ASSESSMENT OF GEOLOGICAL FEATURES RELATED TO RECENT LANDSLIDES IN VOLCANIC ROCKS OF HONG KONG PHASE 2B - ABERDEEN STUDY AREA

GEO REPORT No. 67

C.A.M. Franks, S.D.G. Campbell & W.W.L. Shum

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

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PREFACE

In keeping with our policy of releasing information which may be of general interest to the geotechnical profession and the public, we make available selected internal reports in a series of publications termed the GEO Report series. A charge is made to cover the cost of printing.

The Geotechnical Engineering Office also publishes guidance documents as GEO Publications. These publications and the GEO Reports may be obtained from the Government's Information Services Department. Information on how to purchase these documents is given on the last page of this report.

R.K.S. Chan
Head, Geotechnical Engineering Office
July 1999

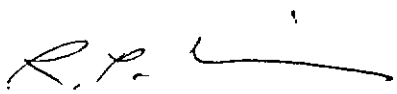
FOREWORD

This report describes geological features in the Aberdeen area of southwest Hong Kong Island in the context of their relationship to the stability of cut and natural slopes. The assessment forms part of a programme of investigations carried out by the Geotechnical Engineering Office following the fatal landslides at Fei Tsui Road and Shum Wan Road in August 1995.

Mr W.W.L.Shum carried out the aerial photograph interpretation of the entire study area, Dr S.D.G.Campbell undertook most of the field observations of geological features and Dr C.A.M.Franks was responsible for the engineering geological assessment, which included features described in ground investigation reports, Island Division Files, Landslide Incident and other related reports. The report presents general conclusions regarding the significance of geological features with respect to slope stability, and makes recommendations for further investigations of selected cut slopes where adverse geological features were observed or are suspected.

The speedy and accurate digital compilation of the maps by members of the Cartographic Unit, under the direction of Ms P.L.Chan, and including Mr K.W.Wong, Mr Y.L. Lee, Ms P.L. Ho and Mrs L.K. Leung, made a significant contribution to the project. Technical support was provided mainly by Mr K.C.Yip, Mr K.C. Chan, Mr W.H. Ho and Mr P.C. Cheng.

Helpful comments have been provided by many GEO colleagues, including Dr C.J.N. Fletcher, Mr H.H. Choy, Mr N.W. Woods and Mr N.P. Koor.



(R.P. Martin)
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ABSTRACT

This report covers the Phase 2B assessment of geological features related to recent landsliding in the Aberdeen area. Phase 2A covering the Chai Wan area has already been reported separately. The study involved aerial photograph interpretation (API), a geological survey and an engineering geology assessment, comprising a desk-study with limited field check. The report includes eight 1:5 000-scale thematic maps.

The study concentrated on identifying slopes that are geologically similar to those that failed at Shum Wan Road and Fei Tsui Road in August 1995, and that have had histories of persistent seepage and multiple minor failure. The key geological feature of the Shum Wan Road landslide was the presence of weak clay seams and clay-infilled joints. These were associated with a zone of anomalously deep weathering associated with locally subvertical volcanic fabric striking subparallel to very closely-spaced joints and to the direction of the slope that failed. The key geological features of the Fei Tsui Road landslide were thick, laterally-extensive concentrations of kaolin dipping out of the slope face, subparallel to the volcanic fabric and persistent steep joint sets.

The API examined a broader area than the main study area. Many relict landslide features were observed and classified according to the nature of the slope in which they occur. Very few recent landslides (post-1945) were noted on natural slopes. Some substantial landform features, evident as topographic depressions and associated with natural slope degradation processes have been identified on several slopes. Some of these are suspected to be associated with previous landsliding but their precise origin is uncertain. Photolineaments, including one set of inferred tension cracks, were also mapped and slopes showing evidence of persistent seepage highlighted.

The geological survey focused on identifying the orientation of eutaxitic foliation (the primary fabric in the volcanic rock) in the dominantly eutaxitic fine ash vitric tuff in the study area (as was the case at both the Fei Tsui Road and Shum Wan Road landslides). These fabrics provide the best means of identifying cut slopes which could contain adversely-orientated features parallel to bedding, as at the Fei Tsui Road landslide, but where such features are obscured by protective covering (chunam, shotcrete, etc.). However, although lithological variation is common, there are relatively few cut slopes in the area in which adverse bedding-parallel features either do, or may occur. More often, abrupt, planar or trough-shaped adversely-orientated discontinuities occur at, or within 5 m of, the PW90/100 to PW0/30 rock mass weathering zone interface. These may be loci for preferential kaolin accumulation which can be laterally continuous, and hence comparable to one of the main geological conditions at the Fei Tsui Road landslide site. These planar discontinuities are also the sites of localised seepage. The style of weathering of the fine ash vitric tuffs differs from the corestone profiles often regarded as typical in Hong Kong. However, corestones are more typical of the weathered coarse ash crystal tuffs. The lack of significant soil profiles on some natural slopes appears to be due to previous landsliding having removed the weathered material. As a consequence, adjoining areas on which the soil profile has been retained may form elevated spurs.

Closely- to widely-spaced subvertical joints, especially parallel to the main faults in the

area, are virtually ubiquitous so that release surfaces, similar to those at the Fei Tsui Road landslide, could occur in most slopes in the area.

The main faults in the area (trending east-northeast and north-northwest) are often zones of deeper weathering, and superficial deposits tend to be thicker above these fault zones also. Hence, where fault zones associated with deep weathering strike parallel or subparallel to the slope direction, an important geological condition similar to that at the Shum Wan Road landslide could occur.

The engineering geology assessment was based mainly on a desk-study of information from a wide variety of sources together with site inspection of selected slopes. Site formation photographs were also used to assess the possible presence of kaolinitic seams, and low-angle discontinuities but few were noted during the study. Ground investigation (GI) boreholes also indicate the presence of kaolin across most of the area but most occurrences have been recorded in material of weathering grade III or better, in contrast to observations made during the geological survey that indicate that most significant occurrences are in material of grade IV and V. This disparity is interpreted in terms of incomplete borehole records of soil material.

Data used in the engineering geology assessment formed the basis of three thematic maps at 1:5 000 scale showing GI information, areas for which geotechnical data are available and landslide incidents. The API and geological survey data were integrated with field observations to produce a further thematic map depicting seepages. Additional 1:5 000-scale maps show registered slopes and registerable slopes (excluding fill slopes) and the Natural Terrain Landslide Inventory for the area.

The study concluded that geological and topographic factors pre-disposing steep slopes to instability include: weathering profiles with abrupt changes in decomposition grade (V/IV to II/I), with either very thin or absent grade III and containing local zones of deeply weathered rock >10 m thick, especially along faults and shear zones; high or transiently high ground water tables; kaolin seams within relict joints in weathered rock masses; closely-jointed rock masses; proximity to coastal cliff sites and to dykes or other intrusions. Intersections of low-angle stress release joints which daylight in the slope also influence landslide development.

Eight natural slope areas with clusters of previous failures may indicate geological conditions adverse to slope stability. All are associated with old coastal cliffs subjected to long periods of *in situ* weathering and coastal erosion. Some adversely-orientated, weathered stress release joints within cliffs, which often contain kaolin infills, will have provided preferential failure surfaces.

The study recommends that twelve slopes (three of which are unregistered) require more detailed inspection, including chunam and shotcrete strips and vegetation clearance, and further engineering geological assessment. These slopes were selected because of the presence of, or potential for, adversely-orientated geological features, including kaolin seams, localised deeply weathered zones, high groundwater conditions and with a history of previous landsliding.

CONTENTS

1. INTRODUCTION

1.1 Objective of the Study

This report describes the results of Phase 2B of the project 'Assessment of Geological Features Related to Recent Landslides in Volcanic Rocks of Hong Kong'. The aim of the project is to identify locations with geological features adverse to slope stability, similar to those that may have influenced the Fei Tsui Road and Shum Wan Road landslides of August 1995. This report deals specifically with a study area around Aberdeen in southwest Hong Kong Island. The Aberdeen area, which includes the site of the Shum Wan Road Landslide, was recommended for further study, including field work, in the Phase 1 report (Strange, 1996) of the project. That report concluded that existing archival data alone were insufficient to identify with confidence and on a systematic basis, those slopes where adverse geological features, similar to those at Fei Tsui Road and Shum Wan Road, might exist.

The objective of the Phase 2B study was to identify engineered slopes containing geological features that are adverse to slope stability, including but not limited to features that are similar to those at either the Fei Tsui Road landslide site (GEO, 1996a) or the Shum Wan Road landslide site (GEO, 1996b), and to carry out a preliminary engineering geological assessment of such features. The features include:

(a) thick (hundreds of millimetres) and laterally extensive (tens of metres) concentrations of kaolin in impermeable and weak layers within rock masses,

(b) completely to highly decomposed (Grade IV/V) tuff along relatively planar rock seams overlying slightly to moderately decomposed tuff (Grade II/III), dipping directly, or obliquely outward from rock slope faces at angles of >c.20°,

(c) stratified volcanic rocks, dipping directly, or obliquely outward from rock slope faces, at angles of >c.20°, as indicated commonly by primary eutaxitic fabric,

(d) stratified volcanic rocks with steep to sub-vertical dip, striking sub-parallel to the local slope direction,

(e) persistent, closely to medium-spaced, tight and rough, planar, steep (dip >60°) joint sets that could form release surfaces,

(f) zones of deep weathering and associated kaolinitic clay seams,

(g) zones of continuous seepage, and

(h) clusters of previous slope failures.

1.2 The Study Area

The study area (Figure 1) is centred around Aberdeen Harbour and Aberdeen Channel, and extends for approximately 3 km from west to east, and 1.75 km from north to south. The north of the area is extensively urbanised and includes Aberdeen and Wong Chuk Hang. Ap Lei Chau, lies in the southwest and the Shum Wan Road landslide site is located in the southeast, on the Nam Long Shan Peninsula.

The area borders high ground to the north and also includes relatively steep slopes around Yuk Kwai Shan (Mount Johnston) on Ap Lei Chau, and Nam Long Shan (Brick Hill). Large numbers of cut slopes and retaining walls have been formed in the area and especially around the major housing developments which include the Tin Wan, Shek Pai Wan, South Horizons, Ap Lei Chau, Lei Tung and Wong Chuk Hang estates. There are areas of reclaimed land along both flanks of Aberdeen Harbour, around Ap Lei Chau, and on the west coast of Nam Long Shan. The pre-reclamation cliff lines provide extensive exposure.

The area reported on here mainly falls on 1:1 000 scale topographic sheets 11SW-23C, 11SW-23 D, 11SW-24C, 11SW-24D, 15NW-3A, 15NW-3B, 15NW-3C, 15NW-3 D,15NW-4A, 15NW-4B, 15NW-4C, 15NW-D, as recommended in the Phase 1 report.

Map Nos. 1 to 8, attached to the end of this report, contain the main results of the study. The data were digitised at 1:1 000 scale in the main for final presentation at 1:5 000 scale on a raster-scanned topographic base.

2. AERIAL PHOTOGRAPH INTERPRETATION (API)

2.1 Objective

The objective of the API was to identify and map land surface features that might be related to land instability problems. The features mapped include:

(a) all relict landforms formed by slope instability,

(b) landforms which may contribute to new slope instability problems because of their effects upon infiltration,

(c) previous landslides, recent (post 1945) and relict,

(d) seepage from natural terrain and cut slopes,

(e) tension cracks, and

(f) photo lineaments, other than those which can be related to land use factors.

The boundaries of the API were set to coincide with catchment, map sheet or development boundaries and they extend further than the boundaries of the main study area, enclosing an area of approximately 600 ha.

2.2 Methodology

A list of the aerial photographs used during the API is given in Table 1. The 1949, 1963, 1967 and 1992 aerial photographs were the most useful for mapping natural terrain features. The larger landform features are best interpreted from the 1967 aerial photographs because their intermediate scale (1:12 500) enables the entire slope from crest to toe to be examined in a single stereopair of photographs. However, they can also be observed in all sets of photographs dating back to 1949.

Smaller relict landslide scars are observed from 1949 onwards, but are less easily recognised in more recent photographs because of increasing vegetation cover on natural terrain.

The 1949, 1963 and 1967 aerial photographs were the most useful for mapping photolineaments and small relict landslide features. Dense vegetation cover or thick tree canopy developed after 1967 prevented the identification of these features on more recent aerial photographs.

The relict landslide features, and any debris or colluvium deposits below them, generally correspond to the "Zones of General Instability" shown in the GASP report for Hong Kong and Kowloon (GCO, 1987a) and the unit "Debris Flow Deposits" shown on the 1:20 000 published Geological Maps (Sheet 11 - Hong Kong and Kowloon, Solid and Superficial Geology (GCO,1986) and 15 - Hong Kong South & Lamma Island, Solid and Superficial Geology (GCO,1987b) and reproduced in Figure 2.

2.3 Review of Existing Information

2.3.1 Previous API Reports

Existing API reports were reviewed and locations of observed instability were transferred to a 1:5 000 scale map (Map No. 1). Relevant information extracted from these reports is given in Appendix 1.

2.3.2 Natural Terrain Landslide Inventory (NTLI)

The NTLI is a territory-wide catalogue of natural terrain landslides based on the use of high altitude aerial photographs to map all observable landslides occurring on natural slopes. During this current study the locations, lengths and years of observation of natural landslides in the study area were extracted from the NTLI database.

2.4 Observations

The current API complemented the information already available from the NTLI. All landslides occurring on cut and natural slopes were mapped from stereopairs of low altitude aerial photographs for the study area. These observations were combined with those from the NTLI and are shown on Map No. 1.

2.4.1 History of Instability

1945 Many of the relict landslides were mapped from this photography. Nam Long Shan Road had already been constructed by this time.

1949 Most of the landslides observed from this photography are relict features, although new landslide scars were evident towards the west side of Ap Lei Chau, up slope from the present Ap Lei Chau Bridge Road.

1963 This photography only covers the northeast part of the Nam Long Shan Peninsula and therefore only a few landslides could be seen.

1964 Landslide scars were observed mostly along the coast of Ap Lei Chau.

1967 Several landslides occurred below Nam Long Shan Road. Others were observed along the recently constructed catchwater on Bennet's Hill and a long runout landslide scar was located just to the north of Nam Long Shan peak.

1970 This photography covers only the northwest part of the Nam Long Shan Peninsula and only one landslide was observed.

1972 One landslide scar was seen, located on the site now occupied by South Wave Court.

1973 Several landslide scars were observed on these photographs, most of which were located near or on cut slopes.

1975 One landslide scar was observed, but as the scar was completely removed during construction of the Lei Tung Estate it is not shown on the API map.

1976 Most of the landslide scars observed were in the northwest corner of the study area, between the Shek Pai Wan and Tin Wan estates. Photolineaments were observed above the Marine Engine Workshops on Ap Lei Chau East, and are interpreted as tension cracks.

1980 Several landslide scars were observed on this photography.

1982 Landslide scars include a single feature southwest of the Police Training School, a cluster south of Ocean Park, and some along the south coast of Ap Lei Chau.

1985 Landslide scars were scattered around the study area with concentrations in Lei Tung Estate, and north of Wong Chuk Hang Road.

1989 One landslide scar was seen near the coast of the Nam Long Shan Peninsula, south of Ocean Park.

1992 Landslide scars observed included two on the south coast of Wong Chuk Hang, one on the north coast of Ap Lei Chau and another on the west coast of Nam Long Shan Peninsula.

1995 Landslide scars were observed on the north and west coasts of Ap Lei Chau.

2.4.2 Seepages

Areas of seepages on cut slopes were inferred, based on a number of characteristics in the aerial photographs. These include: free standing water at the base of slopes, narrow dark bands on generally ligh- coloured slope surfaces, dark tones within drainage gutters or channels, and dark tones across usually lighter-coloured road surfaces. The dark tones can be either water, or mosses and ferns that only grow where there is abundant water.

Heavy seepage was inferred from API at:

(a) cut slopes on Nam Long Shan Road in 1963, 1972, 1973, 1976, 1982 and 1985,

(b) cut slopes south of Ocean Park in 1982,

(c) cut slopes south of Lee Nam Road on Ap Lei Chau in 1976, 1984, 1986 and 1992,

(d) cut slopes near the north-eastern tip of Ap Lei Chau in 1986 and 1995, and

(e) cut slopes around Aberdeen Centre and Tin Wan Estate in 1973 and 1987.

2.5 Areas of Concern

2.5.1 Tension Cracks

A set of inferred tension cracks was observed on the 1976 photographs. The area in which these tension cracks occur has had a long history of slope instability, dating back to 1945. Reference was made in GCO report GCP 1/1/250 (24.4.1986) to these same tension cracks above the Marine Engine Workshops on Ap Lei Chau East (see also GASP XII Report, Plate 88-91, GCO, 1987a).

2.5.2 Areas Inferred to be Susceptible to Landsliding

Several parts of the study area have a history of instability and are inferred to be particularly susceptible to landsliding. These areas are highlighted on Map No. 1. These areas occur either near to the 1949 coast line, or where there is an abrupt slope gradient change near the coast line.

2.6 Conclusions

The following conclusions can be drawn from the API work:

(a) Areas inferred to be particularly susceptible to landsliding associated with natural slope degradation processes have been identified on several slopes. Some of these features cover large areas and are suspected to be associated with previous landsliding as they extend down slope into areas of slope debris, and one may be associated with coastal erosion. There is no evidence of movement on these features subsequent to the earliest available aerial photographs from 1945.

(b) Heavy seepages were identified on cut slopes at several sites, and these correspond well with recorded and observed seepages, including those seen during field inspection in the present study.

3. GEOLOGICAL SURVEY

3.1 Objective

The objective of the survey was to locate and examine geological features that might influence landslide development, especially within, and near cut slopes. The following were recorded where observed:

(a) stratification of principal types of volcanic rocks, and in particular the orientation of eutaxitic fabrics in such rocks. (Note: Eutaxite is a term used for pyroclastic rocks in which welding has occurred, i.e. viscous deformation of vitric fragments, resulting in marked planar fabrics (GCO,1988),

(b) joint orientations,

(c) fault orientations,

(d) concentrations of kaolin,

(e) the nature of the weathering profile and locations of deep weathering,

(f) landslide features in and adjacent to cut slopes, and

(g) seepages associated with discrete geological structures.

Due to time constraints, comprehensive coverage of the study area was not possible and it was necessary to concentrate on those parts of the area close to cut slopes.

As the natural slopes are thickly vegetated, traverses were largely restricted to the main roads and tracks in the area. A few stream sections were also examined, but as the streams commonly coincide with photolineaments and or follow faults, the information they provide is not necessarily representative of adjoining areas.

Generally, cut slopes in the area are covered by chunam or shotcrete, and occasionally stone pitching. In mixed soil and rock slopes in weathered rock, the upper parts of the slope are commonly covered, whereas lower slopes in rock remain exposed, causing bias of observations towards the latter. However, small exposures commonly protrude through the chunam or shotcrete enabling some detailed observations to be made.

Areas of significant seepage were recorded during the survey. In most instances, seepage was associated either with shallowly-inclined joints, with the interface between PW0/30 and PW90/100 rock, or with steeply inclined faults. The most significant examples of seepage, most of which were noted in cut slopes, are listed in Appendix 2.

The main results of the survey are shown on Map No. 2.

3.2 Volcanic Rocks

3.2.1 Correlation and General Structure

On the existing Hong Kong Geological Survey 1:20 000 scale geological maps of the area, (Sheet 11, GCO, 1986 and Sheet 15, GCO, 1987b; Figure 2) most of the study area is shown to be underlain by volcanic rocks of the Ap Lei Chau Formation, mainly comprising fine ash vitric tuff, and including units of eutaxite, and subordinate units of coarse ash, tuff breccia and pyroclastic breccia and sandstone. Further volcanic rocks assigned to the Tai Mo Shan Formation occur on Sheet 11 in the northwest. Since publication of Sheet 11 (GCO, 1986) the rocks shown as Tai Mo Shan Formation on the southern half of the sheet have been reassigned, on the basis of their whole-rock geochemistry, petrography and isotopically-determined ages, to the Mount Davis Formation (Sewell *et al.*, in prep.). This formation is considered to interdigitate with the upper part of the Ap Lei Chau Formation.

