NATURAL TERRAIN LANDSLIDE STUDY THE NATURAL TERRAIN LANDSLIDE INVENTORY

GEO REPORT No. 74

J.P. King

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

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This report was originally produced in November 1997
as GEO Technical Note No. TN 10/97

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First published, January 1999

Prepared by :

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

This publication is available from :

Government Publications Centre,
Ground Floor, Low Block,
Queensway Government Offices,
66 Queensway,
Hong Kong.

Overseas orders should be placed with :

Publications Sales Office,
Information Services Department,
4th Floor, Murray Building,
Garden Road, Central,
Hong Kong.

Price in Hong Kong : HK$208
Price overseas : US$32 (including surface postage)

An additional bank charge of **HK$50** or **US$6.50** is required per cheque made in currencies other than Hong Kong dollars.

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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.

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J.B. Massey
Ag. Principal Government Geotechnical Engineer
January 1999

FOREWORD

The aim of the Natural Terrain Landslide Study is to investigate the distribution, nature and causes of landslides on natural terrain in Hong Kong with the intention of classifying the landslide hazard.

The first phase of the study was the creation of a Natural Terrain Landslide Inventory for Hong Kong (NTLI) compiled from interpretation of high level aerial photographs (API) dating from 1945 to 1994. The NTLI comprises landslide locations plotted on 1:5000-scale maps and limited tabulated data for each landslide. The data were then digitised for analysis using a geographical information system.

This Note describes how the NTLI was compiled and digitised and the associated API studies carried out to determine a recognition factor for the inventory and rate of landslide revegetation.

The work was supervised by Mr J.P. King (GE/PTE1). The API was carried out by Messers A.J.MacMurdo, P.A.Spiers, G.I.Short, B.R.Jenkins and D.P.King of the New South Wales Department of Land and Water Conservation under the supervision of Mr K.A.Emery. Mr P.A.Kirk (GE/GS6) designed the digitisation specification and Mr Foo Min-Tett of Advanced Business Inc. Ltd provided valuable assistance with its implementation. Validation of the digitised data was supervised by Mr W.L.Shum (GE/PTE3) and carried out by Technical Officers Mr W.Y.Lo and Mr Y.H.Chiu. Data entry of the landslide tables was supervised by Mr S.W.Huang (GE/PTE2) who also produced the 1:20,000 scale NTLI maps. Mr Y.H.Chiu (TO/G) is responsible for production of the Figures in this report. The project was overseen by Mr N.W. Woods (SGE/PTE).

(R.P. Martin)
Chief Geotechnical Engineer/Planning

CONTENTS

1. INTRODUCTION

The first phase of the Natural Terrain Landslide Study (NTLS) was the creation of an inventory of natural terrain landslides in Hong Kong (NTLI). The basic data was compiled from interpretation of high level aerial photographs presented on 1:5000 scale maps that show the location of all the identified natural terrain landslides. A report was produced for each map sheet with additional data on each landslide and general comments on the ground covered by the sheet. This data was digitised to form the basis of a geographical information system (GIS) for analysis of the survey results.

This report describes the compilation and digitisation of the Inventory. The development of the study is outlined in Section 2 and the API methodology is given in detail in Section 3. Digitisation and validation of the API maps and reports is detailed in Section 4. Sections 5 and 6 describe the recognition factor study and the revegetation study, two ancillary API studies that were carried out to help assess the frequency of landsliding. Section 7 explains some limitations of the NTLI and Section 8 lists its documentation.

2. BACKGROUND

In early 1995 it was decided to establish a natural terrain landslide catalogue for Hong Kong as the basis of subsequent studies into the distribution of such events. In order to develop a methodology and to provide costing information, a pilot study of three 1:5000 scale map sheets (Table 1) was carried out in February and March 1995 by consultants from the New South Wales Department of Land and Water Conservation (DLWC). Following the pilot study, an outline brief for a "Preliminary Catalogue of Natural Terrain Landslides" was produced. The API study based on the brief was started in September 1995.

The detailed working specification was developed during study of the first few map sheets as different terrain conditions were encountered. This specification is at Appendix A and includes the outline brief, definitions of terminology and a chronology of the development of the specification. The "Preliminary Catalogue" was renamed "The Natural Terrain Landslide Inventory (NTLI)" in December 1996.

The main API study was finished in February 1996. The recognition factor study to quantify the number of landslides that may have been missed or misidentified due to the constraints of the API techniques, and the revegetation study to record the rate of landslide scar revegetation, were carried out by DLWC in October and November 1996.

In January 1996 Advanced Business Inc. Ltd (ABI) was awarded a contract for the digitisation of the 1:5000 scale NTLI maps. Checks of the digital data allowed identification of inconsistencies in the API mapping such as duplicate slide numbers and missing or incorrect data. Validation of both the API mapping and the digitisation continued until June 1996. The NTLI data tables were digitised in-house during August 1996.

In September 1996 all of the NTLI digital data were passed to Intergraph Hong Kong Limited under Agreement CE44/96 for creation of the NTLI Geographic Information System (GIS). The preliminary GIS analysis of the data is reported in GEO Special Project Report SPR 5/97. Further analysis is ongoing, as is documentation of the GIS. The 1:20,000 scale

NTLI maps showing relict and recent landslides were produced in January 1997.

3 COMPILATION METHODOLOGY

3.1 Area Surveyed

3.1.1 Base Maps

The base maps used for the project were the Lands Department 1:5000 scale topographic maps of Hong Kong. Ping Chau Island is not covered by this mapping and to remedy this deficiency a 1:5000 scale base map was prepared from a 1987 aerial photograph with infrastructure extracted from the 1:20,000 scale topographic map. The location of the 163 base maps used are shown on Figures 1 to 25. These base maps cover the whole of Hong Kong although, as explained below, only visible natural terrain without severe gully erosion was surveyed for landslides.

3.1.2 Aerial Photograph Cover

The NTLI was compiled from interpretation of high level aerial photographs taken at altitudes of 10,000 to 20,000 feet to give a nominal scale of 1:20,000 to 1:40,000. Such photographs were taken in 1945, 1964 and 1972 to 1994. In any year the photography may only have partially covered the Territory (particularly in 1945, 1972, 1977, 1980 and 1984) and occasionally prints covering some areas were not available for the study. This resulted in most parts of Hong Kong being surveyed using between 20 and 23 sets of photographs.

The numbers, date, height and coverage of the aerial photographs used for each sheet were recorded in the map sheet report. Any portion of a sheet not covered by photography or obscured by cloud or shadow was marked on the map sheet. Areas without stereo coverage were excluded from the survey area if landslides could not be recognised due to poor resolution. This was particularly common in the 1945 photographs. The sheet information has been combined and Figures 1 to 25 show the extent of the aerial photograph coverage of Hong Kong used for each survey year.

Low level 1967 photographs were used for several map sheets on Hong Kong Island (Table 1) to help identify landslides resulting from the severe rainstorms of 1966. Due to revegetation these landslides might not otherwise have been identified on the next set of high level photographs which were taken in 1974.

The generally poor resolution of 1993 and 1994 photographs may also have resulted in reduced identification of landslides in those years.

3.1.3 Definition of Natural Terrain

Only natural terrain was surveyed for landslides in this study. Natural terrain was defined as :-

Terrain that has not been modified substantially by human activity but including areas *where grazing, hill fires and deforestation may have occurred.*

Large areas of old agricultural terraces and urban development were excluded as modified terrain. The increasing area covered by modified terrain was recorded on each map sheet for the years 1945, 1964, 1973, 1981, 1987 and 1994. Where photography of an area was not available for these years development was recorded for the nearest year available. This resulted in limited areas of development being recorded for the years 1974, 1975, 1976, 1982, 1983, 1988, 1990, 1991 and 1993. Only non-linear features greater than 1 hectare in area and linear features such as roads and catchwaters with their marginal cut and fill slopes more than 25 m wide were recorded as modified terrain. Landslides observed in areas of modified terrain that were too small to record were marked on the map but not included in the inventory.

The history of development recorded by the NTLI is shown on Figure 26. Only landslides recorded in the area of natural terrain in 1994 (Figure 27) are being used in ongoing analysis for landslide susceptibility mapping.

3.1.4 Excluded Features

Areas of intense gully erosion are visible on high level aerial photographs as high reflectance light toned areas. Identification of individual landslides is difficult in these areas. Landsliding may be a factor in the formation and on-going development of such gully systems and a number of landslide scars were recognised in such areas on low level aerial photographs used for the recognition factor survey (Section 5). However, due to the difficulty of recognising individual landslides on the high level photography these areas were excluded from the survey. The gullied areas were however marked on the maps and are shown on Figure 28.

Coastal landslides assumed to be caused by under-cutting from wave erosion were also excluded from the survey. Where the source of a landslide was adjacent to the coast but did not intersect the shoreline and was protected from wave erosion by a rock cliff, platform or bouldery debris, it was not classified as a coastal landslide.

3.2 Landslide Data

The landslide data comprises the mapped data and data tables in the map sheet reports. An example of a map sheet report and part of a map are given in Appendix B.

3.2.1 Map Data

The location of each identified landslide crown was recorded on the 1:5000 scale base map with a cross, and the centreline of any debris trail was marked with a line. Where there was no recognisable debris trail the presumed direction of downslope displacement was shown with a dot. The landslide crowns on each map sheet were given sequential numbers that were combined with the map sheet number to give each landslide in the inventory a unique number e.g. 9SWD442.

3.2.2 Data Tables

The following information on each landslide was recorded in each map sheet report data table.

(i) The year of the photographs on which the landslide was first observed and the year of the last preceding set of photographs on which the landslide could not be identified.

(ii) The width of the landslide scar as greater or less than 20 m wide. (1 = < 20 m and 2 = > 20 m). For the first 37 sheets (Table 1), greater and less than 5 m was first recorded and the 20 m criterion was added later.

(iii) The vegetation cover over the landslide source was recorded in the following four classes :

A = totally bare of vegetation
B = partially bare of vegetation
C = completely covered in grasses
D = covered in shrubs and/or trees

(iv) The ground slope angle across the landslide head, calculated from the distance between the steepest two adjacent contours on the 1:5000 scale map (see Section 7.3).

(v) A cross tag giving the reference number for any other landslide originating from the same source.

3.2.3 Relict Landslides

During mapping, landslides were divided into two groups: recent if they occurred within the time scale of the available aerial photographs and relict if they occurred earlier. Following digitisation relict landslides were defined more rigorously as explained in Section 4.2.

The scars of recent landslides have a distinctive light tone on aerial photographs and are generally bare of vegetation, being in vegetation classes A or B. The time period in which they occurred can be confirmed by reference to earlier aerial photography.

In comparison, relict landslides are covered in grass, shrubs or trees (vegetation classes C or D) but the ground still shows some clear characteristics of a landslide scar. They were mapped when a spoon-shaped depression with a sharp main and/or lateral scarps was either visible or could be reliably inferred from vegetation characteristics.

The following features were not mapped as relict landslides:

(i) broad depressions with smooth and rounded edges and no obvious main scarps. These features may have been formed by landslides but are too degraded to fit the criteria;

(ii) depressions that meet the criteria but are bounded on all sides by rock at the surface. This included scars on and at the crest of sea cliffs;

(iii) heads of incised drainage lines.

The mapped length of the relict landslide is usually the length of the depression. However, the mapped length was extended where displaced landslide debris could be reliably recognised downslope of the depression. Gully erosion downslope of a relict landslide was not included as part of the trail.

Each map sheet report included a separate paragraph describing in general terms the relict landslide scars observed. At some locations a number of small relict scars were present within a single large relict scar. This was reported by recording a cross tag to the large scar.

3.3 Data Recorded on the Map

Other data recorded on the 1:5000 scale base map, in addition to the landslide data, comprised :-

(i) The limits of development for the years 1945, 1964, 1973, 1981, 1987 and 1994 (Section 3.1.3);

(ii) Areas of gully erosion (Section 3.1.4);

(iii) Areas of cloud with the date;

(iv) Areas of shadow with the date;

(v) Areas without aerial photograph cover with the date;

(vi) Areas with a morphology that could be interpreted as the relict debris lobe from a single very large landslide such as a debris avalanche-flow, for later study. The locations are shown on Figure 28.

The legend used to record the above information is included in Appendix B.

3.4 Field Checking

Field checking of interpreted landslides was carried out by the survey team during three days of fieldwork. Locations visited were Lantau Island from Ngong Ping to Tung Chung (Sheets 9SE-B, 9SE-C, 9SE-D, 13NE-A), Shek Uk Shan to Lai Chi Chong (8NW-A, 8NW-C) and Cloudy Hill to the Pat Sin Leng Range (3SE-C and 3SW-D). Field clinometer measurement of the slope angle across the head of landslides was found to be generally within a few degrees of that measured from the 1:5000 scale contours.

3.5 Elevation Data

After the main API study elevation data for the crown and toe of each recorded landslide was taken manually in-house from the 1:5000 scale base maps. This data which was not recorded in the map sheet reports, was verified by manually rechecking 1325 landslides (about 5% of the NTLI total). Only 4% were found to be in error by more than 10 m. The records for those landslides where the elevation data was found to be incorrect were adjusted.

4. DIGITISATION

4.1 Map Data

The contract for digitisation of the NTLI maps was awarded to Advanced Business Inc. Ltd (ABI) on 15 January 1996. The contract included an initial two week period to undertake the trial digitisation of map sheets 8NWA, B, C, D. in order to refine the methodology specified in the Draft Contract Brief. Following these trials, the brief was finalised (Appendix C) and production digitisation into Microstation .dgn files was started at the end of January 1996.

The maps were digitised on a sheet by sheet basis to facilitate validation. As the first sheets were completed and checked it became apparent that there were a number of errors in the original API mapping. The most common of these were duplicate landslide numbers, missing landslides or landslide numbers and the definition of areas on the map by polygons that did not close. To rectify these problems, a data validation procedure was set up as an addition to the API mapping validation procedure that was already in place. The full validation procedure is outlined in Appendix D.

Following digitisation of a map sheet ABI performed basic checks on the data and returned a sheet summary and problem report with the digitised data. In house checks were also carried out and reported on a data capture validation form. Any problems with the data capture were returned to ABI for correction. Problems arising from the original API mapping were returned to DLWC for correction of the hard copy and rectification of the .dgn files in-house. To assist with these corrections ABI supplied a Microstation MDL module they had developed to ensure consistent data capture (Appendix E).

The final validated .dgn files for all map sheets were signed off on a data capture validation sheet and stored in Planning Division. ABI then merged each theme from the sheet files to form a number of .dgn files covering the whole of Hong Kong. The themes extracted were landslide scar locations, landslide text labels, gullied areas, relict debris lobes, development boundaries, no aerial photograph cover and cloud areas, shadow areas. The computer files are listed in Appendix F. These data sets were given to Intergraph for cleaning and preparation for use in the GIS analysis.

As part of the GIS analysis Intergraph derived other data with coverage of all Hong Kong including landslide isopleths, undeveloped terrain in 1994 and the distribution of relict and recent landslides. Intergraph also created a digital terrain model of Hong Kong based on the Land Information Centre 1:20,000 scale topographic maps with a contour interval of 20 m. The most significant computer files containing this cleaned and derived data are listed in Appendix F.

