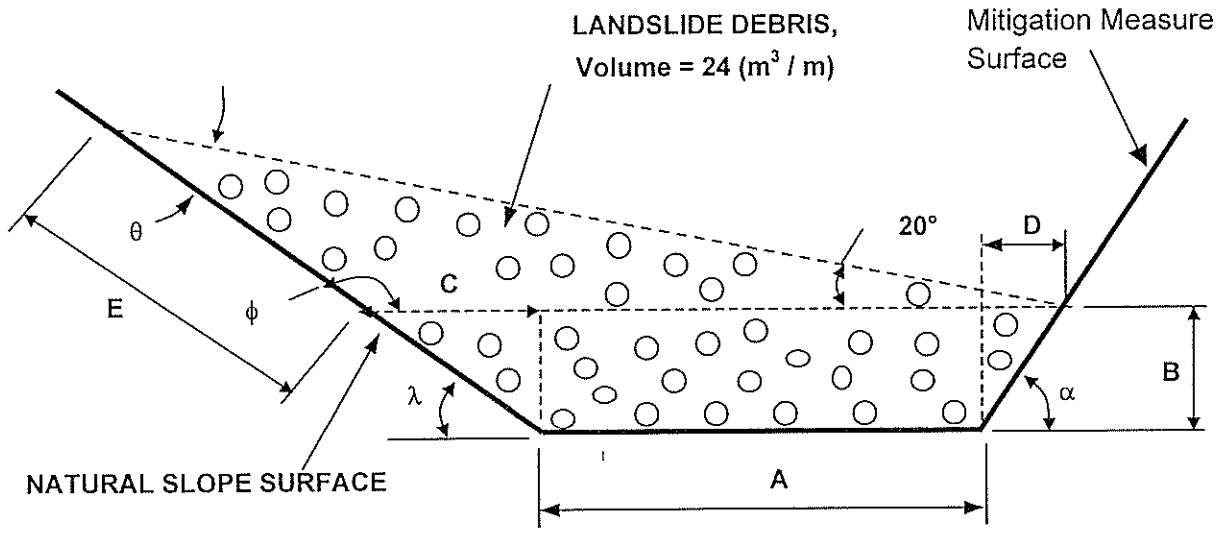
$$\text{Volume} = \frac{1}{2} \times \frac{X \sin \beta}{\sin \theta} \times \sin \phi$$

$$X^2 = \frac{2 \times 24 \times \sin 37}{\sin 10 \times \sin 133}$$

X = 15.08 m

Notes: (1) Volume = Source Volume/10 m (Average figure taken from Mid-Level Studies)

Subject: OPEN HILLSLOPE LANDSLIDE RUN-OUT CALCULATION (Catchment 6A)	Prepared: Smo	Checked: JH	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:



INPUT DATA

λ	57	°
α	32	°
A	1.7	m
B	2.5	m

CALCULATION

$\theta = \lambda - 20$ = 37.00

$D = B / \tan \alpha$ = 4.00

$C = B / \tan \lambda$ = 1.62

$H = A + C + D$ = 7.32

$\phi = 180 - \lambda$ = 123.00

$E = H \sin 20 / \sin \theta$ = 4.16

Volume of Basal Trapezoid

$\text{Area}_T = (2A + D + C) \times B / 2$

= 11.2804 m^3

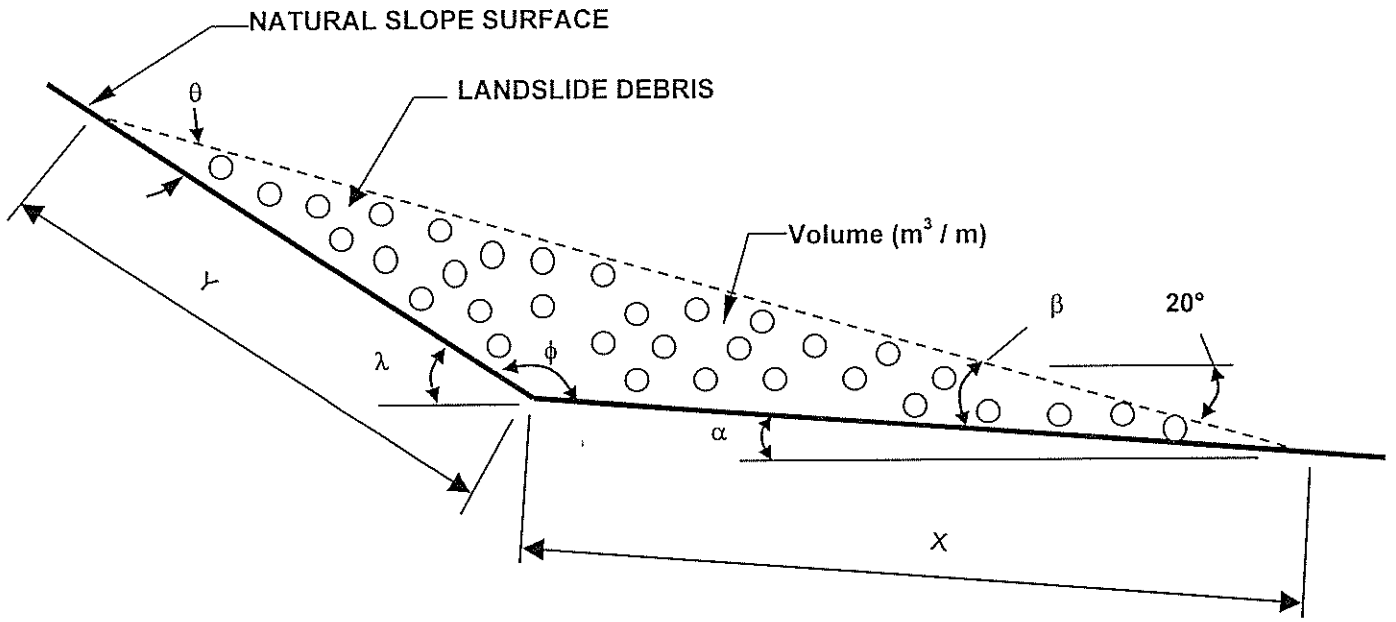
Volume of Upper Triangle

$\text{Area}_\Delta = E\ H \sin \phi / 2$

= 12.78 m^3

Total Volume = $\text{Area}_T + \text{Area}_\Delta$ = **24.07** m^3 / m (Therefore, a 2.5m barrier with a minimum distance of 1.7m from slope toe will contain 24m^3 / m)

Subject: CAPACITY AGAINST OPEN HILLSLOPE LANDSLIDE (Catchment 6A)	Prepared: Smo	Checked: KWK	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:



INPUT DATA

Volume [(1)]	=	**24** m^3 / m
α	=	**10** °
λ	=	**70** °

CALCULATION

$\phi = 180 - 70 + 10 = \mathbf{120}$

$\beta = 20 - \alpha = \mathbf{10}$

$\theta = \lambda - 20 = \mathbf{50}$

Volume $= \frac{1}{2} X Y \sin \phi$ *(1)*

$$\frac{\sin \beta}{Y} = \frac{\sin \theta}{X} \Rightarrow Y = \frac{X \sin \beta}{\sin \theta} \quad (2)$$

sub (2) into (1)

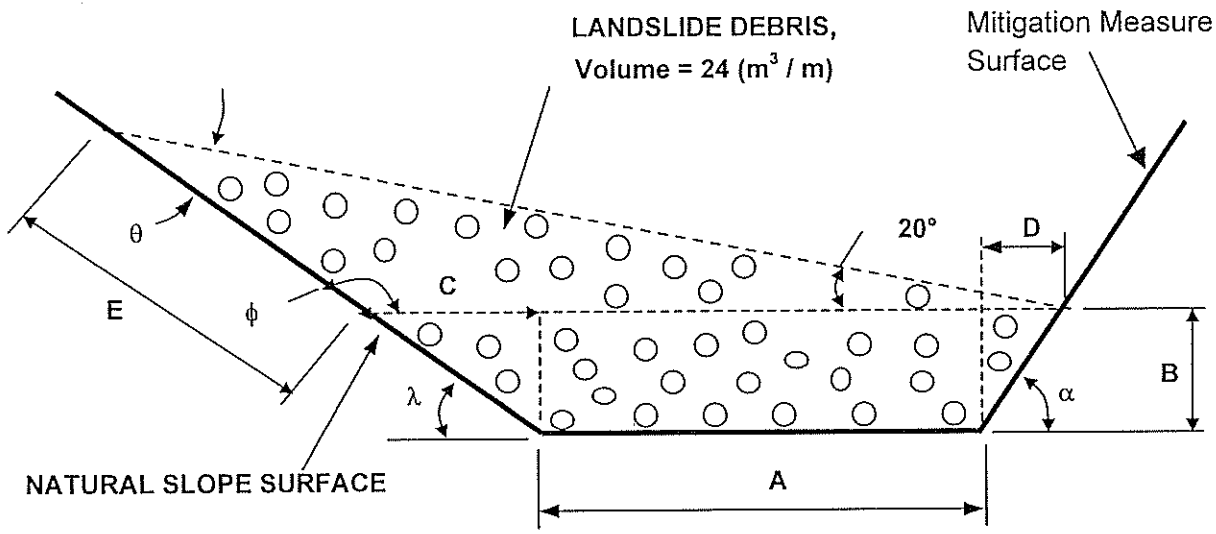
$$\text{Volume} = \frac{1}{2} \times \frac{X \sin \beta}{\sin \theta} \times \sin \phi$$

$$X^2 = \frac{2 \times 24 \times \sin 50}{\sin 10 \times \sin 120}$$

X = 15.64 m

Notes: (1) Volume = Source Volume/10 m (Average figure taken from Mid-Level Studies)

Subject: OPEN HILLSLOPE LANDSLIDE RUN-OUT CALCULATION (Catchment 6B)	Prepared: Smo	Checked: JH	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:



INPUT DATA

λ	70	°
α	32	°
A	2.6	m
B	2.5	m

CALCULATION

$\theta = \lambda - 20$ = 50.00

$D = B / \tan \alpha$ = 4.00

$C = B / \tan \lambda$ = 0.91

$H = A + C + D$ = 7.51

$\phi = 180 - \lambda$ = 110.00

$E = H \sin 20 / \sin \theta$ = 3.35

Volume of Basal Trapezoid

$\text{Area}_T = (2A + D + C) \times B / 2$

= 12.6385 m^3

Volume of Upper Triangle

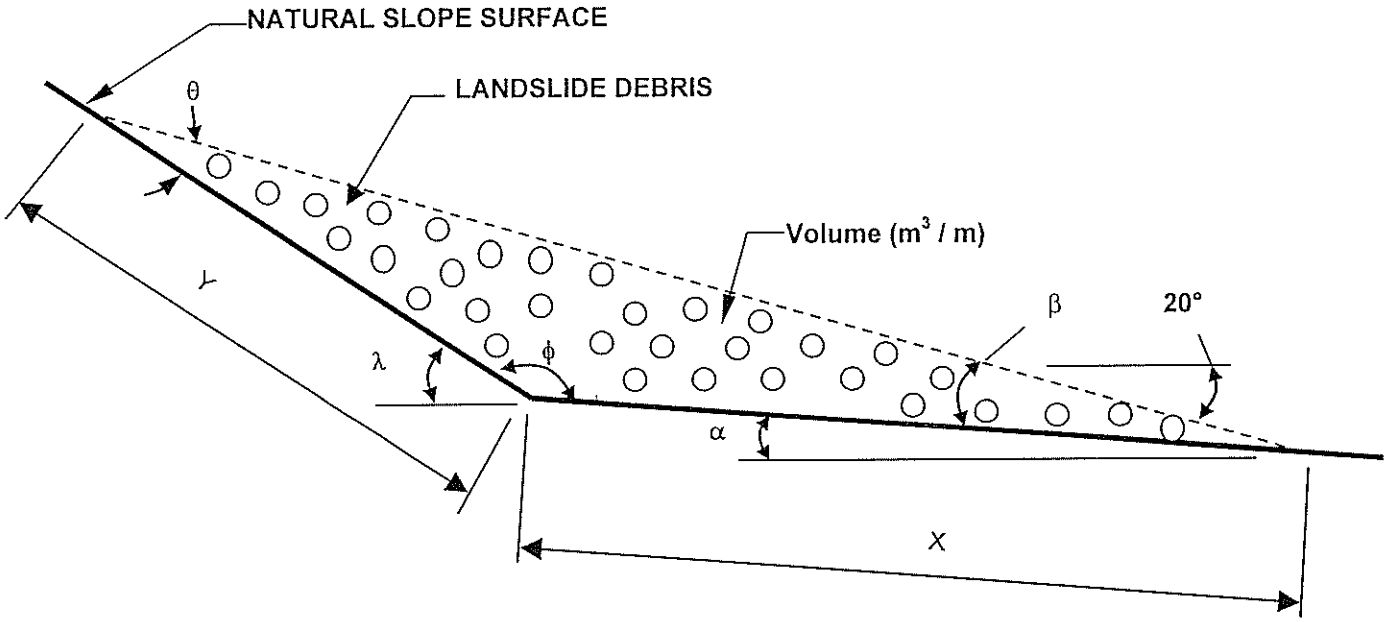
$\text{Area}_\Delta = E H \sin \phi / 2$

= 11.83 m^3

Total Volume = $\text{Area}_T + \text{Area}_\Delta$ = **24.47** m^3 / m

(Therefore, a 2.5m barrier with a minimum distance of 2.6m from slope toe will contain 24m^3 / m)

Subject: CAPACITY AGAINST OPEN HILLSLOPE LANDSLIDE (Catchment 6B)	Prepared: Smo	Checked: KWK	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:



INPUT DATA

Volume [(1)]	=	**24** m^3 / m
α	=	**10** °
λ	=	**50** °

CALCULATION

ϕ	= 180	- 50	+ 10	=	**140**
β	= 20	- α		=	**10**
θ	= λ	- 20		=	**30**

Volume = ½ X Y sin ϕ *(1)*

$$\frac{\sin\beta}{Y} = \frac{\sin\theta}{X} \Rightarrow \quad Y = \frac{X \sin\beta}{\sin\theta} \qquad (2)$$

sub (2) into (1)

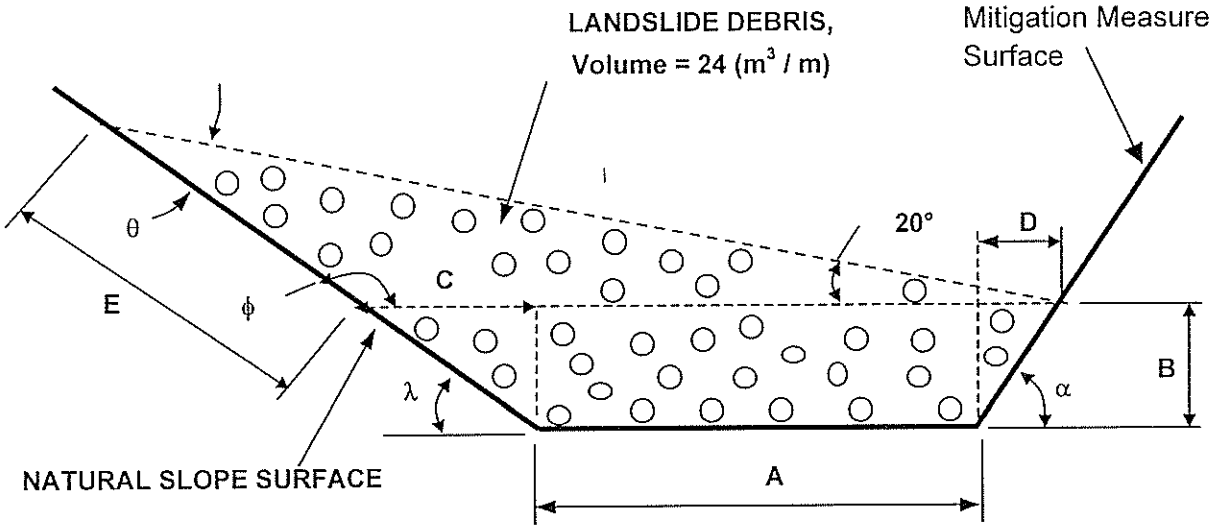
$$\text{Volume} = \frac{1}{2} \times \frac{X \sin\beta}{\sin\theta} \times \sin\phi$$

$$X^2 = \frac{2 \times 24 \times \sin 30}{\sin 10 \times \sin 140}$$

$$X = \underline{14.66} \text{ m}$$

Notes: (1) Volume = Source Volume/10 m (Average figure taken from Mid-Level Studies)

Subject: OPEN HILLSLOPE LANDSLIDE RUN-OUT CALCULATION (Catchment 7)	Prepared: Smo	Checked: KWK	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:



INPUT DATA

λ	50	°
α	32	°
A	1.2	m
B	2.5	m

CALCULATION

$\theta = \lambda - 20$ = 30.00

$D = B / \tan \alpha$ = 4.00

$C = B / \tan \lambda$ = 2.10

Volume of Basal Trapezoid

$Area_T = (2A + D + C) \times B / 2$

= 10.6232 m^3

$H = A + C + D$ = 7.30

$\phi = 180 - \lambda$ = 130.00

$E = H \sin 20 / \sin \theta$ = 4.99

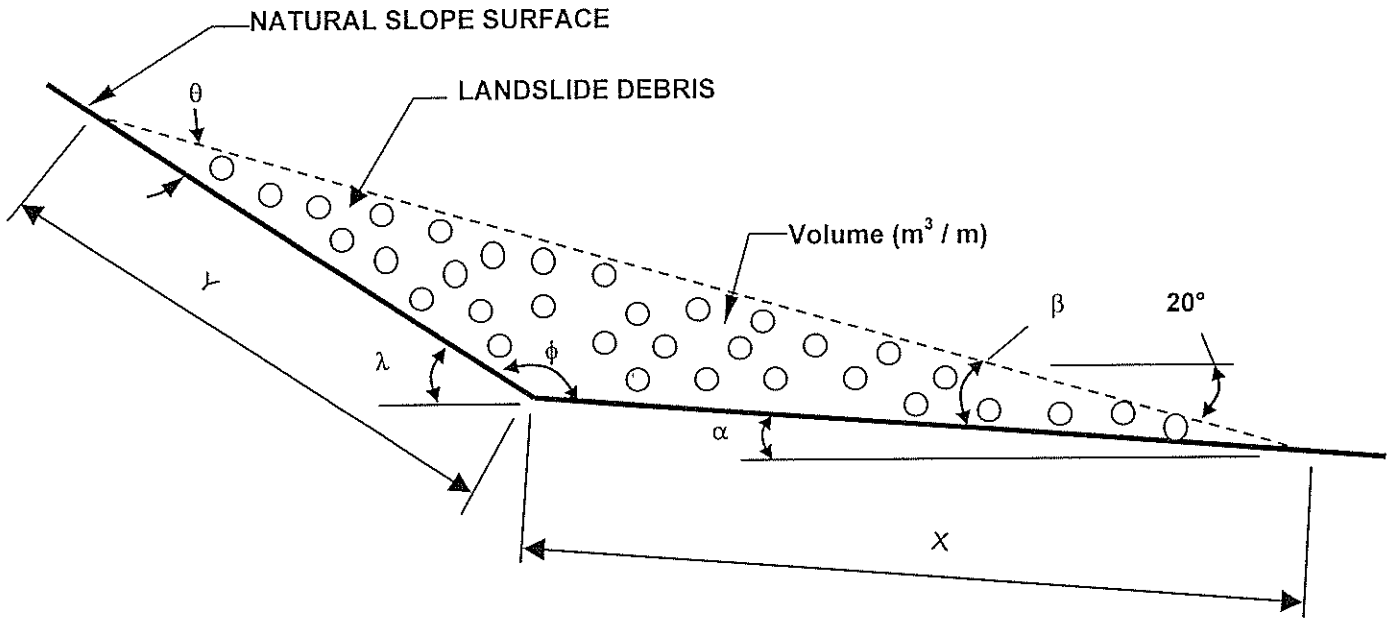
Volume of Upper Triangle

$Area_\Delta = E H \sin \phi / 2$

= 13.96 m^3

Total Volume = $Area_T$ + $Area_\Delta$ = **24.58** m^3 / m (Therefore, a barrier of a minimum distance of 1.2m from slope toe will contain 24m^3 / m)

Subject: CAPACITY AGAINST OPEN HILLSLOPE LANDSLIDE (Catchment 7)	Prepared: Smo	Checked: JH	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:



INPUT DATA

Volume [(1)]	=	**24** m^3 / m
α	=	**10** °
λ	=	**55** °

CALCULATION

$\phi = 180 - 55 + 10 = \mathbf{135}$

$\beta = 20 - \alpha = \mathbf{10}$

$\theta = \lambda - 20 = \mathbf{35}$

Volume = ½ X Y sin ϕ *(1)*

$$\frac{\sin\beta}{Y} = \frac{\sin\theta}{X} \Rightarrow Y = \frac{X \sin\beta}{\sin\theta} \quad (2)$$

sub (2) into (1)

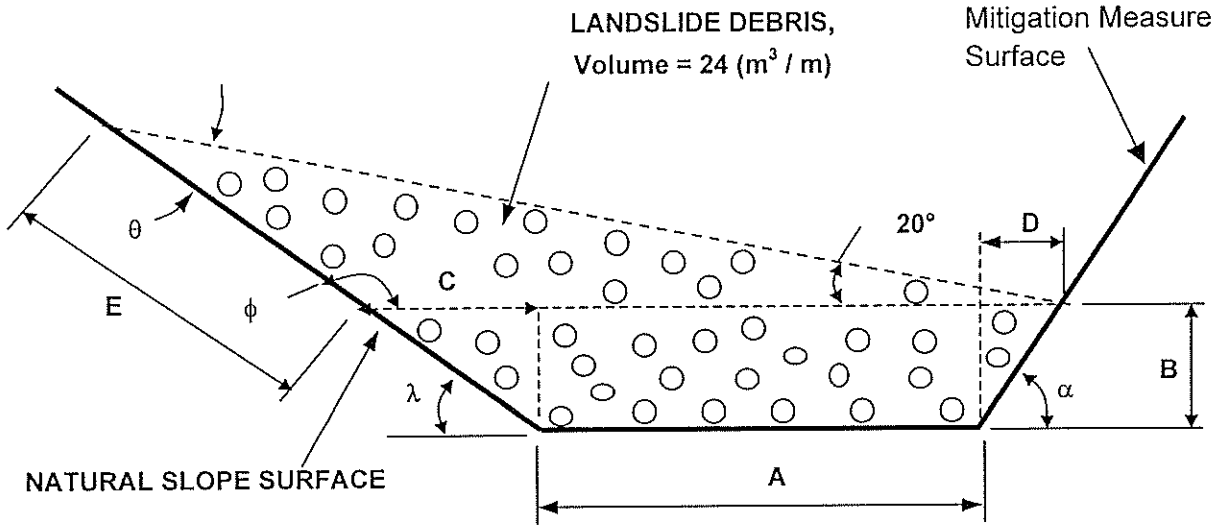
$$\text{Volume} = \frac{1}{2} \times \frac{X \sin\beta}{\sin\theta} \times \sin\phi$$

$$X^2 = \frac{2 \times 24 \times \sin 35}{\sin 10 \times \sin 135}$$

X = 14.97 m

Notes: (1) Volume = Source Volume/10 m (Average figure taken from Mid-Level Studies)

Subject: OPEN HILLSLOPE LANDSLIDE RUN-OUT CALCULATION (Catchment 8)	Prepared: Smo	Checked: JH	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:



INPUT DATA

λ	55	°
α	32	°
A	1.6	m
B	2.5	m

CALCULATION

$\theta = \lambda - 20$ = 35.00

$D = B / \tan\alpha$ = 4.00

$C = B / \tan\lambda$ = 1.75

Volume of Basal Trapezoid

$Area_T = (2A + D + C) \times B / 2$

= 11.1892 m^3

$H = A + C + D$ = 7.35

$\phi = 180 - \lambda$ = 125.00

$E = H \sin 20 / \sin\theta$ = 4.38

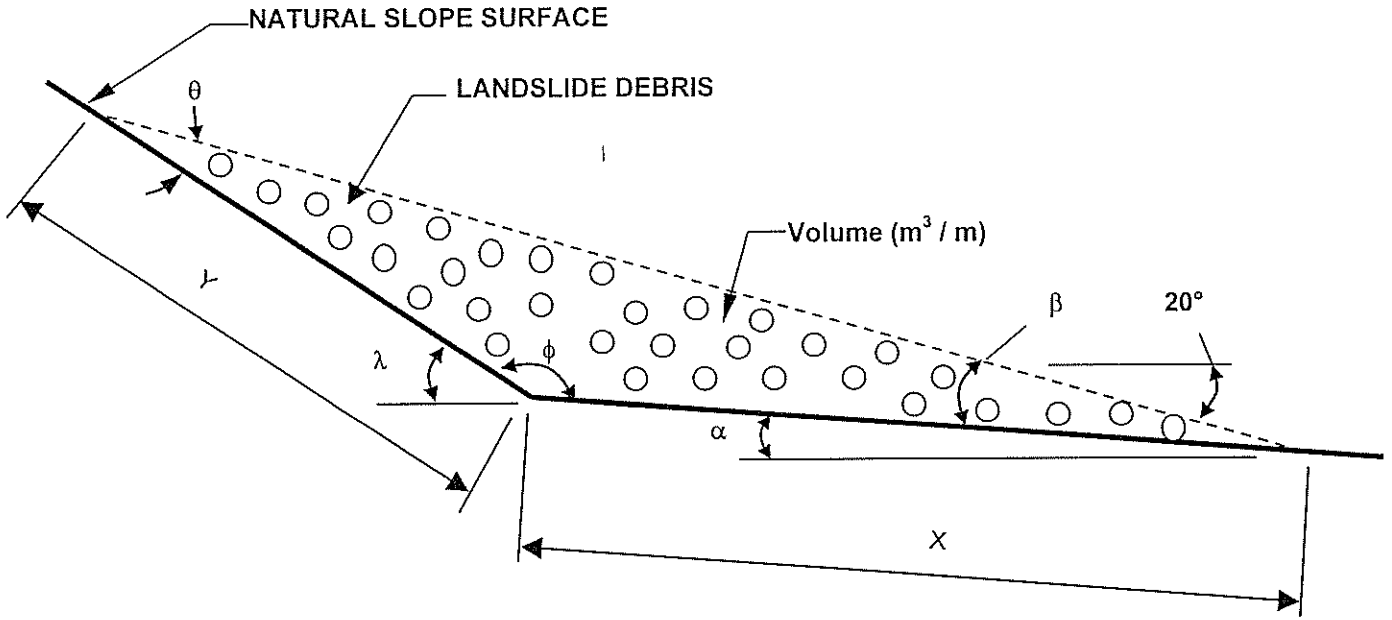
Volume of Upper Triangle

$Area_\Delta = E\ H \sin\phi / 2$

= 13.20 m^3

Total Volume = $Area_T + Area_\Delta$ = **24.39** m^3 / m (Therefore, a 2.5m barrier with a minimum distance of 1.6m from slope toe will contain 24m^3 / m)

Subject: CAPACITY AGAINST OPEN HILLSLOPE LANDSLIDE (Catchment 8)	Prepared: Smo	Checked: KWK	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:



INPUT DATA

Volume [1]	=	24 m^3 / m
α	=	15 °
λ	=	60 °

CALCULATION

$\phi = 180 - 60 + 15 = 135$

$\beta = 20 - \alpha = 5$

$\theta = \lambda - 20 = 40$

Volume = ½ X Y sin ϕ *(1)*

$$\frac{\sin\beta}{Y} = \frac{\sin\theta}{X} \Rightarrow Y = \frac{X \sin\beta}{\sin\theta} \quad (2)$$

sub (2) into (1)

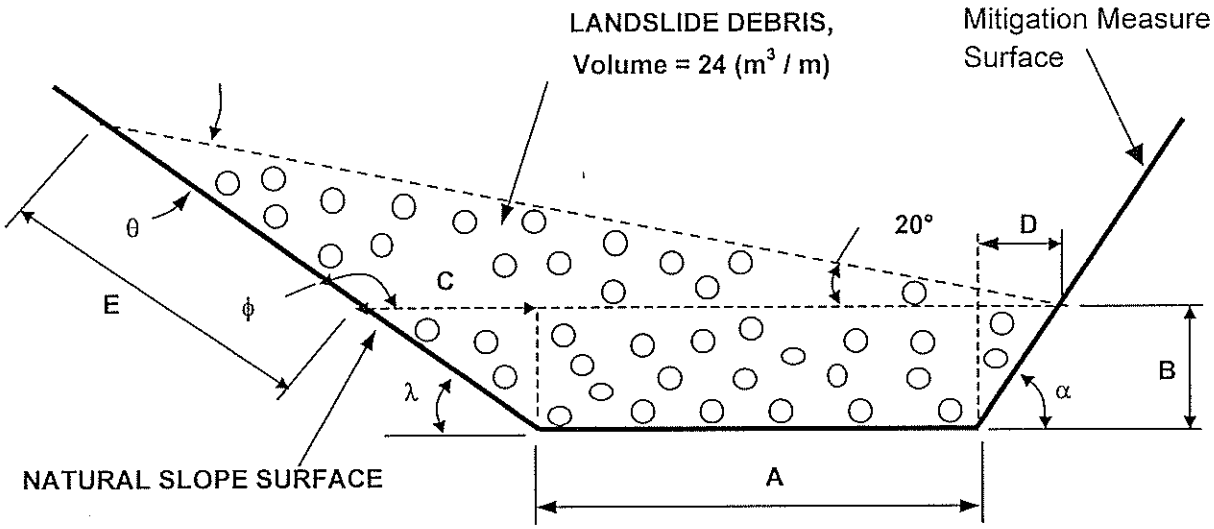
$$\text{Volume} = \frac{1}{2} \times \frac{X \sin\beta}{\sin\theta} \times \sin\phi$$

$$X^2 = \frac{2 \times 24 \times \sin 40}{\sin 5 \times \sin 135}$$

X = 22.38 m

Notes: (1) Volume = Source Volume/10 m (Average figure taken from Mid-Level Studies)

Subject: OPEN HILLSLOPE LANDSLIDE RUN-OUT CALCULATION (Catchment 9)	Prepared: Smo	Checked: JH	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:



INPUT DATA

λ	60	°
α	32	°
A	2	m
B	2.5	m

CALCULATION

$\theta = \lambda - 20 = 40.00$

$D = B / \tan\alpha = 4.00$

$C = B / \tan\lambda = 1.44$

$H = A + C + D = 7.44$

$\phi = 180 - \lambda = 120.00$

$E = H \sin 20 / \sin\theta = 3.96$

Volume of Basal Trapezoid

$\text{Area}_T = (2A + D + C) \times B / 2$

$= 11.8053 \ m^3$

Volume of Upper Triangle

$\text{Area}_\Delta = E\ H \sin\phi / 2$

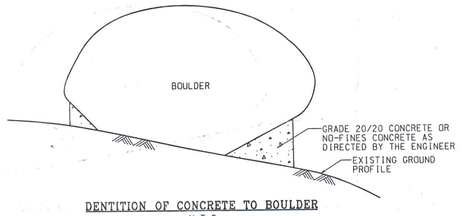
$= 12.77 \ m^3$

Total Volume = $\text{Area}_T + \text{Area}_\Delta$ = 24.57 m^3 / m (Therefore, a 2.5m barrier with a minimum distance of 2.0m from slope toe will contain 24m^3 / m)

Subject: CAPACITY AGAINST OPEN HILLSLOPE LANDSLIDE (Catchment 9)	Prepared: Smo	Checked: KWK	
Project: Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jan-03	Scale:	Figure No.:

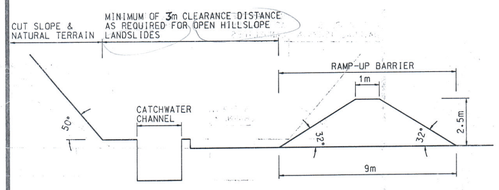
APPENDIX H

Mitigation Strategy Map

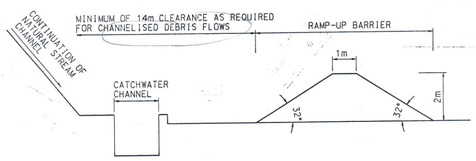


DENTITION OF CONCRETE TO BOULDER
N.T.S.

NOTE :
THE DETAILS SHOWN ON THIS DRAWING ARE FOR INFORMATION ONLY, AND ARE RELATED TO THE TYPICAL SECTION AS SHOWN. THE ACTUAL EXTENT OF WORK SHALL BE DETERMINED ON SITE BY THE ENGINEER.



SCHEMATIC SECTION Y - Y
N.T.S.



SCHEMATIC SECTION Z - Z
N.T.S.

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.
2. ALL LEVELS ARE IN METRES ABOVE PRINCIPAL DATUM.
3. ALL DIMENSIONS ARE TYPICAL AND TO BE CONFIRMED AT DETAILED DESIGN.

LEGENDS:

- NATURAL TERRAIN STUDY BOUNDARY
- RAMP UP BARRIER, 2.5m HIGH BASAL WIDTH OF 9.0m
- PROPOSED STERILE ZONE
- LOCATIONS OF BOULDERS REQUIRING REMOVAL/ DENTITION (D1)

Approved

CAD ref. MAIN : APPENDIX-H.DGN
XREF : B12SW06B,D, B12SW01B,D, B12SW02A,B,C,D & B12SW07A,B,C,D.DGN

Contract no. FD01-052

Contract
GEOTECHNICAL REVIEW AND SITE INVESTIGATION WORKS FOR TSEUNG KWAN O STAGE II/III AFTERUSE DEVELOPMENT

Figure Title
MITIGATION STRATEGY MAP

Figure no. APPENDIX H

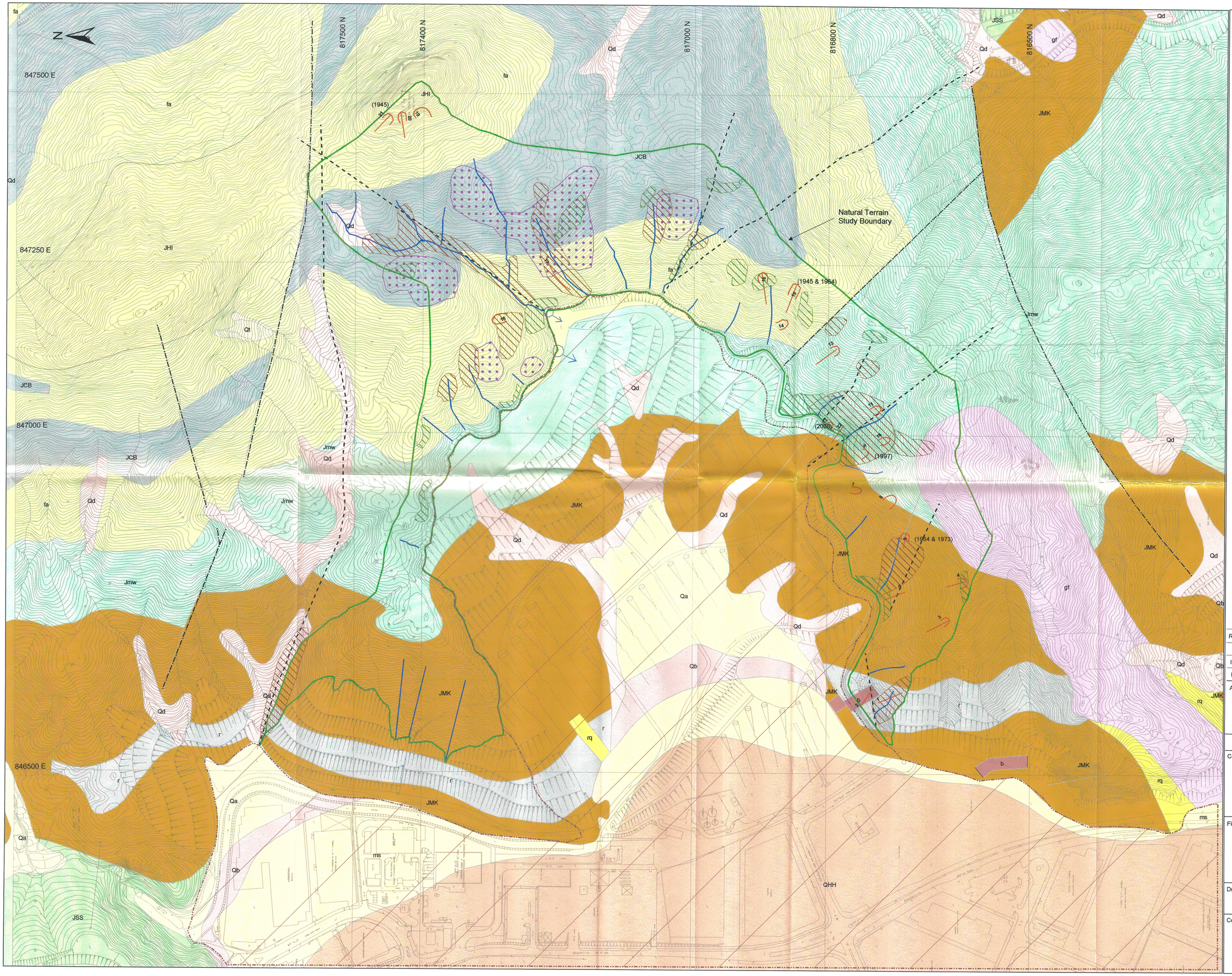
Scale 1:2500

BLACK & VEATCH HONG KONG LIMITED
博威工程顧問有限公司

...\cd\3823110201\appendix-h.dgn Feb. 17, 2003 11:18:26

APPENDIX I

Engineering Geology Map



Legend

- Landslide scar from API (year of landslide event(s))
- Landslide from NTLI
- colluvium
- Rock at or near surface
- fault
- Photogeological lineament
- drainage line
- seepage
- boulder fields
- Existing Fill

Superficial Geology

- Qa - Allumium
- Qb - Beach deposits
- Qd-Debris flow deposits
- Qt - Talus deposits
- QHH - Undivided, mainly dark grey marine mud

Solid Geology

- JHI - Fine ash tuff (High Island Formation)
- JMK-Tuffaceous mudstone, siltstone and breccia
- Jmw - Trachydacity lava
- JCB - Trachydacite and Rhyolite lava
- b - Basalt
- fa - Fine ash tuff Clear Water Bay Formation
- gf - Fine-grained granite
- r - Rhyolite Lava
- rq-Quartzphyric rhyolite

Notes: Map shows the geology of the site during pre-operation stage

Revision	Description			Initial
	Design	Check	Drawn	Check
Initial	SMo	JH	VN	JH
Date	08/2002	08/2002	08/2002	08/2002

Approved

AGREEMENT NO. FD01-052

Contract Title

TSEUNG KWAN O STAGE II/III AFTERUSE DEVELOPMENT

Figure Title

ENGINEERING GEOLOGY MAP

Drawing No.	Scale
APPENDIX I	1:2500

Consultant

Binnie Black & Veatch Hong Kong Limited

Appendix B

Previous GAR 2004

Agreement No. FD 01-052
Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development

Final Geotechnical Assessment Report

[Report No. 382311/FGAP/Issue 1]

Report Authorized For Issue By:	
Raymond P.C. Chan	For and on Behalf of Binnie Black & Veatch Hong Kong Limited

Black & Veatch Hong Kong Limited
11/F, New Town Tower
Pak Hok Ting Street
Shatin, New Territories
Hong Kong

January 04

DOCUMENT CONTROL	**Agreement No. FD 01-052 Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development**	Job No: 382311/0201
AMENDMENT RECORD		Prepared By: BV
Final Geotechnical Assessment Report	Client: Environmental Protection Department	Initial: TC
		Date: February 2003

Pages	Date	Issue No	Description	Initials
All	17 February 2003	A	Draft A submitted to EPD for comment	TC
All	6 May 2003	B	EPD comments incorporated. Submitted to GEO.	TC
All	2 January 2004	1	GEO comments incorporated. Submitted to EPD	TC

SUMMARY

The Hong Kong Environmental Protection Department (EPD) launched in 1996 a Landfill Restoration Programme (LRP) for 13 closed landfills. Tseung Kwan O Landfill II/III is one of the 13 closed landfills.

Tseung Kwan O Landfill Stage II/III (TKO II/III) is located near Tseung Kwan O Bay and was formed by infilling of the Tai Chik Sha Valley. The landfill profile now dips at a gradient of approximately 1 in 3 to the west from the top platform of about 140mPD to 5mPD at the toe, over a horizontal distance of about 750m. The site comprises several waste slopes and is bound by a series of cut slopes, and beyond these cuttings, natural terrain.The restoration works for TKO II/III were completed in 1999 and the landfill is considered safe and environmentally acceptable for afteruse. At present, there are several afteruse proposals for the landfill being explored, including an option to develop the landfill into a recreational facility with material recycling facility for educational purposes (the Park).

In October 2001, the Environmental Protection Department appointed Black & Veatch Hong Kong Ltd. (formerly Binnie Black & Veatch Hong Kong Ltd.) to study the geotechnical feasibility of the Park.

This report summarises the findings of this Assignment and covers the geotechnical design including upgrading/preventive works and cost estimate for the works. The major conclusions and recommendations of this study are summarised below:

Waste slopes

The proposed facilities associated with the Park (with a structural load of not greater than 50 kPa) will not compromise the stability of the waste slopes. Therefore, no upgrading works are required for the waste slopes. It is recommended that good maintenance continue for the waste slopes so that they will meet the required minimum factor of safety within the context of the Park.

Cut slopes

Several soil cut slopes possess minimum calculated factors of safety less than the required value and therefore require upgrading works. These substandard soil slopes can be upgraded by prescriptive measures using soil nails and raking drains, as shown in Table 4.3 and Drawing No. BV/TKO/382311/001.

Several rock cut slopes have loose blocks and open joints on the slope surface. These substandard rock slopes can be upgraded by removal of loose blocks and concrete infilling of open joints, as shown in Table 4.4.

However, these upgrading works would be superseded where adjacent preventive measures against natural terrain hazards will also accommodate the debris expected from cut slope failure.

Natural slopes

Based on the natural terrain hazard assessment results, it is considered that channelised debris flows, open hillslope landslides and boulder falls all form potential harzards to the proposed development.

Site inspection revealed that two potentially high-risk boulders (i.e. Boulders D1 and D2 as shown in Dwawing No. BBV/TKO/382311/002) in Catchment Nos. 2 and 4 require stabilising/preventive measures. It is recommended that Boulder D1 be removed and dentition be carried out on Boulder D2. Removal and breaking up of boulder D1 should be by splitting using pneumatic percussive drilling using either dynamic or chemical means. Care should be taken to avoid dislodging the boulder during splitting. The removal of Boulder D2 would affect the stability of the surrounding boulders and thus dentition has been considered the best stabilising measure.

Two preventive options against open hillslope landslides and channelized debris flows have been proposed. Option 1 is to construct an earth bund as shown in Dwg No. BV/TKO/382311/002, and option 2 is to define a no-build-zone to allow for safe development outside of this zone, as shown in Drawing No. BV/TKO/382311/003.

Conceptual foundation design

The existence of the capping system precludes the use of deep foundations and calls for the use of shallow foundations to support the buildings. It is recommended that each building be supported on a single raft foundation founded on the CDV cover layer.

Calculation results have shown that allowable settlement, rather than bearing capacity, is likely to control the size of a raft foundation. It is recommended that the allowable settlement be determined in the detailed design of the buildings, with due consideration of associated piping and cabling systems.

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1.3	Site geology	2
1.4	Site hydrogeology	2
1.5	Conceptual design of the Park	2
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Table 2.1 Summary of soil strength parameters derived from triaxial tests

Table 2.2 Summary of point load test results for rocks

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Table 4.2 Adopted soil strength parameters for stability analyses

Table 4.3 Calculated minimum factors of safety and recommended upgrading works for soil slopes

Table 4.4 Recommended upgrading works for rock cut slopes

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Figure 1.1 Site Location

Figure 1.2 Study slopes

Figure 6.1 Summary of calculated ultimate bearing capacities

Figure 6.2 Summary of calculated settlements

DRAWINGS

Drawing No. BV/TKO/382311/001 Layout of soil nails and raking drains

Drawing No. BV/TKO/382311/002 Layout of earth bund

Drawing No. BV/TKO/382311/003 Layout of no-build-zone

APPENDICES

Appendix A Conceptual Design of the Park

Appendix B Ground Investigation Results

Appendix C Stability Analyses of Soil Slopes

Appendix D Prescriptive Measures Application Record Sheets

Appendix E Rock Mapping Results

Appendix F Bearing Capacity and Settlement Calculations

Appendix G Summary of Cost Estimate

	Name	Signature	Date
Prepared by	Law Wing Yan / Sui Fong Mo/ Tony Chen		Dec. 2004
Checked by	Tony Chen		Dec. 2004
Reviewed by	Raymond Chan		Dec 2004

1 INTRODUCTION

1.1 Background

The Hong Kong Environmental Protection Department (EPD) launched in 1996 a Landfill Restoration Programme (LRP) for 13 closed landfills. Tseung Kwan O Landfill II/III is one of the 13 closed landfills.

The restoration works for TKO II/III were completed in 1999 and the landfill is considered safe and environmentally acceptable for afteruse. At present, there are several afteruse proposals for the landfill being explored, including an option to develop the landfill into a recreational facility with material recycling facility for educational purposes (the Park).

In October 2001, the Environmental Protection Department appointed Black & Veatch Hong Kong Ltd. (formerly Binnie Black & Veatch Hong Kong Ltd.) to study the geotechnical feasibility of the Park..

1.2 Site description

Tseung Kwan O Landfill Stage II/III (TKO II/III) is located near Tseung Kwan O Bay, as shown in Figure 1, and was formed by infilling of the Tai Chik Sha Valley. The area was formerly a west facing, bowl shaped valley overlooking Tai Chik Sha Wan and a small embayment to Tseung Kwan O Bay. Only a small part of the landfill extends over the original seabed.

The landfill operations filled the northern side of the valley, to the top platform level of 140mPD. The landfill profile now dips at a gradient of approximately 1 in 3 to the west from the top platform at the valley head to 5mPD at the toe, over a horizontal distance of about 750m. The site comprises several waste slopes and is bound by a series of cut slopes, and beyond these cuttings, natural terrain as shown in Figure 2. Table 1.1 lists the waste slopes and cut slopes within the site.

Table 1.1 List of study slopes

Slope GEO Ref. No.	Maintenance Responsibility	Slope GEO Ref. No.	Maintenance Responsibility	Slope GEO Ref. No.	Maintenance Responsibility
Waste Slopes		**Cut Slopes**			
12SW-A/F67	EPD	12SW-A/C76	DSD	12SW-A/C182	EPD
12SW-A/F68	EPD	12SW-A/C173	EPD	12SW-A/C183	EPD
12SW-A/F69	EPD	12SW-A/C174	EPD	12SW-A/C184	EPD
12SW-A/F70	EPD	12SW-A/C175	EPD	12SW-A/C185	EPD
12SW-A/F72	EPD	12SW-A/C176	EPD	12SW-A/C186	EPD
12SW-A/F73	EPD	12SW-A/C177	EPD	12SW-A/C187	EPD
12SW-A/F74	EPD	12SW-A/C178	EPD	12SW-A/C188	EPD
		12SW-A/C180	EPD	12SW-A/C203	DSD
		12SW-A/C181	EPD	12SW-A/C165	Lands D

1.3 Site geology

The geology of the site comprises tuffs, ash and lavas of Upper Jurassic age (Figure 3). The original landform, prior to the construction and operation of the landfill, was a basin enclosed by hills on three sides with a bay on the shore to the west of the site boundary. To the sides of the valley are volcanic rocks of the Repulse Bay Formation, weathered in places to form decomposed volcanic material and covered in part by superficial deposits. The valley floor consists of alluvium, comprising clays, silts and sands. Existing boreholes located around the site show that the volcanic tuff is fractured and jointed.

1.4 Site hydrogeology

The steep hillsides and relatively high permeability of the superficial deposits indicates that the groundwater regime must be highly transient, responding not only to seasonal variation in infiltration but also to rainfall events. Limited groundwater monitoring data indicates that, prior to the restoration of the landfill, the ground water level was below 122mPD.

The basal leachate collection systems on the back face of the formation slopes are on natural ground. Hence the exterior sub-surface water regime is intimately connected with that of the leachate regime.

A sub-soil water abstraction system has been installed as part of the restoration works. This system is designed to limit the amount of groundwater infiltration from the surrounding hillsides into the waste mass, to control leachate generation.

1.5 Conceptual design of the Park

The conceptual design of the Park is shown in Appendix A. The design includes the provision of two buildings and several seating areas at the north-west edge of the landfill on the 140mPD platform, and a steel structure as a recycling facility at the south-east part of the landfill on the 40mPD platform.

1.6 Objective

This draft final report summarises the findings of this Assignment and covers the geotechnical design including upgrading/preventive works and cost estimate for the works. In addition, an alternative 'no-build zone' option is also proposed. The objective is to seek GEO's in-principal approval of the proposed Afteruse so that future development with loadings within the surcharge loads specified in this report would not require re-submission to GEO for comment.

2 SITE INVESTIGATION

A ground investigation programme was carried out by the GEO's Term Contractor in June to July 2002, supervised full time by BV. The investigation comprised 7 drillholes with installations of standpipe/piezometers, 14 trial pits on the natural slopes, and 35 chunam strips on the cut slopes. The locations of the current investigation stations, together with those from the previous investigations, are shown in Appendix B.

Samples of soil and rock were taken for laboratory tests to derive engineering properties. The laboratory test programme included single and multiple stage consolidated undrained triaxial tests with pore water pressure measurement, Atterberg Limits, particle size distribution, moisture content and density tests.

The key results of the ground investigation works and laboratory tests are briefly described below and more details can be referred to Geotechnical Investigation and Laboratory Testing Report (Report No. 382311/GILTR).

2.1 Soil strata and groundwater levels

The deposits forming the slopes can be classified into seven strata types, namely colluvium, completely decomposed rhyolite lava, completely to highly decomposed rhyolite lava, completely decomposed trachdacite lava, completely to highly decomposed trachydacite lava, completely decomposed tuff and completely to highly decomposed tuff.

The derived geological sections and measured groundwater levels are shown in Appendix B.

2.2 Soil and rock strength parameters

The soil shear strength parameters derived from the triaxial tests are summaried in Table 2.1 whilst rock strength parameters derived from point load tests are summarized in Table 2.2.

Table 2.1 Summary of soil strength parameters

Type of material	Calculated Parameters		Recommended Parameters	
	Friction angle ϕ'	Cohesion c' kPa	Friction angle ϕ'	Cohesion c' kPa
Colluvium	39	3	39	3
CD volcanics	39	7	38	7
C/HD volcanics	43	7	38	7

Note: volcanics include tuff, trachydacite lava and rhyolite lava.

2.2 Summary of uniaxial compressive strength for rocks

Rock Type	Max. σ_c (MPa)	Min. σ_c (MPa)
Trachydacite Lava	139.2	34.08
Tuff	179.04	19.2

3 WASTE SLOPES

As documented in Preliminary Geotechnical Assessment Report (Report No. 382311/PGAP), the proposed facilities associated with the Park (with a structural load of not greater than 50kPa) would not compromise the stability of the waste slopes. Furthermore, no signs of slope failure have been observed from visual inspections. It can therefore be concluded that, provided good maintenance continues, the waste slopes will meet the required minimum factor of safety within the context of the Park.

Therefore, no upgrading works are required for the waste slopes.

The relevant stability assessment results presented in Preliminary Geotechnical Assessment Report are summarized in Sections 3.1 to 3.4 for easy reference.

3.1 Summary of Slope Information

The relevant information given by SIRST reports and the designed factors of safety are summarized in Table 3.1.

Table 3.1 Summary of Waste Slope Information

Slope GEO Ref. No.	Year of Construction	Maintenance Responsibility	Total Length (m)	Max. Height (m)	Max. Angle (degree)	Nature of slope	Designed FoS
12SW-A/F67	1984-1995	EPD	440	32	20	fill	1.425
12SW-A/F68	1992-1995	EPD	396	28	25	fill	1.665
12SW-A/F69	1992-1995	EPD	170	80	25	fill	not available
12SW-A/F70	1992-1995	EPD	210	20	20	fill	1.665
12SW-A/F72	1992-1995	EPD	470	28	25	fill	1.665
12SW-A/F73	1992-1995	EPD	145	30	25	fill	1.665
12SW-A/F74	1993-1995	EPD	140	15	20	fill	not available

3.2 Stability Criteria

As the Stage II/III landfill overlooks the new reclamation and industrial area of Area 86 immediately to the west of the western boundary, the potential risk associated with a mass failure of the landfill waste slopes should be classified as high. In accordance with Geotechnical Manual for Slopes (GEO, 1994 and GEO Circular No. 5/97, Geotechnical Manual for Slopes – Guidance on Interpretation, the minimum factor of safety for high risk category is 1.4.

For the Registered Design, all the waste slopes were designed to achieve a minimum factor of safety of 1.4 for a designed surcharge load of 5kPa. For the development of the Park, it is considered that the waste slopes should continue to possess a minimum factor of safety of 1.4.

3.3 Registered Design

Stage II/III landfill is characterized by several waste slopes facing south-west towards the toe of the landfill, and a platform at 40mPD located on the south western corner of the landfill. In the Registered Design, the stability of the landfill was assessed using two cross-sections of the site, i.e. Sections 1-1 and 2-2, as indicated in Figure 2. The waste slopes were designed to achieve a minimum factor of safety of 1.4 for a designed surcharge of 5kPa.

The results of aerial photograph interpretation (API) indicate that no failures have occurred within the landfill site after restoration.

3.4 Impact of the Park

The conceptual design of the Park (Appendix A) illustrates several structures located around the Park. To assess the potential impact of structural loads on the stability of the waste slopes, the stability analyses undertaken for the Registered Design have been re-visited in the current study. A surcharge load of up to 50kPa was applied to Sections 1-1 and 2-2 to simulate each proposed structure. The surcharge load was placed approximately at the location corresponding to the proposed structure. The stability analyses were carried out using SLOPE/W Version 4.0 (BD Ref. No. G0051), adopting the Morgenstern and Price rigorous method to compute the factor of safety.

The calculated minimum factors of safety for different surcharge loads are presented in Table 3.2. It can be seen that all the calculated minimum factors of safety are greater than 1.4 and that the surcharge load of up to 50kPa has insignificant effect on the calculated minimum factors of safety. These stability analyses will need to be reviewed if the structures are to be located at different locations and/or if each structural load is greater than 50kPa.

Table 3.2 Calculated Minimum Factors of Safety for Waste Slopes

Section	Minimum Factor of Safety		
	Designed surcharge	Additional structural surcharge	
	5kPa	10kPa	50kPa
1-1	1.665	1.664	1.660
2-2	1.425	1.425	1.425

4 CUT SLOPES

4.1 General information

The general information about the cut slopes is summarized in Table 4.1

Table 4.1 Summary of general information about cut slopes

Slope GEO Ref. No.	Slope Stripping Log	Maximum Depth of Stripping (m)	Maximum Slope Angle from Stripping Data (degrees)	Nature of Slope	Surface Cover	Special Comments on Strippings	Consequence-to-life category (w.r.t the park)	Required FoS
12SW-A/C76	SS1, SS2, SS3	6.1	78	cut	Vegetation		3	1.1
12SW-A/C173	SS4, SS5, SS6	10.5	58	cut	Vegetation	1) Very closely to closely spaced rock joint	3	1.1
12SW-A/C174	SS7, SS8	37	Varies	cut	50% Bare rock, 50% Vegetation		3	1.1
12SW-A/C175				cut	70% Bare rock, 30% Vegetation		3	1.1
12SW-A/C176	SS9	8.2	65	cut	50%Chunam, 50%Vegetation		3	1.1
12SW-A/C177	SS10, SS11, SS12	9.0	67	cut	Chunam	1) Very closely to closely spaced rock joint	3	1.1
12SW-A/C178	SS14, SS15	3.0	64	cut	Chunam		3	1.1
12SW-A/C180	SS13	8.4	64	cut	Chunam	1) From 3.7 to 4.0m quartzphyric rhyolite dyke	3	1.1
12SW-A/C181	not studied because stability not affect the Park							
12SW-A/C182	SS16, SS17	6.3 to 7.2	50 to 71	cut	Chunam		1	1.2
12SW-A/C183	SS18, SS19, SS20	5.1 to 6.9	50 to 68	cut	Chunam	1) Seepage at 4.1m (SS18) 2) Rock joints, closely to medium spaced	1	1.2
12SW-A/C184	SS21, SS22, SS23	5.3 to 6.8	48 to 52	cut	Chunam	1) Rock joints are closely to medium spaced	1	1.2
12SW-A/C185	SS24	11.7	46	cut	Chunam	1) Medimum spaced rock joints	1	1.2
12SW-A/C186	SS25, SS26	9.4	55	cut	Chunam		1	1.2
12SW-A/C187	SS27	7.0	40	cut	Chunam		3	1.1
12SW-A/C188	SS28, SS29, SS30	7.8	52	cut	Chunam		3	1.1
12SW-A/C203	not studied, newly constructed slope with adequate design FoS							
12SW-A/C165	not studied, newly constructed slope with adequate design FoS							

4.2 Stability criteria

The minimum factor of safety required for each cut slope is determined based on consequence to life associated with the conceptual design of the Park (Appendix B), and in accordance with both Geotechnical Manual for Slopes (GEO, 1994, Ref. 10) and WBTC No. 13/99, Geotechnical Manual for Slopes – Guidance on Interpretation (Ref. 9). We have taken the view that the cut slopes located adjacent to the buildings and seating areas should have a consequence-to-life category of 1 for which the minimum factor of safety is 1.2, and that the other cut slopes should have a consequence-to-life category of 3 for which the minimum factor of safety is >1.0. Nevertheless, we have

adopted 1.1 as the minimum factor of safety for the cut slopes having a consequence-to-life category of 3.

4.3 Soil Slopes

Most of the cut slopes are in soil and their stability analyses and proposed upgrading works are described in Sections 4.3.1 to 4.3.3.

4.3.1 Adopted soil strength parameters

Table 4.2 shows the soil strength parameters used for stability analyses of the cut slopes, adopted based on the triaxial testing results presented in Table 2.1.

Table 4.2 Adopted soil strength parameters

Type of soil	Friction angle ϕ'	Cohesion c' kPa
Colluvium	39	3
C/HD volcanics	38	7
C/HD Tuffaceous breccia/siltstone*	35	5

* Tuffaceous breccia/siltstone was only observed at Slope No. 12SW-A/C173. The stability analysis results (see Appendix C) indicate that the adopted ϕ'=35° and c'=5 kPa are reasonable.

4.3.2 Stability analyses

For the purpose of stability analyses, a series of cross-sections are cut at the critical locations of the cut slopes, as shown in Appendix C. The cross-sections are drawn based on the ground investigation results.

Where a perched water table is considered possible, a 2 m perched water table is assumed above the rock head or the CDV layer.

Stability analyses are carried out on the critical cross-sections using SLOPE/W Version 4.0 (BD Ref. No. G0051), adopting the Morgenstern and Price rigorous method to compute the factor of safety. The computed minimum factors of safety are shown in Appendix C and are summarised in Table 4.3.

The calculation results indicate that Slope Nos. 12SW-A/C76, 12SW-A/C173, 12SW-A/C176, 12SW-A/C177, 12SW-A/C182, 12SW-A/C183 and 12SW-A/C188 all have a calculated minimum safety factor less than the required value and hence require upgrading works.

The other slopes all have a calculated minimum safety factor greater than the required value and therefore do not need to be upgraded.

Table 4.3 Calculated factor of safety and recommended remedial measure for soil slopes

Slope No.	Required FoS	Section	Calculated FoS	Does the slope meet required FoS?	Are prescriptive measures applicable?	Recommended prescriptive measure
12SW-A/C76	1.1	SS2	1.024	No	Yes (Height of slope < 18m)	soil nails
		SS1	1.644	Yes	-	-
		SS3	1.321	Yes	-	-
12SW-A/C173	1.1	SS4	0.890	No	Yes (Height of slope < 18m)	soil nails
		SS5	1.298	Yes	-	-
		SS6	1.026	No	Yes (Height of slope < 18m)	soil nails
12SW-A/C174	1.1	SS7	1.613	Yes	-	-
12SW-A/C175	1.1			-	-	-
12SW-A/C176	1.1	SS9	0.977	No	Yes (Height of slope < 18m)	soil nails
12SW-A/C177	1.1	SS12	1.032	No	Yes (Height of slope < 18m)	soil nails
		SS10	1.231	Yes	-	-
		SS11	1.180	Yes	-	-
12SW-A/C178	1.1	SS15	1.743	Yes	-	-
12SW-A/C180	1.1	SS13	1.312	Yes	-	-
12SW-A/C182	1.2	SS16	0.863	No and seepage is observed	Yes (Height of slope < 10m)	soil nails and raking drains
		SS17	1.254	Yes	-	-
12SW-A/C183	1.2	SS19	1.765	Yes but seepage is observed	Yes (Height of slope < 10m)	raking drains
12SW-A/C184	1.2	SS22	1.451	Yes	-	-
12SW-A/C185	1.2	SS24	1.335	Yes	-	-
12SW-A/C186	1.2	SS25	1.230	Yes	-	-
12SW-A/C187	1.1	SS27	1.456	Yes	-	-
12SW-A/C188	1.1	SS30	1.643	Yes but seepage is observed	Yes (Height of slope < 18m)	raking drains

4.4 Rock slopes

Some portions of Slope Nos. 12SW-A/C76, 12SW-A/C174, 12SW-A/C180 and 12SW-A/C177 are in rock and their stability analyses and proposed upgrading works are described in Sections 4.4.1 to 4.4.2.

4.4.1 Stability analyses

Joint data from rock mapping and chunam stripping from the cut slopes at the base of the natural terrain are analyzed using stereographic hemispherical projection methods, and the results are presented in the form of pole, contour and major planes plots for each

of the slope orientations, included in Appendix E.

A kinematic check is carried out to examine whether the major joint sets and individual joints identified will adversely affect the stability of the slope. The rock joints are generally surface stained and therefore a friction angle of 30° for volcanics has been assumed in all the analyses.

The stereographic projections and kinematic stability checks are carried out using the computer software DIPS 4.0 (Diedrichs & Hoek). The stereoplots show potential unstable zones as:

W - potential wedge failure

P - potential planar failure

T – potential toppling failure

4.4.1.1 Feature No. 12SW-A/C76

Rock mapping and along Strip S33

Summary of Kinematic Analyses

	Kinematically Feasible Failure Mechanism		
Slope Face Dip/Dip Direction	Planar	Wedge	Toppling
70/305	Individual Joint	-	-

1. A total of 7 joints were taken from rock mapping and stripping S33 of predominantly moderately decomposed rock.

2. Individual joint #1 (50/330) falls within the daylight envelope for planar failure. However, the overlying block indicates movement and remedial measures are required.