Field work has largely supported the interpretation of the regional pattern of faults shown on the published maps but the location and interpretation of folds has been modified to some extent in the light of additional orientation data.

The volcanic rocks are underlain by fine to medium-grained granite to the north of the area, but granite has been observed only in the northeast corner of the area (GCO, 1986). A zone containing quartz syenite dykes transects the area from east-northeast to west-southwest, passing through Wong Chuk Hang, probably continuing beneath Aberdeen Harbour and extending to the northwest corner of Ap Lei Chau. The zone of dykes is interpreted as being associated with a major fault zone that can be traced across much of the Territory. Other faults trending east-northeast, northeast and north-northeast are shown on the published geological maps (Sheets 11 and 15) and faults of similar orientation have been observed and inferred during the present survey (Map No. 2). Regional-scale folds, with axes trending variably northwest to west-northwest or west occur across the study area. There are also occasional folds that lie close to major faults, whose axes trend northeast.

3.2.2 Lithology

The dominant rock type of the area is crystal- and lapilli- bearing fine ash vitric tuff of the Ap Lei Chau Formation. The lapilli are commonly flattened and highly attenuated fiamme (Plate 1), typically up to 100 mm in size and typically altered to chlorite, kaolin, calcite and quartz, set within a matrix showing a strongly preferred fabric parallel to the flattening direction of the fiamme, interpreted as eutaxitic foliation (i.e. welding of the tuff). Units showing these features are classified as eutaxites, and they occur as thick units (tens of metres thick) within the study area. The Ap Lei Chau Formation also contains subordinate coarse ash tuff, sandstone, tuffite, tuffaceous siltstone and locally tuff-breccia and pyroclastic breccia. In addition, in the northeast of the area, coarse ash crystal tuffs of the Mount Davis Formation are relatively thick and extensive. Because of the lithological variability within the study area, laterally continuous bedding plane or bedding parallel features, such as occurred at the Fei Tsui Road landslide site, occur in most parts of the area.

Most of the volcanic rock types are bluish grey when fresh, but weather to a light bluish grey and eventually to a light brown, yellowish brown or white with increasing material decomposition. The crystals are mainly of quartz and feldspar and range from fine ash (<0.06 mm) to coarse ash (0.06-2 mm) and lapilli (>2 mm) in size. Biotite and iron-oxide crystals occur but are far less common.

3.2.3 Volcanic Fabrics and Stratification

Most of the rocks are formed from deposits derived from explosive volcanic eruptions (as shown by broken crystals, subangular lithic clasts etc.). In many instances, they contain fabrics formed during compaction of the deposits soon after they were deposited and often while the deposit was still hot. These fabrics can be consistent over large areas (Map No. 2) but greater variability is seen near faults and within fault zones where the fabrics may be sub-vertical.

Primary volcanic fabrics are of particular value in this study as they provide a means to establish the general dip of rock stratification despite the limited exposure available in most cut slopes that have surface protection. Hence, in assessing geological features in cut slopes, it is possible to identify, or predict, those slopes in which stratification dips directly out of the slope, as at the Fei Tsui Road landslide site, or is sub-vertical and striking directly out of the slope, i.e in the same direction as the prevailing slope, as at the Shum Wan Road landslide site. Slopes in which the volcanic fabric varied from these two orientations would lack one of the basic geological features that are considered to have influenced the two landslides. However, even where the general structure dips directly out of a cut slope, this does not necessarily imply that a bedding-parallel feature, similar to that at the Fei Tsui Road landslide site, exists within that slope. Equally, steeply orientated volcanic fabrics striking parallel to the slope direction do not on their own confirm geological conditions like those at Shum Wan Road.

Volcanic fabrics have been measured accurately at some localities, especially where coarse, flattened lapilli (fiamme) are present. More commonly, they were estimated only within broad limits due to local variations in the orientation of the fabric. The volcanic fabrics

are most readily observed in moderately decomposed rock. The fabric data are shown in Figures 4, 6 and 8 for three sub-areas: Ap Lei Chau, Aberdeen and Nam Long Shan Peninsula.

Form lines that display the approximate strike of the volcanic fabrics and bedding in general, have been constructed (Map No. 2) across the area. The dip direction is often shown in addition to the strike and representative estimates of the amount of dip have also been made. The density and continuity of the form lines are largely governed by the density and consistency of observed fabrics and bedding. Unlike the lithological boundaries shown on Map No. 2, which vary in relation to the topography, the form lines are constructed irrespective of local topography.

The form lines have been used to predict the orientation of bedding in slopes that are completely covered by chunam, shotcrete, or stone pitching. Where the form lines and dip direction data suggest that volcanic fabrics are inclined directly out of the slope, then it can be inferred that an adverse geological bedding feature, such as that which influenced the development of the Fei Tsui Road landslide, may exist within the slope. Similarly, where form lines indicate sub-vertical fabrics striking in the same general direction as the prevailing slope in which they occur, then it can be inferred that geological conditions similar to those at the Shum Wan Road landslide may exist in the slope.

Slopes in which the volcanic fabric was observed, or inferred from form lines to dip directly out of the slope, or at a high angle to its strike, are listed in Appendix C. There are relatively few of these slopes as the main fold axes in the area typically trend at a high angle to prevailing natural slopes. Slopes in which the volcanic fabric was observed, or inferred from form lines to dip sub-vertically and strike directly out of the slope, or at a high angle to its strike, are also listed in Appendix C. Generally, the zones in which the fabric is sub-vertical occur within or adjacent to faults and shear zones. These occur in three dominant orientations and there is a greater likelihood of slopes containing features of this type, albeit on a wide range of scales, than adversely-orientated bedding-parallel features.

3.2.4 Joints

Rock joint surveys were carried out for a number of cut slopes in the area. The joint data, shown in Figures 3, 5 and 7 highlight the consistent orientations of the main joint sets in three sub-areas: Ap Lei Chau, Aberdeen and the Nam Long Shan peninsula. The Ap Lei Chau and Aberdeen areas show two dominant sub-vertical joint sets, striking north-northwest and east-northeast, with one low angle set. The Nam Long Shan area has a weakly developed third sub-vertical joint set striking east-west.

The east-northeast and north-northwest striking joint sets are both steeply inclined (>70°). These orientations are generally subparallel to the main faults and photolineaments. Some of the steeply-inclined 'joints' have been the loci of minor faults, as shown by slickensides, and the interface between the PW90/100 and PW0-30, or PW30/50 commonly changes its depth of development abruptly across these joints. Within or close to faults, the spacing of the joints subparallel to the faults generally decreases. In cut slopes, these zones of closely to very closely spaced joints are often observed to be associated with deeper weathering (e.g. in Slopes 15NW-A/C14 and 17) and with significant seepage.

The shallowly-inclined joints are more variable in orientation. They range from subhorizontal (Plates 2 and 3) to having a significant down-slope component of dip in relation to the topography (Plates 2 and 3), and are interpreted mainly as stress relief joints generated during erosion of the terrain. They may locally influence the development of landslides (Plate 2), especially where they occur at or near the interface between the PW90/100 and PW0/30 rock mass weathering zone (e.g.in Slope 11SW-D/C86), and in these instances their orientation approximates to that of the basal surface of rupture of the failure. Low-angle joints also occur in conjugate sets. Their concave-upward intersections may be a further influence on landslide development where the joint intersections plunge in the same direction as the natural slope (Plate 4), or plunge adversely from a cut slope.

3.2.5 Faults

The main faults shown on the published geological map (Sheets 11 and 15, Figure 2) have been confirmed by field observation or interpretation (Map No. 2). The two main fault sets strike northeast varying to east-northeast, and northwest varying to north-northwest. Minor faults of both orientations were rarely observed. Faults trending slightly west of north also occur. The major faults typically form topographic depressions, reflecting relatively deeper weathering. Kaolin may occur in significant concentrations within faults near surface but it appears to decrease in abundance with depth, for example, in cut slope 15NW-B/C87 on the Lei Tung Estate. This relationship suggests that the kaolin forms, and/or accumulates in response to weathering. Fault-related depressions also tend to be loci of deeper weathering, thicker soil development, thicker accumulation of superficial deposits, and high ground water tables.

3.2.6 Folds

Fold style and orientation varies markedly across the study area and there is a pronounced difference in the orientation of fold axes to the north and south of the zone of the quartz syenite dykes that crosses the area from east-northeast to west-southwest, passing through Wong Chuk Hang and extending to northwest Ap Lei Chau. To the north of this zone, the folds are generally upright and tight with axes trending from northwest to southeast, or occasionally northeast. Fold wavelengths vary between approximately 1 and 2 km. South of the zone, the folds are typically open, have axes trending from west-northwest to east-southeast, and fold wavelengths vary approximately from 100 m to 1 km. The zone is interpreted as a major fault or shear zone.

3.2.7 Concentrations of Kaolin

Observed concentrations of kaolin are shown on Map No. 2. Such concentrations were infrequent and they were rarely seen in fresh to slightly decomposed rock, except for discrete discontinuity infillings within a few metres of the PW0/30 and PW90/100 rock mass weathering interface. Kaolin concentrations, generally 10 mm or less thick but locally up to tens of millimetres thick, are more common in the more intensely weathered rock profile. They infill steeply- and shallowly-inclined discontinuities, and occur as white and buff clays.

Laterally continuous kaolinitic clay infillings are rarely exposed but can occur at or near the PW0/30 and PW90/100 rock mass weathering interface, although exposure of this interface is limited in cut slopes due especially to the vegetation cover that commonly occurs at this level. Kaolin concentrations (Plate 5) can be traced for metres and rarely up to tens of metres in some cut slopes (e.g. unregistered cut slope 15NW-3B/S10 within the Lei Tung Estate, Ap Lei Chau, Plate 6). Unlike the Chai Wan area (Campbell & Koor, 1996), where the more laterally continuous kaolin seams occur almost exclusively within the PW0/30 rock mass, some of the more continuous concentrations in the Aberdeen area occur within discontinuities (e.g. stress release joints or faults) at least in part within the PW90/100 rock mass, although these typically occur at depths of five metres or less below the main PW0/30 interface, and the kaolin seams are interpreted as being associated with weathering as in the Chai Wan area.

The key observations of kaolin are summarized below in section 4.2.3 where they are also assessed in terms of their engineering significance.

3.3 Conclusions

The geological survey has identified the following important geological features:

(a) The bedrock geology mainly comprises lapilli-bearing coarse and eutaxitic (commonly) fine ash vitric tuffs, crystal tuffs and well-bedded fine ash tuffs and volcaniclastic sedimentary rocks.

(b) Eutaxitic volcanic fabrics occur across much of the area, but are highly variable in orientation and inclination. Their presence has helped to identify cut slopes in which outward-dipping stratification occurs.

(c) Kaolin is far more commonly found in the PW0/30 and PW30/50 rock mass weathering zones (of predominantly Grades IV and V material) than in the PW 50/90 or PW90/100 zones (of predominantly Grade III to I material). Kaolin may concentrate at, or parallel to, the often abrupt and typically joint-controlled (i.e. planar sub-horizontal and sub-vertical) PW0/30 and PW90/100 interface. This suggests that the kaolin formed, and/or accumulated within discontinuities, during weathering.

(d) The PW0/30 and PW90/100 zone interface locally steps abruptly to different levels across sub-vertical joints, and on a larger scale across faults. Deeper weathering tends to occur in the hanging wall of these faults.

(e) Faults mainly strike northeast, varying to east-northeast, and northwest, varying to north-northwest. They are associated with zones in which the orientations of volcanic

fabrics may be anomalous.

(f) In general two steeply-inclined joint sets are dominant and are sub-parallel to the main faults. The steep joints are locally infilled with kaolin, especially within the PW0/30 zone.

4. ENGINEERING GEOLOGICAL ASSESSMENT

4.1 Objective

An engineering geological assessment has been made of the study area, primarily by a desk study search with limited field observations, together with observations from the geology and API survey. Sources of information for the desk study were identified in the Phase 1 report by Strange (1996). The data sources listed in the Phase 1 report have been used and extended to include those GI reports that have subsequently become available. This section of the report summarises the desk study information obtained and makes use of the geology and API survey findings to assess the engineering significance at a number of engineered slopes.

4.2 Summary of Information

4.2.1 Information Sources

The sources found most useful were the Landslip Incident Reports, Ground Investigation Reports, Stage 1 and Stage 2 Reports and the Binnie and Partners Landslide Study Reports (Binnie & Partners, 1977a and 1977b). Additional data sources included the Systematic Inspection of Features in the Territory (SIFT) study and Island Division files. All sources of information used in the desk study are tabulated in Appendix D to I.

Relevant information extracted from the desk study is presented on four 1:5 000 thematic maps, described in Sections 4.2.2 to 4.2.5. The maps were used initially to identify features which may potentially fit all, or some of the features listed in Section 1.1. Site inspection was made at a number sites where the desk study data indicated engineering geological conditions potentially adverse to slope stability.

4.2.2 Landslide Incident Map

The Landslide Incident Map (Map No. 5) contains the locations of all known landslide incidents, reported to GEO since 1978, together with landslide scars noted in the Binnie and Partners Slope Catalogue field sheets. A total of 109 landslide incidents have been recorded in the study area since 1978. However, thirty-seven of the incidents (from 1978 to 1983) could not be located accurately as no incident report was available for inspection. Of these, five incidents had only landslip cards and no incident report and also could not be located. In addition some eleven incidents were not plotted as no size of failure was given in the incident report. Of the remaining sixty-one incident reports, sixteen involved small fill slopes in squatter areas.

The landslides have been split into five main groups, based on information contained on the Landslide Incident Reports such as volume of landslide and description of the failed material. The landslide groups are as follows: landslides greater than 50 m^3 in volume; landslides greater than 5 m^3 but less than 50 m^3 in volume; retaining wall failures; landslides less than 5 m^3 in volume; and surface erosion. The information recorded on the incident reports is generally not detailed enough to determine the nature of the failure material or the detailed mode of failure. Photographs accompanying the report were also used in determining the nature of the landslide and any relevant geological features.

Particular clusters of landslides were identified which, based on photographic evidence and geometry of landslide scar, indicate failures within zones of more deeply weathered rock. These are discussed briefly as follows:

(a) Ten landslides have occurred in the cut slopes adjacent to Peel Rise and the Island School. Evidence for two of the landslides was observed during the Binnie and Partners 1977-78 Slope Catalogue exercise and have been noted in the slope catalogue entries for slopes 11SW-D/CR51 and 52. Two of the landslides (G 11/8/82 and HK 85/8/3) have no information except the date and location. Of the other landslides, HK 89/3/2 and HK 92/5/139 are minor surface erosion while HK 88/1/2, HK 92/5/138 and HK 85/4/14 are minor failures of less than 5 m^3 of decomposed bedrock. HK 89/3/2 is a large but shallow failure of about 45 m^3 caused by a ruptured water main. HK 88/6/4 is a large failure of the natural slope (albeit significantly influenced by man-made cut slopes below) involving about 100 m^3 of highly and completely decomposed volcanic tuff. HK 92/5/139 occurred at the edge of a previous failure and involved two separate landslides of about 30 m^3 each in highly decomposed volcanic tuff.

(b) At an adjacent site a very large failure HK 8/16 /82 was estimated to be about 200 m^3 and occurred in a slope above Peel Rise. This failure is described on the landslide record card as a "wedge" failure in a cut slope extending into the colluvium on a natural slope above. However, the site photograph clearly shows a distinct planar failure surface. Evidence for one previous landslide below Peel Rise was observed during the Binnie and Partners 1977-78 Slope Catalogue exercise and have been noted in the slope catalogue entry for 11SW-D/C44. In addition there was a previous small failure HK 89/5/30 of less than 4 m^3 from cut slope 11SW-D/C43, in completely and highly decomposed volcanic tuff.

(c) Evidence for three previous landslides at Tin Wan Hill Road was observed during the Binnie and Partners 1977-78 Slope Catalogue exercise and have been noted in the slope catalogue entries for slopes 11SW-C/C11, 11SW-C/C13 and C15

respectively. Air photograph interpretation for slope 11SW-C/C13 indicates previous instability between the years 1963 and 1967, between 1967 and 1972 and again between 1983 and 1985. Further details on failures at this slope in 1983 and 1985 are given in GCO reports by Johnson (1984) and Irfan (1986). Incident HK 3/3/83 occurred in slope 11SW-C/C15 and the failure debris was estimated at 1500 m^3. Incident HK 39/82 occurred in slope 11SW-C/C13 and was a minor rock fall failure. However, continuing slow moving instability at this site culminated in August 1985 in a large failure estimated at 2,500 m^3 of decomposed tuff and colluvium (Irfan et al, 1987). Two minor incidents of less than 1 m^3, HK 90/3/2 and HK 92/5/192, occurred in slopes 11SW-C/C13 and 15 respectively. A large failure (HK 89/5/22) of about 36 m^3 of highly and completely decomposed volcanic tuff occurred in cut slope 11SW-C/C11.

(d) Yip Kan Street has been the site of a number of previous landslide incidents in cut slope 11SW-D/C86. One previous failure was observed during the Binnie and Partners 1977-78 Slope Catalogue exercise. No details are available for the incident 12/81 other than location. One very large planar failure 5/81 was estimated to be about 200 m^3 along composite joints in slightly decomposed to highly decomposed volcanic tuff. A more detailed report on this latter incident was carried out by the GCO (GCO, 1981) which confirmed that the failure took place by sliding and toppling of rock blocks along joints dipping between 20° and 45° out of the slope. Another very large planar failure HK 92/10/1 of highly decomposed tuff overlying moderately decomposed tuff was estimated to be about 90 m^3 which occurred at the same time and in similar materials as a planar failure HK 92/10/2 of about 24 m^3. The geology at this cut slope exposes tuff and a large quartz syenite dyke. Many of the planar joints within the rock mass are oriented adversely with regard to slope stability.

(e) Tong Bin Lane is the site of one very large landslide HK 94/7/58 estimated to be about 400 m^3 of highly and completely decomposed volcanic tuff, caused by infiltration of surface water through insufficient surface protection to cut slope 11SW-D/C91. Four previous landslides have also occurred on this slope. HK 96/6/10 was a small failure less than 5 m^3 attributed to erosion, whilst HK 93/9/35, HK 94/7/57a and 57b were larger failures between 10 m^3 to 15 m^3 of decomposed bedrock and generally attributed to blocked drains and broken surface protection.

(f) Lee Nam Road/ Ap Lei Chau Bridge Road is the site of five previous landslide incidents in cut slope 15NW-A/C1. One of

these incidents (HK 96/6/7) was minor erosion due to inadequate surface protection. Two of the failures (HK 95/8/83 and HK 93/9/96) are moderate size incidents of about 15 m^3 and 10 m^3 respectively of highly decomposed tuff and boulders. These incidents appear to be due to high ground water conditions at the time of failure. In addition two large failures HK 94/8/16 (Plate 7) and HK 96/9/5 estimated to be about 90 m^3 of completely and highly decomposed tuff and boulders are associated with high ground water conditions and relict joints. The relict joints observed at the site of incident HK96/9/5 are infilled with kaolinitic clay.

(g) Shum Wan Road/Nam Long Shan Road has two sites of interest, one to the north of David Trench Home for the Aged and one south of this. The northern site has six previous minor landslide incidents and one larger incident of about 20 m^3 which occurred during the years 1985 to 1987. These failures were associated with squatter huts which have since been removed. To the south of the David Trench Home six landslide incidents occurred during the period 1982 to 1983 for which no details other than location are known. At least one of these incidents HK 6/48/83 is related to squatter areas which have since been removed. The others are either associated with the road cutting (15NW-B/C103) or the fill embankment for Nam Long Shan Road. However, one major landslide HK 95/8/49 of about 20,000 m^3 occurred in August 1995 immediately south of this cluster. This landslide was deep seated, primarily within a natural slope, and involved completely and highly decomposed tuff together with less decomposed bedrock and some minor amounts of fill. High groundwater conditions combined with extensive seams of kaolinitic clay and relict joints infilled with kaolinitic clay facilitated the failure.

(h) Aberdeen Praya Road is the site of three previous landslides within cut retaining wall slope 11SW-C/CR36. Two of these HK 95/8/53 and 79 comprised 10 m^3 and 15 m^3 of highly and completely decomposed tuff and resulted from groundwater infiltration through inadequate surface protection. A larger failure HK 87/3/8 involved groundwater infiltration into an unprotected rock cut slope and comprised about 40 m^3 of moderately to completely decomposed tuff.