4.2 Data Tables

The landslide data tables from the API sheet reports were digitised in-house, checked and entered into Dbase database program as SLIDEOO3.DB data table (later renamed BASIC.TXT in the Geoscience Data Base). The elevation data (Section 3.6) was also entered into this table. The data was then linked to the .dgn landslide graphic elements to form the first part of the NTLI Geographic Information System (GIS).

A second data table was then derived from GIS and database queries. This includes; the height (H) and length (L) of each landslide scar, the H/L ratio, the geological unit within which the landslide source is located, the NTLI geological group to which this belongs, the vegetation category, the GASP terrain classification landform and erosion classes in which the source occurs, and the relict or recent status of the landslide. Relict landslides were defined as those with vegetation cover C or D in the years 1945, 1963, 1967, or 1972. This definition of relict and recent landslides differs slightly from that used during API mapping (Section 3.2.3) and has been used for the 1:20,000 and 1:50,000 scale NTLI maps. It is also used for the first analysis of both the data tables presented in Evans et al 1997.

Using the tables in the map sheet reports the day and month of the photography taken each year on each sheet was digitised. This was used to derive a data table named PHOTO_D that gave the day and month of the photography on which each slide was observed. This was used to allocate each landslide to a rainy season for analysis of the relationship between rainfall and natural terrain landslides (Evans 1997).

5. RECOGNITION FACTOR SURVEY

The NTLI was compiled from high level aerial photographs which have a small scale and limited resolution. Some landslide scars will have been missed and other features, such as small fill slopes, excavations, paths and graves will have been incorrectly identified as landslide scars. This would have been most significant for smaller features on slopes facing away from the centre of the photograph and in areas of shadow. To quantify these types of errors DLWC were asked to carry out a supplementary API study - the recognition factor survey. The study brief and a short report on the methodology and results of the survey is given in Appendix G.

Interpretation of low level aerial photographs was carried out in areas for which there was both high and low level coverage within one year of each other. The photography used ranged from 1973 to 1994. The survey, which covered parts of ten map sheets in areas of varying bedrock geology, simply involved recording the number of recent landslides mis-classified or not recorded by the original NTLI survey. Six hundred and fifteen recent landslides were reviewed on the low level survey. This represents about 7% of the total number of recent landslides in the NTLI. Of these, 5.7% were found to have been mis-identified as natural terrain landslides while 2.6% were landslides with more than one source that had been recorded as a single landslide. In the area where these 615 landslides were resurveyed, 147 new landslides were identified. A summary of this data is given in Table 2. It shows that overall about 20% of recent landslides visible on the low level aerial photographs were missed in the original survey.

After the newly identified landslides were added, the proportion of the total number of landslides on any one sheet only changed by a maximum of 1.6%. This indicates that although the high level survey for the NTLI may have missed significant numbers of landslides it is a suitable database for relative hazard identification and susceptibility mapping.

A further recognition factor survey was carried out for two areas on Lantau Island where a large number of landslides had occurred in 1993 and which had been the subject of a detailed ground survey (Wong et al 1996). The ground survey and low level aerial photograph interpretation identified 67 landslides against the 50 in the NTLI. This means that about 25% of the 1993 recent landslides in those areas were missed by the NTLI survey.

6. REVEGETATION SURVEY

Landslide vegetation cover is used to differentiate between recent and relict landslides but can also be used to estimate the time interval between when the landslide occurred and the year that it is first seen on the aerial photographs. To help quantify the rate of revegetation another supplementary API study was carried out by DLWC. The brief for this study and report on the results of the study are at Appendix G together with an example of a basic data sheet.

A total of 95 landslides were selected from areas with good successive annual photography cover and with different types of bedrock, aspect, topography, vegetation and landslide size. This data was recorded for each landslide together with observations of the % vegetation cover on both the landslide source and trail. The number of observations at individual landslides varied from 3 to 22 over time periods of 8 to 49 years.

Vegetation cover was observed to vary considerably with the season in which it was recorded. The averaged results for all the landslides surveyed are given on Figure 29. These show that revegetation was much faster for the trail than the source. In general a landslide trail had revegetated 70% in 5 years, 90 % by 8 years and 100% by 18 years. A landslide source revegetated 70% in 20 to 30 years and after 35 years was often no more than 90 % revegetated. Further analysis of the study results may allow further subdivision to reflect the influence of such factors as bedrock, aspect, slope angle and topography.

7. LIMITATIONS OF THE NTLI

7.1 Recognition

The general limitations in the resolution, time period and coverage of the aerial photographs used for the study are detailed in Section 3.1.2. These limitations will have resulted in some landslides that occurred from 1945 to 1994 not being recorded. Even in areas with good aerial photograph cover the recognition factor survey carried out for the period 1973 to 1994 indicated that 20% to 25% of recent landslides may have been missed (Section 5). For earlier years in which photography was less frequent and often had poorer resolution the detection rate for recent landslides may have been even lower.

No recognition factor has been established for relict landslides. Due to the lack of tonal contrast of these scars on high level aerial photographs and the more subjective nature of their recognition, it is likely that they had a lower recognition factor than the recent landslides. It is probable that many more relict landslides would have been recognised on low level aerial photographs as is indicated by several recent detailed site assessments of natural terrain.

7.2 Scale

The NTLI was compiled from aerial photographs with a nominal scale of 1:20,000 to 1:40,000 that were viewed through X3 lenses. The base map scale of 1:5000 was therefore appropriate to the scale of data collection. However due to this basic scale limitation, and in order to reduce mapping time, the width of each landslides was only recorded in terms of a width class of greater or less than 20 m. For some map sheets (Table 1) width was also recorded in classes of greater or less than 5 m.

The occurrence of landslides on natural terrain is often controlled by subtle variations in topography which are not reflected on 1:5000 scale maps. The recorded location of an individual landslide should thus only be used to identify its approximate location. This generally is not sufficiently accurate for analysis with respect to the geomorphological factors that may have caused the landslide. For such analysis it is appropriate to more accurately relocate the landslide on larger scale plans such as the 1:1000 series.

7.3 Slope Angle Classes

The slope angle at the source of each landslide was assessed by measuring the distance between contours on the 1:5000 scale base maps to the nearest 1 mm for angles less than 24° and 0.5 mm for angles greater than 24°. The result of using this technique was that the effective upper limit to measurement was 45°, slopes of less than 11° were not subdivided and slope angles in between became artificially grouped in the classes <11°,11°-13°,13°-15°,15°-16°,16°-18°,18°-22°,22°-24°,24°-27°,27°-30°,30°-34°,34°-39°,39°-45°,>45°. These span a variable number of degrees rather than being an unbiased record of the slope to the nearest degree. The slope angle at the source of a number of landslides was obtained with clinometer during field checking and in general the results were within a few degrees of that recorded from the map.

For initial analysis, some of the slope angle classes were combined (Evans et al 1997). For analysis of landslide susceptibility they were superseded by slope angle groups with regular 5° increments taken from a digital elevation model of Hong Kong which was created for the NTLS from data derived from a 1:20,000 scale topographic map with 20 m contour intervals. This relatively coarse data set was used due to the relative ease of data input and processing compared with the alternative scales of 1:5000 or 1:1000. However, in any application of the NTLI analyses the appropriate slope angle to use should be obtained from a 1:20,000 scale topographic map. This slope angle may not be appropriate for other aspects of the assessment of a small site.

7.4 Date of Occurrence

The date of the photography on which each landslide was first identified was recorded, as was the date of any previous photograph on which it was not present (Section 4.2). These dates indicate the time period during which the landslide occurred. This can be a relatively long period where there are large gaps in the photographic record such as between 1945 and 1964 and 1972.

A date period cannot be given for landslides first identified on the earliest photography to cover a sheet unless the age of the scar is assumed. Such landslides are mainly relict but include some recent landslides.

Landslides after 1994 are not recorded in the NTLI.

7.5 Exclusions

Apart from landslides in coastal areas and gullied terrain (Section 3.4.1), other landslides not recorded due to limitations of the survey techniques include:-

(i) Landslides with small displacements that are only indicated by subtle variation in topography and tension cracks. Such landslides were observed on the ground during the field checking at Pat Sin Leng. Similar large tension cracks have been observed on low level aerial photographs near Po Kat Tsui Village, Fanling.

(ii) Degraded scarps that may be interpreted as the scars of very large creeping landslides such as at Area 19 Tuen Mun.

7.6 Classification

Most of the landslides recorded in the NTLI are probably both channelised and open slope debris slides, debris flows, complex debris slide-flows, or composite debris slide-flow-falls (Varnes and Cruden 1996). In addition to these typical natural terrain landslides a number of other exceptional types of landslides occur on natural terrain in Hong Kong. Some of these that have been recorded in the inventory as landslides or relict debris lobes include :

(i) a very large deep rock slide scar at Kwai Tau Leng is recorded as a landslide.

(ii) relict landslides with a bouldery ridge forming the trail could be the scar from small rock avalanches. In some cases these were recorded as both landslides and relict lobes.

(iii) A very large wide relict landslide above Tai O village on Lantau was recorded as a debris lobe but not a landslide.

Despite these variations all the landslides in the NTLI are represented on the map in the same way with a cross representing the landslide crown and a line depicting the debris trail. This is appropriate for most of the natural terrain landslides in the inventory which have relatively small sources and long narrow trails with a variable length. However exceptional landslides cannot generally be identified in the NTLI. In particular, the NTLI will not reflect variations in volume and the significant change of hazard that this represents. A relatively small volume landslide that is likely to have little consequence has been recorded in the same way as a considerably larger event.

On the basis of the recorded data NTLI landslides can only be subdivided on the basis of trail length and the crude width and vegetation cover classes. The vegetation classes are used to define relict and recent landslides as outlined in Section 7.7. The width classes can be combined with trail length to identify a sub-set of larger landslides. Trail length may also help to indicate whether or not the debris from a landslide became channelised. A longer trail, particularly when it coincides with a drainage line, probably indicates channelisation.

7.7 Relict and Recent Landslides

Relict and recent landslides are defined on the basis of vegetation cover and year of observation (Section 3.3). This division is fundamental to analysis of the inventory. A recent landslide can be observed on a photograph, the date period of its occurrence can be established and any thin debris deposits and trails can be easily identified. Relict landslide scars in contrast are overgrown and degraded and may require considerable interpretation to identify them. Thin debris deposits in a trail will be overgrown and very difficult to identify from aerial photographs. All that can be identified from API is a linear depression assumed to have been the source of a landslide and any thick debris deposits immediately downslope. Thus the trail length recorded for relict landslides is a different property to that of recent landslides. Trails of relict landslides may indicate a linear depression, a convex pile of debris or a bouldery linear ridge.

The date of occurrence of relict landslides cannot be established although the revegetation survey suggests that they occurred more than 20 years before the date the landslide was first recorded. They could be the scars of landslides that occurred hundreds of years previously. Further detailed investigations are needed to establish an age range for relict landslides.

8. DOCUMENTATION

8.1 The Natural Terrain Landslide Inventory

The Natural Terrain Landslide Inventory is now available for reference in the Civil Engineering Library as a series of 1:20,000 scale maps showing relict and recent landslides. This can be a useful indicator of the presence of past landsliding near a site but should always be supplemented with detailed low level API to bring it up to date, better classify the landslides and understand the history and geomorphology of slopes adjacent to a site. The absence of relict or recent landslides recorded on a slope does not necessarily indicate a low susceptibility to landsliding. The intense rainfall that triggers landslides in Hong Kong is often very localised and the absence of recorded landslides may be due to the absence of heavy rain at that site within the timescale that a landslide scar can be recognised at the site.

The above observations and the limitations of the NTLI discussed in Section 7 make it important that the cautionary notes attached to the maps should always be attended to. These read as follows :-

IMPORTANT NOTES

The landslides shown on this map were identified by interpretation of high-altitude aerial photographs taken during the period 1945 to 1994. Some landslides will have been missed for the following reasons:

> *The scale and resolution of the aerial photographs. Additional landslides may be identifiable using low-altitude aerial photographs.*
>
> *High-altitude aerial photography was not carried out for the period 1946 to 1963 inclusive.*
>
> *Aerial photographs are not available for certain areas in some other years*
>
> *Some areas are obscured by cloud cover or shadow in certain years*

This map should only be used to provide a general indication of the distribution of landsliding on natural terrain and should not be relied on for assessments of individual sites. Such assessments should include amongst other things, a through review of all available high- and low-altitude aerial photographs.

Requests for further data about this map should be addressed to:

> *Chief Geotechnical Engineer/Planning*
> *Geotechnical Engineering Office*
> *11th Floor, Civil Engineering Building,*
> *101 Princess Margaret Road,*
> *Homantin, Kowloon,*
> *Hong Kong*

8.2 Sheet Reports and Maps

The original hand drawn 1:5000 scale map sheets and map sheet reports are held in Planning Division. A set of copies are available for reference by interested parties.

8.3 Geographic Information System

A limited part of the NTLS geographic information system is now prepared for routine queries and has been installed as part of the Planning Division Geoscience Database. The specification for this is in Appendix F. The data available is the landslide locations and numbers linked to the basic and derived data tables described in Section 4.2. The basic information with the derived relict or recent status of the landslides will be incorporated into the GEO Slope Information System (SIS).

The whole NTLS GIS that has been used for analysis is a collection of basic, cleaned and derived computer files sized more than 4 gigabytes. This is held in Planning Division for further development. Some of the more significant computer files are listed in Appendix F.

With regular annual updating and ongoing correction of the NTLI it will form an up to date listing of all identified natural terrain landslides in Hong Kong. With additional data recorded for some of the landslides the NTLI would become a more broad based database of natural terrain landslides in Hong Kong. This data set would not be suitable for the rigorous statistical analysis carried out on the existing NTLI.

8.4 Analysis

Analysis of the NTLI is ongoing. Initial general analyses are presented in Evans et al (1997). Analysis of landslide distribution with respect to rainfall is in Evans (1997). Further analysis with respect to susceptibility to landsliding and landslide frequency is in Evans and King (1997).

9. REFERENCES

Cruden,D.M. & Varnes,D.J. (1996). Landslide Types and Processes. In: R.L.Shuster and A.K.Turner(eds), Landslides, Investigation and Mitigation, Transportation Research Board Special Report 247, National Academy Press, Washington. pp 36-75.

Evans,N.C.(1997). Natural Terrain Landslide Study: Preliminary Assessment of the Influence of Rainfall on Natural Terrain Landslide Initiation. Geotechnical Engineering Office, Hong Kong, Discussion Note DN 1/97, 28p.