3. It is therefore recommended that loose blocks be removed or remedial measures such as concrete infilling be carried out.

Along Strips S1, S3 and S32

Orientation of Major Joint Sets and Intersections

Mean of major Joint Sets and Joint Intersections	Mean Dip/Dip Direction
1	74/293
2	39/340
3	80/081
4	65/218
12	35/011
13	50/003
14	63/237
23	37/358
24	29/293
34	49/160

Summary of Kinematic Analyses

	Kinematically Feasible Failure Mechanism		
Slope Face Dip/Dip Direction	Planar	Wedge	Toppling
63/005	#2, 12, 13, 23	Individual joints	Individual joints

1. A total of 24 joints have been taken from rocks ranging from highly to moderately decomposed.
2. Major joint set #2 and the intersection of joint sets 12, 13 and 23 fall within the daylight envelope for planar and wedge failure mechanism.
3. Individual joints (78/165 & 79/200) lie within the daylight envelope for toppling failure.
4. Therefore, planar, wedge and toppling failure mechanisms are kinematically feasible along this slope. However, site inspection did not reveal any obvious potential failures.

4.4.1.2 Feature No. 12SW-A/C174

Rock mapping and along Strip S7

Orientation of Major Joint Sets and Intersections

Mean of major Joint Sets and Joint Intersections	Mean Dip/Dip Direction
1	12/002
2	87/239
3	78/345
4	82/310
12	11/328
13	04/074
14	10/038
23	76/317
24	83/305
34	77/000

Summary of Kinematic Analyses

	Kinematically Feasible Failure Mechanism		
Slope Face Dip/Dip Direction	Planar	Wedge	Toppling
45/270	Individual joint	Individual joint	Individual joints

1. A total of 66 joints were taken from rock mapping and the stripping S7 of predominantly moderately to slightly decomposed rock.

2. Individual joints fall within the daylight envelope for toppling failure indicating that toppling failure mechanism is kinematically feasible.

3. Individual joints (30/323 and 32/300) lie within the daylight envelope for planar and wedge failures respectively. However, potential failures have been removed. The intersection between joints #12 falls within the daylight envelope but within the friction circle.

4. The rock face is generally fractured with loose blocks and open joints. It is therefore highly recommended that the slope be cut back with removal of the loose blocks. Further slope inspection should be carried to ascertain whether stabilisation measures will be required.

Rock mapping and along Strip S8

Orientation of Major Joint Sets and Intersections

Mean of major Joint Sets and Joint Intersections	Mean Dip/Dip Direction
1	85/144
2	85/245
3	14/082
4	56/013
12	82/192
13	13/055
14	46/059
23	04/155
24	47/329
34	13/092

Summary of Kinematic Analyses

	Kinematically Feasible Failure Mechanism		
Slope Face Dip/Dip Direction	Planar	Wedge	Toppling
70/335	-	#4	#1

1. A total of 16 joints were taken from the rock mapping and stripping S8 of highly to moderately decomposed rock.

2. Major joint set #1 (85/144) falls within the daylight envelope for toppling failure indicating that toppling failure mechanisms is kinematically feasible.

3. Major joint set #4 (56/013) falls within the daylight envelope for planar and wedge failure indicating that planar failure mechanism is kinematically feasible.

4. Site inspection did not reveal any obvious toppling, plannar or wedge failures.

5. Open joints and loose blocks were identified on the rock face which will need to be cleared before any remedial measures are carried out.

4.4.1.3 Feature No. 12SW-A/C180

Along Strip S13

Summary of Kinematic Analyses

	Kinematically Feasible Failure Mechanism		
Slope Face Dip/Dip Direction	Planar	Wedge	Toppling
64/320	-	Individual joint	-

1. A total of 4 joints have been taken from moderately decomposed rock.
2. An individual joint (59/290) falls within the daylight envelope for planar and wedge failure indicating that planar failure mechanism is kinematically feasible. However, site inspection did not identify any obvious potential failures.
3. Loose blocks were observed on slope face and these should be removed.

4.4.1.4 Feature No. 12SW-A/C177

Along Strips S11 & S12

Summary of Kinematic Analyses

	Kinematically Feasible Failure Mechanism		
Slope Face Dip/Dip Direction	Planar	Wedge	Toppling
67/320	-	Individual joints	-

With a mean slope face of 67/320:

1. A total of 26 joints have been taken from highly to moderately decomposed rock.
2. Individual joints (60/290 and 52/275) fall within the daylight envelope for planar and wedge failure indicating that planar failure mechanism is kinematically feasible.
3. The intersection of joint set 13 falls within the daylight envelope but within the friction circle.
4. Site inspection did not reveal any obvious potential failures.

4.4.2 Upgrading Works

In accordance with GEO Report No. 56, all the above-mentioned sub-standard soil slopes can be upgraded by prescriptive measures, as shown in Table 4.3. The recommended prescriptive measures are soil nailing for increasing the factor of safety and raking drains for releasing groundwater.

The record sheets for prescriptive measures application are presented in Appendix D,

whilst the layout of the proposed soil nails and raking drains are shown in Drawing No. BV/TKO/382311/001.

The proposed upgrading works for the rock cut slopes are summarized in Table 4.4.

Table 4.4 Recommended upgrading works for rock cut slopes

Feature No.	Results of Stability Analysis and Recommended Works
12SW-A/C174	• Potential toppling and planar failures, fractured slope surface and open joints. • Cutting back of slope and removal of loose blocks. • Further slope inspection should be carried out after removal of loose blocks to ascertain whether stabilization measures will be required.
12SW-A/C76	• Planar, wedge and toppling failure mechanisms kinematically feasible but no potential failures observed during site inspections. • removal of loose blocks and concrete infilling of open joints
12SW-A/C180	• Planar failure mechanisms kinematically feasible, however, no obvious potential failures identified. • Removal of loose blocks.
12SW-A/C177	• planar failure mechanism kinematically feasible, however, site inspections did not reveal any obvious potential failures. • No upgrading works required.

However, these upgrading works would be superseded where adjacent preventive measures against natural terrain hazards will also accommodate the debris expected from cut slope failure. As will be discussed in Section 5, two preventive options against natural terrain hazards are proposed, namely, option 1 to construct an earth bund and option 2 to define a no-build-zone.

With option 1, because the proposed earth bund covers all the cut slopes except Slope No. 12SW-A/C188, upgrading works are only required for Slope No. 12SW-A/C188.

With option 2, because the proposed no-build-zone covers all the cut slopes, no upgrading works are required.

5 NATURAL SLOPES

5.1 General

A detailed natural terrain hazard assessment has been carried out and the findings are summarized in the Natural Terrain Hazard Assessment Report, Report No. 382311/NTHA. The main findings are briefly described below.

5.2 Natural terrain hazard assessment

The API in association with the NTLI Datebase and site walkover confirm that there is evidence of relict and recent landslides within the study area.

Based on the assessment results, it is considered that channelised debris flows, open hillslope landslides and boulder falls all form potential hazards to the proposed development.

5.2.1 Boulder and rock falls

Previous boulder stabilisation works had been carried out. However, site inspection revealed that two potentially high-risk boulders (i.e. Boulders D1 and D2 as shown in Dwawing No. BBV/TKO/382311/002) in Catchment Nos. 2 and 4 require stabilising/preventive measures. It is recommended that Boulder D1 be removed and dentition be carried out on Boulder D2. Removal and breaking up of boulder D1 should be by splitting using pneumatic percussive drilling using either dynamic or chemical means. Care should be taken to avoid dislodging the boulder during splitting. The removal of Boulder D2 would affect the stability of the surrounding boulders and thus dentition has been considered the best stabilising measure.

The only location where rockfalls are considered a possibility is in Catchment 4 where numerous rock outcrops occur within the 80m high natural terrain, which slopes at an angle of between 23° to 32° (predominantly <30°) and are covered by vegetation. Given that the friction angle between boulder and slope surface would have greater than 30° (i.e. slope angle predominantly < friction angle) boulder movement triggered by erosion or thermal effects are unlikely to occur.

The relevant assessment results are reproduced in Tables 5.1 to 5.5 for easy reference.

Table 5.1 Design Requirements Summary Table
(after Natural Terrain Hazard Assessment Report)

Catchment	Facility	Facility Group (1)	Consequence Class (3)	Susceptibility Class (4)	Design Requirements (2)
1	Built-up area	3	II - Moderately close	X	N
2	Formed slope	3	II - Very close	D	N
3	Temporary offices	1	II - Moderately close	C	CE
4	Access Road	3	III - Moderately close	C	CE
5	Access Road	3	III - Moderately close	C	CE
6A	Access Road	3	III - Moderately close	C	CE
6B	Access Road	3	III - Moderately close	C	CE
7	Access Road	3	III - Moderately close	B	CE
8	Access Road	3	III - Moderately close	C	CE
9	Access Road	3	III - Moderately close	B	CE
	Steel Structure	3	III-Far	B	CE

Note: (1) Please refer to Table 1 of GEO SPR 1/2002
(2) Please refer to Table 2 of GEO SPR 1/2002
(3) Please refer to Table 3 of GEO SPR 1/2002
(4) Please refer to Table 4 of GEO SPR 1/2002
X Does not affect landfill platform

Table 5.2 Estimation of Channelised Debris Flow Volume for Each Catchment (after Natural Terrain Hazard Assessment Report)

Catchment No.	Susceptibility Class	Design Landslide Event	Upper Drainage Line Angle (degrees)	Lower Drainage Line Angle (degrees)	Source Volume (m^3)	9% Deposition of Initial Volume from Main Scrap	Length of Drainage Line (m)	Possible Length of Erosion (i.e.Colluvium in Drainage Line & gradient >20°) (m)	Designed Erosion Rate (m^3/m)	Entrainment Volume (m^3)	Run-out Volume (m^3)	Trail Width (m)	Thickness of Deposition (m)	Length of Deposition (streambed gradient <20°) (m)	Total Volume of Deposition on Channel (m^3)	Final Run-out Volume (m^3)	Expected Run-out Distance (m)
3	C	CE	28	5	240	22	208	208	2.3	478.4	697	6	3.22	0	0	**697**	36.05
4 (Case 2)	C	CE	36	5	240	22	145	145	2.3	333.5	552	6	2.96	0	0	**552**	31.06
5	C	CE	29	5	240	22	208	208	2.3	478.4	697	6	3.27	0	0	**697**	35.48
6A	C	CE	41	10	240	22	144	144	2.3	331.2	550	6	2.02	0	0	**550**	45.34
6B	C	CE	32	10	240	22	144	144	2.3	331.2	550	6	1.71	0	0	**550**	53.48
7	B	CE	32	10	240	22	178	178	2.3	409.4	628	6	1.96	0	0	**628**	53.48
8	C	CE	32	10	240	22	190	190	2.3	437	655	6	2.04	0	0	**655**	53.48
9	B	CE	31	15	240	21.6	210	210	2.3	483	701	6	1.07	0	0	**701**	109.37

Note:

1. Refer to Table 9, GEO Report No. 57, of channelised failure:
   % deposition of initial volume from main scrap = **9%**
   Erosion Rate = **3.66 m^3/m (WCE) or 2.3 m^3/m (CE)**
   Trail width = **6m** (CE), **8m** (WCE)
   Thickness of deposition should be read in conjunction with summary table of debris flow calculation in Appendix I
2. N/A = Not Applicable because out of project area.

Table 5.3
Summary Table for Channelised Debris Flows
(after Natural Terrain Hazard Assessment Report)

Catchment No.	Design Landslide Event	Entry Channel Slope Angle (°)	Final Run-Out Volume (m^3)	Expected Run-Out Distance (m)
3	CE	56	697	36.05
4 (Case 1)	CE	42	0	-
4 (Case 2)	CE	36	552	31.06
5	CE	29	697	35.48
6A	CE	41	550	45.34
6B	CE	32	550	53.48
7	CE	32	628	53.48
8	CE	32	655	53.48
9	CE	31	701	109.37

Table 5.4
Summary Table for Open Hillslope Landslides
(after Natural Terrain Hazard Assessment Report)

Catchment No.	Design Landslide Event	Slope Angle (°) at Slope Toe	Final Run-Out Volume (m^3/m)	Expected Run-Out Distance (m)
3	CE	56	24	11.84
4	CE	60	24	12.06
5	CE	59	24	12.01
6A	CE	57	24	15.08
6B	CE	70	24	15.64
7	CE	50	24	14.66
8	CE	55	24	14.97
9	CE	60	24	22.38

Table 5.5
Summary of Boulder Survey
(after Natural Terrain Hazard Assessment Report)

Boulder No.	Size (m^3)	Catchment No.	Shape	Stability Rating (1)	Risk Rating (2)	Potential failure Mechanism (3)	Stabilisation/ Preventive Works
1	2.88	2	Cubic-subrounded	M	H	R	Removal
2	1.44	4	Cubic-subangular	M	H	T	Dentition

Notes: (1) M-Medium
(2) H-High
(3) R- Rolling
T-Toppling

5.2.2 Open hillslope landslides and channelised debris flows

The perimeter enclosing the run-out distances due to both open hillslope landslides and channelised debris flows is marked in Drawing No. BV/TKO/382311/002. Based on the calculation results, it is recommended that a 2.5m high earth bund, located at a minimum distance of 4m from the toe of the slopes, be constructed to contain any debris flows, as also shown in Drawing No. BV/TKO/382311/002. However, parts of the existing access road which is the only access road leading to the top 140mPD platform, would be blocked by the proposed earth bund and need to be diverted.

An alternative option that does not require diversion of the access road is discussed in Section 5.3.

5.3 'No build zone' option

An alternative option that does not require diversion of the access road is to define a 'no-build zone', outside of which no development will be affected by any potential hazards, even if the total area of the development has to be reduced upon the establishment of the 'no-build-zone' within the landfill site.

Such a no-build-zone can be defined based on the calculated run-distances discussed in Section 5.2 and is shown in Drawing No. BV/TKO/382311/003, with its boundary being defined as one meter further away from the calculated run-out distance boundary. Note the following points:

- The majority of the platform at 140 mPD is located outside of the no-build-zone and can therefore be used for development, as per the conceptual design which would only require the set up of a couple of movable containers as offices.

- The entire platform at 40 mPD is located outside of the no-build-zone and can therefore be used for development. The conceptual design indicates that a steel structure for recycling facility is to be constructed on this platform.

- Some parts of the access road are located within the no-build-zone. Instead of carrying out extensive road diversion works and slope stabilization works, it is recommended to close the road on signs (e.g. bad weather) indicating a potential danger to the road.

5.4 Adopted Option

The 'no-build-zone' option, as shown in Drawing No. BV/TKO/382311/003, is considered an economic and feasible approach to safeguard the proposed Park, and is therefore the adopted option.

6 CONCEPTUAL FOUNDATION DESIGN

6.1 General

The conceptual design of the Park (Appendix B) illustrates one steel structure located on the 40 mPD platform, and two structures and some seating areas located on the 140 mPD platform.

As documented in Registered Design No. STG2/STE/SUB/003/Issue 2, the restored Stage II/III landfill site consists of a linear low density polyethylene (LLDPE) geomembrane as a capping system, overlying a single cover layer of CDV placed over the waste. The CDV cover layer is generally 850 mm thick and is compacted to 90% of the standard Proctor density. The use of this capping system is to minimise water infiltration, reduce leachate generation and control leachate levels.

6.2 Foundation Options

It is recommended that shallow foundations, instead of deep foundations, should be used to support the proposed buildings in order not to damage the capping system.

In order to minimise settlement, in particular differential settlement, it is further recommended that each building be supported on a single raft foundation of adequate size.

The size of the raft foundation can be determined based on the acceptable settlement and bearing capacity, as described below:

- Bearing Capacity: Figure 6.1 shows the relationship between the ultimate bearing capacity and the width of a raft foundation, for two different embedded depths, i.e. at ground surface and at 0.65 m below the ground surface. It shows that the ultimate bearing capacity increases with both foundation width and embedded foundation depth. It further shows that the ultimate bearing capacity is substantially reduced if the underlying waste is taken into account and any beneficial contribution from the synthetic capping layer to the bearing capacity is ignored. However, even for this worse case scenario, a 5m wide by 40m long raft foundation still has an ultimate bearing capacity of approximately 100 kPa; for a safety factor of 3 as normally adopted for shallow foundations, this ultimate bearing capacity translates to an allowable bering capacity of approximately 33 kPa.

- Settlement: Figures 6.2(a) and (b) indicate that settlement increases with increasing applied loading, as expected. If the beneficial effect of the foundation stiffness is conservatively ignored, the calculated settlement reaches approximately 0.5 m for an applied loading of approximately 30 kPa. Due consideration should be given to piping and cabling systems associated with a building when assessing whether this magnitude of settlement is acceptable or not.

It is likely that the settlement, rather than bearing capacity, will control the size of the

raft foundation.

More details of the bearing capacity and settlement calculations are presented in Appendix F.

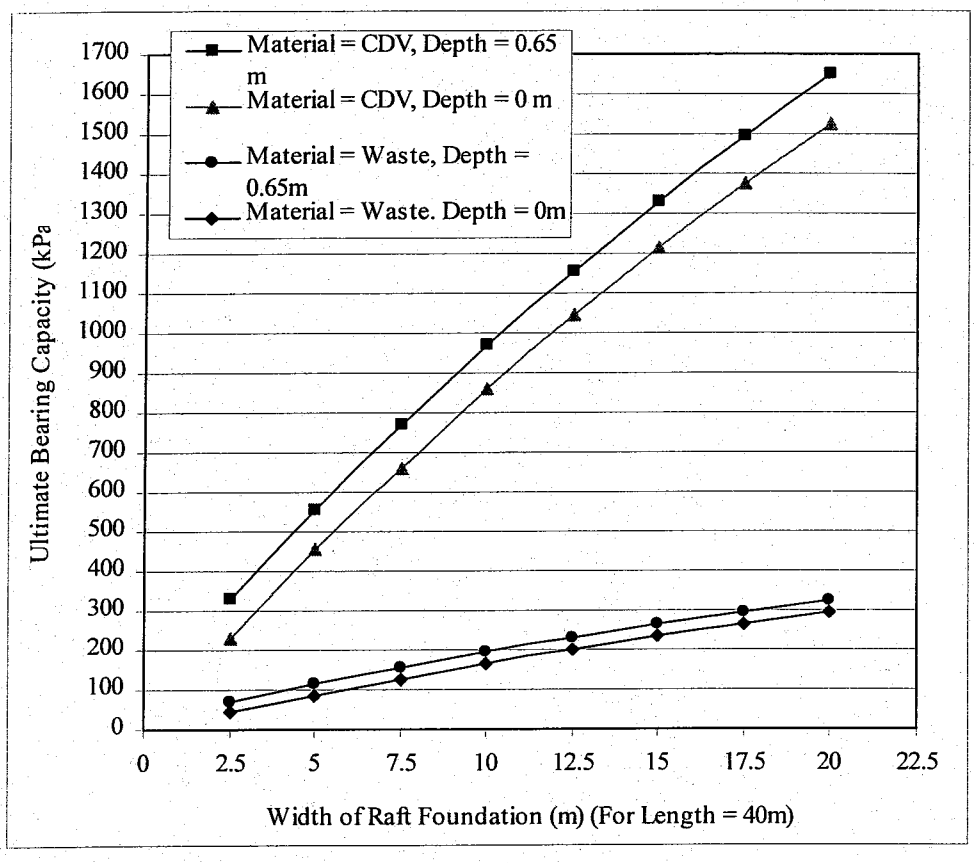
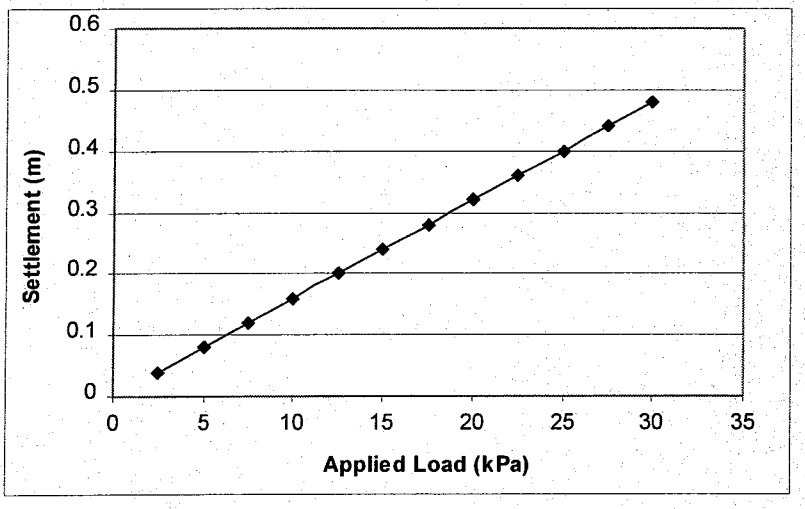
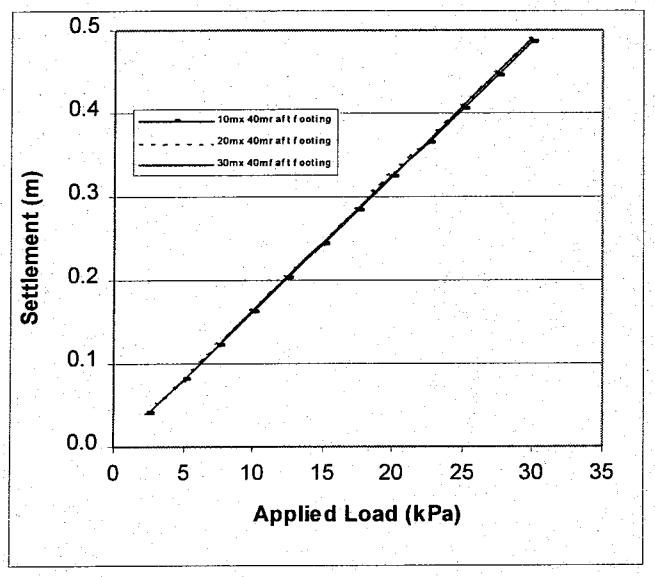


Figure 6.1 Relationship between calculated ultimate bearing capacity and foundation width



(a) 140 mPD platform



(b) 40 mPD platform

Figure 6.2 Relationship between calculated settlement and applied loading

7 COST ESTIMATE

The cost estimates for various construction works are presented in Appendix G.

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 Waste slopes

The proposed facilities associated with the Park (with a structural load of not greater than 50 kPa) will not compromise the stability of the waste slopes. Therefore, no upgrading works are required for the waste slopes. It is recommended that good maintenance be continued for the waste slopes so that they can meet the required minimum factor of safety within the context of the Park.

8.2 Cut slopes

Several soil cut slopes possess minimum calculated factors of safety less than the required value and therefore require upgrading works. These substandard soil slopes can be upgraded by prescriptive measures using soil nails and raking drains, as shown in Table 4.3 and Drawing No. BV/TKO/382311/001.

Several rock cut slopes have loose blocks and open joints on the slope surface. These substandard rock slopes can be upgraded by removal of loose blocks and concrete infilling of open joints, as shown in Table 4.4.

However, these upgrading works would be superseded where adjacent preventive measures against natural terrain hazards will also accommodate the debris expected from cut slope failure. Two preventive options against natural terrain hazards are proposed in Section 5, namely, option 1 to construct an earth bund and option 2 to define a no-build-zone.

With option 1, because the proposed earth bund covers all the cut slopes except Slope No. 12SW-A/C188, upgrading works are only required for Slope No. 12SW-A/C188.

With option 2, because the proposed no-build-zone covers all the cut slopes, no upgrading works are required.

8.3 Natural slopes

Based on the natural terrain hazard assessment results, it is considered that channelised debris flows, open hillslope landslides and boulder falls all form potential harzards to the proposed development.

Site inspection revealed that two potentially high-risk boulders (i.e. Boulders D1 and D2 as shown in Dwawing No. BBV/TKO/382311/002) in Catchment Nos. 2 and 4 require stabilising/preventive measures. It is recommended that Boulder D1 be removed and dentition be carried out on Boulder D2. Removal and breaking up of boulder D1 should be by splitting using pneumatic percussive drilling using either dynamic or chemical means. Care should be taken to avoid dislodging the boulder during splitting. The removal of Boulder D2 would affect the stability of the surrounding boulders and thus dentition is considered the best stabilising measure.

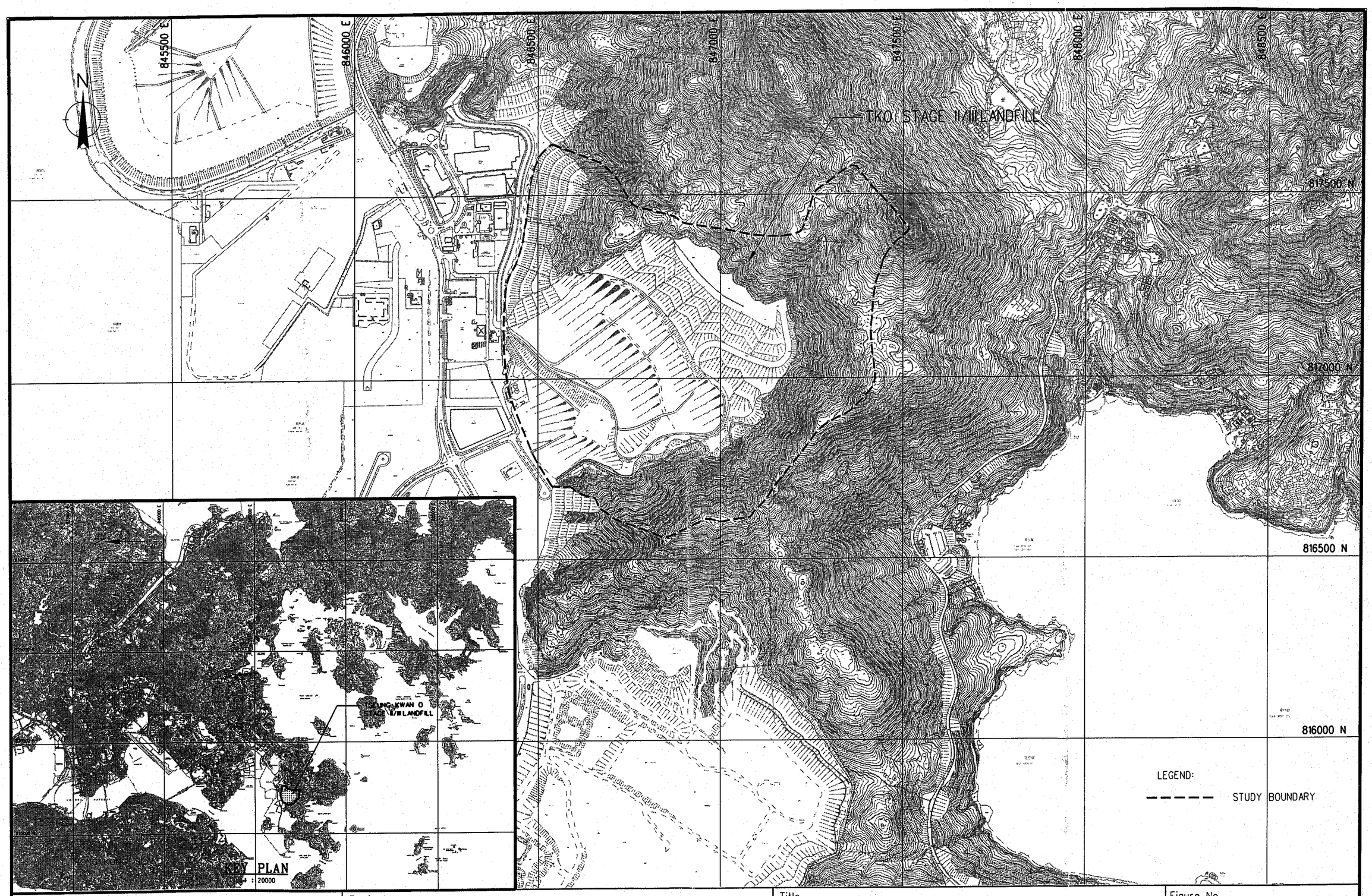
Two preventive options against open hillslope landslides and channelized debris flows have been proposed. Option 1 is to construct an earth bund as shown in Dwg No. BV/TKO/382311/002, and option 2 is to define a no-build-zone to allow for safe development outside of this zone, as shown in Drawing No. BV/TKO/382311/003. Option 2 is considered to be economic and feasible.

8.4 Conceptual foundation design

The existence of the capping system precludes the use of deep foundations and calls for the use of shallow foundations to support the buildings. It is recommended that each building be supported on a single raft foundation founded on the CDV cover layer.

Calculation results have shown that allowable settlement, rather than bearing capacity, is likely to control the size of a raft foundation. It is recommended that the allowable settlement be determined in the detailed design of the buildings, with due consideration of associated piping and cabling systems.

FIGURES



BLACK & VEATCH HONG KONG LIMITED
博威工程顧問有限公司

Project
Tseung Kwan O Stage II/III Landfill Afteruse Development

Prepared By: SMO

Checked By: KWK

Title
SITE LOCATION PLAN

Figure No.
1

Scale
1 : 10000

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N

E 847400

E 847200

E 847000

E 846800

E 846600

E 846400

N 817600

N 817400

N 817200

N 817000

N 816800

N 816600

N 816400

12SW-A/C182

12SW-A/C178

12SW-A/C180

12SW-A/C177

12SW-A/C176

12SW-A/C174

12SW-A/C175

12SW-A/C173
PART 'I'

12SW-A/C76

12SW-A/C183
PART 'I'

12SW-A/C184

12SW-A/C185

12SW-A/C186

12SW-A/C187

12SW-A/C188

12SW-A/C181
PART 'I'
PART 'D'

12SW-A/C189

12SW-A/C190

12SW-A/C191

12SW-A/C192

12SW-A/F74

12SW-A/F73

12SW-A/F72
PART 'B'

12SW-A/F68

12SW-A/F70

12SW-A/F69

12SW-A/F67

PART 'G'

PART 'H'

PART 'D'

ENTRANCE 'C'

LEGEND:

- LANDFILL BOUNDARY
- STUDY BOUNDARY
- GEO REGISTERED FILL SLOPE
- GEO REGISTERED CUT SLOPE

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.
2. ALL LEVELS ARE IN METRES ABOVE PRINCIPAL DATUM.
3. ALL DIMENSIONS ARE TYPICAL AND TO BE CONFIRMED AT DETAILED DESIGN.

Approved

CAD ref. MAIN : Figure-geo3.dgn
XREF : tkosf-db.dgn, 2-ptrd.dgn, s2fccon.dgn & A1-Title.dgn

Contract no.

Contract
GEOTECHNICAL REVIEW AND SITE INVESTIGATION WORKS FOR TSEUNG KWAN O STAGE II/III AFTERUSE DEVELOPMENT

Figure Title
TSEUNG KWAN O STAGE II/III LANDFILL GEO REGISTERED SLOPES

Figure no. 2

Scale 1:2000(A1) 1:4000(A3)

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DRAWINGS

SLOPE NO.	PORTION		NORTHING (m)	EASTING (m)	RECOMMENDED PRESCRIPTIVE MEASURES
12SW-A/C183	G	G1	817220.82	847180.71	RAKING DRAINS AT SPECIFIC SEEPAGE
		G2	817203.05	847123.66	
12SW-A/C188	H	H1	817400.00	846796.18	RAKING DRAINS AT SPECIFIC SEEPAGE
		H2	817322.76	846600.63	
12SW-A/C175	I	C2	816777.27	846973.03	SOIL NAIL LAYOUT : TYPE (a) NUMBER OF ROWS OF SOIL NAILS, N 4 NAIL DIAMETER, f_r(mm) 25 HOLE DIAMETER, f_h(mm) 100 HORIZONTAL SPACING, S_h(m) 1.5 LENGTH OF SOIL NAILS, L (m) 8.5
		I1	816813.17	847031.82	

SLOPE NO.	PORTION		NORTHING (m)	EASTING (m)	RECOMMENDED PRESCRIPTIVE MEASURES
12SW-A/C76	A	A1	816755.10	846634.64	SOIL NAIL LAYOUT : TYPE (d) NUMBER OF ROWS OF SOIL NAILS, N 3 NAIL DIAMETER, f_r(mm) 25 HOLE DIAMETER, f_h(mm) 100 HORIZONTAL SPACING, S_h(m) 1.5 LENGTH OF SOIL NAILS, L (m) 7.5
		A2	816739.09	846674.15	
12SW-A/C173	B	B1	816768.77	846836.47	SOIL NAIL LAYOUT : TYPE (f) NUMBER OF ROWS OF SOIL NAILS, N 5 NAIL DIAMETER, f_r(mm) 32 HOLE DIAMETER, f_h(mm) 100 HORIZONTAL SPACING, S_h(m) 1.5 LENGTH OF SOIL NAILS, L (m) 10
		B2	816801.32	846880.94	
12SW-A/C173	C	C1	816816.15	846942.64	SOIL NAIL LAYOUT : TYPE (d) NUMBER OF ROWS OF SOIL NAILS, N 3 NAIL DIAMETER, f_r(mm) 25 HOLE DIAMETER, f_h(mm) 100 HORIZONTAL SPACING, S_h(m) 1.5 LENGTH OF SOIL NAILS, L (m) 7.5
		C2	816777.27	846973.03	
12SW-A/C176	D	D1	816860.12	847082.42	SOIL NAIL LAYOUT : TYPE (a) NUMBER OF ROWS OF SOIL NAILS, N 4 NAIL DIAMETER, f_r(mm) 25 HOLE DIAMETER, f_h(mm) 100 HORIZONTAL SPACING, S_h(m) 1.5 LENGTH OF SOIL NAILS, L (m) 9.5
		D2	816892.24	847128.77	
12SW-A/C177	E	E1	816975.12	847152.95	SOIL NAIL LAYOUT : TYPE (f) NUMBER OF ROWS OF SOIL NAILS, N 5 NAIL DIAMETER, f_r(mm) 32 HOLE DIAMETER, f_h(mm) 100 HORIZONTAL SPACING, S_h(m) 2 LENGTH OF SOIL NAILS, L (m) 10.0
		E2	817009.07	847178.46	
12SW-A/C182	F	F1	817155.94	847205.15	SOIL NAIL LAYOUT : TYPE (a) NUMBER OF ROWS OF SOIL NAILS, N 6 NAIL DIAMETER, f_r(mm) 25 HOLE DIAMETER, f_h(mm) 100 HORIZONTAL SPACING, S_h(m) 1.5 LENGTH OF SOIL NAILS, L (m) 10.0 RAKING DRAINS AT SPECIFIC SEEPAGE
		F2	817196.31	847183.84	

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.
2. ALL LEVELS ARE IN METRES ABOVE PRINCIPAL DATUM.
3. ALL DIMENSIONS ARE TYPICAL AND TO BE CONFIRMED AT DETAILED DESIGN.
4. FOR DETAILS PF SOIL NAIL ARRANGEMENT, REFER TO GEO REPORT NO. 56 (SECOND EDITION), FIGURE A12.
5. FOR SOIL NAIL DETAILS, REFER TO CED DRAWING NOS. C2106/1E, 2B & 3C.
6. FOR RAKING DRAIN DETAILS, REFER TO CED DRAWING NO. C2403.
7. EXACT LOCATIONS OF SOIL NAILS AND RAKING DRAINS TO BE SPECIFIED BY ENGINEER ON SITE.

LEGEND:

LANDFILL BOUNDARY

PORTION

Approved

CAD ref. MAIN : 382311-001.dgn
XREF : lkosl-ob.dgn, 2-ptrd.dgn, s2fccon.dgn & A1-title.dgn

Contract no. FD01-052

Contract
GEOTECHNICAL REVIEW AND SITE INVESTIGATION WORKS FOR TSEUNG KWAN O STAGE II/III AFTERUSE DEVELOPMENT

Drawing Title
TSEUNG KWAN O STAGE II/III LANDFILL RECOMMENDED MEASURES FOR EXISTING CUT SLOPES

Drawing no. BV/TKO/382311/001

Scale 1:2000(A1) 1:4000(A3)

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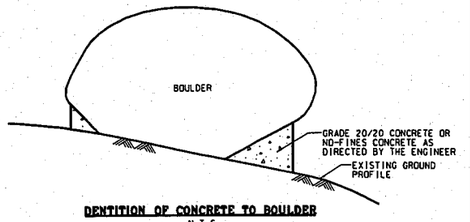
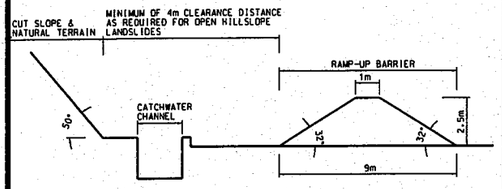


DENTITION OF CONCRETE TO BOULDER
N.T.S.

NOTE :
THE DETAILS SHOWN ON THIS DRAWING ARE FOR INFORMATION ONLY. AND ARE RELATED TO THE TYPICAL SECTION AS SHOWN. THE ACTUAL EXTENT OF WORK SHALL BE DETERMINED ON SITE BY THE ENGINEER.



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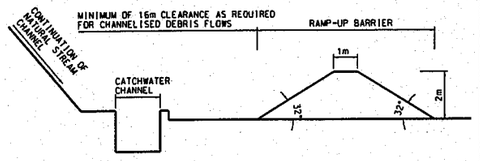

SCHEMATIC SECTION Z - Z
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NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.
2. ALL LEVELS ARE IN METRES ABOVE PRINCIPAL DATUM.
3. ALL DIMENSIONS ARE TYPICAL AND TO BE CONFIRMED AT DETAILED DESIGN.

LEGENDS:

- NATURAL TERRAIN STUDY BOUNDARY
- RAMP UP BARRIER, 2.5m HIGH BASAL WIDTH OF 9.0m
- PROPOSED STERILE ZONE
- D1 LOCATIONS OF BOULDERS REQUIRING REMOVAL/ DENTITION

SETTING OUT POINTS :

POINT	EASTING (m)	NORTHING (m)
1	846876.78	817361.76
2	846903.88	817362.17
3	846928.43	817346.75
4	846962.29	817333.39
5	846970.32	817313.26
6	846977.43	817288.06
7	846994.54	817267.82
8	847025.85	817245.22
9	847042.25	817224.74
10	847064.09	817208.17
11	847101.78	817187.53
12	847155.32	817159.75
13	847171.18	817135.70
14	847178.17	817109.34
15	847180.15	817075.42
16	847171.2	817045.83
17	847139.19	817003.79
18	847110.44	816976.84
19	847078.55	816953.17
20	847054.33	816922.90
21	847022.32	816910.10
22	847008.49	816899.33
23	846999.72	816880.86
24	846988.19	816860.24
25	846965.69	816848.75
26	846936.17	816849.95
27	846901.46	816854.07
28	846871.96	816850.42
29	846850.51	816837.81
30	846830.2	816820.45
31	846816.29	816812.04
32	846781.75	816802.04
33	846761.9	816791.36
34	846744.19	816765.82
35	846736.86	816760.34
36	846711.64	816773.79
37	846663.89	816789.67
38	846629.16	816791.78
39	846602.16	816779.71
40	846575.75	816758.75
41	846537.75	816734.75

Approved

CAD ref. MAIN : 382311-002.DGN
XREF : B12SW06B,D, B12SW01B,D, B12SW02A,B,C,D & B12SW07A,B,C,D.DGN

Contract no. FD01-052

Contract
GEOTECHNICAL REVIEW AND SITE INVESTIGATION WORKS FOR TSEUNG KWAN O STAGE II/III APTERUSE DEVELOPMENT

Drawing Title
MITIGATION STRATEGY MAP

Drawing no. BV/TKO/382311/002

Scale 1:2500(A1) 1:5000(A3)

BLACK & VEATCH HONG KONG LIMITED
博威工程顧問有限公司

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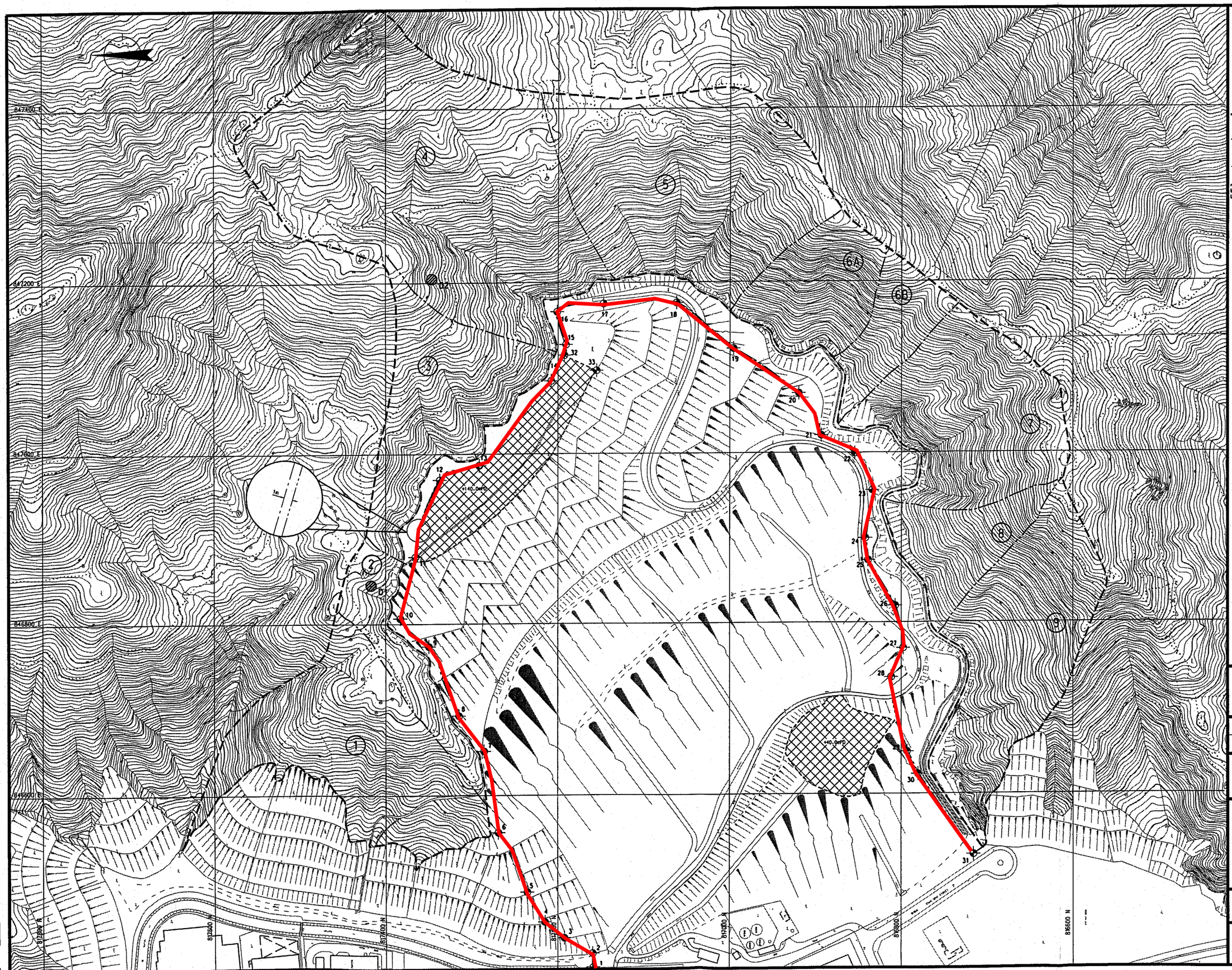

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.
2. ALL LEVELS ARE IN METRES ABOVE PRINCIPAL DATUM.
3. ALL DIMENSIONS ARE TYPICAL AND TO BE CONFIRMED AT DETAILED DESIGN.

LEGENDS:

- NATURAL TERRAIN STUDY BOUNDARY
- CALCULATED RUN OUT DISTANCE
- BOUNDARY OF NO BUILD ZONE
- AREA ALLOCATED FOR AFTERUSE FACILITIES

SETTING OUT POINTS :

POINT	EASTING (m)	NORTHING (m)
1	846398.63	817158.37
2	846415.36	817159.10
3	846433.88	817192.23
4	846452.62	817215.13
5	846487.81	817236.03
6	846557.08	817269.72
7	846651.36	817286.20
8	846692.52	817315.39
9	846773.61	817350.23
10	846806.75	817383.30
11	846878.89	817365.81
12	846969.65	817337.49
13	846986.49	817291.61
14	847085.52	817208.02
15	847127.78	817150.65
16	847165.91	817201.15
17	847175.40	817146.64
18	847176.17	817062.23
19	847122.56	816995.76
20	847070.11	816919.40
21	847020.52	816892.83
22	846999.29	816853.53
23	846955.69	816833.14
24	846899.21	816841.21
25	846873.23	816838.01
26	846819.56	816807.12
27	846769.79	816797.75
28	846735.86	816811.46
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30	846622.94	816780.44
31	846529.60	816715.87
32	847115.15	817193.49
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Approved

CAD ref.

Contract no. FD01-052

Contract: GEOTECHNICAL REVIEW AND SITE INVESTIGATION WORKS FOR TSEUNG KWAN O STAGE II/III AFTERUSE DEVELOPMENT

Drawing Title: MAP FOR NO BUILD ZONE OPTION

Drawing no. BV/TKO/382311/003

Scale 1:2000(A1) 1:4000(A3)

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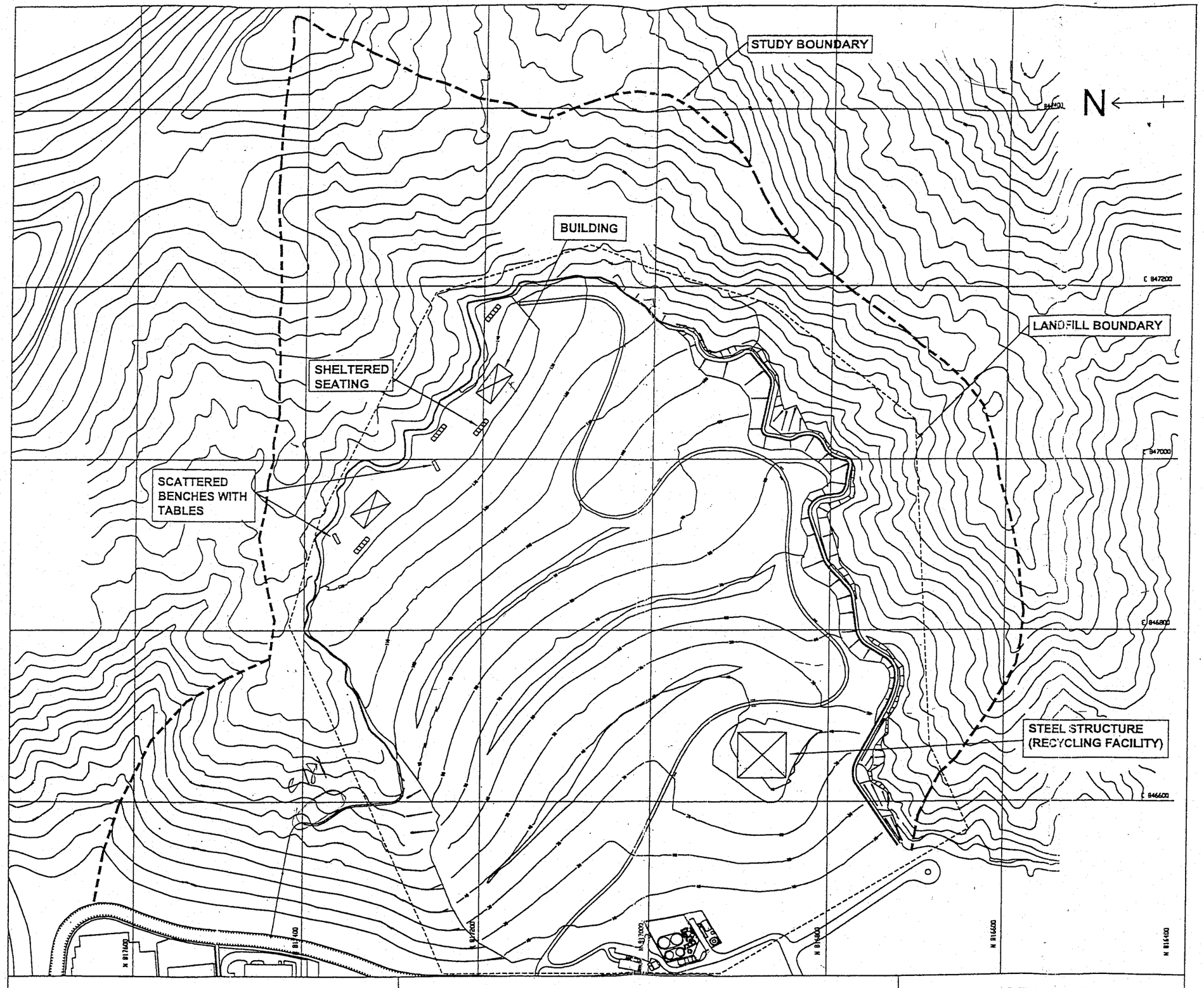
APPENDIX A
Conceptual Design of the Park



ENVIRONMENTAL PROTECTION DEPARTMENT
THE GOVERNMENT OF THE HONG KONG
SPECIAL ADMINISTRATIVE REGION

Appendix 2 - Tseung Kwan O Landfill Stage II/III
Conceptual Design

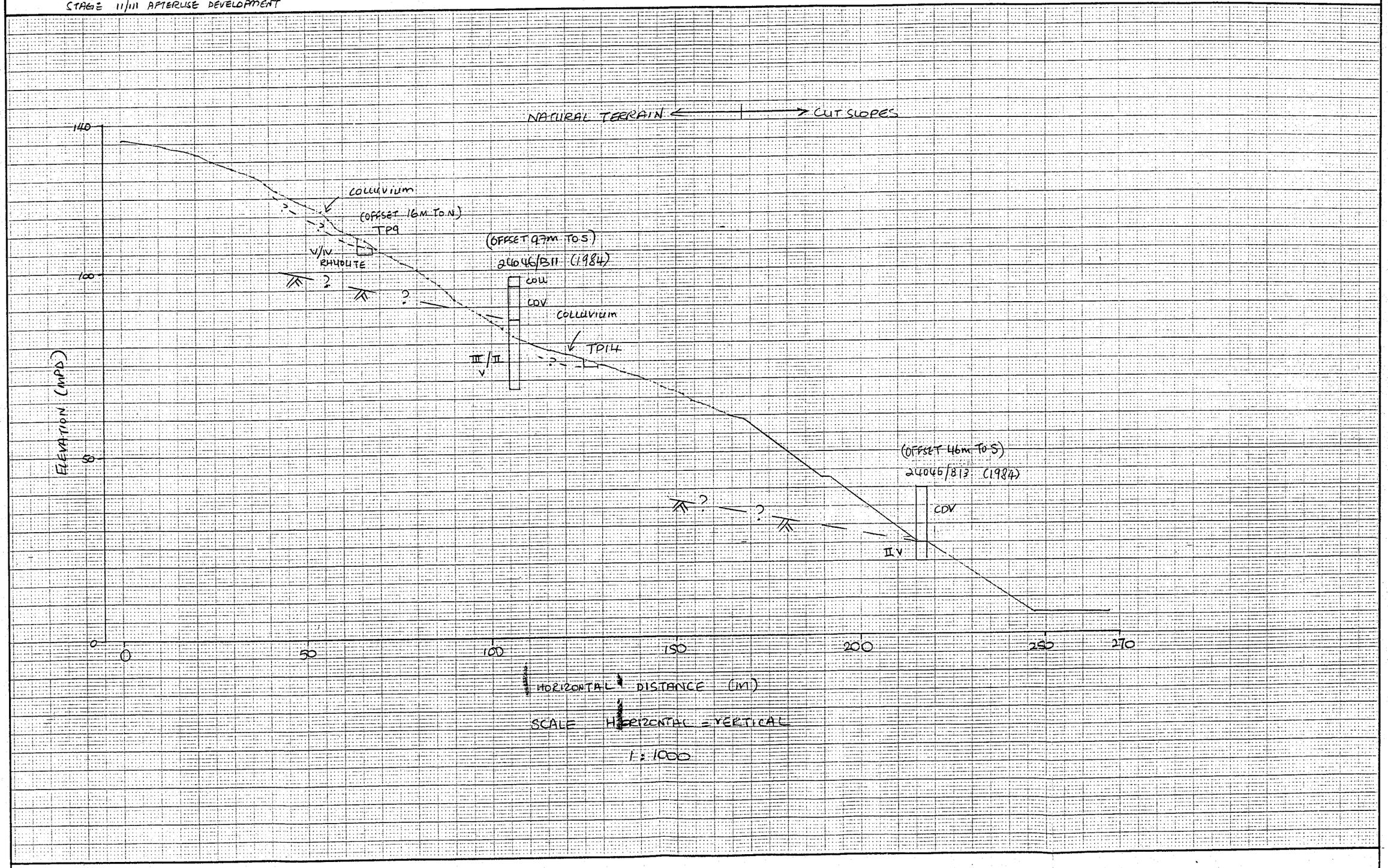
EP/SP/29/95

2001-29D.DWG

20 JULY 2001

APPENDIX B
Ground Investigation Results

AGREEMENT NO. FD01-052
Project TSEUNG KWAN O LANDFILL Subject SECTION A-A Job number 2311/0202 Page of
STAGE II/III AFTERUSE DEVELOPMENT



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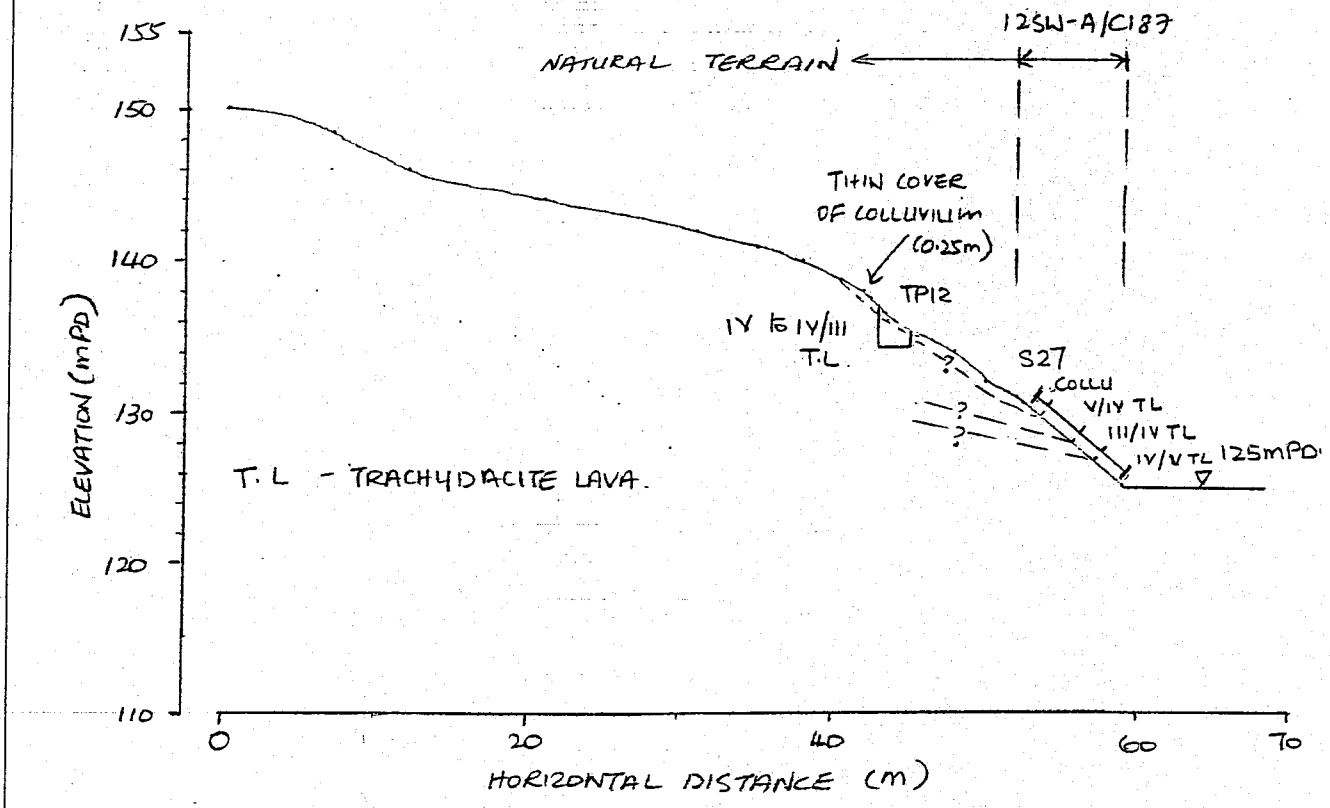
Date 08/02 Date

Binnie Black & Veatch Hong Kong Limited
Engineers and Scientists

Project AGREEMENT NO. FD01-052
TSEUNG KWAN O LANDFILL STAGE II/III AFTERUSE DEVELOPMENT

Subject SECTION B-B. Job number 2311 | 0202 Page of



SECTION B-B

SCALE 1:500

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Binnie Black & Veatch Hong Kong Limited
Engineers and Scientists

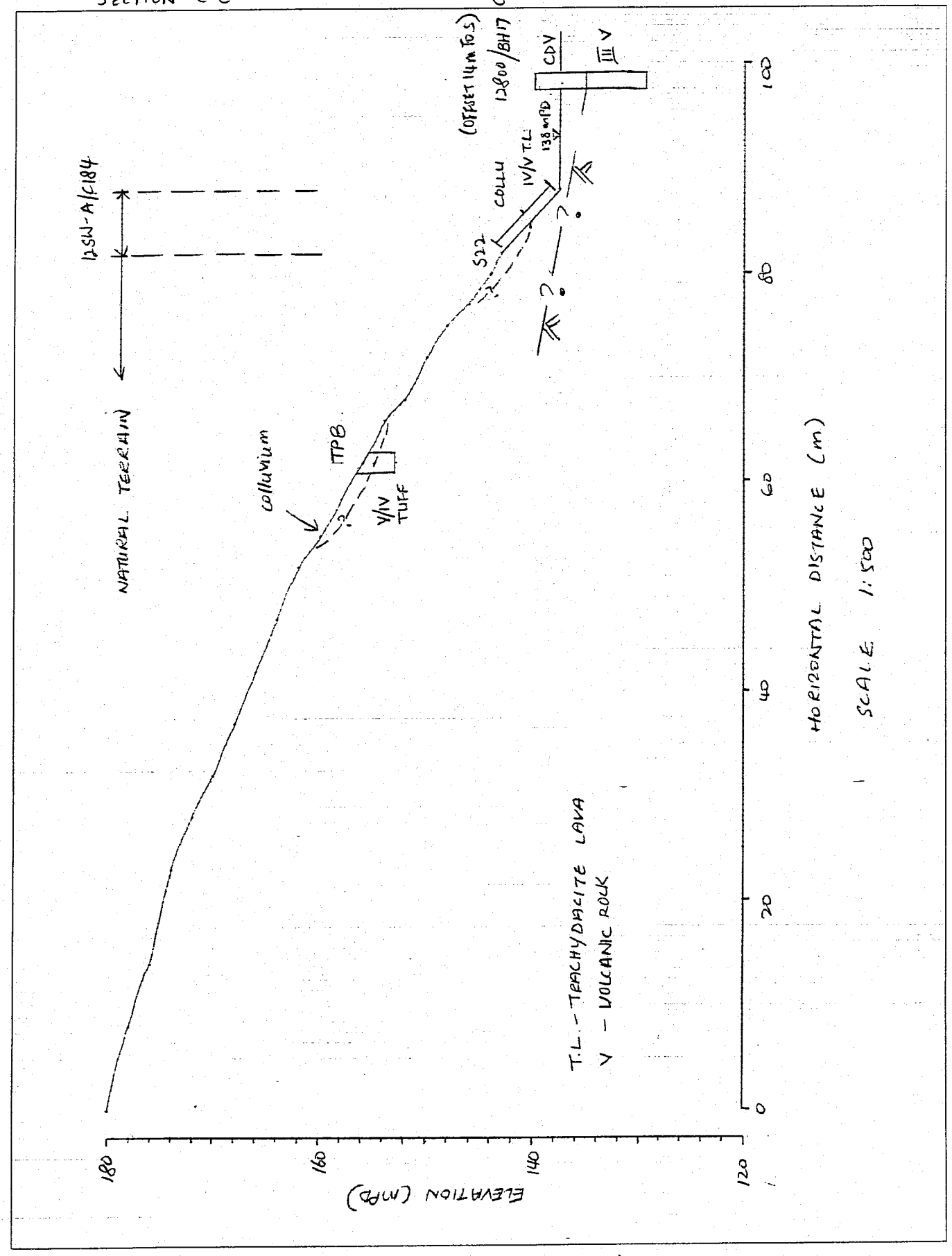
Binnie

Project AGREEMENT NO. FD 01-052
TSEUNG KWAN O LANDFILL STAGE II/III AFTERUSE DEVELOPMENT

Subject SECTION C-C (1988)