Natural landslide scars mapped as part of the GEO's Natural Terrain Landslide Study are presented on the Natural Landslide Inventory Map (Map No.6). Some 163 such features have been identified within the study area. The majority of these are concentrated on Ap Lei Chau and the area around Nam Long Shan.

4.2.3 Ground Investigation Map

The Ground Investigation Map (Map No.6) summarises information contained in all the known ground investigations (GI) made in the study area. The boundary of each GI site is shown together with a summary of the level of the top of PW90/100 (partially weathered rock generally decomposition grade III or better). The presence of kaolin has been identified if noted in the logs. Typically, the depth to top of PW90/100 weathered rock mass is inferred from the borehole logs to be 5m to 10m below original ground level. Where the density of boreholes is judged to be sufficient, two isolines have been drawn to generalise zones of more deeply weathered bedrock (>10 m to < 15 m, and > 15 m). It should be noted that these weathered zones and depths have been inferred from boreholes carried out during a specific GI at a certain date and in some locations excavations associated with extensive site formation made after the date of the GI may have removed significant depths of weathered material, for example at Lei Tung Estate, Ap Lei Chau. These areas of deeper weathering generally coincide with major fault zones and lithological contacts, however some zones at Tin Wan Hill Road and Shum Wan Hill Road do not appear to be associated with such features but are likely to be zones where the joint spacing is close to very close.

In total, 222 GI reports have been identified from the GIU within the study area and these are listed in Appendix F. Thirteen reports were not available during the study period. An additional 17 GI reports not listed in the GIU have identified from Island Division files and these are also listed in Appendix F. In general, the reports contained enough information to determine the level of continuous grade III rock, but were often lacking in detailed descriptions of the soil fabric and character. Ground water records observed from standpipes or standpipe piezometers installed in the drill holes, are contained in most of the reports, but these have not in general been plotted on the map since the monitoring periods are generally for only one week following the completion of the GI and the season in which the readings have been taken varies. Kaolin is most often described as smears, dustings or infillings of joints within grade III rock or better. However, in some reports the presence of kaolin seams has been noted within the highly and completely decomposed (grade IV and grade V) rock.

Kaolin as identified from the GI information appears to occur over the entire study area. It has predominantly been identified within rock of grade III or better as infillings along joints. This is in contrast to site observations where kaolin concentrations have been identified mainly within PW0/30 or PW30/50 rock masses of predominantly grade IV/V rock, and particularly at the interface with the PW90/100 rock mass zone. Kaolin has only rarely been observed within the grade III or better rock (PW90/100), and most of these occurrences are within c.5 m of the interface with PW0/30 or PW30/50 rock masses. The variance between the GI data and site observations is considered to be sampling related since kaolin at or near the PW0/30 and PW90/100 rock mass weathering zone interface would be difficult to sample. Also, kaolin concentrations recovered from the PW0/30 zone would mostly be contained in mazier tubes and not always described. Locations where significant amounts of kaolin have been recorded in the GI reports are summarised below:

(a) Significant kaolin bearing joint infills up to 5 mm thick were recorded in a large number of drill holes within grade III and grade II tuff in the natural slope above Shum Wan Road (Map No.6).

(b) The GI carried out for the fire station at Ap Lei Chau Bridge Road notes kaolinitic clay infills up to 5 mm thick on joints within grade II and grade III tuff.

(c) Kaolinitic clay veins up to 10 mm thick forming a possible failure plane at about 8 m to 10 m below the ground surface was identified in several boreholes in the GI for slope 11SW-C/C13 on Tin Wan Hill Road.

(d) Kaolinitic clay infills up to 5 mm thick on relict joints were noted in trial pits in grade IV tuff along Peel Rise above the Island Road Government School.

(e) Kaolinitic clay infills up to 10 mm thick on joints were noted in several boreholes from the GI above Yue Kwong Road in grade II/III tuff underlying a zone of deep weathering.

(f) Kaolinitic clay veins and infills up to 15 mm thick on relict joints were noted in grade IV tuff exposed in the top of slope 15NW-A/C1 on Lee Nam Road, Ap Lei Chau.

(g) Thin seams of kaolinitic clay, up to 10 mm thick, on joints within grade IV/III fine ash tuff were noted in the slope 15NW-B/C92 above the bus station within the Lei Tung Estate, Ap Lei Chau.

(h) A thick seam of kaolinitic clay up to 150 mm thick on a sub-horizontal joint was noted within grade II/III tuff dipping about 20° out of the unregistered cut slope 15NW-3B/S10 (Plate 8) within the Lei Tung Estate, Ap Lei Chau. Heavy seepage was noted along this feature at the time of field inspection in November 1996 (Plate 6).

Areas of deeper weathering (>10 m and > 15m) have been noted at:

(a) Shum Wan Road/Nam Fung Road landslide,

(b) Tin Wan Hill Road,

(c) Peel Rise,

(d) South side of Lei Tung Estate, and

(e) Yue Kwong Road.

Rock joint data has been obtained from a number of GI reports found in the GIU and District files and also from some limited field observations during this study. The data reveals

four major pole concentrations; two sub-vertical joint sets striking east-northeast and north-northwest which are in the same approximate orientation to the trend of major faulting and photo lineations in the area, a low-angle set of sheeting joints with variable dip direction, and a more weakly developed sub-vertical set striking approximately east-west. Locations where persistent low angle joints have been noted dipping out of cut slopes are;

(a) Unregistered slope 11SW-23D/S15 behind 66-72 Aberdeen Main Road,

(b) Unregistered slope 11SW-23D/S34 adjacent to Yue Fai Road,

(c) Slopes 11SW-D/C123 and 11SW-D/CR1 behind Aberdeen Technical School,

(d) Slope 11SW-D/C635 adjacent Yue Fai Road,

(e) Slope 11SW-D/C86 adjacent to Yip Kan Street, and

(f) Slope 15NW-A/C3 adjacent to Lee Nam Road.

4.2.4 Report Map

The Report Map (Map No. 7) shows the distribution of the various reports and files studied (listed in Appendix H), annotated with salient information which is summarised below:

(a) Slopes 11SW-D/CR51 and CR52 located below Peel Rise. Zones of extensive seepage (Map No. 4) along both slopes are reported. Special Project Report SPR 4/89 noted perched groundwater conditions above colluvium overlying decomposed tuff. The landslide was noted to be slow moving for a long time prior to a sudden and rapid failure.

(b) Slope 11SW-D/C11 adjacent to Tin Wan Hill Road. Low-angle joints are noted in previous reports dipping out of the rock cut slope, together with low-angle zones of partially weathered rock with kaolinitic clay-filled relict joints and extensive seepage (Map No. 4). The failure surface is reported to be irregular taking advantage of the closely jointed nature of the weathered bedrock but with some sections along low angle kaolinitic clay smeared joints.

(c) Slopes 11SW-D/C86 adjacent to Yip Kan Street. The failure at this slope occurred during excavation of the adjacent lot between Yip Kan Street and Ying Hip Street. The failure occurred along the planar interface between highly

decomposed tuff and slightly to moderately decomposed tuff.

(d) Slope 11SW-D/C639 adjacent to Ying Hip Street. Photographic records of the slope during site formation showing, in particular, zones of weathering having abrupt interfaces with grade II rock.

(e) Shum Wan Road Landslide. A detailed report to investigate the cause of this landslide is available (GEO, 1996).

4.2.5 Seepage Map

The Seepage Map (Map No. 4) presents data on historical and present-day distribution of seepage within the study area. Seepage information has been obtained from Binnie and Partners 1977-78 Slope Catalogue, Stage 1 and 2 Study reports, API interpretation and data collected during the field survey for this study.

Slopes which have had significant historical and present-day seepage include: slopes 15NW-3B/S10 in the Lei Tung Estate; 15NW-A/C1 above Lee Nam Road/Ap Lei Chau Bridge Road; 11SW-D/C91 above Tong Bin Lane; 11SW-D/C81 above Aberdeen Main Road and 11SW-D/CR51 & 52 below Peel Rise.

4.3 Discussion

4.3.1 General

Based on the API, geological mapping and the engineering geology desk study, fifteen slopes have been identified which are considered to have features adverse to slope stability. These features are similar to those observed at the Shum Wan Road and Fei Tsui Road landslide sites but in addition include other features such as zones of persistent seepage and areas with clusters of previous landslides. These slopes are identified below together with a brief justification for including each of the features. Additional physical investigation work will be required at some of these sites. The findings are summarised in Table 2.

4.3.2 Slope 15NW-A/C1 Corner of Ap Lei Chau Bridge Road and Lee Nam Road

The eutaxitic fabric dips steeply to the south-southwest (i.e. obliquely into the slope). A zone of locally deeper weathering (>15 m) is inferred from borehole observations within the anticlinal axis which trends through the slope. Two subvertical joint sets which dip into the slope dominate the very closely spaced jointed rock mass. Groundwater seepage is observed at a high level. The exposed bedrock is completely to highly decomposed and many of the relict joints within the decomposed rock are infilled with white and light brown kaolinitic clay. Six previous landslide incidents have been documented between 1993 and 1996.

4.3.3 Unregistered Slope 15NW-3B/S10 Lei Tung Estate

Unfavourable conditions at this site include a weathered seam of kaolinitic clay which dips out of the slope at about mid-height. The seam is about 150mm thick within grade II tuff. The seam dips at a low angle (c.30-35°), appears planar, and extensive groundwater seepage was noted from it during a site inspection in November 1996. That this slope is unregistered and few details are available in the GIU or District files gives some cause for concern as it is unknown what design criteria have been applied.

4.3.4 Slope 15NW-B/C92 adjacent to the Bus Terminus at Lei Tung Estate

This slope is cut into decomposed fine ash tuff. Extensive thin infills of kaolinitic clay up to 10mm thick occur within sub-horizontal and sub-vertical relict joints exposed in the grade IV/V decomposed bedrock. No seepage was noted at the time of inspection (November, 1996). However, a service reservoir is located at the slope crest (Plate 9). A previous failure occurred during construction of the adjacent cut slope which was subsequently backfilled with rock.

4.3.5 Slopes 11SW-D/C44,43, 41 and 11SW-D/CR51, 52 below Peel Rise

These slopes have a history of landsliding, some of which were large. Ground investigations revealed extensive kaolinitic clay infills of relict joints within the Grade V/IV decomposed tuff. Also, evidence of high groundwater conditions was noted in previous studies.

4.3.6 Slope 11SW-D/C86 adjacent to Yip Kan Street

This slope has a history of previous landslide incidents two of which were large failures. The weathering profile shows abrupt changes from PW0/30 (predominantly Grade V/IV) to PW90/100 (predominantly Grade II). Rock joint data indicate two prominent sub-vertical joint sets striking NW-SE and NE-SW with numerous low angle joints, some up to several metres in length, dipping out of the slope. At the time of site inspection in November 1996 groundwater seepage was noted from a number of localities along the slope at mid-height.

4.3.7 Slopes 11SW-C/C11, C13, C15 and Unregistered Slope 11SW-23C/S51 adjacent to Tin Wan Hill Road

These slopes have a history of heavy groundwater seepage from within and above the cut slopes. In addition kaolinitic clay veins associated with relict joints were observed during the ground investigation within Grade V/IV decomposed tuff.

4.3.8 Slope 11SW-D/C91 adjacent to Tong Bin Lane

This slope has had a history of small to moderate size landslides. During site inspection (November 1996) heavy groundwater seepage was noted from mid-height of the slope (Plate 10).

4.3.9 Unregistered slope 11SW-23D/S15 behind 66-72 Aberdeen Main Road

Examination of District file 2107/90 reveals that this cut rock slope has a planar feature dipping 20° out of the slope (Plate 11). The slope is covered with c.75 mm of shotcrete with a number of weepholes that were dry at the time of inspection (November 1996), but staining of lower weepholes indicates previous seepage. It is unclear whether this low angle feature has been fully considered in the slope design and it is suggested that the potential for failure along this feature should be evaluated following more detailed physical inspections.

4.3.10 Slopes Checked by GCO/GEO

Out of the fifteen slopes, it appears from the files obtained from the Island District Division that ten have been checked by GCO/GEO in some form and five have not been checked (Table 2). Where available the slope designs have been examined to determine whether the engineering geological models assumed have accounted for the suspected Fei Tsui Road or Shum Wan Road landslide type features.

Most of the slope stability analyses contained in the checking files have considered shallow failure potential through soil materials and only in a few cases has failure along low angle discontinuities been addressed. Even in these few cases the strength parameters adopted are higher than the lower bound values obtained in the Fei Tsui Road landslide investigation. As such, plane failure was not considered as a major failure mechanism and therefore slope stability designs did not take this into account. Some of the slope stability analyses contained in the checking files have also considered deeper seated failure surfaces in some form in zones of deep weathering. However, the groundwater conditions adopted in these latter cases were not that high and did not reflect conditions similar to those observed at the Shum Wan Road landslide site.

Detailed studies have previously been carried out by GCO/GEO for some of the slopes (11SW-D/C51,52 and 11SW-D/C44,43) below Peel Rise and adjacent to Tin Wan Hill Road (11SW-C/C13, C15). However, only the studies at 11SW-D/CR51,52 and 11SW-C/C13 addressed deep seated failure and the effect of kaolinitic clay seams. Therefore it is considered that only these latter three slopes need no further study.

4.3.11 Limitations of the Study

This study has reviewed a large amount of existing archival data together with limited field observations of cut slopes and exposures. These data have been used to determine those slopes in which it is considered geological features exist which may affect the existing

stability. Complete archival data for all of the registerable cut slopes in the study area is not available and hence this study should not be regarded as a comprehensive statement of the existing stability of all the slopes in the area. In addition, for each of the slopes identified as having geological features that are adverse to stability, the significance and extent of these features in relation to stability is not always clear. Based on a review of all the available data, where uncertainties regarding the stability are considered to exist then the slopes have been selected as requiring further detailed study.

5. CONCLUSIONS

A number of geological and topographic factors are indicated as pre-disposing steep slopes to instability within the Aberdeen study area. These are:

(a) weathering profiles with;

  i) abrupt changes in decomposition grade from Grade V/IV to Grade II/I with either very thin Grade III or Grade II absent, and,

  ii) zones of deeply weathered rock, more than 10 m thick, which thin laterally and down slope,

(b) high ground water table, or potential for development of transient high ground water table,

(c) kaolinitic clay seams within relict joints in the weathered rock mass,

(d) closely jointed rock mass,

(e) history of previous instabilities,

(f) coastal cliff sites, and

(g) close to quartz syenitic dykes or other intrusions.

As a result of the desk study and limited field mapping carried out, of the 328 registerable cut slopes or retaining walls identified within the study area, it is considered that twelve slopes may have engineering geological conditions which are adverse to stability. These slopes are:

(a) 15NW-A/C1 at the corner of Ap Lei Chau Bridge Road and Lee Nam Road,

(b) 15NW-B/C92 behind the Bus Terminus at Lei Tung Estate,

(c) unregistered Slope 15NW-3B/S10 in Lei Tung Estate,

(d) 11SW-D/C86 adjacent to Yip Kan Street,

(e) 11SW-D/C91 adjacent to Tong Bin Lane,

(f) unregistered slope 11SW-23D/S15 adjacent to 66-72 Aberdeen Main Road,

(g) 11SW-D/C41,44 and 43 below Peel Rise, and

(h) 11SW-C/C11, C15 and unregistered slope 11SW-23C/S51 adjacent to Tin Wan Hill.

In addition eight natural slope areas have clusters of previous failures that may indicate geological conditions adverse to slope stability. These areas are indicated in Map 1 and are primarily on the south and north sides of Ap Lei Chau and also at the Shum Wan Road landslide site. These areas are all old coastal cliffs, subjected to lengthy in situ weathering and erosion. The weathered stress release joints within these cliffs, which often contain kaolinitic clay infills, will have provided preferential failure surfaces where adversely oriented for slope stability.

6. RECOMMENDATIONS

(a) On the basis of this study further detailed studies are recommended to investigate the slopes listed in Section 5 above. It is recommended that GI's consisting of chunam strips, trial pits, drill holes and some laboratory testing are required to determine if geological conditions adverse to slope stability exist at the slopes.

(b) It is recommended that trial trenches are excavated to investigate the nature and interpretation of the natural slope areas identified by API and inferred to be susceptible to landsliding.

(c) In conjunction with the GI, a study of the engineering properties of kaolinitic clay-bearing, completely to highly decomposed tuff is recommended. An initial literature review will be required in conjunction with some laboratory testing. Block samples for testing should be taken from cut slope 15NW-3B/S10.

7. REFERENCES

Binnie & Partners (1977a). Landslide Studies Phase 1 Re-appraisal Cut and Natural Slopes and Retaining Walls.

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LIST OF TABLES

Table 1 - List of Photographs Used for the API

YEAR	AERIAL PHOTO NO.
1945	Y00291 - Y00293
	Y00330 - Y00337
	Y00376 - Y00378
1949	Y01131 - Y01137
	Y01139 - Y01140
1963	Y06773 - Y06775
	Y06789 - Y06791
	Y06856 - Y06857
	Y06861 - Y06867
	Y06914 - Y06915
	Y06917 - Y06921
1964	Y12796 - Y12799
1967	Y13156 - Y13158
	Y13236 - Y13239
1969	Y14640 - Y14641
1970	Y15927
	Y15929 - Y15931
1972	1862 - 1868
	3701 - 3703
1975	11675 - 11677
1976	12836
	20553
	12830 - 12834
	15864 - 15867
1977	20554 - 20556
1978	23697 - 23698
	23703 - 23708
	23738 - 23740
1980	33230 - 33233
	32613 - 32614
1981	37513
1982	40963
	45360
	44411 - 44415
	45295 - 45298
	45436 - 45438

YEAR	AERIAL PHOTO NO.
1984	53772 - 53773
	53811 - 53812
	56705 - 56707
	56744 - 56748
1985	A00870 - A00871
	A01656 - A01662
1986	A04086 - A04089
	A06081 - A06082
	A06111 - A06116
1987	A10401 - A10406
	A10410 - A10411
1988	A12508 - A12509
	A14544 - A14546
	A14551 - A14555
1989	A19397
1990	A20761 - A20763
	A23888 - A23892
1991	A27956 - A27962
	A27997 - A27999
	A28010 - A28011
1992	A31077 - A31078
	A31080 - A31082
	A31118 - A31119
	A32589 - A32592
1993	A37072
	A35162 - A35167
1994	A39650 - A39654
	CN7986 - CN7990
	CN8008 - CN8010
1995	CN11690
	CN11713 - CN11714
	CN11717 - CN11718
	CN11738 - CN11739
1996	CN13748 - CN13749
	CN13751 - CN13753

Table 2 - Engineering Geology Assessment Summary

Slope No.	11SW-												15NW-		
	D/C41	D/C43	D/C44	D/CR51	D/CR52	D/C86	C/C11	C/C13	C/C15	***23C/S51***	C/C91	***23D/S15***	A/C1	***3B/S10***	B/C92
Kaolin clay rich seams	√	√	√	√	√	x	√	√	√	x	x	x	√	√	√
Seams Laterally extensive (>5m)	not known	not known	not known	√	√	x	not known	√	not known	x	x	x	√	√	√
Seams relatively planar	not known	not known	not known	√	√	x	not known	√	not known	x	x	x	√	√	√
Seams dip > 20 ° out of slope face	not known	not known	not known	x	x	x	not known	√	not known	not known	x	√	x	√	x
Eutaxitic Tuff	√	√	√	√	√	x	√	√	√	√	√	√	√	√	√
Joints dip > 20 ° & < 40° out of slope face	not known	not known	not known	x	x	√	√	√	√	√	x	√	x	√	x
Eutaxitic fabric dips out of slope surface	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
PW0/30 on top of PW90/100	not known	not known	not known	x	x	√	√	√	x	x	x	x	x	√	x
Weathering > 10 m deep	x	√	√	√	√	x	√	√	not known	√	x	x	√	x	√
Past Failure Clusters	√	√	√	√	√	√	√	√	√	x	√	√	√	x	√
Seepage	√	√	√	√	√	√	√	√	√	x	√	√	√	√	x
Slope Checked by GCO/GEO	√	√	√	√	√	√	x	√	√	x	x	√	x	x	√

Note: Slope No. in bold italics are unregistered features.