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Wong,H.N., Chen,Y.M. & Lam,K.C.(1996). Factual Report on the November 1993 Natural Terrain Landslides in Three Study Areas on Lantau Island. Geotechnical Engineering Office, Hong Kong, Special Project Report, SPR 10/96

LIST OF TABLES

Table 1: Map Sheets with Non-standard Survey

Pilot Study Sheets (revised in main study)			
3SW-D	9SE-B	11SE-C	
Surveyed with low level 1967 photographs			
11NE-D	11SW-A	11SW-C	11SW-D
11SE-A	11SE-B	11SE-C	11SE-D
15NW-B			
Surveyed with 1995 photography			
3SW-D			
The 5 m width criterion also recorded			
2SE-A	2SE-C	2SW-B	2SW-C
2SW-D	5NE-B	5NE-C	5NE-D
5SE-A	5SE-B	5SE-C	5SE-D
5SW-D	6NE-A	6NW-A	6NW-B
6SW-C	6SW-D	8NE-A	8NE-B
8NE-C	8NE-D	8NW-D	8SE-A
8SE-B	8SE-C	8SE-D	8SW-B
8SW-D	9SE-A	9SE-C	9SE-D
9SW-B	9SW-C	9SW-D	13NE-B
13NE-C			

Table 2 - Results of the Recognition Factor Study

Sheet No.	NTL Re-sampled	Proportion of total	Mis- identified		Sources missed		New NTL	NTL missed	New NTL sheet sample	Proportion of new total	Change in proportion
	No.	No.	No.	%	No.	%	No.	%	No.	%	%
3NW-D	5	0.8	0	0	0	0	3	37.5	8	1.0	+ 0.2
4SW-A	8	1.3	1	12.5	0	0	4	33.3	12	1.6	+ 0.3
6SE-C	46	7.5	1	2.2	1	2.1	6	11.5	52	6.8	- 0.7
6SE-D	4	0.6	0	0	0	0	0	0	4	0.5	- 0.1
6SW-A	153	24.9	4	2.6	11	6.7	47	23.5	200	26.2	+ 1.3
7NW-A	81	13.0	4	4.9	5	5.8	15	15.6	96	12.6	- 0.4
8NW-A	30	4.8	0	0	0	0	22	42.3	52	5.5	+ 0.7
9SW-D	138	22.4	9	6.5	1	0.7	33	19.3	171	22.4	0
9SE-D	67	10.9	12	17.9	0	0	9	11.8	76	10	- 0.9
13NE-A	83	13.5	6	7.2	1	1.2	8	8.8	91	11.9	- 1.6
Total	615		35	5.7	19	3.0	147	19.3	762		