Job number

Page of



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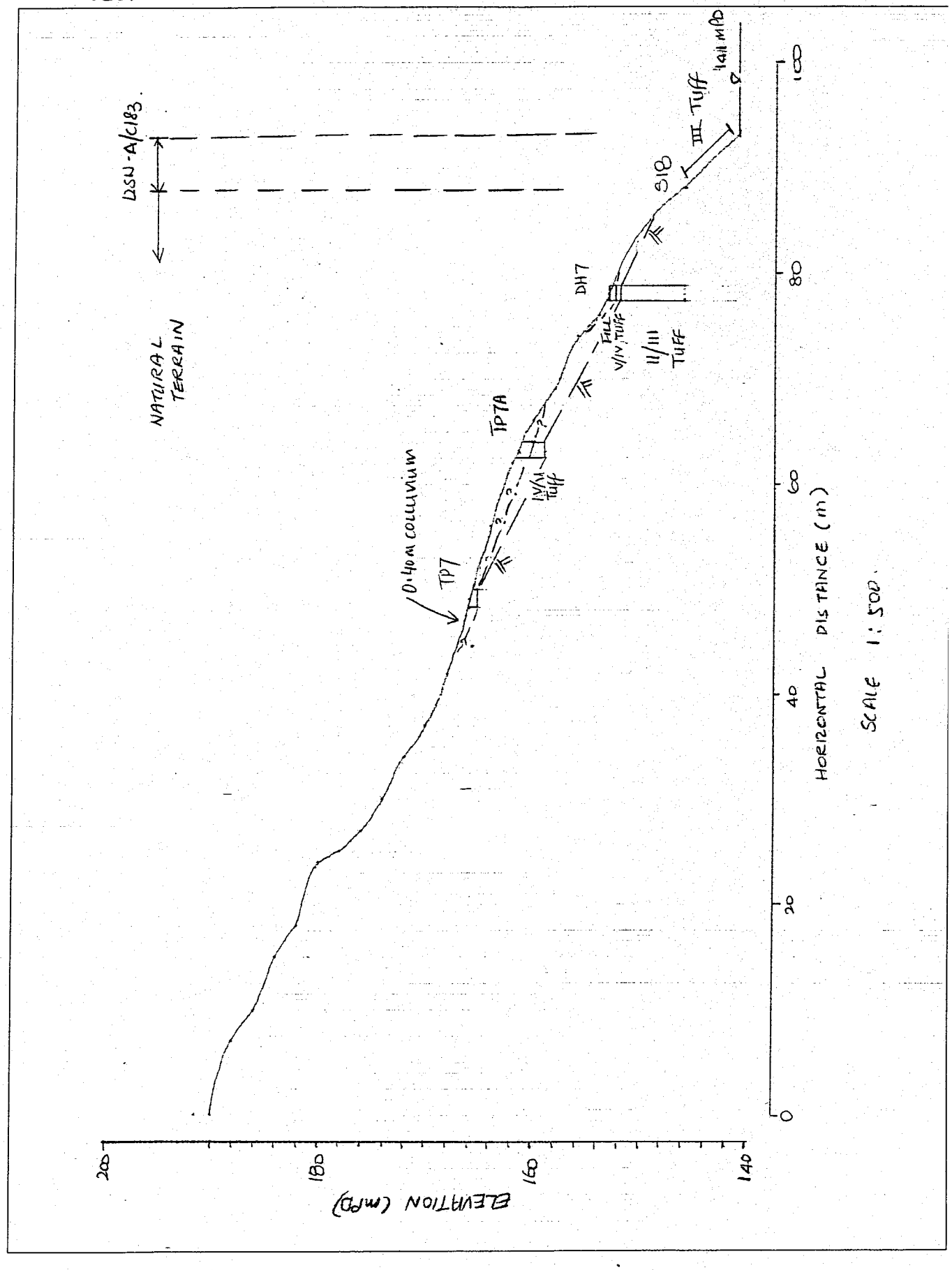
Project AGREEMENT NO. FD 01/92 TSEUNG KWAN O LANDFILL STAGE II/III AFTERUSE DEVELOPMENT

Subject SECTION D-D

Job number

Page of



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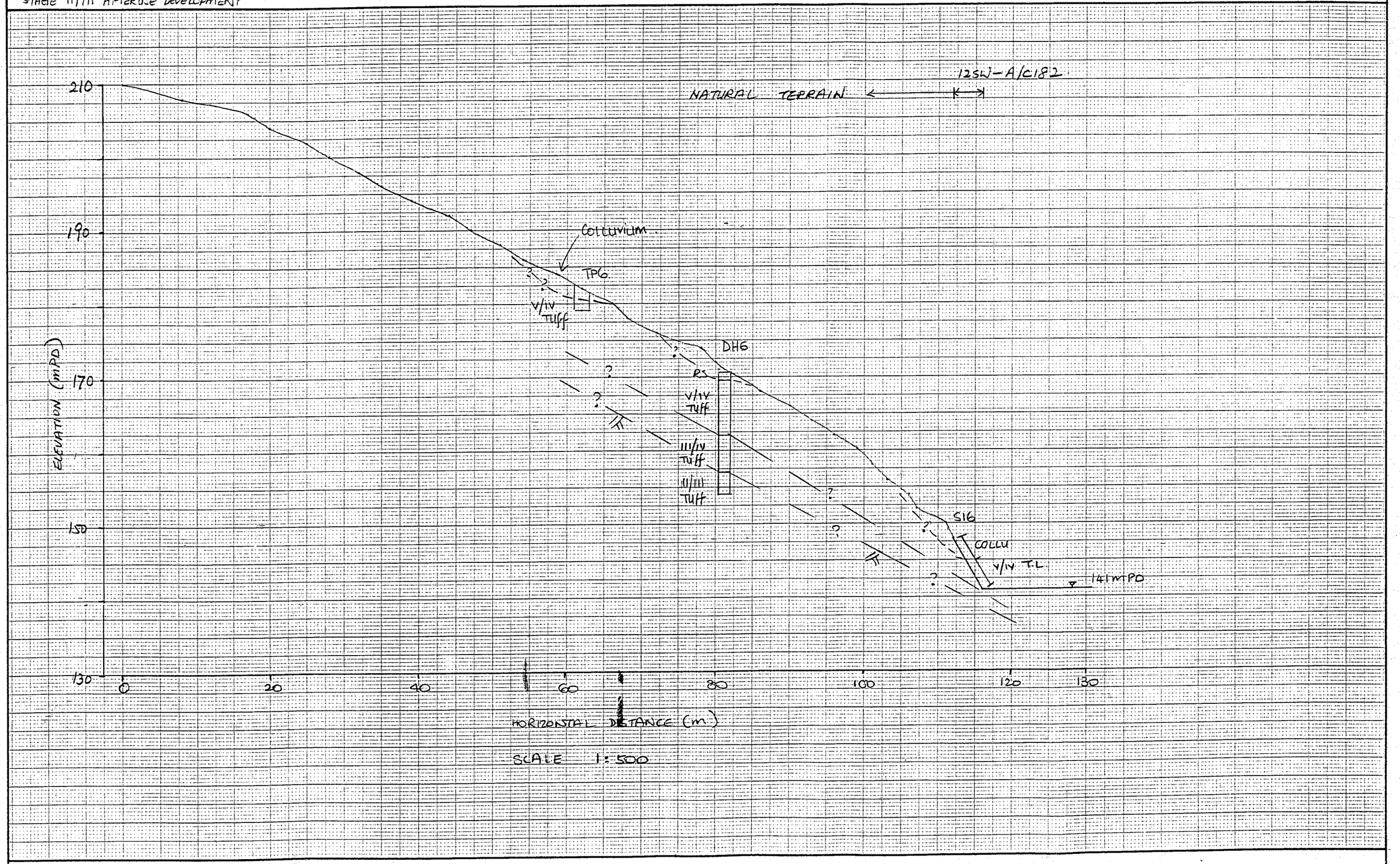
Project TSEUNG KWAN O LANDFILL Subject SECTION E - E Job number 2311/0301 Page of
STAGE II/III AFTERUSE DEVELOPMENT



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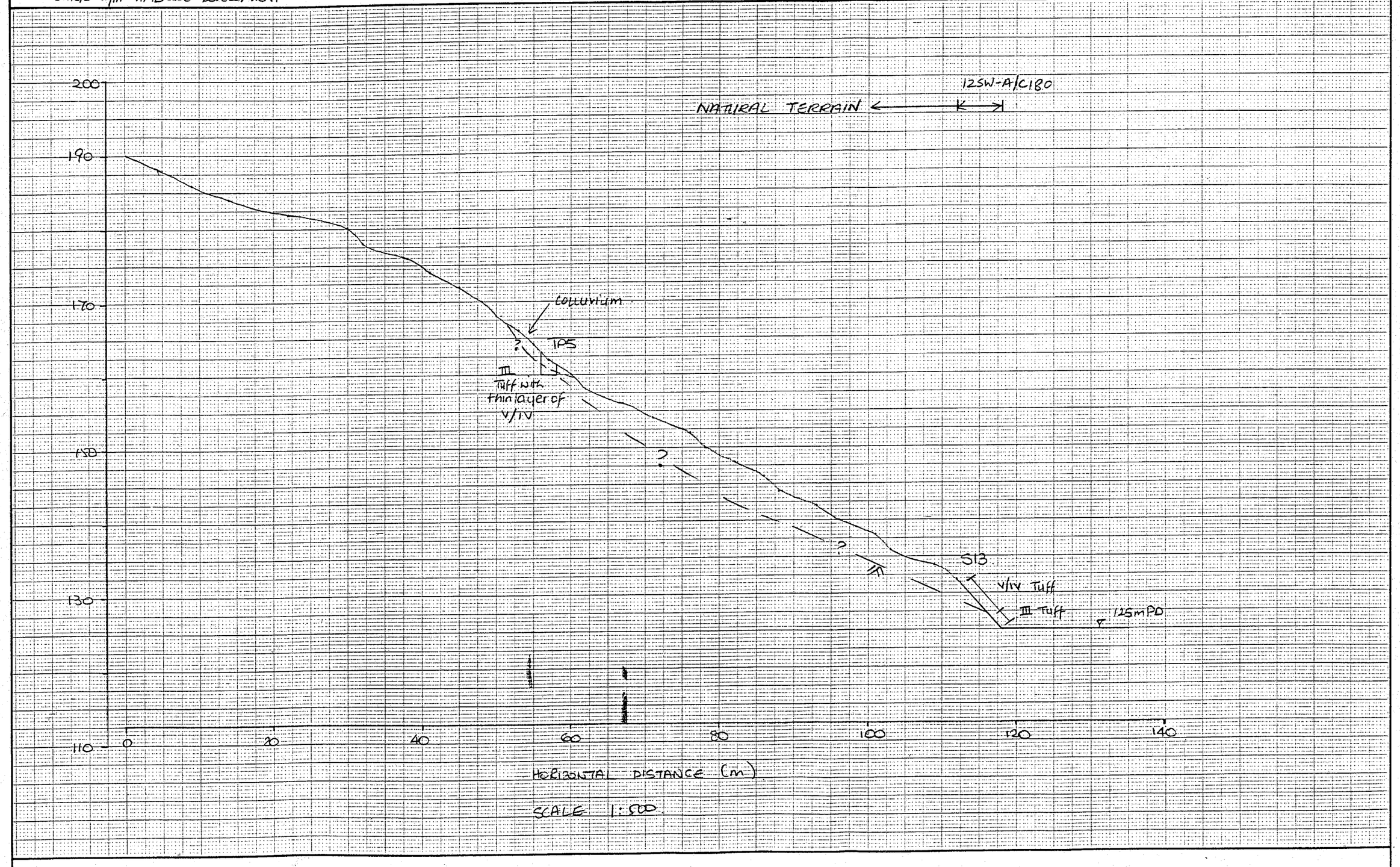
Date 08/02 Date

AGREEMENT NO. FD01-052
Project TSEUNG KWAN O LANDFILL Subject SECTION F-F
STAGE II/III AFTERUSE DEVELOPMENT
Job number 2311/0201 Page of



Computed by SMO Checked by Distribution Filed in
Date 08/02 Date

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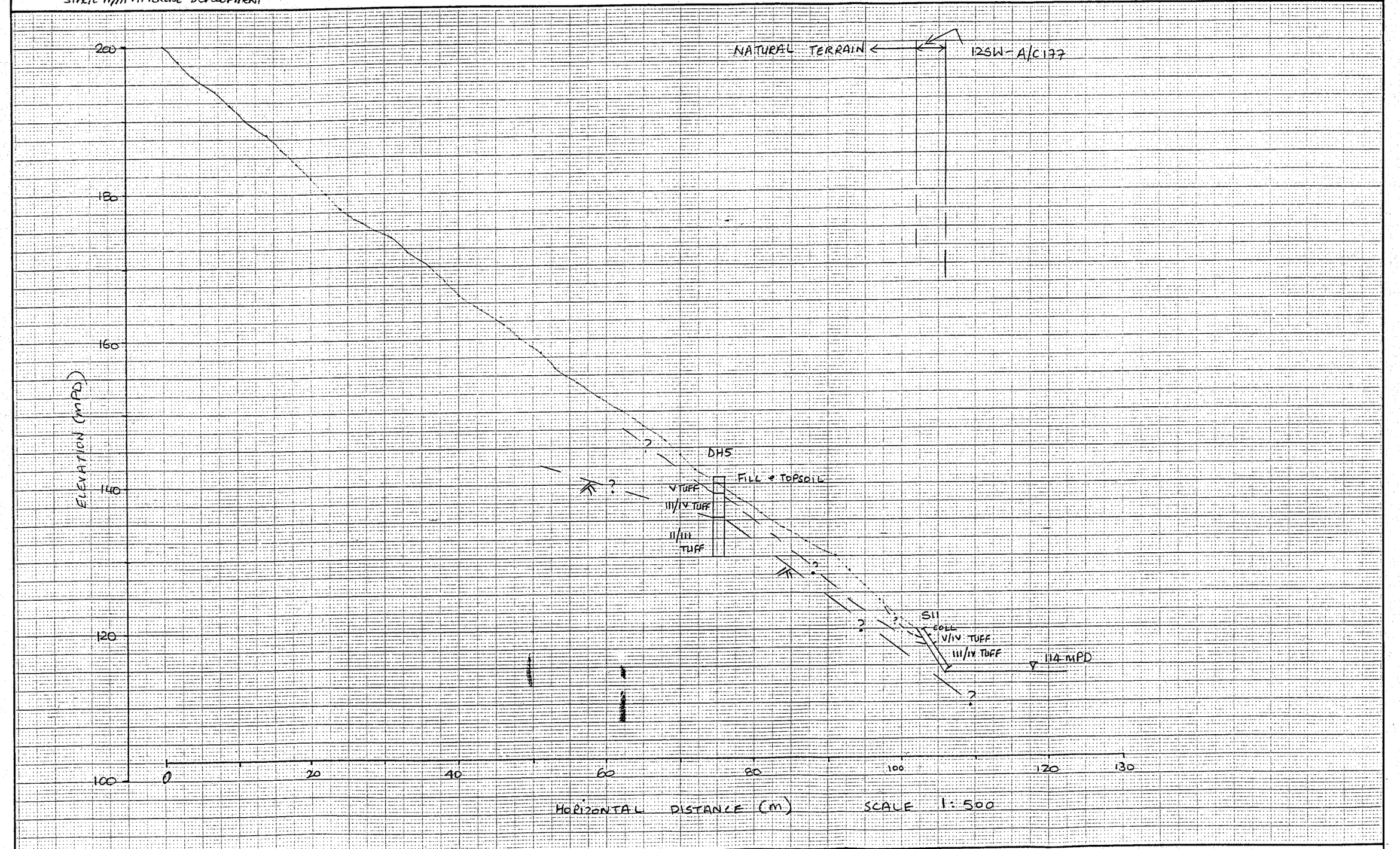
AGREEMENT No. FD 01-052
Project TSEUNG KWAN O LANDFILL Subject SECTION G-G
STAGE II/III AFTERUSE DEVELOPMENT

Job number 38231/2201 Page of



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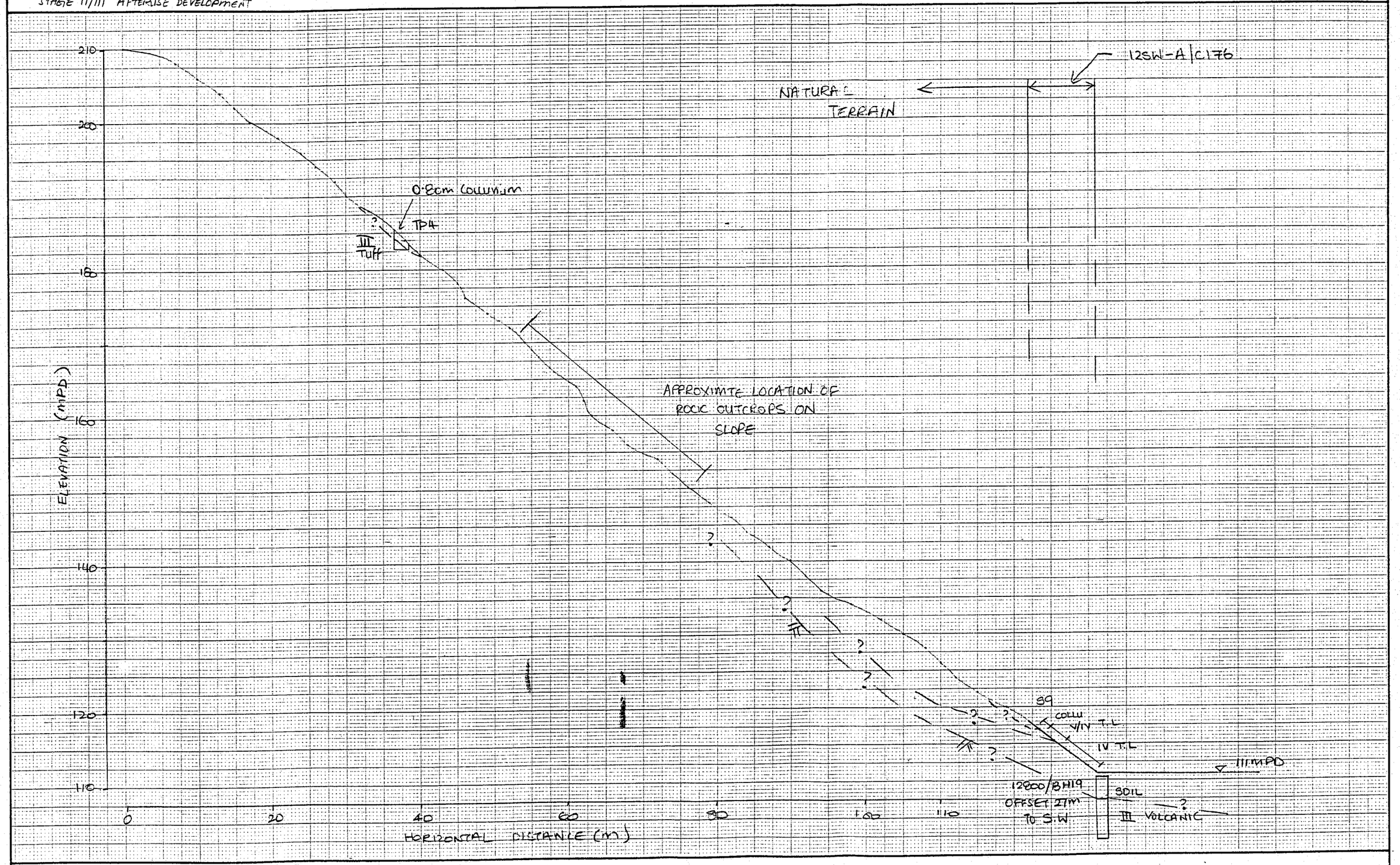
Date 08/02 Date

AGREEMENT NO. FD01-052
Project TSEUNG KWAN O LANDFILL Subject SECTION H-H
STAGE II/III AFTERUSE DEVELOPMENT
Job number 382311/0201 Page of



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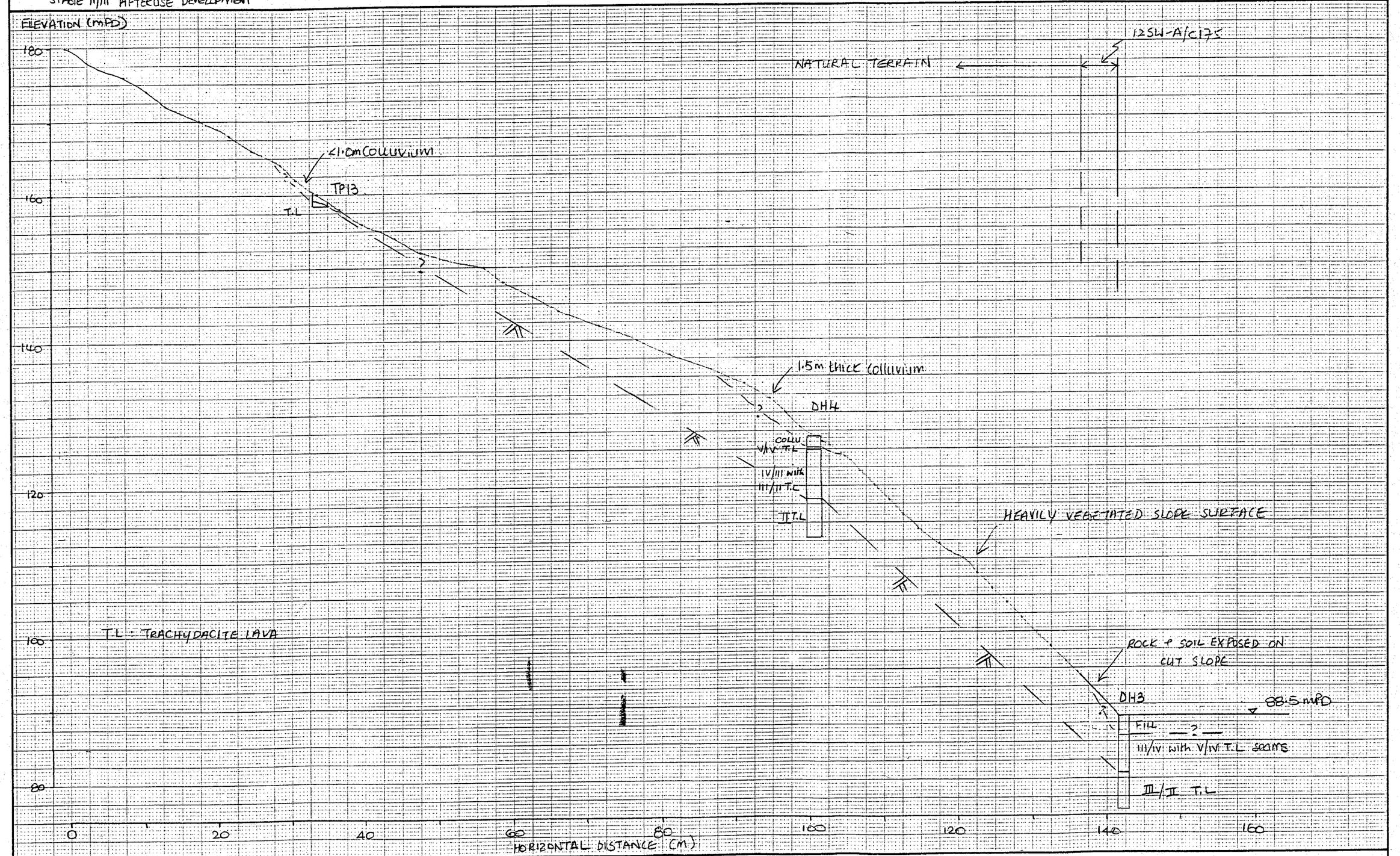
Date 08/02 Date

AGREEMENT NO. FD01-C52
Project TSEUNG KWAN O LANDFILL Subject SECTION I - I
STAGE II/III AFTERUSE DEVELOPMENT
Job number 382311/0201 Page of



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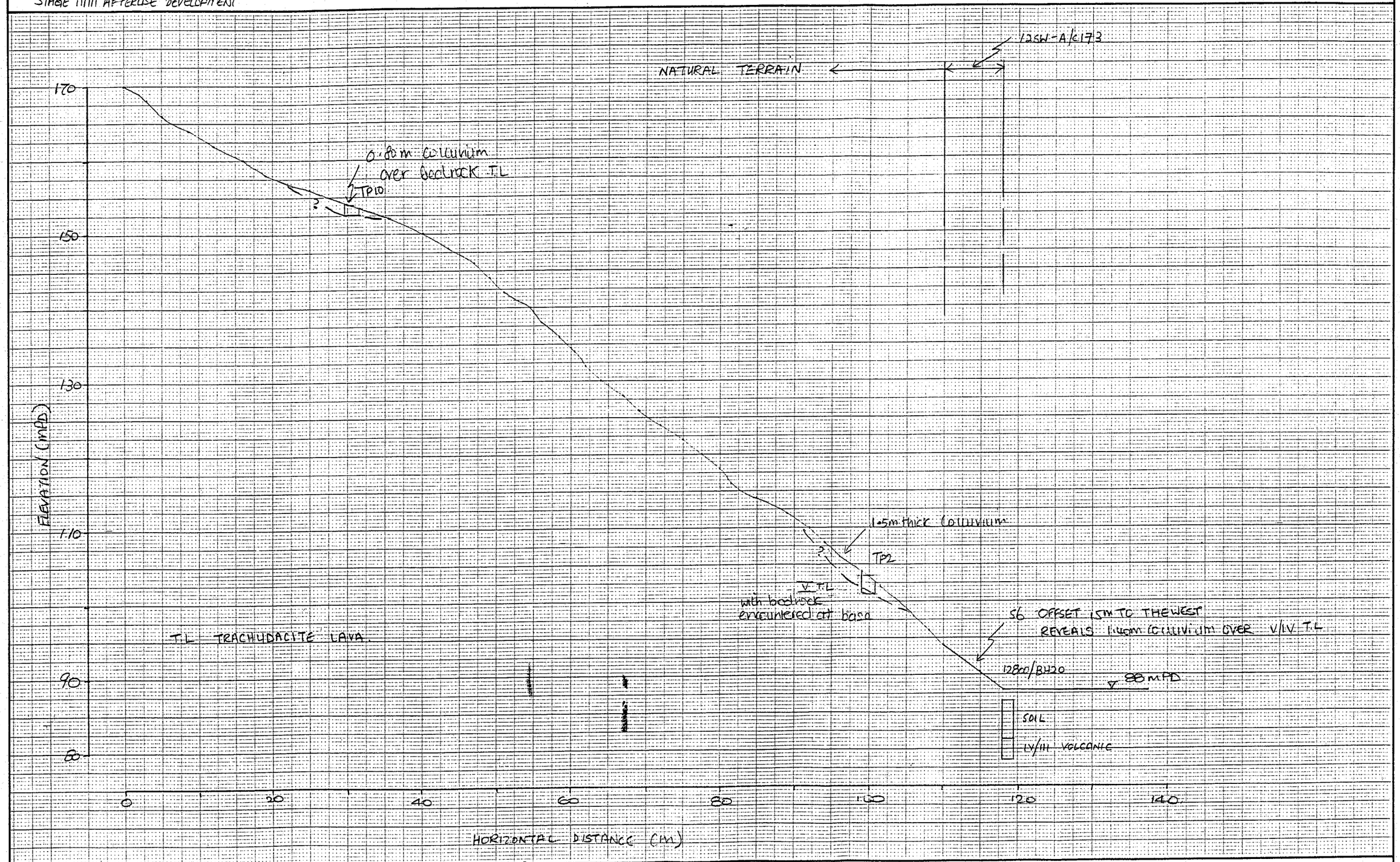
Project TSEUNG KWAN O LANDFILL Subject SECTION J-J Job number 382311/0201 Page of
STAGE II/III AFTERUSE DEVELOPMENT



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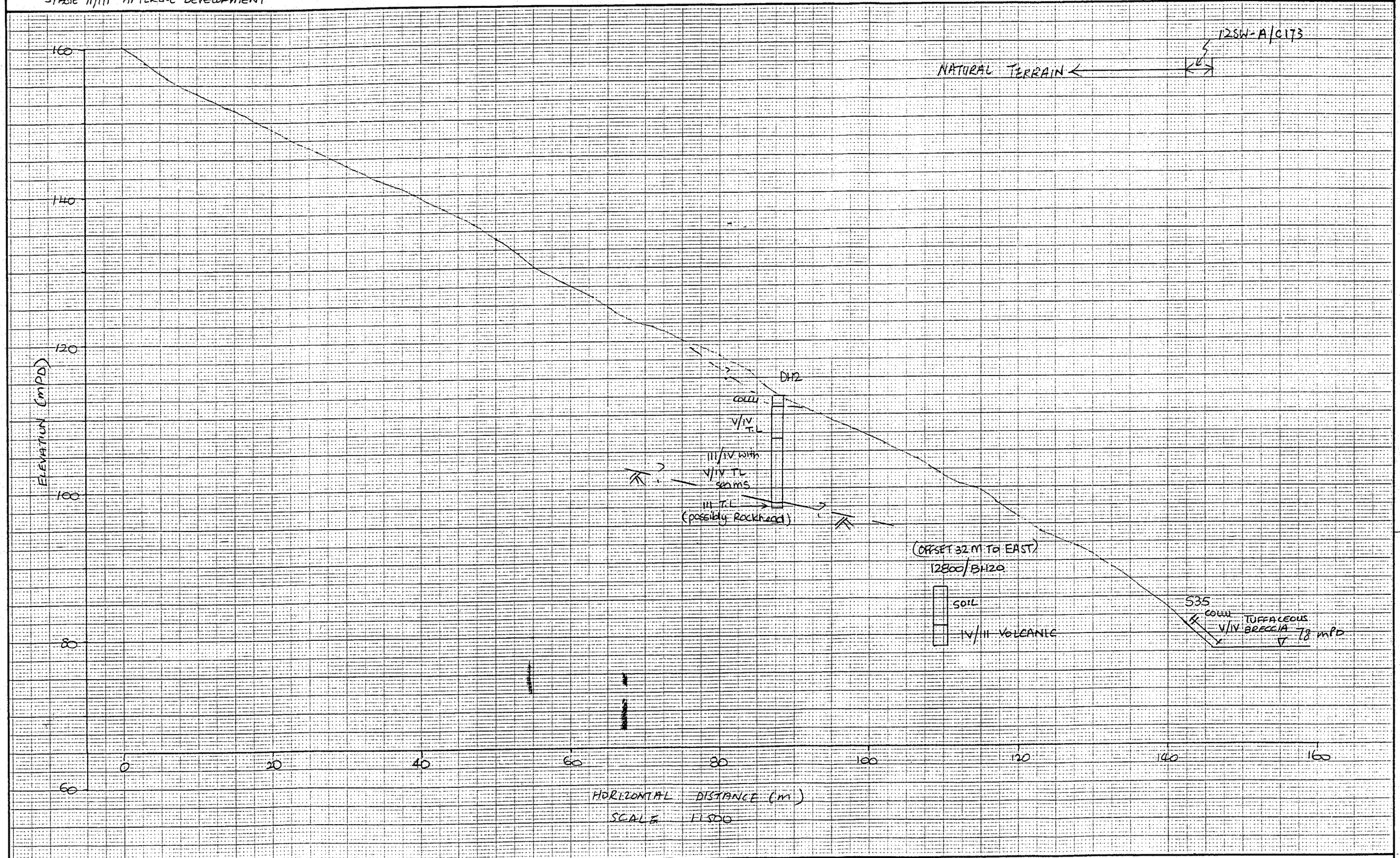
Date 08/02 Date

Binnie Black & Veatch Hong Kong Limited
Engineers and Scientists

Binnie

AGREEMENT NO. FD 01-052
Project TSEUNG KWAN O LANDFILL Subject SECTION K-K.
STAGE II/III AFTERUSE DEVELOPMENT
Job number 382311/0201 Page of



Computed by SMO Checked by Distribution Filed in
Date 08/02 Date

Binnie Black & Veatch Hong Kong Limited
Engineers and Scientists

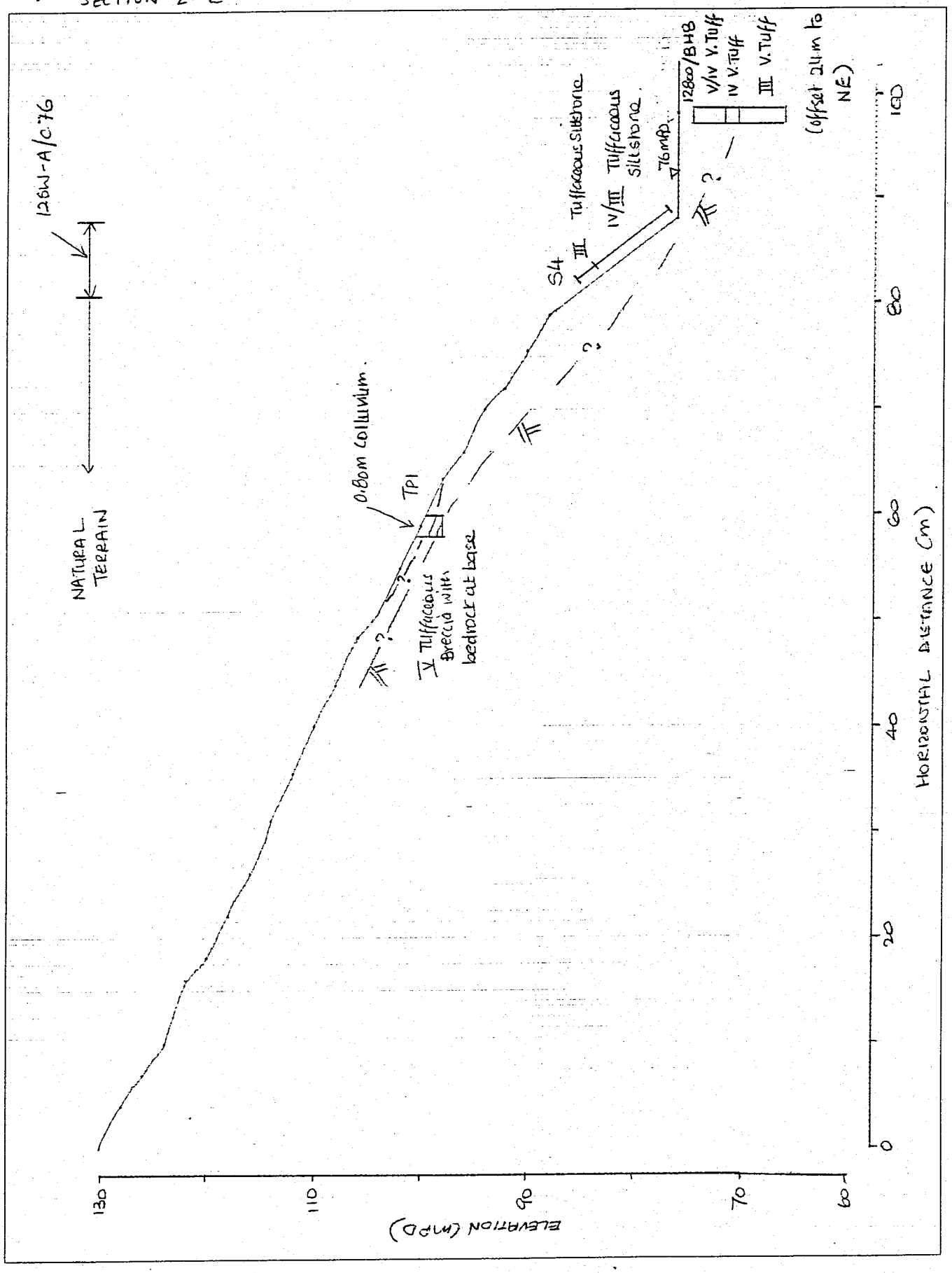
Binnie

Project AGREEMENT NO. FD01 - 052
TSEUNG KWAN O LANDFILL STAGE II/III AFFORESE DEVELOPMENT

Subject SECTION L-L

Job number 382311/0201

Page of



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Checked by

Distribution

Filed in

SCALE : 1:500

Date 08/02

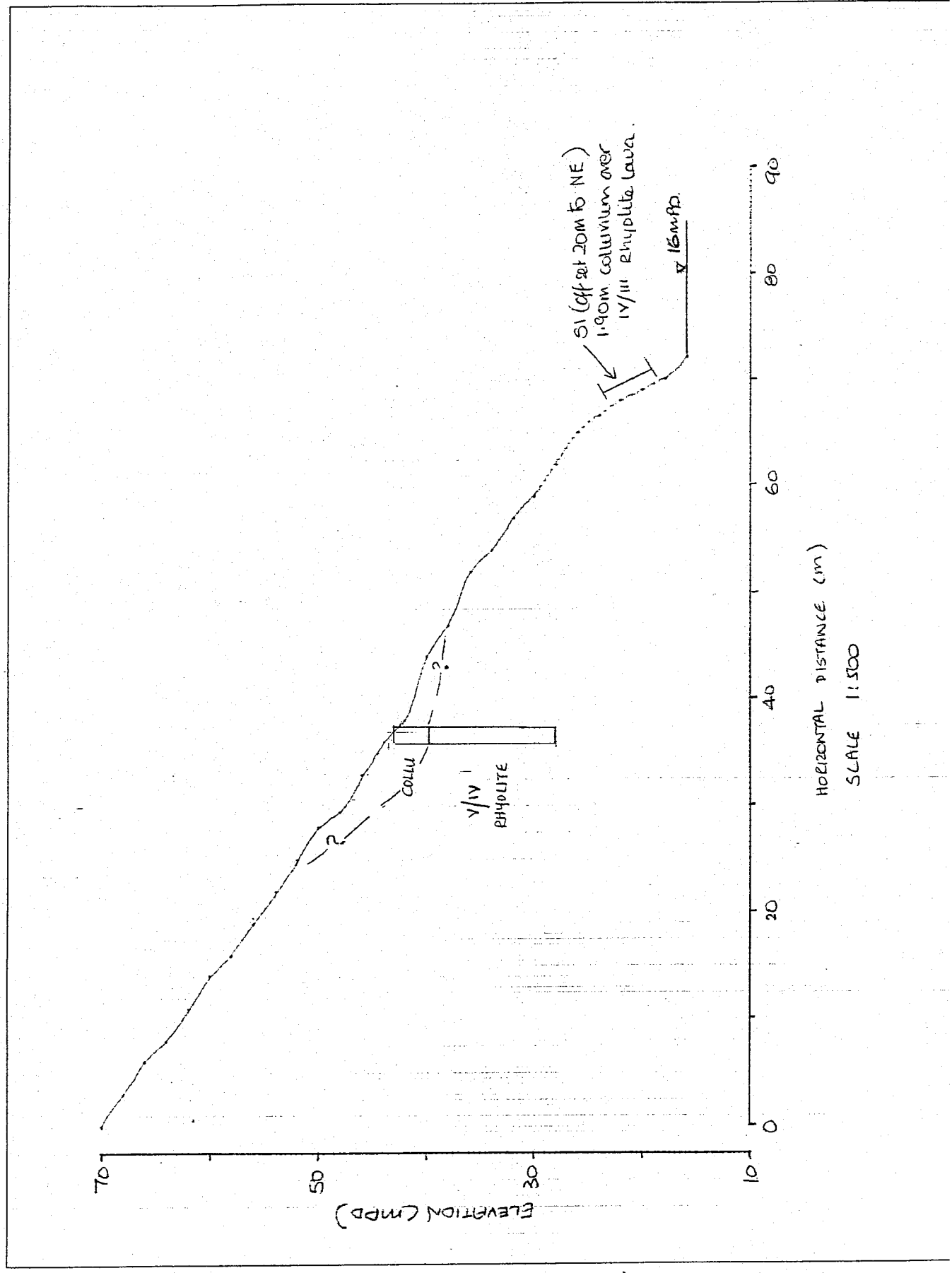
Date

Binnie Black & Veatch Hong Kong Limited
Engineers and Scientists

Project AGREEMENT NO. FD01-052 TSEUNG KWAN O LANDFILL STAGE II/III AFTERUSE DEVELOPMENT

Subject SECTION M-M

Job number 382311/0201 Page of



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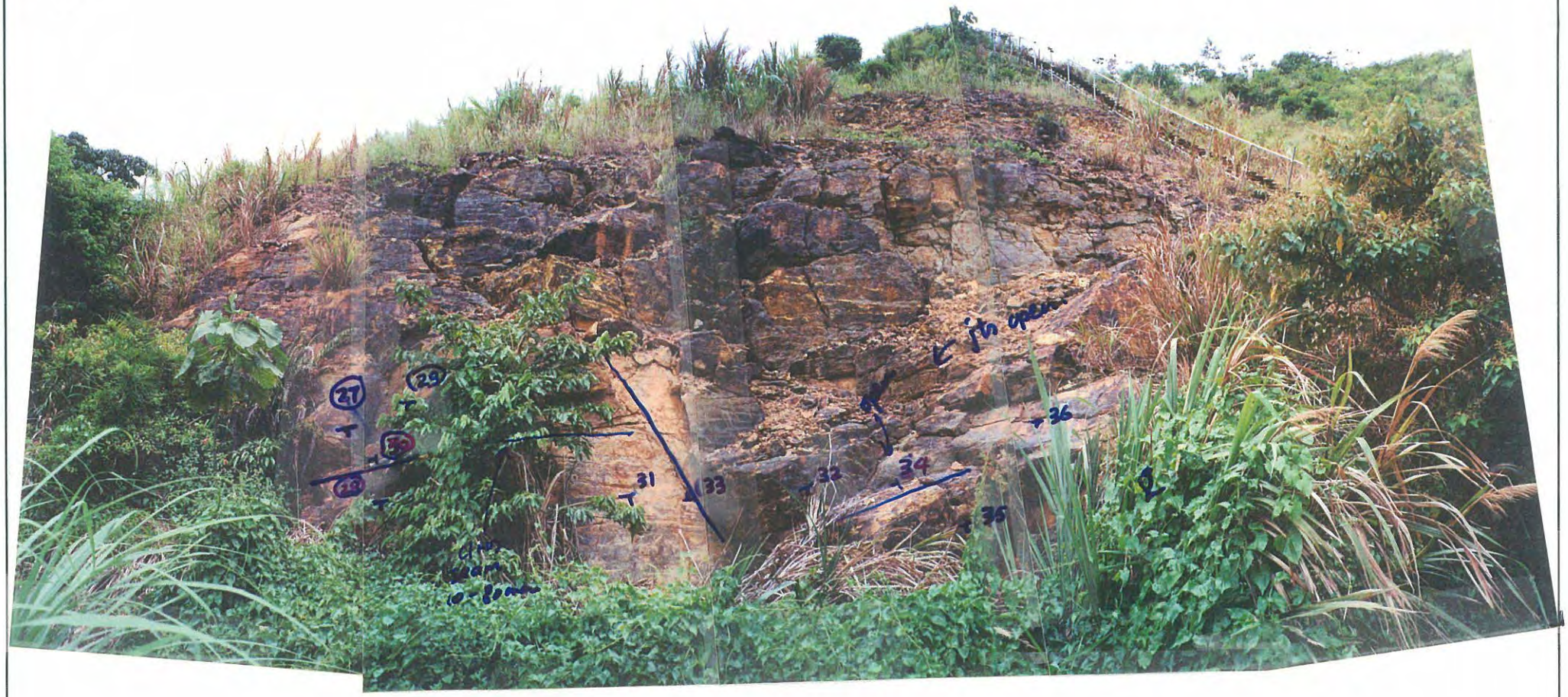
Date 08/02 Date

Subject	Prepared	Checked	
Feature No. 12SW-A/C174 (Along Strip S7)	Smo	KWK	Binnie
Project	**Date**	**Scale**	**Photo No.**
Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development	Jul-02	N/A	1

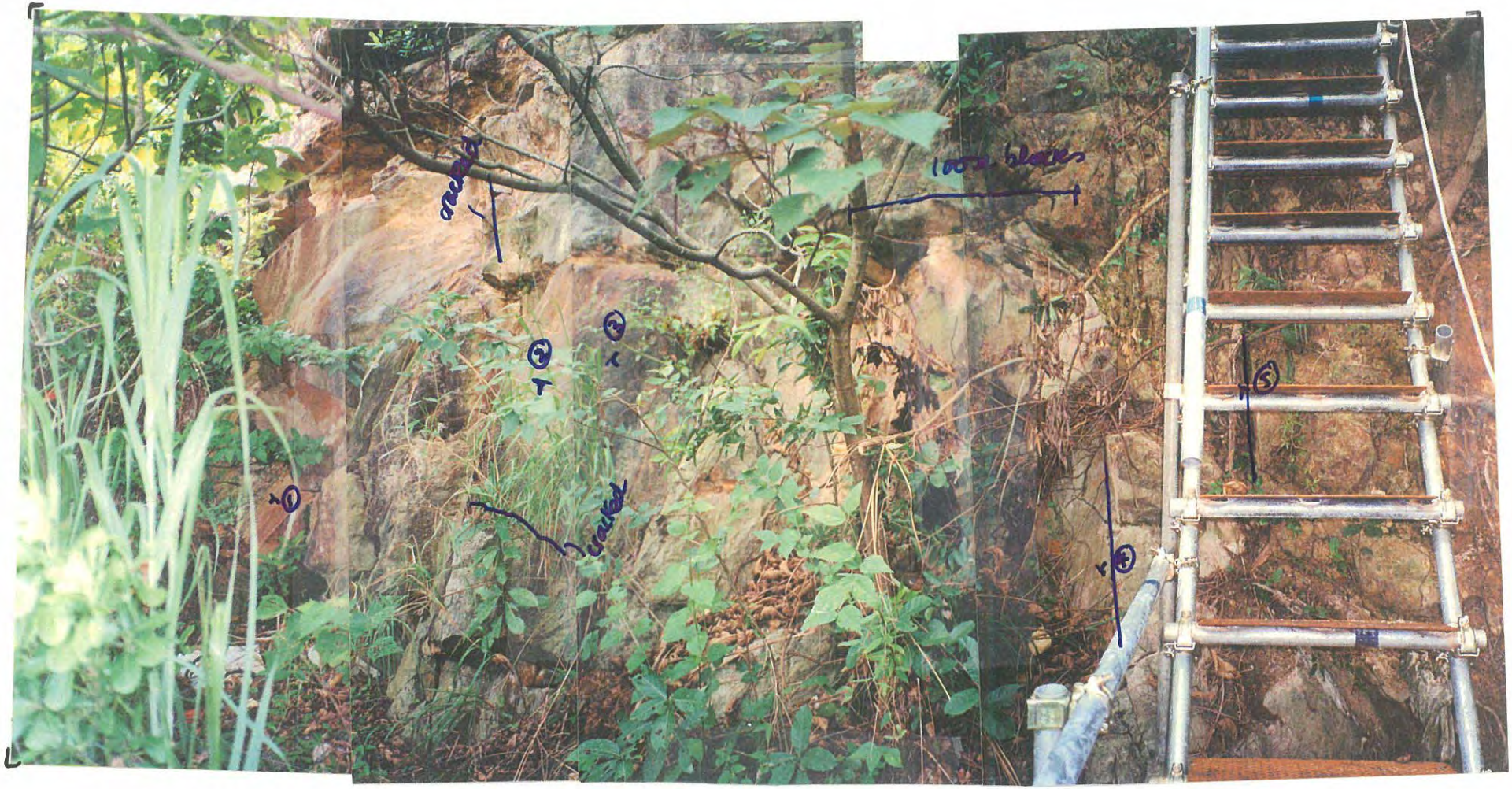
Subject		Prepared	Checked	
	Feature No. 12SW-A/C174 (Along Strip S7)	Smo	KWK	Binnie
Project		Date	Scale	Photo No.
	Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development	Jul-02	N/A	2



Subject		Prepared	Checked	
	Feature No. 12SW-A/C174 (Along Strip S7)	Smo	KWK	Binnie
Project		Date	Scale	Photo No.
	Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development	Jul-02	N/A	3

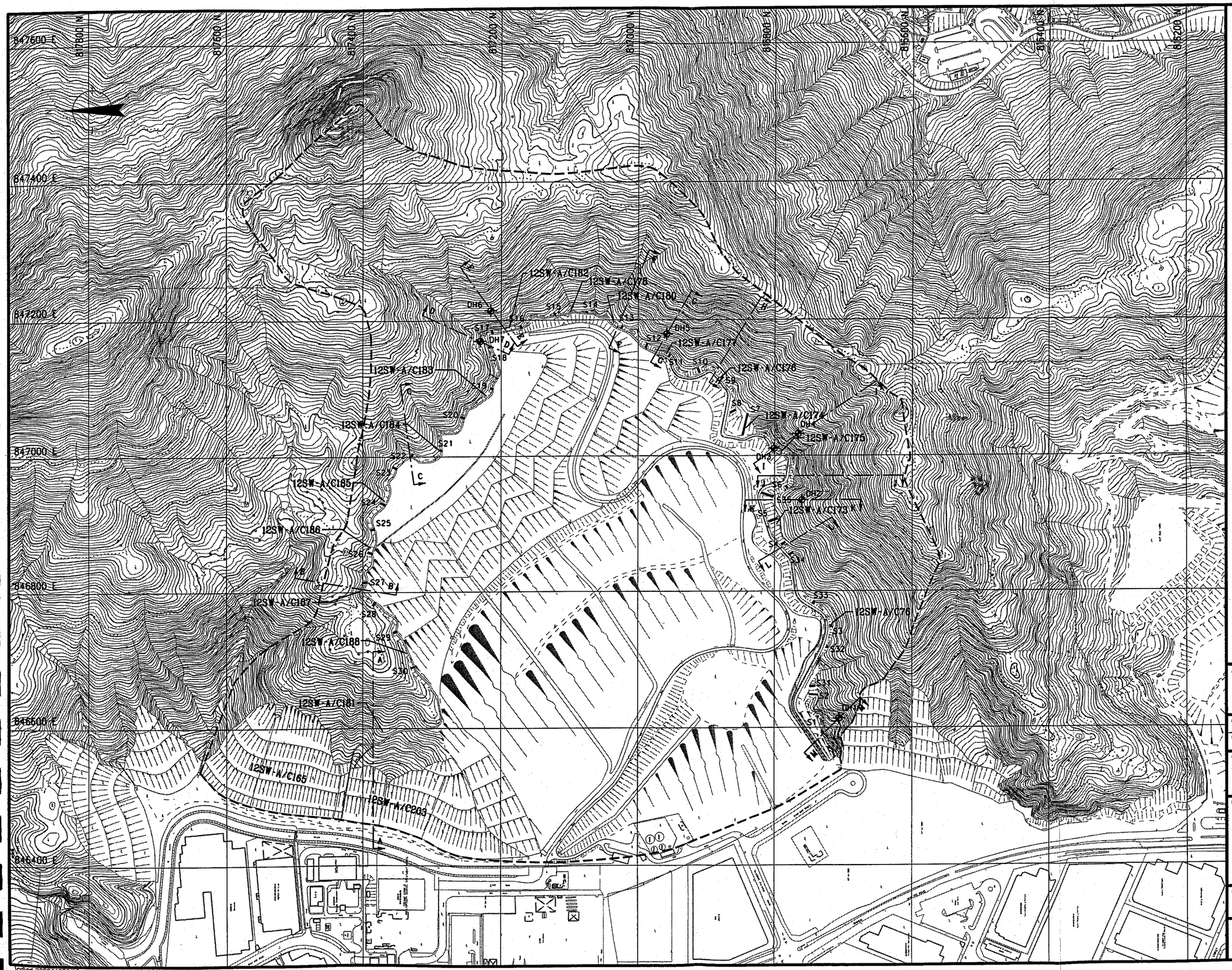
Subject	Prepared	Checked	
FEATURE NO. 12SW-A/C174 (along Strip S8)	Smo	KWK	Binnie
Project	**Date**	**Scale**	**Photo No.**
Agreement No. FD01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development	7 / 2002	N/A	4

Subject		Prepared	Checked	Binnie
	FEATURE NO. 12SW-A/C174 (along Strip S8)	Smo	KWK	
Project		Date	Scale	Photo No.
	Agreement No. FD01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development	7 / 2002	N/A	5



Subject: Feature No. 12SW-A/C76 (Along Strip S33)	Prepared: Smo	Checked: KWK	Binnie
Project: Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Jul-02	Scale: N/A	Photo No.: 6

APPENDIX C
Stability Analyses of Soil Slopes



NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.
2. ALL LEVELS ARE IN METRES ABOVE PRINCIPAL DATUM.
3. ALL DIMENSIONS ARE TYPICAL AND TO BE CONFIRMED AT DETAILED DESIGN.

LEGENDS:

DH1 — RECENT DRILLHOLES

S1 — RECENT SLOPE STRIPPING AND LOCATION OF GEOLOGICAL SECTION FOR CUT SLOPE

STUDY BOUNDARY

Approved

CAD ref. MAIN : FIGURE-C1.DGN
XREF : B12SW06B.D, B12SW01B.D, B12SW02A,B,C,D & B12SW07A,B,C,D.DGN

Contract no. FD01-052

Contract
GEOTECHNICAL REVIEW AND SITE INVESTIGATION WORKS FOR TSEUNG KWAN O STAGE II/III AFTERUSE DEVELOPMENT

Figure Title
LOCATIONS OF GEOLOGICAL SECTIONS FOR STABILITY ANALYSIS OF CUT SLOPES

Figure no. C1

Scale 1 : 5000

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博威工程顧問有限公司

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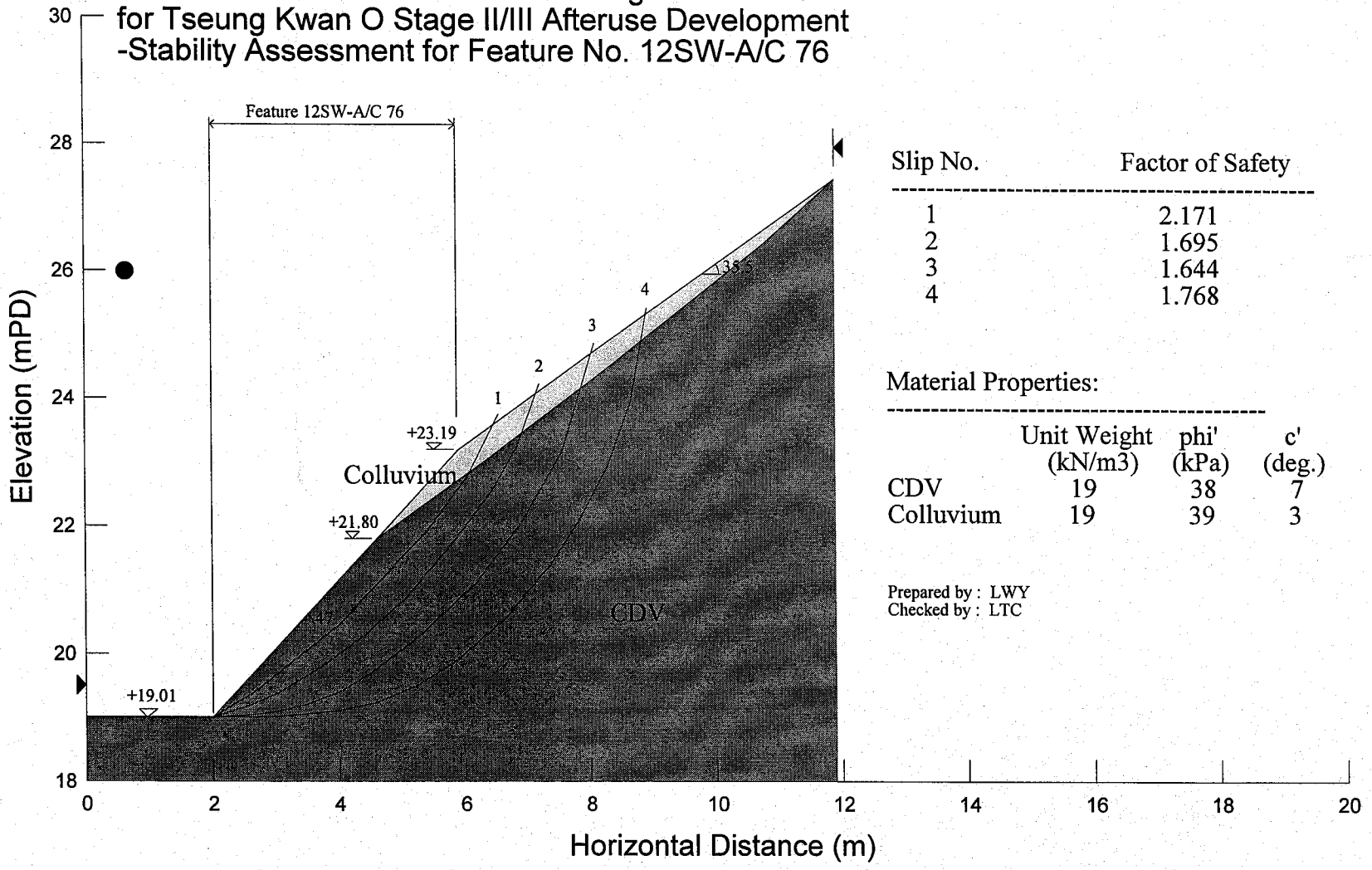
Geotechnical Review and Site Investigation Works
for Tseung Kwan O Stage II/III Afteruse Development
-Stability Assessment for Feature No. 12SW-A/C 76



Slip No.	Factor of Safety
1	2.171
2	1.695
3	1.644
4	1.768

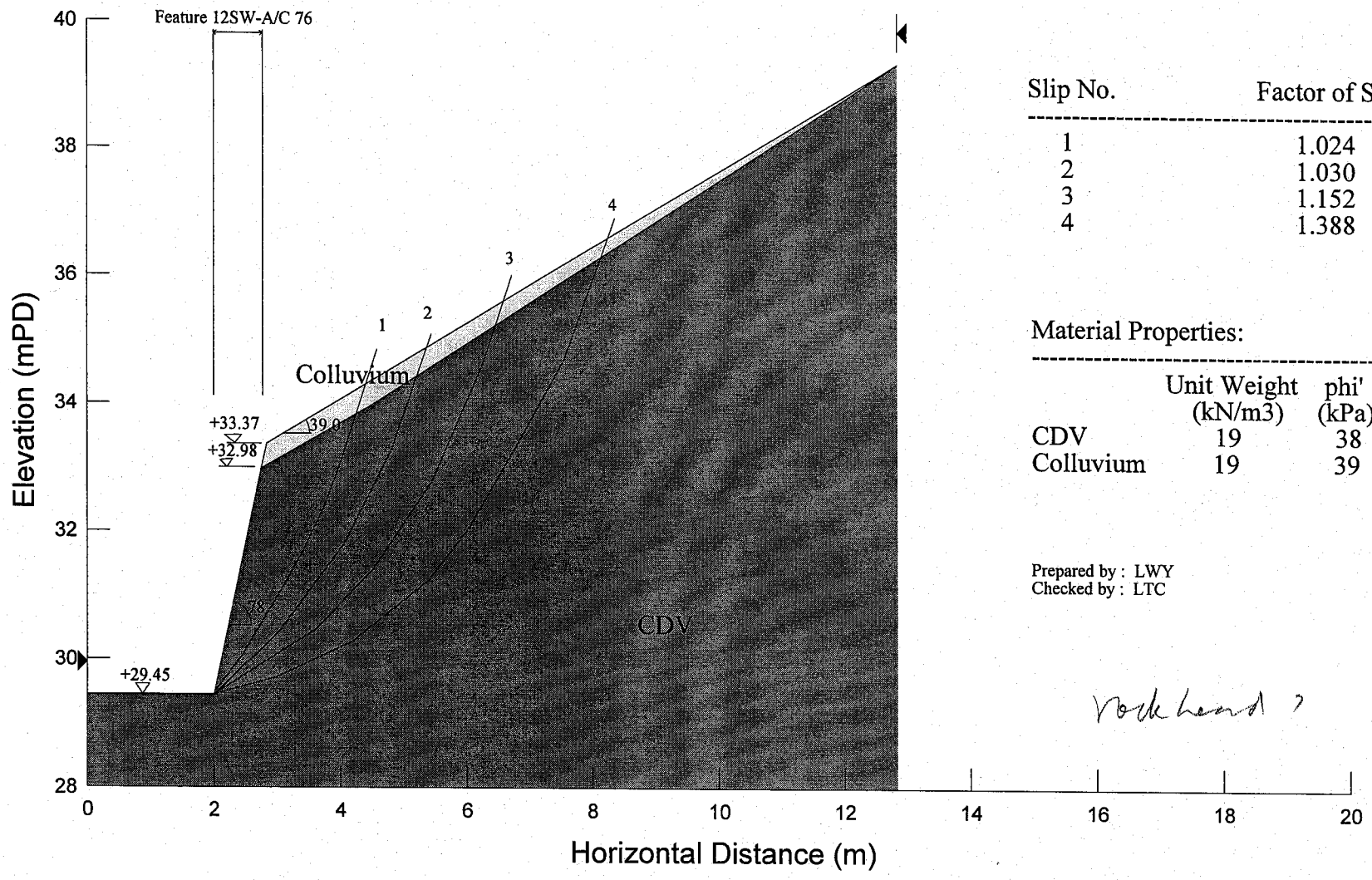
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	38	7
Colluvium	19	39	3

Prepared by : LWY
Checked by : LTC

Section SS1

Geotechnical Review and Site Investigation Works for Tseung Kwan O Stage II/III Afteruse Development -Stability Assessment for Feature No. 12SW-A/C 76



Slip No.	Factor of Safety
1	1.024
2	1.030
3	1.152
4	1.388

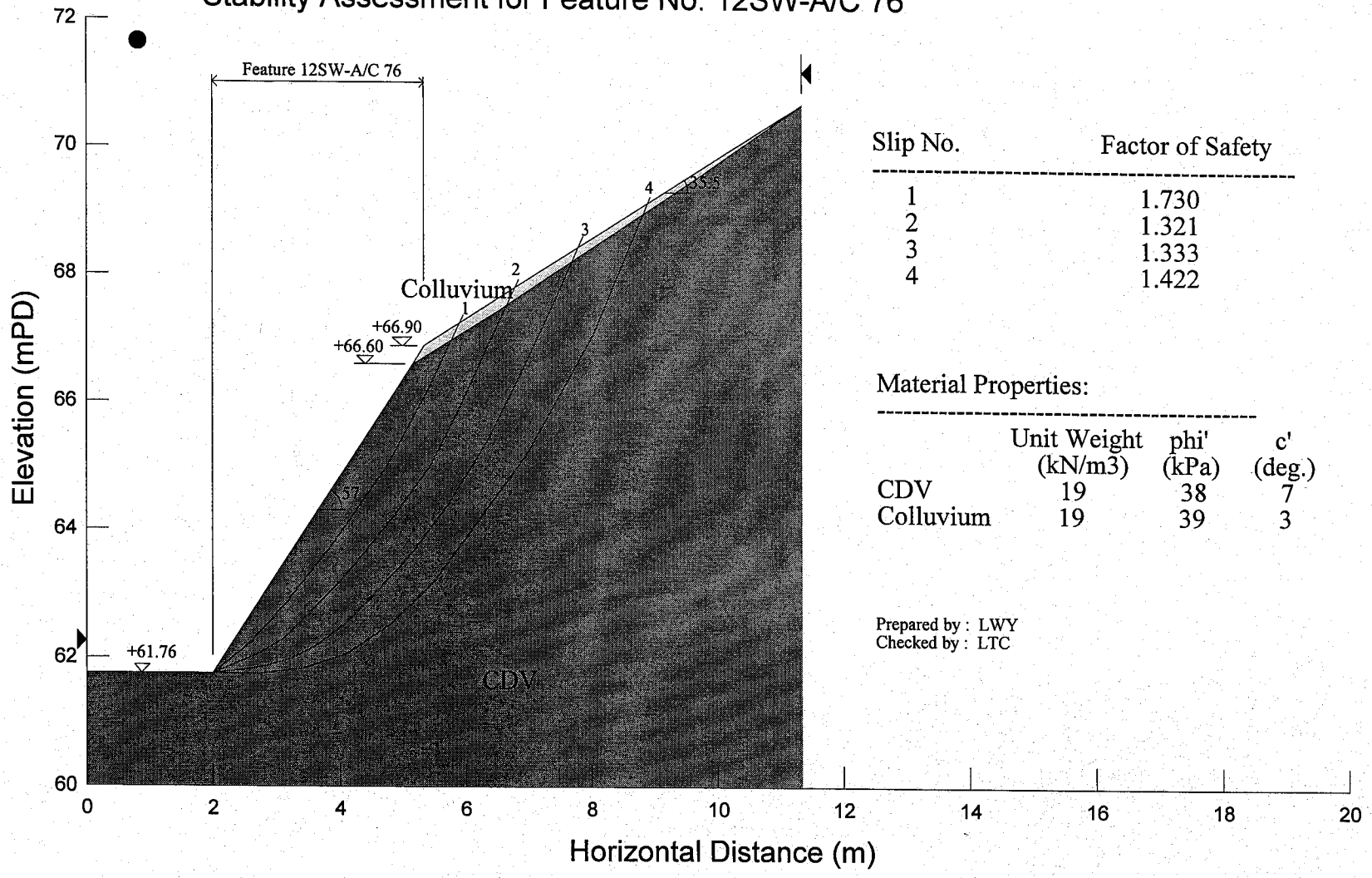
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	38	7
Colluvium	19	39	3