LIST OF FIGURES

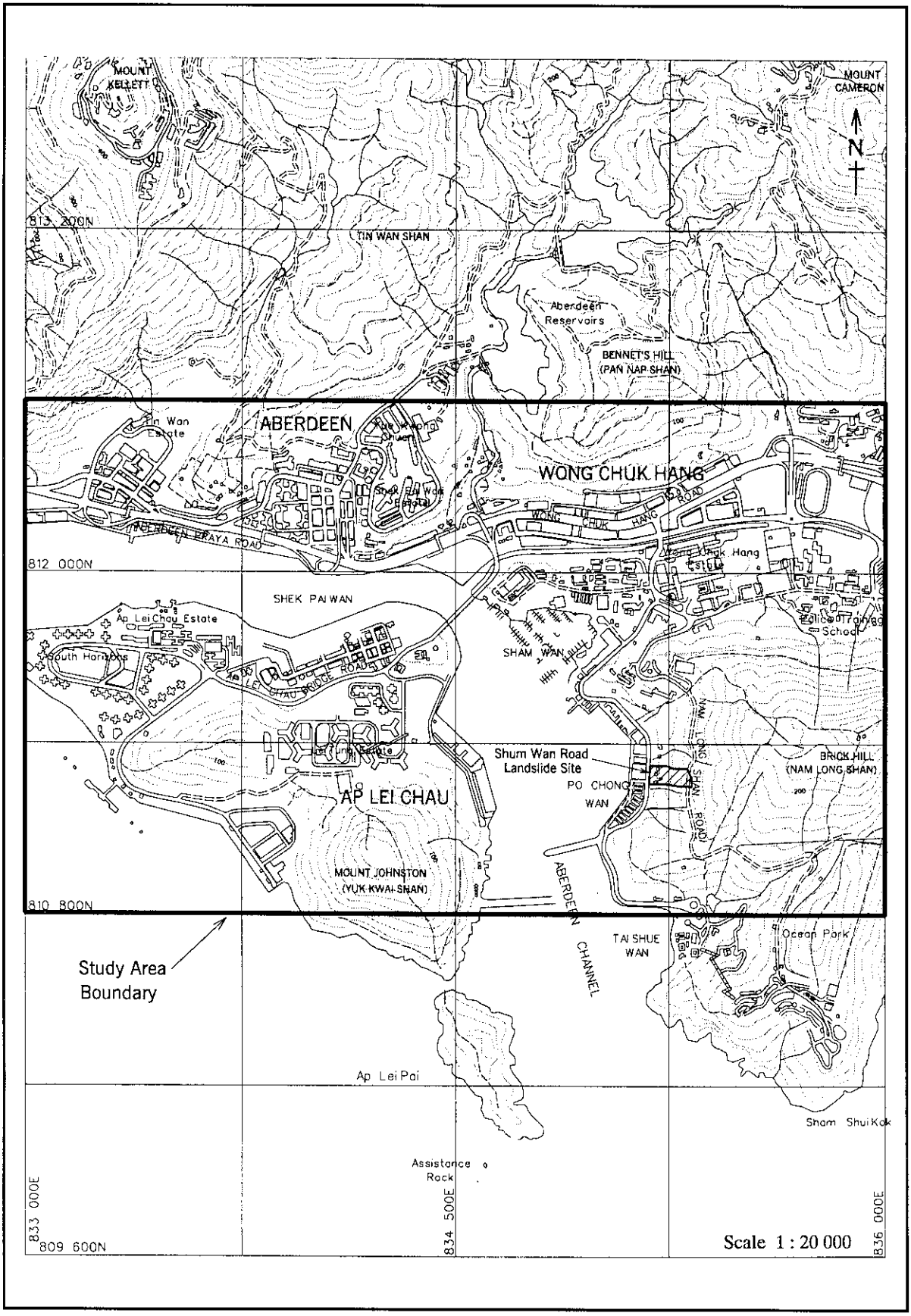

Figure 1 - The Aberdeen Study Area

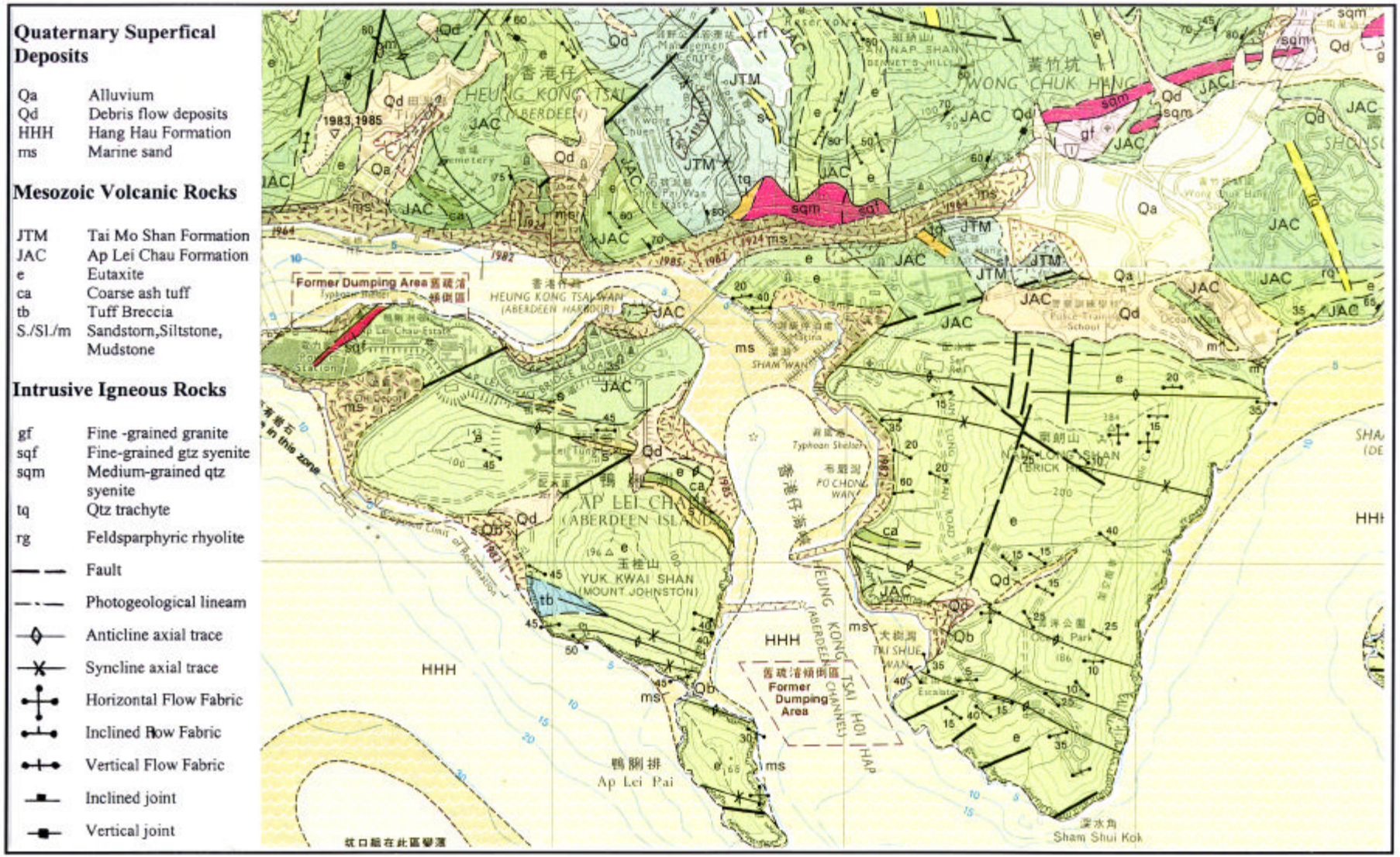

Figure 2 - Hong Kong and Kowloon Solid and Superfical Geology (Sheet 11, Scale 1:20,000; GCO, 1986) and Hong Kong South and Lamma Island (Sheet 15, Scale 1:20,000; GCO, 1987)

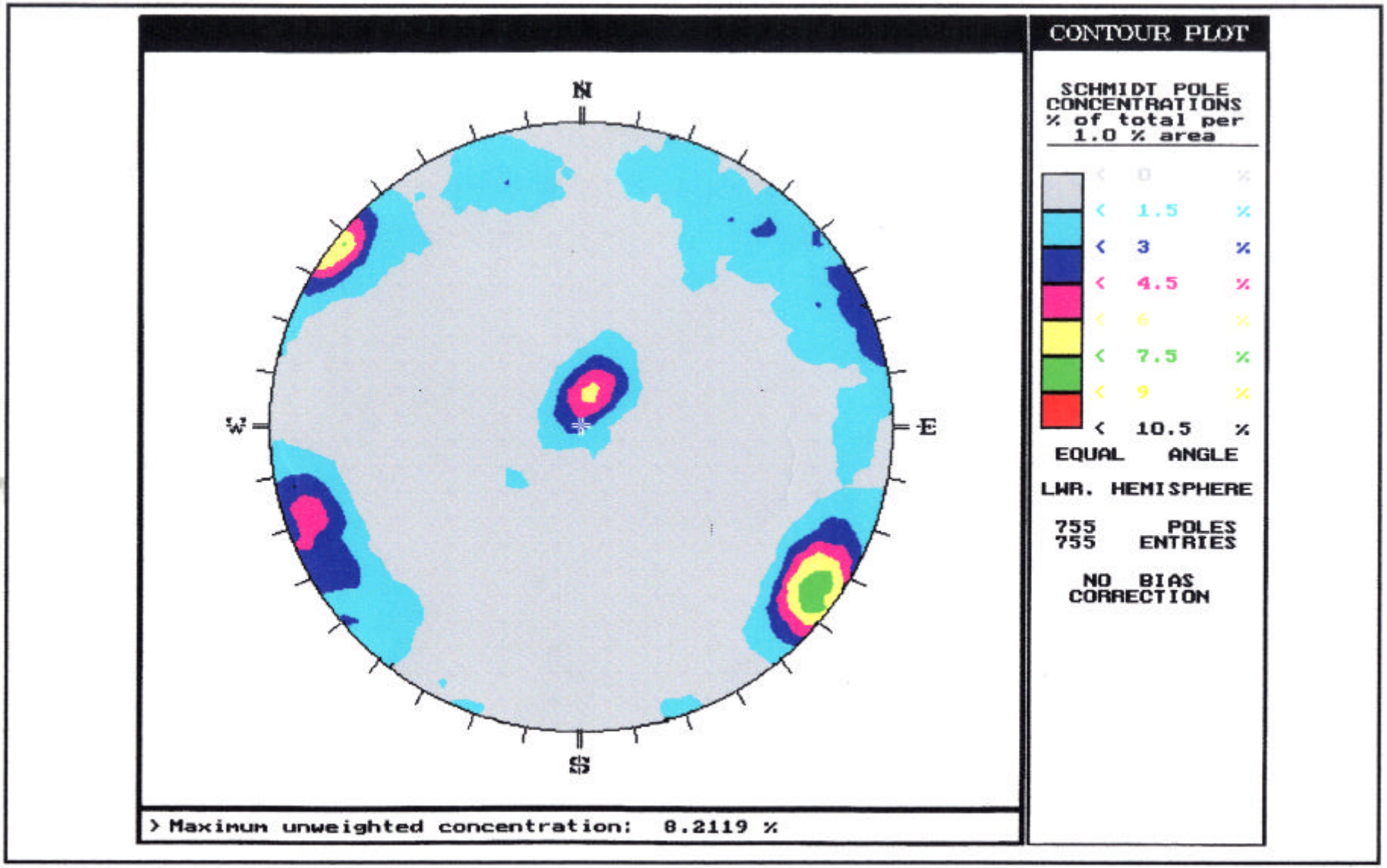

Figure 3 - Contoured Stereoplot (Lower Hemisphere) of Poles to Joints, form the Ap Lei Chau Area

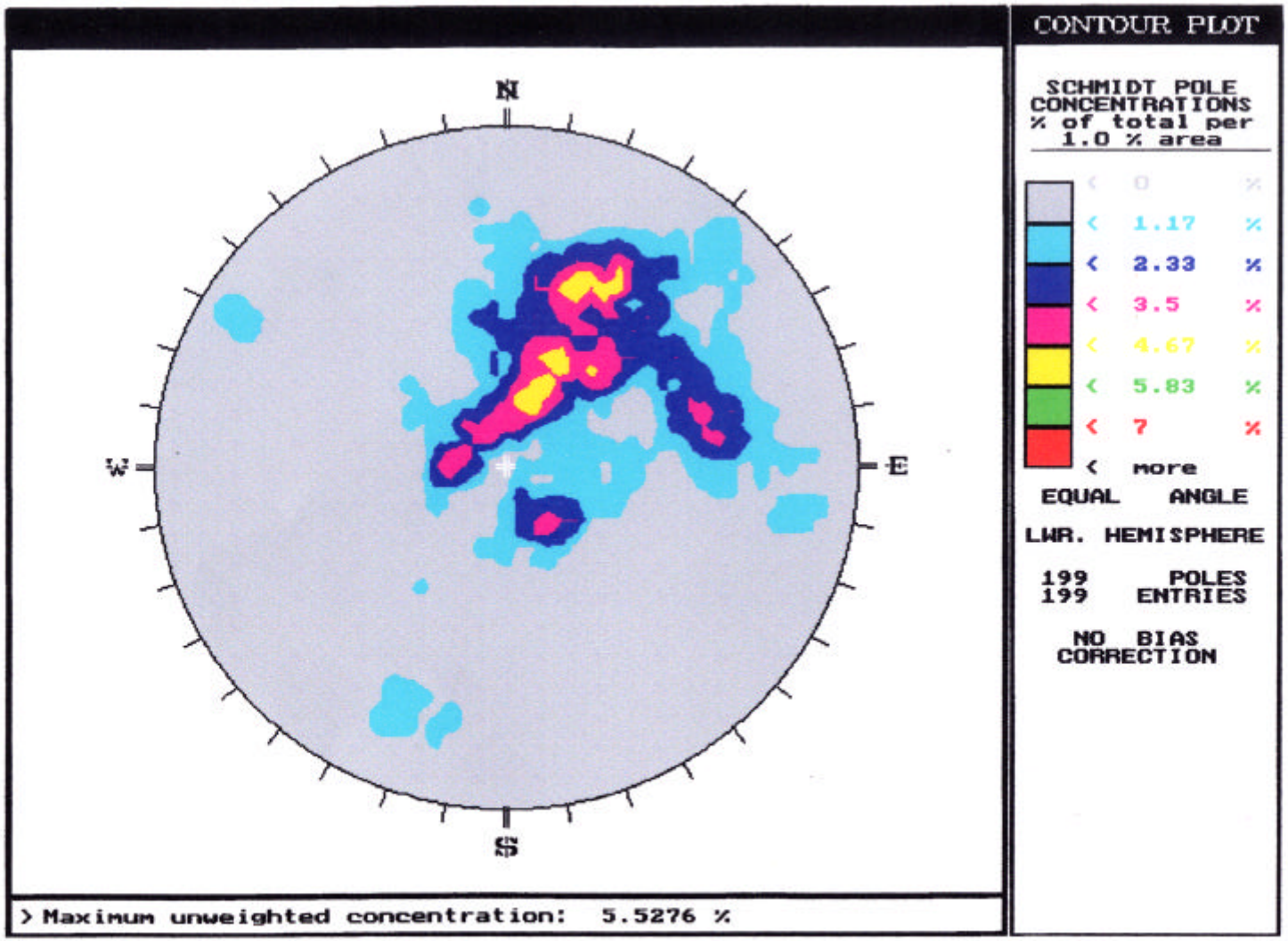

Figure 4 - Contoured Stereoplot (Lower Hemisphere) of Poles to Primary Volcanic Rock Fabrics, Mainly Including Eutaxitic Fabrics, from the Ap Lei Chau Area Shown on Map No.2

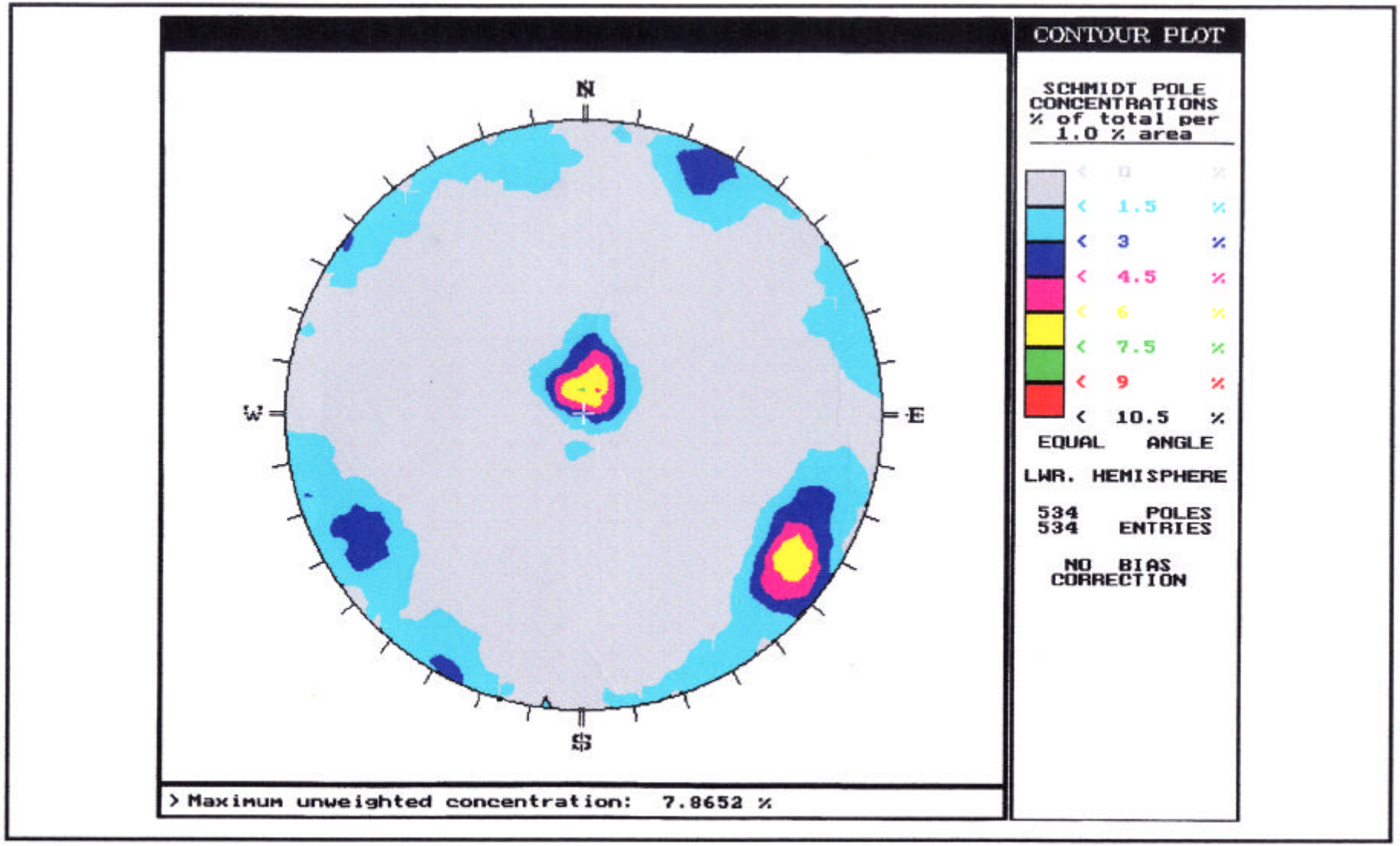

Figure 5 - Contoured Stereoplot (Lower Hemisphere) of Poles to Joints, from the Aberdeen and Wong Chuk Hang Areas