LIST OF FIGURES

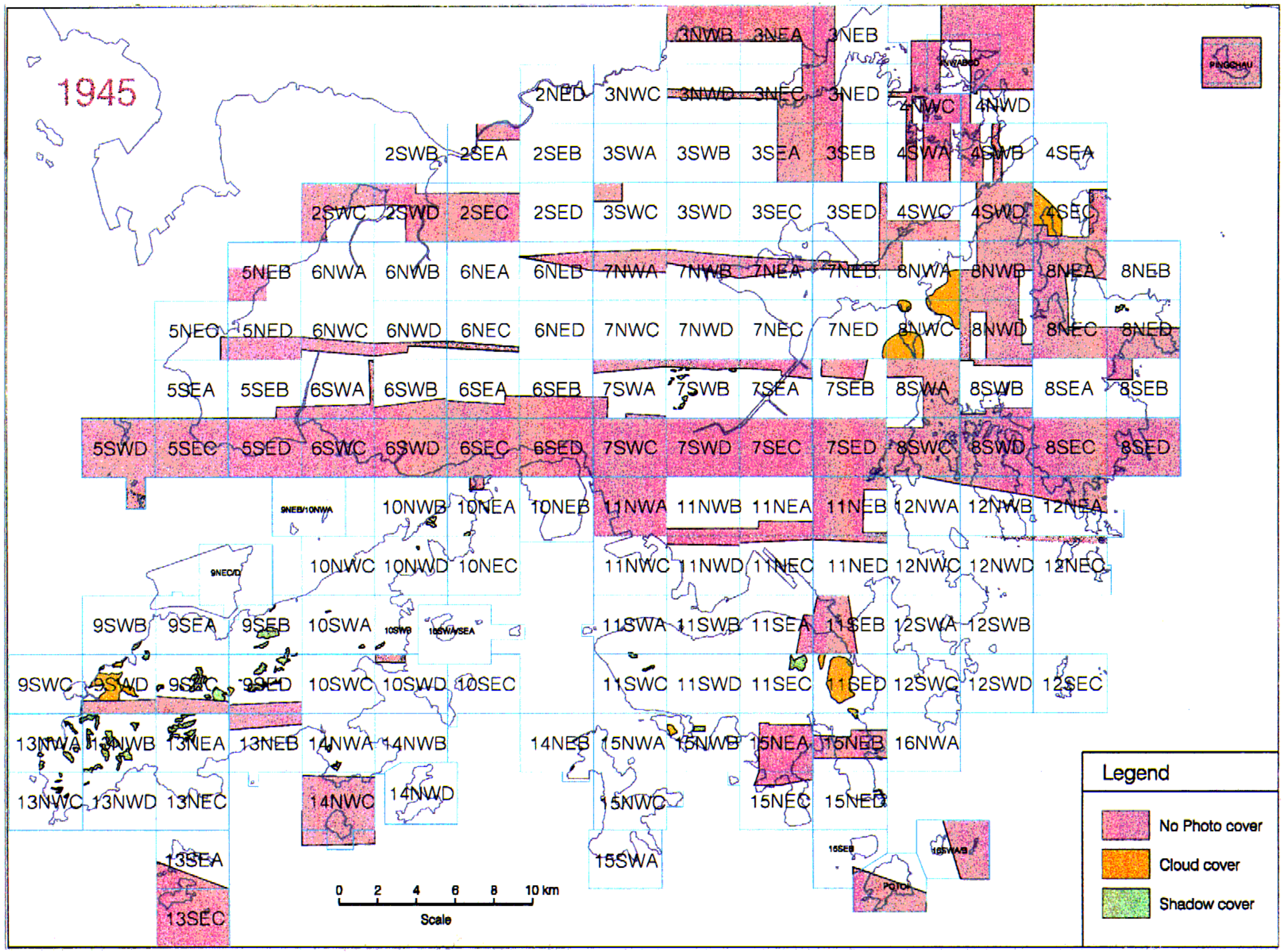


Figure 1 - Aerial Photograph coverage used for 1945 Survey

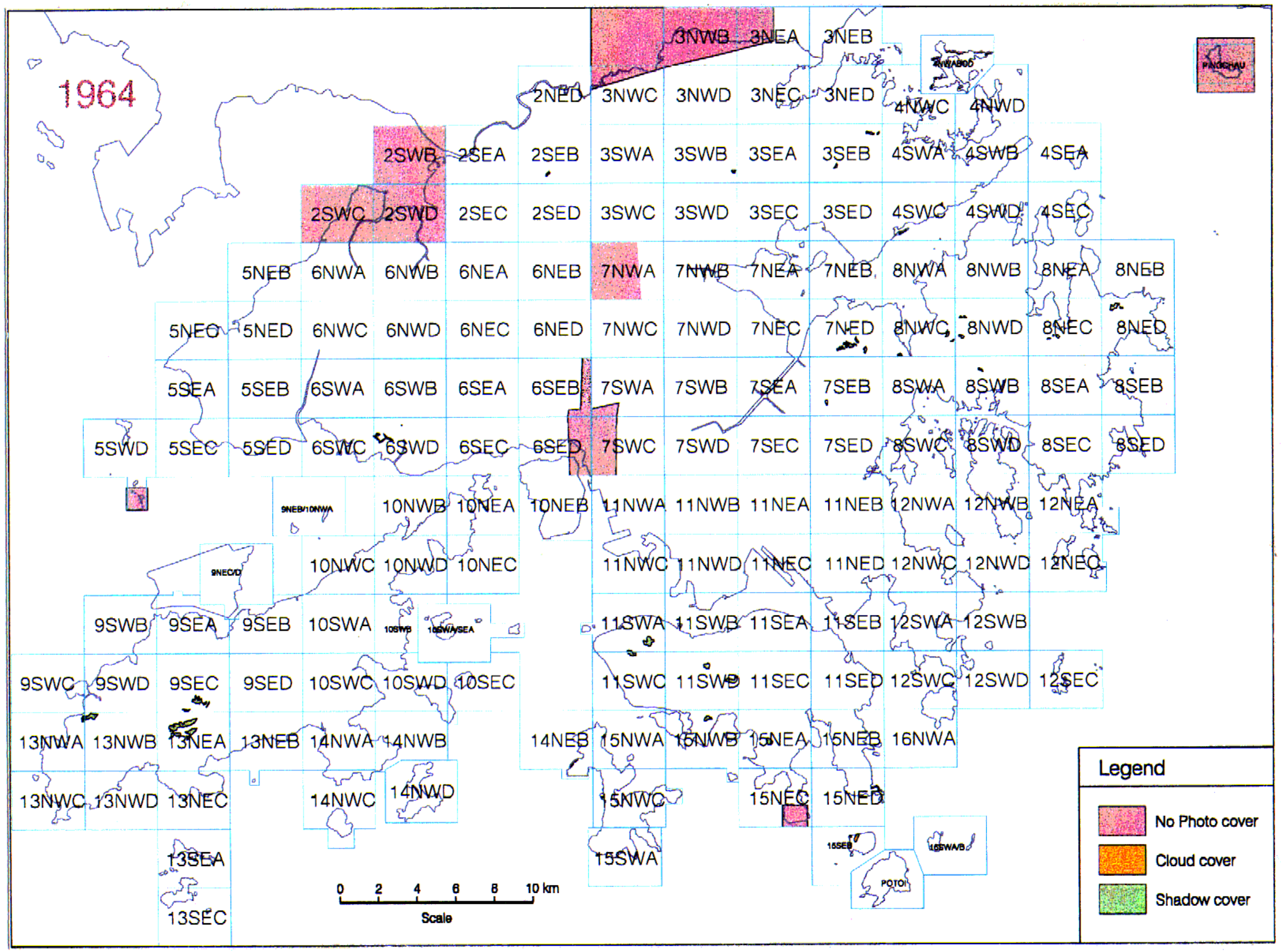


Figure 2 - Aerial Photograph coverage used for 1964 Survey

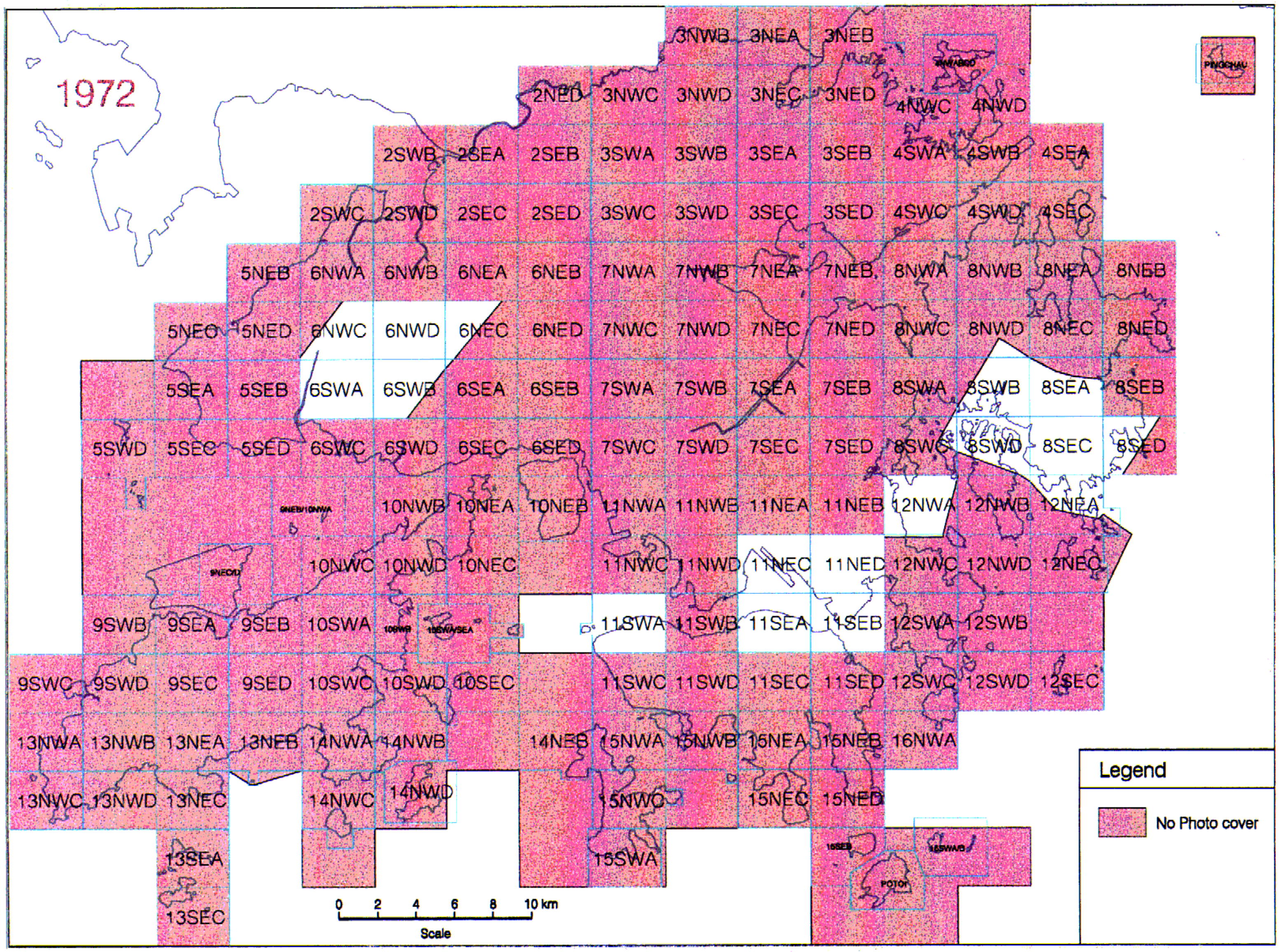


Figure 3 - Aerial Photograph coverage used for 1972 Survey

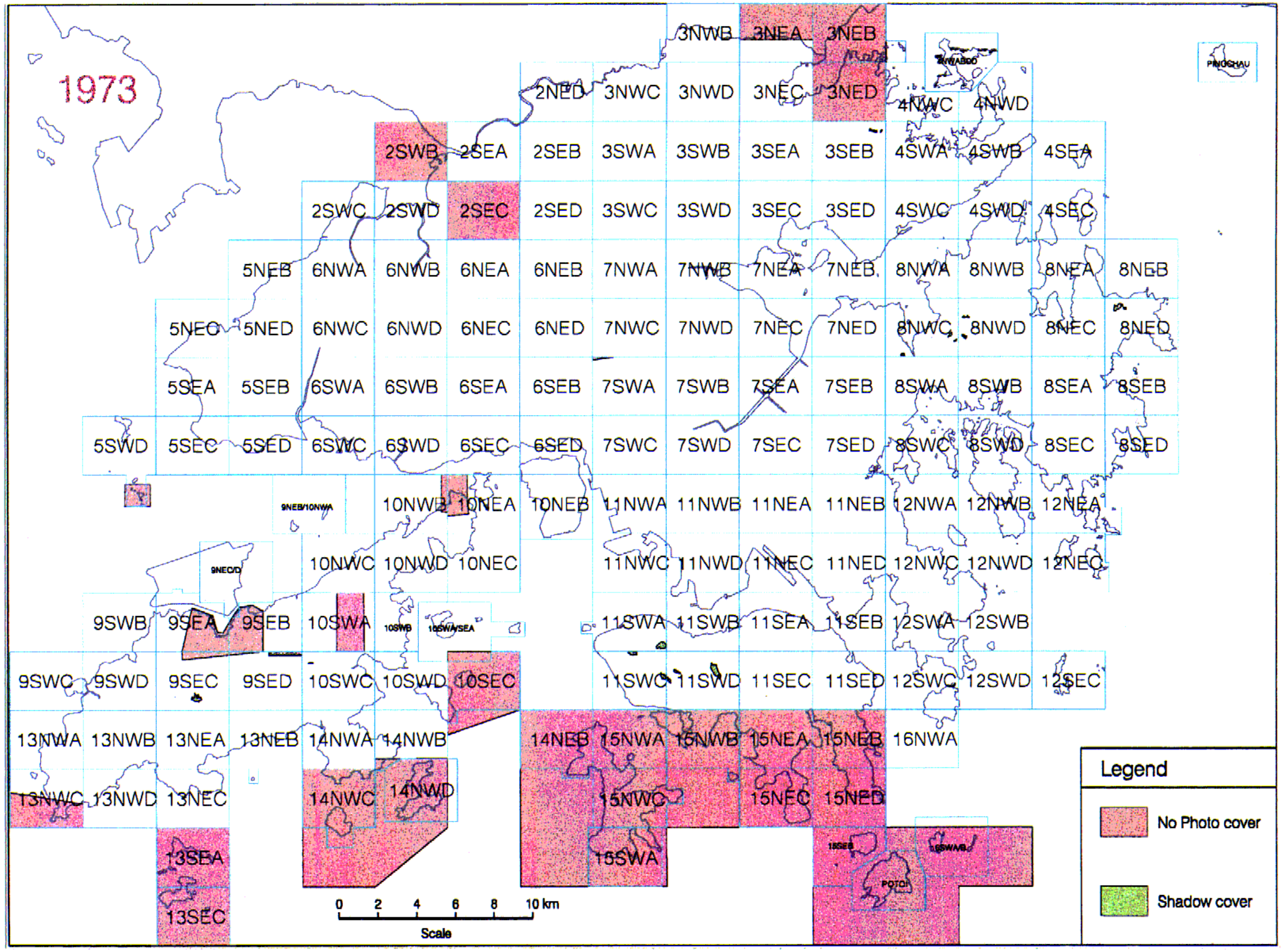


Figure 4 - Aerial Photograph coverage used for 1973 Survey

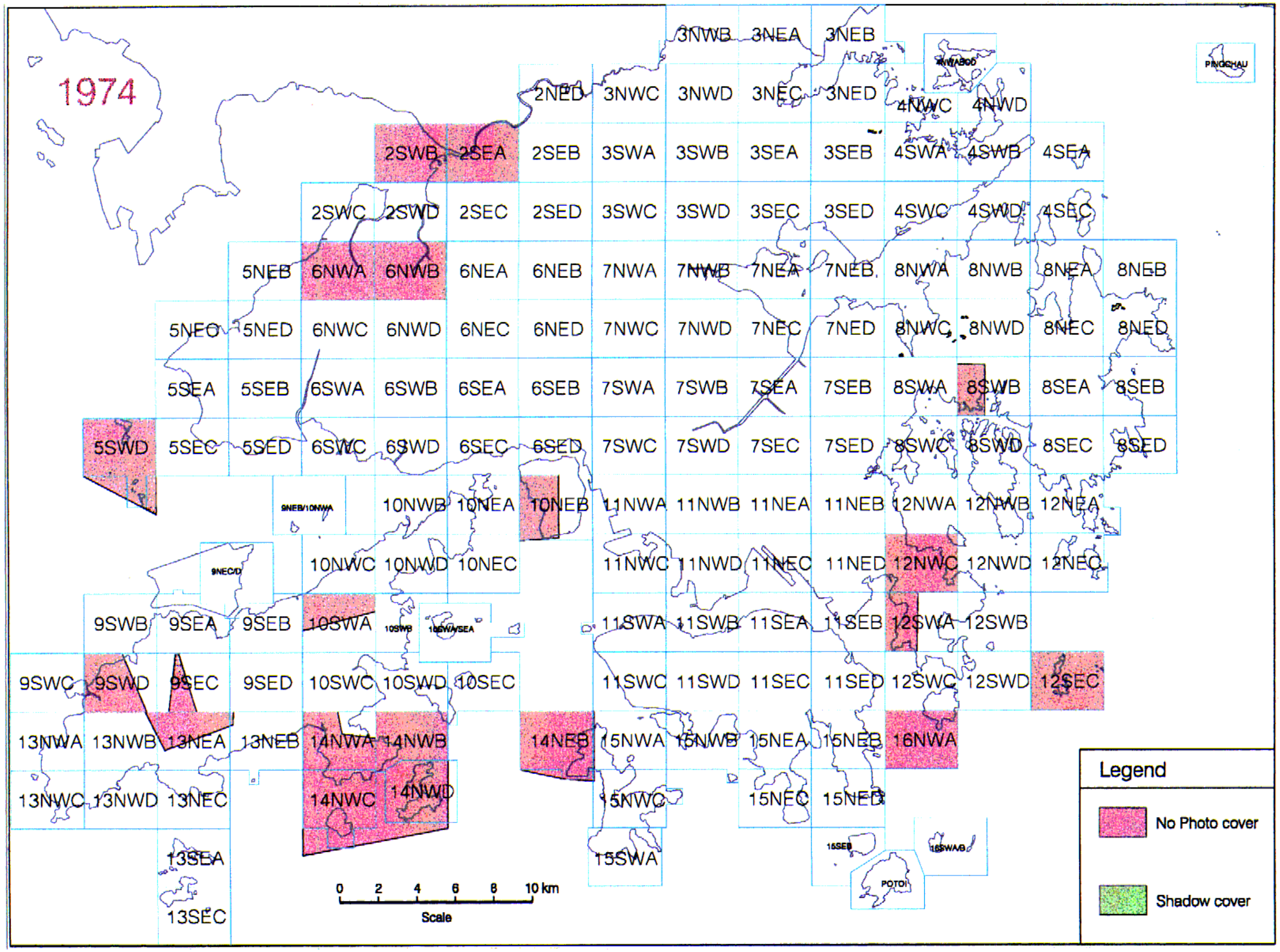