Prepared by : LWY
Checked by : LTC

Section SS2

Geotechnical Review and Site Investigation Works for Tseung Kwan O Stage II/III Afteruse Development -Stability Assessment for Feature No. 12SW-A/C 76



Slip No.	Factor of Safety
1	1.730
2	1.321
3	1.333
4	1.422

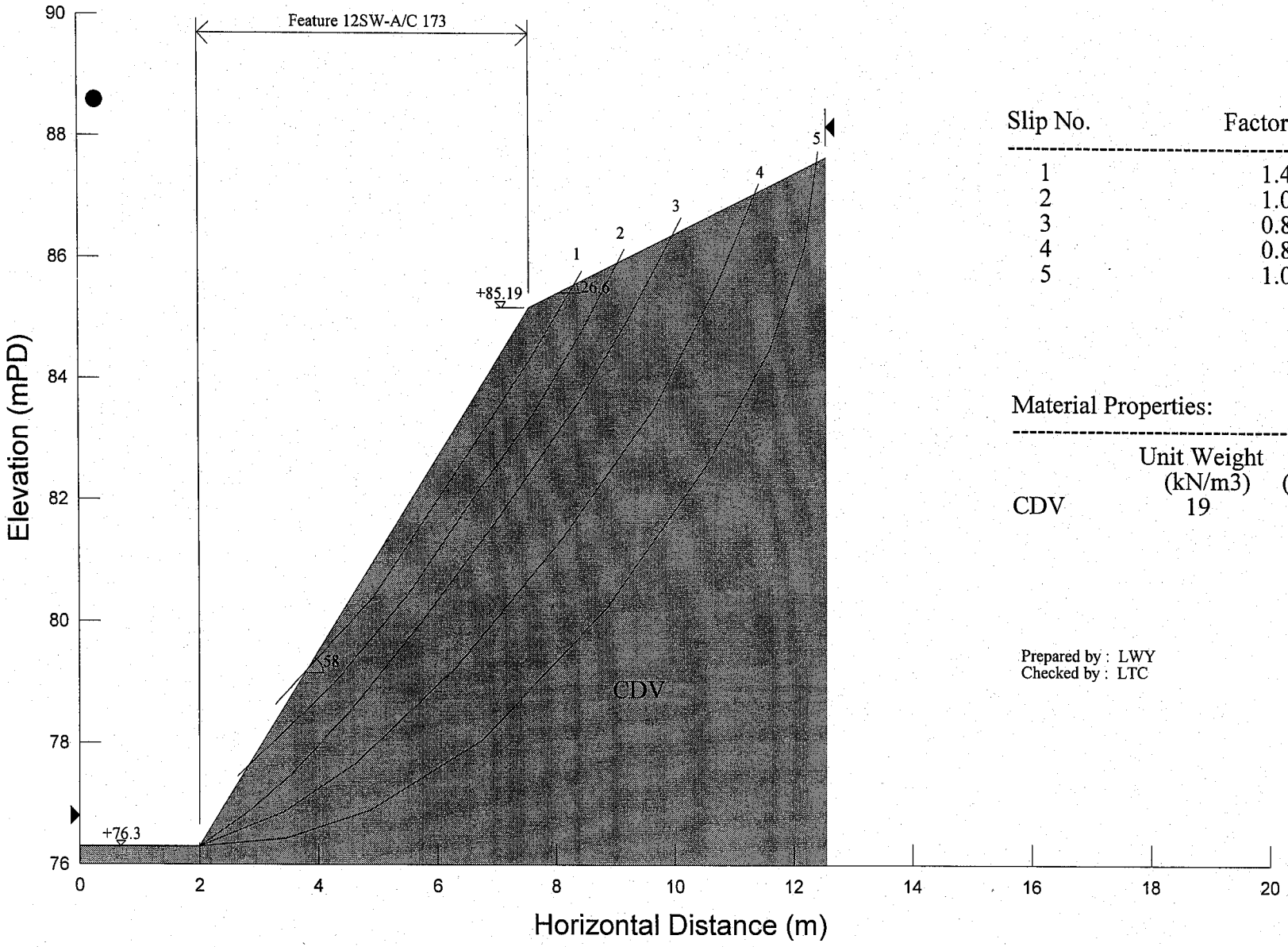
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	38	7
Colluvium	19	39	3

Prepared by : LWY
Checked by : LTC

Section SS3

Geotechnical Review and Site Investigation Works for Tseung Kwan O Stage II/III Afteruse Development -Stability Assessment for Feature No. 12SW-A/C 173



Slip No.	Factor of Safety
1	1.469
2	1.016
3	0.890
4	0.898
5	1.060

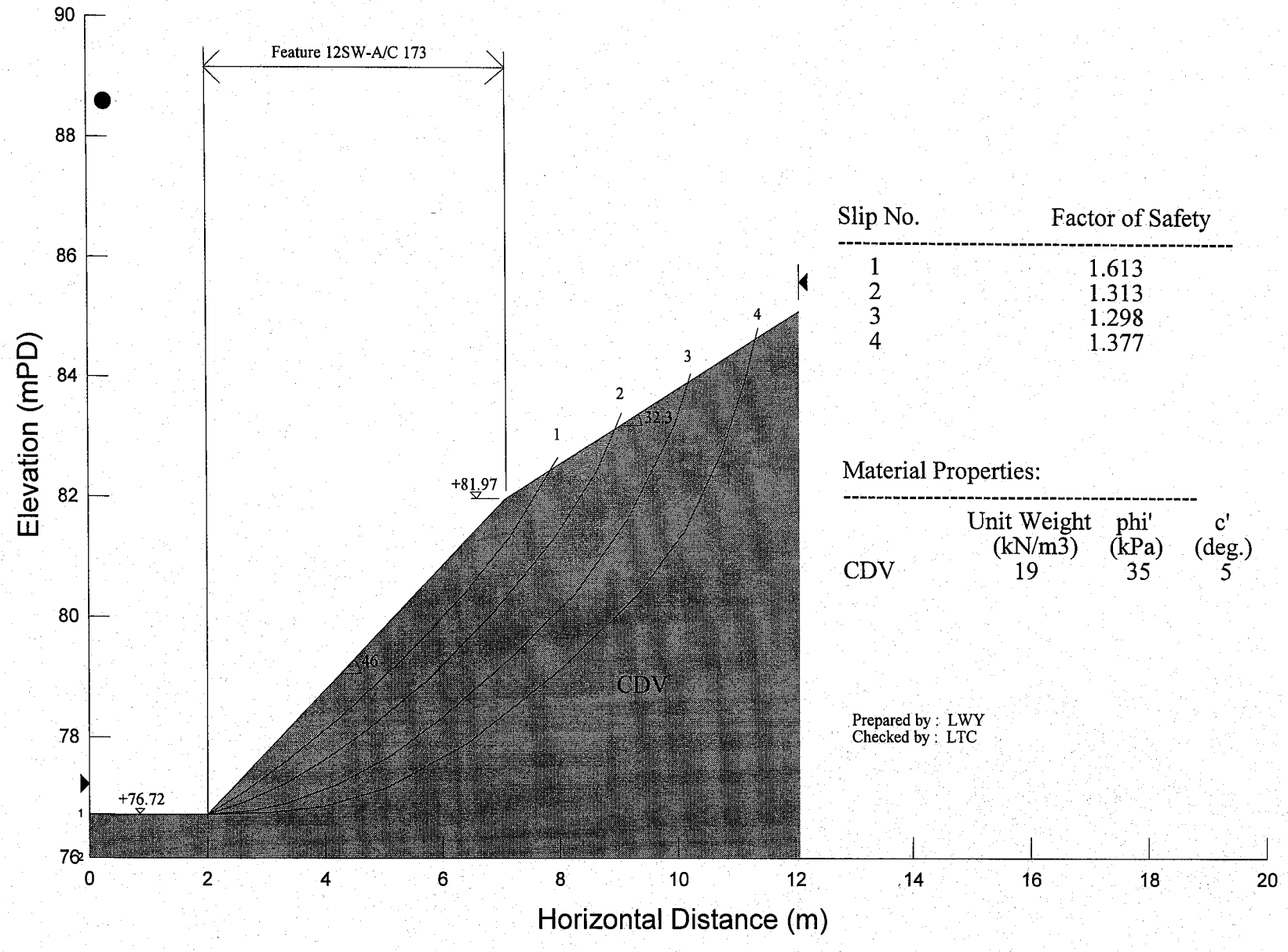
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	35	5

Prepared by : LWY
Checked by : LTC

Section SS4

Geotechnical Review and Site Investigation Works
for Tseung Kwan O Stage II/III Afteruse Development
-Stability Assessment for Feature No. 12SW-A/C 173



Slip No.	Factor of Safety
1	1.613
2	1.313
3	1.298
4	1.377

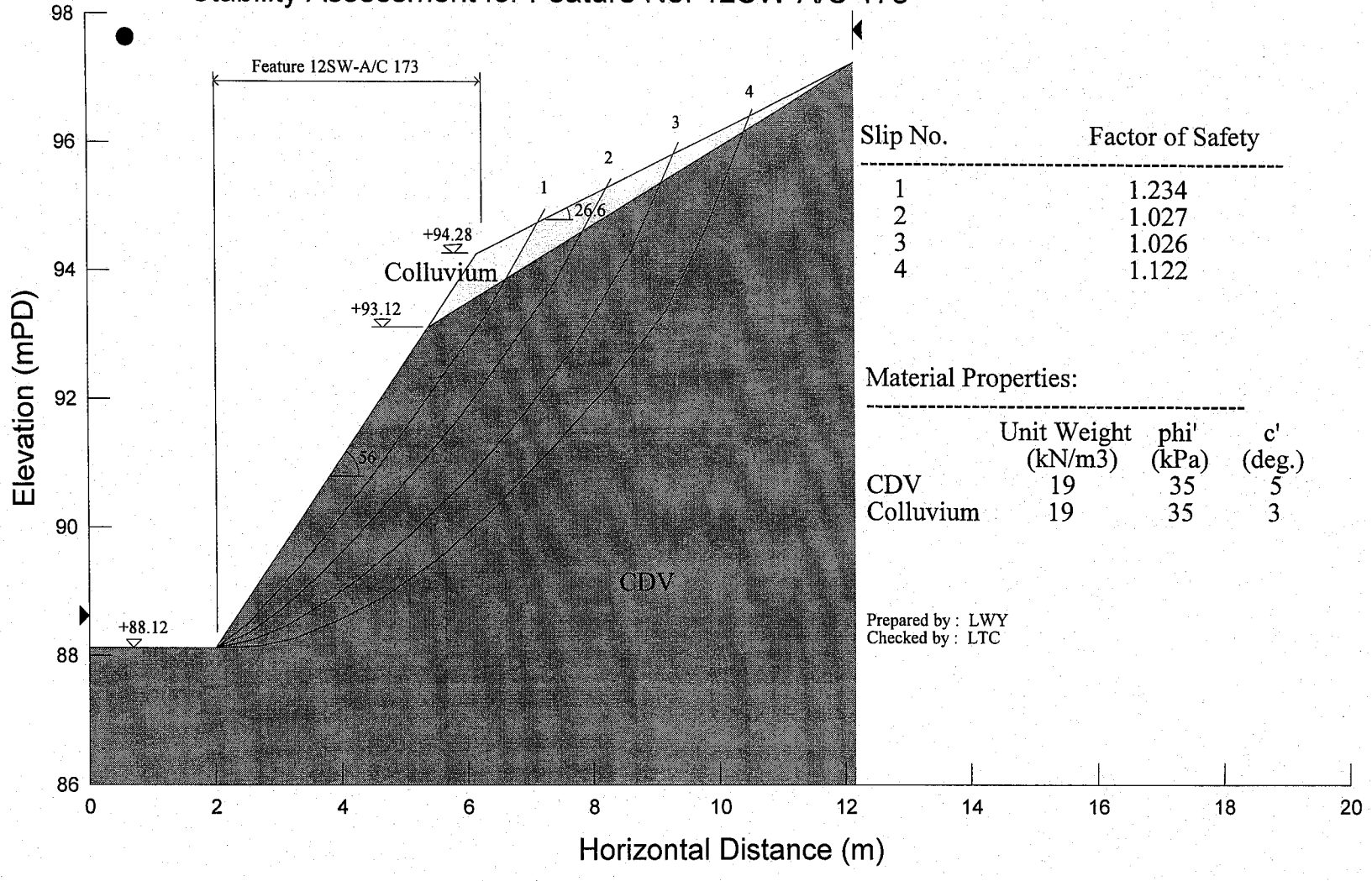
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	35	5

Prepared by : LWY
Checked by : LTC

Section SS5

Geotechnical Review and Site Investigation Works
for Tseung Kwan O Stage II/III Afteruse Development
-Stability Assessment for Feature No. 12SW-A/C 173



Slip No.	Factor of Safety
1	1.234
2	1.027
3	1.026
4	1.122

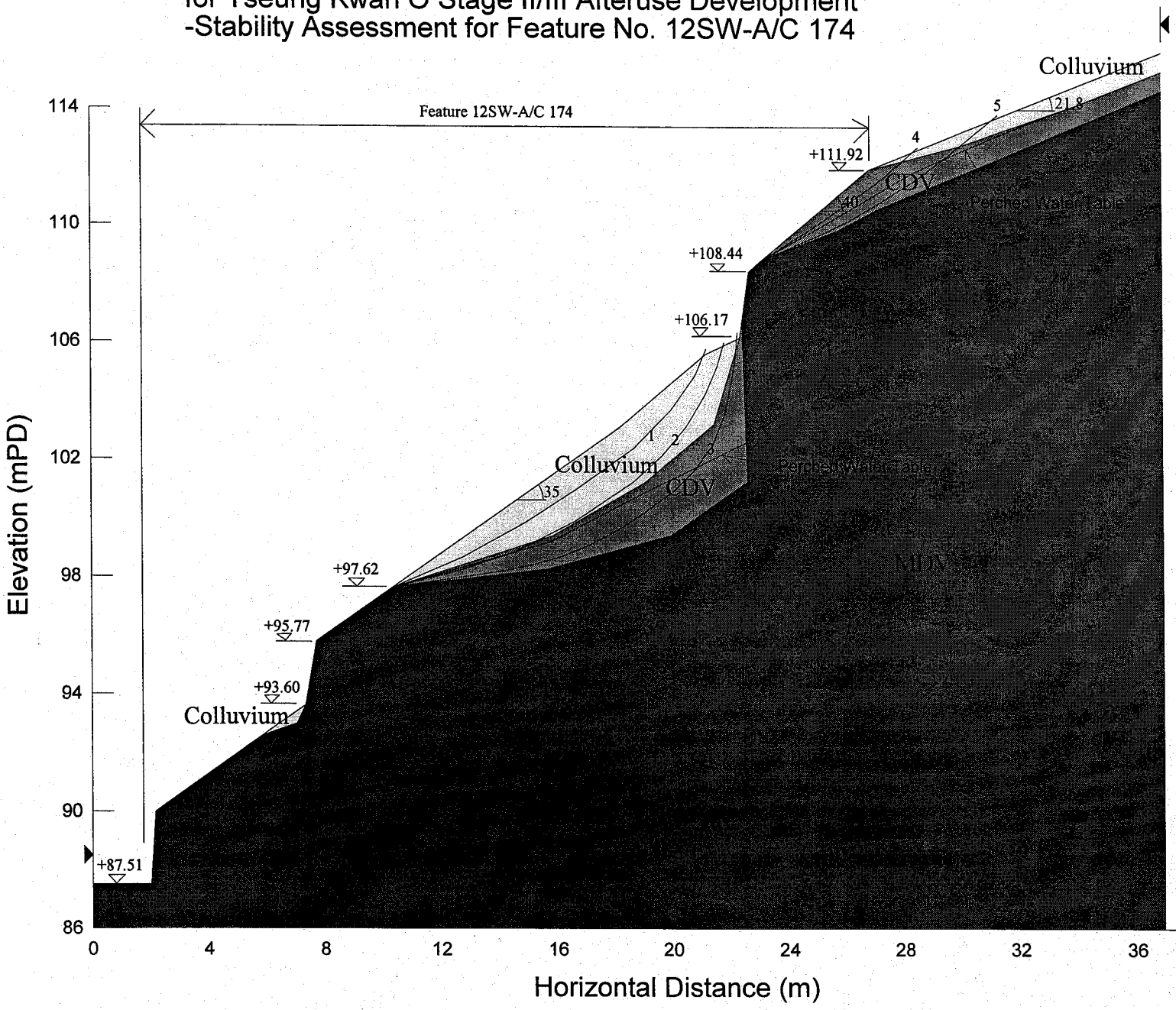
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	35	5
Colluvium	19	35	3

Prepared by : LWY
Checked by : LTC

Section SS6

Geotechnical Review and Site Investigation Works for Tseung Kwan O Stage II/III Afteruse Development -Stability Assessment for Feature No. 12SW-A/C 174



Slip No.	Factor of Safety
1	1.613
2	1.635
3	1.728
4	3.215
5	2.143

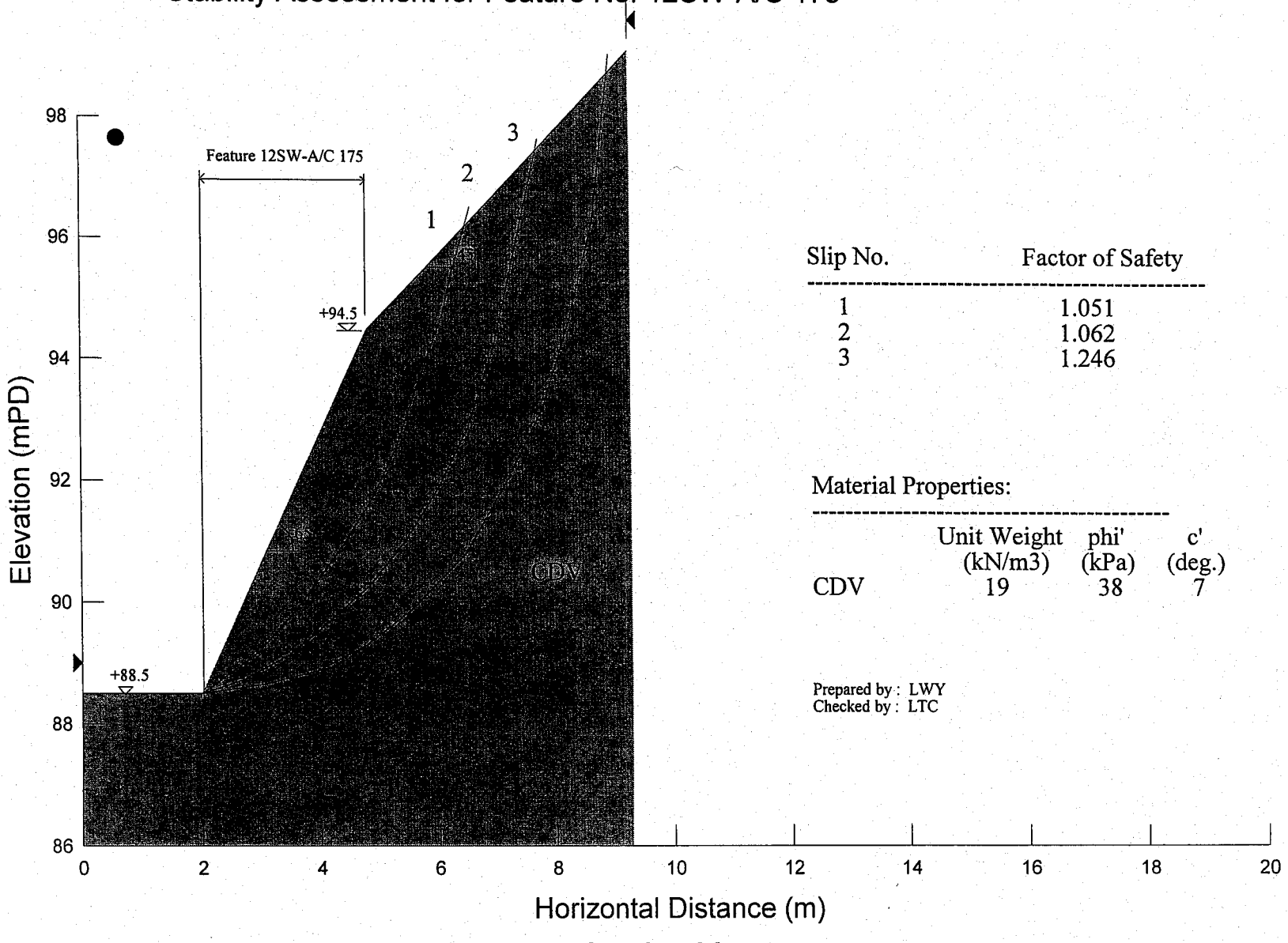
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.
CDV	19	38	7
Colluvium	19	39	3

Prepared by : LWY
Checked by : LTC

Section SS7

Geotechnical Review and Site Investigation Works for Tseung Kwan O Stage II/III Afteruse Development -Stability Assessment for Feature No. 12SW-A/C 175



Slip No.	Factor of Safety
1	1.051
2	1.062
3	1.246

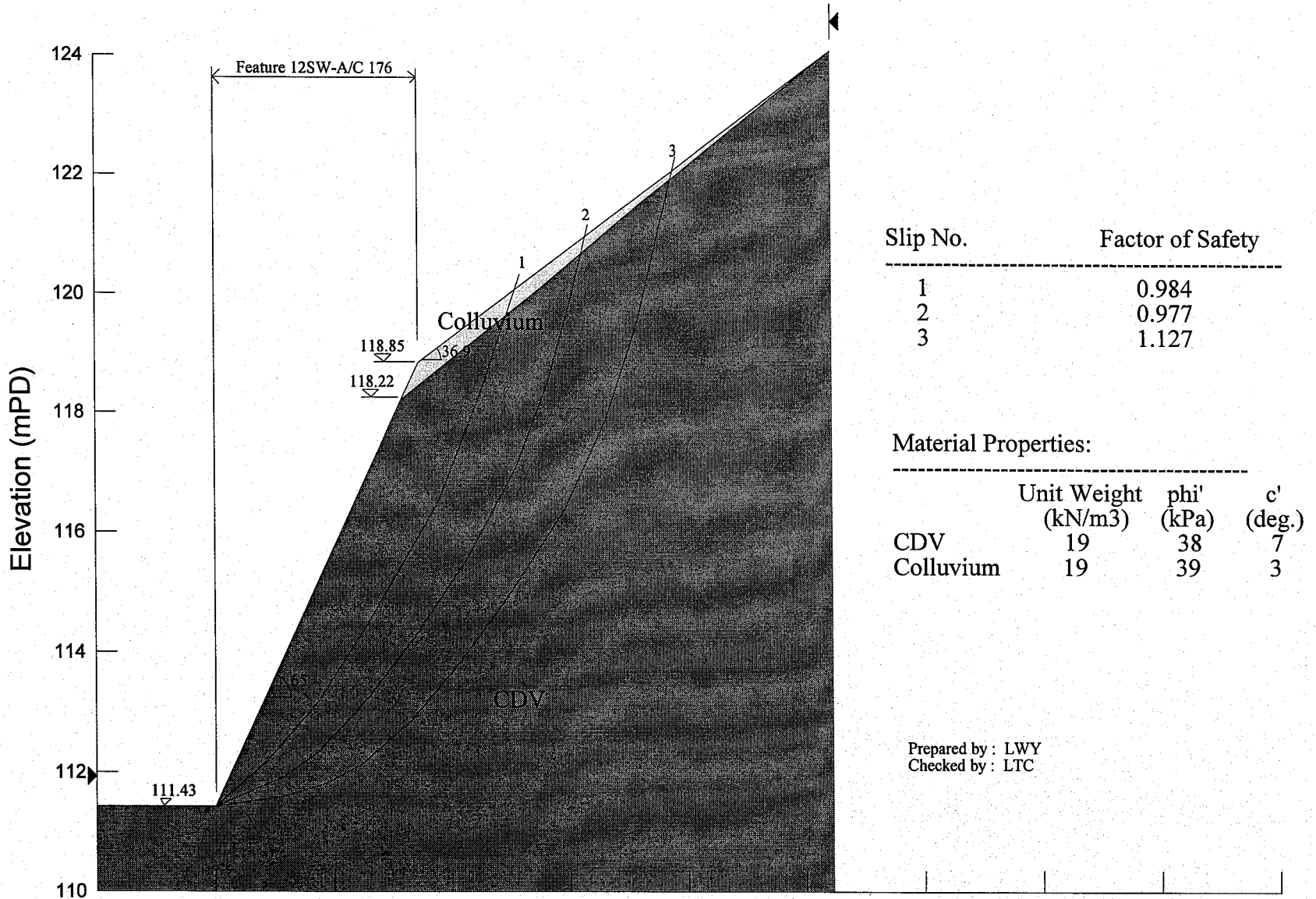
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	38	7

Prepared by : LWY
Checked by : LTC

Section I-I

Geotechnical Review and Site Investigation Works for Tseung Kwan O Stage II/III Afteruse Development -Stability Assessment for Feature No. 12SW-A/C 176



Slip No.	Factor of Safety
1	0.984
2	0.977
3	1.127

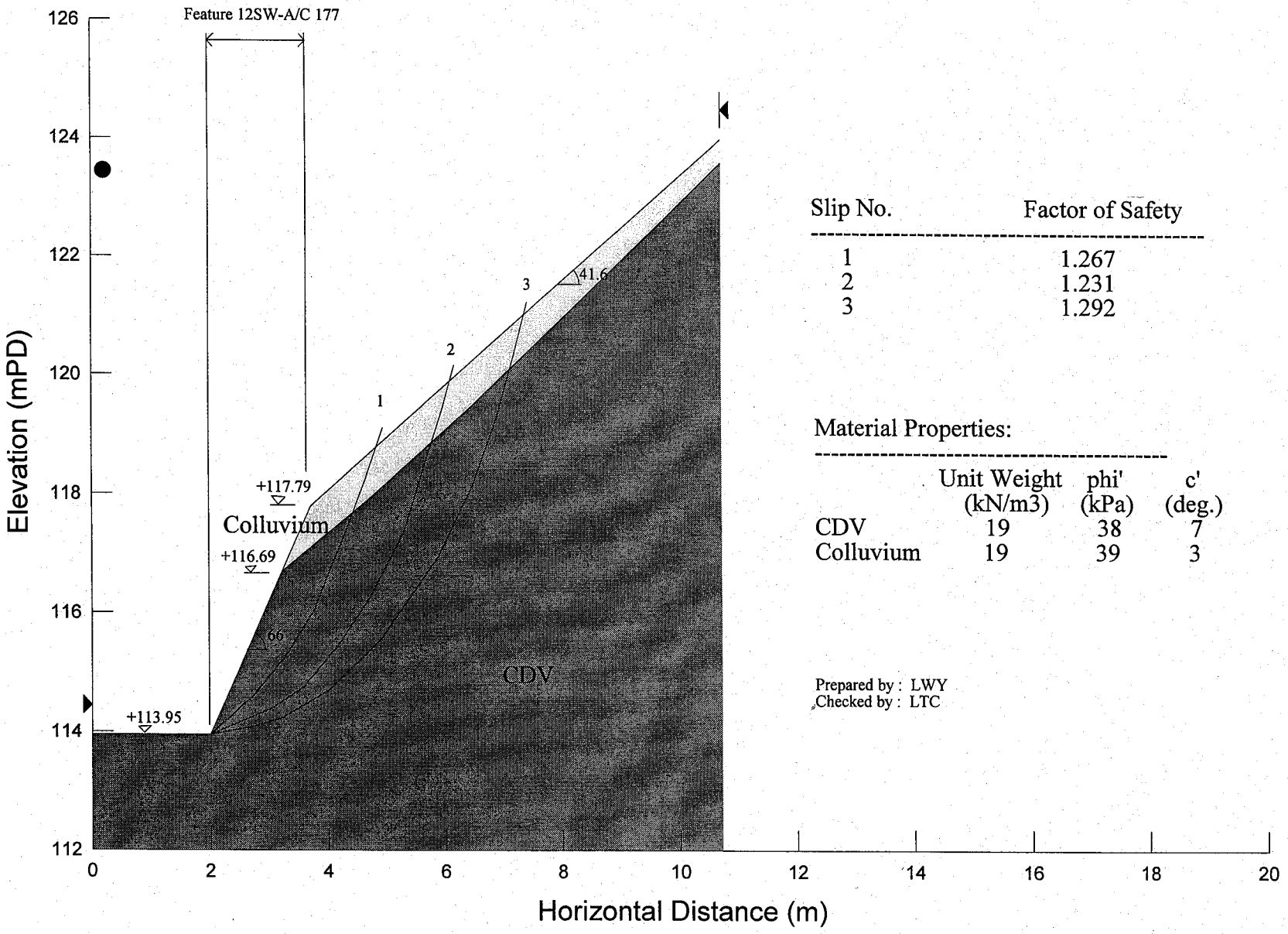
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	38	7
Colluvium	19	39	3

Prepared by : LWY
Checked by : LTC

Section SS9

Geotechnical Review and Site Investigation Works for Tseung Kwan O Stage II/III Afteruse Development -Stability Assessment for Feature No. 12SW-A/C 177



Slip No.	Factor of Safety
1	1.267
2	1.231
3	1.292

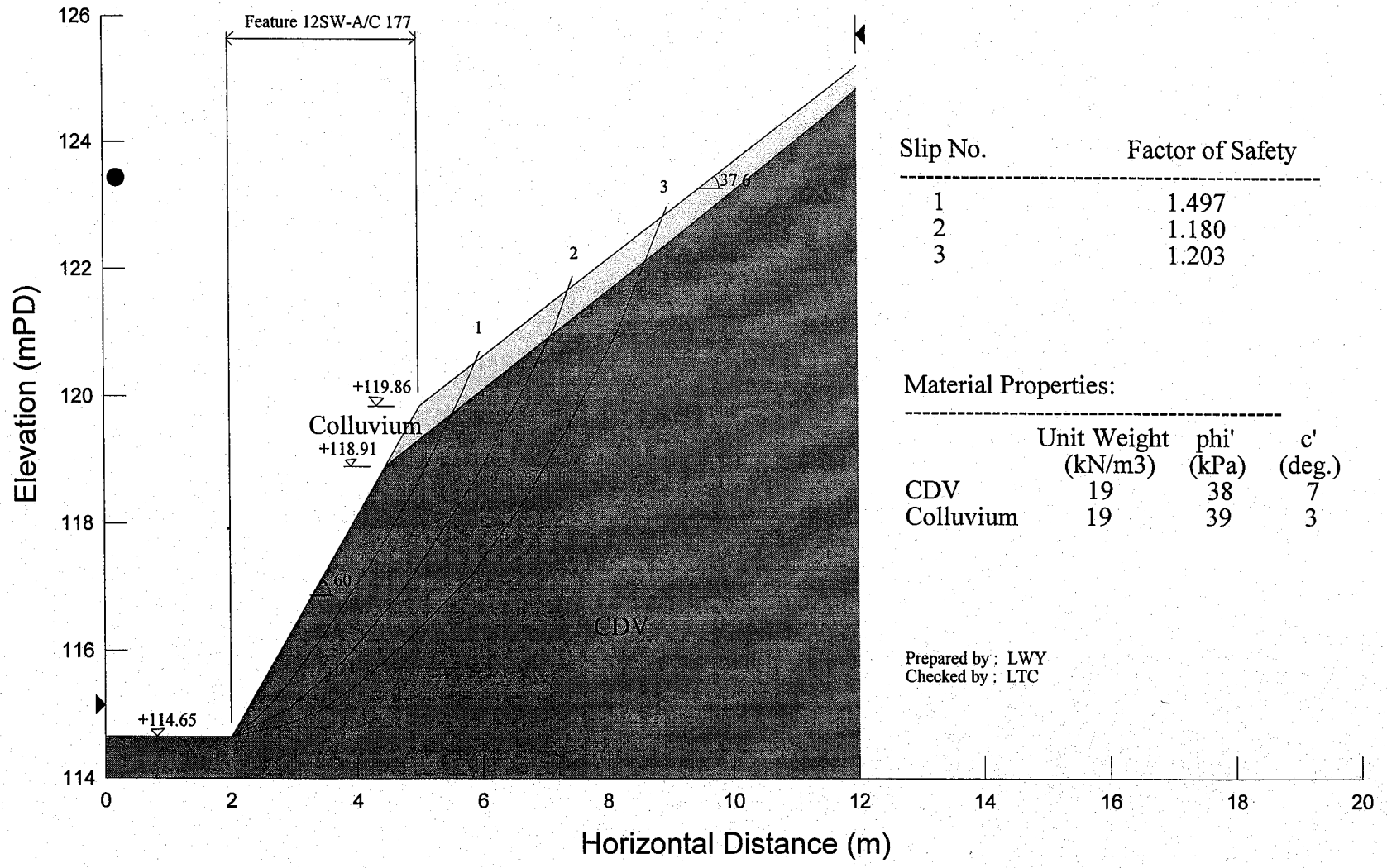
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	38	7
Colluvium	19	39	3

Prepared by : LWY
Checked by : LTC

Section SS10

Geotechnical Review and Site Investigation Works
for Tseung Kwan O Stage II/III Afteruse Development
-Stability Assessment for Feature No. 12SW-A/C 177



Slip No.	Factor of Safety
1	1.497
2	1.180
3	1.203

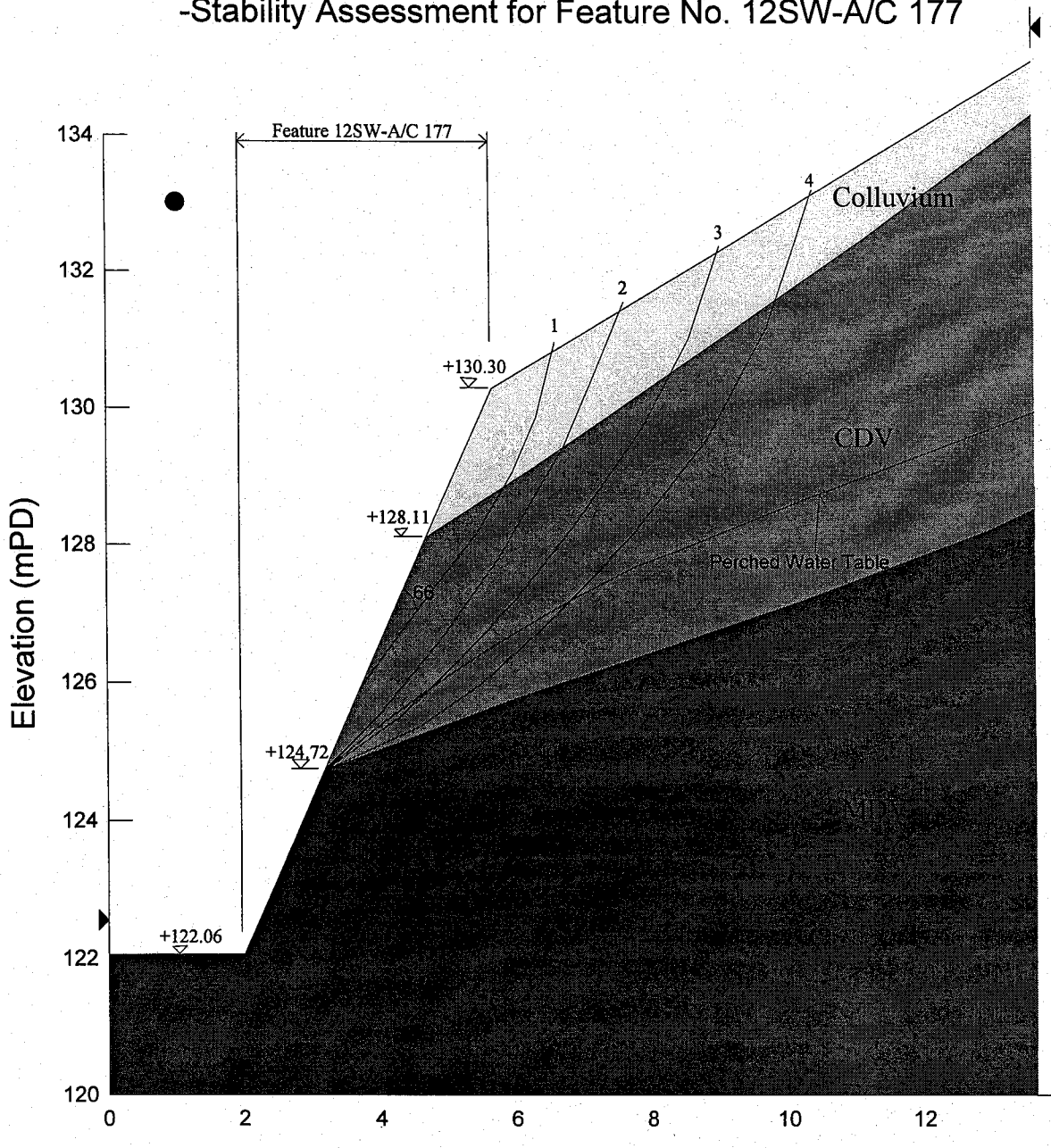
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	38	7
Colluvium	19	39	3

Prepared by : LWY
Checked by : LTC

Section SS11

Geotechnical Review and Site Investigation Works for Tseung Kwan O Stage II/III Afteruse Development -Stability Assessment for Feature No. 12SW-A/C 177



Slip No.	Factor of Safety
1	1.250
2	1.032
3	1.040
4	1.087

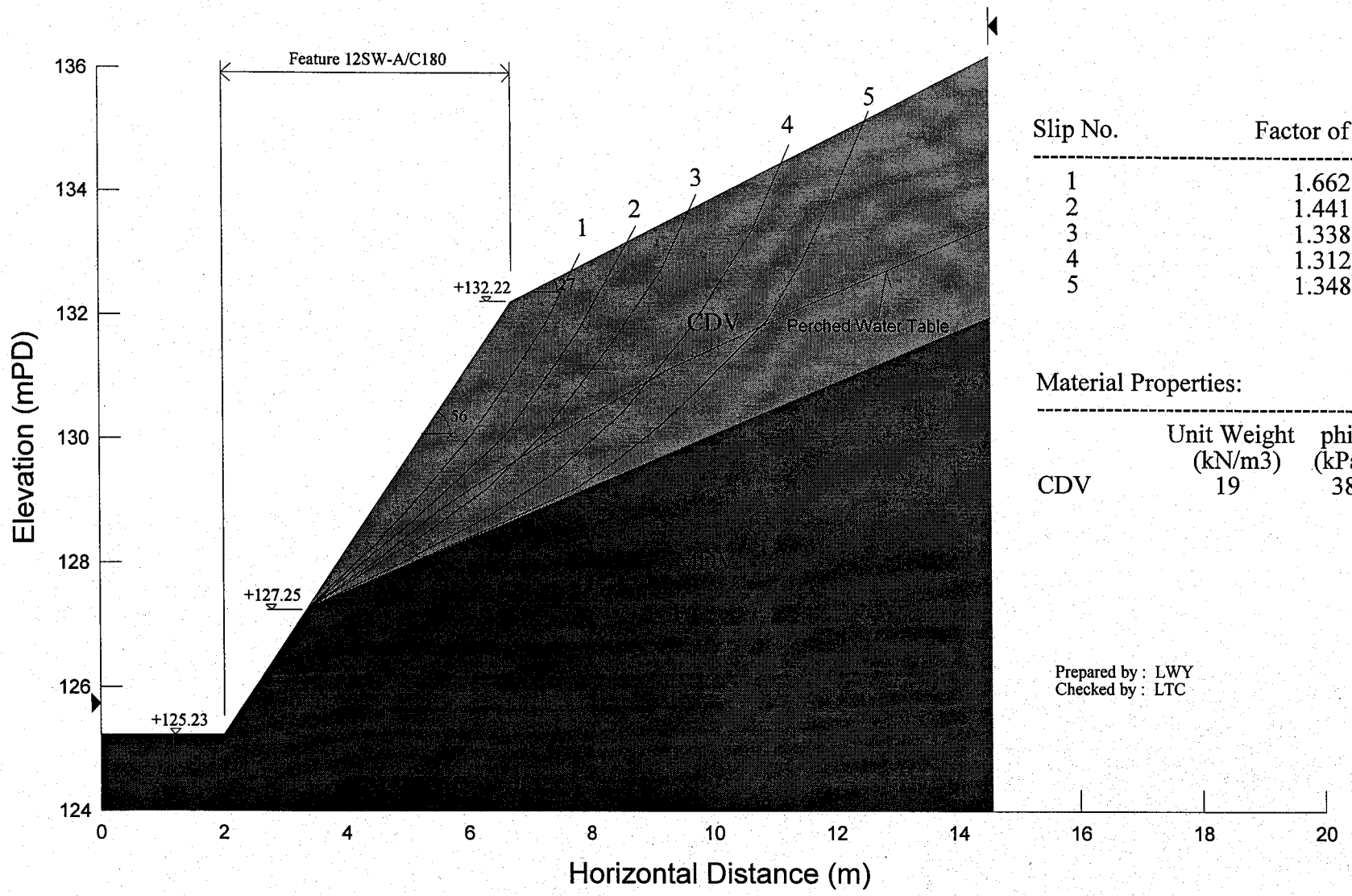
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	38	7
Colluvium	19	39	3

Prepared by : LWY
Checked by : LTC

Section SS12

Geotechnical Review and Site Investigation Works for Tseung Kwan O Stage II/III Afteruse Development -Stability Assessment for Feature No. 12SW-A/C 180



Slip No.	Factor of Safety
1	1.662
2	1.441
3	1.338
4	1.312
5	1.348

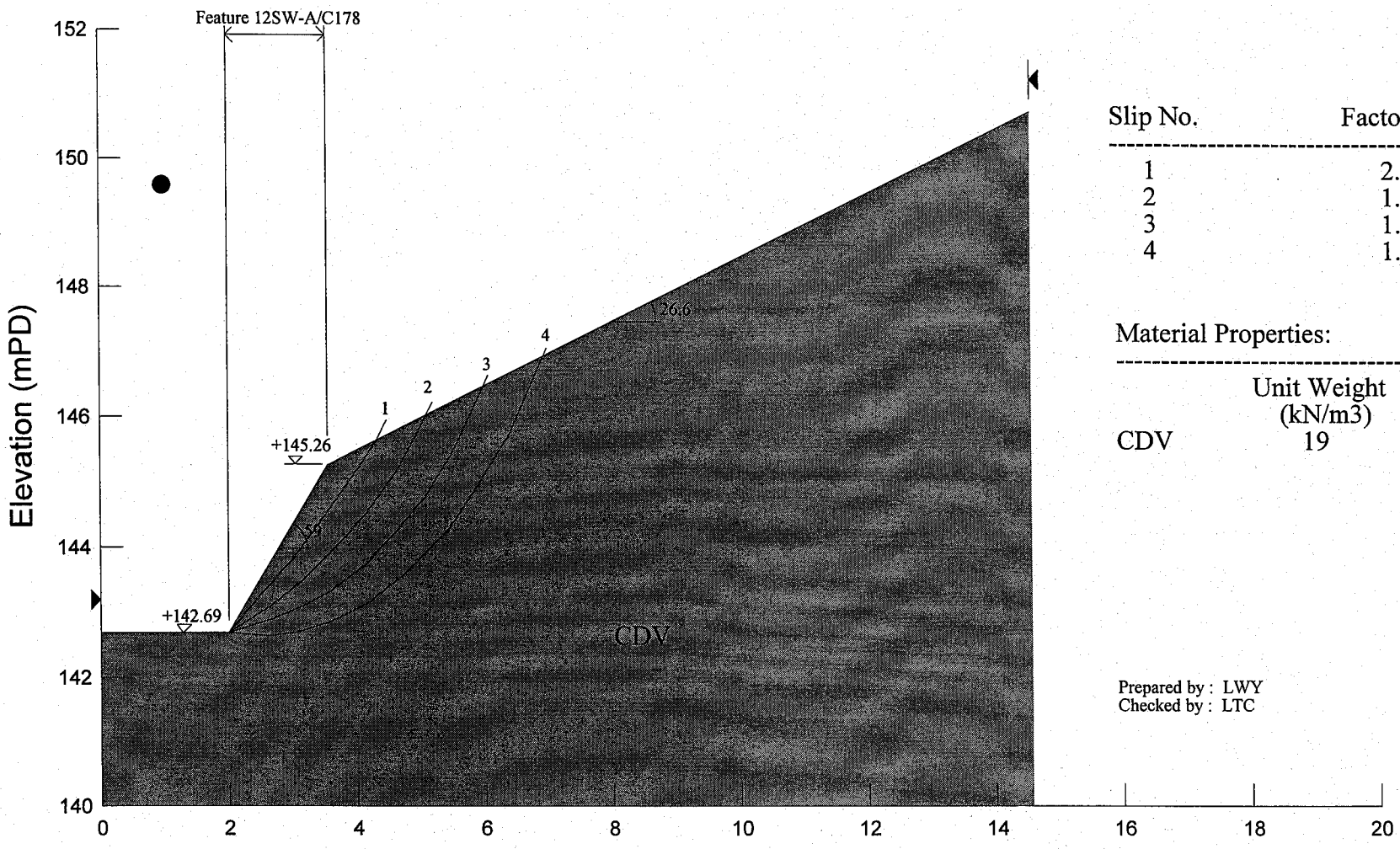
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	38	7

Prepared by : LWY
Checked by : LTC

Section SS13

Geotechnical Review and Site Investigation Works for Tseung Kwan O Stage II/III Afteruse Development -Stability Assessment for Feature No. 12SW-A/C 178



Slip No.	Factor of Safety
1	2.611
2	1.758
3	1.743
4	1.927

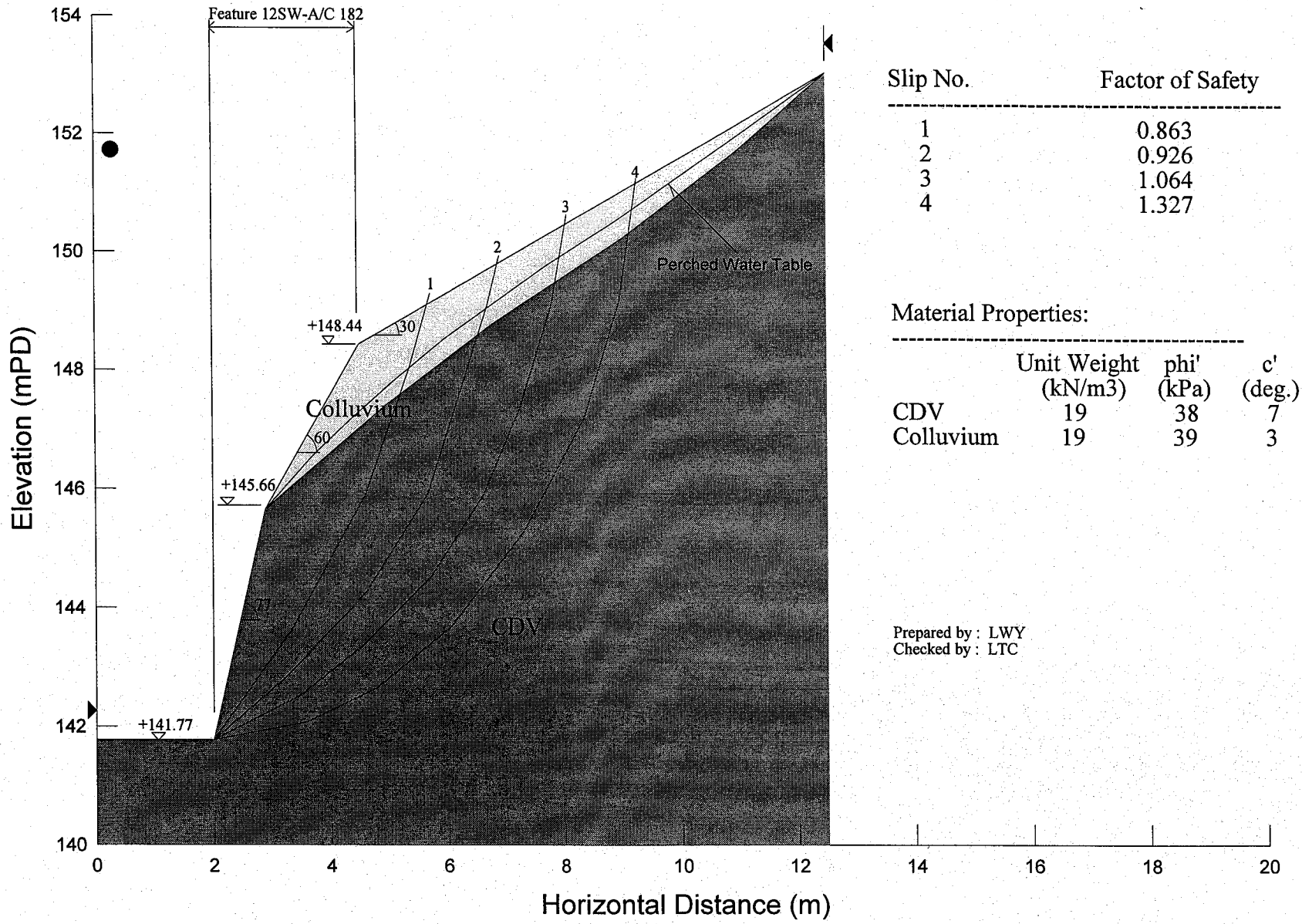
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	38	7

Prepared by : LWY
Checked by : LTC

Section SS15

Geotechnical Review and Site Investigation Works for Tseung Kwan O Stage II/III Afteruse Development -Stability Assessment for Feature No. 12SW-A/C 182



Slip No.	Factor of Safety
1	0.863
2	0.926
3	1.064
4	1.327

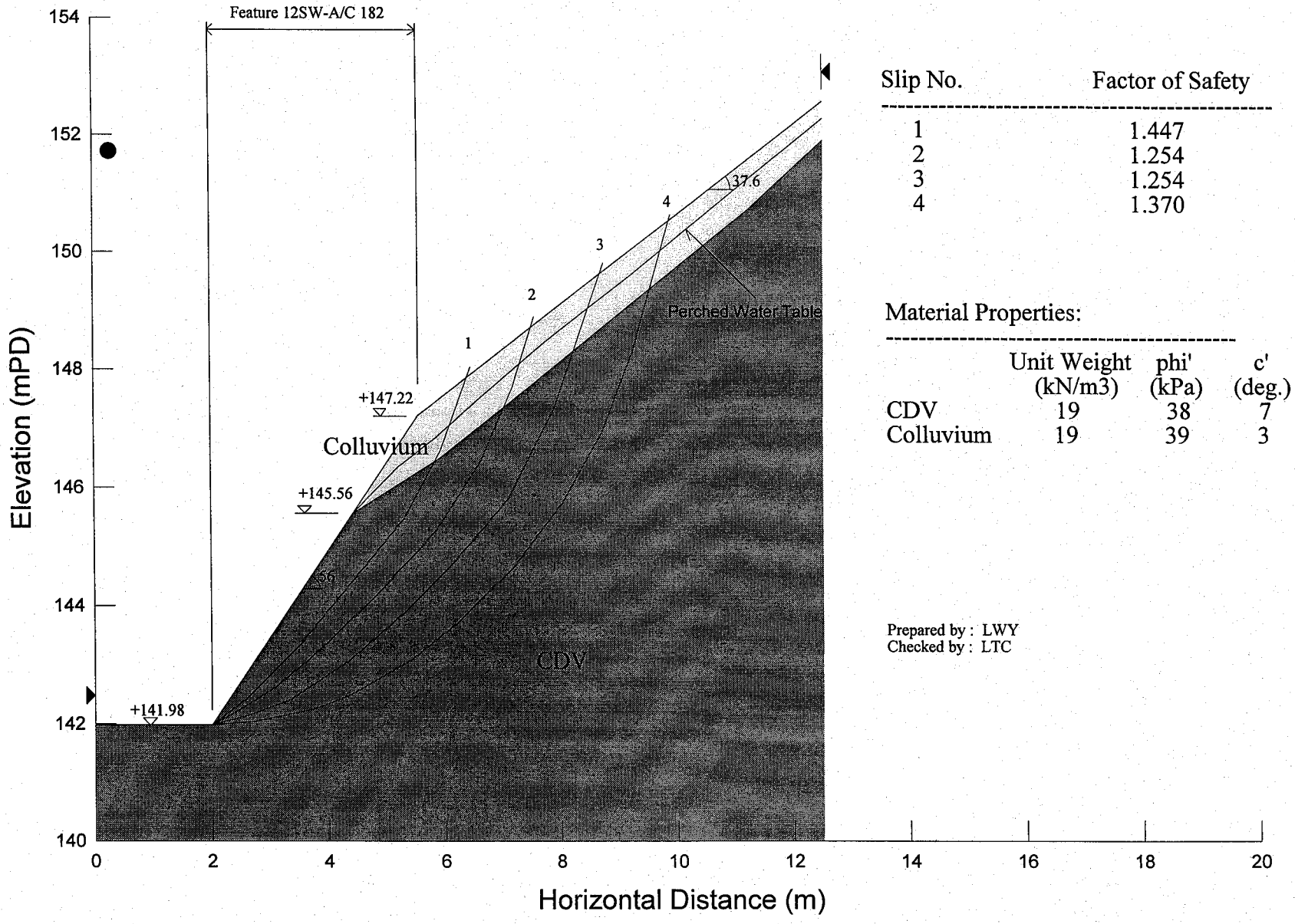
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	38	7
Colluvium	19	39	3

Prepared by : LWY
Checked by : LTC

Section SS16

Geotechnical Review and Site Investigation Works for Tseung Kwan O Stage II/III Afteruse Development -Stability Assessment for Feature No. 12SW-A/C 182



Slip No.	Factor of Safety
1	1.447
2	1.254
3	1.254
4	1.370

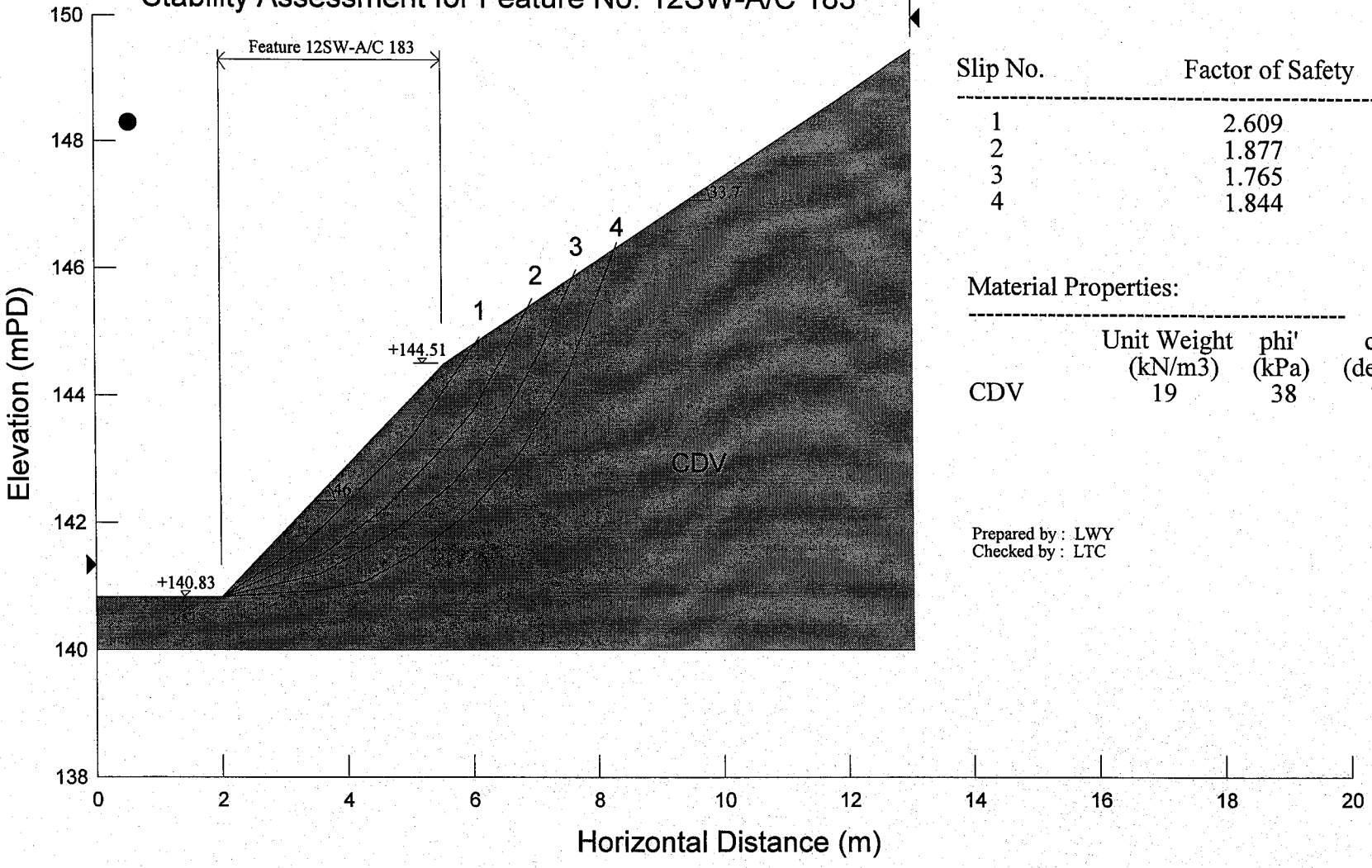
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	38	7
Colluvium	19	39	3

Prepared by : LWY
Checked by : LTC

Section SS17

Geotechnical Review and Site Investigation Works for Tseung Kwan O Stage II/III Afteruse Development -Stability Assessment for Feature No. 12SW-A/C 183



Slip No.	Factor of Safety
1	2.609
2	1.877
3	1.765
4	1.844

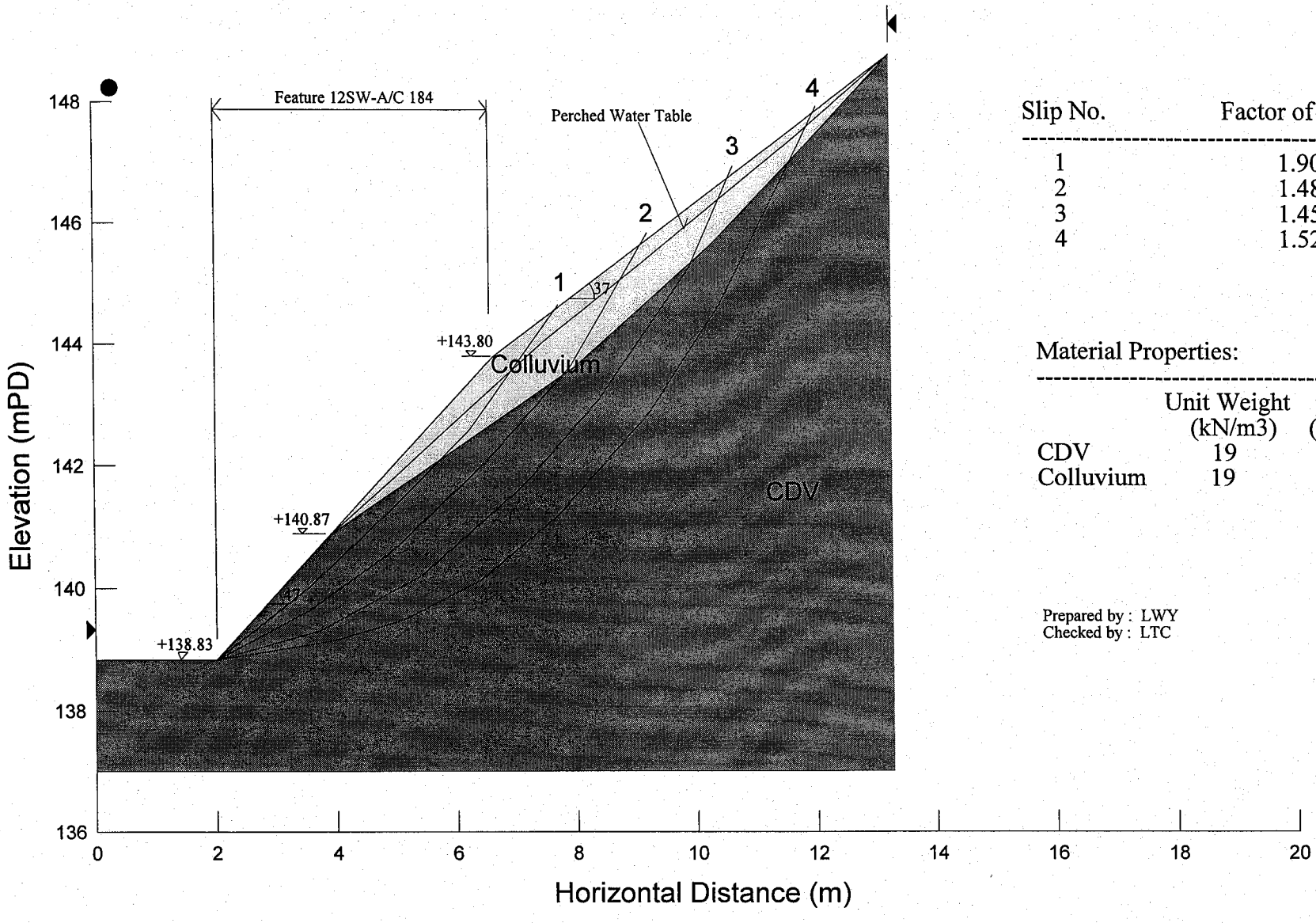
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	38	7

Prepared by : LWY
Checked by : LTC

Section SS19

Geotechnical Review and Site Investigation Works for Tseung Kwan O Stage II/III Afteruse Development -Stability Assessment for Feature No. 12SW-A/C 184