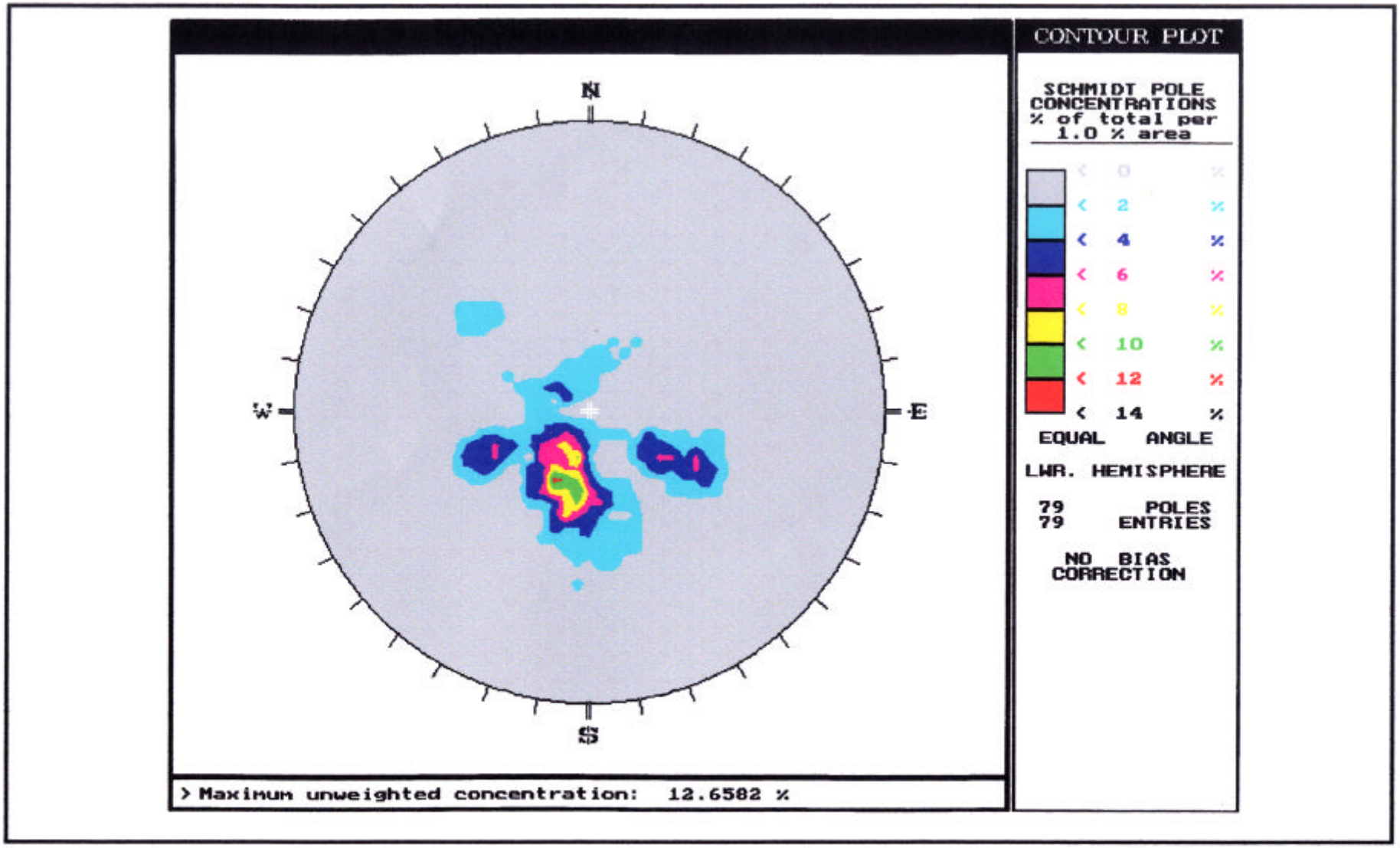

Figure 6 - Contoured Stereoplot (Lower Hemisphere) of Poles to Primary Volcanic Rock Fabrics, Mainly Including Eutaxitic Fabrics Aberdeen and Wong Chuk Hang area Shown on Map No.2

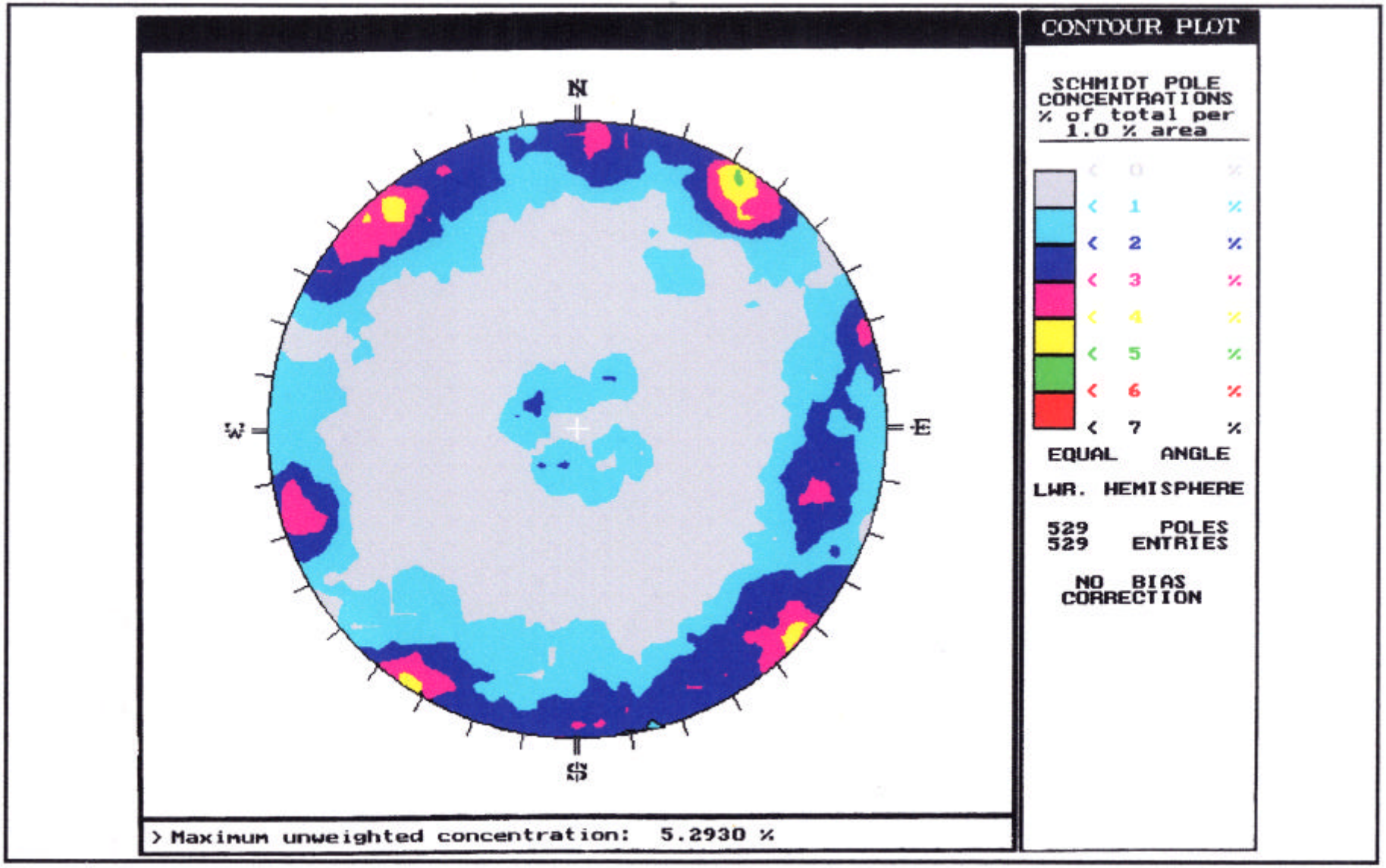

Figure 7 - Contoured Stereoplot (Lower Hemisphere) of Poles to Joints, from the Nam Long Shan Area

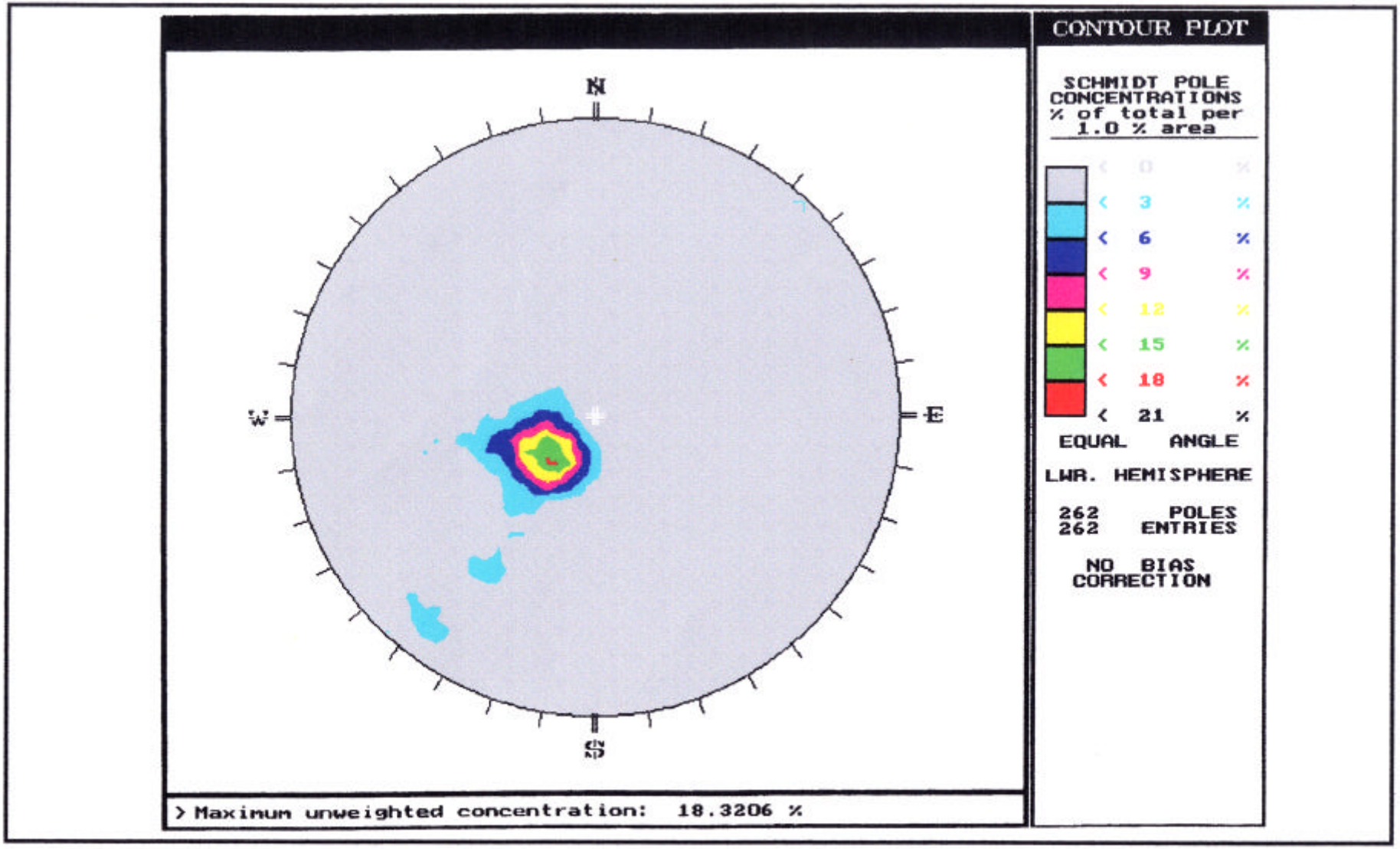

Figure 8 - Contoured Stereoplot (Lower Hemisphere) of Poles to Primary Volcanic Rock Fabrics, Mainly Including Eutaxitic Fabrics, from the Nam Long Shan Area Shown on Map No.2

LIST OF PLATES

Plate 1 - Typical Volcanic Fabric with Aligned Lapilli and Fine Eutaxitic Foliation in Slope 15NW-B/C87 (833830E 811315N). (Taken 25/10/96)

Plate 2 - North Flank of Large Ancient Landslide Scar (833335E 811350N) Along the Former Coastline, North of Slope 15NW-A/C3, Showing the Relationship of the Soil Profile to Joints (Subvertical, Subhorizontal and Inclined Parallel to the Natural Slope); the Inclined Planar Discontinuity (Lower Right) is at or near to the Basal Surface of Rupture of the Landslide. (Taken 3/10/96)

Plate 3 - Unregistered Slope (833550E 811500N) on Road Leading to Water Service Reservoir within Eutaxitic Fine Ash Vitric Tuff, Showing the Development of Subhorizontal and Inclined (Parallel to the Natural Slope) Stress Release Joints and Their Relationship to the Interface Between the PW90/100 and PW0/30 Rock Mass Weathering Zones. (Taken 1/10/96)

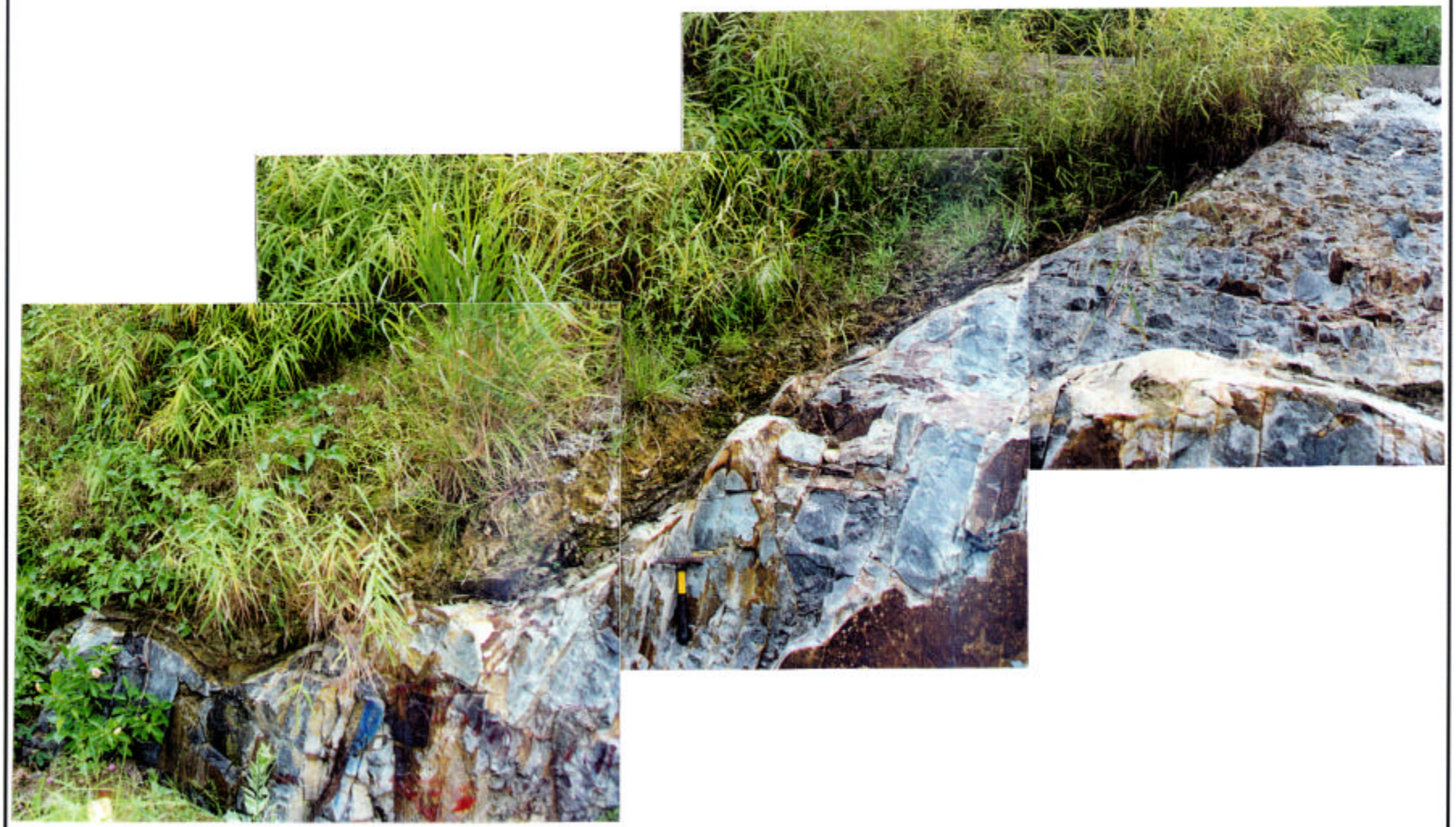

Plate 4 - Unregistered Slope (833470E 811360N) as in Plate 3, Showing An Abrupt Discontinuity between the PW90/100 Rock Mass Weathering Zone and Colluvium; the Concave-Upward Discontinuity Comprises Two Shallowly-inclined Stress-release Joint Sets, Whose Intersection Plunges Approximately Down-slope. (Taken 1/10/96)

Plate 5 - Highly to Completely Weathered Fine Ash Vitric Tuff Containing Abundant, Laterally-continuous Kaolin Veins, Occurring Immediately below the Plane That Formed the Basal Surface of a Failure That Occurred in Slope 15NW-B/C6 (835265E 811620N) on Nam Long Shan Road in 1965. (Taken 8/5/96)

Plate 6 - Unregistered Slope 15NW-3B/S10 (834250E 811530N), in Lei Tung Estate Showing a Relatively Planar Weathered Seam (Largely Covered by Chunam) of Kaolinitic Clay, c.150 mm Thick, Dipping c.30-35° out of the Slope at about Mid-height within Grade II Tuff. Extensive Groundwater Seepage was Noted from the Seam during Site Inspection. (Taken 12/11/96)

Plate 7 - Slope 15NW-A/C1, Corner of Ap Lei Chau Bridge Road and Lee Nam Road (833650E 811620N). Completely to Highly Decomposed Tuff with Many Relict Joints Infilled with Kaolinitic Clay. Six Landslide Incidents Have Occurred in This Slope Between 1993 and 1996, the Most Recent (Right-Hand Side Covered by Sheeting) Occurred on 5/9/96. (Taken 1/10/96)

Plate 8 - Close-up (834255E 811530N) of Weathered Kaolinitic Clay Seam in Unregistered Slope 15NW-3B/S10, Lei Tung Estate as Shown in plate 3. (Taken 12/11/96)

Plate 9 - Slope 15NW-B/C92 (834100E 811300N), by the Bus Terminus at Lei Tung Estate, in Decomposed Siliceous Fine Ash Tuff with Extensive Kaolinitic Clay Infills in Relict Joints within Grade IV/V Decomposed Bedrock. (Taken 12/11/96)

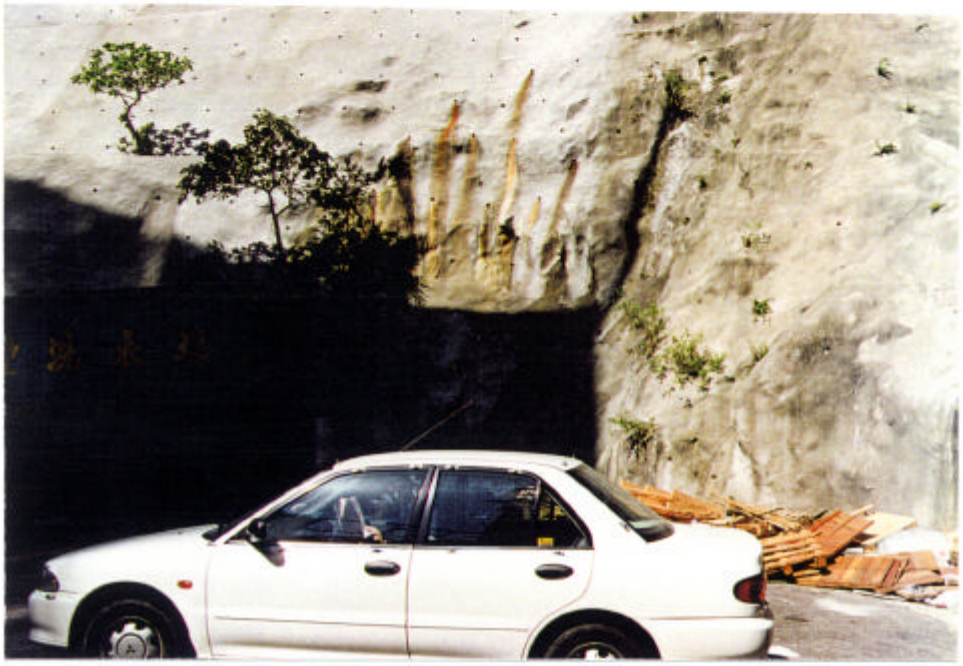

Plate 10 - Slope 11SW-D/C91 (835440E 812420N) adjacent to Tong Bin Lane, Has Had Previous Small to Moderate Size Landslides. Heavy Groundwater Seepage was Noted from Slope Mid-height during Site Inspection. (Taken 12/11/96)