Figure 5 - Aerial Photograph coverage used for 1974 Survey

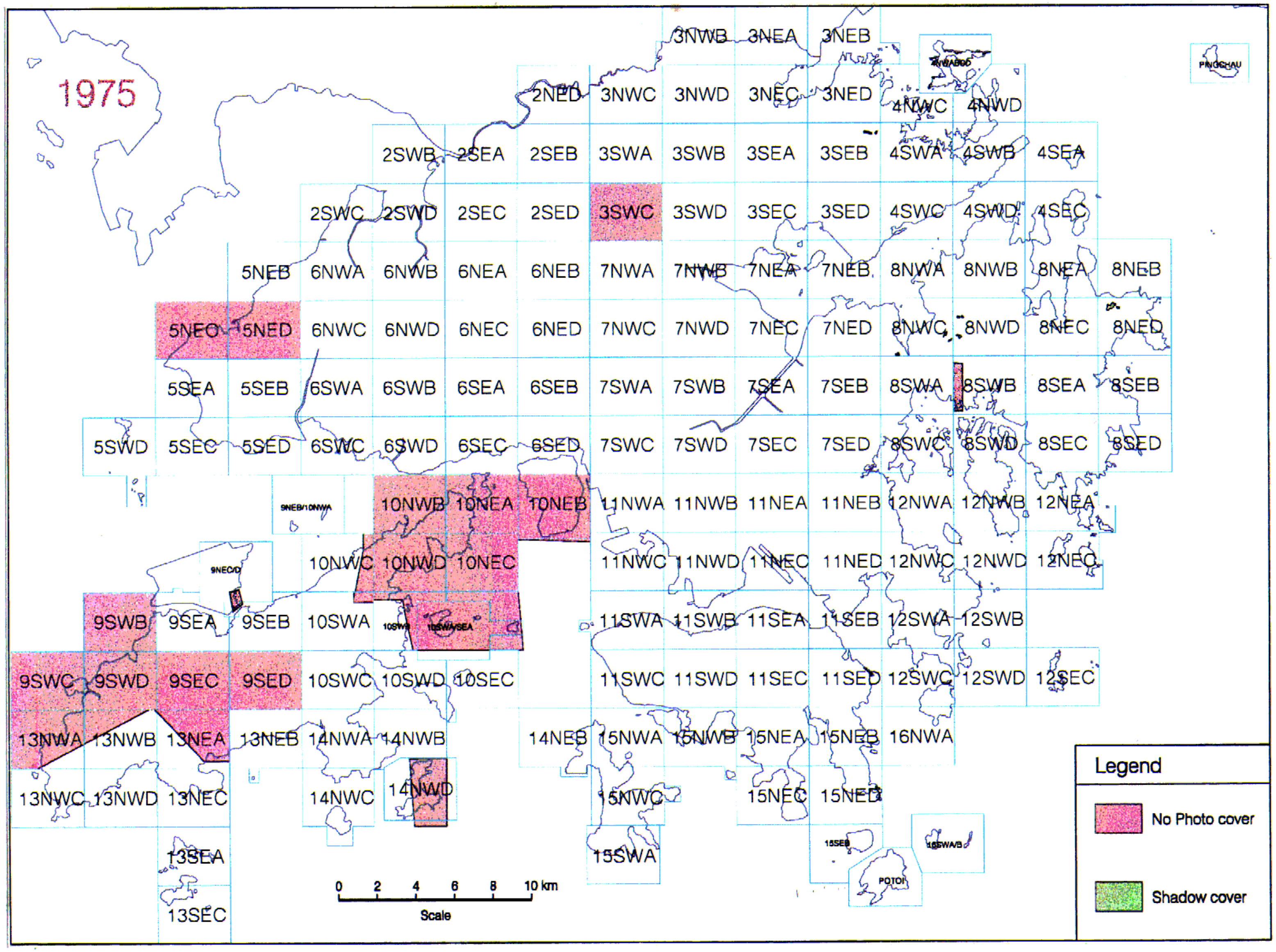


Figure 6 - Aerial Photograph coverage used for 1975 Survey

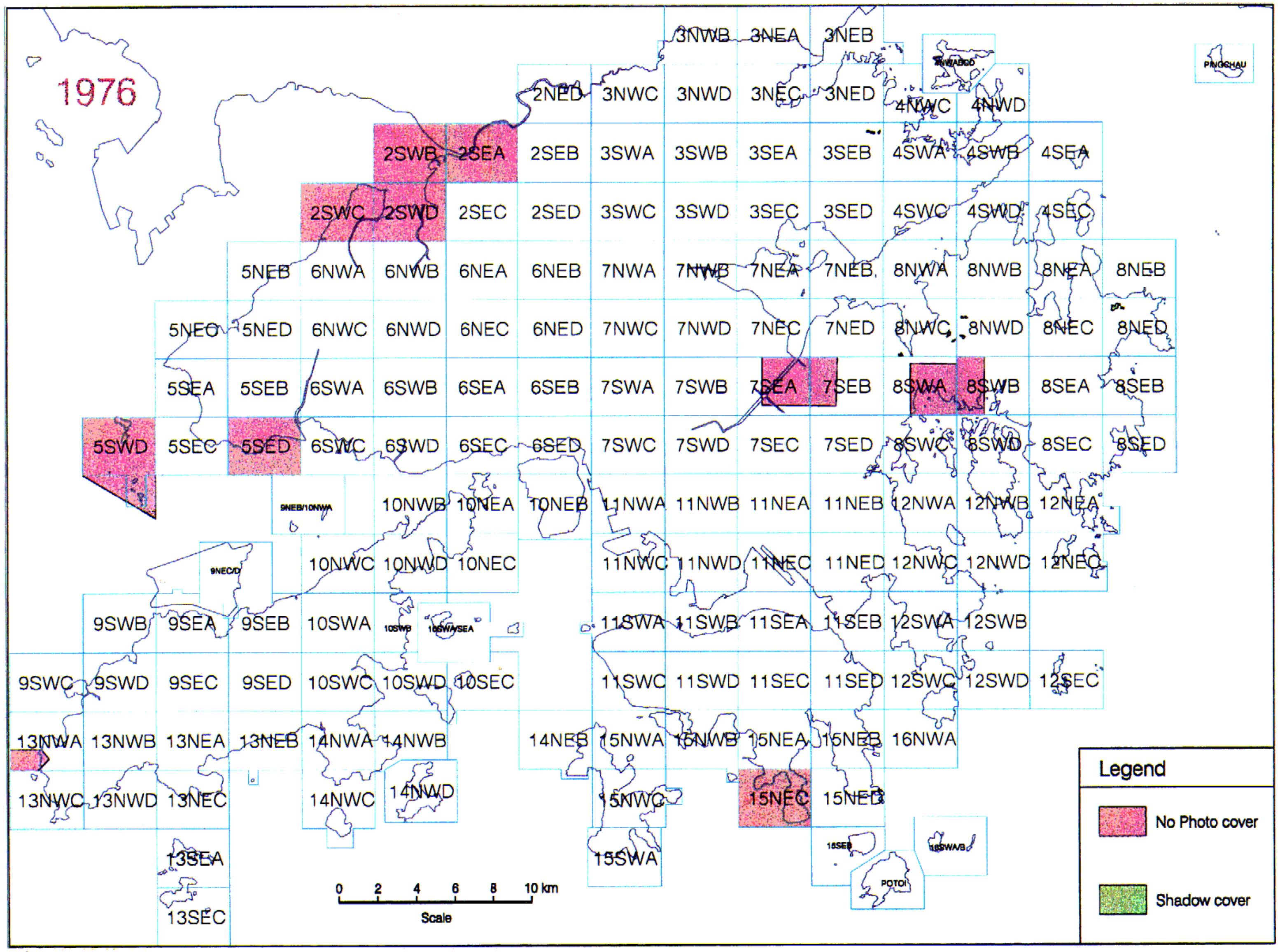


Figure 7 - Aerial Photograph coverage used for 1976 Survey

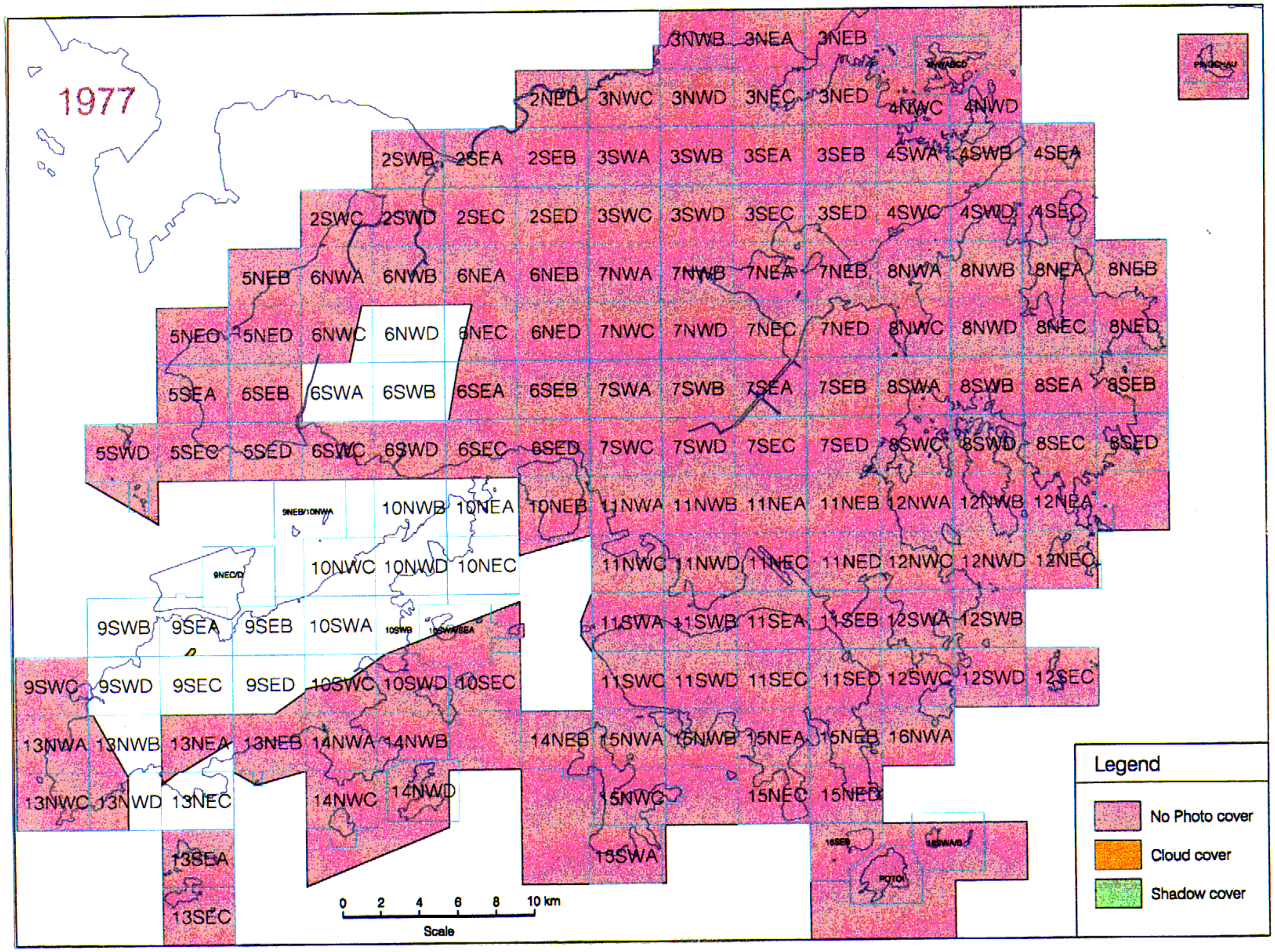


Figure 8 - Aerial Photograph coverage used for 1977 Survey

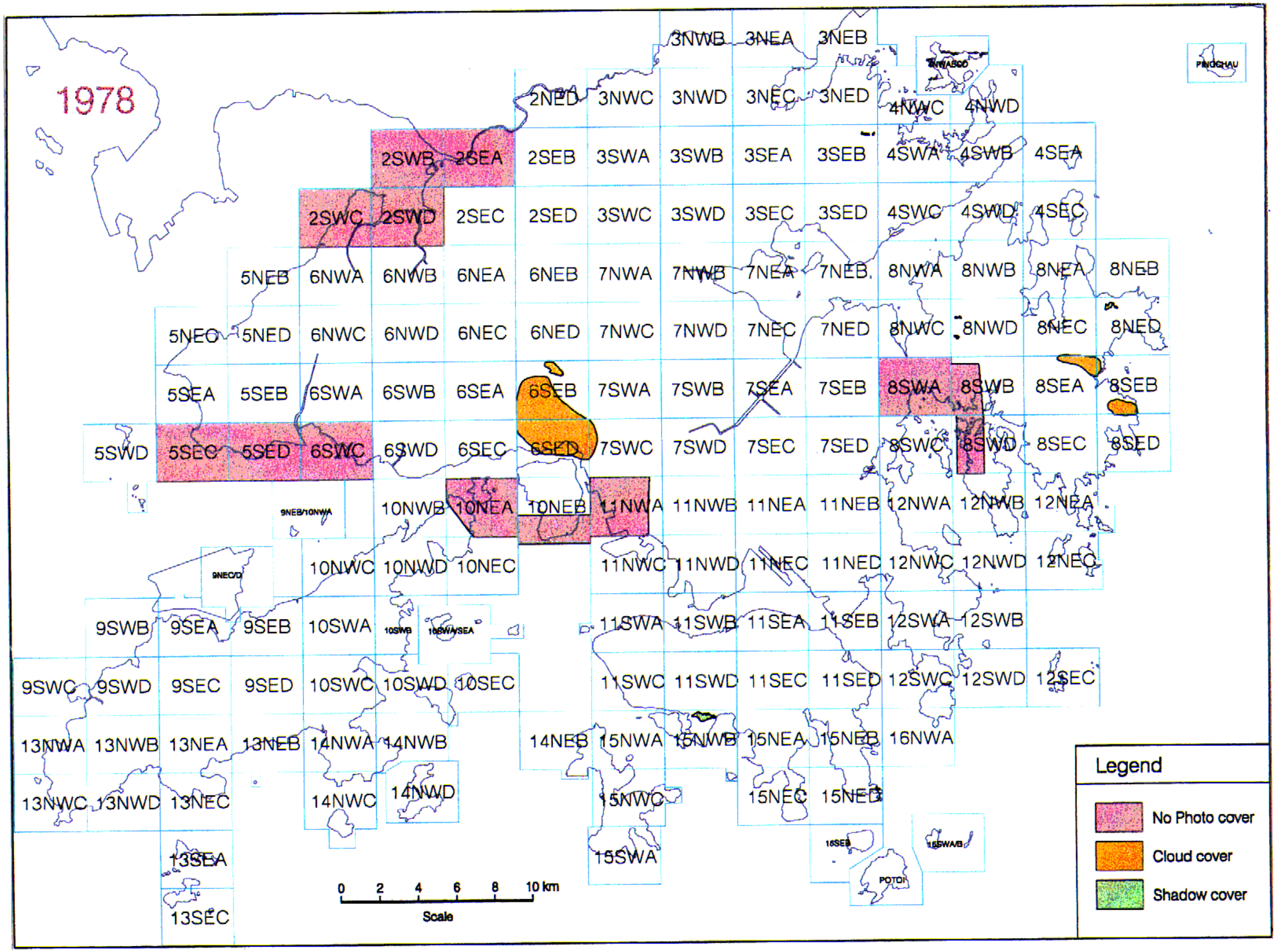


Figure 9 - Aerial Photograph coverage used for 1978 Survey