Slip No.	Factor of Safety
1	1.902
2	1.480
3	1.451
4	1.522

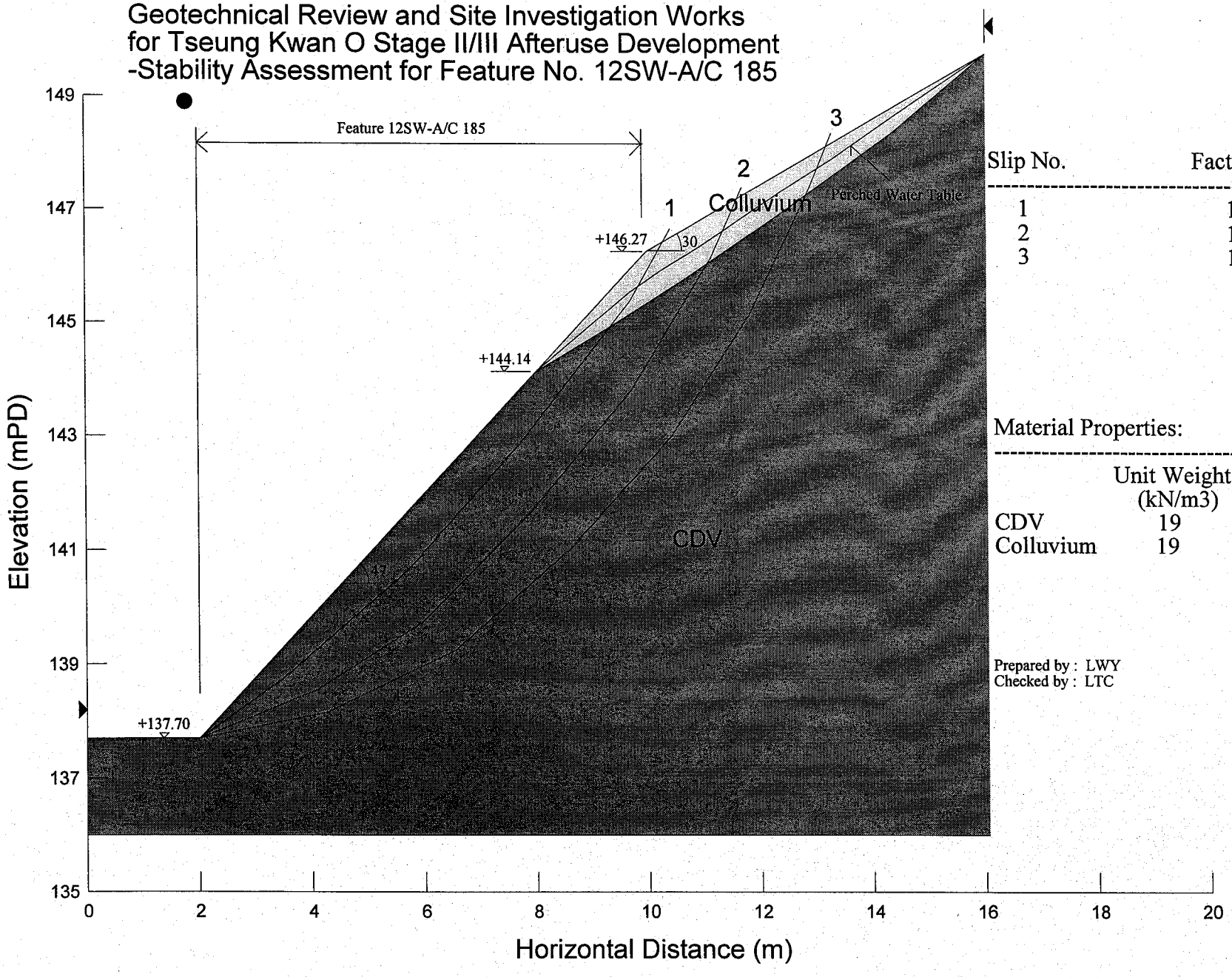
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	38	7
Colluvium	19	39	3

Prepared by : LWY
Checked by : LTC

Section SS22

Geotechnical Review and Site Investigation Works
for Tseung Kwan O Stage II/III Afteruse Development
-Stability Assessment for Feature No. 12SW-A/C 185



Slip No.	Factor of Safety
1	1.736
2	1.335
3	1.346

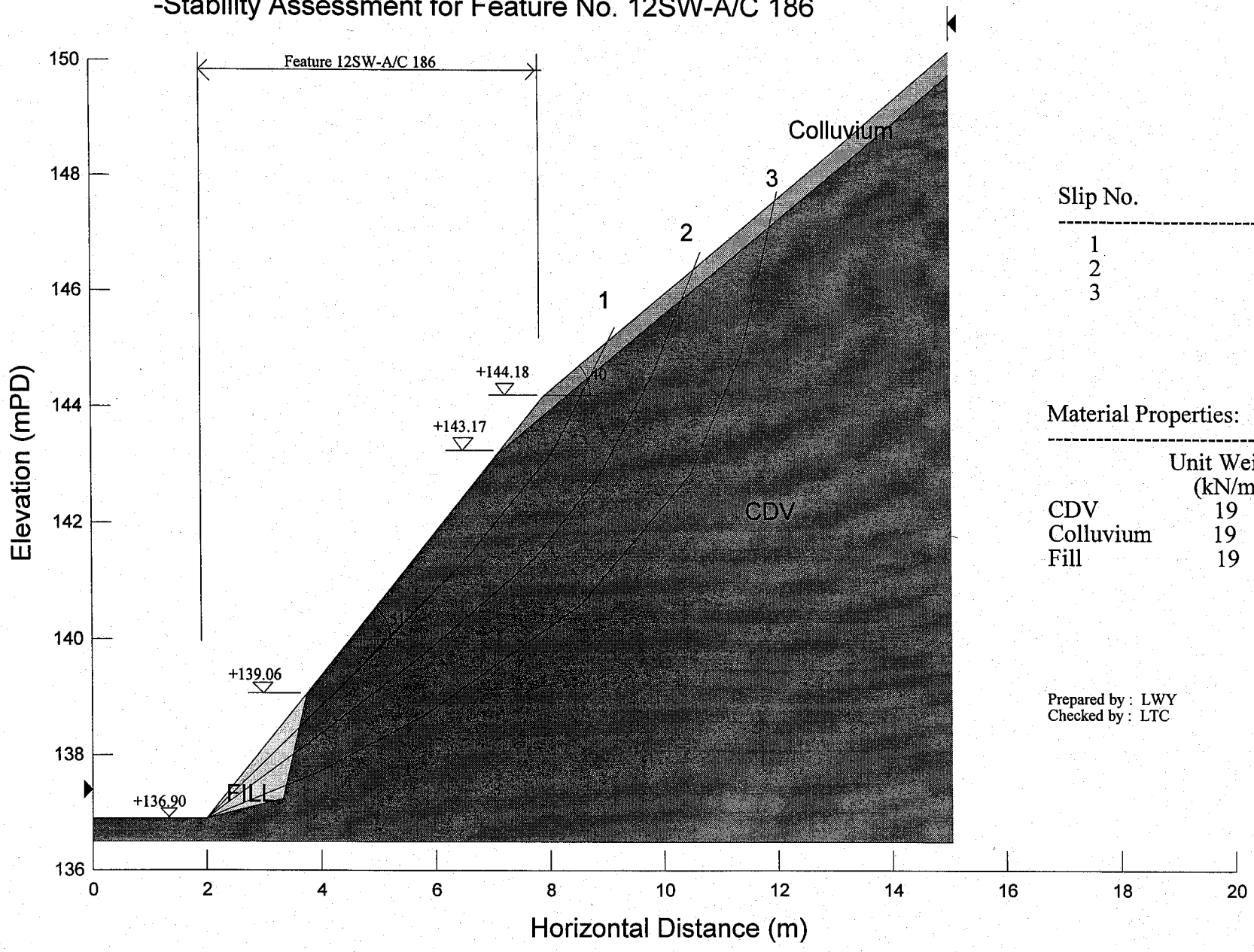
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	38	7
Colluvium	19	39	3

Prepared by : LWY
Checked by : LTC

Section SS24

Geotechnical Review and Site Investigation Works for Tseung Kwan O Stage II/III Afteruse Development -Stability Assessment for Feature No. 12SW-A/C 186



Slip No.	Factor of Safety
1	1.517
2	1.230
3	1.240

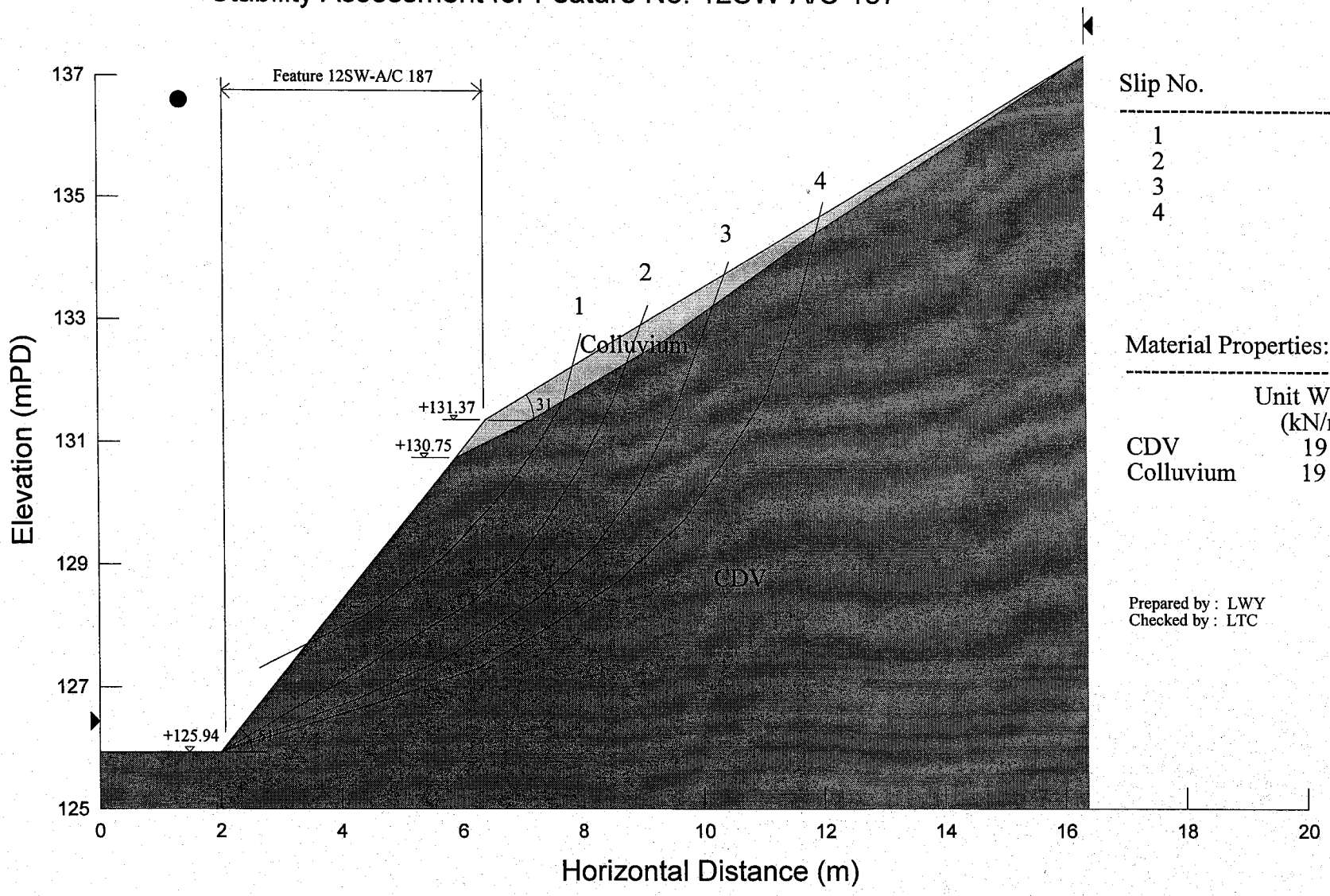
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	38	7
Colluvium	19	39	3
Fill	19	38	0

Prepared by : LWY
Checked by : LTC

Section SS25

Geotechnical Review and Site Investigation Works for Tseung Kwan O Stage II/III Afteruse Development -Stability Assessment for Feature No. 12SW-A/C 187



Slip No.	Factor of Safety
1	1.653
2	1.456
3	1.483
4	1.567

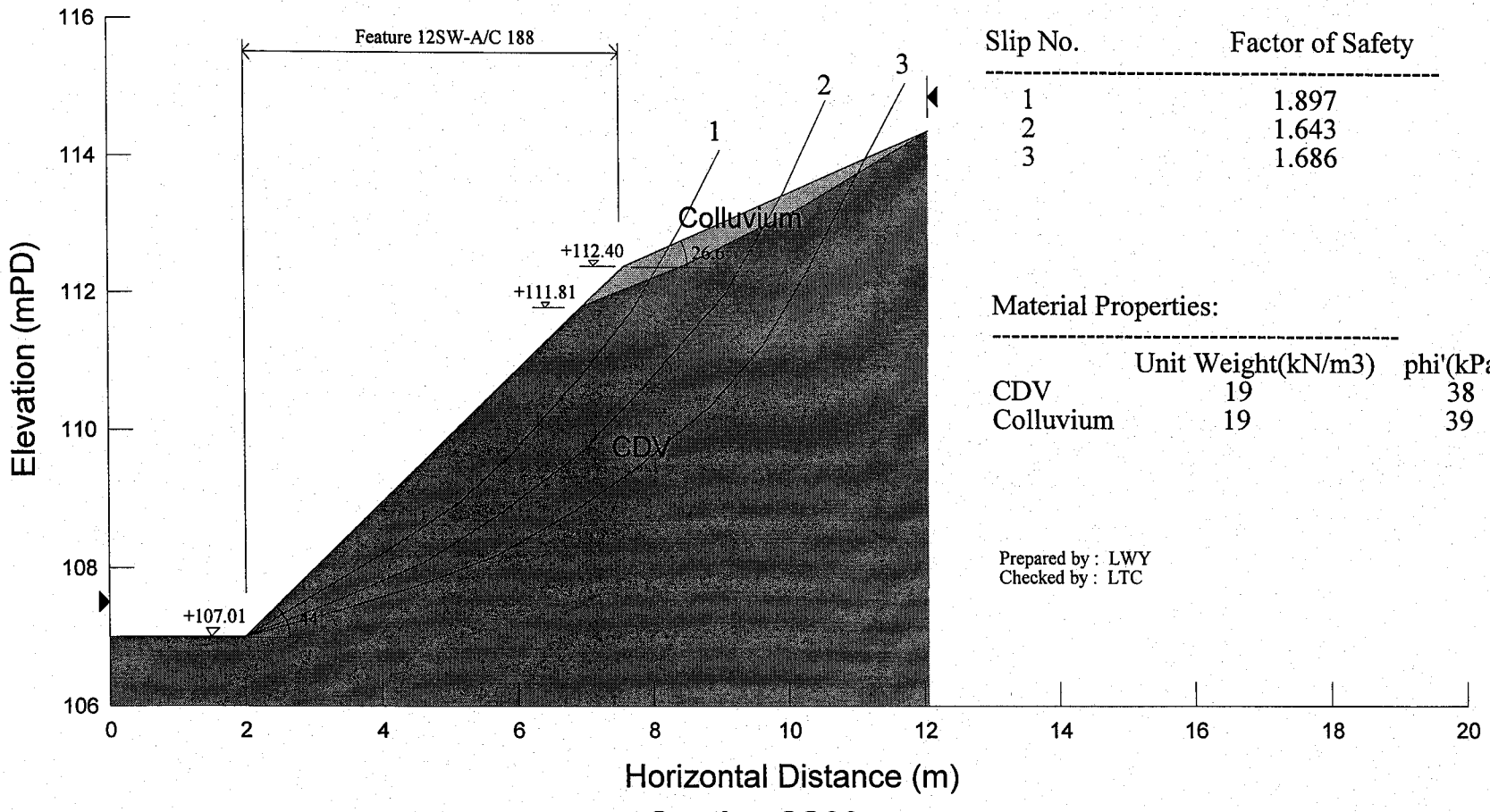
Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	38	7
Colluvium	19	39	3

Prepared by : LWY
Checked by : LTC

Section SS27

- Geotechnical Review and Site Investigation Works for Tseung Kwan O Stage II/III Afteruse Development -Stability Assessment for Feature No. 12SW-A/C 188



Slip No.	Factor of Safety
1	1.897
2	1.643
3	1.686

Material Properties:

	Unit Weight(kN/m3)	phi'(kPa)	c'(deg.)
CDV	19	38	7
Colluvium	19	39	3

Prepared by : LWY
Checked by : LTC

Section SS30

APPENDIX D
Prescriptive Measures Application Record Sheets

Feature No.	Recommended Prescriptive Measures				
12SW-A/C76 (Section SS2)	Soil nail	Layout:	Type	(d)	
			Number of rows of soil nails, N	3	
			Nail diameter, f_r(mm)	25	mm
			Hole diameter, f_h (mm)	100	mm
			Horizontal spacing, S_h (m)	1.5	m
			Length of soil nails, L (m)	7.5	m
12SW-A/C173 (Section SS4)	Soil nail	Layout:	Type	(f)	
			Number of rows of soil nails, N	5	
			Nail diameter, f_r(mm)	32	mm
			Hole diameter, f_h (mm)	100	mm
			Horizontal spacing, S_h (m)	1.5	m
			Length of soil nails, L (m)	10	m
12SW-A/C173 (Section SS6)	Soil nail	Layout:	Type	(d)	
			Number of rows of soil nails, N	3	
			Nail diameter, f_r(mm)	25	mm
			Hole diameter, f_h (mm)	100	mm
			Horizontal spacing, S_h (m)	1.5	m
			Length of soil nails, L (m)	7.5	m
12SW-A/C176	Soil nail	Layout:	Type	(e)	
			Number of rows of soil nails, N	4	
			Nail diameter, f_r(mm)	25	mm
			Hole diameter, f_h (mm)	100	mm
			Horizontal spacing, S_h (m)	1.5	m
			Length of soil nails, L (m)	9.5	m
12SW-A/C177 (Section SS12)	Soil nail	Layout:	Type	(f)	
			Number of rows of soil nails, N	5	
			Nail diameter, f_r(mm)	32	mm
			Hole diameter, f_h (mm)	100	mm
			Horizontal spacing, S_h (m)	2	m
			Length of soil nails, L (m)	10.0	m
12SW-A/C182 (Section SS16)	Soil nail	Layout:	Type	(e)	
			Number of rows of soil nails, N	6	
			Nail diameter, f_r(mm)	25	mm
			Hole diameter, f_h (mm)	100	mm
			Horizontal spacing, S_h (m)	1.5	m
			Length of soil nails, L (m)	10.0	m
	Raking drains at specific seepage				
12SW-A/C183	Raking drains at specific seepage				
12SW-A/C188	Raking drains at specific seepage				

Record Sheet for Prescriptive Measures Application

Slope Reference No.: 12SW-A/C76 (Section SS2)	**Location:** Tseung Kwan O Landfill Stage II/III
Geometry/Consequence:	**Qualifying criteria:**
Slope Gradient: 78° Slope Height: 3.92 m Upslope Gradient: 39° Group of Facilities Affected: ~~1 / 2 / 3~~ / 4 ~~/ 5~~ Consequence to life Category: ~~1 / 2~~ / 3 Record of Engineer Inspection: ~~YES~~ / NO If Yes, Inspection Date: - Geology Map No: 12	1) Pre-GCO Slope? ☑ YES ☐ NO 2) Within Consequence and Geometry Limits? ☑ YES ☐ NO 3) Within Area of selected formations of Granite or Volcanics? ☑ YES ☐ NO 4) Adverse Geological conditions present? ☐ YES ☑ NO 5) Adverse Groundwater Conditions? ☐ YES ☑ NO

Record of Landslides

Date:	Scar Height (m)	Failure Volume (m^3)	GEO Incident No.
1) None			
2)			
3)			

Type Of Improvement Works

☐ Preventive Maintenance ☐ Urgent Repair to the current Landslide ☑ Upgrading works (~~LPM~~)

Design Objective	Prescriptive Measure Recommended		Figure No.
☐ Improve surface protection	☐ 1.1.1	Cover slope face with shotcrete.	A1
	☐ 1.1.2	Locally trim and remove loose materials	-
☐ Improve local stability	1.1.3	Fill local areas with no-fines concrete:	
	☐	(a) at upper part of slope	A2
	☐	(b) at lower part of slope	A2
	☐ 1.1.4	Cover upslope area with shotcrete	A3
☐ Improve surface drainage	☐ 1.2.1	Provide surface drainage channels	-
	☐ 1.2.2	Provide slope crest channel with upstand	A3
☐ Improve subsurface drainage ☐ Provide contingency subsurface drainage measures	2.1	Provide drainage behind impermeable surface cover:	
	☐	(a) with no fines concrete toe	A4
	☐	(b) with relief drains	A5
	2.2	Cover slope face with no-fines concrete:	
	☐	(a) at upper part of slope	A6
	☐	(b) at lower part of slope or on berm	A7
	2.3	Provide raking drains:	
	☐	(a) at upper part of slope	A8
	☐	(b) at lower part of slope	A9
	☐	(c) at specific seepage or potential seepage areas	-
	☐ 2.4	Provide cut-off drain above slope crest	A10
	☐ 2.5	Provide toe drain	A10
	☐ 2.6	Provide counterfort drains at upper part of slope	A11
☑ Provide support to improve overall slope stability.	☑ 3.1	Provide soil nails with a FOS increase in range: ~~A / B /~~ C	A12
☐ Others (please specify)	☐	Other measures (please specify)	

Attachments:

☐ Site Location Plan ☐ Photographs ☐ Records of Engineer Inspection

☐ Plan, sketches/drawings showing locations/layout/key dimensions of the proposed prescriptive measures

Designed: W. Y. Law	**Signature:**	**Checked: Tony Chen**	**Signature:**
Post: AE	**Date:**	**Post: SE**	**Date:**

Agreement No. FD 01-052
Geotechnical Review and Site Investigation Works
For Tseung Kwan O Landfill Stage II/III
Afteruse Development

Feature 12SW-A/C76 (Section SS2)

From SLOPE/W Analysis

Consequence-to-life Category	3
Required FoS	1.1
Calculated FoS	1.024
Range of FoS Increase for Prescriptive Application of Soil Nailing	C

Refer to Section SS2

maximum height of the feature, H = 3.92 m

Upslope gradient β = 39 °

Surcharge q = 5 kPa

Maximum effective height

$H_e = H \times (1 + 0.35\tan\beta) + q/20$

$= 5.28$ m

From Table A2 of GEO Report No. 56 (Issue 2),

Soil Nail Layout is as follows:

Type	(d)	
Number of rows of soil nails, N	3	
Nail diameter, ϕ_r(mm)	25	mm
Hole diameter, ϕ_h (mm)	100	mm
Horizontal spacing, S_h (m)	1.5	m
Length of soil nails, L (m)	7.5	m

Computed by: Checked by:

Date Date

Table A2 - Standard Soil Nail Layout

Standard Soil Nail Layout	H_e (m)	ϕ_r (mm)	ϕ_h (mm)	A			B			C		
				N	L(m)	S_h(m)	N	L(m)	S_h(m)	N	L(m)	S_h(m)
(a)	3.0	25	100	2	3.5	1.5	2	3.5	1.5	2	3.5	1.5
(b)	4.0	25	100	2	4.5	1.5	2	4.5	1.5	2	4.5	1.5
(c)	5.0	25	100	3	6.0	1.5	3	6.0	1.5	3	6.0	2.0
(d)	7.5	25	100	4	9.0	1.5	3	8.5	1.5	3	7.5	1.5
(e)	10.0	25	100	6	10.0	1.5	4	9.5	1.5	4	8.5	1.5
(f)	12.5	32	100	6	11.0	1.5	5	10.0	1.5	5	10.0	2.0
(g)	15.0	32	100	7	12.0	1.5	6	11.0	1.5	6	11.0	2.0
(h)	17.5	32	100	8	13.0	1.5	8	11.5	2.0	7	11.5	2.0
(i)	20.0	32	100	10	13.5	2.0	9	12.0	2.0	8	12.0	2.0
(j)	22.5	32	100	11	14.0	2.0	9	12.0	2.0	8	12.0	2.0
(k)	25.0	32	100	12	14.5	2.0	10	12.0	2.0	8	12.0	2.0

Notes:

(1) H_e is the maximum effective slope height, ϕ_r the nail diameter, ϕ_h the hole diameter S_h the horizontal spacing of nails, and N & L the number of rows and length of the soil nails respectively.

(2) For H_e between any of the two consecutive values, the soil nail layout corresponding to the higher H_e value should be adopted.

(3) Soil nails should be evenly spaced over the slope face.

(4) N is the number of soil nails per vertical column required at the critical section, i.e. the section with the maximum effective height, H_e. At other parts of the slope, soil nails should be provided at vertical and horizontal spacings similar to that at the critical section. Alternatively, different soil nail layouts according to the maximum H_e of that part of the slope may be adopted.

(5) 'A', 'B' and 'C' refer to a large factor of safety increase ($0.3 < \Delta FOS \leq 0.5$), a medium factor of safety increase ($0.1 < \Delta FOS \leq 0.3$) and a small factor of safety increase ($0 < \Delta FOS \leq 0.1$) respectively.

(6) If in the process of drilling rock is encountered such that part of the soil nails will be installed in rock (e.g. installation through a PW50/90 zone or better, see Geoguide 3), the designer may exercise professional judgement to reduce the nail length L. In the absence of site-specific ground investigation, sound engineering judgement is required to ensure that the nails are not prematurely terminated in corestone boulders.

(7) The designer should check the land status to see whether the nails encroach into adjoining land and if so whether this is acceptable to the land owner.

Record Sheet for Prescriptive Measures Application

Slope Reference No.: 12SW-A/C173 (Section SS4)	**Location:** Tseung Kwan O Landfill Stage II/III
Geometry/Consequence:	**Qualifying criteria:**
Slope Gradient: 58° Slope Height: 9 m Upslope Gradient: 26.6° Group of Facilities Affected: ~~1 / 2 / 3~~ / 4 ~~/ 5~~ Consequence to life Category: ~~1 / 2~~ / 3 Record of Engineer Inspection: ~~YES~~ / NO If Yes, Inspection Date: - Geology Map No: 12	1) Pre-GCO Slope? ☑ YES ☐ NO 2) Within Consequence and Geometry Limits? ☑ YES ☐ NO 3) Within Area of selected formations of Granite or Volcanics? ☑ YES ☐ NO 4) Adverse Geological conditions present? ☐ YES ☑ NO 5) Adverse Groundwater Conditions? ☐ YES ☑ NO

Record of Landslides

Date:	Scar Height (m)	Failure Volume (m^3)	GEO Incident No.
1) None			
2)			
3)			

Type Of Improvement Works

☐ Preventive Maintenance ☐ Urgent Repair to the current Landslide ☑ Upgrading works (~~LPM~~)

Design Objective	Prescriptive Measure Recommended		Figure No.
☐ Improve surface protection	☐ 1.1.1	Cover slope face with shotcrete.	A1
	☐ 1.1.2	Locally trim and remove loose materials	-
☐ Improve local stability	1.1.3	Fill local areas with no-fines concrete:	
	☐	(a) at upper part of slope	A2
	☐	(b) at lower part of slope	A2
	☐ 1.1.4	Cover upslope area with shotcrete	A3
☐ Improve surface drainage	☐ 1.2.1	Provide surface drainage channels	-
	☐ 1.2.2	Provide slope crest channel with upstand	A3
☐ Improve subsurface drainage ☐ Provide contingency subsurface drainage measures	2.1	Provide drainage behind impermeable surface cover:	
	☐	(a) with no fines concrete toe	A4
	☐	(b) with relief drains	A5
	2.2	Cover slope face with no-fines concrete:	
	☐	(a) at upper part of slope	A6
	☐	(b) at lower part of slope or on berm	A7
	2.3	Provide raking drains:	
	☐	(a) at upper part of slope	A8
	☐	(b) at lower part of slope	A9
	☐	(c) at specific seepage or potential seepage areas	-
	☐ 2.4	Provide cut-off drain above slope crest	A10
	☐ 2.5	Provide toe drain	A10
	☐ 2.6	Provide counterfort drains at upper part of slope	A11
☑ Provide support to improve overall slope stability.	☑ 3.1	Provide soil nails with a FOS increase in range: ~~A~~ / B / ~~C~~	A12
☐ Others (please specify)	☐	Other measures (please specify)	

Attachments:

☐ Site Location Plan ☐ Photographs ☐ Records of Engineer Inspection

☐ Plan, sketches/drawings showing locations/layout/key dimensions of the proposed prescriptive measures

Designed: W. Y. Law	**Signature:**	**Checked: Tony Chen**	**Signature:**
Post: AE	**Date:**	**Post: SE**	**Date:**

Agreement No. FD 01-052
Geotechnical Review and Site Investigation Works
For Tseung Kwan O Landfill Stage II/III
Afteruse Development

Feature 12SW-A/C173 (Section SS4)

From SLOPE/W Analysis

Consequence-to-life Category	3
Required FoS	1.1
Calculated FoS	0.89
Range of FoS Increase for Prescriptive Application of Soil Nailing	B

Refer to Section SS4

maximum height of the feature, H = 9 m

Upslope gradient β = 26.6 °

Surcharge q = 5 kPa

Maximum effective height

$H_e = H \times (1 + 0.35\tan\beta) + q/20$

$= 10.83$ m

From Table A2 of GEO Report No. 56 (Issue 2),

Soil Nail Layout is as follows:

Type	(f)	
Number of rows of soil nails, N	5	
Nail diameter, ϕ_r(mm)	32	mm
Hole diameter, ϕ_h (mm)	100	mm
Horizontal spacing, S_h (m)	1.5	m
Length of soil nails, L (m)	10.0	m

Computed by: Checked by:

Date Date

Table A2 - Standard Soil Nail Layout

Standard Soil Nail Layout	H_e (m)	ϕ_r (mm)	ϕ_h (mm)	A			B			C		
				N	L(m)	S_h(m)	N	L(m)	S_h(m)	N	L(m)	S_h(m)
(a)	3.0	25	100	2	3.5	1.5	2	3.5	1.5	2	3.5	1.5
(b)	4.0	25	100	2	4.5	1.5	2	4.5	1.5	2	4.5	1.5
(c)	5.0	25	100	3	6.0	1.5	3	6.0	1.5	3	6.0	2.0
(d)	7.5	25	100	4	9.0	1.5	3	8.5	1.5	3	7.5	1.5
(e)	10.0	25	100	6	10.0	1.5	4	9.5	1.5	4	8.5	1.5
(f)	12.5	32	100	6	11.0	1.5	5	10.0	1.5	5	10.0	2.0
(g)	15.0	32	100	7	12.0	1.5	6	11.0	1.5	6	11.0	2.0
(h)	17.5	32	100	8	13.0	1.5	8	11.5	2.0	7	11.5	2.0
(i)	20.0	32	100	10	13.5	2.0	9	12.0	2.0	8	12.0	2.0
(j)	22.5	32	100	11	14.0	2.0	9	12.0	2.0	8	12.0	2.0
(k)	25.0	32	100	12	14.5	2.0	10	12.0	2.0	8	12.0	2.0

Notes:

(1) H_e is the maximum effective slope height, ϕ_r the nail diameter, ϕ_h the hole diameter S_h the horizontal spacing of nails, and N & L the number of rows and length of the soil nails respectively.

(2) For H_e between any of the two consecutive values, the soil nail layout corresponding to the higher H_e value should be adopted.

(3) Soil nails should be evenly spaced over the slope face.

(4) N is the number of soil nails per vertical column required at the critical section, i.e. the section with the maximum effective height, H_e. At other parts of the slope, soil nails should be provided at vertical and horizontal spacings similar to that at the critical section. Alternatively, different soil nail layouts according to the maximum H_e of that part of the slope may be adopted.

(5) 'A', 'B' and 'C' refer to a large factor of safety increase ($0.3 < \Delta FOS \leq 0.5$), a medium factor of safety increase ($0.1 < \Delta FOS \leq 0.3$) and a small factor of safety increase ($0 < \Delta FOS \leq 0.1$) respectively.

(6) If in the process of drilling rock is encountered such that part of the soil nails will be installed in rock (e.g. installation through a PW50/90 zone or better, see Geoguide 3), the designer may exercise professional judgement to reduce the nail length L. In the absence of site-specific ground investigation, sound engineering judgement is required to ensure that the nails are not prematurely terminated in corestone boulders.

(7) The designer should check the land status to see whether the nails encroach into adjoining land and if so whether this is acceptable to the land owner.

Record Sheet for Prescriptive Measures Application

Slope Reference No.: 12SW-A/C173 (Section SS6)	**Location:** Tseung Kwan O Landfill Stage II/III
Geometry/Consequence:	**Qualifying criteria:**
Slope Gradient: 56° Slope Height: 6.16 m Upslope Gradient: 26.6° Group of Facilities Affected: ~~1 / 2 / 3~~ / 4 ~~/ 5~~ Consequence to life Category: ~~1 / 2~~ / 3 Record of Engineer Inspection: ~~YES~~ / NO If Yes, Inspection Date: - Geology Map No: 12	1) Pre-GCO Slope? ☑ YES ☐ NO 2) Within Consequence and Geometry Limits? ☑ YES ☐ NO 3) Within Area of selected formations of Granite or Volcanics? ☑ YES ☐ NO 4) Adverse Geological conditions present? ☐ YES ☑ NO 5) Adverse Groundwater Conditions? ☐ YES ☑ NO

Record of Landslides

Date:	Scar Height (m)	Failure Volume (m^3)	GEO Incident No.
1) None			
2)			
3)			

Type Of Improvement Works

☐ Preventive Maintenance ☐ Urgent Repair to the current Landslide ☑ Upgrading works (~~LPM~~)

Design Objective	Prescriptive Measure Recommended		Figure No.
☐ Improve surface protection	☐ 1.1.1	Cover slope face with shotcrete.	A1
	☐ 1.1.2	Locally trim and remove loose materials	-
☐ Improve local stability	1.1.3	Fill local areas with no-fines concrete:	
	☐	(a) at upper part of slope	A2
	☐	(b) at lower part of slope	A2
	☐ 1.1.4	Cover upslope area with shotcrete	A3
☐ Improve surface drainage	☐ 1.2.1	Provide surface drainage channels	-
	☐ 1.2.2	Provide slope crest channel with upstand	A3
☐ Improve subsurface drainage ☐ Provide contingency subsurface drainage measures	2.1	Provide drainage behind impermeable surface cover:	
	☐	(a) with no fines concrete toe	A4
	☐	(b) with relief drains	A5
	2.2	Cover slope face with no-fines concrete:	
	☐	(a) at upper part of slope	A6
	☐	(b) at lower part of slope or on berm	A7
	2.3	Provide raking drains:	
	☐	(a) at upper part of slope	A8
	☐	(b) at lower part of slope	A9
	☐	(c) at specific seepage or potential seepage areas	-
	☐ 2.4	Provide cut-off drain above slope crest	A10
	☐ 2.5	Provide toe drain	A10
	☐ 2.6	Provide counterfort drains at upper part of slope	A11
☑ Provide support to improve overall slope stability.	☑ 3.1	Provide soil nails with a FOS increase in range: ~~A / B /~~ C	A12
☐ Others (please specify)	☐	Other measures (please specify)	

Attachments:

☐ Site Location Plan ☐ Photographs ☐ Records of Engineer Inspection

☐ Plan, sketches/drawings showing locations/layout/key dimensions of the proposed prescriptive measures

Designed: W. Y. Law	**Signature:**	**Checked: Tony Chen**	**Signature:**
Post: AE	**Date:**	**Post: SE**	**Date:**

Feature 12SW-A/C173 (Section SS6)

From SLOPE/W Analysis

Consequence-to-life Category	3
Required FoS	1.1
Calculated FoS	1.026
Range of FoS Increase for Prescriptive Application of Soil Nailing	C

Refer to Section SS6

maximum height of the feature, H = 6.16 m

Upslope gradient β = 26.6 °

Surcharge q = 5 kPa

Maximum effective height

$H_e = H \times (1 + 0.35\tan\beta) + q/20$

$= 7.49$ m

From Table A2 of GEO Report No. 56 (Issue 2),

Soil Nail Layout is as follows:

Type	(d)	
Number of rows of soil nails, N	3	
Nail diameter, ϕ_r(mm)	25	mm
Hole diameter, ϕ_h (mm)	100	mm
Horizontal spacing, S_h (m)	1.5	m
Length of soil nails, L (m)	7.5	m

Computed by: Checked by:

Date Date

Table A2 - Standard Soil Nail Layout

Standard Soil Nail Layout	H_e (m)	ϕ_r (mm)	ϕ_h (mm)	A			B			C		
				N	L(m)	S_h(m)	N	L(m)	S_h(m)	N	L(m)	S_h(m)
(a)	3.0	25	100	2	3.5	1.5	2	3.5	1.5	2	3.5	1.5
(b)	4.0	25	100	2	4.5	1.5	2	4.5	1.5	2	4.5	1.5
(c)	5.0	25	100	3	6.0	1.5	3	6.0	1.5	3	6.0	2.0
(d)	7.5	25	100	4	9.0	1.5	3	8.5	1.5	3	7.5	1.5
(e)	10.0	25	100	6	10.0	1.5	4	9.5	1.5	4	8.5	1.5
(f)	12.5	32	100	6	11.0	1.5	5	10.0	1.5	5	10.0	2.0
(g)	15.0	32	100	7	12.0	1.5	6	11.0	1.5	6	11.0	2.0
(h)	17.5	32	100	8	13.0	1.5	8	11.5	2.0	7	11.5	2.0
(i)	20.0	32	100	10	13.5	2.0	9	12.0	2.0	8	12.0	2.0
(j)	22.5	32	100	11	14.0	2.0	9	12.0	2.0	8	12.0	2.0
(k)	25.0	32	100	12	14.5	2.0	10	12.0	2.0	8	12.0	2.0

Notes:

(1) H_e is the maximum effective slope height, ϕ_r the nail diameter, ϕ_h the hole diameter S_h the horizontal spacing of nails, and N & L the number of rows and length of the soil nails respectively.

(2) For H_e between any of the two consecutive values, the soil nail layout corresponding to the higher H_e value should be adopted.

(3) Soil nails should be evenly spaced over the slope face.

(4) N is the number of soil nails per vertical column required at the critical section, i.e. the section with the maximum effective height, H_e. At other parts of the slope, soil nails should be provided at vertical and horizontal spacings similar to that at the critical section. Alternatively, different soil nail layouts according to the maximum H_e of that part of the slope may be adopted.

(5) 'A', 'B' and 'C' refer to a large factor of safety increase ($0.3 < \Delta FOS \leq 0.5$), a medium factor of safety increase ($0.1 < \Delta FOS \leq 0.3$) and a small factor of safety increase ($0 < \Delta FOS \leq 0.1$) respectively.

(6) If in the process of drilling rock is encountered such that part of the soil nails will be installed in rock (e.g. installation through a PW50/90 zone or better, see Geoguide 3), the designer may exercise professional judgement to reduce the nail length L. In the absence of site-specific ground investigation, sound engineering judgement is required to ensure that the nails are not prematurely terminated in corestone boulders.

(7) The designer should check the land status to see whether the nails encroach into adjoining land and if so whether this is acceptable to the land owner.

Record Sheet for Prescriptive Measures Application

Slope Reference No.: 12SW-A/C175	**Location:** Tseung Kwan O Landfill Stage II/III
Geometry/Consequence:	**Qualifying criteria:**
Slope Gradient: 65° Slope Height: 6 m Upslope Gradient: 45° Group of Facilities Affected: ~~1 / 2 / 3~~ / 4 ~~/ 5~~ Consequence to life Category: ~~1 / 2~~ / 3 Record of Engineer Inspection: ~~YES~~ / NO If Yes, Inspection Date: - Geology Map No: 12	1) Pre-GCO Slope? ☑ YES ☐ NO 2) Within Consequence and Geometry Limits? ☑ YES ☐ NO 3) Within Area of selected formations of Granite or Volcanics? ☑ YES ☐ NO 4) Adverse Geological conditions present? ☐ YES ☑ NO 5) Adverse Groundwater Conditions? ☐ YES ☑ NO

Record of Landslides

Date:	Scar Height (m)	Failure Volume (m^3)	GEO Incident No.
1) None			
2)			
3)			

Type Of Improvement Works

☐ Preventive Maintenance ☐ Urgent Repair to the current Landslide ☑ Upgrading works (~~LPM~~)

Design Objective	Prescriptive Measure Recommended		Figure No.
☐ Improve surface protection	☐ 1.1.1	Cover slope face with shotcrete.	A1
	☐ 1.1.2	Locally trim and remove loose materials	-
☐ Improve local stability	1.1.3	Fill local areas with no-fines concrete:	
	☐	(a) at upper part of slope	A2
	☐	(b) at lower part of slope	A2
	☐ 1.1.4	Cover upslope area with shotcrete	A3
☐ Improve surface drainage	☐ 1.2.1	Provide surface drainage channels	-
	☐ 1.2.2	Provide slope crest channel with upstand	A3
☐ Improve subsurface drainage ☐ Provide contingency subsurface drainage measures	2.1	Provide drainage behind impermeable surface cover:	
	☐	(a) with no fines concrete toe	A4
	☐	(b) with relief drains	A5
	2.2	Cover slope face with no-fines concrete:	
	☐	(a) at upper part of slope	A6
	☐	(b) at lower part of slope or on berm	A7
	2.3	Provide raking drains:	
	☐	(a) at upper part of slope	A8
	☐	(b) at lower part of slope	A9
	☐	(c) at specific seepage or potential seepage areas	-
	☐ 2.4	Provide cut-off drain above slope crest	A10
	☐ 2.5	Provide toe drain	A10
	☐ 2.6	Provide counterfort drains at upper part of slope	A11
☑ Provide support to improve overall slope stability.	☑ 3.1	Provide soil nails with a FOS increase in range: ~~A / B /~~ C	A12
☐ Others (please specify)	☐	Other measures (please specify)	

Attachments:

☐ Site Location Plan ☐ Photographs ☐ Records of Engineer Inspection

☐ Plan, sketches/drawings showing locations/layout/key dimensions of the proposed prescriptive measures

Designed: W. Y. Law	**Signature:**	**Checked: Tony Chen**	**Signature:**
Post: AE	**Date:**	**Post: SE**	**Date:**

Agreement No. FD 01-052
Geotechnical Review and Site Investigation Works
For Tseung Kwan O Landfill Stage II/III
Afteruse Development

Feature 12SW-A/C175

From SLOPE/W Analysis

Consequence-to-life Category	3
Required FoS	1.1
Calculated FoS	1.051
Range of FoS Increase for Prescriptive Application of Soil Nailing	C

Refer to Section I-I

maximum height of the feature, H = 6 m

Upslope gradient β = 45 °

Surcharge q = 5 kPa

Maximum effective height

$H_e = H \times (1 + 0.35\tan\beta) + q/20$

$= 8.35$ m

From Table A2 of GEO Report No. 56 (Issue 2),

Soil Nail Layout is as follows:

Type	(e)	
Number of rows of soil nails, N	4	
Nail diameter, ϕ_r(mm)	25	mm
Hole diameter, ϕ_h (mm)	100	mm
Horizontal spacing, S_h (m)	1.5	m
Length of soil nails, L (m)	8.5	m

Computed by: Checked by:

Date Date

Table A2 - Standard Soil Nail Layout

Standard Soil Nail Layout	H_e (m)	ϕ_r (mm)	ϕ_h (mm)	A			B			C		
				N	L(m)	S_h(m)	N	L(m)	S_h(m)	N	L(m)	S_h(m)
(a)	3.0	25	100	2	3.5	1.5	2	3.5	1.5	2	3.5	1.5
(b)	4.0	25	100	2	4.5	1.5	2	4.5	1.5	2	4.5	1.5
(c)	5.0	25	100	3	6.0	1.5	3	6.0	1.5	3	6.0	2.0
(d)	7.5	25	100	4	9.0	1.5	3	8.5	1.5	3	7.5	1.5
(e)	10.0	25	100	6	10.0	1.5	4	9.5	1.5	4	8.5	1.5
(f)	12.5	32	100	6	11.0	1.5	5	10.0	1.5	5	10.0	2.0
(g)	15.0	32	100	7	12.0	1.5	6	11.0	1.5	6	11.0	2.0
(h)	17.5	32	100	8	13.0	1.5	8	11.5	2.0	7	11.5	2.0
(i)	20.0	32	100	10	13.5	2.0	9	12.0	2.0	8	12.0	2.0
(j)	22.5	32	100	11	14.0	2.0	9	12.0	2.0	8	12.0	2.0
(k)	25.0	32	100	12	14.5	2.0	10	12.0	2.0	8	12.0	2.0

Notes:

(1) H_e is the maximum effective slope height, ϕ_r the nail diameter, ϕ_h the hole diameter S_h the horizontal spacing of nails, and N & L the number of rows and length of the soil nails respectively.

(2) For H_e between any of the two consecutive values, the soil nail layout corresponding to the higher H_e value should be adopted.

(3) Soil nails should be evenly spaced over the slope face.

(4) N is the number of soil nails per vertical column required at the critical section, i.e. the section with the maximum effective height, H_e. At other parts of the slope, soil nails should be provided at vertical and horizontal spacings similar to that at the critical section. Alternatively, different soil nail layouts according to the maximum H_e of that part of the slope may be adopted.

(5) 'A', 'B' and 'C' refer to a large factor of safety increase ($0.3 < \Delta FOS \leq 0.5$), a medium factor of safety increase ($0.1 < \Delta FOS \leq 0.3$) and a small factor of safety increase ($0 < \Delta FOS \leq 0.1$) respectively.

(6) If in the process of drilling rock is encountered such that part of the soil nails will be installed in rock (e.g. installation through a PW50/90 zone or better, see Geoguide 3), the designer may exercise professional judgement to reduce the nail length L. In the absence of site-specific ground investigation, sound engineering judgement is required to ensure that the nails are not prematurely terminated in corestone boulders.

(7) The designer should check the land status to see whether the nails encroach into adjoining land and if so whether this is acceptable to the land owner.

Record Sheet for Prescriptive Measures Application

Slope Reference No.: 12SW-A/C176	**Location:** Tseung Kwan O Landfill Stage II/III
Geometry/Consequence:	**Qualifying criteria:**
Slope Gradient: 65° Slope Height: 7.42 m Upslope Gradient: 36.9° Group of Facilities Affected: ~~1 / 2 / 3~~ / 4 /~~5~~ Consequence to life Category: ~~1 / 2~~ / 3 Record of Engineer Inspection: ~~YES~~ / NO If Yes, Inspection Date: - Geology Map No: 12	1) Pre-GCO Slope? ☑ YES ☐ NO 2) Within Consequence and Geometry Limits? ☑ YES ☐ NO 3) Within Area of selected formations of Granite or Volcanics? ☑ YES ☐ NO 4) Adverse Geological conditions present? ☐ YES ☑ NO 5) Adverse Groundwater Conditions? ☐ YES ☑ NO

Record of Landslides

Date:	Scar Height (m)	Failure Volume (m^3)	GEO Incident No.
1) None			
2)			
3)			

Type Of Improvement Works

☐ Preventive Maintenance ☐ Urgent Repair to the current Landslide ☑ Upgrading works (~~LPM~~)

Design Objective		Prescriptive Measure Recommended	Figure No.
☐ Improve surface protection	☐	1.1.1 Cover slope face with shotcrete.	A1
	☐	1.1.2 Locally trim and remove loose materials	-
☐ Improve local stability		1.1.3 Fill local areas with no-fines concrete:	
	☐	(a) at upper part of slope	A2
	☐	(b) at lower part of slope	A2
	☐	1.1.4 Cover upslope area with shotcrete	A3
☐ Improve surface drainage	☐	1.2.1 Provide surface drainage channels	-
	☐	1.2.2 Provide slope crest channel with upstand	A3
☐ Improve subsurface drainage ☐ Provide contingency subsurface drainage measures		2.1 Provide drainage behind impermeable surface cover:	
	☐	(a) with no fines concrete toe	A4
	☐	(b) with relief drains	A5
		2.2 Cover slope face with no-fines concrete:	
	☐	(a) at upper part of slope	A6
	☐	(b) at lower part of slope or on berm	A7
		2.3 Provide raking drains:	
	☐	(a) at upper part of slope	A8
	☐	(b) at lower part of slope	A9
	☐	(c) at specific seepage or potential seepage areas	-
	☐	2.4 Provide cut-off drain above slope crest	A10
	☐	2.5 Provide toe drain	A10
	☐	2.6 Provide counterfort drains at upper part of slope	A11
☑ Provide support to improve overall slope stability.	☑	3.1 Provide soil nails with a FOS increase in range:~~A~~ / B /~~C~~	A12
☐ Others (please specify)	☐	Other measures (please specify)	

Attachments:

☐ Site Location Plan ☐ Photographs ☐ Records of Engineer Inspection

☐ Plan, sketches/drawings showing locations/layout/key dimensions of the proposed prescriptive measures

Designed: W. Y. Law	**Signature:**	**Checked: Tony Chen**	**Signature:**
Post: AE	**Date:**	**Post: SE**	**Date:**

Feature 12SW-A/C176

From SLOPE/W Analysis

Consequence-to-life Category	3
Required FoS	1.1
Calculated FoS	0.977
Range of FoS Increase for Prescriptive Application of Soil Nailing	B

Refer to Section SS9

maximum height of the feature, H = 7.42 m

Upslope gradient β = 36.9 °

Surcharge q = 5 kPa

Maximum effective height

$$H_e = H \times (1 + 0.35\tan\beta) + q/20$$
$$= 9.62 \text{ m}$$

From Table A2 of GEO Report No. 56 (Issue 2),

Soil Nail Layout is as follows:

Type	(e)	
Number of rows of soil nails, N	4	
Nail diameter, ϕ_r(mm)	25	mm
Hole diameter, ϕ_h (mm)	100	mm
Horizontal spacing, S_h (m)	1.5	m
Length of soil nails, L (m)	9.5	m

Computed by: Checked by:

Date Date

Table A2 - Standard Soil Nail Layout

Standard Soil Nail Layout	H_e (m)	ϕ_r (mm)	ϕ_h (mm)	A			B			C		
				N	L(m)	S_h(m)	N	L(m)	S_h(m)	N	L(m)	S_h(m)
(a)	3.0	25	100	2	3.5	1.5	2	3.5	1.5	2	3.5	1.5
(b)	4.0	25	100	2	4.5	1.5	2	4.5	1.5	2	4.5	1.5
(c)	5.0	25	100	3	6.0	1.5	3	6.0	1.5	3	6.0	2.0
(d)	7.5	25	100	4	9.0	1.5	3	8.5	1.5	3	7.5	1.5
(e)	10.0	25	100	6	10.0	1.5	4	9.5	1.5	4	8.5	1.5
(f)	12.5	32	100	6	11.0	1.5	5	10.0	1.5	5	10.0	2.0
(g)	15.0	32	100	7	12.0	1.5	6	11.0	1.5	6	11.0	2.0
(h)	17.5	32	100	8	13.0	1.5	8	11.5	2.0	7	11.5	2.0
(i)	20.0	32	100	10	13.5	2.0	9	12.0	2.0	8	12.0	2.0
(j)	22.5	32	100	11	14.0	2.0	9	12.0	2.0	8	12.0	2.0
(k)	25.0	32	100	12	14.5	2.0	10	12.0	2.0	8	12.0	2.0

Notes:

(1) H_e is the maximum effective slope height, ϕ_r the nail diameter, ϕ_h the hole diameter S_h the horizontal spacing of nails, and N & L the number of rows and length of the soil nails respectively.

(2) For H_e between any of the two consecutive values, the soil nail layout corresponding to the higher H_e value should be adopted.

(3) Soil nails should be evenly spaced over the slope face.

(4) N is the number of soil nails per vertical column required at the critical section, i.e. the section with the maximum effective height, H_e. At other parts of the slope, soil nails should be provided at vertical and horizontal spacings similar to that at the critical section. Alternatively, different soil nail layouts according to the maximum H_e of that part of the slope may be adopted.

(5) 'A', 'B' and 'C' refer to a large factor of safety increase ($0.3 < \Delta FOS \leq 0.5$), a medium factor of safety increase ($0.1 < \Delta FOS \leq 0.3$) and a small factor of safety increase ($0 < \Delta FOS \leq 0.1$) respectively.

(6) If in the process of drilling rock is encountered such that part of the soil nails will be installed in rock (e.g. installation through a PW50/90 zone or better, see Geoguide 3), the designer may exercise professional judgement to reduce the nail length L. In the absence of site-specific ground investigation, sound engineering judgement is required to ensure that the nails are not prematurely terminated in corestone boulders.

(7) The designer should check the land status to see whether the nails encroach into adjoining land and if so whether this is acceptable to the land owner.

Record Sheet for Prescriptive Measures Application

Slope Reference No.: 12SW-A/C177 (Section SS12)	**Location:** Tseung Kwan O Landfill Stage II/III
Geometry/Consequence:	**Qualifying criteria:**
Slope Gradient: 66° Slope Height: 8.24 m Upslope Gradient: 30° Group of Facilities Affected: ~~1~~ / ~~2~~ / ~~3~~ / 4 / ~~5~~ Consequence to life Category: ~~1~~ / ~~2~~ / 3 Record of Engineer Inspection: ~~YES~~ / NO If Yes, Inspection Date: - Geology Map No: 12	1) Pre-GCO Slope? ☑ YES ☐ NO 2) Within Consequence and Geometry Limits? ☑ YES ☐ NO 3) Within Area of selected formations of Granite or Volcanics? ☑ YES ☐ NO 4) Adverse Geological conditions present? ☐ YES ☑ NO 5) Adverse Groundwater Conditions? ☐ YES ☑ NO

Record of Landslides

Date:	Scar Height (m)	Failure Volume (m^3)	GEO Incident No.
1) None			
2)			
3)			

Type Of Improvement Works

☐ Preventive Maintenance ☐ Urgent Repair to the current Landslide ☑ Upgrading works (~~LPM~~)

Design Objective	Prescriptive Measure Recommended		Figure No.
☐ Improve surface protection	☐ 1.1.1	Cover slope face with shotcrete.	A1
	☐ 1.1.2	Locally trim and remove loose materials	-
☐ Improve local stability	1.1.3	Fill local areas with no-fines concrete:	
	☐	(a) at upper part of slope	A2
	☐	(b) at lower part of slope	A2
	☐ 1.1.4	Cover upslope area with shotcrete	A3
☐ Improve surface drainage	☐ 1.2.1	Provide surface drainage channels	-
	☐ 1.2.2	Provide slope crest channel with upstand	A3
☐ Improve subsurface drainage ☐ Provide contingency subsurface drainage measures	2.1	Provide drainage behind impermeable surface cover:	
	☐	(a) with no fines concrete toe	A4
	☐	(b) with relief drains	A5
	2.2	Cover slope face with no-fines concrete:	
	☐	(a) at upper part of slope	A6
	☐	(b) at lower part of slope or on berm	A7
	2.3	Provide raking drains:	
	☐	(a) at upper part of slope	A8
	☐	(b) at lower part of slope	A9
	☐	(c) at specific seepage or potential seepage areas	-
	☐ 2.4	Provide cut-off drain above slope crest	A10
	☐ 2.5	Provide toe drain	A10
	☐ 2.6	Provide counterfort drains at upper part of slope	A11
☑ Provide support to improve overall slope stability.	☑ 3.1	Provide soil nails with a FOS increase in range: ~~A~~ / ~~B~~ / C	A12
☐ Others (please specify)	☐	Other measures (please specify)	

Attachments:

☐ Site Location Plan ☐ Photographs ☐ Records of Engineer Inspection

☐ Plan, sketches/drawings showing locations/layout/key dimensions of the proposed prescriptive measures

Designed: W. Y. Law	**Signature:**	**Checked: Tony Chen**	**Signature:**
Post: AE	**Date:**	**Post: SE**	**Date:**

Agreement No. FD 01-052
Geotechnical Review and Site Investigation Works
For Tseung Kwan O Landfill Stage II/III
Afteruse Development

Feature 12SW-A/C177 (Section SS12)

From SLOPE/W Analysis

Consequence-to-life Category	3
Required FoS	1.1
Calculated FoS	1.032
Range of FoS Increase for Prescriptive Application of Soil Nailing	C

Refer to Section SS12

maximum height of the feature, H = 8.24 m

Upslope gradient β = 30 °

Surcharge q = 5 kPa

Maximum effective height

$H_e = H \times (1 + 0.35\tan\beta) + q/20$

$= 10.15$ m

From Table A2 of GEO Report No. 56 (Issue 2),

Soil Nail Layout is as follows:

Type	(f)	
Number of rows of soil nails, N	5	
Nail diameter, ϕ_r(mm)	32	mm
Hole diameter, ϕ_h (mm)	100	mm
Horizontal spacing, S_h (m)	2	m
Length of soil nails, L (m)	10.0	m

Computed by: Checked by:

Date Date

Table A2 - Standard Soil Nail Layout

Standard Soil Nail Layout	H_e (m)	ϕ_r (mm)	ϕ_h (mm)	A			B			C		
				N	L(m)	S_h(m)	N	L(m)	S_h(m)	N	L(m)	S_h(m)
(a)	3.0	25	100	2	3.5	1.5	2	3.5	1.5	2	3.5	1.5
(b)	4.0	25	100	2	4.5	1.5	2	4.5	1.5	2	4.5	1.5
(c)	5.0	25	100	3	6.0	1.5	3	6.0	1.5	3	6.0	2.0
(d)	7.5	25	100	4	9.0	1.5	3	8.5	1.5	3	7.5	1.5
(e)	10.0	25	100	6	10.0	1.5	4	9.5	1.5	4	8.5	1.5
(f)	12.5	32	100	6	11.0	1.5	5	10.0	1.5	5	10.0	2.0
(g)	15.0	32	100	7	12.0	1.5	6	11.0	1.5	6	11.0	2.0
(h)	17.5	32	100	8	13.0	1.5	8	11.5	2.0	7	11.5	2.0
(i)	20.0	32	100	10	13.5	2.0	9	12.0	2.0	8	12.0	2.0
(j)	22.5	32	100	11	14.0	2.0	9	12.0	2.0	8	12.0	2.0
(k)	25.0	32	100	12	14.5	2.0	10	12.0	2.0	8	12.0	2.0

Notes:

(1) H_e is the maximum effective slope height, ϕ_r the nail diameter, ϕ_h the hole diameter S_h the horizontal spacing of nails, and N & L the number of rows and length of the soil nails respectively.

(2) For H_e between any of the two consecutive values, the soil nail layout corresponding to the higher H_e value should be adopted.

(3) Soil nails should be evenly spaced over the slope face.

(4) N is the number of soil nails per vertical column required at the critical section, i.e. the section with the maximum effective height, H_e. At other parts of the slope, soil nails should be provided at vertical and horizontal spacings similar to that at the critical section. Alternatively, different soil nail layouts according to the maximum H_e of that part of the slope may be adopted.

(5) 'A', 'B' and 'C' refer to a large factor of safety increase ($0.3 < \Delta FOS \leq 0.5$), a medium factor of safety increase ($0.1 < \Delta FOS \leq 0.3$) and a small factor of safety increase ($0 < \Delta FOS \leq 0.1$) respectively.

(6) If in the process of drilling rock is encountered such that part of the soil nails will be installed in rock (e.g. installation through a PW50/90 zone or better, see Geoguide 3), the designer may exercise professional judgement to reduce the nail length L. In the absence of site-specific ground investigation, sound engineering judgement is required to ensure that the nails are not prematurely terminated in corestone boulders.

(7) The designer should check the land status to see whether the nails encroach into adjoining land and if so whether this is acceptable to the land owner.

Record Sheet for Prescriptive Measures Application

Slope Reference No.: 12SW-A/C182 (Section SS16)	**Location:** Tseung Kwan O Landfill Stage II/III
Geometry/Consequence:	**Qualifying criteria:**
Slope Gradient: 71° Slope Height: 6.67 m Upslope Gradient: 30° Group of Facilities Affected: 1 / ~~2 / 3 / 4 / 5~~ Consequence to life Category: 1 / ~~2 / 3~~ Record of Engineer Inspection: ~~YES~~ / NO If Yes, Inspection Date: - Geology Map No: 12	1) Pre-GCO Slope? ☑ YES ☐ NO 2) Within Consequence and Geometry Limits? ☑ YES ☐ NO 3) Within Area of selected formations of Granite or Volcanics? ☑ YES ☐ NO 4) Adverse Geological conditions present? ☐ YES ☑ NO 5) Adverse Groundwater Conditions? ☐ YES ☑ NO

Record of Landslides

Date:	Scar Height (m)	Failure Volume (m^3)	GEO Incident No.
1) None			
2)			
3)			

Type Of Improvement Works

☐ Preventive Maintenance ☐ Urgent Repair to the current Landslide ☑ Upgrading works (~~LPM~~)

Design Objective	Prescriptive Measure Recommended		Figure No.
☐ Improve surface protection	☐ 1.1.1	Cover slope face with shotcrete.	A1
	☐ 1.1.2	Locally trim and remove loose materials	-
☐ Improve local stability	1.1.3	Fill local areas with no-fines concrete:	
	☐	(a) at upper part of slope	A2
	☐	(b) at lower part of slope	A2
	☐ 1.1.4	Cover upslope area with shotcrete	A3
☐ Improve surface drainage	☐ 1.2.1	Provide surface drainage channels	-
	☐ 1.2.2	Provide slope crest channel with upstand	A3
☑ Improve subsurface drainage ☐ Provide contingency subsurface drainage measures	2.1	Provide drainage behind impermeable surface cover:	
	☐	(a) with no fines concrete toe	A4
	☐	(b) with relief drains	A5
	2.2	Cover slope face with no-fines concrete:	
	☐	(a) at upper part of slope	A6
	☐	(b) at lower part of slope or on berm	A7
	2.3	Provide raking drains:	
	☐	(a) at upper part of slope	A8
	☐	(b) at lower part of slope	A9
	☑	(c) at specific seepage or potential seepage areas	-
	☐ 2.4	Provide cut-off drain above slope crest	A10
	☐ 2.5	Provide toe drain	A10
	☐ 2.6	Provide counterfort drains at upper part of slope	A11
☑ Provide support to improve overall slope stability.	☑ 3.1	Provide soil nails with a FOS increase in range:-A / ~~B / C~~	A12
☐ Others (please specify)	☐	Other measures (please specify)	

Attachments:

☐ Site Location Plan ☐ Photographs ☐ Records of Engineer Inspection

☐ Plan, sketches/drawings showing locations/layout/key dimensions of the proposed prescriptive measures

Designed: W. Y. Law **Post: AE**	**Signature:** **Date:**	**Checked: Tony Chen** **Post: SE**	**Signature:** **Date:**

Agreement No. FD 01-052
Geotechnical Review and Site Investigation Works
For Tseung Kwan O Landfill Stage II/III
Afteruse Development

Feature 12SW-A/C182 (Section SS16)

From SLOPE/W Analysis

Consequence-to-life Category	1
Required FoS	1.2
Calculated FoS	0.863
Range of FoS Increase for Prescriptive Application of Soil Nailing	A

Refer to Section SS16

maximum height of the feature, H = 6.67 m

Upslope gradient β = 30 °

Surcharge q = 5 kPa

Maximum effective height

$H_e = H \times (1 + 0.35\tan\beta) + q/20$

= 8.27 m

From Table A2 of GEO Report No. 56 (Issue 2),

Soil Nail Layout is as follows:

Type (e)

Number of rows of soil nails, N 6

Nail diameter, ϕ_r(mm) 25 mm

Hole diameter, ϕ_h (mm) 100 mm

Horizontal spacing, S_h (m) 1.5 m

Length of soil nails, L (m) 10.0 m

Computed by: Checked by:

Date Date

Table A2 - Standard Soil Nail Layout

Standard Soil Nail Layout	H_e (m)	ϕ_r (mm)	ϕ_h (mm)	A			B			C		
				N	L(m)	S_h(m)	N	L(m)	S_h(m)	N	L(m)	S_h(m)
(a)	3.0	25	100	2	3.5	1.5	2	3.5	1.5	2	3.5	1.5
(b)	4.0	25	100	2	4.5	1.5	2	4.5	1.5	2	4.5	1.5
(c)	5.0	25	100	3	6.0	1.5	3	6.0	1.5	3	6.0	2.0
(d)	7.5	25	100	4	9.0	1.5	3	8.5	1.5	3	7.5	1.5
(e)	10.0	25	100	6	10.0	1.5	4	9.5	1.5	4	8.5	1.5
(f)	12.5	32	100	6	11.0	1.5	5	10.0	1.5	5	10.0	2.0
(g)	15.0	32	100	7	12.0	1.5	6	11.0	1.5	6	11.0	2.0
(h)	17.5	32	100	8	13.0	1.5	8	11.5	2.0	7	11.5	2.0
(i)	20.0	32	100	10	13.5	2.0	9	12.0	2.0	8	12.0	2.0
(j)	22.5	32	100	11	14.0	2.0	9	12.0	2.0	8	12.0	2.0
(k)	25.0	32	100	12	14.5	2.0	10	12.0	2.0	8	12.0	2.0

Notes:

(1) H_e is the maximum effective slope height, ϕ_r the nail diameter, ϕ_h the hole diameter S_h the horizontal spacing of nails, and N & L the number of rows and length of the soil nails respectively.