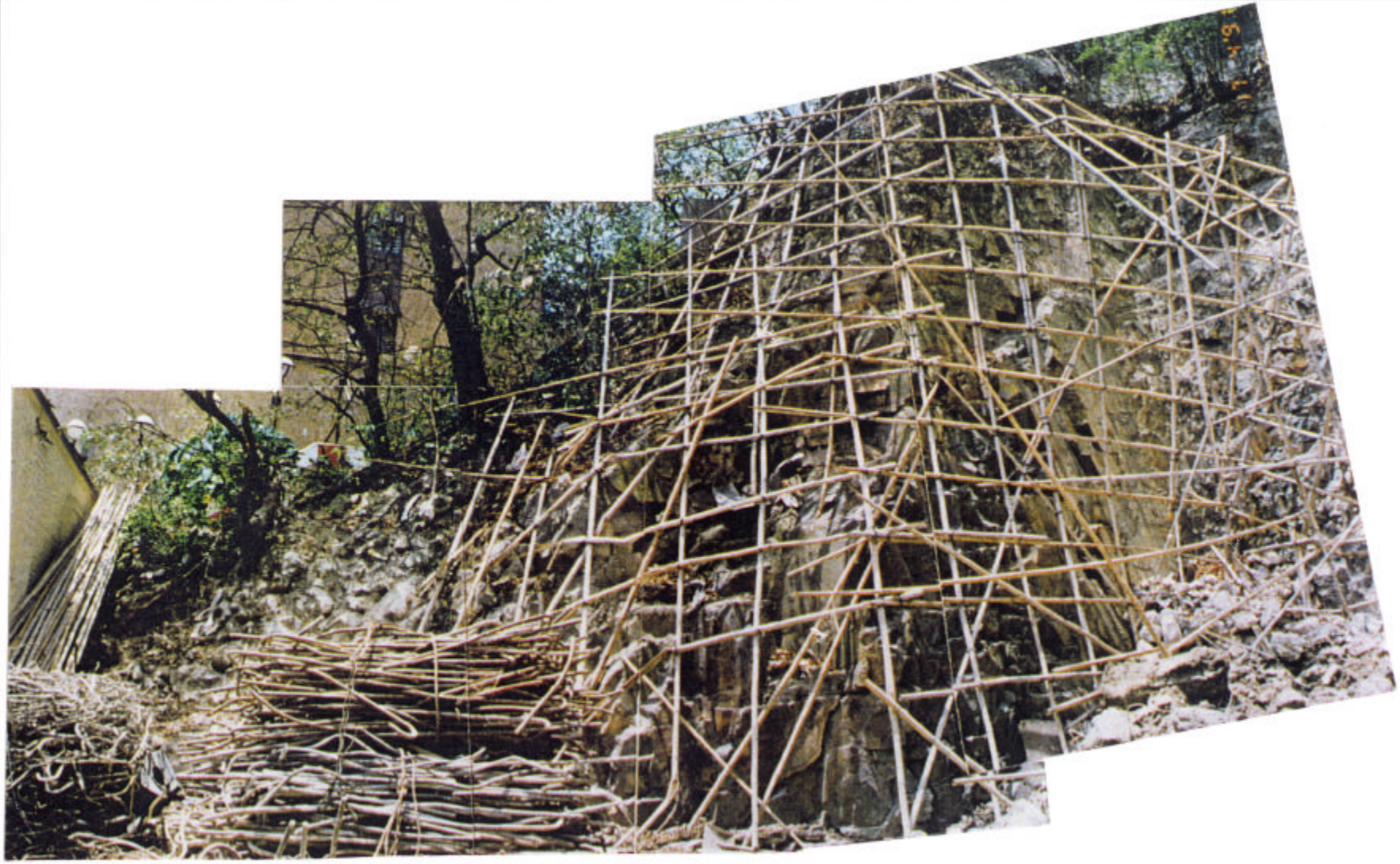

Plate 11 - Unregistered Slope 11SW-23D/S15 (834260E 812070N) behind 66-72 Aberdeen Main Road, Photographed during Site Formation (District file 21/07/90) Showing a Planar Feature Dipping 20° out of the Rock Slope. (Taken 21/7/90)

APPENDIX A

SELECTED RECORDS FROM PREVIOUS API REPORTS

SELECTED RECORDS FROM PREVIOUS API REPORTS

(GCP 1/1/423), 9.1981 Location : Examination Centre, Yip Kan Street

A serious slope failure occurred on September 1981 during site formation for the industrial site immediately to the west of the Examination Centre site, Yip Kan Street.

..... in view of the instability of the road cuttings and the extremely shallow base slip surface in the major slip in Police School Road (atypical of Hong Kong slips) it is possible that there are local outcrops of water lain sedimentary RBs rocks in these locations

(GCN 5/2/19), 1.1984 Location : Yue Kwong Road

..... in 1972 a fairly recent slip scar is evident on cut-slope C65 .....

(GCN 5/2/21), 5.1983 Location : Tin Wan Hill Road

It is apparent from the aerial photographs that the failure was only shallow (2-3 metres) involving slipping of the residual soil/completely decomposed rock mantle over the underlying bedrock with failure occurring at or near the interface. The "soil/rock interface appears to be quite an abrupt boundary. Another landslide occurred on the same location at May or August 1982. That landslide involved retrogression of the original slip.

(GCN 5/2/24), 10.1984 Location : Aberdeen Main Road

The slips observed apparently originated along the toe of the slope which is the ground water discharge zone of the overlying catchment area north of the site. The rise in ground water coupled with the discharge of the stream and locally thick soil mantle are probably the main reasons for the frequent landslips.

(GCP 1/1/250 III), 8.1987 Location : Peel Rise

A high ground water table is expected on both sites. This is indicated by the seepage evident on the cleared squatter area above Peel Rise.

APPENDIX B

SEEPAGES OBSERVED DURING THE STUDY

SEEPAGES OBSERVED DURING THE STUDY

The most significant examples of seepage noted during the field survey were in slopes:

(a) 11SW-D/C40 (north side of Aberdeen Main Road); towards base of partly shotcrete-covered slope, near drainage line. (Inspected 7/10/96)

(b) 15NW-A/C1 (south of the intersection of Ap Lei Chau Bridge Road and Lee Nam Road); from moderately-inclined joints, commonly infilled with white to buff kaolin, near base of a recent landslide scar (Inspected 1/10/96)

(c) 15NW-A/C14 (on northeast side (833486E 811220N) of Lee Nam Road); extensive seepage mainly from adverse low-angle joint, but seepage source largely obscured by vegetation; also associated with local deep weathering profile related to a fault trending north-northwest; also significant seepage 7-8 m up cut slope at 833455E 811228N associated with adversely-oriented low-angle joint. (Inspected 3/10/96)

(d) 15NW-A/C3 (east side of Lee Nam Road); locally significant seepage associated with adversely-orientated low-angle joints. (Inspected 3/10/96)

(e) 15NW-A/C2 (southeast side of Lee Nam Road); significant seepage, especially from adversely-orientated joints at 833395E 811437N and 833410E 811450N, from up to 8 m high in slope below site of water tank. (Inspected 3/10/96)

(f) 11SW-D/C86 (north side of Yip Kan Street); significant seepage from low-angle, adversely-orientated joints (834845E 812250N) and from the interface between Grade II/III and Grade IV/V. (Inspected 14/10/96)

(g) 11SW-D/C91 (northwest side of Tong Bin Lane); extensive seepage especially in western 35 m of slope, from low-angle, adversely-orientated joints at various levels in slope, including near interface between Grade II/III and Grade IV/V, and extensive seepage from weepholes in concrete buttresses at several levels; also from low-angle adversely-orientated joints near east end of slope and in turning circle at east end of Tong Bin Lane at base of old failure scars. (Inspected 16/10/96)

(h) 11SW-D/C640 (northern side of Tong Bin Lane), seepage mainly locally from low-angle adversely-orientated joints,

with extensive seepage between 2-5 m up the slope between 835100E 812295N and 835125E 812293N (Inspected 16/10/96).

(i) Unregistered slope (northwest side of Lee Nam Road, Ap Lei Chau); near west end of road (833737E 811665N), seepage from low-angle joint oblique to cut slope near slope base. (Inspected 23/10/96)

(j) Unregistered cut slope 15NW-3B/S10 (Lei Tung Estate); in fine ash tuff and fine-grained volcaniclastic siltstones of Grade II, major seepage from a weathered seam with kaolinitic clay dipping adversely from the slope at mid-slope height between 834255E 811528N and 834235E 811563N. (Inspected 30/10/96)

(k) 15NW-A/C18 to the east of Ap Lei Chau Industrial Estate, minor active seepage and evidence of past seepage with staining below weepholes especially between 833915E 810950N and 833933E 811220N at various height, mainly associated with low-angle adversely-orientated joints at heights between 1 and 8 m above the base of the slope. Also significant seepage from low-angle adversely-orientated joints between 833915E 811135N and 833905E 811153N associated with a topographic low and drainage line above intersected by the cut slope. (Inspected 11/11/96)

APPENDIX C

RELATIONSHIPS OF VOLCANIC FABRICS TO CUT SLOPES IN THE ABERDEEN STUDY AREA

RELATIONSHIPS OF VOLCANIC FABRICS TO CUT SLOPES

Slopes in which the primary volcanic fabric was observed to dip adversely, either directly out of the slope, or at a high angle to its strike include:

(a) parts of slope 15NW-A/C18 facing southwards; between 833860E 811850N and 833710E 811180N, where the fabric dips obliquely out of the slope at very steep angles towards the east (70-90°) but at more moderate angles towards the west (15-40°); and in the vicinity of 833550N 811180E where the fabric dips approximately out of the slopes at moderate angles (15-56°).

(b) 15NW-A/C14, between 833480E 811230N and 833550E 811220N, where the fabric generally dips out, or obliquely out of the southwest facing slope at low to moderate inclination (15-45°).

(c) Unregistered slopes on the north side of Shum Wan Road within Ocean Park on the north side of Tai Shue Wan where southward-dipping fabric is inclined directly to obliquely out of the slope at angles of 20-40°.

Slopes in which the primary volcanic fabric is inferred to dip adversely, either directly out of the slope, or at a high angle to its strike, but where no direct observation was made during the present study include:

(a) The eastern part of 15NW-A/C1 on the south side of Ap Lei Chau Bridge Road, as a west-northwest trending anticline is projected to pass approximately through the slope; the eastern part of the slope may also contain adverse stratification/fabric, and if so the slopes to the north of Ap Lei Chau Bridge Road, including 15NW-B/C28 and adjoining unregistered slopes could also contain adverse stratification/fabric also, but constraint is poor.

(b) 15NW-B/C100, south of the intersection of Ap Lei Chau Bridge Road and the link road to Lei Tung Estate; the existing 1:20 000 scale maps suggest outward dipping structure (35°) from the slope, but due to lack of exposure this was not independently confirmed during the present study.

(c) Locally along the catchwater between 833820E 812600N and 833940E 812570N in small unregistered slopes where the existing 1:20 000 scale maps suggest outward dipping structure (55°) from the slope, but due to lack of exposure this was not independently confirmed during the present

study.

(d) 15NW-B/C113, especially but not exclusively the western end of the slope on the south side of Lee Chi Road, and the adjoining unregistered slope to the west at the rear of the Kam Fat Building, where stratification in surrounding rocks is ortheasterly dipping and dips variably directly to obliquely out of the slope at angles of up to 32°, but generally about 20°.

APPENDIX D

LANDSLIP INCIDENT REPORTS

Appendix D - Landslip Incident Reports

Year	Report Number	Remarks
1978	14/78	Landslide card only
1979	14/79	Landslide card only
1981	21/81	No report & no landslide card
	05/81	Landslide card only
	12/81	No report & no landslide card
1982	H8/19/82	No report & no landslide card
	H8/20/82	No report & no landslide card
	HK6/57/82	No report & no landslide card
	4/5/82	No report & no landslide card
	HK88/82	No report & no landslide card
	H83/82	Landslide card only
	HK1/3/82	No report & no landslide card
	G12/8/82	No report & no landslide card
	H41/82	No report & no landslide card
	H8/29/82	No report & no landslide card
	H8/17/82	No report & no landslide card
	G33/82,20/82	No report & no landslide card
	H65/82	No report & no landslide card
	H39/82	The report is missing
	HK8/5/82	No report & no landslide card
	H8/16/82	Landslide card only
	G11/8/82	No report & no landslide card
	H8/37/82	No report & no landslide card
	8/36/82	No report & no landslide card
1983	HK6/48/83	No report & no landslide card
	H6/50/83	No report & no landslide card
	HK6/34/83	No report & no landslide card
	HK6/56/83	No report & no landslide card
	HK3/13/83	No report & no landslide card
	HK3/3/83	No report & no landslide card
	HK6/49/83	No report & no landslide card
	HK3/4/83	No report & no landslide card

Appendix D - Landslip Incident Reports

Year	Report Number	Remarks
1983	HK17/3/83	No report & no landslide card
	HK16/47/83	No report & no landslide card
	HK6/43/83	No report & no landslide card
	HK1/3/83	No report & no landslide card
	HK5/3/83	No report & no landslide card
	HK6/27/83	No report & no landslide card
1985	HK85/9/13	Squatter area, minor failure
	HK85/8/2	Squatter area, minor failure
	HK85/8/3	The report is missing
	85/4/14	Small boulder fall
	HK85/8/16	Cut slope retaining wall
	HK85/8/11	Squatter area, minor failure
	HK85/8/18	Squatter area, retaining wall failure
1986	HK86/9/2	Squatter area, minor failure
	HK86/5/1	Minor soil and rock failure
	HK86/10/2	No scale of failure; not located on map, squatter area
	HK86/6/3	Squatter area
	HK86/10/3	Squatter area, minor failure
	HK86/7/11	Squatter area, retaining wall failure
	HK86/9/5	No scale of failure; not located on map, squatter area
	HK86/8/10	Squatter area, minor failure
1987	87/5/3	Soil cut slope
	87/7/10	No scale of failure; not located on map, squatter area
	87/3/4	Squatter area, minor fill failure
	87/4/2	Squatter area, minor failure
	87/9/5	No scale of failure; not located on map, squatter
	87/1/1	No scale of failure; not located on map, squatter
	87/3/6	No scale of failure; not located on map
	87/3/8	Large soil/rock failure below retaining wall, jointed tuff
	87/9/2	No scale of failure; not located on map
	87/7/1	Squatter area, minor failure
	87/7/6	Squatter area, minor failure

Appendix D - Landslip Incident Reports

Year	Report Number	Remarks
1987	87/7/7	Squatter area, large failure retaining wall
1988	88/6/4	Very large failure, soil/rock natural slope
	88/1/2	Minor failure, rock block
1989	89/5/47	Distress, masonry retaining wall
	89/5/48	Minor rock fall
	89/5/30	Small failure soil cut slope
	89/3/2	Moderately size failure soil cut slope
	89/5/22	Moderately size failure soil cut slope
1990	90/3/2	Small boulder fall
1991	91/10/11	Boulder fall
1992	92/5/192	Minor erosion of chunamed slope
	92/5/80	Minor failure soil cut slope
	92/5/138	Minor erosion
	92/5/139	Moderate size soil/rock cut slope failure, Island Road Government School
	92/10/1	Very large, soil/rock failure, planar feature
	92/10/2	Moderately size soil/rock cut slope failure
	92/5/137	Minor failure, erosion of crack chunam
	92/5/119	Moderately size soil/rock cut slope failure
	92/5/16	Minor rock fall
	92/5/131	Minor failure erosion of rock
	92/5/152	Minor erosion
	92/5/43	Location is uncertain, moderately size soil/rock failure
	92/8/3	Moderately size failure of catchwater, location uncertain
1993	93/9/35	Moderate size rock failure, blocked surface drainage
	93/9/6	Small rock fall
	93/6/6	Small rock fall
1994	94/8/2	Minor failure, surface erosion
	94/7/8	Minor rock fall
	94/7/58	Very large soil/rock failure
	94/7/57	Minor failure
	94/9/5	Minor failure

Appendix D - Landslip Incident Reports

Year	Report Number	Remarks
1994	94/8/16	Very large failure planar failure along relict joints
1995	HK95/5/79	Moderate size failure, cut retaining wall
	HK95/8/53	Moderate size soil failure
	HK95/8/48	Large size soil/rock failure
	HK95/8/62	Moderate size failure, no surface protect for slope
	HK95/8/91	Moderate size soil/rock failure
	HK95/8/35	Not a failure, muddy water only; not located on map
	HK95/8/83	Moderate size soil failure
	HK95/7/3	Minor soil failure, blocked drainage
	HK95/8/96	Moderate size block soil/rock failure, kaolinite or joints
	HK95/8/49	Very large soil/rock failure, Shum Wan Road, affecting natural slope, kaolinite or joints
	HK95/8/61	Moderate size fill slope failure
	HK95/8/9	Minor soil failure
1996	HK96/5/1	Large failure of soil/rock
	HK96/6/7	Minor failure of soil/rock
	HK96/6/10	Minor soil failure, wall of poor surface protection
	HK96/9/5	Large size failure of soil/rock cut slope recently shotcreted high ground water table

APPENDIX E

BINNIE & PARTNERS - SLOPE CATALOGUE 1977-78

Appendie E - Binnie & Partners - Slope Catalogue 1977-1978

Sheet Number	Feature Number
11-SW-23C	11SW-C/C08
	11SW-C/C09
	11SW-C/C10
	11SW-C/C11
	11SW-C/C13
	11SW-C/C14
	11SW-C/C15
	11SW-C/C17
	11SW-C/C20
	11SW-C/C27
	11SW-C/C28
	11SW-C/C30
	11SW-C/C32
	11SW-C/C33
	11SW-C/C34
	11SW-C/CR35
	11SW-C/CR36
	11SW-C/CR37
	11SW-C/CR38
	11SW-C/CR39
11-SW-23D	11SW-D/C38
	11SW-D/C39
	11SW-D/C40
	11SW-D/C41
	11SW-D/C43
	11SW-D/C44
	11SW-D/C45
	11SW-D/C46
	11SW-D/C49
	11SW-D/C50
	11SW-D/C51
	11SW-D/C52

Appendie E - Binnie & Partners - Slope Catalogue 1977-1978

Sheet Number	Feature Number
11-SW-23D	11SW-D/C53
	11SW-D/C54
	11SW-D/C55
	11SW-D/C57
	11SW-D/C58
	11SW-D/C59
	11SW-D/C61
	11SW-D/C64
	11SW-D/C65
	11SW-D/C66
	11SW-D/C67
	11SW-D/C68
	11SW-D/C69
	11SW-D/C70
	11SW-D/C71
	11SW-D/C72
	11SW-D/C74
	11SW-D/C75
	11SW-D/C76
	11SW-D/C77
	11SW-D/C78
	11SW-D/C79
	11SW-D/C80
	11SW-D/C81
	11SW-D/C82
	11SW-D/C622
	11SW-D/CR623
	11SW-D/C644
	11SW-D/C662
	11SW-D/C663
11-SW-24C	11SW-D/CR1
	11SW-D/C83

Appendie E - Binnie & Partners - Slope Catalogue 1977-1978

Sheet Number	Feature Number
11-SW-24C	11SW-D/C85
	11SW-D/C86
	11SW-D/C87
	11SW-D/C119
	11SW-D/C123
	11SW-D/CR124
	11SW-D/C175
	11SW-D/C639
	11SW-D/C640
	11SW-D/C641
	11SW-D/C642
	11SW-D/C643
11-SW-24D	11SW-D/C90
	11SW-D/C91
	11SW-D/C94
	11SW-D/C95
	11SW-D/C96
	11SW-D/C97
	11SW-D/C98
	11SW-D/C99
	11SW-D/C100
	11SW-D/C101
	11SW-D/C102
	11SW-D/C631
	15NW-B/C13
15-NW-3A	15NW-A/C01
	15NW-A/C02
	15NW-A/C04
	15NW-A/C05
	15NW-A/C06
	15NW-A/C07
15-NW-3B	15NW-B/C18