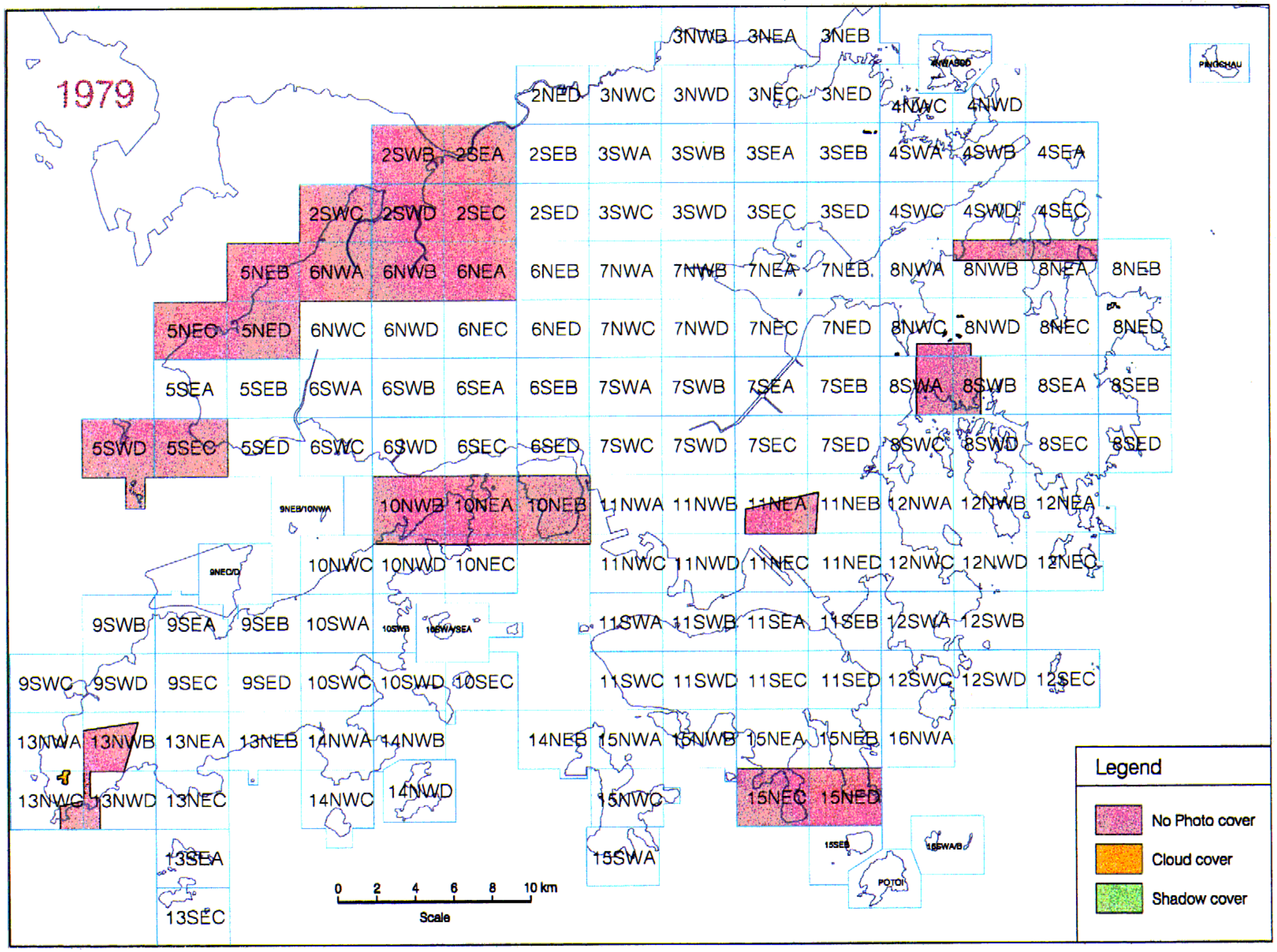


Figure 10 - Aerial Photograph coverage used for 1979 Survey

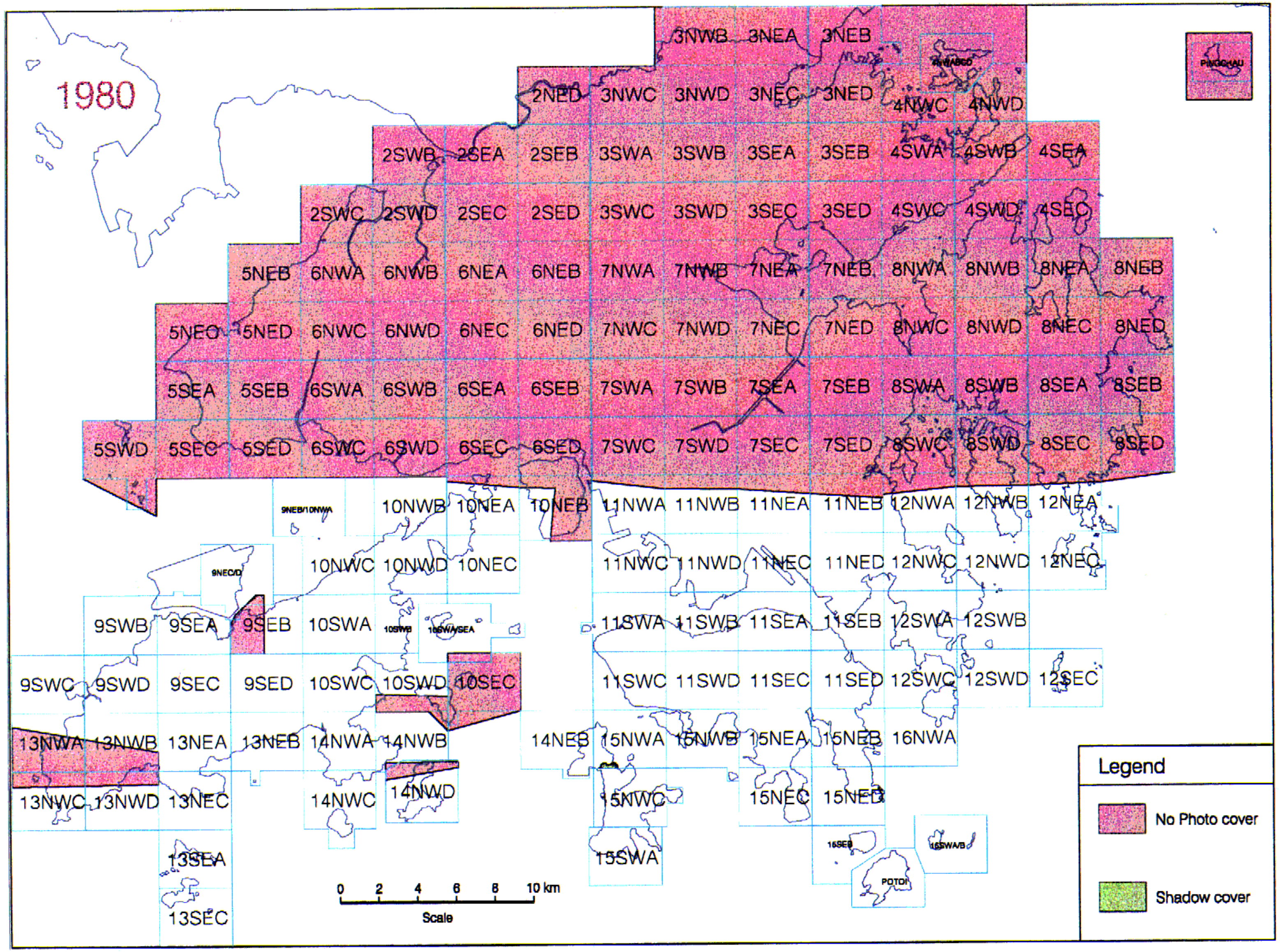


Figure 11 - Aerial Photograph coverage used for 1980 Survey

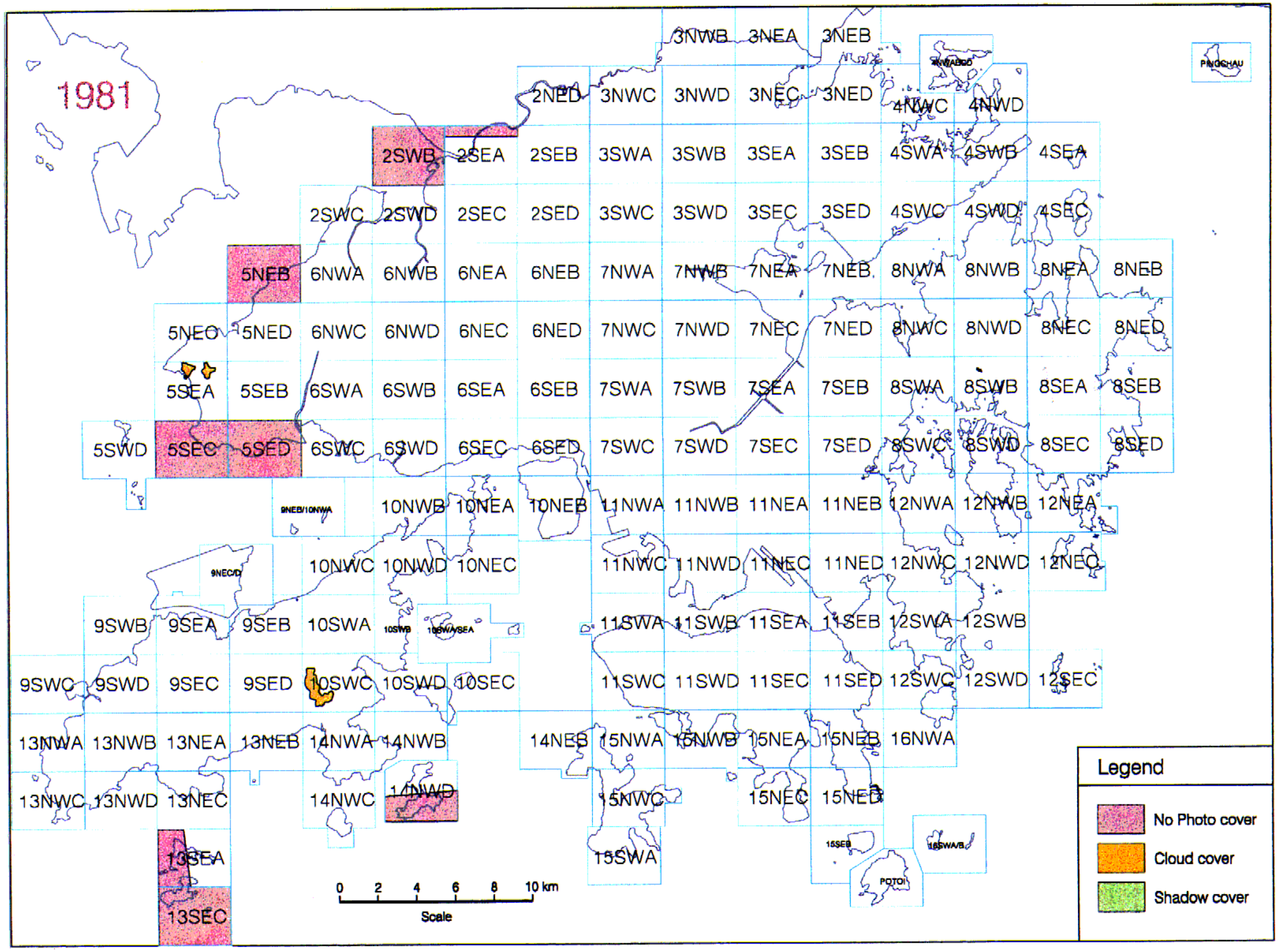


Figure 12 - Aerial Photograph coverage used for 1981 Survey

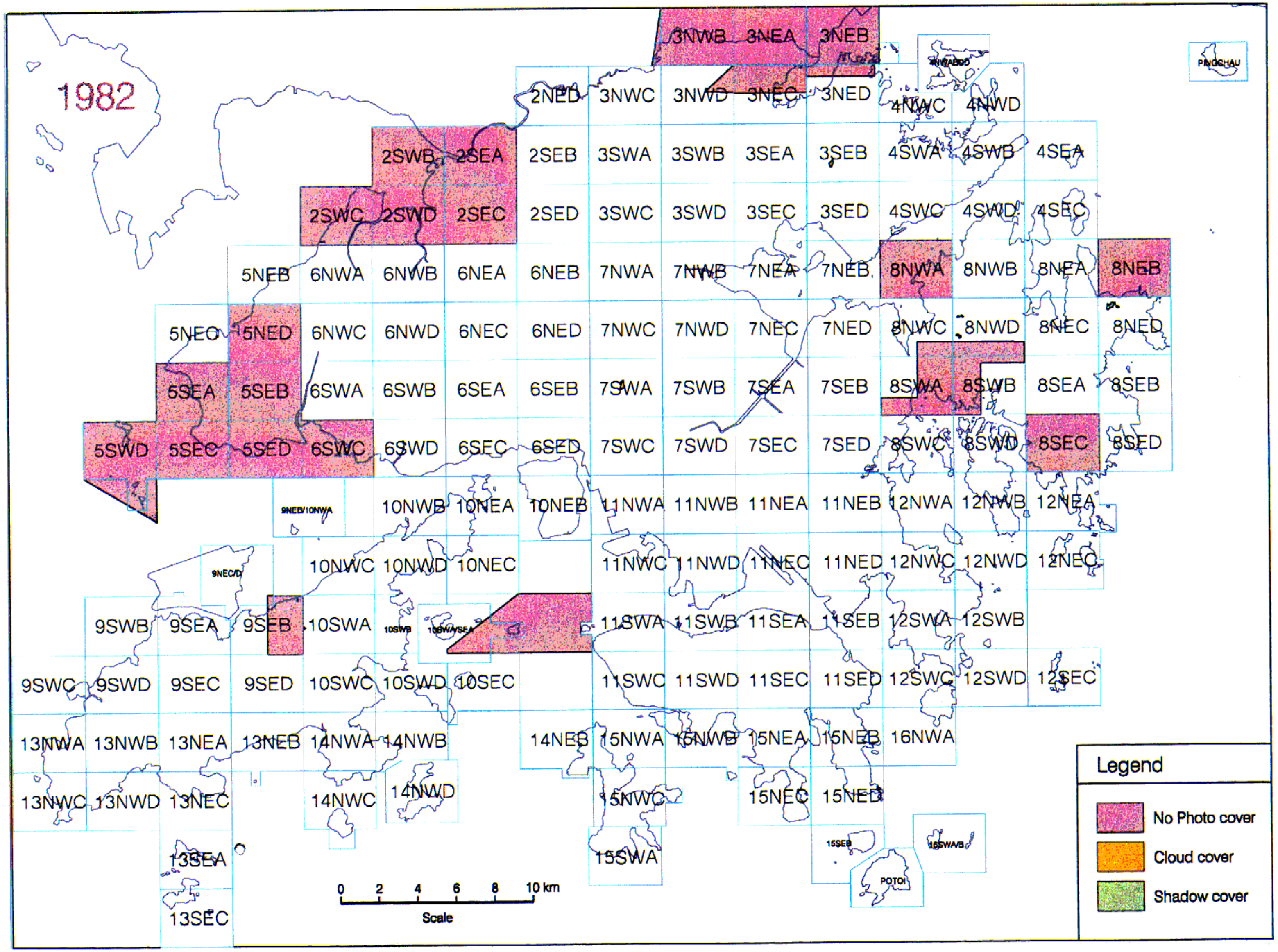


Figure 13 - Aerial Photograph coverage used for 1982 Survey

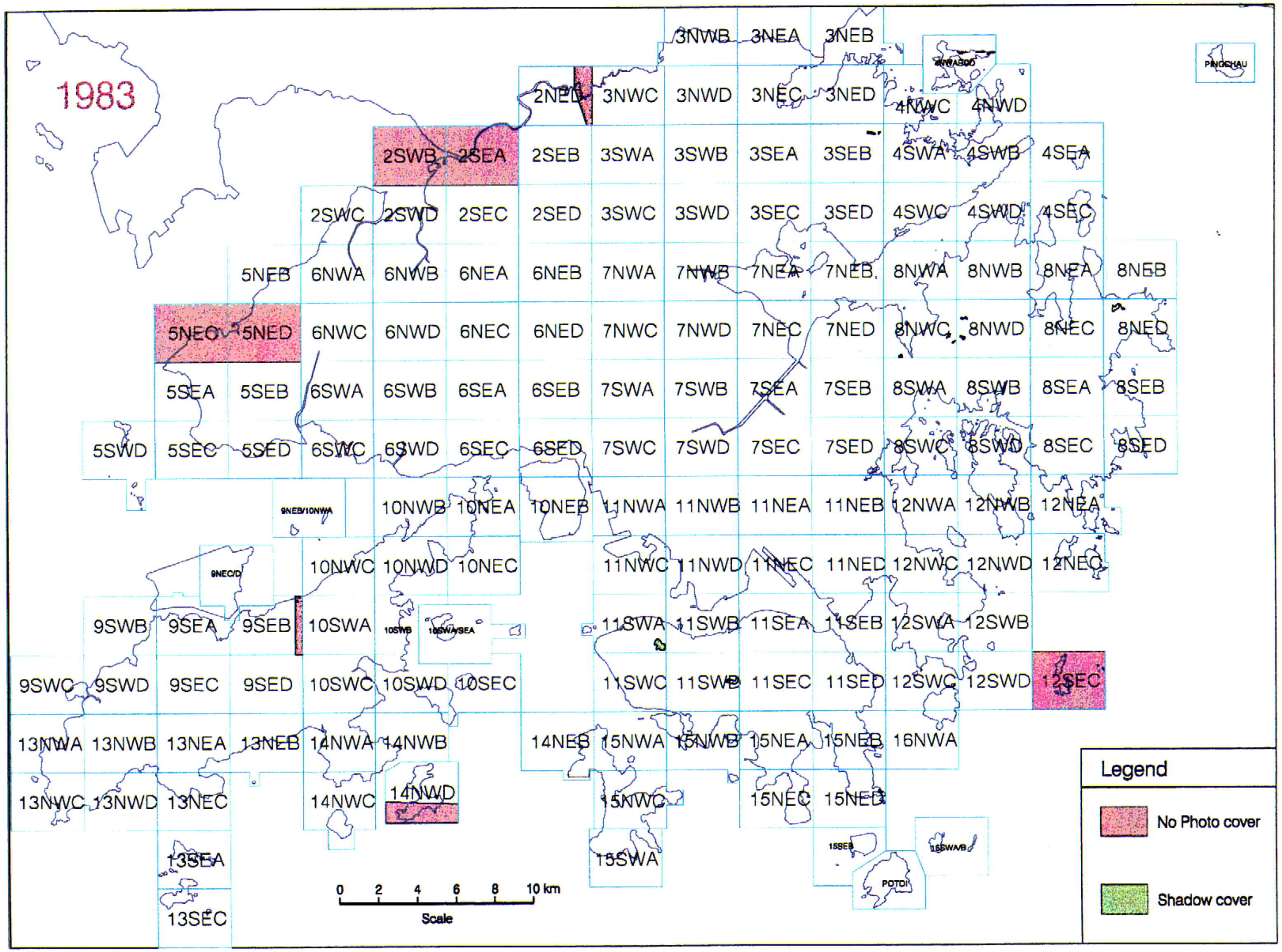


Figure 14 - Aerial Photograph coverage used for 1983 Survey