(2) For H_e between any of the two consecutive values, the soil nail layout corresponding to the higher H_e value should be adopted.

(3) Soil nails should be evenly spaced over the slope face.

(4) N is the number of soil nails per vertical column required at the critical section, i.e. the section with the maximum effective height, H_e. At other parts of the slope, soil nails should be provided at vertical and horizontal spacings similar to that at the critical section. Alternatively, different soil nail layouts according to the maximum H_e of that part of the slope may be adopted.

(5) 'A', 'B' and 'C' refer to a large factor of safety increase ($0.3 < \Delta FOS \leq 0.5$), a medium factor of safety increase ($0.1 < \Delta FOS \leq 0.3$) and a small factor of safety increase ($0 < \Delta FOS \leq 0.1$) respectively.

(6) If in the process of drilling rock is encountered such that part of the soil nails will be installed in rock (e.g. installation through a PW50/90 zone or better, see Geoguide 3), the designer may exercise professional judgement to reduce the nail length L. In the absence of site-specific ground investigation, sound engineering judgement is required to ensure that the nails are not prematurely terminated in corestone boulders.

(7) The designer should check the land status to see whether the nails encroach into adjoining land and if so whether this is acceptable to the land owner.

Record Sheet for Prescriptive Measures Application

Slope Reference No.: 12SW-A/C183	**Location:** Tseung Kwan O Landfill Stage II/III
Geometry/Consequence:	**Qualifying criteria:**
Slope Gradient: 46° Slope Height: 3.68 m Upslope Gradient: 33.7° Group of Facilities Affected: 1 / ~~2 / 3 / 4 / 5~~ Consequence to life Category: 1 / ~~2 / 3~~ Record of Engineer Inspection: ~~YES~~ / NO If Yes, Inspection Date: - Geology Map No: 12	1) Pre-GCO Slope? ☑ YES ☐ NO 2) Within Consequence and Geometry Limits? ☑ YES ☐ NO 3) Within Area of selected formations of Granite or Volcanics? ☑ YES ☐ NO 4) Adverse Geological conditions present? ☐ YES ☑ NO 5) Adverse Groundwater Conditions? ☐ YES ☑ NO

Record of Landslides

Date:	Scar Height (m)	Failure Volume (m^3)	GEO Incident No.
1) None			
2)			
3)			

Type Of Improvement Works

☐ Preventive Maintenance ☐ Urgent Repair to the current Landslide ☑ Upgrading works (~~LPM~~)

Design Objective	Prescriptive Measure Recommended		Figure No.
☐ Improve surface protection	☐ 1.1.1	Cover slope face with shotcrete.	A1
	☐ 1.1.2	Locally trim and remove loose materials	-
☐ Improve local stability	1.1.3	Fill local areas with no-fines concrete:	
	☐	(a) at upper part of slope	A2
	☐	(b) at lower part of slope	A2
	☐ 1.1.4	Cover upslope area with shotcrete	A3
☐ Improve surface drainage	☐ 1.2.1	Provide surface drainage channels	-
	☐ 1.2.2	Provide slope crest channel with upstand	A3
☑ Improve subsurface drainage ☐ Provide contingency subsurface drainage measures	2.1	Provide drainage behind impermeable surface cover:	
	☐	(a) with no fines concrete toe	A4
	☐	(b) with relief drains	A5
	2.2	Cover slope face with no-fines concrete:	
	☐	(a) at upper part of slope	A6
	☐	(b) at lower part of slope or on berm	A7
	2.3	Provide raking drains:	
	☐	(a) at upper part of slope	A8
	☐	(b) at lower part of slope	A9
	☑	(c) at specific seepage or potential seepage areas	-
	☐ 2.4	Provide cut-off drain above slope crest	A10
	☐ 2.5	Provide toe drain	A10
	☐ 2.6	Provide counterfort drains at upper part of slope	A11
☐ Provide support to improve overall slope stability.	☐ 3.1	Provide soil nails with a FOS increase in range:-A / B / C	A12
☐ Others (please specify)	☐	Other measures (please specify)	

Attachments:

☐ Site Location Plan ☐ Photographs ☐ Records of Engineer Inspection

☐ Plan, sketches/drawings showing locations/layout/key dimensions of the proposed prescriptive measures

Designed: W. Y. Law	**Signature:**	**Checked: Tony Chen**	**Signature:**
Post: AE	**Date:**	**Post: SE**	**Date:**

Record Sheet for Prescriptive Measures Application

Slope Reference No.: 12SW-A/C188	**Location:** Tseung Kwan O Landfill Stage II/III
Geometry/Consequence:	**Qualifying criteria:**
Slope Gradient: 44° Slope Height: 5.39 m Upslope Gradient: 26.6° Group of Facilities Affected: ~~1 / 2 / 3~~ / 4 /~~5~~ Consequence to life Category: ~~1 / 2~~ / 3 Record of Engineer Inspection: ~~YES~~ / NO If Yes, Inspection Date: - Geology Map No: 12	1) Pre-GCO Slope? ☑ YES ☐ NO 2) Within Consequence and Geometry Limits? ☑ YES ☐ NO 3) Within Area of selected formations of Granite or Volcanics? ☑ YES ☐ NO 4) Adverse Geological conditions present? ☐ YES ☑ NO 5) Adverse Groundwater Conditions? ☐ YES ☑ NO

Record of Landslides

Date:	Scar Height (m)	Failure Volume (m^3)	GEO Incident No.
1) None			
2)			
3)			

Type Of Improvement Works

☐ Preventive Maintenance ☐ Urgent Repair to the current Landslide ☑ Upgrading works (~~LPM~~)

Design Objective	Prescriptive Measure Recommended		Figure No.
☐ Improve surface protection	☐ 1.1.1	Cover slope face with shotcrete.	A1
	☐ 1.1.2	Locally trim and remove loose materials	-
☐ Improve local stability	1.1.3	Fill local areas with no-fines concrete:	
	☐	(a) at upper part of slope	A2
	☐	(b) at lower part of slope	A2
	☐ 1.1.4	Cover upslope area with shotcrete	A3
☐ Improve surface drainage	☐ 1.2.1	Provide surface drainage channels	-
	☐ 1.2.2	Provide slope crest channel with upstand	A3
☑ Improve subsurface drainage ☐ Provide contingency subsurface drainage measures	2.1	Provide drainage behind impermeable surface cover:	
	☐	(a) with no fines concrete toe	A4
	☐	(b) with relief drains	A5
	2.2	Cover slope face with no-fines concrete:	
	☐	(a) at upper part of slope	A6
	☐	(b) at lower part of slope or on berm	A7
	2.3	Provide raking drains:	
	☐	(a) at upper part of slope	A8
	☐	(b) at lower part of slope	A9
	☑	(c) at specific seepage or potential seepage areas	-
	☐ 2.4	Provide cut-off drain above slope crest	A10
	☐ 2.5	Provide toe drain	A10
	☐ 2.6	Provide counterfort drains at upper part of slope	A11
☐ Provide support to improve overall slope stability.	☐ 3.1	Provide soil nails with a FOS increase in range:-A / B / C	A12
☐ Others (please specify)	☐	Other measures (please specify)	

Attachments:

☐ Site Location Plan ☐ Photographs ☐ Records of Engineer Inspection

☐ Plan, sketches/drawings showing locations/layout/key dimensions of the proposed prescriptive measures

Designed: W. Y. Law	**Signature:**	**Checked:** Tony Chen	**Signature:**
Post: AE	**Date:**	**Post:** SE	**Date:**

APPENDIX E
Rock Mapping Results

DISCONTINUITY SURVEY DATA SHEET

Project: **Agreement No.FD 01-052, Tseung Kwan O Landfill Stage II/III**
Location: **Feature No. 12SW-A/C76 (along Strip S33)**
Date: **10th July 2002**
Geologist: **Smo** Ref. no.: **2311/0201**

No.	Chainage	Type	Dip	Dip Direction	Persistence	Aperture	Nature of Filling	Consistence of infilling	Surface Roughness	Width of Differentially Weathered Zone (mm)	Water	Joint Spacing	Frequency	Remarks
1		2	50	330	4		2		1		1	1	1	open joint
2		2	70	355	2	6	2		2		1	1	2	
3		2	71	275	2	6	2		1		1	1	1	
4		2	85	213	1.5	5-6	2		1		1	1	1	
5		2	84	213	1	5-6	1/2		3		1	1	1	
6		2	88	210										joint from S33
7		2	63	215										joint from S33
8		2	60	215										Strip S3
9		2	75	265										
10		2	72	290										
11		2	70	293										
12		2	80	295										
13		2	70	220										
14		2	50	315										
15		2	75	60										
16		2	45	330										
17		2	40	270										
18		2	40	14										Strip S32
19		2	88	15										
20		2	79	84										
21		2	80	330										
22		2	88	333										
23		2	39	340										
24		2	80	255										
25		2	30	349										
26		2	13	24										
27		2	82	78										
28		2	60	360										
29		2	80	50										
30		2	78	165										Strip S1
31		2	79	200										

Type
0 Fault Zone
1. Fault
2. Joint
3. Cleavage
4. Shear
6. Fissure
7. Tension Crack
8. Foliation
9. Bedding

Dip, Dip Direction
(Expressed in degrees)

Persistence
(Expressed in meters)

Aperture
1. Wide (>200mm)
2. Mod. wide (60-200mm)
3. Mod. narrow (20-60mm)
4. Narrow (6-20mm)
5. Very narrow (2-6mm)
6. Ext. narrow (<2mm)
7. Tight

Nature of infilling
1. Clean
2. Surface staining
3. Non-cohesive
4. Cohesive
5. Cemented
6. Calcite
7. Chlorite, Tale
8. Others-clay
9. Manganese

Consistency of Soil strength
1. Soft
2. Firm
3. Stiff
4. Hard

Rock strength
5. Weak
6. Mod. strong
7. Strong
8. Very strong

Roughness
1. Rough stepped
2. Rough undulating
3. Rough planar
4. Smooth stepped
5. Smooth undulating
6. Smooth planar
7. Slickensided stepped
8. Slickensided undulating
9. Slickensided planar

Water
1. Dry
2. Seepage
3. Slight flow <0.1 l/sec.
4. Mod. flow 0.1 - 1 l/sec.
5. High flow >1 l/sec.

Set Joint Spacing
1. Widely >600mm
2. Medium 200-600mm
3. Closely 60-200mm
4. V.closely 20-60mm
5. E.closely <20mm

Frequency
no. of joints/m

DISCONTINUITY SURVEY DATA SHEET

Project: **Agreement No.FD 01-052, Tseung Kwan O Landfill Stage II/III**
Location: **Feature No. 12SW-A/C174**
Date: **8th July 2002**
Geologist: **Smo** Ref. no.: **2311/0202**

No.	Chainage	Type	Dip	Dip Direction	Persistence	Aperture	Nature of Filling	Consistence of infilling	Surface Roughness	Width of Differentially Weathered Zone (mm)	Water	Joint Spacing	Frequency	Remarks
1		2	84	53	3	5	2		2		1	1-2	2	
2		2	10	1	1	5-6	2		1		1	2-3	3	
3		2	3	328	2	5-6	2		1		1	2-3	3	
4		2	81	50	1-2	5-6	2/9		2		1	1-2	2	
5		2	70	231	2	5	2		1		1	1	2	slightly open joint (3mm)
6		2	88	240	2-3	5	2		1		1	1	2	slightly open joint (5mm)
7		2	86	53	1	6	9		2		1	3	2	
8		2	23	28	1.5	6	2		2		1	1	2	
9		2	75	233	1.5	6	9		2		1	2	2-3	
10		2	74	105	1.5	6	9		1-2		1	1	1	
11		2	90	245	3	6	9		2		1	1	2	
12		2	90	220	2	6	2		2		1	1-2	2-3	
13		2	73	52	2	6	2/9		2		1	1	1	
14		2	80	60	4	6	2/9		1		1	1	2	
15		2	12	31	4	6	2/9		1-2		1	1	1	
16		2	10	357	4	6	2/9		1-2		1	1	1	
17		2	89	10	1.5	6	2/9		2		1	1	2	
18		2	50	316	2	5-6	2/9		1		1	1	1	
19		2	22	337	2	5	2/9		2		1	1-2	2	HD and soil along joint
20		2	82	263	3-4	5-6	2/9		1		1	1	2	
21		2	12	27	3-4	6	2/9		1		1	1	2	
22		2	78	256	5	6	2/9		1		1	1	2	
23		2	80	345	1-2	5-6	2/9		1		1	1	1	
24		2	84	85	>5	6	2/9		1		1	1	1-2	
25		2	85	92	>5	6	2/9		1		1	1	1-2	
26		2	88	45	1-2	6	9		1		1	1	1	
27		2	81	245	>5		2/9		3		1	2	3	open joint 10mm
28		2	87	231	2		2/9		1		1	2	2	open joint 3-5mm
29		2	90	310	1	5-6	2/9		1		1	1	1	
30		2	30	323	1.5	5	2/9		1		1	1	2	
31		2	73	242	4-5	4	2/9		1		1	2	3	open joint 10mm
32		2	88	245	>5	5	9		1		1	2	3	open joint <3mm
33		2	58	149	4	4-5	2		1		1	1	1	
34		2	18	10	3-4	5	2/9		1		1	2	2	
35		2	88	248	3	5	9		2		1	1	2	open joint <3mm
36		2	32	300	2	6	9		2		1	1	1	
37		2	80	310										joints from chunam strip S7
38		2	85	310										
39		2	76	234										
40		2	76	325										
41		2	88	54										
42		2	88	240										
43		2	80	240										
44		2	76	234										

Type
0. Fault Zone
1. Fault
2. Joint
3. Cleavage
4. Shear
6. Fissure
7. Tension Crack
8. Foliation
9. Bedding

Dip, Dip Direction
(Expressed in degrees)

Persistence
(Expressed in meters)

Aperture
1. Wide (>200mm)
2. Mod. wide (60-200mm)
3. Mod. narrow (20-60mm)
4. Narrow (6-20mm)
5. Very narrow (2-6mm)
6. Ext. narrow (<2mm)
7. Tight

Nature of infilling
1. Clean
2. Surface staining
3. Non-cohesive
4. Cohesive
5. Cemented
6. Calcite
7. Chlorite, Tale
8. Others-clay
9. Manganese

Consistency of Soil strength
1. Soft
2. Firm
3. Stiff
4. Hard

Consistency of Rock strength
5. Weak
6. Mod. strong
7. Strong
8. Very strong

Roughness
1. Rough stepped
2. Rough undulating
3. Rough planar
4. Smooth stepped
5. Smooth undulating
6. Smooth planar
7. Slickensided stepped
8. Slickensided undulating
9. Slickensided planar

Water
1. Dry
2. Seepage
3. Slight flow <0.1 l/sec.
4. Mod. flow 0.1 - 1 l/sec.
5. High flow >1 l/sec.

Set Joint Spacing
1. Widely >600mm
2. Medium 200-600mm
3. Closely 60-200mm
4. V.closely 20-60mm
5. E.closely <20mm

Frequency
no. of joints/m

DISCONTINUITY SURVEY DATA SHEET

Project: **Agreement No.FD 01-052, Tseung Kwan O Landfill Stage II/III**
Location: **Feature No. 12SW-A/C174**
Date: **8th July 2002**
Geologist: **Smo** Ref. no.: **2311/0202**

No.	Chainage	Type	Dip	Dip Direction	Persistence	Aperture	Nature of Filling	Consistence of infilling	Surface Roughness	Width of Differentially Weathered Zone (mm)	Water	Joint Spacing	Frequency	Remarks
45		2	78	229										
46		2	29	30										
47		2	87	290										
48		2	2	15										
49		2	78	265										
50		2	88	265										
51		2	81	256										
52		2	78	170										
53		2	77	350										
54		2	88	40										
55		2	77	340										
56		2	15	10										
57		2	88	250										
58		2	79	69										
59		2	80	57										
60		2	88	34										
61		2	62	120										
62		2	80	220										
63		2	80	230										
64		2	5	318										
65		2	5	275										
66		2	83	55										

Type

0. Fault Zone
1. Fault
2. Joint
3. Cleavage
4. Shear
6. Fissure
7. Tension Crack
8. Foliation
9. Bedding

Dip, Dip Direction

(Expressed in degrees)

Persistence

(Expressed in meters)

Aperture

1. Wide (>200mm)
2. Mod. wide (60-200mm)
3. Mod. narrow (20-60mm)
4. Narrow (6-20mm)
5. Very narrow (2-6mm)
6. Ext. narrow (<2mm)
7. Tight

Nature of infilling

1. Clean
2. Surface staining
3. Non-cohesive
4. Cohesive
5. Cemented
6. Calcite
7. Chlorite, Tale
8. Others-clay
9. Manganese

Consistency of

Soil strength

1. Soft
2. Firm
3. Stiff
4. Hard

Rock strength

5. Weak
6. Mod. strong
7. Strong
8. Very strong

Roughness

1. Rough stepped
2. Rough undulating
3. Rough planar
4. Smooth stepped
5. Smooth undulating
6. Smooth planar
7. Slickensided stepped
8. Slickensided undulating
9. Slickensided planar

Water

1. Dry
2. Seepage
3. Slight flow <0.1 l/sec.
4. Mod. flow 0.1 - 1 l/sec.
5. High flow >1 l/sec.

Set Joint Spacing

1. Widely >600mm
2. Medium 200-600mm
3. Closely 60-200mm
4. V.closely 20-60mm
5. E.closely <20mm

Frequency

no. of joints/m

DISCONTINUITY SURVEY DATA SHEET

Project: **Agreement No.FD 01-052, Tseung Kwan O Landfill Stage II/III**
Location: **Feature No. 12SW-A/C174 (along Strip S8)**
Date: **10th July 2002**
Geologist: **Smo** Ref. no.: **2311/0202**

No.	Chainage	Type	Dip	Dip Direction	Persistence	Aperture	Nature of Filling	Consistence of infilling	Surface Roughness	Width of Differentially Weathered Zone (mm)	Water	Joint Spacing	Frequency	Remarks
1		2	80	147	5		2		2		1	1	1	open 20-50mm
2		2	89	148	5		2		2		1	1	1	open 20-50mm
3		2	80	239	1-2	6	2		1		1	2	2	
4		2	87	136	1	5-6	2		1		1	2	2	
5		2	80	86	1	5-6	2		2		1	2	2	
6		2	65	228	1	6	1/2		1		1	1	1	
7		2	90	70	2	5-6	1/2		1		1	2	2	
8		2	15	81										
9		2	14	83										
10		2	15	330										
11		2	72	89										
12		2	56	12										
13		2	56	13										
14		2	85	245										
15		2	88	202										
16		2	62	227										

Type
0. Fault Zone
1. Fault
2. Joint
3. Cleavage
4. Shear
6. Fissure
7. Tension Crack
8. Foliation
9. Bedding

Dip, Dip Direction
(Expressed in degrees)

Persistence
(Expressed in meters)

Aperture
1. Wide (>200mm)
2. Mod. wide (60-200mm)
3. Mod. narrow (20-60mm)
4. Narrow (6-20mm)
5. Very narrow (2-6mm)
6. Ext. narrow (<2mm)
7. Tight

Nature of infilling
1. Clean
2. Surface staining
3. Non-cohesive
4. Cohesive
5. Cemented
6. Calcite
7. Chlorite, Tale
8. Others-clay
9. Manganese

Consistency of Soil strength
1. Soft
2. Firm
3. Stiff
4. Hard

Consistency of Rock strength
5. Weak
6. Mod. strong
7. Strong
8. Very strong

Roughness
1. Rough stepped
2. Rough undulating
3. Rough planar
4. Smooth stepped
5. Smooth undulating
6. Smooth planar
7. Slickensided stepped
8. Slickensided undulating
9. Slickensided planar

Water
1. Dry
2. Seepage
3. Slight flow <0.1 l/sec.
4. Mod. flow 0.1 - 1 l/sec.
5. High flow >1 l/sec.

Set Joint Spacing
1. Widely >600mm
2. Medium 200-600mm
3. Closely 60-200mm
4. V.closely 20-60mm
5. E.closely <20mm

Frequency
no. of joints/m

DISCONTINUITY SURVEY DATA SHEET

Project: **Agreement No.FD 01-052, Tseung Kwan O Landfill Stage II/III**
Location: **Feature No. 12SW-A/C180 (Strip C13) & C177 (along Strips S11& S12)**
Date: **10th July 2002**
Geologist: **Smo** Ref. no.: **2311/0201**

No.	Chainage	Type	Dip	Dip Direction	Persistence	Aperture	Nature of Filling	Consistence of infilling	Surface Roughness	Width of Differentially Weathered Zone (mm)	Water	Joint Spacing	Frequency	Remarks
Feature No. 12SW-A/C180														
1		2	59	290										Strip S13
2		2	80	296										
3		2	88	255										
4		2	73	296										
Feature No. 12SW-A/C177														
1		2	69	294										Strip S12
2		2	85	281										
3		2	81	102										
4		2	80	104										
5		2	85	195										
6		2	78	87										
7		2	78	88										
8		2	80	87										
9		2	81	2										
10		2	82	233										
11		2	84	89										
12		2	86	248										
13		2	80	88										
14		2	86	253										
15		2	87	255										
16		2	80	99										
17		2	78	103										
18		2	85	20										Strip S11
19		2	87	40										
20		2	52	275										
21		2	60	290										
22		2	70	20										
23		2	75	244										
24		2	77	30										
25		2	83	290										
26		2	70	0										

Type
0. Fault Zone
1. Fault
2. Joint
3. Cleavage
4. Shear
6. Fissure
7. Tension Crack
8. Foliation
9. Bedding

Dip, Dip Direction
(Expressed in degrees)

Persistence
(Expressed in meters)

Aperture
1. Wide (>200mm)
2. Mod. wide (60-200mm)
3. Mod. narrow (20-60mm)
4. Narrow (6-20mm)
5. Very narrow (2-6mm)
6. Ext. narrow (<2mm)
7. Tight

Nature of infilling
1. Clean
2. Surface staining
3. Non-cohesive
4. Cohesive
5. Cemented
6. Calcite
7. Chlorite, Tale
8. Others-clay
9. Manganese

Consistency of Soil strength
1. Soft
2. Firm
3. Stiff
4. Hard

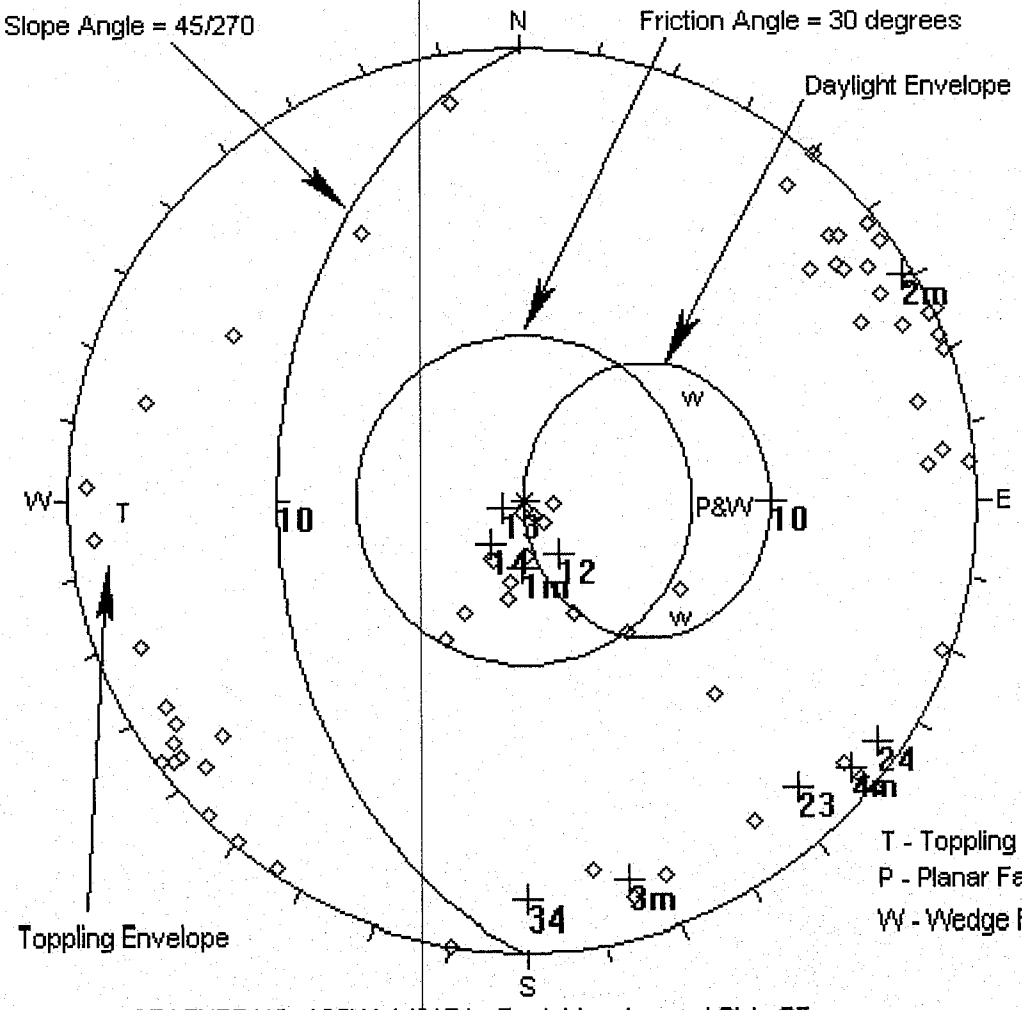
Rock strength
5. Weak
6. Mod. strong
7. Strong
8. Very strong

Roughness
1. Rough stepped
2. Rough undulating
3. Rough planar
4. Smooth stepped
5. Smooth undulating
6. Smooth planar
7. Slickensided stepped
8. Slickensided undulating
9. Slickensided planar

Water
1. Dry
2. Seepage
3. Slight flow <0.1 l/sec.
4. Mod. flow 0.1 - 1 l/sec.
5. High flow >1 l/sec.

Set Joint Spacing
1. Widely >600mm
2. Medium 200-600mm
3. Closely 60-200mm
4. V.closely 20-60mm
5. E.closely <20mm

Frequency
no. of joints/m



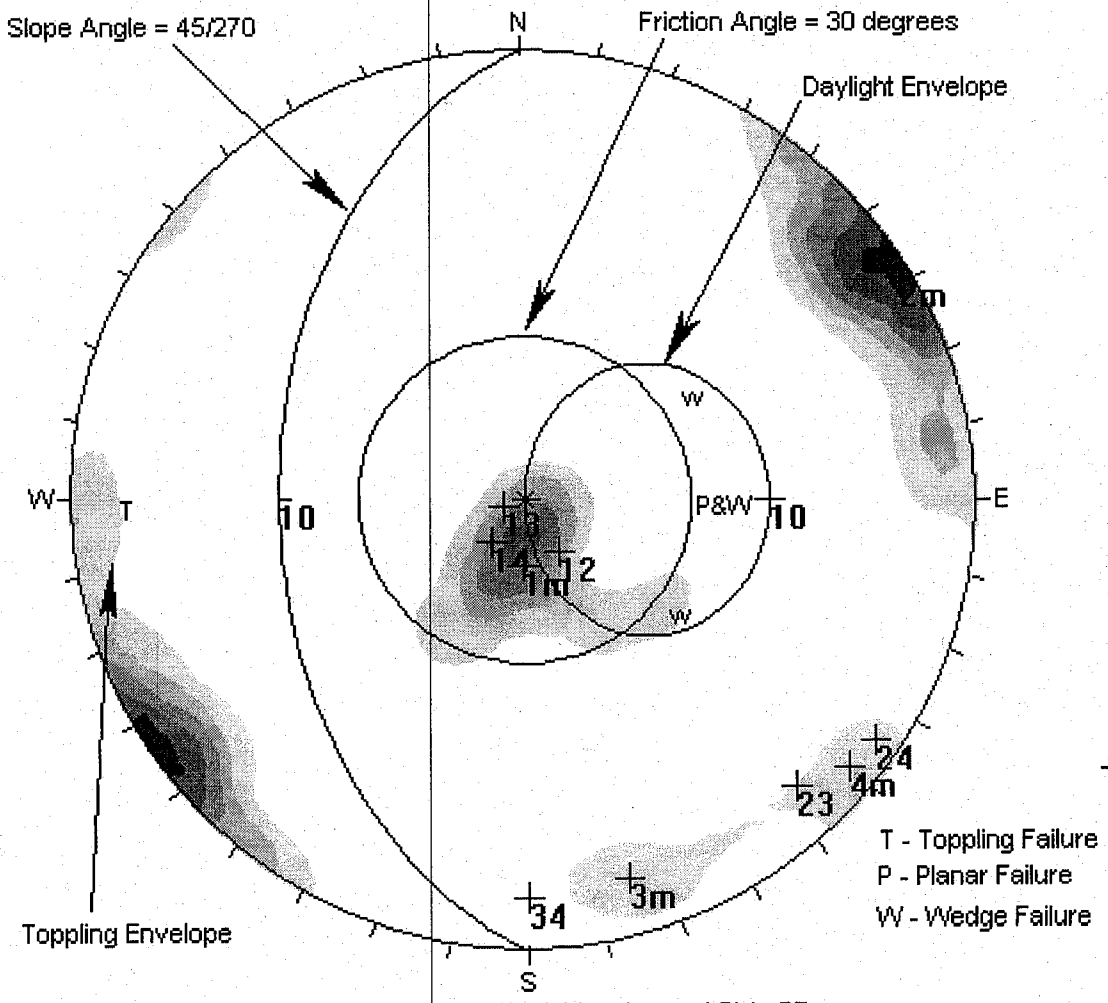
◇ Poles

T - Toppling Failure
P - Planar Failure
W - Wedge Failure

Equal Area
Lower Hemisphere
66 Poles
66 Entries

FEATURE NO. 12SW-A/C174 - Rock Mapping and Strip S7

Subject: Feature No. 12SW-A/C174 POLE PLOT	Prepared: Smo	Checked: JH	Binnie
Project: Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Aug-02	Scale: N/A	Figure No.: 1



FEATURE NO. 12SW-A/C174 - Rock Mapping and Strip S7

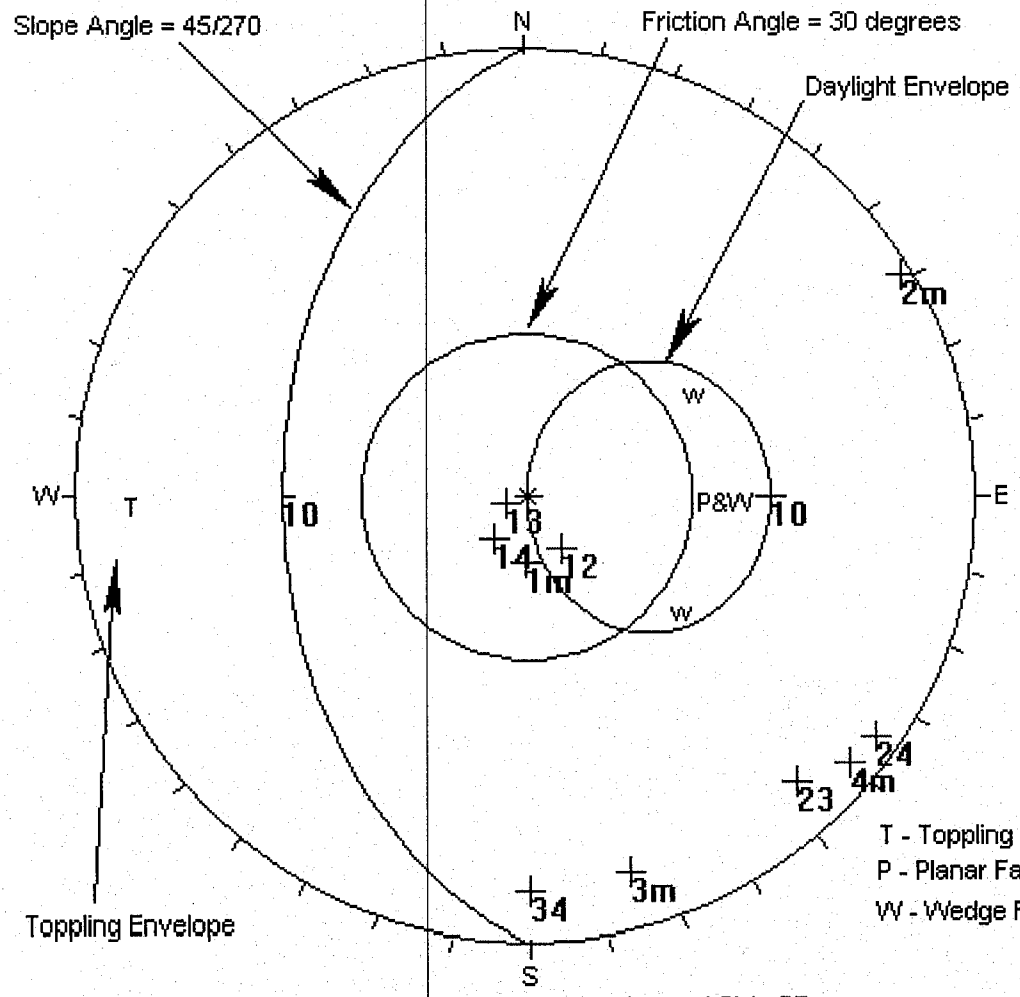
Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 1.50 %
1.50 ~ 4.00 %
4.00 ~ 6.50 %
6.50 ~ 9.00 %
9.00 ~ 11.50 %
11.50 ~ 14.00 %
>14.00 %

No Bias Correction
Max. Conc. = 12.9394%

Equal Area
Lower Hemisphere
66 Poles
66 Entries

Subject	Prepared	Checked	Binnie
Feature No. 12SW-A/C174 CONTOUR PLOT	Smo	JH	
Project	**Date**	**Scale**	**Figure No.**
Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development	Aug-02	N/A	2



T - Toppling Failure
P - Planar Failure
W - Wedge Failure

Orientations

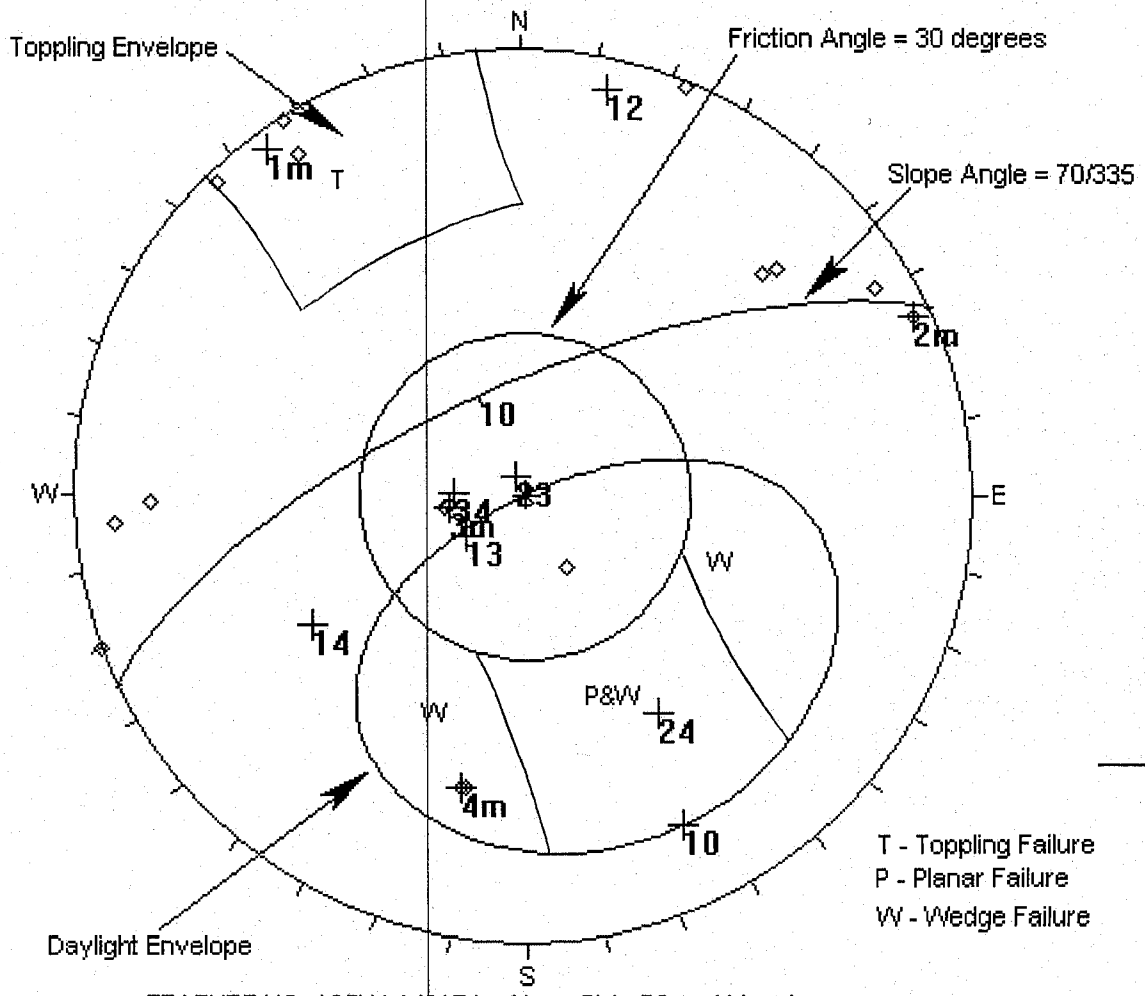
ID		Dip / Direction
12		011 / 328
13		004 / 74
14		010 / 38
23		076 / 317
24		083 / 305
34		077 / 360
10		045 / 270
1	m	012 / 2
1	w	012 / 2
2	m	087 / 239
2	w	087 / 239

More... (See text)

Equal Area
Lower Hemisphere
66 Poles
66 Entries

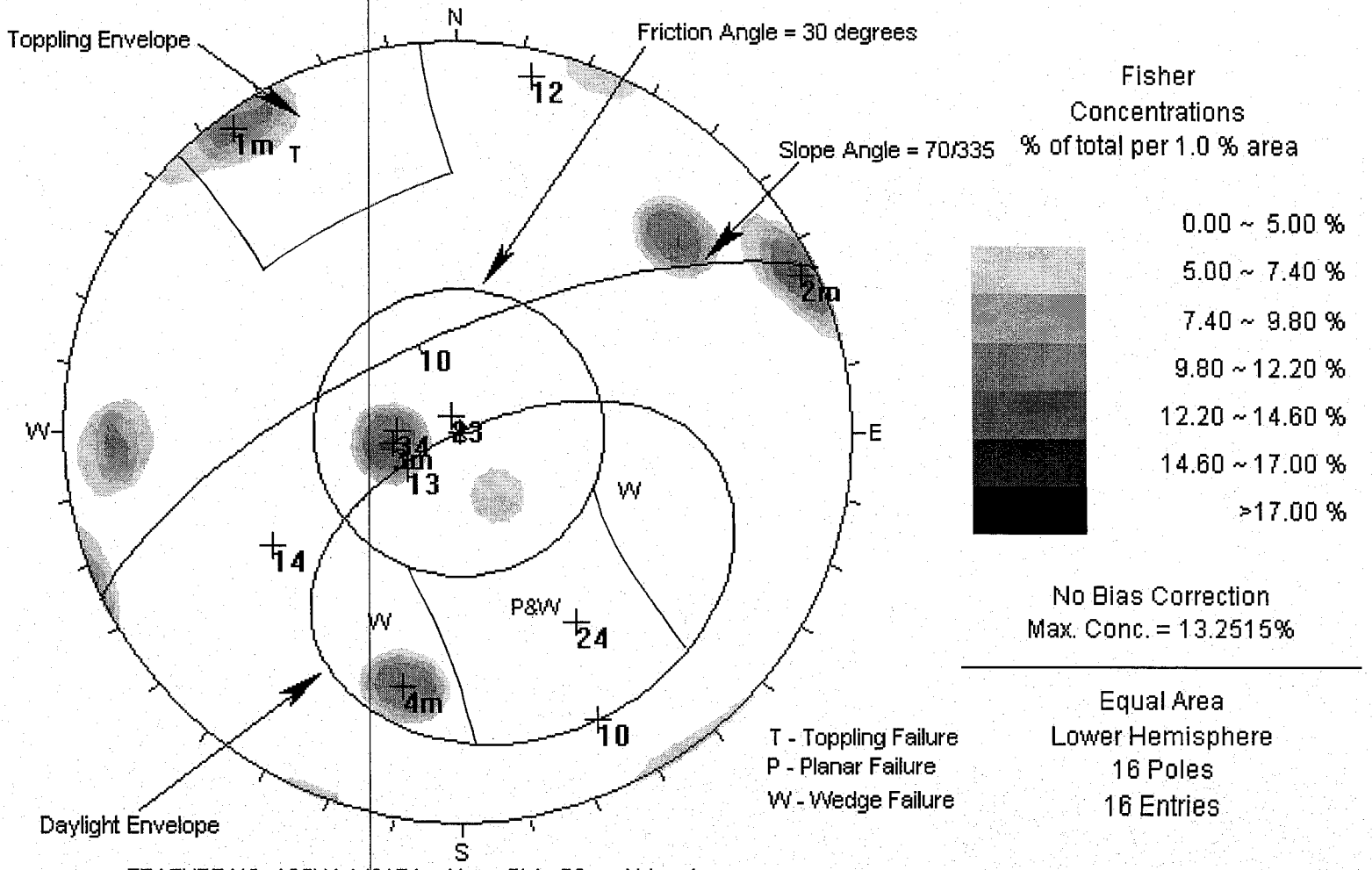
FEATURE NO. 12SW-A/C174 - Rock Mapping and Strip S7

Subject		Prepared	Checked	
Feature No. 12SW-A/C174 MAJOR PLANES PLOT		Smo	JH	Binnie
Project		Date	Scale	Figure No.
Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development		Aug-02	N/A	3



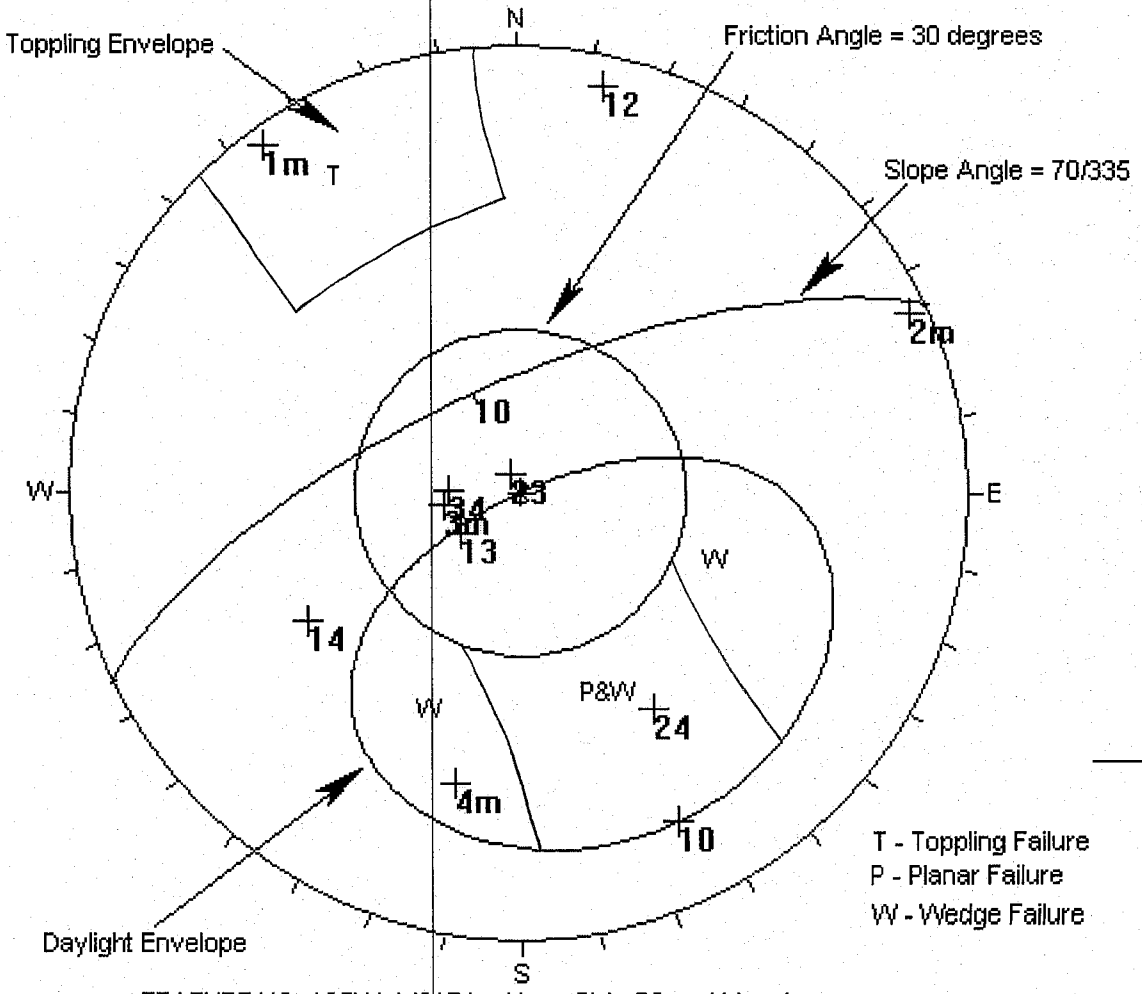
FEATURE NO. 12SW-A/C174 - Along Strip S8 and Mapping

Subject		Prepared	Checked	
Feature No. 12SW-A/C174 (Along Strip S8) POLE PLOT		Smo	JH	Binnie
Project		Date	Scale	Figure No.
Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development		Aug-02	N/A	4



FEATURE NO. 12SW-A/C174 - Along Strip S8 and Mapping

Subject	Prepared	Checked	
Feature No. 12SW-A/C174 (Along Strip S8) CONTOUR PLOT	Smo	JH	Binnie
Project	**Date**	**Scale**	**Figure No.**
Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development	Aug-02	N/A	5



FEATURE NO. 12SW-A/C174 - Along Strip S8 and Mapping

Orientations

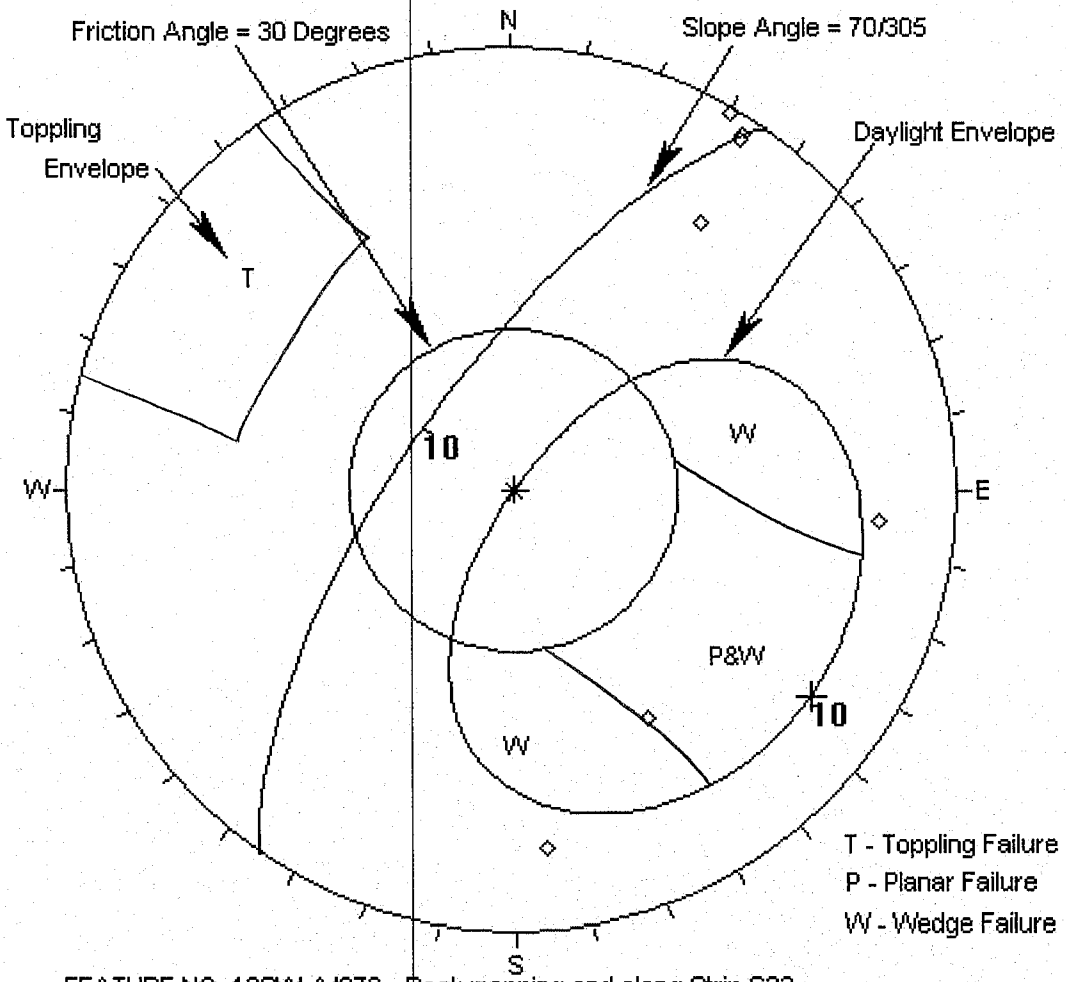
ID		Dip / Direction
12		082 / 192
13		013 / 55
14		046 / 59
23		004 / 155
24		047 / 329
34		013 / 92
10		070 / 335
1	m	085 / 144
1	w	085 / 144
2	m	085 / 245
2	w	085 / 245

More... (See text)

Equal Area
Lower Hemisphere
16 Poles
16 Entries

Subject: Feature No. 12SW-A/C174 (Along Strip S8) MAJOR PLANES PLOT	Prepared: Smo	Checked: JH	Binnie
Project: Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Aug-02	Scale: N/A	Figure No.: 6

TSEUNG KWAN O LANDFILL STAGE II/III AFTERUSE DEVELOPMENT

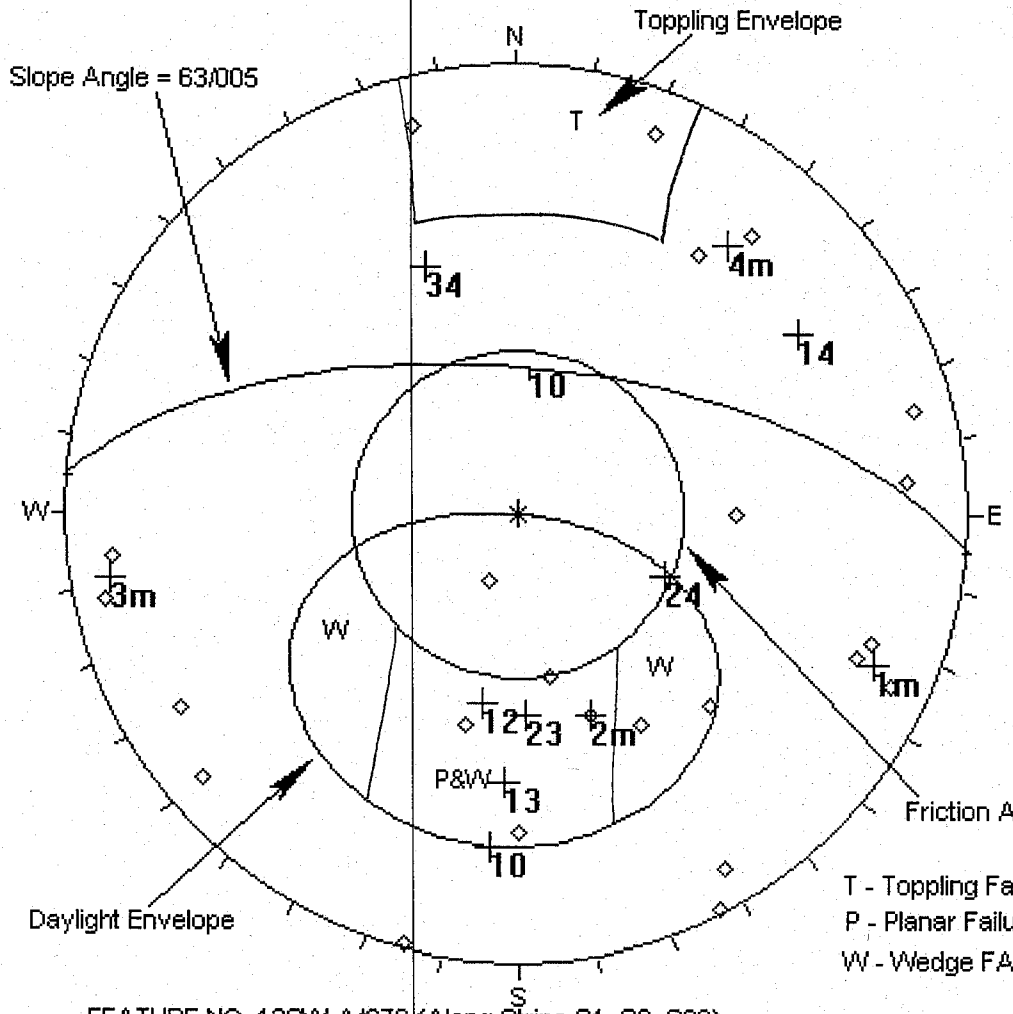


◇ Poles

Equal Area
Lower Hemisphere
7 Poles
7 Entries

FEATURE NO. 12SW-A/C76 - Rock mapping and along Strip S33

Subject		Prepared	Checked	
	Feature No. 12SW-A/C76 (Along Strip S33) POLE PLOT	Smo	KWK	Binnie
Project		Date	Scale	Figure No.
	Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development	Jul-02	N/A	7



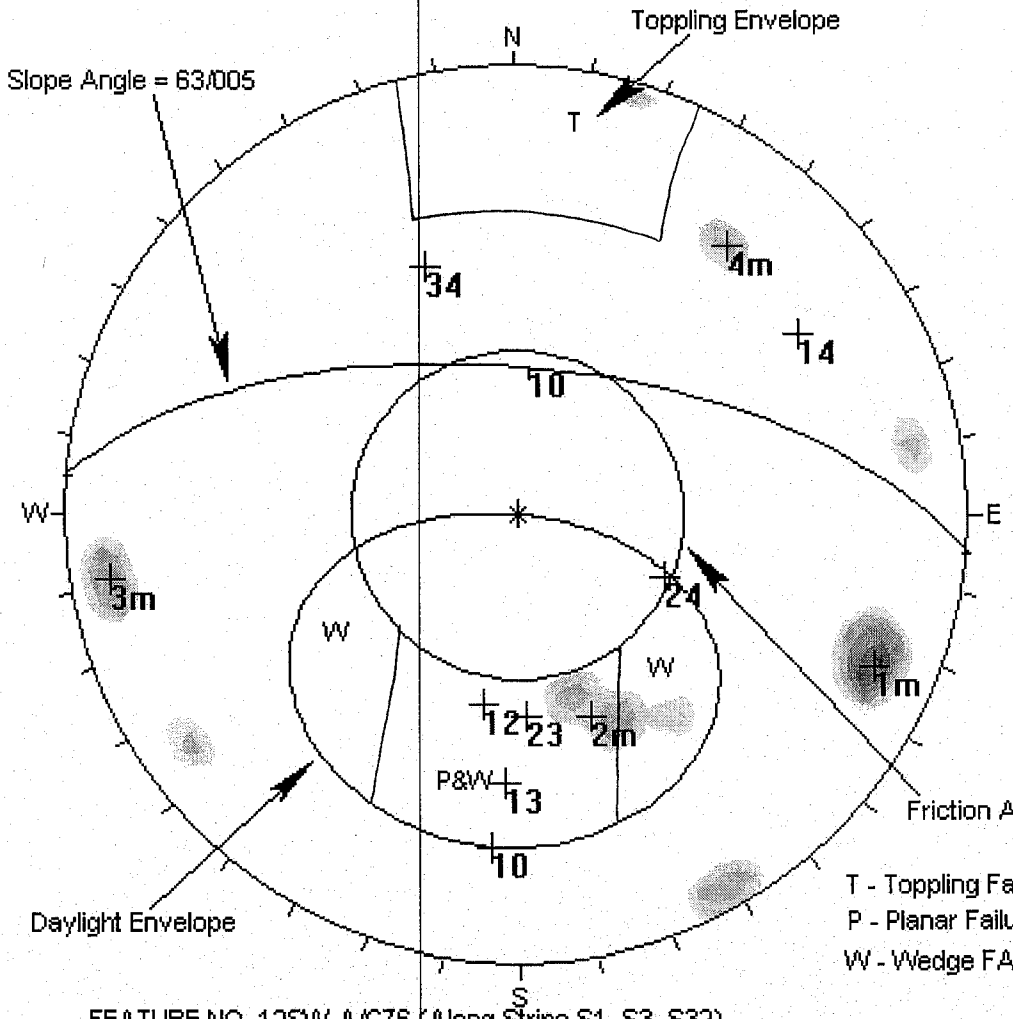
◇ Poles

T - Toppling Failure
P - Planar Failure
W - Wedge FAilure

Equal Area
Lower Hemisphere
24 Poles
24 Entries

FEATURE NO. 12SW-A/C76 (Along Strips S1, S3, S32)

Subject: Feature No. 12SW-A/C76 (Along Strips S1,S3, & S32) POLE PLOT	Prepared: Smo	Checked: JH	Binnie
Project: Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Aug-02	Scale: N/A	Figure No.: 8



FEATURE NO. 12SW-A/C76 (Along Strips S1, S3, S32)

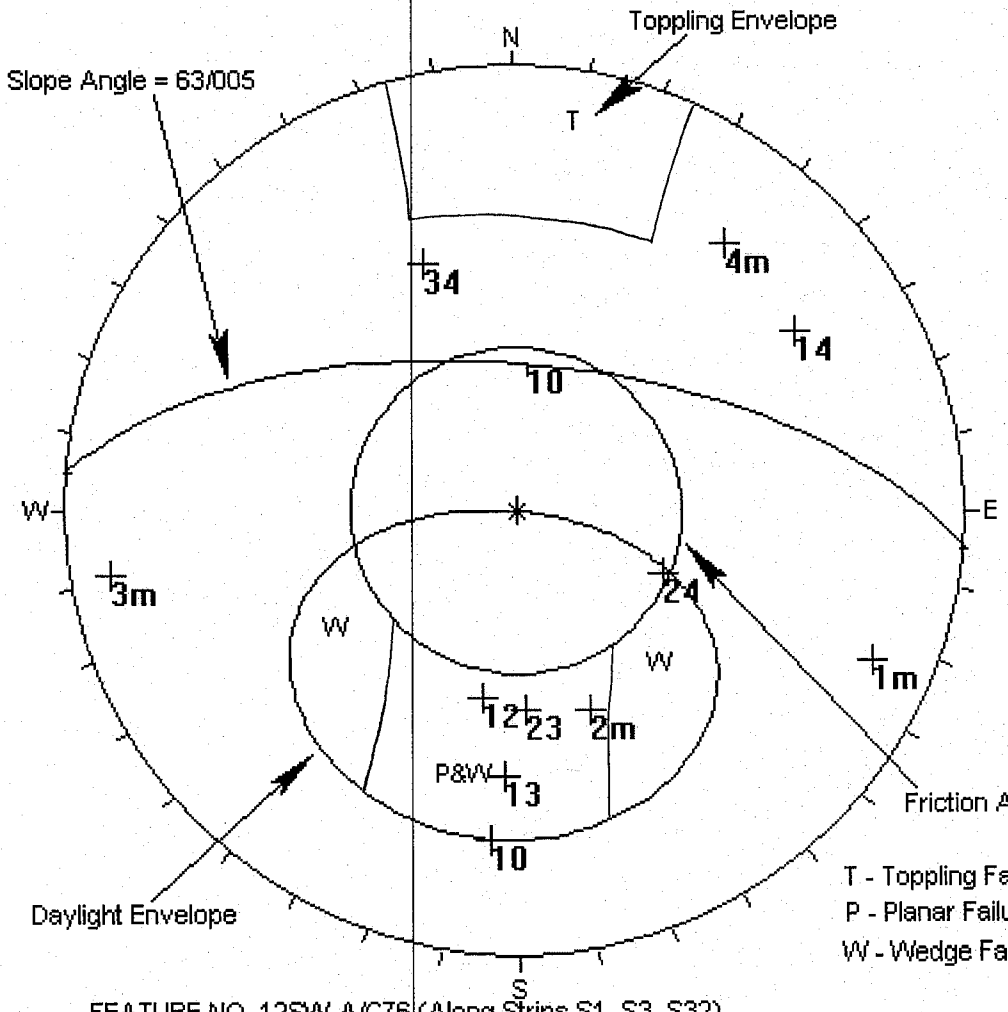
Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 5.00 %
5.00 ~ 6.40 %
6.40 ~ 7.80 %
7.80 ~ 9.20 %
9.20 ~ 10.60 %
10.60 ~ 12.00 %
>12.00 %