Appendie E - Binnie & Partners - Slope Catalogue 1977-1978

Sheet Number	Feature Number
15-NW-3B	15NW-B/C19
	15NW-B/C67
	15NW-B/C28
15-NW-3C	15NW-A/C03
15-NW-4A	15NW-B/C01
	15NW-B/C02
	15NW-B/C03
	15NW-B/C04
	15NW-B/C05
	15NW-B/C06
	15NW-B/C07
	15NW-B/C08
	15NW-B/C46
	15NW-B/C47
	15NW-B/C75
	15NW-B/C76
	15NW-B/CR80
15-NW-4B	15NW-B/C61
	15NW-B/C63
	15NW-B/C64
	15NW-B/C65
	15NW-B/C66
	15NW-B/C74
	15NW-B/C09
	15NW-B/C11
	15NW-B/C12
	15NW-B/C14
	15NW-B/C15
	15NW-B/C16
	15NW-B/C17
	15NW-B/C24
15-NW-4C	15NW-B/C77

Appendie E - Binnie & Partners - Slope Catalogue 1977-1978

Sheet Number	Feature Number
15-NW-4C	15NW-B/C78
	15NW-B/C79
15-NW-4D	15NW-B/C39
	15NW-B/C40
	15NW-B/C41
	15NW-B/C43
	15NW-B/C44
	15NW-B/C45

APPENDIX F

GROUND INVESTIGATION REPORTS

Appendix F - Ground Investigation Reports

Report No.	Contract No.	Works Order No.	Contract Title	Remarks	No. of Boreholes
107	-	-	A.I.L. 287 Aberdeen Main Rd.,H.K.	No input data, due to no coordinates	
110	-	-	27-29 Tsung Man Street A.I.L. 372 & 378	No input data, due to no coordinates	
512	-	-	Wong Chuk Hang Interchange	-	7
623	-	-	A.I.L. 333 Shek Pai Wan Road, Aberdeen, H.K.	No input data, due to no coordinates	
668	-	-	Site Investigation Report for Nos. 14-22, Ka Wo Street, Hong Kong	No input data, due to no coordinates	
669	-	-	A.I.L.381, Tsung Man St. Aberdeen, H.K.	No input data, due to no coordinates	
1390	410/79	Q7/2/4.5	Site Investigation Final Report Site: Ap Lei Chau Fresh & Salt Water Supplies	-	10
1399	410/79	Q7/2/4.3	Site Investigation Final Report Site: Ap Lei Chau West Industrial Area	-	6
1617	-	-	A.I.L. 66, at 158 Aberdeen Main St., H.K.	No input data, due to no coordinates	
1949	-	-	Development of Ap Lei Chau & Proposed Bridge	No input data, due to no coordinates	
1956	-	-	Rd. Through Aberdeen Stage II Phase I	No input data, due to no coordinates	

Appendix F - Ground Investigation Reports

Report No.	Contract No.	Works Order No.	Contract Title	Remarks	No. of Boreholes
1959	-	-	Ap Lei Chau Bridge	No input data, due to no coordinates	
2037	-	-	Wong Chuk Hang Interchange	No input data, due to no coordinates	
2390	-	-	Site Investigation Report on Ap Lei Chau	No input data, due to no coordinates	
2406	-	-	Site Investigation Report Site: Tin Wan Market - Aberdeen	No input data, due to no coordinates	
2410	-	-	Site Investigation Report Site: Aberdeen Market	-	8
2438	-	-	Site Investigation Report Tin Wan Market - Aberdeen II	No input data, due to no coordinates	
2707	410/79	Q7/2/4.90	Site Investigation Final Report Site: Police Training School, Stage 5	-	21
2893	427/79	Q7/2/3.4(6)	Site Investigation Report Site: Wong Chuk Hang Fresh Water Service Reservoir	-	11
2930	416/79	-	Landslide Study Site Investigation Site: Tin Wan Estate	-	1
2934	416/79	-	Landslide Study Site Investigation Site: Nam Long Shan	-	1
3216	402/81	Q7/2/6.23	Site Investigation: Hong Kong and Kowloon Site: Ap Lei Chau Bridge	-	1

Appendix F - Ground Investigation Reports

Report No.	Contract No.	Works Order No.	Contract Title	Remarks	No. of Boreholes
3461	-	-	Site Investigation: Ap Lei Chau Bridge Southern Approach Road	No input data, due to no coordinates	
3462	-	-	Site Investigation Report on Ap Lei Chau Bridge Southern Approach Road	-	18
3581	402/81	Q7/2/6.148	Site Investigation: Hong Kong and Kowloon Site: Road & Drainage Works Adjacent to APIL 90	-	1
4412	402/81	Q7/2/6.177	Site Investigation Hong Kong and Kowloon Site: Item 154P in Category AB of Public Works Programme Aberdeen Marine Base	-	8
4543	2/GCO/1983	Q7/2/9.8	Site Investigation: Aberdeen Sports Ground	-	6
4609	98/1981	74	Site Investigation Report on Tin Wan Estate	-	4
4941	2/GCO/1983	Q7/2/9.7	Site Investigation: HDM3(3) - Staunton Creek Nullah Stage II NO. AA1 to AA5 Drillholes	-	5
4980	446/1981	Q7/2/7.118	Site Investigation Report HDM3(3) Staunton Creek Nullah Stage II	-	2
5064	-	Q7/2/9.99	Tin Wan Hill Road - Aberdeen slope 11SW-C/C13	-	7
5287	2/GCO/1983	Q7/2/9.99	Site Investigation: Police Training School Stage V - Phase 3	-	5
5371	2/GCO/83	Q7/2/9.95	Site Investigation: Aberdeen Reclamation Stage II Phase 2B Remaining Portion and Phase 2C	-	5

Appendix F - Ground Investigation Reports

Report No.	Contract No.	Works Order No.	Contract Title	Remarks	No. of Boreholes
5406	9/GCO/83	Q7/2/10.9	Site Investigation Report 203P Aberdeen Marine Bore-proposed Jetty	-	5
5409	2/GCO/1983	Q7/2/9.88	Site Investigation: Footbridge across Wong Chuk Hang Road near AIL151	-	4
5581	2/GCO/1983	PW7/2/9.118	Additional Site Investigation: Tin Wan Hill Road	-	6
5999	2/GCO/83	PW7/2/09.199	Site Investigation: Cooked Food Centre & Children's Playground at Nam Long Shan Road	-	5
R006297	-	-	Landslide Study Phase IIC Report on the Stability of Slope in the Aberdeen Area January 1978	-	6
6526	2/GCO/83	PW7/2/09.215	Site Investigation Report: RCP at Ap Lei Chau Main Street	-	2
6662	GC/85/02	PW7/2/13.1	Site Investigation: Slope 11SW-C/C34, 11 and 12 Tang Fung Street, Shek Pai Wan	-	2
6803	GC/85/02	PW7/2/13.4	Additional Site Investigation (3rd Phase): Tin Wan Hill Road, Slope 11SW-C/C13	-	6
7106	9/GCO/83	Q7/2/10.31	Site Investigation Report on Ap Lei Chau North Reclamation	-	15
7224	436/1977	-	Landslide Study Phase II - Site Investigation Final Site Investigation Report (Vol.5 of 5)	No input data, due to no coordinates	
7362	GC/85/04	PW Q7/2/14.9	Site Investigation Report on Ap Lei Chau North Reclamation Final Report	-	11

Appendix F - Ground Investigation Reports

Report No.	Contract No.	Works Order No.	Contract Title	Remarks	No. of Boreholes
7431	GC/85/02	PW7/2/13.76	Site Investigation: LPM 86/87 Programme Slope No. 11SW-D/CR 51 & CR52, behind Island Road Government School, Aberdeen	-	7
7599	-	-	Site Investigation Report 56-62 Shek Pai Wan Road	No input data, due to no coordinates	
7605	-	-	AIL 152 RP 39 Wong Chuk Hang Road, H.K.	No input data, due to no coordinates	
7726	-	-	Site Investigation Report A.I.L. 158, Tsung Man St., Aberdeen, HK	No input data, due to no coordinates	
8022	-	-	Site Investigation Report A.I.L. No.110 & Ext. No. 190 Aberdeen Main Road, Aberdeen, HK	No input data, due to no coordinates	
8326	-	-	Site Investigation Report on A.I.L. No. 53 Wong Chuk Hang Road	No input data, due to no coordinates	
8468	-	-	Project No. : 8170 Apil 107 Ap Lei Chau, HK	No input data, due to no coordinates	
8607	-	-	Geotechnical Engineering Report on Stability of Existing cutting slope at Tai Wong Ye Shrine, Wong Chuk Road, Hong Kong	No input data, due to no coordinates	
8640	GC/85/02	PW7/2/13.178	Site Investigation: Item No.20MC in Category B of Public Works Programme, Ap Lei Chau Clinic	-	8
8747	GC/85/02	PW7/2/13.229	Site Investigation: Reclamation Development at Aberdeen Waterfront	-	1
9223	-	-	Site Investigation Report Site: A.I.L. 87 S.A., S.B. & R.P. Nos.1-3 Wu Nam Street & Aberdeen Main Rd, HK	No input data, due to no coordinates	

Appendix F - Ground Investigation Reports

Report No.	Contract No.	Works Order No.	Contract Title	Remarks	No. of Boreholes
9529	-	-	A.I.L. 156 Site Investigation Report: No. 216-218, Aberdeen Main Street, Hong Kong	No input data, due to no coordinates	
9584	-	-	The HK Society for the Aged Core & Attention Home, Aberdeen, HK (Geotechnical Report)	No input data, due to no coordinates	
9639	GC/87/02	PW7/2/19.24	Site Investigation: Retaining Wall 11SW-C/R3, Rear of 20-22 Tin Wan Street Aberdeen	-	1
9760	-	-	Site Investigation: A.I.L. Aberdeen Main Road, Hong Kong	No input data, due to no coordinates	
10367	GC/87/02	PW7/2/19.40	Site Investigation: Item No. 11 LP Slope Stabilisation and Site Formation Works for Detective Training School at Nam Fung Road	-	12
11200	GC/87/02	PW7/2/19.102	Site Investigation: Ap Lei Chau North Reclamation	No input data, due to no coordinates	
11796	GC/87/02	PW7/2/19.150	Site Investigation: 361 TH - Interchange at J/O Aberdeen Praya Road/Tin Wan Praya Road and Associated Works Volume I	-	14
11797	GC/87/02	PW7/2/19.150	Site Investigation: 361 TH Interchange at J/O Aberdeen Praya Road/ Tin Wan Praya and Associated Works Volume II	-	14
11872	GC/87/02	PW7/2/19.190	Site Investigation: 167 CL Ap Lei Chau North Reclamation - Phase II	-	3
11897	GC/87/02	PW7/2/19.189	Site Investigation: Remedial Works at Peel Rise, Aberdeen	-	2
12083	GC/87/02	PW7/2/19.171	Site Investigation: Stage 2 Study, Slope No.11SW-D/C39 at 232 Aberdeen Main Street	-	1

Appendix F - Ground Investigation Reports

Report No.	Contract No.	Works Order No.	Contract Title	Remarks	No. of Boreholes
12144	GC/87/02	PW7/2/19.229	Site Investigation: LPM 1986/87, Slope No. 11SW-D/CR51 & 52 at Peel Rise	-	1
12145	-	-	Site Location: Peel Rise Project: Island Road Government School Landslip	-	1
12163	GC/87/02	PW7/2/19.252	Site Investigation: Police Training School, Aberdeen, Phase III, Rifle and Pistol Range Improvements	-	4
12363	GC/87/02	PW7/2/19.216	Site Investigation: LPM 1989/90, Slope No. 11SW-D/CR76 at Aberdeen	-	5
12675	GC/87/02	PW7/2/19.196	Site Investigation: Slope No. 15NW-B/C63, Behind Married Quarters, Police Training School, Aberdeen	-	3
12745	-	-	Ap Lei Chau Site B - Geotechnical Report on the Proposed Site Formation Works	-	33
12842	GC/89/03	PW7/2/27.6	Ground Investigation: Neighbourhood Community Centre - Wong Chuk Hang	-	10
12930	GC/89/03	PW7/2/27.3	Ground Investigation: 36 OTH - Access Road to Wong Chuk Hang Estate and Associated Works Volume I	-	15
12948	GC/89/03	PW7/2/27.43	Ground Investigation: LPM 90/91 - Slope No. 11SW-C/C10 Shek Wan Road, Aberdeen	-	5
13178	GC/89/03	PW7/2/27.57	Ground Investigation: LPM 1990/91, Slope No. 11SW-D\C40 at Aberdeen Main Road	-	2
13239	GC/89/03	PW7/2/27.73	S.I. LPM 1990/91, Slope No. 11SW-D/FR73, Heung Yi Road, Aberdeen	-	

Appendix F - Ground Investigation Reports

Report No.	Contract No.	Works Order No.	Contract Title	Remarks	No. of Boreholes
14051	143/88	219	Site Investigation: Tin Wan Estate Redevelopment	-	12
14189	GC/89/03	PW7/2/27.140	Ground Investigation: PWP Item No.55DS - Ap Lei Chau Pumping Station and Associated Rising Main	-	5
15552	-	-	Boring Records Site: Nos.184-188 Aberdeen Main Road	No input data, due to no coordinates	
15553	-	-	Geotechnical Assessment on the Stability of the Rear Rock Slope at Nos. 58 & 58A, Old Main Street, Aberdeen, Hong Kong	No input data, due to no coordinates	
15559	-	-	A.P.I.L. 118 - 120, Ap Lei Chau	-	8
15606	143/1988	209	Shek Pai Wan / Yue Kwong Chuen Redevelopment Fieldwork Report	-	8
15618	143/1988	233	Shek Pai Wan / Yue Kwong Chuen Redevelopment Fieldwork Report	-	5
15619	143/1988	239	Tin Wan Estate Redevelopment Fieldwork Report	-	13
15626	-	-	-	Report not available.	-
15627	-	-	-	Report not available.	-
15633	-	-	-	Report not available.	-

Appendix F - Ground Investigation Reports

Report No.	Contract No.	Works Order No.	Contract Title	Remarks	No. of Boreholes
15643	-	278	S.I. Shum Wan Road Psps Stage 2	-	6
15674	GC/91/05	PW7/2/33.22	S.I. Ground Investigation Stage 2 Study, Slope No. 11SW - D/C 54, Pui Tak Canossion Collage, Aberdeen	-	3
15730	-	-	-	Report not available.	-
15762	-	-	-	Report not available.	-
15802	GC/91/05	Pw7/2/33.22	S.I. Ground Investigation Second Ap Lei Chau Bridge and Associated Work Vol. 2	-	
15828	GC/89/05	PW7/2/29.62	Site Investigation Report	-	2
16657	-	-	-	Report not available.	-
16843	-	-	-	Report not available.	-
16849	-	-	-	Report not available.	-
16903	-	-	-	Report not available.	-
16904	-	-	-	Report not available.	-

Appendix F - Ground Investigation Reports

Report No.	Contract No.	Works Order No.	Contract Title	Remarks	No. of Boreholes
17181	-	-	-	Report not available.	-
17191	-	-	-	Report not available.	-
17252	-	-	-	Report not available.	-
19009	-	-	Ocean Park - Inflight Aviary Exhibition Hall Geotechnical Assessment	No input data, due to no coordinates	
19690	GE93/06	GE/93/06.96	S.I. Redevelopment of Aberdeen Rehabilitation Centre at 4 Welfare Road, Wong Chuk Hang	-	17
19920	-	-	A.P.I.L. 100 & 103, 1-7 Hang Shing Street Report on the Design of Site Formation Works, Ap Lei Chau	-	7
19943	-	-	127 - 139 Ap Lei Chau Main Street Geotechnical Report	-	5
19944	-	-	Proposed Residential Bldg., at 127-139, Ap Lei Chau Main St., Geotechnical Assessment	No input data, due to no coordinates	
19952	-	-	Geotechnical Engineering Report on Stability of existing cutting slope at Tai Wong Ye Shrine, Wong Chuk Hang Road, HK	No input data, due to no coordinates	
20104	GE/93/06	GE/93/06.74	S.I. Proposed Bus Layby at Aberdeen Reservoirs Road.	-	2
20361	-	-	Site Formation and Structural Design Calculations for Proposed Refuse Storage for Nam Long Hospital on a Site Extension to R.B.L. 861 Brick Hill, Aberdeen, Hong Kong	-	2

Appendix F - Ground Investigation Reports

Report No.	Contract No.	Works Order No.	Contract Title	Remarks	No. of Boreholes
20912	HKHA 91/92	M22	S.I. Shek Pai Wan Estate Slope Study	-	4
21185	HKHA 91/92	M89	S.I. Shek Pai Wan Estate Stage 2 Study Slope 11SW-D/R5, C66, FR9 & FR10	-	11
21206	HKHA 91/92	PS9	S.I. Ap Lei Chau Drive DSPS AP Lei Chau	-	7
21248	TC C309	ASD 003710	Ground Investigation Report Site: Ap Lei Chau U.C. Complex Ap Lei Chau, H.K. South	-	6
21263	TC C309	ASD 003725	Ground Investigation Report Site: Squash & Tennis Complex at Chung Mei, Aberdeen	-	5
21301	TC C309	ASD 3745 (Volume 1 of 22)	Ground Investigation Report Site: School Improvement Programme Ph.I, Package 2: School P10 Aplcichau Kaifong Primary School, Ap Lei Chau	-	4
21302	TC C309	ASD 3745 (Volume 2 of 22)	Ground Investigation Report Site: School Improvement Programme Ph.I, Package 2: School P11 St. Peter's Catholic Primary School, Ap Lei Chau	-	4
21519	GE/93/11	GE/93/11SA.29	Landslip Site at Shum Wan Road, Aberdeen Ground Investigation Factual Fieldwork Report Volume I	-	8
21534	GE/93/11	GE/93/11SA.34	Permanent Remedial Works Location: Shum Wan Road Landslide Ground Investigation Factual Fieldwork Report Volume I	-	30
21590	GE/95/06	GE/95/06.63	Sham Wan Road Landslide Factual Fieldwork Report	-	1

Appendix F - Ground Investigation Reports

Report No.	Contract No.	Works Order No.	Contract Title	Remarks	No. of Boreholes
2101/92	S910	-	Site Investigation Work for cable route from Ap Lei Chau to Nam Fung Road	-	11
2028/94	-	-	54 - 56 Old Main Street, Aberdeen	-	4
2031/95	-	W488	Site Investigation Works proposed Industrial / Godown Development Ap Lei Chau Island Lot No. 129 Ap Lei Chau East	-	17
3056/95	-	5M594/SI	Slope Remedial Proposal for Consent Application of Remaining Mini-Piling Works for Canadian International School H.K. at Nam Long Shan Road, A.I.L. 417 Aberdeen	-	22
3/1/481	-	-	Aberdeen Rehabilitation Centre Redevelopment, Aberdeen	-	26
3/1/489	PW410/79	-	Wong Chuk Hang Police Training School, Aberdeen	-	9
3/1/792	-	-	Secondary School in Lai Tung Estate at Ap Lei Chau (near the Sea)	-	8
3/1/793	-	-	Secondary School in Lai Tung Estate at Ap Lei Chau (near the Market)	-	4
3/1/813	GC/91/05	PW7/2/33.98	Yue Kwong Skills Centre	-	13
DH223/66/ HK	-	HK-BU 681	Behind No. 220 Aberdeen Main Road, Hong Kong	-	4
DH219/76/ HK	-	-	Report on David Trench for the Aged, 29 Nam Long Shan Road, A.I.L.330, Aberdeen, H.K.	-	7

Appendix F - Ground Investigation Reports

Report No.	Contract No.	Works Order No.	Contract Title	Remarks	No. of Boreholes
DH360/78/ HK	-	-	1, Wong Chuk Hang Road, Hong Kong		4
DH312/94/ HK	-	-	Remedial Works at Ap Lei Chau Terminals Marine Lot No. 63		4
2057/88	-	HHS/07/04	49-55 Main Street, Ap Lei Chau, Hong Kong	-	5
2031/82	-	874	A.I.L. 365, Shek Pai Wan Road, Aberdeen, Hong Kong	-	5
0011/88	-	-	APIL 121 Ap Lei Chau, Hong Kong	-	7
2107/90	-	-	A.I.L. 419,Nos 66 - 72, Aberdeen Main Road, H.K.	-	17

APPENDIX G

ISLAND DIVISION FILES

Appendix G - Island Division Files for the Aberdeen Study Area

AOP - Architectural Office Project
BLD - BLD Duplicate File
HP - Housing Project
DHF - Dangerous Hill File

Sheet No.	Type of File	File Ref.	Title	Remarks
11SW-23C	AOP	3/1/011	Tin Wan Market and Recreation Site Hing Wo Street, Tin Wan Aberdeen	Not particularly useful.
		3/1/336	Tin Wan Estate Playground, Tin Wan New Street, Tin Wan	Not particularly useful.
		3/1/366	Shek Pai Wan Road Refuse Collection Point, Shek Pai Wan Road	Not particularly useful.
		3/1/688	Aberdeen Rest Garden & Children Playground Tin Wan Hill Road	Not particularly useful.
		3/1/712	-	Not available.
	HP	3/2/085	Tin Wan Estate Housing Department Staff Quarter.	1979 report on 11SW - C/C15, noted two previous slips reports
		3/2/109	Tin Wan Hill Estate	11SW-C/C31, GEO checked submission.
		3/2/156	Tin Wan Praya Road, Aberdeen	Lease conditions, not particularly useful.
		3/2/169	Tin Wan Estate Redevelopment	Some triaxial test data
	BLD	2007/82	244 Aberdeen Main Road	Geotechnical report.
		2031/82	Shek Pai Wan Road	Geotechnical report.
		2072/79	A.I.L. 400, Aberdeen	Not particularly useful.
		3020/84	244 Aberdeen Main Road	Some photos of rock anchored caisson wall, not particularly useful.
	DHF	DH510/72/HK	11 Tang Tung Street, Aberdeen	Some photos of slope.
11SW-23D	AOP	3/1/105	Southern City District Office 22, Aberdeen Main Road Aberdeen	Not particularly useful.