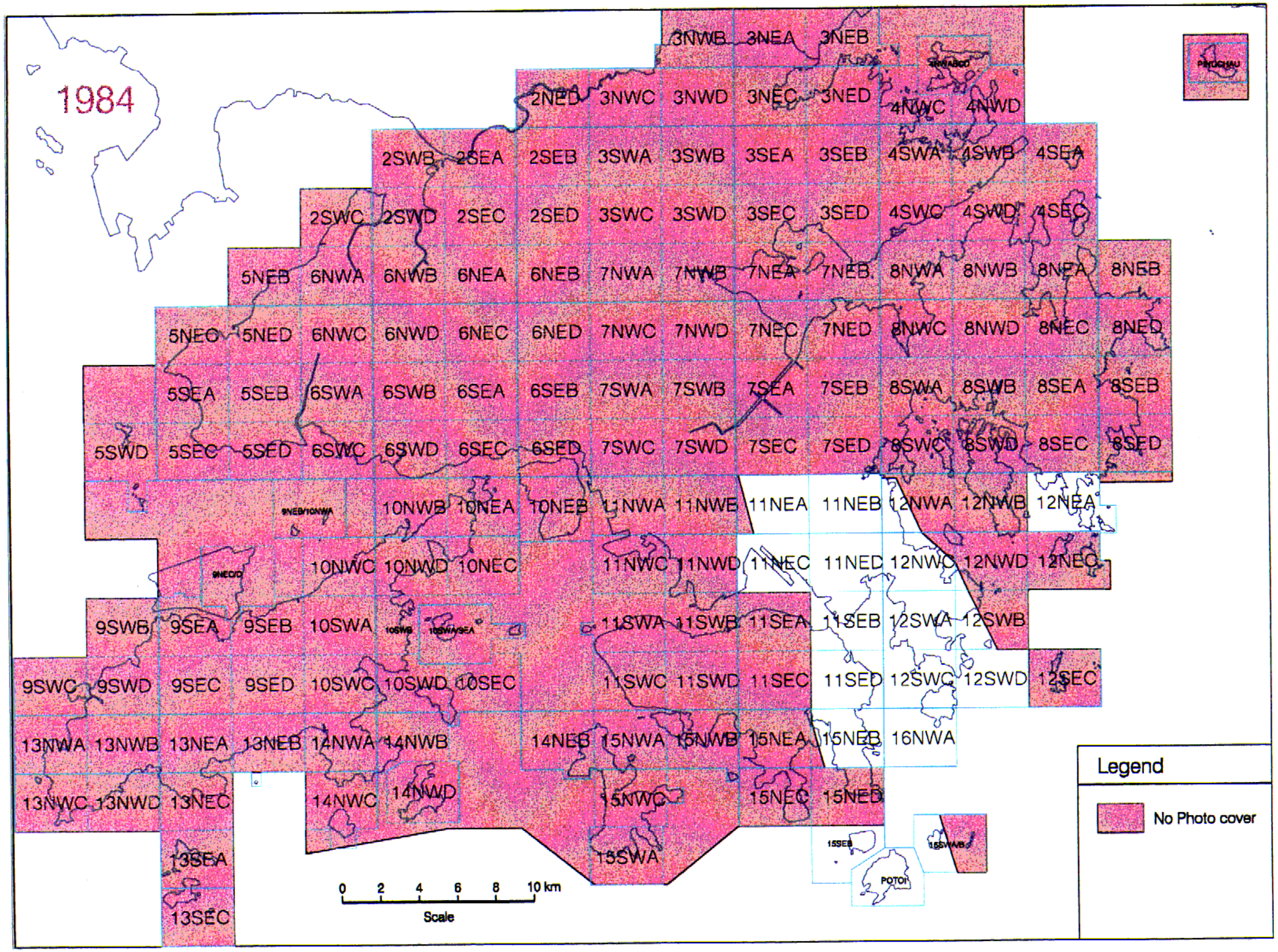


Figure 15 - Aerial Photograph coverage used for 1984 Survey

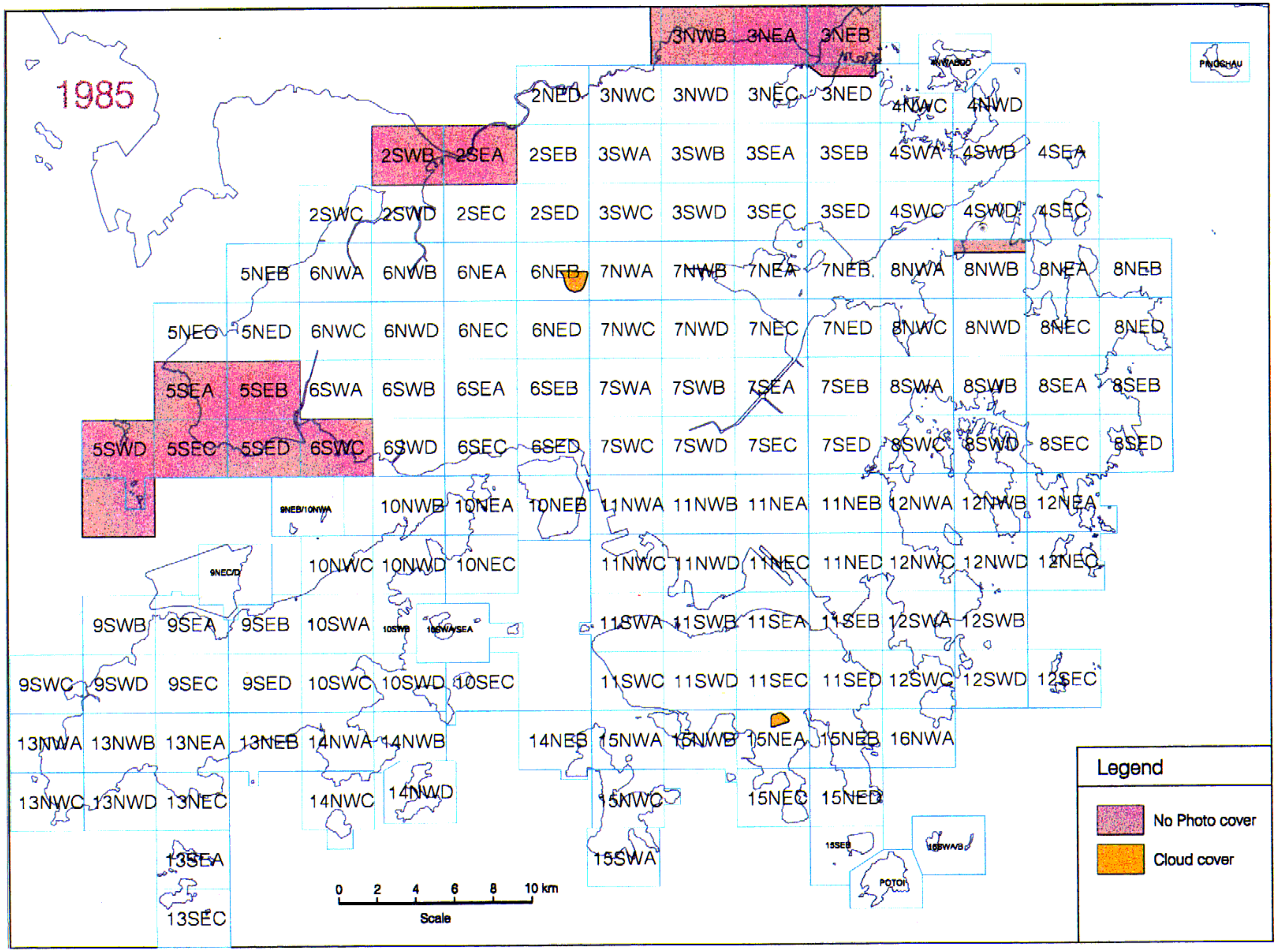


Figure 16 - Aerial Photograph coverage used for 1985 Survey

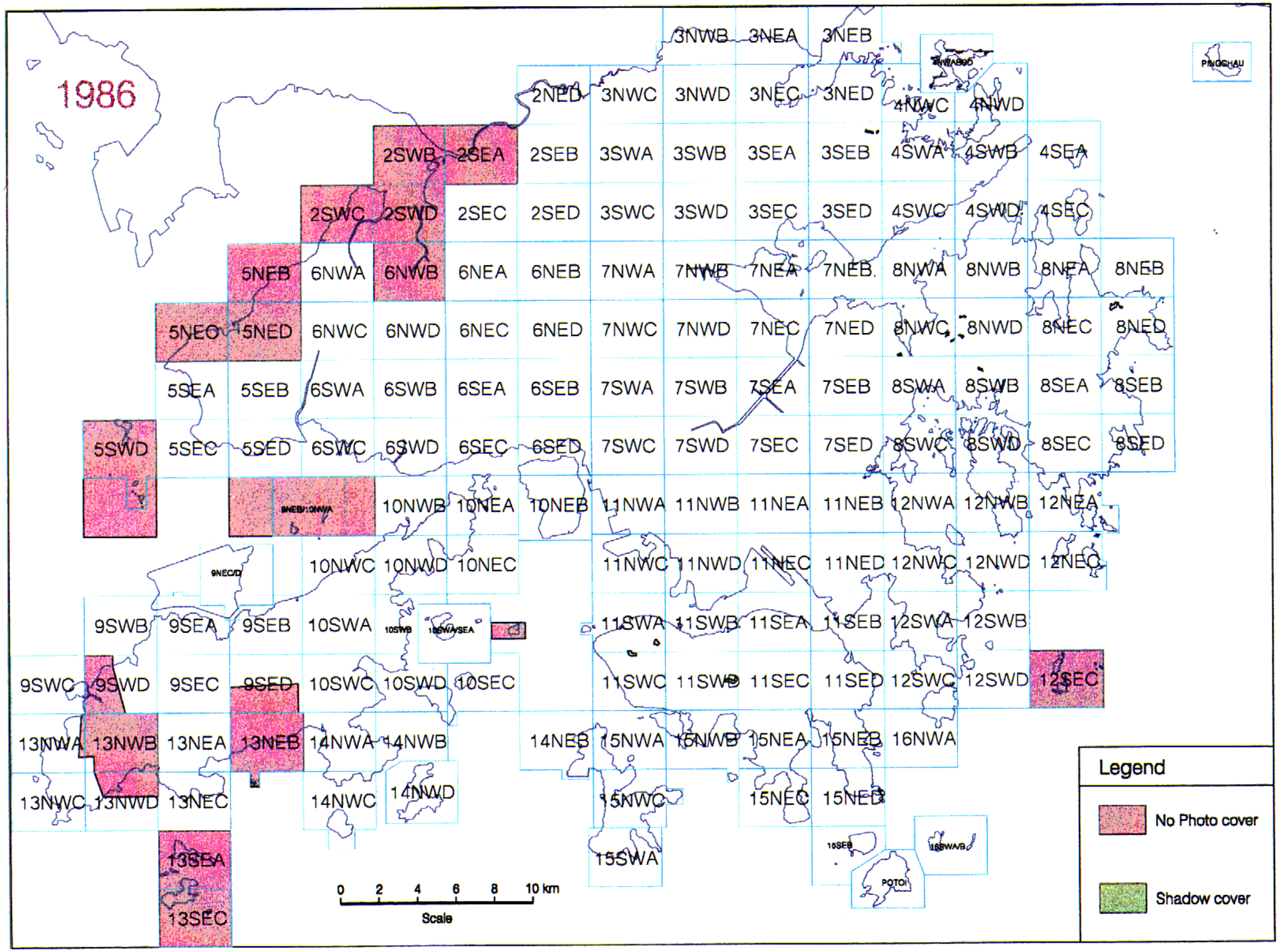


Figure 17 - Aerial Photograph coverage used for 1986 Survey

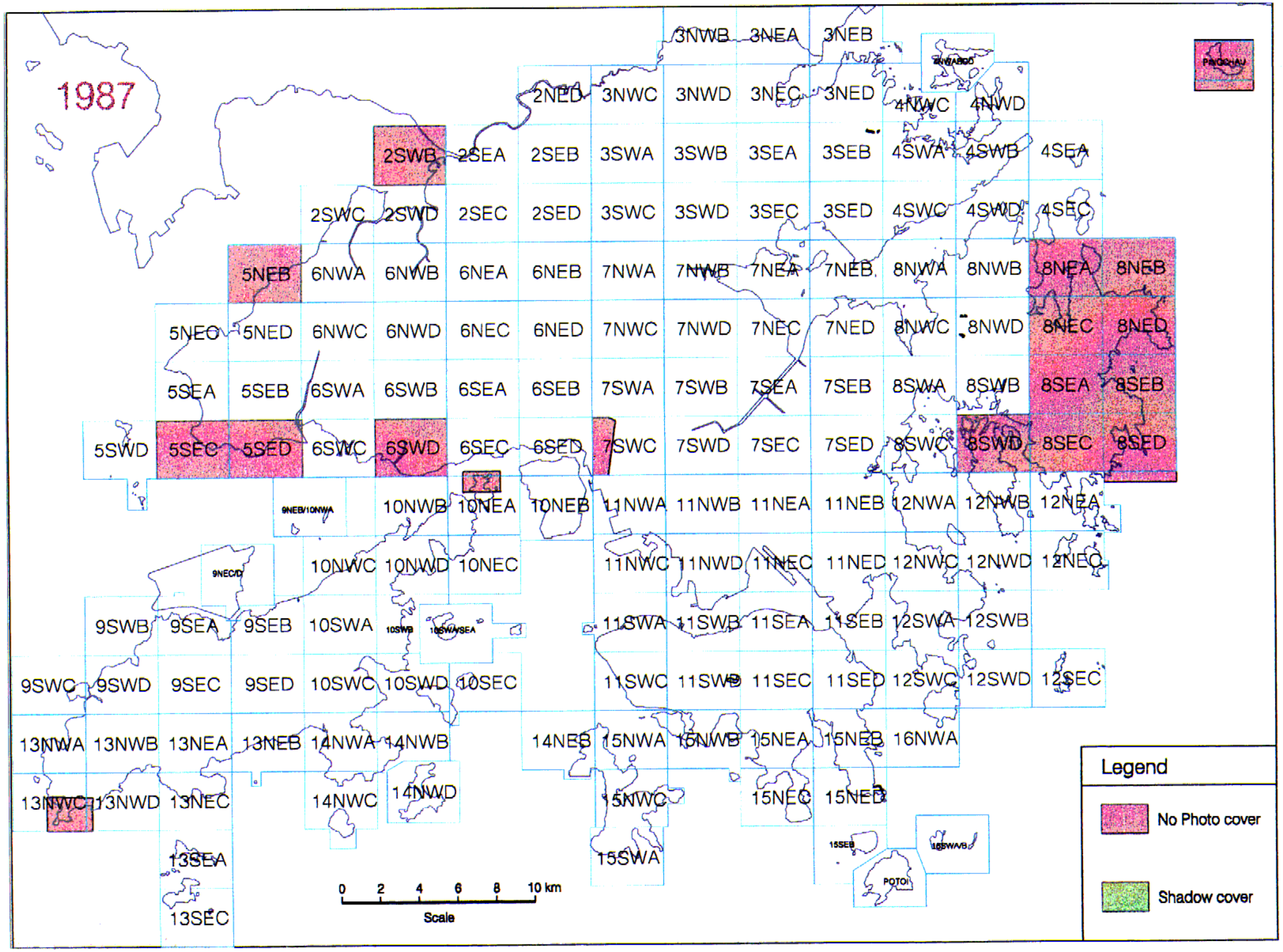


Figure 18 - Aerial Photograph coverage used for 1987 Survey

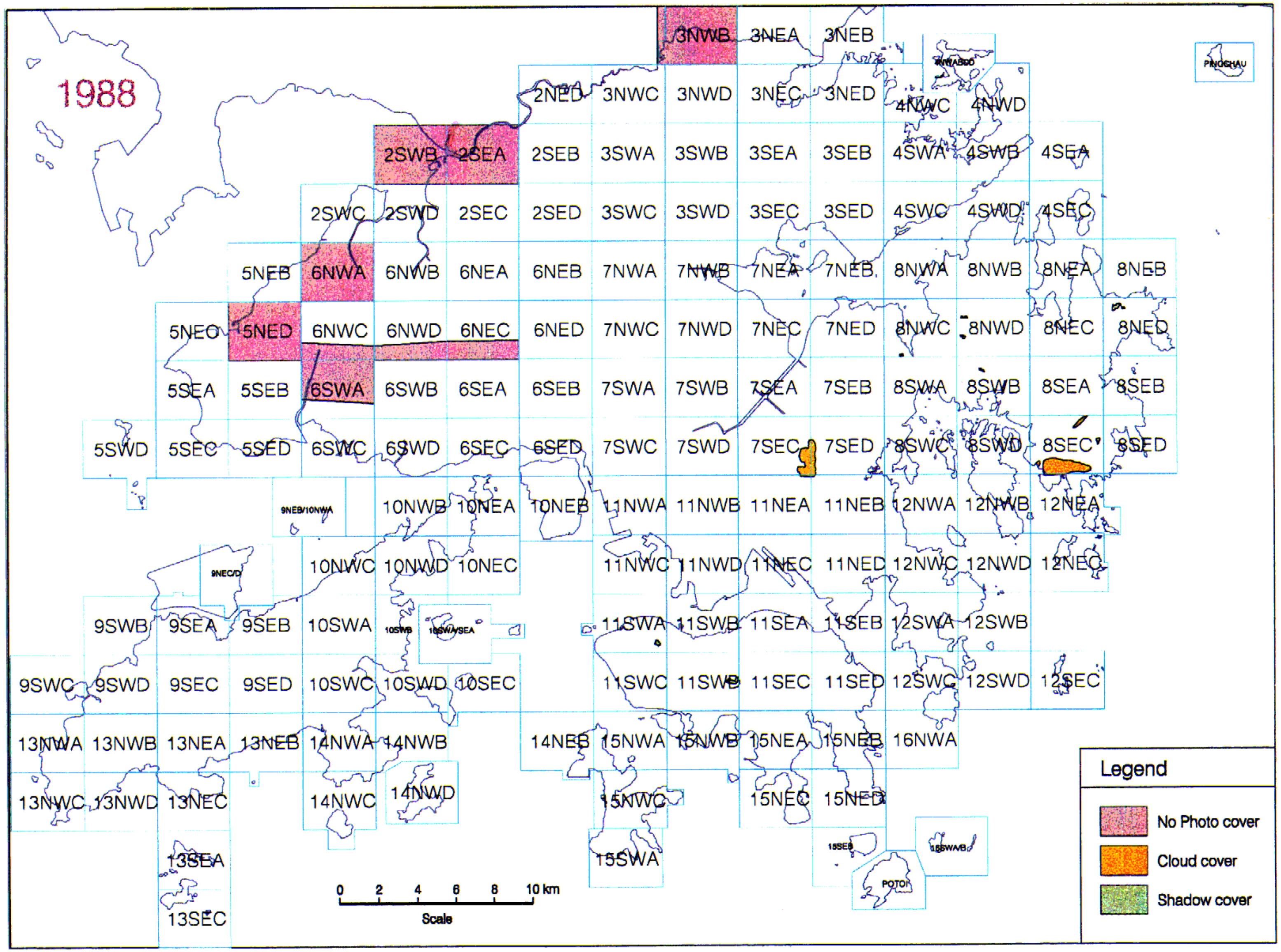