No Bias Correction
Max. Conc. = 11.0483%

Equal Area
Lower Hemisphere
24 Poles
24 Entries

Subject: Feature No. 12SW-A/C76 (Along Strips S1,S3, & S32) CONTOUR PLOT	Prepared: Smo	Checked: JH	Binnie
Project: Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Aug-02	Scale: N/A	Figure No.: 9



FEATURE NO. 12SW-A/C76 (Along Strips S1, S3, S32)

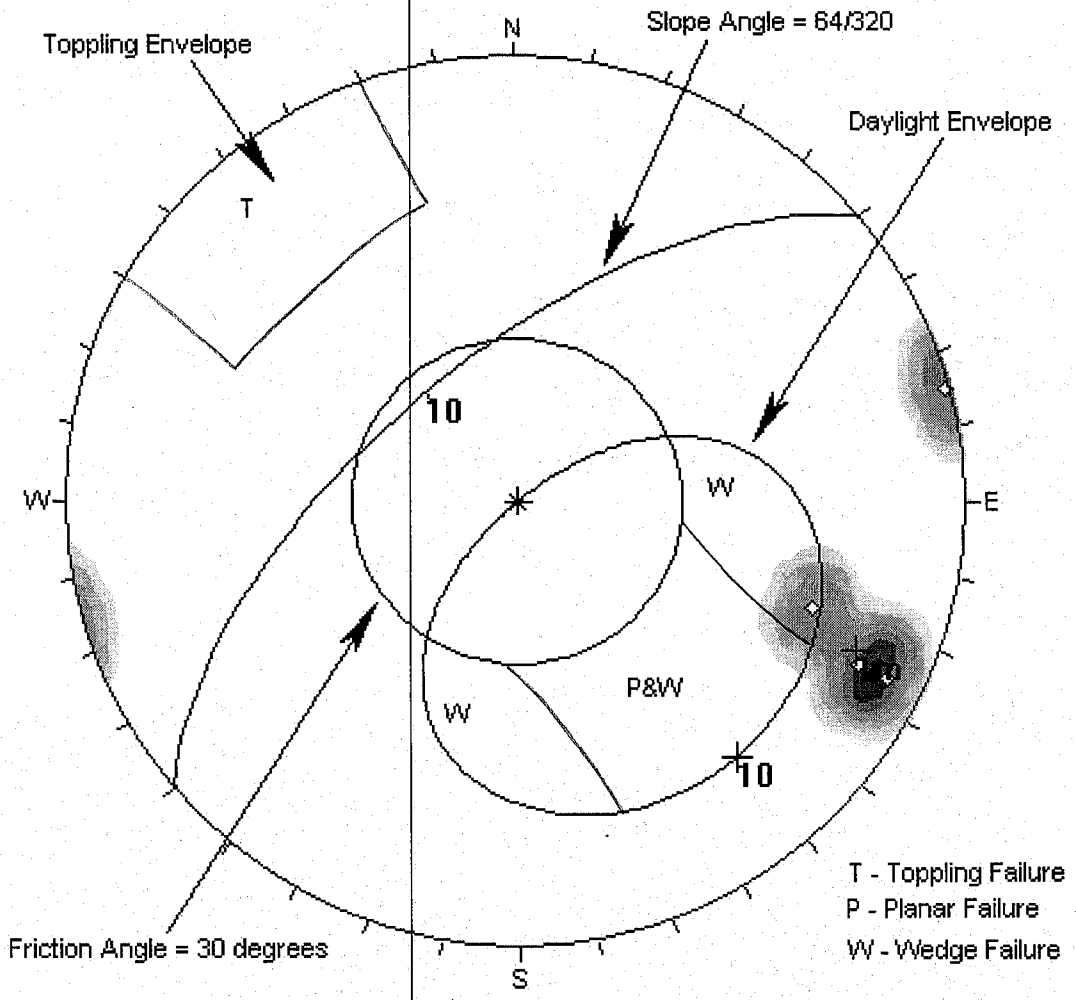
Orientations

ID		Dip / Direction
12		035 / 11
13		050 / 3
23		037 / 358
10		063 / 5
14		063 / 237
24		029 / 293
34		049 / 160
1	m	074 / 293
1	w	074 / 293
2	m	039 / 340
2	w	039 / 340

More... (see text)

Equal Area
Lower Hemisphere
24 Poles
24 Entries

Subject: Feature No. 12SW-A/C76 (Along Strips S1,S3, & S32) MAJOR PLANES PLOT	Prepared: Smo	Checked: JH	Binnie
Project: Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Aug-02	Scale: N/A	Figure No.: 10

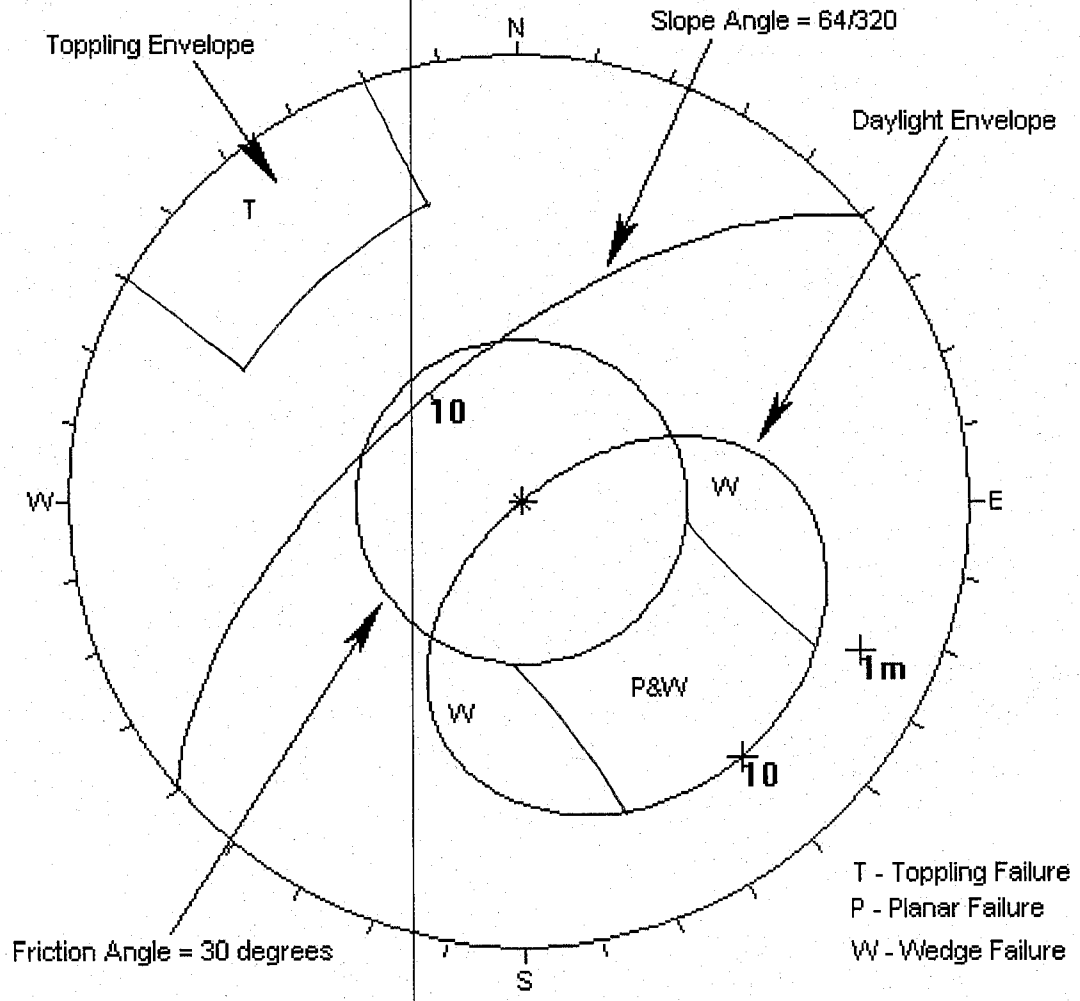


FEATURE NO. 12SW-A/C180 (Along Strip S13)

◇ Poles

Equal Area
Lower Hemisphere
4 Poles
4 Entries

Subject: Feature No. 12SW-A/C180 (Along Strip S13) POLE & CONTOUR PLOT	Prepared: Smo	Checked: JH	Binnie
Project: Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Aug-02	Scale: N/A	Figure No.: 26



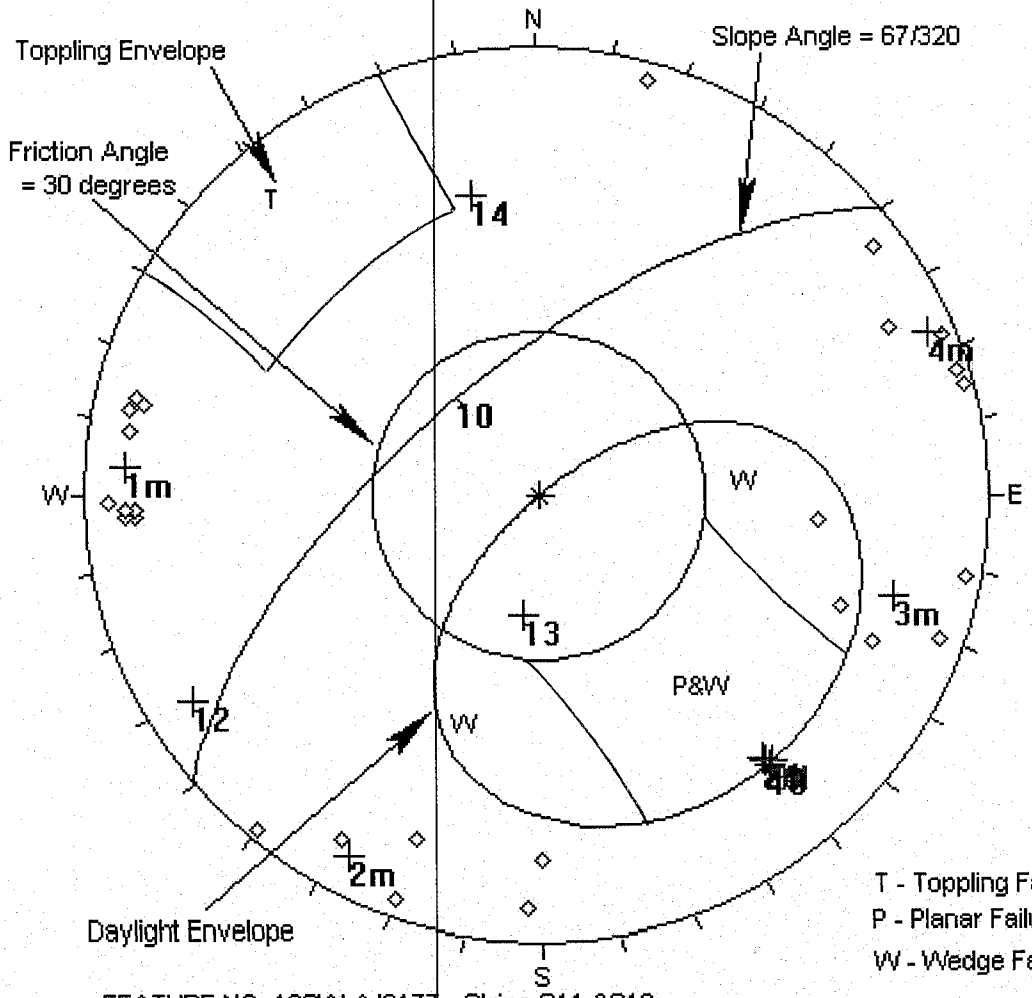
FEATURE NO. 12SW-A/C180 (Along Strip S13)

Orientations

ID		Dip / Direction
10		064 / 320
1	m	071 / 294
1	w	071 / 294

Equal Area
Lower Hemisphere
4 Poles
4 Entries

Subject: Feature No. 12SW-A/C180 (Along Strip S13) MAJOR PLANES PLOT	Prepared: Smo	Checked: JH	Binnie
Project: Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Aug-02	Scale: N/A	Figure No.: 27



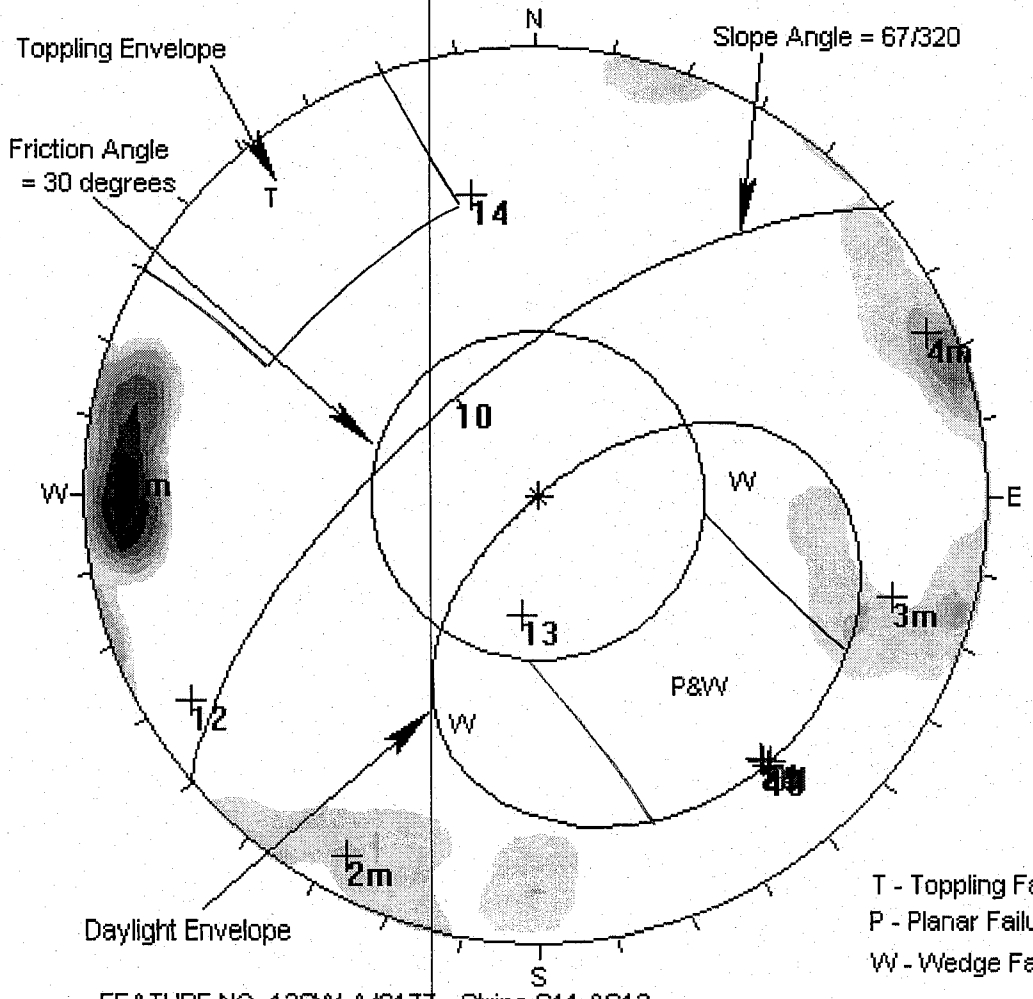
FEATURE NO. 12SW-A/C177 - Strips S11 &S12

◇ Poles

T - Toppling Failure
P - Planar Failure
W - Wedge Failure

Equal Area
Lower Hemisphere
26 Poles
26 Entries

Subject: Feature No. 12SW-A/C177 (Along Strips S11 & S12) POLE PLOT	Prepared: Smo	Checked: JH	Binnie
Project: Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development	Date: Aug-02	Scale: N/A	Figure No.: 28



FEATURE NO. 12SW-A/C177 - Strips S11 &S12

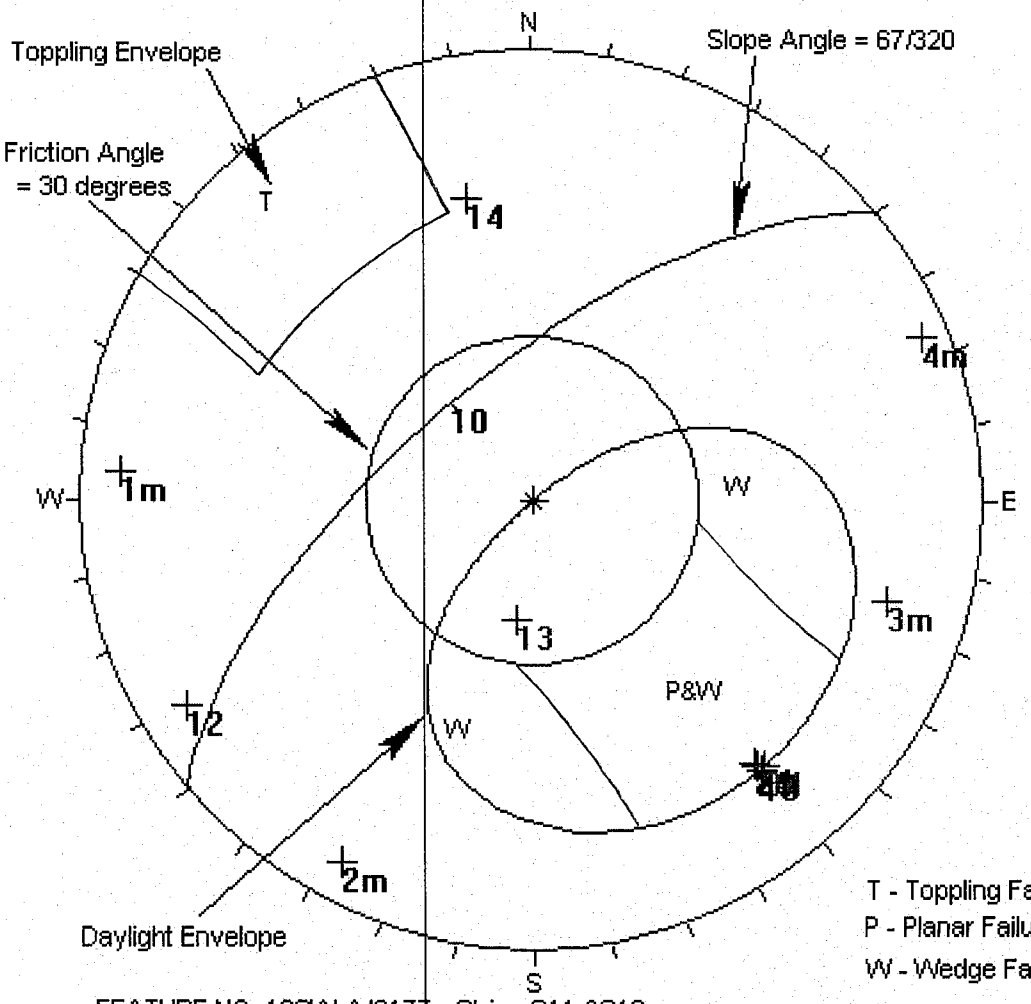
Fisher
Concentrations
% of total per 1.0 % area

0.00 ~ 3.00 %
3.00 ~ 6.00 %
6.00 ~ 9.00 %
9.00 ~ 12.00 %
12.00 ~ 15.00 %
15.00 ~ 18.00 %
>18.00 %

No Bias Correction
Max. Conc. = 20.7395%

Equal Area
Lower Hemisphere
26 Poles
26 Entries

Subject		Prepared	Checked	
Feature No. 12SW-A/C177 (Along Strips S11 & S12) CONTOUR PLOT		Smo	JH	Binnie
Project		Date	Scale	Figure No.
Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development		Aug-02	N/A	29



FEATURE NO. 12SW-A/C177 - Strips S11 &S12

T - Toppling Failure
P - Planar Failure
W - Wedge Failure

Orientations

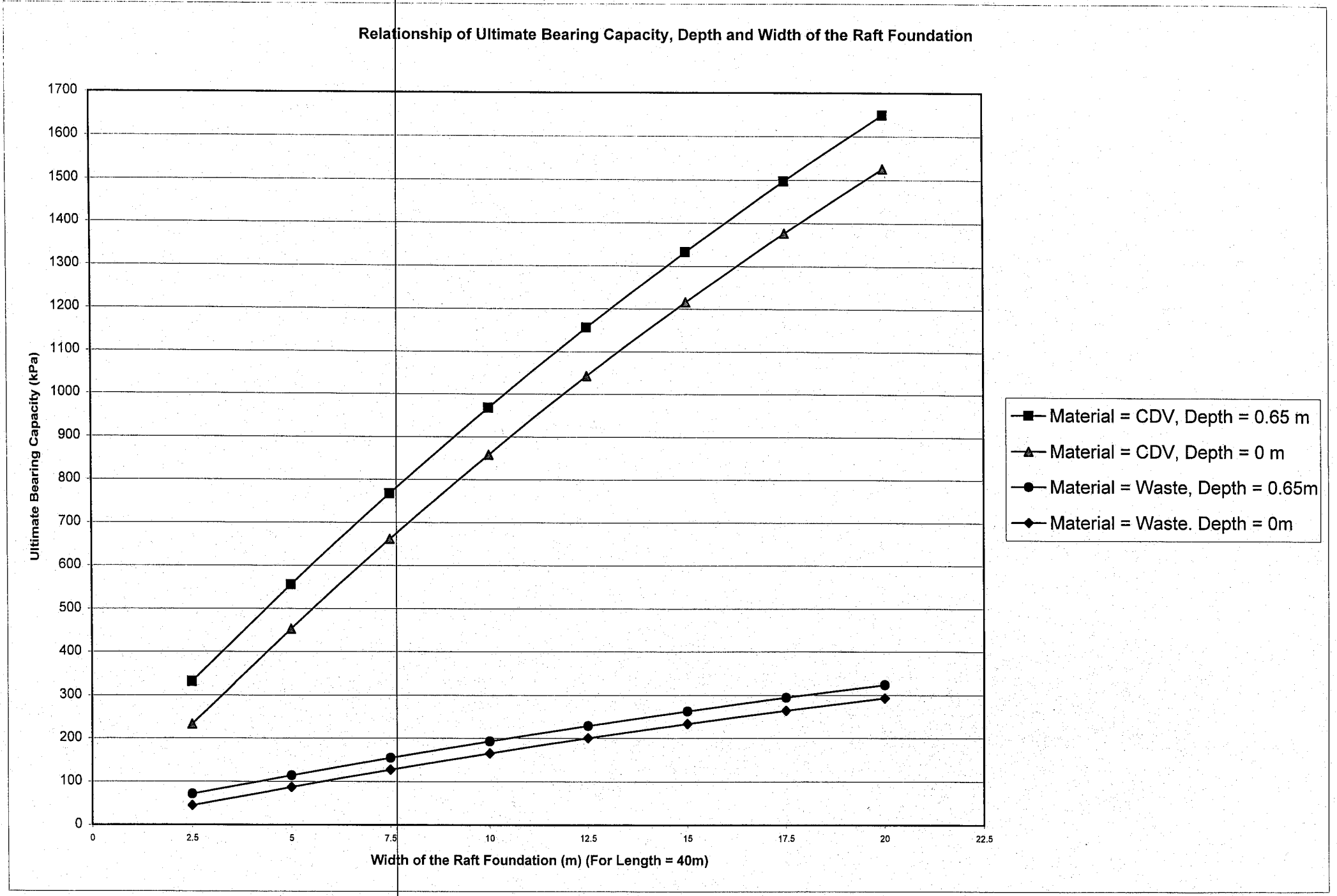
ID		Dip / Direction
12		078 / 59
13		022 / 8
14		058 / 168
23		066 / 320
24		065 / 320
34		067 / 319
10		067 / 320
1	m	080 / 94
1	w	080 / 94
2	m	080 / 28
2	w	080 / 28

More... (See text)

Equal Area
Lower Hemisphere
26 Poles
26 Entries

Subject		Prepared	Checked	
Feature No. 12SW-A/C177 (Along Strips S11 & S12) MAJOR PLANES PLOT		Smo	JH	Binnie
Project		Date	Scale	Figure No.
Agreement No. FD 01-052, Tseung Kwan O Landfill Stage II/III Afteruse Development		Aug-02	N/A	30

APPENDIX F
Bearing Capacity and Settlement Calculations


Relationship of Ultimate Bearing Capacity, Depth and Width of the Raft Foundation
Ultimate Bearing Capacity (kPa)
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
Width of the Raft Foundation (m) (For Length = 40m)
Material = CDV, Depth = 0.65 m
Material = CDV, Depth = 0 m
Material = Waste, Depth = 0.65m
Material = Waste. Depth = 0m

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m^3)
Waste beneath the foundation	0	25	13

Width of foundation,	B	=	2.5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0.65	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m^3	
Unit weight of concrete,	γ_{conc}	=	24	kN/m^3	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m^3)
Waste beneath the foundation	0.0	21.2	13

Lateral Force, F_d = 0.0 kN

Eccentricity, e_b = 0.00 m
e_l = 0.00 m

Effective width, B' = (B-2*e_b) = 2.50 m
Effective length, L' = (L-2*e_l) = 40.00 m

Pressure on the raft foundation = 30.00 kPa
Therefore, bearing pressure, q = 25.61 kPa

Total normal force, N = q*B'*L'
2560.60 kN

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq — Geoguide Figure A1 & A2

Effective area of foundation base,	A'	=	B'*L'	=	100.00 m^2
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ$_{ground}$))	=	0.00
	m_l	=	(2+B'/L')/(1+B'/L')	=	1.94
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ$_{ground}$))*tan(π/4+ϕ$_{ground}$/2)^2	=	7.24
	Nc	=	(Nq-1)/tan(ϕ$_{ground}$)	=	16.06
	Ng	=	2*(Nq+1)*tan(ϕ$_{ground}$)	=	6.40
Shape Factors,	sq	=	1+tan(ϕ$_{ground}$)*B'/L'	=	1.02
	sc	=	1+Nq/Nc*B'/L'	=	1.03
	sg	=	1-0.4*B'/L'	=	0.98
Inclination Factors,	iq	=	(1-K_i)^m_l	=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ$_{ground}$))	=	1.00
	ig	=	(1-K_i)^(m_l+1)	=	1.00
Tilt Factors,	tq	=	tg	=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ$_{ground}$))	=	1.00
	tg	=	(1-ω*tan(ϕ$_{ground}$))^2	=	1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44
	gc	=	exp(-2*β*tan(ϕ$_{ground}$))	=	0.78
	gg	=	gq	=	0.44

Effective Unit Weight of soil, γ' = 13 kN/m^3
Overburden Pressure on Founding Level q' = γ'*d*cosβ
= 8.008643 kN/m

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq
= 70.81 kPa

Factor of safety on bearing = 2.8

Conclusion, q(ult) > q OK

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0	25	13

Width of foundation,	B	=	5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0.65	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0.0	21.2	13

Lateral Force,	F_d	=	0.0	kN	
Eccentricity,	e_b	=	0.00	m	
	e_l	=	0.00	m	
Effective width,	B'	=	$(B-2*e_b)$	=	5.00 m
Effective length,	L'	=	$(L-2*e_l)$	=	40.00 m
Pressure on the raft foundation		=	30.00	kPa	
Therefore, bearing pressure,	q	=	27.50	kPa	
Total normal force,	N	=	q*B'*L'		
			5500.55	kN	

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity,	q(ult)	=	$c_{ground}*Nc*sc*ic*tc*gc + 0.5*\gamma'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq$			Geoguide Figure A1 & A2
Effective area of foundation base,	A'	=	B'*L'	=	200.00 m²	
	K_i	=	$F_d/(N+c_{ground}*A'/\tan(\phi_{ground}))$	=	0.00	
	m_i	=	(2+B'/L')/(1+B'/L')	=	1.89	
Bearing Capacity Factors,	Nq	=	$\exp(\pi*\tan(\phi_{ground}))*\tan(\pi/4+\phi_{ground}/2)^2$	=	7.24	
	Nc	=	$(Nq-1)/\tan(\phi_{ground})$	=	16.06	
	Ng	=	$2*(Nq+1)*\tan(\phi_{ground})$	=	6.40	
Shape Factors,	sq	=	$1+\tan(\phi_{ground})*B'/L'$	=	1.05	
	sc	=	1+Nq/Nc*B'/L'	=	1.06	
	sg	=	1-0.4*B'/L'	=	0.95	
Inclination Factors,	iq	=	$(1-K_i)^{m_i}$	=	1.00	
	ic	=	$iq-(1-iq)/(Nc*\tan(\phi_{ground}))$	=	1.00	
	ig	=	$(1-K_i)^{(m_i+1)}$	=	1.00	
Tilt Factors,	tq	=	tg	=	1.00	
	tc	=	$tq-(1-tq)/(Nc*\tan(\phi_{ground}))$	=	1.00	
	tg	=	$(1-\omega*\tan(\phi_{ground}))^2$	=	1.00	
Ground Slope Factors,	gq	=	$(1-\tan\beta)^2$	=	0.44	
	gc	=	$\exp(-2*\beta*\tan(\phi_{ground}))$	=	0.78	
	gg	=	gq	=	0.44	
Effective Unit Weight of soil,	γ'	=	13	kN/m³		
Overburden Pressure on Founding Level	q'	=	γ'*d*cosβ			
		=	8.008643	kN/m		
Ultimate Bearing Capacity,	q(ult)	=	$c_{ground}*Nc*sc*ic*tc*gc + 0.5*\gamma'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq$			
		=	113.80	kPa		
Factor of safety on bearing		=	4.1			
Conclusion,	q(ult)	>	q	OK		

Prepared by: LWY
Checked by: LTC

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0	25	13

Width of foundation,	B	=	7.5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0.65	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0.0	21.2	13

Lateral Force, F_d = 0.0 kN

Eccentricity, e_b = 0.00 m
e_l = 0.00 m

Effective width, B' = (B-2*e_b) = 7.50 m
Effective length, L' = (L-2*e_l) = 40.00 m

Pressure on the raft foundation = 30.00 kPa
Therefore, bearing pressure, q = 28.20 kPa

Total normal force, N = q*B'*L'
8459.71 kN

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq — Geoguide Figure A1 & A2

Effective area of foundation base,	A'	=	B'*L'	=	300.00 m²
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00
	m_i	=	(2+B'/L')/(1+B'/L')	=	1.84
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	7.24
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	16.06
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	6.40
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.07
	sc	=	1+Nq/Nc*B'/L'	=	1.08
	sg	=	1-0.4*B'/L'	=	0.93
Inclination Factors,	iq	=	(1-K_i)^m_i	=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00
	ig	=	(1-K_i)^(m_i+1)	=	1.00
Tilt Factors,	tq	=	tg	=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.78
	gg	=	gq	=	0.44

Effective Unit Weight of soil, γ' = 13 kN/m³
Overburden Pressure on Founding Level q' = γ'*d*cosβ
= 8.008643 kN/m

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq
= 154.50 kPa

Factor of safety on bearing = 5.5

Conclusion, q(ult) > q OK

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0	25	13

Width of foundation,	B	=	10	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0.65	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0.0	21.2	13

Lateral Force, F_d = 0.0 kN

Eccentricity, e_b = 0.00 m
e_l = 0.00 m

Effective width, B' = (B-2*e_b) = 10.00 m
Effective length, L' = (L-2*e_l) = 40.00 m

Pressure on the raft foundation = 30.00 kPa
Therefore, bearing pressure, q = 28.56 kPa

Total normal force, N = q*B'*L'
11424.22 kN

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq — Geoguide Figure A1 & A2

Effective area of foundation base,	A'	=	B'*L'	= 400.00 m²
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	= 0.00
	m_l	=	(2+B'/L')/(1+B'/L')	= 1.80
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	= 7.24
	Nc	=	(Nq-1)/tan(ϕ_{ground})	= 16.06
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	= 6.40
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	= 1.10
	sc	=	1+Nq/Nc*B'/L'	= 1.11
	sg	=	1-0.4*B'/L'	= 0.90
Inclination Factors,	iq	=	(1-K_i)^m_i	= 1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	= 1.00
	ig	=	(1-K_i)^(m_i+1)	= 1.00
Tilt Factors,	tq	=	tg	= 1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	= 1.00
	tg	=	(1-ω*tan(ϕ_{ground}))^2	= 1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2	= 0.44
	gc	=	exp(-2*β*tan(ϕ_{ground}))	= 0.78
	gg	=	gq	= 0.44

Effective Unit Weight of soil, γ' = 13 kN/m³
Overburden Pressure on Founding Level q' = γ'*d*cosβ
= 8.008643 kN/m

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq
= 192.91 kPa

Factor of safety on bearing = 6.8

Conclusion, q(ult) > q OK

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0	25	13

Width of foundation,	B	=	12.5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0.65	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0.0	21.2	13

Lateral Force,	F_d	=	0.0	kN			
Eccentricity,	e_b	=	0.00	m			
	e_l	=	0.00	m			
Effective width,	B'	=	(B-2*e_b)		=	12.50	m
Effective length,	L'	=	(L-2*e_l)		=	40.00	m
Pressure on the raft foundation		=	30.00	kPa			
Therefore, bearing pressure,	q	=	28.78	kPa			
Total normal force,	N	=	q*B'*L'				
			14390.97	kN			

Determine Ultimate Bearing Capacity, q(ult)

						Geoguide
Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq			Figure A1 & A2
Effective area of foundation base,	A'	=	B'*L'	=	500.00 m²	
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00	
	m_i	=	(2+B'/L')/(1+B'/L')	=	1.76	
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	7.24	
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	16.06	
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	6.40	
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.12	
	sc	=	1+Nq/Nc*B'/L'	=	1.14	
	sg	=	1-0.4*B'/L'	=	0.88	
Inclination Factors,	iq	=	(1-K_i)^m_i	=	1.00	
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00	
	ig	=	(1-K_i)^(m_i+1)	=	1.00	
Tilt Factors,	tq	=	tg	=	1.00	
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00	
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00	
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44	
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.78	
	gg	=	gq	=	0.44	
Effective Unit Weight of soil,	γ'	=	13	kN/m³		
Overburden Pressure on Founding Level	q'	=	γ'*d*cosβ			
		=	8.008643	kN/m		
Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq			
		=	229.03	kPa		
Factor of safety on bearing		=	8.0			
Conclusion,	q(ult)	>	q	OK		

Prepared by: LWY
Checked by: LTC

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0	25	13

Width of foundation,	B	=	15	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0.65	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0.0	21.2	13

Lateral Force,	F_d	=	0.0	kN	
Eccentricity,	e_b	=	0.00	m	
	e_l	=	0.00	m	
Effective width,	B'	=	$(B-2*e_b)$	=	15.00 m
Effective length,	L'	=	$(L-2*e_l)$	=	40.00 m
Pressure on the raft foundation		=	30.00	kPa	
Therefore, bearing pressure,	q	=	28.93	kPa	
Total normal force,	N	=	q*B'*L'		
			17358.88	kN	

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity,	q(ult)	=	$c_{ground}*Nc*sc*ic*tc*gc + 0.5*\gamma'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq$			Geoguide Figure A1 & A2
Effective area of foundation base,	A'	=	B'*L'	=	600.00 m²	
	K_i	=	$F_d/(N+c_{ground}*A'/\tan(\phi_{ground}))$	=	0.00	
	m_i	=	(2+B'/L')/(1+B'/L')	=	1.73	
Bearing Capacity Factors,	Nq	=	$\exp(\pi*\tan(\phi_{ground}))*\tan(\pi/4+\phi_{ground}/2)^2$	=	7.24	
	Nc	=	$(Nq-1)/\tan(\phi_{ground})$	=	16.06	
	Ng	=	$2*(Nq+1)*\tan(\phi_{ground})$	=	6.40	
Shape Factors,	sq	=	$1+\tan(\phi_{ground})*B'/L'$	=	1.15	
	sc	=	1+Nq/Nc*B'/L'	=	1.17	
	sg	=	1-0.4*B'/L'	=	0.85	
Inclination Factors,	iq	=	$(1-K_i)^{m_i}$	=	1.00	
	ic	=	$iq-(1-iq)/(Nc*\tan(\phi_{ground}))$	=	1.00	
	ig	=	$(1-K_i)^{(m_i+1)}$	=	1.00	
Tilt Factors,	tq	=	tg	=	1.00	
	tc	=	$tq-(1-tq)/(Nc*\tan(\phi_{ground}))$	=	1.00	
	tg	=	$(1-\omega*\tan(\phi_{ground}))^2$	=	1.00	
Ground Slope Factors,	gq	=	$(1-\tan\beta)^2$	=	0.44	
	gc	=	$\exp(-2*\beta*\tan(\phi_{ground}))$	=	0.78	
	gg	=	gq	=	0.44	
Effective Unit Weight of soil,	γ'	=	13	kN/m³		
Overburden Pressure on Founding Level	q'	=	γ'*d*cosβ			
		=	8.008643	kN/m		
Ultimate Bearing Capacity,	q(ult)	=	$c_{ground}*Nc*sc*ic*tc*gc + 0.5*\gamma'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq$			
		=	262.86	kPa		
Factor of safety on bearing		=	9.1			
Conclusion,	q(ult)	>	q	OK		

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0	25	13

Width of foundation,	B	=	17.5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0.65	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0.0	21.2	13

Lateral Force,	F_d	=	0.0	kN		
Eccentricity,	e_b	=	0.00	m		
	e_l	=	0.00	m		
Effective width,	B'	=	(B-2*e_b)		=	17.50 m
Effective length,	L'	=	(L-2*e_l)		=	40.00 m
Pressure on the raft foundation		=	30.00	kPa		
Therefore, bearing pressure,	q	=	29.04	kPa		
Total normal force,	N	=	q*B'*L'			
			20327.45	kN		

Determine Ultimate Bearing Capacity, q(ult)

						Geoguide Figure A1 & A2
Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq			
Effective area of foundation base,	A'	=	B'*L'		=	700.00 m²
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))		=	0.00
	m_i	=	(2+B'/L')/(1+B'/L')		=	1.70
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2		=	7.24
	Nc	=	(Nq-1)/tan(ϕ_{ground})		=	16.06
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})		=	6.40
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'		=	1.17
	sc	=	1+Nq/Nc*B'/L'		=	1.20
	sg	=	1-0.4*B'/L'		=	0.83
Inclination Factors,	iq	=	(1-K_i)^m_i		=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))		=	1.00
	ig	=	(1-K_i)^(m_i+1)		=	1.00
Tilt Factors,	tq	=	tg		=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))		=	1.00
	tg	=	(1-ω*tan(ϕ_{ground}))^2		=	1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2		=	0.44
	gc	=	exp(-2*β*tan(ϕ_{ground}))		=	0.78
	gg	=	gq		=	0.44
Effective Unit Weight of soil,	γ'	=	13	kN/m³		
Overburden Pressure on Founding Level	q'	=	γ'*d*cosβ			
		=	8.008643	kN/m		
Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq			
		=	294.40	kPa		
Factor of safety on bearing		=	10.1			
Conclusion,	q(ult)	>	q	OK		

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0	25	13

Width of foundation,	B	=	20	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0.65	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0.0	21.2	13

Lateral Force, F_d = 0.0 kN

Eccentricity, e_b = 0.00 m
e_l = 0.00 m

Effective width, B' = (B-2*e_b) = 20.00 m
Effective length, L' = (L-2*e_l) = 40.00 m

Pressure on the raft foundation = 30.00 kPa
Therefore, bearing pressure, q = 29.12 kPa

Total normal force, N = q*B'*L'
23296.45 kN

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq — Geoguide Figure A1 & A2

Effective area of foundation base,	A'	=	B'*L'	=	800.00 m²
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00
	m_i	=	(2+B'/L')/(1+B'/L')	=	1.67
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	7.24
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	16.06
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	6.40
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.19
	sc	=	1+Nq/Nc*B'/L'	=	1.23
	sg	=	1-0.4*B'/L'	=	0.80
Inclination Factors,	iq	=	(1-K_i)^m_i	=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00
	ig	=	(1-K_i)^(m_i+1)	=	1.00
Tilt Factors,	tq	=	tg	=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.78
	gg	=	gq	=	0.44

Effective Unit Weight of soil, γ' = 13 kN/m³
Overburden Pressure on Founding Level q' = γ'*d*cosβ
= 8.008643 kN/m

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq
= 323.65 kPa

Factor of safety on bearing = 11.1

Conclusion, q(ult) > q OK

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0	25	13

Width of foundation,	B	=	2.5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0.0	21.2	13

Lateral Force,	F_d	=	0.0	kN		
Eccentricity,	e_b	=	0.00	m		
	e_l	=	0.00	m		
Effective width,	B'	=	(B-2*e_b)	=	2.50	m
Effective length,	L'	=	(L-2*e_l)	=	40.00	m
Pressure on the raft foundation		=	30.00	kPa		
Therefore, bearing pressure,	q	=	17.13	kPa		
Total normal force,	N	=	q*B'*L'			
			1712.92	kN		

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq			Geoguide Figure A1 & A2
Effective area of foundation base,	A'	=	B'*L'	=	100.00	m²
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00	
	m_l	=	(2+B'/L')/(1+B'/L')	=	1.94	
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	7.24	
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	16.06	
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	6.40	
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.02	
	sc	=	1+Nq/Nc*B'/L'	=	1.03	
	sg	=	1-0.4*B'/L'	=	0.98	
Inclination Factors,	iq	=	(1-K_i)^m_l	=	1.00	
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00	
	ig	=	(1-K_i)^(m_l+1)	=	1.00	
Tilt Factors,	tq	=	tg	=	1.00	
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00	
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00	
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44	
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.78	
	gg	=	gq	=	0.44	
Effective Unit Weight of soil,	γ'	=	13	kN/m³		
Overburden Pressure on Founding Level	q'	=	γ'*d*cosβ			
		=	0	kN/m		
Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq			
		=	44.66	kPa		
Factor of safety on bearing		=	2.6			
Conclusion,	q(ult)	>	q	OK		

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0	25	13

Width of foundation,	B	=	5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0.0	21.2	13

Lateral Force,	F_d	=	0.0	kN		
Eccentricity,	e_b	=	0.00	m		
	e_l	=	0.00	m		
Effective width,	B'	=	(B-2*e_b)		=	5.00 m
Effective length,	L'	=	(L-2*e_l)		=	40.00 m
Pressure on the raft foundation		=	30.00	kPa		
Therefore, bearing pressure,	q	=	21.48	kPa		
Total normal force,	N	=	q*B'*L'			
			4295.07	kN		

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq		Geoguide Figure A1 & A2
Effective area of foundation base,	A'	=	B'*L'	= 200.00 m²	
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	= 0.00	
	m_l	=	(2+B'/L')/(1+B'/L')	= 1.89	
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	= 7.24	
	Nc	=	(Nq-1)/tan(ϕ_{ground})	= 16.06	
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	= 6.40	
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	= 1.05	
	sc	=	1+Nq/Nc*B'/L'	= 1.06	
	sg	=	1-0.4*B'/L'	= 0.95	
Inclination Factors,	iq	=	(1-K_i)^m_l	= 1.00	
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	= 1.00	
	ig	=	(1-K_i)^(m_l+1)	= 1.00	
Tilt Factors,	tq	=	tg	= 1.00	
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	= 1.00	
	tg	=	(1-ω*tan(ϕ_{ground}))^2	= 1.00	
Ground Slope Factors,	gq	=	(1-tanβ)^2	= 0.44	
	gc	=	exp(-2*β*tan(ϕ_{ground}))	= 0.78	
	gg	=	gq	= 0.44	
Effective Unit Weight of soil,	γ'	=	13	kN/m³	
Overburden Pressure on Founding Level	q'	=	γ'*d*cosβ		
		=	0	kN/m	
Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq		
		=	87.03	kPa	
Factor of safety on bearing		=	4.1		
Conclusion,	q(ult)	>	q	OK	

Prepared by: LWY
Checked by: LTC

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m^3)
Waste beneath the foundation	0	25	13

Width of foundation,	B	=	7.5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m^3	
Unit weight of concrete,	γ_{conc}	=	24	kN/m^3	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m^3)
Waste beneath the foundation	0.0	21.2	13

Lateral Force, F_d = 0.0 kN

Eccentricity, e_b = 0.00 m
e_l = 0.00 m

Effective width, B' = (B-2*e_b) = 7.50 m
Effective length, L' = (L-2*e_l) = 40.00 m

Pressure on the raft foundation = 30.00 kPa
Therefore, bearing pressure, q = 23.46 kPa

Total normal force, N = q*B'*L' = 7037.85 kN

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq — Geoguide Figure A1 & A2

Effective area of foundation base,	A'	=	B'*L'	=	300.00 m^2
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00
	m_i	=	(2+B'/L')/(1+B'/L')	=	1.84
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	7.24
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	16.06
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	6.40
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.07
	sc	=	1+Nq/Nc*B'/L'	=	1.08
	sg	=	1-0.4*B'/L'	=	0.93
Inclination Factors,	iq	=	(1-K_i)^m_i	=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00
	ig	=	(1-K_i)^(m_i+1)	=	1.00
Tilt Factors,	tq	=	tg	=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.78
	gg	=	gq	=	0.44

Effective Unit Weight of soil, γ' = 13 kN/m^3
Overburden Pressure on Founding Level q' = γ'*d*cosβ = 0 kN/m

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq
= 127.12 kPa

Factor of safety on bearing = 5.4

Conclusion, q(ult) > q OK

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m^3)
Waste beneath the foundation	0	25	13

Width of foundation,	B	=	10	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m^3	
Unit weight of concrete,	γ_{conc}	=	24	kN/m^3	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m^3)
Waste beneath the foundation	0.0	21.2	13

Lateral Force,	F_d	=	0.0	kN		
Eccentricity,	e_b	=	0.00	m		
	e_l	=	0.00	m		
Effective width,	B'	=	(B-2*e_b)		=	10.00 m
Effective length,	L'	=	(L-2*e_l)		=	40.00 m
Pressure on the raft foundation		=	30.00	kPa		
Therefore, bearing pressure,	q	=	24.60	kPa		
Total normal force,	N	=	q*B'*L'			
			9838.28	kN		

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq		Geoguide Figure A1 & A2
Effective area of foundation base,	A'	=	B'*L'	=	400.00 m^2
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00
	m_i	=	(2+B'/L')/(1+B'/L')	=	1.80
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	7.24
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	16.06
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	6.40
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.10
	sc	=	1+Nq/Nc*B'/L'	=	1.11
	sg	=	1-0.4*B'/L'	=	0.90
Inclination Factors,	iq	=	(1-K_i)^m_i	=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00
	ig	=	(1-K_i)^(m_i+1)	=	1.00
Tilt Factors,	tq	=	tg	=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.78
	gg	=	gq	=	0.44
Effective Unit Weight of soil,	γ'	=	13	kN/m^3	
Overburden Pressure on Founding Level	q'	=	γ'*d*cosβ		
		=	0	kN/m	
Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq		
		=	164.91	kPa	
Factor of safety on bearing		=	6.7		
Conclusion,	q(ult)	>	q	OK	

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m^3)
Waste beneath the foundation	0	25	13

Width of foundation,	B	=	12.5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m^3	
Unit weight of concrete,	γ_{conc}	=	24	kN/m^3	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m^3)
Waste beneath the foundation	0.0	21.2	13

Lateral Force,	F_d	=	0.0	kN	
Eccentricity,	e_b	=	0.00	m	
	e_l	=	0.00	m	
Effective width,	B'	=	(B-2*e_b)	=	12.50 m
Effective length,	L'	=	(L-2*e_l)	=	40.00 m
Pressure on the raft foundation		=	30.00	kPa	
Therefore, bearing pressure,	q	=	25.33	kPa	
Total normal force,	N	=	q*B'*L'		
			12665.92	kN	

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq			Geoguide Figure A1 & A2
Effective area of foundation base,	A'	=	B'*L'	=	500.00 m^2	
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00	
	m_l	=	(2+B'/L')/(1+B'/L')	=	1.76	
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	7.24	
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	16.06	
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	6.40	
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.12	
	sc	=	1+Nq/Nc*B'/L'	=	1.14	
	sg	=	1-0.4*B'/L'	=	0.88	
Inclination Factors,	iq	=	(1-K_i)^m_l	=	1.00	
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00	
	ig	=	(1-K_i)^(m_l+1)	=	1.00	
Tilt Factors,	tq	=	tg	=	1.00	
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00	
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00	
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44	
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.78	
	gg	=	gq	=	0.44	
Effective Unit Weight of soil,	γ'	=	13	kN/m^3		
Overburden Pressure on Founding Level	q'	=	γ'*d*cosβ			
		=	0	kN/m		
Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq			
		=	200.41	kPa		
Factor of safety on bearing		=	7.9			
Conclusion,	q(ult)	>	q	OK		

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0	25	13

Width of foundation,	B	=	15	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0.0	21.2	13

Lateral Force, F_d = 0.0 kN

Eccentricity, e_b = 0.00 m
e_l = 0.00 m

Effective width, B' = (B-2*e_b) = 15.00 m
Effective length, L' = (L-2*e_l) = 40.00 m

Pressure on the raft foundation = 30.00 kPa
Therefore, bearing pressure, q = 25.85 kPa

Total normal force, N = q*B'*L'
15508.55 kN

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq — Geoguide Figure A1 & A2

Effective area of foundation base,	A'	=	B'*L'	=	600.00 m²
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00
	m_i	=	(2+B'/L')/(1+B'/L')	=	1.73
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	7.24
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	16.06
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	6.40
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.15
	sc	=	1+Nq/Nc*B'/L'	=	1.17
	sg	=	1-0.4*B'/L'	=	0.85
Inclination Factors,	iq	=	(1-K_i)^m_i	=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00
	ig	=	(1-K_i)^(m_i+1)	=	1.00
Tilt Factors,	tq	=	tg	=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.78
	gg	=	gq	=	0.44

Effective Unit Weight of soil, γ' = 13 kN/m³
Overburden Pressure on Founding Level q' = γ'*d*cosβ
= 0 kN/m

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq
= 233.62 kPa

Factor of safety on bearing = 9.0

Conclusion, q(ult) > q OK

Prepared by: LWY
Checked by: LTC

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0	25	13

Width of foundation,	B	=	17.5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0.0	21.2	13

Lateral Force,	F_d	=	0.0	kN		
Eccentricity,	e_b	=	0.00	m		
	e_l	=	0.00	m		
Effective width,	B'	=	(B-2*e_b)		=	17.50 m
Effective length,	L'	=	(L-2*e_l)		=	40.00 m
Pressure on the raft foundation		=	30.00	kPa		
Therefore, bearing pressure,	q	=	26.23	kPa		
Total normal force,	N	=	q*B'*L'			
			18360.31	kN		

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq		Geoguide Figure A1 & A2
Effective area of foundation base,	A'	=	B'*L'	=	700.00 m²
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00
	m_l	=	(2+B'/L')/(1+B'/L')	=	1.70
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	7.24
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	16.06
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	6.40
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.17
	sc	=	1+Nq/Nc*B'/L'	=	1.20
	sg	=	1-0.4*B'/L'	=	0.83
Inclination Factors,	iq	=	(1-K_i)^m_l	=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00
	ig	=	(1-K_i)^(m_l+1)	=	1.00
Tilt Factors,	tq	=	tg	=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.78
	gg	=	gq	=	0.44
Effective Unit Weight of soil,	γ'	=	13	kN/m³	
Overburden Pressure on Founding Level	q'	=	γ'*d*cosβ		
		=	0	kN/m	
Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq		
		=	264.54	kPa	
Factor of safety on bearing		=	10.1		
Conclusion,	q(ult)	>	q	OK	

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0	25	13

Width of foundation,	B	=	20	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Waste beneath the foundation	0.0	21.2	13

Lateral Force,	F_d	=	0.0	kN		
Eccentricity,	e_b	=	0.00	m		
	e_l	=	0.00	m		
Effective width,	B'	=	(B-2*e_b)		=	20.00 m
Effective length,	L'	=	(L-2*e_l)		=	40.00 m
Pressure on the raft foundation		=	30.00	kPa		
Therefore, bearing pressure,	q	=	26.52	kPa		
Total normal force,	N	=	q*B'*L'			
			21218.05	kN		

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq				Geoguide Figure A1 & A2
Effective area of foundation base,	A'	=	B'*L'		=	800.00 m²	
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))		=	0.00	
	m_i	=	(2+B'/L')/(1+B'/L')		=	1.67	
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2		=	7.24	
	Nc	=	(Nq-1)/tan(ϕ_{ground})		=	16.06	
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})		=	6.40	
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'		=	1.19	
	sc	=	1+Nq/Nc*B'/L'		=	1.23	
	sg	=	1-0.4*B'/L'		=	0.80	
Inclination Factors,	iq	=	(1-K_i)^m_i		=	1.00	
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))		=	1.00	
	ig	=	(1-K_i)^(m_i+1)		=	1.00	
Tilt Factors,	tq	=	tg		=	1.00	
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))		=	1.00	
	tg	=	(1-ω*tan(ϕ_{ground}))^2		=	1.00	
Ground Slope Factors,	gq	=	(1-tanβ)^2		=	0.44	
	gc	=	exp(-2*β*tan(ϕ_{ground}))		=	0.78	
	gg	=	gq		=	0.44	
Effective Unit Weight of soil,	γ'	=	13	kN/m³			
Overburden Pressure on Founding Level	q'	=	γ'*d*cosβ				
		=	0	kN/m			
Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq				
		=	293.17	kPa			
Factor of safety on bearing		=	11.1				
Conclusion,	q(ult)	>	q	OK			

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0	35	18.6

Width of foundation,	B	=	2.5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0.65	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0.0	30.3	18.6

Lateral Force, F_d = 0.0 kN

Eccentricity, e_b = 0.00 m
e_i = 0.00 m

Effective width, B' = (B-2*e_b) = 2.50 m
Effective length, L' = (L-2*e_i) = 40.00 m

Pressure on the raft foundation = 30.00 kPa
Therefore, bearing pressure, q = 30.00 kPa

Total normal force, N = q*B'*L'
3000.00 kN

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq — Geoguide Figure A1 & A2

Effective area of foundation base,	A'	=	B'*L'	=	100.00 m²
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00
	m_i	=	(2+B'/L')/(1+B'/L')	=	1.94
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	18.96
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	30.78
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	23.30
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.04
	sc	=	1+Nq/Nc*B'/L'	=	1.04
	sg	=	1-0.4*B'/L'	=	0.98
Inclination Factors,	iq	=	(1-K_i)^m_i	=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00
	ig	=	(1-K_i)^(m_i+1)	=	1.00
Tilt Factors,	tq	=	tg	=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.68
	gg	=	gq	=	0.44

Effective Unit Weight of soil, γ' = 18.6 kN/m³
Overburden Pressure on Founding Level q' = γ'*d*cosβ
= 11.45852 kN/m

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq
= 331.57 kPa

Factor of safety on bearing = 11.1

Conclusion, q(ult) > q OK

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0	35	18.6

Width of foundation,	B	=	5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0.65	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0.0	30.3	18.6

Lateral Force,	F_d	=	0.0	kN	
Eccentricity,	e_b	=	0.00	m	
	e_l	=	0.00	m	
Effective width,	B'	=	(B-2*e_b)	=	5.00 m
Effective length,	L'	=	(L-2*e_l)	=	40.00 m
Pressure on the raft foundation		=	30.00	kPa	
Therefore, bearing pressure,	q	=	30.00	kPa	
Total normal force,	N	=	q*B'*L'		
			6000.00	kN	

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq			Geoguide Figure A1 & A2
Effective area of foundation base,	A'	=	B'*L'	=	200.00 m²	
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00	
	m_l	=	(2+B'/L')/(1+B'/L')	=	1.89	
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	18.96	
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	30.78	
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	23.30	
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.07	
	sc	=	1+Nq/Nc*B'/L'	=	1.08	
	sg	=	1-0.4*B'/L'	=	0.95	
Inclination Factors,	iq	=	(1-K_i)^m_i	=	1.00	
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00	
	ig	=	(1-K_i)^(m_i+1)	=	1.00	
Tilt Factors,	tq	=	tg	=	1.00	
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00	
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00	
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44	
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.68	
	gg	=	gq	=	0.44	
Effective Unit Weight of soil,	γ'	=	18.6	kN/m³		
Overburden Pressure on Founding Level	q'	=	γ'*d*cosβ			
		=	11.45852	kN/m		
Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq			
		=	555.59	kPa		
Factor of safety on bearing		=	18.5			
Conclusion,	q(ult)	>	q	OK		

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0	35	18.6

Width of foundation,	B	=	7.5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0.65	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0.0	30.3	18.6

Lateral Force,	F_d	=	0.0	kN	
Eccentricity,	e_b	=	0.00	m	
	e_l	=	0.00	m	
Effective width,	B'	=	(B-2*e_b)	=	7.50 m
Effective length,	L'	=	(L-2*e_l)	=	40.00 m
Pressure on the raft foundation		=	30.00	kPa	
Therefore, bearing pressure,	q	=	30.00	kPa	
Total normal force,	N	=	q*B'*L'		
			9000.00	kN	

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq			Geoguide Figure A1 & A2
Effective area of foundation base,	A'	=	B'*L'	=	300.00 m²	
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00	
	m_i	=	(2+B'/L')/(1+B'/L')	=	1.84	
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	18.96	
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	30.78	
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	23.30	
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.11	
	sc	=	1+Nq/Nc*B'/L'	=	1.12	
	sg	=	1-0.4*B'/L'	=	0.93	
Inclination Factors,	iq	=	(1-K_i)^m_i	=	1.00	
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00	
	ig	=	(1-K_i)^(m_i+1)	=	1.00	
Tilt Factors,	tq	=	tg	=	1.00	
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00	
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00	
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44	
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.68	
	gg	=	gq	=	0.44	
Effective Unit Weight of soil,	γ'	=	18.6	kN/m³		
Overburden Pressure on Founding Level	q'	=	γ'*d*cosβ			
		=	11.45852	kN/m		
Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq			
		=	767.68	kPa		
Factor of safety on bearing		=	25.6			
Conclusion,	q(ult)	>	q	OK		

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0	35	18.6

Width of foundation,	B	=	10	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0.65	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0.0	30.3	18.6

Lateral Force,	F_d	=	0.0	kN		
Eccentricity,	e_b	=	0.00	m		
	e_i	=	0.00	m		
Effective width,	B'	=	(B-2*e_b)		=	10.00 m
Effective length,	L'	=	(L-2*e_i)		=	40.00 m
Pressure on the raft foundation		=	30.00	kPa		
Therefore, bearing pressure,	q	=	30.00	kPa		
Total normal force,	N	=	q*B'*L'			
			12000.00	kN		

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq		Geoguide Figure A1 & A2
Effective area of foundation base,	A'	=	B'*L'	= 400.00 m²	
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	= 0.00	
	m_i	=	(2+B'/L')/(1+B'/L')	= 1.80	
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	= 18.96	
	Nc	=	(Nq-1)/tan(ϕ_{ground})	= 30.78	
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	= 23.30	
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	= 1.15	
	sc	=	1+Nq/Nc*B'/L'	= 1.15	
	sg	=	1-0.4*B'/L'	= 0.90	
Inclination Factors,	iq	=	(1-K_i)^m_i	= 1.00	
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	= 1.00	
	ig	=	(1-K_i)^(m_i+1)	= 1.00	
Tilt Factors,	tq	=	tg	= 1.00	
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	= 1.00	
	tg	=	(1-ω*tan(ϕ_{ground}))^2	= 1.00	
Ground Slope Factors,	gq	=	(1-tanβ)^2	= 0.44	
	gc	=	exp(-2*β*tan(ϕ_{ground}))	= 0.68	
	gg	=	gq	= 0.44	
Effective Unit Weight of soil,	γ'	=	18.6	kN/m³	
Overburden Pressure on Founding Level	q'	=	γ'*d*cosβ		
		=	11.45852	kN/m	
Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq		
		=	967.86	kPa	
Factor of safety on bearing		=	32.3		
Conclusion,	q(ult)	>	q	OK	

Prepared by: LWY
Checked by: LTC

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0	35	18.6

Width of foundation,	B	=	12.5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0.65	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0.0	30.3	18.6

Lateral Force,	F_d	=	0.0	kN	
Eccentricity,	e_b	=	0.00	m	
	e_l	=	0.00	m	
Effective width,	B'	=	(B-2*e_b)	=	12.50 m
Effective length,	L'	=	(L-2*e_l)	=	40.00 m
Pressure on the raft foundation		=	30.00	kPa	
Therefore, bearing pressure,	q	=	30.00	kPa	
Total normal force,	N	=	q*B'*L'		
			15000.00	kN	

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq			Geoguide Figure A1 & A2
Effective area of foundation base,	A'	=	B'*L'	=	500.00 m²	
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ$_{ground}$))	=	0.00	
	m_l	=	(2+B'/L')/(1+B'/L')	=	1.76	
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ$_{ground}$))*tan(π/4+ϕ$_{ground}$/2)^2	=	18.96	
	Nc	=	(Nq-1)/tan(ϕ$_{ground}$)	=	30.78	
	Ng	=	2*(Nq+1)*tan(ϕ$_{ground}$)	=	23.30	
Shape Factors,	sq	=	1+tan(ϕ$_{ground}$)*B'/L'	=	1.18	
	sc	=	1+Nq/Nc*B'/L'	=	1.19	
	sg	=	1-0.4*B'/L'	=	0.88	
Inclination Factors,	iq	=	(1-K_i)^m_l	=	1.00	
	ic	=	iq-(1-iq)/(Nc*tan(ϕ$_{ground}$))	=	1.00	
	ig	=	(1-K_i)^(m_l+1)	=	1.00	
Tilt Factors,	tq	=	tg	=	1.00	
	tc	=	tq-(1-tq)/(Nc*tan(ϕ$_{ground}$))	=	1.00	
	tg	=	(1-ω*tan(ϕ$_{ground}$))^2	=	1.00	
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44	
	gc	=	exp(-2*β*tan(ϕ$_{ground}$))	=	0.68	
	gg	=	gq	=	0.44	
Effective Unit Weight of soil,	γ'	=	18.6	kN/m³		
Overburden Pressure on Founding Level	q'	=	γ'*d*cosβ			
		=	11.45852	kN/m		
Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq			
		=	1156.11	kPa		
Factor of safety on bearing		=	38.5			
Conclusion,	q(ult)	>	q	OK		