Appendix G - Island Division Files for the Aberdeen Study Area

AOP - Architectural Office Project
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Sheet No.	Type of File	File Ref.	Title	Remarks
11SW-23D	AOP	3/1/701	Aberdeen Jockey Club Clinic	Sub-horizontal joints, heavy seepage, subsequently shotcreted slope.
		3/1/813	Social Welfare Facilities in Yue Kwong Road, Aberdeen	Deep weathering noted ie. GI report, Kaolinite and yellow clay observed.
	HP	3/2/004	Aberdeen Old Main Street, Yue Fai Court	Some photos and joint measurements, sub-horizontal joints API report of previous slips.
		3/2/041	Yue Kwong Road Home Ownership Scheme Stage II, Yue Kwong Road, Aberdeen	Not particularly useful.
		3/2/174	PS PS at Aberdeen Praya Road	Not particularly useful.
	BLD	1769/54	-	Not available.
		2008/86	Yue Kwong Road, Aberdeen	Many photos of soil / rock cut slope excavations, some joint measurements.
		2014/81	94 - 98 Aberdeen Main Street	Not particularly useful, some photos of slope.
		2016/91	118H - 120 Old Main Street, Aberdeen	Not particularly useful.
		2017/92	22, Aberdeen Main Road	GI report and core photographs.
		2025/83	94 - 98 Aberdeen Main Street	Not particularly useful.
		2028/94	54 - 56, Old Main Street, Aberdeen	GI data.
		2032/82	2 - 10 Aberdeen Main Street	No useful.
		2033/91	170 - 172 Aberdeen Road	Not particularly useful.
		2035/85	2 - 10 Aberdeen Main Road - A.I.L 2,3,4,117	Geotechnical report, API report highlight old slope failures.
		2043/85	Aberdeen Main Road, Cheng Tu Road	Not particularly useful.

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AOP - Architectural Office Project
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Sheet No.	Type of File	File Ref.	Title	Remarks
11SW-23D	BLD	2048/87	-	Not available.
		2051/85	St Peters Anglo Chinese School	Stability analysis of shallow soil failure.
		2055/92	54 - 56 Old Main Street	Not particularly useful.
		2063/89	8 - 10 Wu Pak Street, Aberdeen	Not particularly useful.
		2065/80	64 - 70 Old Main Street, Aberdeen	Not particularly useful, some photos of slope.
		2069/78	-	Not available.
		2099/89	-	Not available.
		2101/80	234 Aberdeen Main Road	Not particularly useful, some photos of slope.
		2104/85	-	Not available.
		2107/90	66 - 72 Aberdeen Main Road	Geotech. report, rock joint measurements, borehole datas. Photos show major open feature 20° dip steeply adverse to stability. Potential for toppling failures.
		3033/84	24 - 26 Aberdeen Main Road A.L.L.76	Memos highlight serious Geotech. problem for development of slope.
		3076/77	Aberdeen Main Road A.I.L. 391	Not particularly useful.
	DHF	DH102/91/HK	232 Aberdeen Main Road	Not particularly useful.
		DH15/82/HK	Aberdeen Main Road	Not particularly useful.
		DH16/84/HK	Aberdeen Main Road A.I.L. 95	Not particularly useful.
		DH200/92/HK	18 - 20 Aberdeen main Road A.I.L. 382 ,	Not particularly useful.
		DH223/66/HK	220 Aberdeen Main Road	GI data at St. Pauls School.

Appendix G - Island Division Files for the Aberdeen Study Area

AOP - Architectural Office Project
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Sheet No.	Type of File	File Ref.	Title	Remarks
11SW-23D	DHF	DH512/72/HK	30 Aberdeen main Road, A.I.L. 76 S.K.	Not particularly useful.
		DH151/82/HK	Pui Tak Canossion College, 200 Peel Rise	11SW-D/C54, analysis of shallow soil slip C'=7KN/m², ϕ'=31°
11SW-24C	AOP	3/1/104	Nam Long Shan Children Playground, Aberdeen	Not particularly useful.
		3/1/142	Aberdeen Main Road Sitting Out Area, Aberdeen	Not particularly useful.
		3/1/146	Nam Long Shan Road Sitting Out Area J/O Nam Long Shan Road & Heung Yip Road Brick Hill	Not particularly useful.
		3/1/151	Yip Kan Street G.S.D. Storage Depot (Formerly Hong Kong Island Vehicle Examination Centre) Yip Kan Street, Wong Chuk Hang, Aberdeen	Some comments on boulders on natural slope.
		3/1/481	Aberdeen Rehabitation Centre, Heung Yip Road, Aberdeen	Some slope photos and GI data.
	HP	3/2/172	Wong Chuk Hang Estate, Special Area Inspection.	Not particularly useful.
	BLD	2061/82	Tai Wong Ye Shrine, Wong Chuk Hang	GI report test pits only.
		2085/79	Geotechnical Report A.I.L. 396 Yip Kam Street	No report in the file.
		2086/79	Wong Chuk Hang - A.I.L. 399	Many files relating to slope failure in 1981 photos,low angle joints, stereoplot of joints, photos. Weathering front photo shows abrupt change in weathering front.Very blocky site of continuous instability.
		2101/92	Seashore at Wong Chuk Hang adjacent to Ap Lei Chau Bridge Road.	GI Data data and report.
		3031/77	Aberdeen Main Road.	Not particularly useful.
		3078/89*	-	Not available.

Appendix G - Island Division Files for the Aberdeen Study Area

AOP - Architectural Office Project
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Sheet No.	Type of File	File Ref.	Title	Remarks
11SW-24C	DHF	DH159/81/HK	Yip Kan Street - A.I.L. 399	Low angle joints, Yip Kan Street slip in 1983
		DH360/78/HK	Aberdeen Technical School, 1 Wong Chuk Hang Road	Aberdeen Technical School, joint data and GI data. Kaolinite's clay in relief joints.
11SW-24D	AOP	3/1/059	Nam Fung Road, Wong Chuk Hang Pest Control Strores & Quarters	Not particularly useful.
		3/1/135	Wong Chuk Hang Police R & F Married Quarters	Not particularly useful, some photos.
		3/1/489	Police Training School	Deep weathering noted in GI report.
	HP	3/2/172*	Wong Chuk Hang Estate, Speacial Area Inspection.	Not particularly useful.
	BLD	2045/81	12 Yip Fat Street, Aberdeen	Lease terms, not particularly useful.
		3032/92	Aberdeen Main Road.	Not particularly useful.
		3077/95	2 Heung Yip Road, Aberdeen	Not particularly useful.
		3122/87	Aberdeen Inland Lot 283 - 53, Wong Chuk Hang Road	Not particularly useful.
	DHF	DH404/78/HK	125 Wong Chuk Hang Road A.I.L. 15	Not particularly useful.
15NW-3A	AOP	3/1/121	Ap Lei Chau Sitting - Out Area, Ap Lei Chau	Not particularly useful.
		3/1/245	-	Not available.
		3/1/448	Ap Lei Chau Sub-divisional Fire Station, Ap Lei Chau	Sub-horizontal joints, deep weathering, variable weathering front (may be fault).
	HP	3/2/014	Ap Lei Chau Estate	Not particularly useful.
	BLD	0011/88*	A.P.M.L. 63, Ap Lei Chau, Shell Road	Geotechnical report.
		2005/89	West Commercial Centre, Ap Lei Chau	very many files, not particularly useful.

Appendix G - Island Division Files for the Aberdeen Study Area

AOP - Architectural Office Project
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Sheet No.	Type of File	File Ref.	Title	Remarks
15NW-3A	BLD	2035/88	Proposed New 132 KV Cable, Ap Lei Chau	Not particularly useful.
15NW-3B	AOP	3/1/424	Ap Lei Chau Main Street Children's Playground Ap Lei Chau	Not particularly useful.
		3/1/725	Sitting-Out-Area at Site Adjacent to 87 Main Street Ap Lei Chau	Not particularly useful.
		3/1/742	Ap Lei Chau Clinic	Not particularly useful.
		3/1/792	Secondary School in Lei Tung Estate at Ap Lei Chau (near the sea)	PGA report 10/92, GI data, Kaolinite
		3/1/793	Secondary School in Lei Tung Estate at Ap Lei Chau (near the market)	PGA report 9/92, API report, GI data.
		3/1/811	583 MR- Local Open Space at J/O Shan Ming Street	Not particularly useful.
		3/1/817	Recreational Development of the 'LO' Site at Hung Shing Street	PGA report 9/95, GI data.
	BLD	2005/81	73 - 79 Ap Lei Chau Main Street	Not useful.
		2013/83	Ap Lei Chau Main Street.	Not particularly useful, some photos.
		2019/83	-	Not available.
		2029/86	95 Ap Lei Chau Main Street	Some photos of chunamed cut slope, not particularly useful.
		2032/81	Ap Lei Chau Main Street, Hung Shing Street	Not particularly useful.
		2048/82	38, Sam Shi Street	Not particularly useful, some site photos.
		2051/81	Ap Lei Chau - I.L. 110	Not particularly useful.
		2057/88	49 - 55 Main Street, Ap Lei Chau	GI report and core photos.

Appendix G - Island Division Files for the Aberdeen Study Area

AOP - Architectural Office Project
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Sheet No.	Type of File	File Ref.	Title	Remarks
15NW-3B	BLD	2095/81	97 - 103 Ap Lei Chau Main Street	Not useful.
		2098/80	Ap Lei Chau	Not particularly useful.
		2102/92	Ap Lei Chau Bridge Road	GI data.
		2106/79	Ap Lei Chau	Some designcalc's for cut slope, not particularly useful.
15NW-3C	BLD	0011/88*	A.P.M.L. 63, Ap Lei Chau, Shell Road	Geotechnical report.
		2011/81	Ap Lei Chau West	Many photos of rock slope during construction. Some adverse joints but now may be scaled off.
		2086/88	AP Lei Chau West, SHX 408	Not particularly useful.
	DHF	DH312/94/HK	Ap Lei Chau Terminals	GI data.
15NW-3D	AOP	3/1/744	Proposed soccer pitch on the deck of reservoir at South of Lei Tung Estate, Ap Lei Chau	Not particularly useful.
	HP	3/2/015	Slope behind block G, Ap Lei Chau Site B, Modified Scheme	Detailed mapping of joints in excavated rock slopes.
		3/2/173	Lei Tung Estate	Not particularly useful, some photos.
	BLD	2003/87	Ap Lei Chau West, A.P.I.L.	Not particularly useful.
		2031/95*	Ap Lei Chau Praya Road	GI data.
		2059/90	Ap Lei Chau West, A.P.I.L. 123	Not particularly useful.
		2062/94	Lee Hing Street, Ap Lei Chau West	Photos of excavation base.
		2071/86	Ap Lei Chau West, A.P.I.L. 116	Potos of excavated rock slope, low angle joints

Appendix G - Island Division Files for the Aberdeen Study Area

AOP - Architectural Office Project
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Sheet No.	Type of File	File Ref.	Title	Remarks
15NW-4A	AOP	3/1/418	Shum Wan Road Vocational Training Centre for the Disabled Wong Chuk Hang	Not particularly useful.
		3/1/522	Shum Wan Road Refuse Collection Point Shum Wan Road Aberdeen	Not particularly useful.
		3/1/732*	-	Not available.
		3/1/781	Pao Yuen Kong Swimming Pool Complex	Not particularly useful.
	HP	3/2/051	Welfare Road, Aberdeen	Same rock joint measurements.
		3/2/172*	Wong Chuk Hang Estate, Special Area Inspection	Same rock joint measurements.
	BLD	2090/85	13 Shum Wan Road	Geotech. report, some photos, not particularly useful.
		3078/89*	2 Welfare Road	Not particularly useful, some photos.
		2046/82	Nam Long Sham Road	Not particularly useful.
	DHF	DH219/76/HK	David Tench Home	GI data, deep weathering noted.
		DH158/92	Inside the Aberdeen Marine Club	Some information on landslip incidents.
15NW-4B	AOP	3/1/732*	-	Not available.
	HP	3/2/172*	Wong Chuk Hang Estate, Special Area Inspection	Not particularly useful.
	BLD	2155/77	Police Station Road	Slope stability analysis report.
		3056/95	Canadian International School	GI Data, Kaolinite noted.
		3027/88*	Nam Long Sham Road, Wong Chuk Hang	Not particularly useful. GI Summary indicate weathering up to 10m deep.
	DHF	DH62/89/HK	2 Police School Road	Not particularly useful, some photos.

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Sheet No.	Type of File	File Ref.	Title	Remarks
15NW-4C	BLD	2031/95*	Ap Lei Chau Praya Road	Boulder study Ap Lei Chau
		3005/96*	Proposed Breeding Facility, Ocean Park	Geotech. report, not particularly useful.
	DHF	DH179/95/HK	26 Shum Wan Road	Not particularly useful.
15NW-4D	BLD	3005/96*	Proposed Breeding Facility Ocean Park	Geotech. report, not particularly useful.
		3024/86	Ocean Park	Not particularly useful.
		3027/88*	Nam Long Shan Road, Wong Chuk Hang	Not particularly useful. GI Summary indicate weathering up to 10m deep.
		3041/86	Ocean Park	Not particularly useful, some photos.
	DHF	DH120/82/HK	Ocean Park, Nam Long Shan Road	Landslip at Ocean Park, report on slope remedial works, GI report.

* Repeated Files

APPENDIX H

STAGE 1, 2 AND 3 STUDY REPORTS

Appendix H - Stage 1, 2 & 3 Study Reports

Report Type	Title	Reference No.
Stage 1 Study Report	Cut Slope 11SW-D/C97 above & at North of the Nurses' & Sister's Quarters, Grantham Hospital	S1R 27/90
	Cut Slope 11SW-D/C98 below and at South of the Senior Staffs' Quarters, Grantham Hospital	S1R 28/90
	Cut Slope 11SW-D/C100 above & at North of the Cardia-Thoraic Block, Grantham Hospital	S1R 29/90
	Cut Slope 11SW-D/C101 above & at North of a Capel in the Grantham Hospital	S1R 30/90
	Cut Slope 11SW-D/C102 above & at North of a Staffs' Quarters, Grantham Hospital	S1R 31/90
	Cut Slope 11SW-D/C96 Pedestrian Access Road to Grantham Hospital	S1R 26/90
	Cut Slope 11SW-D/C99 above & at North of Doctors' Quarters Grantham Hospital Aberdeen	S1R 68/88
	Cut Slope 11SW-D/C38&39 Behind No.232 Aberdeen Main Road	S1R 33/87
	Cut Slope 15NW-B/C63 behind Married Quarters Police Training School Wong Chuk Hang	S1R 96/86
	Cut Slope 11SW-D/C81 & 11SW-D/C622 North of Nos. 22-64, Aberdeen Main Road	S1 121/79
	Cut Slope 11SW-D/CR76 Nos.64-80, Old Main Street, Aberdeen	S1 124/79
	Cut Slope 11SW-D/CR623 Slope Around Portal 117, Old Main Street, Aberdeen	S1 128/79
	Cut Slope 11SW-D/CR51 11SW-D/CR52 above and at North of Island Road Government School, Aberdeen	S1 15/80
Stage 2 Study Report	Cut Slope 11SW-D/C75 54-58A, Old Main St., Aberdeen	S2R 25/90
	Cut Slope 11SW-D/C40 Aberdeen Main Road (Private Slope)	S2R 7/91
	Cut Slope 11SW-D/C39 No.232 Aberdeen Main St.	S2R 10/91
Stage 3 Study Report	Cut Slope 11SW-D/C81 behind 22-26 Aberdeen Main Road	S3 7/85
	Cut Slope and Retaining Wall 11SW-D/CR51 & CR52 Tsung Man Street	S3R 18/87
	Cut Slope 15NW-B/C63 behind Married Quarters Police Training School Wong Chuk Hang, H.K.	S3R 19/90

APPENDIX I

GEO REPORTS - ADVISORY REPORTS AND SPECIAL PROJECT REPORTS

Appendix I - GEO Reports - Advisory Report and Special Project Report

Report Type	Title	Reference No.
Advisory Report	Rock Slope Stability Assessment & Remedial Measures Proposal Ap Lei Chau Reclamation	ADR 6/90
	Site Formation Works For Ap Lei Chau No.2 F.W. Service Reservoir	ADR 20/92
	Remedial Works to the Soil Slopes behind Ap Lei Chau North Reclamation - Phase I	ADR 9/91
	Monitoring and Maintenance of Ground Anchors at Shek Pai Wan Road	ADR 2/87
	Geotechnical Design of Access Road to Wong Chuk Hang Estate	ADR 25/90
	Monitoring and Maintenance of Ground Anchors at Ap Lei Chau Bridge Road	ADR 10/87
	Geotechnical Design of Ap Lei Chau Clinic	ADR 21/87
	Testing and Inspection of Ground Anchors at Ap Lei Chau	ADR 18/84
	Review on Stability of Anchored Caisson Wall at Ap Lei Chau	ADR 2/84
	Exhumation of Ground Anchors at Ap Lei Chau	ADR 3/85
Special Project Report	Landslide Studies: Island Road Goverrnment School Landslip, Aberdeen Vol.I	SPR 4/89
	Landslide Studies: Island Road Goverrnment School Landslip, Aberdeen Vol.II	SPR 4/89
	Mode and Mechanism of a Complex Failure at Tin Wan Hill	SPR 2/86
	Landslide at Tin Wan Hill Road, October 1983 - Preliminary Studies	SPR 3/84

LIST OF DRAWINGS
(all at 1:5 000 scale)

Drawing No.	
GS-SP/15-NW-B/752	Map No. 1 - Aerial Photograph Interpretation
GS-SP/15-NW-B/750	Map No. 2 - Geological Fabrics and Features
GS-SP/15-NW-B/745	Map No. 3 - Man Made Slopes (Excluding Fill Slopes)
GS-SP/15-NW-B/747	Map No. 4 - Seepages
GS-SP/15-NW-B/744	Map No. 5 - Landslide Incidents
GS-SP/15-NW-B/748	Map No. 6 - Ground Investigation
GS-SP/15-NW-B/746	Map No. 7 - Report Summary
GS-SP/15-NW-B/751	Map No. 8 - Natural Terrain Landslide Inventory