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0	35	18.6

Width of foundation,	B	=	15	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0.65	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0.0	30.3	18.6

Lateral Force, F_d = 0.0 kN

Eccentricity, e_b = 0.00 m
e_l = 0.00 m

Effective width, B' = (B-2*e_b) = 15.00 m
Effective length, L' = (L-2*e_l) = 40.00 m

Pressure on the raft foundation = 30.00 kPa
Therefore, bearing pressure, q = 30.00 kPa

Total normal force, N = q*B'*L'
18000.00 kN

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq — Geoguide Figure A1 & A2

Effective area of foundation base,	A'	=	B'*L'	=	600.00 m²
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ$_{ground}$))	=	0.00
	m_l	=	(2+B'/L')/(1+B'/L')	=	1.73
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ$_{ground}$))*tan(π/4+ϕ$_{ground}$/2)^2	=	18.96
	Nc	=	(Nq-1)/tan(ϕ$_{ground}$)	=	30.78
	Ng	=	2*(Nq+1)*tan(ϕ$_{ground}$)	=	23.30
Shape Factors,	sq	=	1+tan(ϕ$_{ground}$)*B'/L'	=	1.22
	sc	=	1+Nq/Nc*B'/L'	=	1.23
	sg	=	1-0.4*B'/L'	=	0.85
Inclination Factors,	iq	=	(1-K_i)^m_l	=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ$_{ground}$))	=	1.00
	ig	=	(1-K_i)^(m_l+1)	=	1.00
Tilt Factors,	tq	=	tg	=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ$_{ground}$))	=	1.00
	tg	=	(1-ω*tan(ϕ$_{ground}$))^2	=	1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44
	gc	=	exp(-2*β*tan(ϕ$_{ground}$))	=	0.68
	gg	=	gq	=	0.44

Effective Unit Weight of soil, γ' = 18.6 kN/m³
Overburden Pressure on Founding Level q' = γ'*d*cosβ
= 11.45852 kN/m

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq
= 1332.44 kPa

Factor of safety on bearing = 44.4

Conclusion, q(ult) > q OK

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0	35	18.6

Width of foundation,	B	=	17.5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0.65	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0.0	30.3	18.6

Lateral Force,	F_d	=	0.0	kN	
Eccentricity,	e_b	=	0.00	m	
	e_l	=	0.00	m	
Effective width,	B'	=	(B-2*e_b)	=	17.50 m
Effective length,	L'	=	(L-2*e_l)	=	40.00 m
Pressure on the raft foundation		=	30.00	kPa	
Therefore, bearing pressure,	q	=	30.00	kPa	
Total normal force,	N	=	q*B'*L'		
			21000.00	kN	

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq — Geoguide Figure A1 & A2

Effective area of foundation base,	A'	=	B'*L'	=	700.00 m²
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00
	m_l	=	(2+B'/L')/(1+B'/L')	=	1.70
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	18.96
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	30.78
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	23.30
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.26
	sc	=	1+Nq/Nc*B'/L'	=	1.27
	sg	=	1-0.4*B'/L'	=	0.83
Inclination Factors,	iq	=	(1-K_i)^m_l	=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00
	ig	=	(1-K_i)^(m_l+1)	=	1.00
Tilt Factors,	tq	=	tg	=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.68
	gg	=	gq	=	0.44

Effective Unit Weight of soil,	γ'	=	18.6	kN/m³
Overburden Pressure on Founding Level	q'	=	γ'*d*cosβ	
		=	11.45852	kN/m
Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq	
		=	1496.86	kPa
Factor of safety on bearing		=	49.9	
Conclusion,	q(ult)	>	q	OK

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0	35	18.6

Width of foundation,	B	=	20	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0.65	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0.0	30.3	18.6

Lateral Force, F_d = 0.0 kN

Eccentricity, e_b = 0.00 m
e_l = 0.00 m

Effective width, B' = (B-2*e_b) = 20.00 m
Effective length, L' = (L-2*e_l) = 40.00 m

Pressure on the raft foundation = 30.00 kPa
Therefore, bearing pressure, q = 30.00 kPa

Total normal force, N = q*B'*L'
24000.00 kN

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq — Geoguide Figure A1 & A2

Effective area of foundation base,	A'	=	B'*L'	=	800.00 m²
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00
	m_i	=	(2+B'/L')/(1+B'/L')	=	1.67
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	18.96
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	30.78
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	23.30
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.29
	sc	=	1+Nq/Nc*B'/L'	=	1.31
	sg	=	1-0.4*B'/L'	=	0.80
Inclination Factors,	iq	=	(1-K_i)^m_i	=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00
	ig	=	(1-K_i)^(m_i+1)	=	1.00
Tilt Factors,	tq	=	tg	=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.68
	gg	=	gq	=	0.44

Effective Unit Weight of soil, γ' = 18.6 kN/m³
Overburden Pressure on Founding Level q' = γ'*d*cosβ
= 11.45852 kN/m

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq
= 1649.35 kPa

Factor of safety on bearing = 55.0

Conclusion, q(ult) > q OK

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0	35	18.6

Width of foundation,	B	=	2.5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0.0	30.3	18.6

Lateral Force,	F_d	=	0.0	kN		
Eccentricity,	e_b	=	0.00	m		
	e_l	=	0.00	m		
Effective width,	B'	=	(B-2*e_b)		=	2.50 m
Effective length,	L'	=	(L-2*e_l)		=	40.00 m
Pressure on the raft foundation		=	30.00	kPa		
Therefore, bearing pressure,	q	=	30.00	kPa		
Total normal force,	N	=	q*B'*L'			
			3000.00	kN		

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq		Geoguide Figure A1 & A2
Effective area of foundation base,	A'	=	B'*L'	=	100.00 m²
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00
	m_i	=	(2+B'/L')/(1+B'/L')	=	1.94
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	18.96
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	30.78
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	23.30
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.04
	sc	=	1+Nq/Nc*B'/L'	=	1.04
	sg	=	1-0.4*B'/L'	=	0.98
Inclination Factors,	iq	=	(1-K_i)^m_i	=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00
	ig	=	(1-K_i)^(m_i+1)	=	1.00
Tilt Factors,	tq	=	tg	=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.68
	gg	=	gq	=	0.44
Effective Unit Weight of soil,	γ'	=	18.6	kN/m³	
Overburden Pressure on Founding Level	q'	=	γ'*d*cosβ		
		=	0	kN/m	
Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq		
		=	232.45	kPa	
Factor of safety on bearing		=	7.7		
Conclusion,	q(ult)	>	q	OK	

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0	35	18.6

Width of foundation,	B	=	5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0.0	30.3	18.6

Lateral Force, F_d = 0.0 kN

Eccentricity, e_b = 0.00 m; e_i = 0.00 m

Effective width, B' = (B-2*e_b) = 5.00 m
Effective length, L' = (L-2*e_i) = 40.00 m

Pressure on the raft foundation = 30.00 kPa
Therefore, bearing pressure, q = 30.00 kPa

Total normal force, N = q*B'*L' = 6000.00 kN

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq — Geoguide Figure A1 & A2

Effective area of foundation base,	A'	=	B'*L'	=	200.00 m²
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00
	m_i	=	(2+B'/L')/(1+B'/L')	=	1.89
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	18.96
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	30.78
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	23.30
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.07
	sc	=	1+Nq/Nc*B'/L'	=	1.08
	sg	=	1-0.4*B'/L'	=	0.95
Inclination Factors,	iq	=	(1-K_i)^m_i	=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00
	ig	=	(1-K_i)^(m_i+1)	=	1.00
Tilt Factors,	tq	=	tg	=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.68
	gg	=	gq	=	0.44

Effective Unit Weight of soil, γ' = 18.6 kN/m³
Overburden Pressure on Founding Level q' = γ'*d*cosβ = 0 kN/m

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq
= 452.97 kPa

Factor of safety on bearing = 15.1

Conclusion, q(ult) > q OK

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0	35	18.6

Width of foundation,	B	=	7.5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0.0	30.3	18.6

Lateral Force, F_d = 0.0 kN

Eccentricity, e_b = 0.00 m
e_l = 0.00 m

Effective width, B' = (B-2*e_b) = 7.50 m
Effective length, L' = (L-2*e_l) = 40.00 m

Pressure on the raft foundation = 30.00 kPa
Therefore, bearing pressure, q = 30.00 kPa

Total normal force, N = q*B'*L'
9000.00 kN

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq — Geoguide Figure A1 & A2

Effective area of foundation base,	A'	=	B'*L'	=	300.00 m²
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00
	m_i	=	(2+B'/L')/(1+B'/L')	=	1.84
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	18.96
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	30.78
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	23.30
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.11
	sc	=	1+Nq/Nc*B'/L'	=	1.12
	sg	=	1-0.4*B'/L'	=	0.93
Inclination Factors,	iq	=	(1-K_i)^m_i	=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00
	ig	=	(1-K_i)^(m_i+1)	=	1.00
Tilt Factors,	tq	=	tg	=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.68
	gg	=	gq	=	0.44

Effective Unit Weight of soil, γ' = 18.6 kN/m³
Overburden Pressure on Founding Level q' = γ'*d*cosβ
= 0 kN/m

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq
= 661.58 kPa

Factor of safety on bearing = 22.1

Conclusion, q(ult) > q OK

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0	35	18.6

Width of foundation,	B	=	10	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0.0	30.3	18.6

Lateral Force,	F_d	=	0.0	kN		
Eccentricity,	e_b	=	0.00	m		
	e_l	=	0.00	m		
Effective width,	B'	=	(B-2*e_b)		=	10.00 m
Effective length,	L'	=	(L-2*e_l)		=	40.00 m
Pressure on the raft foundation		=	30.00	kPa		
Therefore, bearing pressure,	q	=	30.00	kPa		
Total normal force,	N	=	q*B'*L'			
			12000.00	kN		

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq			Geoguide Figure A1 & A2
Effective area of foundation base,	A'	=	B'*L'		=	400.00 m²
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))		=	0.00
	m_i	=	(2+B'/L')/(1+B'/L')		=	1.80
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2		=	18.96
	Nc	=	(Nq-1)/tan(ϕ_{ground})		=	30.78
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})		=	23.30
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'		=	1.15
	sc	=	1+Nq/Nc*B'/L'		=	1.15
	sg	=	1-0.4*B'/L'		=	0.90
Inclination Factors,	iq	=	(1-K_i)^m_i		=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))		=	1.00
	ig	=	(1-K_i)^(m_i+1)		=	1.00
Tilt Factors,	tq	=	tg		=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))		=	1.00
	tg	=	(1-ω*tan(ϕ_{ground}))^2		=	1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2		=	0.44
	gc	=	exp(-2*β*tan(ϕ_{ground}))		=	0.68
	gg	=	gq		=	0.44
Effective Unit Weight of soil,	γ'	=	18.6	kN/m³		
Overburden Pressure on Founding Level	q'	=	γ'*d*cosβ			
		=	0	kN/m		
Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq			
		=	858.27	kPa		
Factor of safety on bearing		=	28.6			
Conclusion,	q(ult)	>	q	OK		

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0	35	18.6

Width of foundation,	B	=	12.5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0.0	30.3	18.6

Lateral Force,	F_d	=	0.0	kN		
Eccentricity,	e_b	=	0.00	m		
	e_l	=	0.00	m		
Effective width,	B'	=	(B-2*e_b)		=	12.50 m
Effective length,	L'	=	(L-2*e_l)		=	40.00 m
Pressure on the raft foundation		=	30.00	kPa		
Therefore, bearing pressure,	q	=	30.00	kPa		
Total normal force,	N	=	q*B'*L'			
			15000.00	kN		

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq		Geoguide Figure A1 & A2
Effective area of foundation base,	A'	=	B'*L'	=	500.00 m²
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00
	m_i	=	(2+B'/L')/(1+B'/L')	=	1.76
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	18.96
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	30.78
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	23.30
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.18
	sc	=	1+Nq/Nc*B'/L'	=	1.19
	sg	=	1-0.4*B'/L'	=	0.88
Inclination Factors,	iq	=	(1-K_i)^m_i	=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00
	ig	=	(1-K_i)^(m_i+1)	=	1.00
Tilt Factors,	tq	=	tg	=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.68
	gg	=	gq	=	0.44
Effective Unit Weight of soil,	γ'	=	18.6	kN/m³	
Overburden Pressure on Founding Level	q'	=	γ'*d*cosβ		
		=	0	kN/m	
Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq		
		=	1043.03	kPa	
Factor of safety on bearing		=	34.8		
Conclusion,	q(ult)	>	q	OK	

Prepared by: LWY
Checked by: LTC

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0	35	18.6

Width of foundation,	B	=	15	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0.0	30.3	18.6

Lateral Force, F_d = 0.0 kN

Eccentricity, e_b = 0.00 m
e_l = 0.00 m

Effective width, B' = (B-2*e_b) = 15.00 m
Effective length, L' = (L-2*e_l) = 40.00 m

Pressure on the raft foundation = 30.00 kPa
Therefore, bearing pressure, q = 30.00 kPa

Total normal force, N = q*B'*L'
18000.00 kN

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq — Geoguide Figure A1 & A2

Effective area of foundation base,	A'	=	B'*L'	=	600.00 m²
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00
	m_i	=	(2+B'/L')/(1+B'/L')	=	1.73
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	18.96
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	30.78
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	23.30
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.22
	sc	=	1+Nq/Nc*B'/L'	=	1.23
	sg	=	1-0.4*B'/L'	=	0.85
Inclination Factors,	iq	=	(1-K_i)^m_i	=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00
	ig	=	(1-K_i)^(m_i+1)	=	1.00
Tilt Factors,	tq	=	tg	=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.68
	gg	=	gq	=	0.44

Effective Unit Weight of soil, γ' = 18.6 kN/m³
Overburden Pressure on Founding Level q' = γ'*d*cosβ
= 0 kN/m

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq
= 1215.88 kPa

Factor of safety on bearing = 40.5

Conclusion, q(ult) > q OK

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0	35	18.6

Width of foundation,	B	=	17.5	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0.0	30.3	18.6

Lateral Force, F_d = 0.0 kN

Eccentricity, e_b = 0.00 m
e_l = 0.00 m

Effective width, B' = $(B-2*e_b)$ = 17.50 m
Effective length, L' = $(L-2*e_l)$ = 40.00 m

Pressure on the raft foundation = 30.00 kPa
Therefore, bearing pressure, q = 30.00 kPa

Total normal force, N = q*B'*L' = 21000.00 kN

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity, q(ult) = $c_{ground}*Nc*sc*ic*tc*gc + 0.5*\gamma'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq$ — Geoguide Figure A1 & A2

Effective area of foundation base,	A'	=	B'*L'	=	700.00 m²
	K_i	=	$F_d/(N+c_{ground}*A'/\tan(\phi_{ground}))$	=	0.00
	m_i	=	(2+B'/L')/(1+B'/L')	=	1.70
Bearing Capacity Factors,	Nq	=	$\exp(\pi*\tan(\phi_{ground}))*\tan(\pi/4+\phi_{ground}/2)^2$	=	18.96
	Nc	=	$(Nq-1)/\tan(\phi_{ground})$	=	30.78
	Ng	=	$2*(Nq+1)*\tan(\phi_{ground})$	=	23.30
Shape Factors,	sq	=	$1+\tan(\phi_{ground})*B'/L'$	=	1.26
	sc	=	1+Nq/Nc*B'/L'	=	1.27
	sg	=	1-0.4*B'/L'	=	0.83
Inclination Factors,	iq	=	$(1-K_i)^{m_i}$	=	1.00
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_ground))	=	1.00
	ig	=	$(1-K_i)^{(m_i+1)}$	=	1.00
Tilt Factors,	tq	=	tg	=	1.00
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_ground))	=	1.00
	tg	=	$(1-\omega*\tan(\phi_{ground}))^2$	=	1.00
Ground Slope Factors,	gq	=	$(1-\tan\beta)^2$	=	0.44
	gc	=	$\exp(-2*\beta*\tan(\phi_{ground}))$	=	0.68
	gg	=	gq	=	0.44

Effective Unit Weight of soil, γ' = 18.6 kN/m³
Overburden Pressure on Founding Level q' = γ'*d*cosβ = 0 kN/m

Ultimate Bearing Capacity, q(ult) = $c_{ground}*Nc*sc*ic*tc*gc + 0.5*\gamma'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq$
= 1376.80 kPa

Factor of safety on bearing = 45.9

Conclusion, q(ult) > q OK

I. DESIGN PARAMETERS

1) Parameters

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0	35	18.6

Width of foundation,	B	=	20	m	
Length of foundation,	L	=	40	m	
Angle of foundation slab tilt,	ω	=	0	deg.	Not > 45°
Depth in front of the foundation,	d	=	0	m	
Slope angle,	β	=	18.6	deg.	
Surcharge,	p	=	10	kPa	
Unit weight of water,	γ_w	=	10	kN/m³	
Unit weight of concrete,	γ_{conc}	=	24	kN/m³	

2) Check bearing capacity failure

Partial material factor, γ_m = 1.2

Factored material properties:

	c' (kPa)	ϕ' (deg.)	γ' (kN/m³)
Ground soil beneath the foundation	0.0	30.3	18.6

Lateral Force, F_d = 0.0 kN

Eccentricity, e_b = 0.00 m
e_l = 0.00 m

Effective width,	B'	=	(B-2*e_b)	=	20.00 m
Effective length,	L'	=	(L-2*e_l)	=	40.00 m

Pressure on the raft foundation = 30.00 kPa
Therefore, bearing pressure, q = 30.00 kPa

Total normal force, N = q*B'*L'
24000.00 kN

Determine Ultimate Bearing Capacity, q(ult)

Ultimate Bearing Capacity,	q(ult)	=	c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq			Geoguide Figure A1 & A2
Effective area of foundation base,	A'	=	B'*L'	=	800.00 m²	
	K_i	=	F_d/(N+c_{ground}*A'/tan(ϕ_{ground}))	=	0.00	
	m_i	=	(2+B'/L')/(1+B'/L')	=	1.67	
Bearing Capacity Factors,	Nq	=	exp(π*tan(ϕ_{ground}))*tan(π/4+ϕ_{ground}/2)^2	=	18.96	
	Nc	=	(Nq-1)/tan(ϕ_{ground})	=	30.78	
	Ng	=	2*(Nq+1)*tan(ϕ_{ground})	=	23.30	
Shape Factors,	sq	=	1+tan(ϕ_{ground})*B'/L'	=	1.29	
	sc	=	1+Nq/Nc*B'/L'	=	1.31	
	sg	=	1-0.4*B'/L'	=	0.80	
Inclination Factors,	iq	=	(1-K_i)^m_i	=	1.00	
	ic	=	iq-(1-iq)/(Nc*tan(ϕ_{ground}))	=	1.00	
	ig	=	(1-K_i)^(m_i+1)	=	1.00	
Tilt Factors,	tq	=	tg	=	1.00	
	tc	=	tq-(1-tq)/(Nc*tan(ϕ_{ground}))	=	1.00	
	tg	=	(1-ω*tan(ϕ_{ground}))^2	=	1.00	
Ground Slope Factors,	gq	=	(1-tanβ)^2	=	0.44	
	gc	=	exp(-2*β*tan(ϕ_{ground}))	=	0.68	
	gg	=	gq	=	0.44	

Effective Unit Weight of soil, γ' = 18.6 kN/m³
Overburden Pressure on Founding Level q' = γ'*d*cosβ
= 0 kN/m

Ultimate Bearing Capacity, q(ult) = c_{ground}*Nc*sc*ic*tc*gc + 0.5*γ'*B'*Ng*sg*ig*tg*gg + q'*Nq*sq*iq*tq*gq
= 1525.81 kPa

Factor of safety on bearing = 50.9

Conclusion, q(ult) > q OK

Black & Veatch Hong Kong Limited
Engineers and Scientists

Project : Geotechnical Review and Site Investigation Works for Tseung Kwan O Landfill Stage II/III Afteruse Development

Subject : Calculation of Settlement of Platform

Settlement of Waste

To estimate the settlement of waste due to building loading, the following equation is adopted:

$\Delta H = paH_w$

where
- ΔH is the settlement
- H_w is the thickness of compressible waste
- p is the applied loading (kPa) at foundation level
- a is a coefficient relating to primary settlement

Settlement of Soil

To estimate the settlement of soil due to building loading, the following equation is adopted:

$\Delta H = m_v pH\alpha$

where
- ΔH is the settlement
- H is the thickness of soil layer
- p is the applied loading (kPa) at foundation level
- m_v is coefficient of volume compressibility
- α is load factor

140mPD Platform

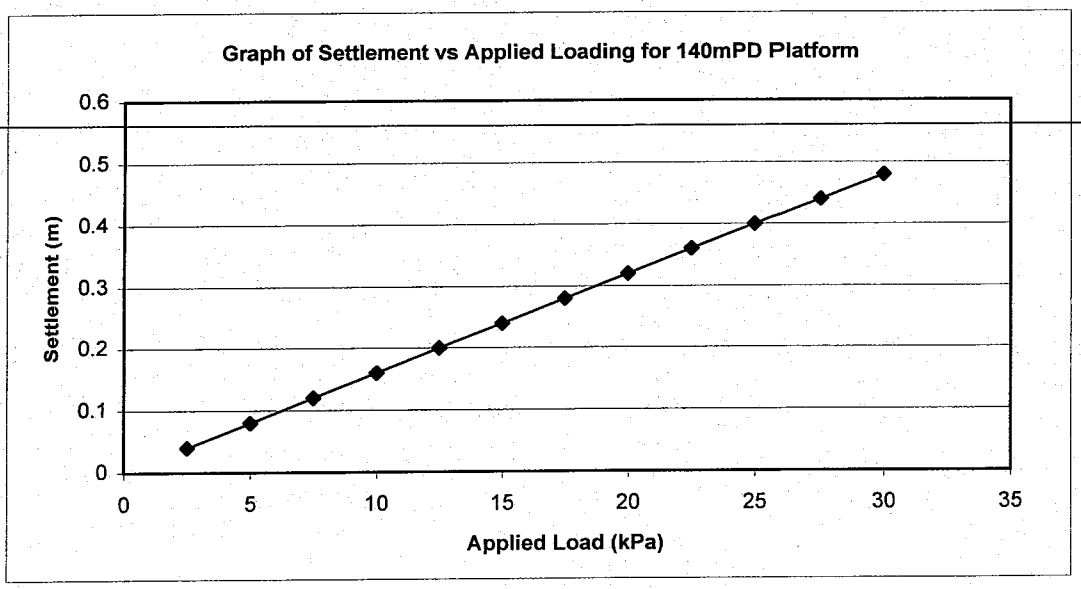
Since CDV/HDV underlies waste, only settlement due to waste is considered.

For settlement due to waste

H_w = 40 m

a = 0.0004 kPa^{-1} (Adopted from Report STG1/STE/SUB/001/Issue 2)

p (kPa)	ΔH (m) Waste
2.5	0.04
5	0.08
7.5	0.12
10	0.16
12.5	0.2
15	0.24
17.5	0.28
20	0.32
22.5	0.36
25	0.4
27.5	0.44
30	0.48



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Checked by : LTC Date :2/17/03

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Subject : Calculation of Settlement of Platform

40mPD Platform

Since there are layers of marine mud and alluvium under waste, settlement due to both waste, the marine mud and alluvium are considered

For settlement due to waste

H_w = 40 m

a = 0.0004 kPa^{-1}

For settlement due to marine mud

H_m = 4.5 m

m_v = 0.00035 m^2/kN (Adopted from Report STG1/STE/SUB/001/Issue 2)

$$\alpha = \frac{10 \times 40}{(10+H_w \times 2)(40+H_w \times 2)} = 0.04938$$ (For raft footing having a dimension of 10m x 40m)

$$\alpha = \frac{20 \times 40}{(20+H_w \times 2)(40+H_w \times 2)} = 0.06667$$ (For raft footing having a dimension of 20m x 40m)

$$\alpha = \frac{30 \times 40}{(30+H_w \times 2)(40+H_w \times 2)} = 0.09091$$ (For raft footing having a dimension of 30m x 40m)

For settlement due to alluvium

H_a = 3 m

m_v = 0.00087 m^2/kN (Adopted from Report STG1/STE/SUB/001/Issue 2)

$$\alpha = \frac{10 \times 40}{[10+(H_w + H_m) \times 2][(40+(H_w + H_m) \times 2]} = 0.03132$$ (For raft footing having a dimension of 10m x 40m)

$$\alpha = \frac{20 \times 40}{[20+(H_w + H_m) \times 2][(40+(H_w + H_m) \times 2]} = 0.05689$$ (For raft footing having a dimension of 20m x 40m)

$$\alpha = \frac{30 \times 40}{[30+(H_w + H_m) \times 2][(40+(H_w + H_m) \times 2]} = 0.07817$$ (For raft footing having a dimension of 30m x 40m)

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Subject : Calculation of Settlement of Platform

(For raft footing having a dimension of 10m x 40m)

Δσ' (kPa)	ΔH (m) Waste	ΔH (m) Marine Mud	ΔH (m) Alluvium	ΔH (m) Total
2.5	0.04000	0.00019	0.00020	0.04040
5	0.08000	0.00039	0.00041	0.08080
7.5	0.12000	0.00058	0.00061	0.12120
10	0.16000	0.00078	0.00082	0.16160
12.5	0.20000	0.00097	0.00102	0.20199
15	0.24000	0.00117	0.00123	0.24239
17.5	0.28000	0.00136	0.00143	0.28279
20	0.32000	0.00156	0.00163	0.32319
22.5	0.36000	0.00175	0.00184	0.36359
25	0.40000	0.00194	0.00204	0.40399
27.5	0.44000	0.00214	0.00225	0.44439
30	0.48000	0.00233	0.00245	0.48479

(For raft footing having a dimension of 20m x 40m)

Δσ' (kPa)	ΔH (m) Waste	ΔH (m) Marine Mud	ΔH (m) Alluvium	ΔH (m) Total
2.5	0.04000	0.00026	0.00037	0.04063
5	0.08000	0.00053	0.00074	0.08127
7.5	0.12000	0.00079	0.00111	0.12190
10	0.16000	0.00105	0.00148	0.16253
12.5	0.20000	0.00131	0.00186	0.20317
15	0.24000	0.00158	0.00223	0.24380
17.5	0.28000	0.00184	0.00260	0.28444
20	0.32000	0.00210	0.00297	0.32507
22.5	0.36000	0.00236	0.00334	0.36570
25	0.40000	0.00263	0.00371	0.40634
27.5	0.44000	0.00289	0.00408	0.44697
30	0.48000	0.00315	0.00445	0.48760

(For raft footing having a dimension of 30m x 40m)

Δσ' (kPa)	ΔH (m) Waste	ΔH (m) Marine Mud	ΔH (m) Alluvium	ΔH (m) Total
2.5	0.04000	0.00036	0.00051	0.04087
5	0.08000	0.00072	0.00102	0.08174
7.5	0.12000	0.00107	0.00153	0.12260
10	0.16000	0.00143	0.00204	0.16347
12.5	0.20000	0.00179	0.00255	0.20434
15	0.24000	0.00215	0.00306	0.24521
17.5	0.28000	0.00251	0.00357	0.28608
20	0.32000	0.00286	0.00408	0.32694
22.5	0.36000	0.00322	0.00459	0.36781
25	0.40000	0.00358	0.00510	0.40868
27.5	0.44000	0.00394	0.00561	0.44955
30	0.48000	0.00430	0.00612	0.49042

Prepared By: LWY Date :2/17/03
Checked by : LTC Date :2/17/03

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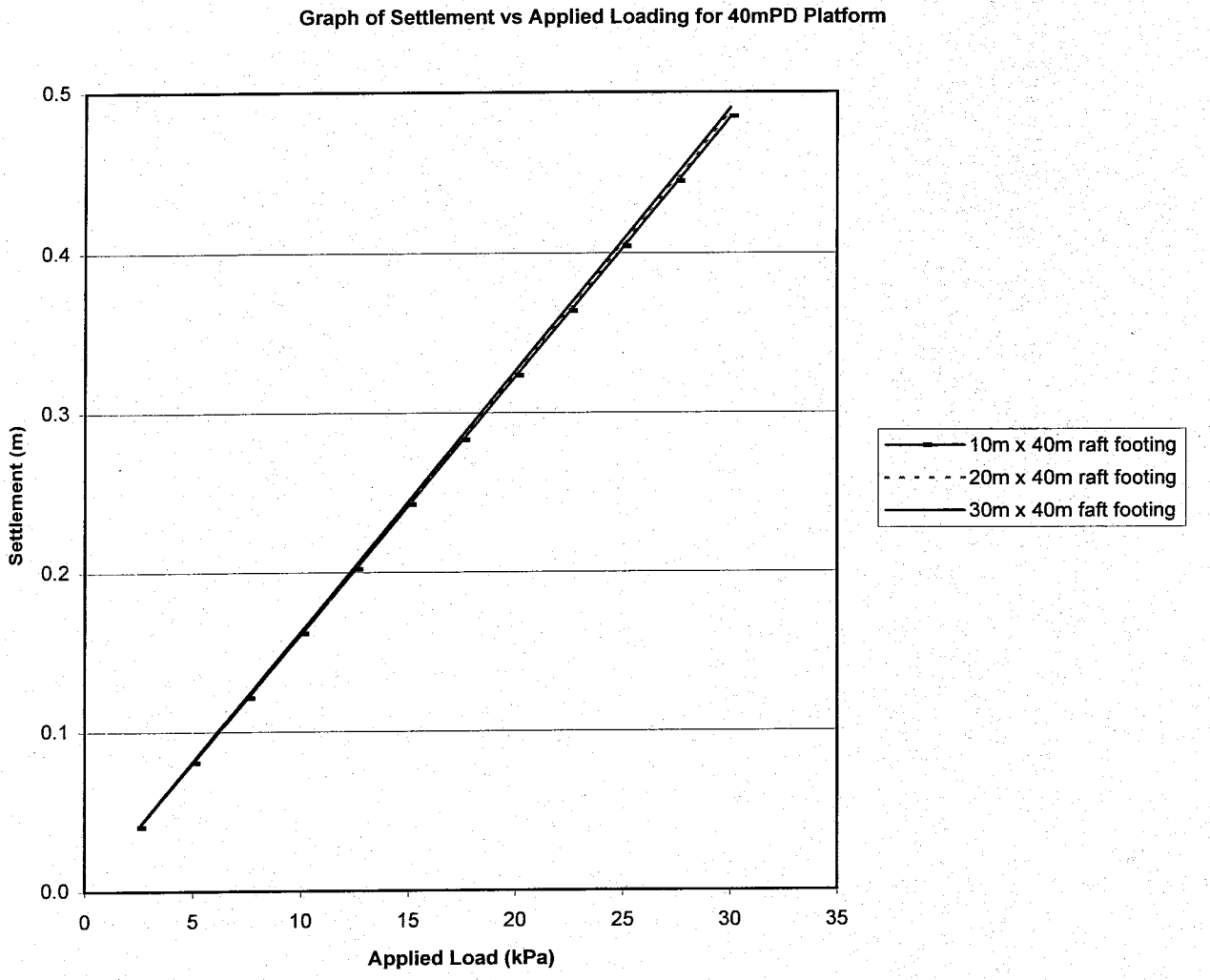
Subject : Calculation of Settlement of Platform



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APPENDIX G
SUMMARY OF COST ESTIMATE

Item	Description	Quantity	Unit	Rate	$
	EARTHWORK				
	Filling				
	Deposition and compaction of Grade 200 rock fill :-				
1	In general filling areas including slopes	12500	m^3	$240.00	$3,000,000.00
	GEOTECHNICAL WORKS				
	Slope Inspection				
2	Inspection scaffolding	0	m^2	$35.00	$0.00
3	Preliminary stripping to impermeable surface on slope	0	m^2	$60.00	$0.00
	Removal of Impermeable Slope Surface				
4	Removal of impermeable surface of artificial hard material, chunam, thickness not exceeding 75mm, without reinforcing mesh	0	m^2	$90.00	$0.00
5	Extra over for item for item 3 for each additional 25mm thickness or part thereof in excess of 75mm	0	m^2	$25.00	$0.00
6	Removal of impermeable surface of artificial hard material, shotcrete, thickness not exceeding 75mm, without reinforcing mesh.	0	m^2	$90.00	$0.00
7	Removal of impermeable surface of artificial hard material, shotcrete, thickness not exceeding 75mm, with reinforcing mesh.	0	m^2	$110.00	$0.00
8	Extra over for item for item 6 for each additional 25mm thickness or part thereof in excess of 75mm	0	m^2	$30.00	$0.00

Prepared by: LWY
Checked by : LTC

Item	Description	Quantity	Unit	Rate	$
	Rock Scaling, Removing of Boulders, Sealing and Infilling Rock Joints, and Mesh Protection				
9	Rock scaling	0	m^2	$50.00	$0.00
10	Removing of boulders	20	m^3	$470.00	$9,400.00
11	Mesh protection as Standard Drawing C 2205A	0	m^2	$100.00	$0.00
12	Sealing rock joints with 1:3 cement mortar	0	m^3	$805.00	$0.00
13	Infilling rock joint:				
14	with no-fines concrete	0	m^3	$805.00	$0.00
15	with Grade 20/20 concrete	5	m^3	$800.00	$4,000.00
16	with soil-cement fill	0	m^3	$300.00	$0.00
	Relief Drains				
17	Relief drains 200 mm wide as Standard Drawing C 2404B	0	m	$95.00	$0.00
	Raking Drains				
18	Establishment of equipment for raking drain	3	item	$5,000.00	$15,000.00
19	Moving equipment	27	nr	$200.00	$5,400.00
20	Drilling drain hole, upwards at an angle of 0° - 45° to the horizontal, length not exceeding 25m, minimum diameter 80mm	27	m	$170.00	$4,590.00
21	Raking drains, upwards at an angle of 0° - 45° to the horizontal as Standard Drawing 2403A, length not exceeding 25m, Type 3	27	m	$200.00	$5,400.00

Item	Description	Quantity	Unit	Rate	$
	Rock Dowels				
	Rock dowels as Standard Drawing C 2202A, X mm diameter, Y metre in length: X mm Y m				
22	25 4	0	nr	$1,085.00	$0.00
23	32 4	20	nr	$1,200.00	$24,000.00
24	32 5	0	nr	$1,420.00	$0.00
25	32 6	0	nr	$2,085.00	$0.00
	Rock Bolts				
26	Establishment of equipment for rock bolts	0	item	$4,910.00	$0.00
27	Moving equipment for rock bolts	0	nr	$380.00	$0.00
28	Rock bolts as Standard Drawing C 2201, working load 80kN, 1m free length	0	nr	$1,580.00	$0.00
	Surface Protection				
	Grade 20 sprayed concrete with A252 welded mesh to BS 4461:				
29	100 mm thick	300	m^2	$310.00	$93,000.00
	Soil Nails				
30	Establishment of equipment for soil nails and pull-out tests	6	item	$15,000.00	$90,000.00
31	Moving equipment for soil nails and pull-out tests	846	nr	$350.00	$296,100.00

Item	Description	Quantity	Unit	Rate	$
	Soil nails as Standard Drawings C2106/1F, C2106/2C and C2106/3D 25 mm diameter, in hole of 100 mm diameter, of length:				
32	4 m	0	nr	$1,072.40	$0.00
33	6 m	0	nr	$1,600.00	$0.00
34	7 m	0	nr	$1,865.00	$0.00
35	8 m	201	nr	$2,240.00	$450,240.00
36	9 m	0	nr	$2,520.00	$0.00
37	10 m	320	nr	$2,800.00	$896,000.00
38	11 m	0	nr	$2,930.00	$0.00
39	12 m	0	nr	$3,200.00	$0.00
40	13 m	0	nr	$3,575.00	$0.00
	Soil nails as Standard Drawings C2106/1F, C2106/2C and C2106/3D 32 mm diameter, in hole of 100 mm diameter, of length:				
41	5 m	0	nr	$1,530.00	$0.00
42	6 m	0	nr	$1,680.00	$0.00
43	7 m	0	nr	$2,255.00	$0.00
44	8 m	0	nr	$2,335.00	$0.00
45	10 m	325	nr	$2,765.00	$898,625.00
46	12 m	0	nr	$3,260.00	$0.00

CORRESPONDENCE

801218

Environmental Protection Department
Hong Kong SAR Government

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From : Philip LEE

To : Mr. Tony Chen

Company: Black & Veatch Hong Kong Ltd

Our Ref. : EP184/06/B/10-01 (VIII)

Your Fax No. : 2601 3988

Our Telephone No: 2872 1817

Our Fax No. : 2591 6662

Date/~~Time~~ Fax Sent : 2.1.2004

This message consists of 1+13 page(s) (including this leader page)

Please notify Philip Lee on Tel. No. 2872 1817 if message received is incomplete.

RECEIVED BY FAX			
ACTION REQUIRED BY	LTC		
FILE			
REPLY	BY	DATE	
TO SEE			

Message:

Agreement No. FD 01-02
Geotechnical Review and Site Investigation Works for
Tseung Kwan O Landfill Stage II/III Afteruse Development
Draft Final Geotechnical Assessment Report (Draft B)

Responses to Comments

Please find attached EPD's memo to GEO dd. 23.12.2003 and GEO's "no further comments" memo ref GCME 2/B 15/8 of 30.12.2003.

2. Please arrange to finalize the report by incorporating GEO's current and previous comments and responses to comments. In particular, please include the notes of meeting on 27.8.2003 in the final report as per GEO's request. The notes of meeting on 27.8.03 and the related correspondences with GEO are attached for your easy reference.

3. Please arrange to prepare 6 copies of the Final Report and submit them to us. In addition, please also provide the electronic files of the drawings in the report for our record as discussed this morning.

Encl.

Regards,

Philip Lee
EPD

→ S(FD)3 31/12

by fax

MEMO

From	CGE/ME, GEO, CED	To	DEP
Ref.	in GCME 2/B15/8	(Attn.:	Mr. Philip LEE 31/12/03
Tel. No.	2762 5233	Your Ref.	( ) in EP 184/06/B/10-1(VIII)
Fax. No.	2714 0245	dated	23.12.2003 Fax. No. 2591 6662
Date	30 December, 2003	Total Pages	1

Geotechnical Review and Site Investigation Works
For Tseung Kwan O Landfill Stage II/III
Afteruses Development
Draft Final Geotechnical Assessment Report (Draft B)

Responses to Comments

I refer to your above memo enclosing the responses to comments for the captioned report.

2. The responses to comments are noted. I have no further geotechnical comment.

(J. C. L. LAU)
for Chief Geotechnical Engineer/Mainland East
Geotechnical Engineering Office
Civil Engineering Department

JCLL/TMFL
T 3.12

MEMO

From : Director of Environmental Protection	**To:** CGE/ME, GEO, CED
Ref : ( ) in EP 184/06/B/10-1 (VIII)	(Attn.: Mr. J.C.L. LAU)
Tel : 2872 1817	**Your Ref :** ( ) in GCME 2/B15/8
Fax : 2591 6662	**Dated :** 10.11.2003 **Fax. No.:** 2714 0245
Date : 23 December 2003	**Total pages :** 1 + 4

Geotechnical Review and Site Investigation Works
For Tseung Kwan O Landfill Stage II/III
Afteruses Development
Draft Final Geotechnical Assessment Report (Draft B)

Responses to Comments

I refer to your above memo enclosing some comments on the consultant's responses to comments.

2. We have forwarded your comments to the consultants for review and the responses to your comments in your above memo are:

Para. 3: Noted. We shall seek further comment from GEO should the option of slope upgrading be adopted in future.

Para. 4: The proposed boulder stabilization work has been discussed in section 5.1.2 of the report in the previous submission to GEO in May and the design of the dentition of concrete was also shown in drawing no. BV/TKO/382311/002 of the report (relevant pages are extracted from the report and attached for your easy reference).
The consultant also confirmed that the design of dentition of concrete to the boulder is in accordance with common practice in Hong Kong (please refer to the attached copy of standard drawing no. HD/STD/G/GS-19 for example).

Para. 5 The stability of the slopes affecting or affected by the proposed after-use facility at +40m PD platform has been assessed in previous submissions, as discussed in Section 3 of the current report.

Para. 6: Noted. The notes of meeting will be included in the final report for completeness and be submitted to GEO for record.

3. I trust that the above responses have addressed your comments. I should be grateful if you would issue a "no further comment" memo to us so that we can instruct the consultant to wrap up the project and issue the final report.

4. Your early reply as soon as possible is highly appreciated. Please contact me if you have any further questions.

(Philip Lee)
Environmental Protection Officer
for Director of Environmental Protection

by fax

MEMO

From	CGE/ME, GEO, CED	To	DEP
Ref.	in GCME 2/B15/8	(Attn.:	Mr. Lawrence S. H. Cheung
Tel. No.	2762 5233	Your Ref.	( ) in EP 184/06/B/10-01
Fax. No.	2714 0245	dated	7.10.2003 Fax. No. 2591 6662
Date	10 November, 2003	Total Pages	1

Geotechnical Review and Site Investigation Works
For Tseung Kwan O Landfill Stage II/III
Afteruses Development
Draft Final Geotechnical Assessment Report (Draft B)

Responses to Comments

I refer to your above memo enclosing the responses to comments for the captioned report.

2. I have no geotechnical objection in principle to the adoption of the no-build zone option subject to conditions as agreed previously at our meeting on 27.8.2003.

3. In view of the adoption of the no-build zone option as the preferred landslide risk mitigation scheme for the proposed afteruses development, I would not comment on item 2(a) of the Response to Comments further at this time. However, should the option of slope upgrading be used in future, you are advised to seek further comment from this office.

4. Please submit details of the proposed boulder stabilization works as shown on drawing No. BV/TKO/382311/003 to GEO for comment prior to commencement of the works.

5. Please clarify if the +40mPD platform would also be used for afteruses facilities and if any structures will be erected, please also clarify if the stability of the slopes affecting or be affected by the facility has been assessed in the previous submission. If not, it should be submitted to GEO for comment.

6. Please include notes of meeting on 27.8.2003 in the final report for completeness and submit the report to GEO for record in due course.

(J. C. L. LAU)
for Chief Geotechnical Engineer/Mainland East
Geotechnical Engineering Office
Civil Engineering Department

JCLL/TMFL

(14)

MEMO

From	Director of Environmental Protection	*To*	CGE/ME,GEO,CED
Ref.	*In* EP 184/06/B/10-01	*(Attn:*	Mr. Jimmy Lau
Tel. No.	2872 1803	*Your Ref.*	*In* GCME 2/B15/8
Fax. No.	2591 6662	*Dated*	25.6.2003 *Fax. No.* 2877 0594
Date	7 October 2003	*Total Pages*	13

Geotechnical Review and Site Investigation Works
For Tseung Kwan O Landfill Stage II/III
Afteruses Development
Draft Final Geotechnical Assessment Report (Draft B)

I refer to the above quoted memo and the subsequent meeting on 27.8.03 with your colleagues (Mr. KY Tang, Tony YK Ho, Vitus MC Chan, and Eric KS Fung) concerning the captioned report. Please find the attached responses to comments for your comments.

2. In addition to answer your queries in your previous memo, the Consultants proposed to add paragraph 5.4 stating that no-building zone is considered as the adopted option because it is most economic and feasible approach to safeguard the proposed Park The attached drawing no BV/TKO/382311/033 has highlighted the extent of area on the platform +140 mPD for afteruse activities. This area will be properly delineated from the "no build zone" with fencing and warning signs at suitable locations.

3. In addition, EPD will make reference of the LCSD safety procedures for inclement weather in the Tuen Mun Golf Driving Range in the future liaision with the potential users to devise some safety procedures for the use of the plateform +140 mPD.

4. You may like to note that we are currently seeking the endorsement of the Landfill Afteruse Working Group's support in the proposed usage. Should you have any query, please contact me for further clarification.

(Lawrence SH Cheung)
Senior Environmental Protection Officer
For Director of Environmental Protection

Encl.

Letter reference: GCME 2/B15/8

Date: 25 June 2003

Item	Comment	Response
2 (a)	Stability Analyses of Cut Slopes	
	(i) Justification for geological models and design groundwater assumptions depicted in sections for stability analyses of soil slopes is required. Besides, the locations of the sections shall be given. Without the above information, it is difficult to comment on the stability analyses and the proposed slope upgrading works.	(i) As mentioned in Section 4.3.2, the geological models and groundwater levels have been adopted based on the ground investigation results, particularly the slope stripping results. The sections are cut at the stripping locations; for easy reference, the locations are shown in attached Figure C1, i.e. Location of Geological Sections for Stability Analysis.
	(ii) Justification for adoption of the minimum factors of safety given in Table 2 of Appendix A of WBTC No. 13/99 is required.	(ii) The justification for adopting the required factors of safety is given in Section 4.2.
	(iii) It is noted that the stability analysis of slope 12SW-A/C175 is missing in the report.	(iii) The analysis results for slope 12SW-A/C175 are now attached. Soil nailing is proposed to upgrade this substandard slope, as shown in attached Dwg No. BV/TKO/382311/001.
	(iv) According to our district records, some landslips have occurred at the cut slopes over the past few years (e.g. Incident Nos. 2001/06/0049 and 2003/06/0139). An assessment of whether the proposed slope upgrading works can effectively eliminate the reoccurrence of similar failures shall be given.	(iv) The two incidents occurred at slope nos. 12SW-A/C175 (Incident No. 2001/06/0049) and 12SW-A/C177 (Incident No. 2003/06/0139). Upgrading works have been proposed under this study to mitigate further failure. **Concluding Remark:** As mentioned at the end of Section 4.4.2, **no** upgrading works will be actually required to upgrade any of the substandard cut slopes as they are superseded by the proposed adjacent preventive measures against natural terrain hazards, i.e. the proposed no-build zone which is the

Letter reference: GCME 2/B15/8

Date: 25 June 2003

Item	Comment	Response
		adopted option (see attached text Section 5.4). Please note that, in the natural terrain hazard assessment, the cut slopes were taken into account already (i.e. the height of the cut slope was considered), in accordance with GEO SPR 1/2002. The report has nevertheless included the stability analyses for the cut slopes for completeness.
2 (b)	Natural Terrain Hazard Study (NTHS) (i) Please remind the consultant to include the revised NTHS calculations for catchment no. 7 into the final report.	(i) Noted.
2 (c)	Option 1 – Earth Bund (i) It is noted that the earth bund design has considered only slope failure occurred at the natural terrain. Further calculations to demonstrate that the earth bund can accommodate the debris resulted from a combination of filures occurred at both the natural terrain and cut slopes shall be given.	(i) As mentioned in our above response to Item 2(a), the cut slopes have already been taken into account in the natural terrain hazard assessment. Therefore, the proposed earth bund will be able to contain debris from cut slope failure.
	(ii) Further design details to prevent the failure debris from flowing downstream along the area within the earth bund, in particular under heavy rainstorm conditions, shall be provided.	(ii) Any debris due to natural terrain hazards or cut slope failure will be able to be contained within the earth bund.
2 (d)	Option – No-build zone (i) I have no in-principle geotechnical objection to the no-build zone option proposed in the report subject to the following: • The no-build zone must not form a part of the proposed Park.	(i) Noted. • The no-build zone will not form part of the proposed Park.

5.2.2 *Open hillslope landslides and channelised debris flows*

The perimeter enclosing the run-out distances due to both open hillslope landslides and channelised debris flows is marked in Drawing No. BV/TKO/382311/002. Based on the calculation results, it is recommended that a 2.5m high earth bund, located at a minimum distance of 4m from the toe of the slopes, be constructed to contain any debris flows, as also shown in Drawing No. BV/TKO/382311/002. However, parts of the existing access road which is the only access road leading to the top 140mPD platform, would be blocked by the proposed earth bund and need to be diverted.

An alternative option that does not require diversion of the access road is discussed in Section 5.3.

5.3 'No build zone' option

An alternative option that does not require diversion of the access road is to define a 'no-build zone', outside of which no development will be affected by any potential hazards, even if the total area of the development has to be reduced upon the establishment of the 'no-build-zone' within the landfill site.

Such a no-build-zone can be defined based on the calculated run-distances discussed in Section 5.2 and is shown in Drawing No. BV/TKO/382311/003, with its boundary being defined as one meter further away from the calculated run-out distance boundary. Note the following points:

- The majority of the platform at 140 mPD is located outside of the no-build-zone and can therefore be used for development, as per the conceptual design which would only require the set up of a couple of movable containers as offices.

- The entire platform at 40 mPD is located outside of the no-build-zone and can therefore be used for development. The conceptual design indicates that a steel structure for recycling facility is to be constructed on this platform.

- Some parts of the access road are located within the no-build-zone. Instead of carrying out extensive road diversion works and slope stabilization works, it is recommended to close the road on signs (e.g. bad weather) indicating a potential danger to the road.

5.4 Adopted Option

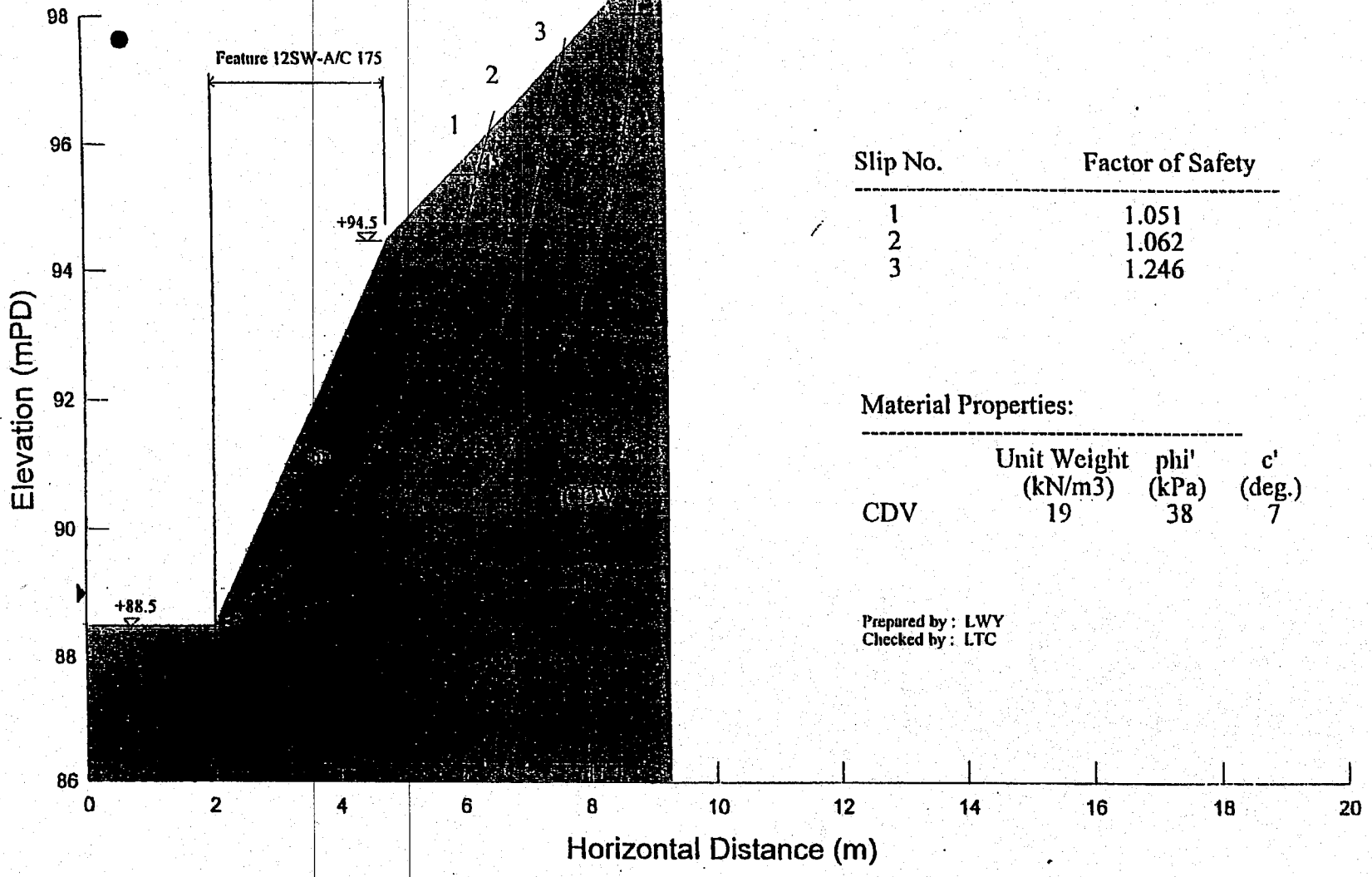
The 'no-build-zone' option, as shown in Drawing No. BV/TKO/382311/003, is considered an economic and feasible approach to safeguard the proposed Park, and is therefore the adopted option.

Letter reference: GCME 2/B15/8

Date: 25 June 2003

Item	Comment	Response
	• No access road is allowed to be located within the no-build zone.	• As mentioned in Section 5.3, administrative measures will be enforced to close the access road on signs (e.g. bad weather) indicating a potential danger to the road.
	• The no-build zone must be fenced off to prevent public access. Appropriate signs should be placed to warn the public to stay away from the no-build zone.	• The areas allocated for after-use development are shown in attached Dwg No. BV/TKO/382311/003.
	(ii) Owing to our comments given in paragraphs 2(a) and 2(c), the extent of the no-build zone shall be further justified.	(ii) The extent of the no-build zone does not need to be revised as explained in our above responses to Items 2(a) and 2(c).
2 (e)	Foundation design (i) The effect of differential settlement on the bearing capacity calculated shall be considered.	(i) Differential settlement will be considered in detailed design of the structures.

Geotechnical Review and Site Investigation Works for Tseung Kwan O Stage II/III Afteruse Development -Stability Assessment for Feature No. 12SW-A/C 175



Slip No.	Factor of Safety
1	1.051
2	1.062
3	1.246

Material Properties:

	Unit Weight (kN/m3)	phi' (kPa)	c' (deg.)
CDV	19	38	7

Prepared by : LWY
Checked by : LTC

Section I-I

Annex IV(1)

Operating Guidelines for Staff of TMRSC On Tropical Cyclones

MR. Hung LCSD Area 19 Driving Range Tel: 2466 261

The Centre Manager or the shift supervisors should arrange appropriate actions to deal with various storm signal as specified below:

Typhoon signal	Actions	Remark
No.1	(i) inform the public via notices about the following:- - issuing of typhoon signal no.1. - closure of the centre once typhoon signal no.3 being issued. (ii) keep alert the change in weather condition. (iii) ensure all loose objects and equipment stored in a safe place.	
No.3	(i) inform the public via notices at the booking office and at the entrance of the centre about the following:- - issuing of typhoon no.3. - closure of the centre. (ii) arrange to lower down the LCSD supernet system and inform concern maintenance parties(EMSD) to standby. (iii) arrange disconnection or fastening of the safety net of the archery range. (iv) ensure all trees and litter bins being fixed. (v) evacuate all the users of the centre except those requiring counter services. (vi) keep alert the change in weather condition. (vii) take reasonable step to prevent the damage of properties. (viii) check the drainage to clear all blockage.	(i) booking counter remains open for - advance booking only - reallocation / refund application - user registration - public enquiry (ii) contract-out cleansing horticulnural maintenance & security services remain. (Note: if typhoon signal No.8 is lowered within 2 hrs of the end of staff duty hours, staff concerned are not required to reported on duty.)
No.8	(i) arrange the closure of the whole centre. (ii) arrange the public, all staff and centre workers to leave the centre safely. (iii) ensure power-off and the whole administrative block being locked.	(i) only the security guards left to man the centre. (ii) closure of the main gate is required.
Canceling of No.8 to No.3	(i) arrange to check and damage of properties injury, slope failure and any accident.	(i) all LCSD duty staff should return to the office as soon as possible. (within 2 hours under normal circumstances)
	(ii) prepare the typhoon damage report and report verbally to SM(OPU)2 immediately and send the written report within 24 hours. (iii) arrange to necessary repair and clearance of the damaging debris, plant debris, blockage of drainage and refuse. (iv) provide counter services only as Typhoon signal No.3 above.	(ii) all cleansing and horticulture maintenance service should be provided within 2 hours. (iii) staff serving the Pro Shop and General Restauram should be on standby basis and to provide immediate services just after the canceling No.3 signal. (iv) all services to the public except the booking and enquiry services are still suspended.
Canceling of No.3	(i) arrange full services to the public. (ii) ensure the staff of Pro shop & General Restaurant to provide service at the same time.	(i) Centre Manager should report within 24 hours to SM(OPU)2 on any accidents, injury or arrange of facilities of the Centre caused by the tropical cyclone. (ii) Centre Manager should report within 20 hours to LM (T/L)NTW on any damaged trees after typhoon.

Annex IV(

Operational Guidelines for Staff of TMRSC on Rainstorm

The Centre Manager or the shift duty i/c should arrange appropriate actions during rainstorm as specified below:

Rainstorm Warning signal	Actions	Remark
Green	(i) check drainage as to remove any blockage materials. (ii) check the driving range to see whether the driving bays are still suitable for public use and arrange reallocation or suspend booking of affeced sessions if the driving bays are unsuitable to use. (iii) keep alert the change in weather condition.	
Amber	(i) check drainage as to remove any blockage materials. (ii) check the diving range to see whether the driving bays are still suitable for public use and arrange reallocation or suspend booking of affeced sessions if the driving bays are unsuitable to use. (iii) keep alert the change in weather condition. (iv) inform the public via notices about the following - the hoisting of "Amber" rainstorm warning signal. - Closure of the centre once "Red" rainstorm warning hoisted.	
Red	(i)&(iii) (v) arrange the closure of the centre and evaculate all users safely. (vi) keep alert on the stability of slopes. (vii) inform the public via the P.A. and the notice about the following - hoisting of "Red" rainstorm warning signal. - closure of the centre and suspension of all activities.	- users are allowed to stay indoors if they have difficulty in leaving the centre.
Black	(viii) arrange all staff to stay indoor. (ix) inform the public staying indoor via notices and the P.A about the following - hoisting of "Black" rainstorm warning signal. - closure of the centre and suspension of all activities.	- centre had been closed during "red" storm warning signal. - users are allowed to stay indoor if they have difficulty in leaving the centre. (Note: if the "Black" rainstorm signal is hoisted before the opening of the centre, all staff should stay at home or any other safe place.)
Lowering of Black	(x) check any damage of properties, injury, slope failure and any accident. (xi) report damage verbally to SM(OPU) immediately and then send written report within 24 hours. (xii) arrange necessary repair and clearance of debris and refuse.	- all centre duty staff should return to the office as soon as possible (within 2 hours under normal circumstances) if the condition of note(I) above occurs. - Centre Manger should report within 24 hours to SM(OPU) on any accidents, injuries and damages of facilities of the Centre caused by the rainstorm. - Centre Manager should report within 20 hours to LM (T/L)NTW on any damaged trees after canceling of rainstorm signal.

By Fax & Post

(11)

MEMO

From	Director of Environmental Protection	*To*	SGE/NTE, GEO,CED
Ref.	*in* EP 184/06/B/10-01	*(Attn:*	Mr.KY Tang / Y.K. Ho)
Tel. No.	2872 1803	*Your Ref.*	(6) *In* GCME 2/B 15/8
Fax. No.	2591 6662	*Dated*	25.6.2003 *Fax. No.* 2714 0245
Date	29 August, 2003	*Total Pages*	2

Recreational Afteruse Proposals in Tseung Kwan O (Stage II/III) Landfill
Notes of meeting on 27.8.03

Subsequent to the meeting held on 27.8.03 concerning the captioned issue, please find the attached notes of meeting for your reference.

2. To elaborate the briefing presented in the meeting, I shall prepare a set of information paper summarizing the details of the proposed recreational afteruse and EPD's undetaking for your further consideration.

(Lawrence SH Cheung)
Senior Environmental Protection Officer
For Director of Environmental Protection

Encl.

c.c. BVHKL (Attn: Mr. Tony Chen fax no. 2601 3988)

Recreational Afteruse Proposals in Tseung Kwan O (Stage II/III) Landfill
Notes of meeting on 27.8.2003 at GEO

Present:	Mr. KY Tang	SGE/NTE, GEO
	Mr Tong YK Ho	GE/NTE2, GEO
	Mr. Vitus MC Chan	SGE/Planning &Terrain Evaluation,GEO
	Mr. Eric KS Fung	GE/Planning & Terrain Evaluation 2,GEO
	Mr. Lawrence SH Cheung	S(FD)3/EPD
	Mr. PL Ip	E(FD)7/EPD

1. The meeting was held to discuss the proposed afteruse activites in the restored Tseung Kwan O (Stage II/III) Landfill and the geotechnical assessment recently prepared by Black & Veatch Hong Kong Limited.

2. In view of the shortage of recreational space in Tseung Kwan O Town, EPD was under pressure to open the restored landfills to the public. EPD briefed GEO on the recreational proposal from Hong Kong Air Cadet Corp (HKACC), which will include an access to the upper platform to play model aeroplane. From the current preliminary estimation, only about 4 to 8 vehicles will be involved and no structures will be installed on the platform. EPD confirmed that stringent safety measures could be imposed on the users if the application was found acceptable in principle.

3. Subsequent to a series of discussion, the following issues were agreed in principle:

   (i) The model aeroplane flying activity would be confined in the top platform +140 mPD except for the eastern corner in view of the risk of channelised debris (detailed layout plan will be provided separately);
   (ii) Regarding the potential risk at the downhill slope, users would be forbidden to walk on the slope i.e. picking up their descended aeroplane, and delegates from the restoration contractor will be deployed to assist the users;
   (iii) No structure would be installed on the platform +140 mPD; the restoration contractor would provide space somewhere within the site area for storage purposes;
   (iv) EPD would consider to complete stabilisation works to the two boulders at the uphill slope;
   (v) Regarding the potential risk of the access road, EPD would establish some safety procedures with the restoration contractor and HKACC. These procedures would include:

      * closure of the site during inclement weather;
      * some kinds of traffic management to be established for the use of the access road;
      * regular safety briefings to their cadets instructors to be established;
      * strict control on the number of vehicles to use the access road;
      * insurance on their personnel due to the risk of land slide;

   (vi) GEO advised that the golf driving range in Tuen Mun Area 19 had similar potential risk of landslide; LCSD had established some safety procedures for which EPD could make reference;

4. EPD will prepare a set of information paper summarizing the details of the proposed recreational afteruse and EPD's undertaking in the future management for GEO/CED's further consideration.