Figure 19 - Aerial Photograph coverage used for 1988 Survey

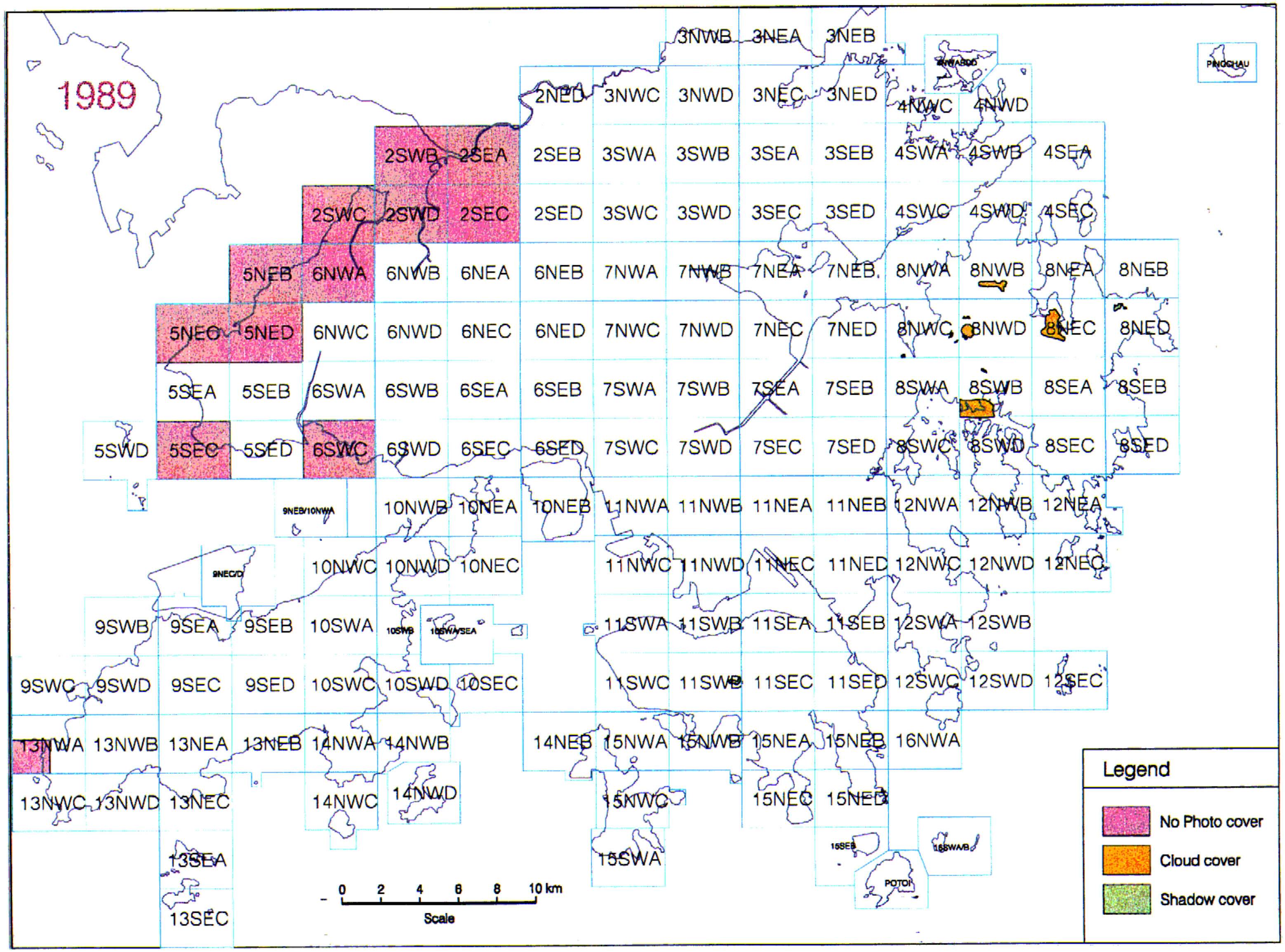


Figure 20 - Aerial Photograph coverage used for 1989 Survey

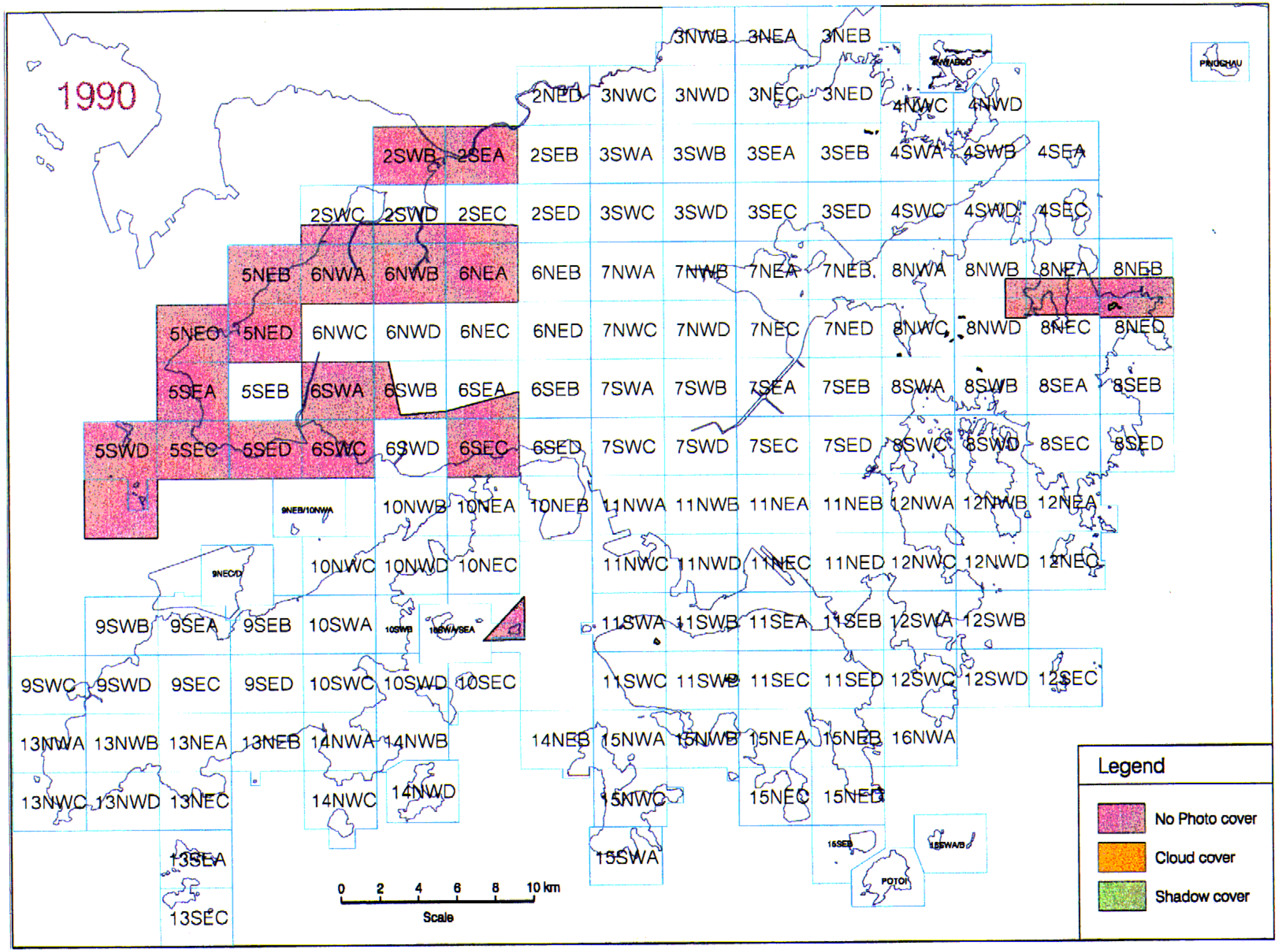


Figure 21 - Aerial Photograph coverage used for 1990 Survey

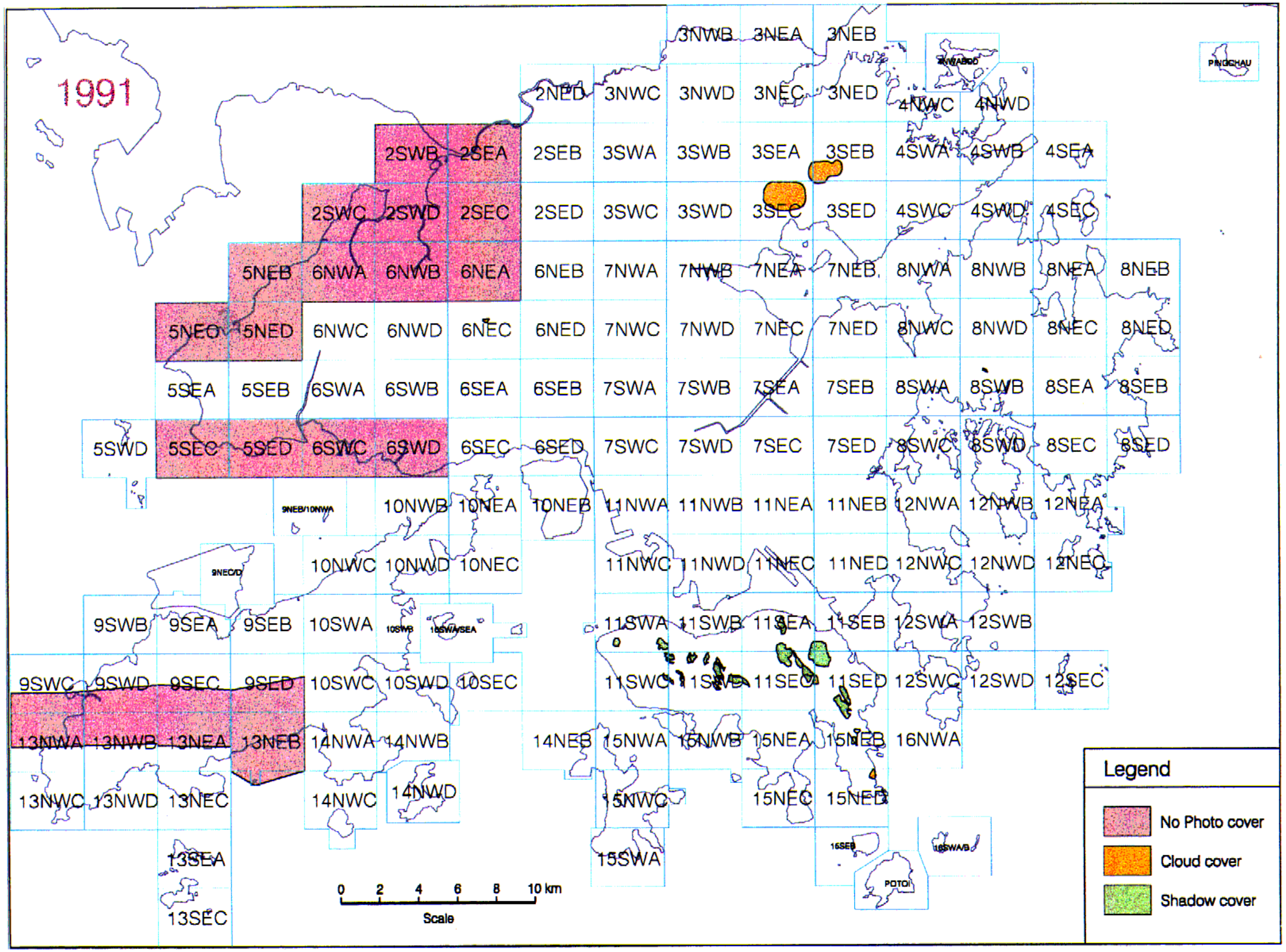


Figure 22 - Aerial Photograph coverage used for 1991 Survey

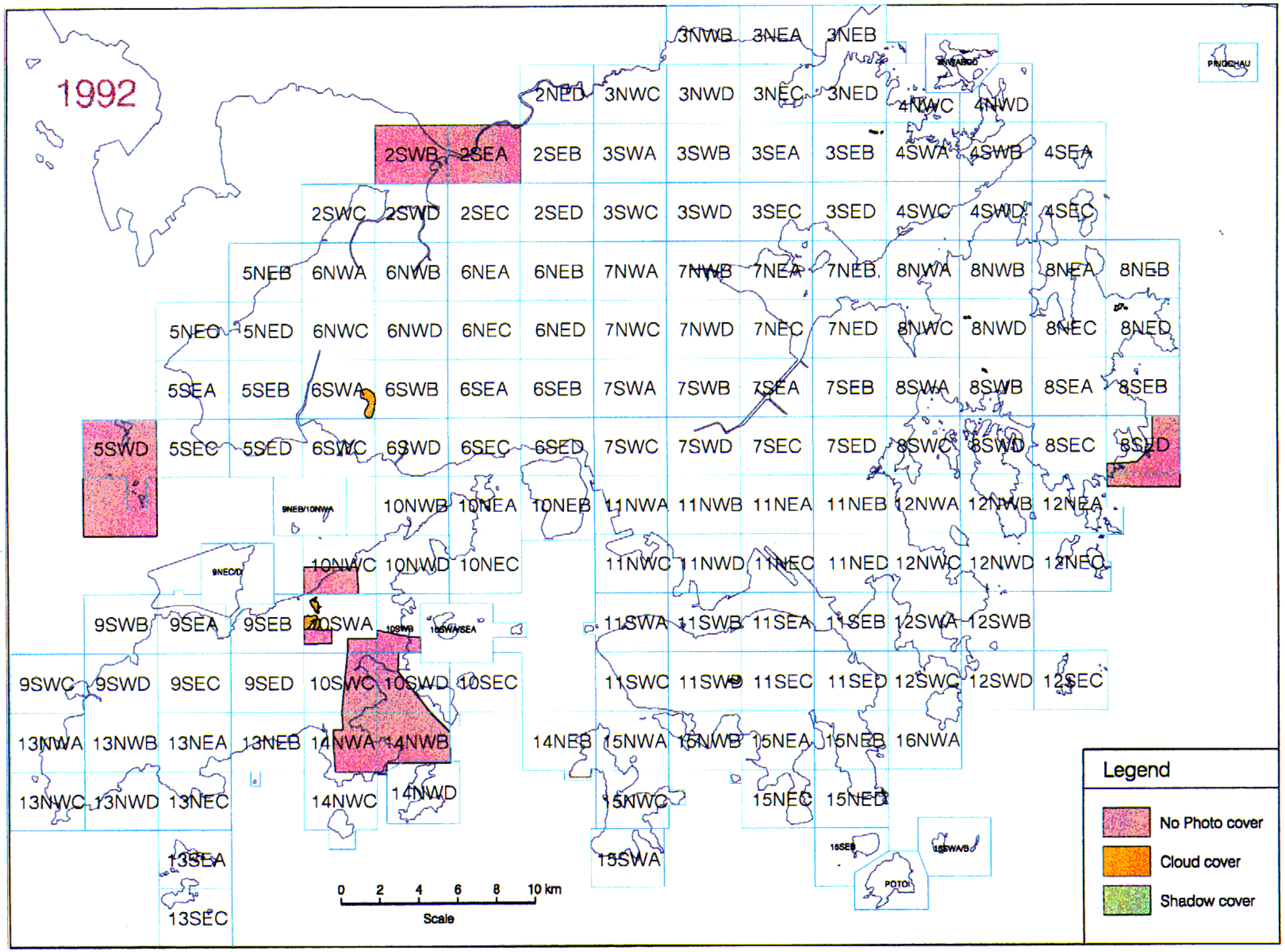


Figure 23 - Aerial Photograph coverage used for 1992 Survey

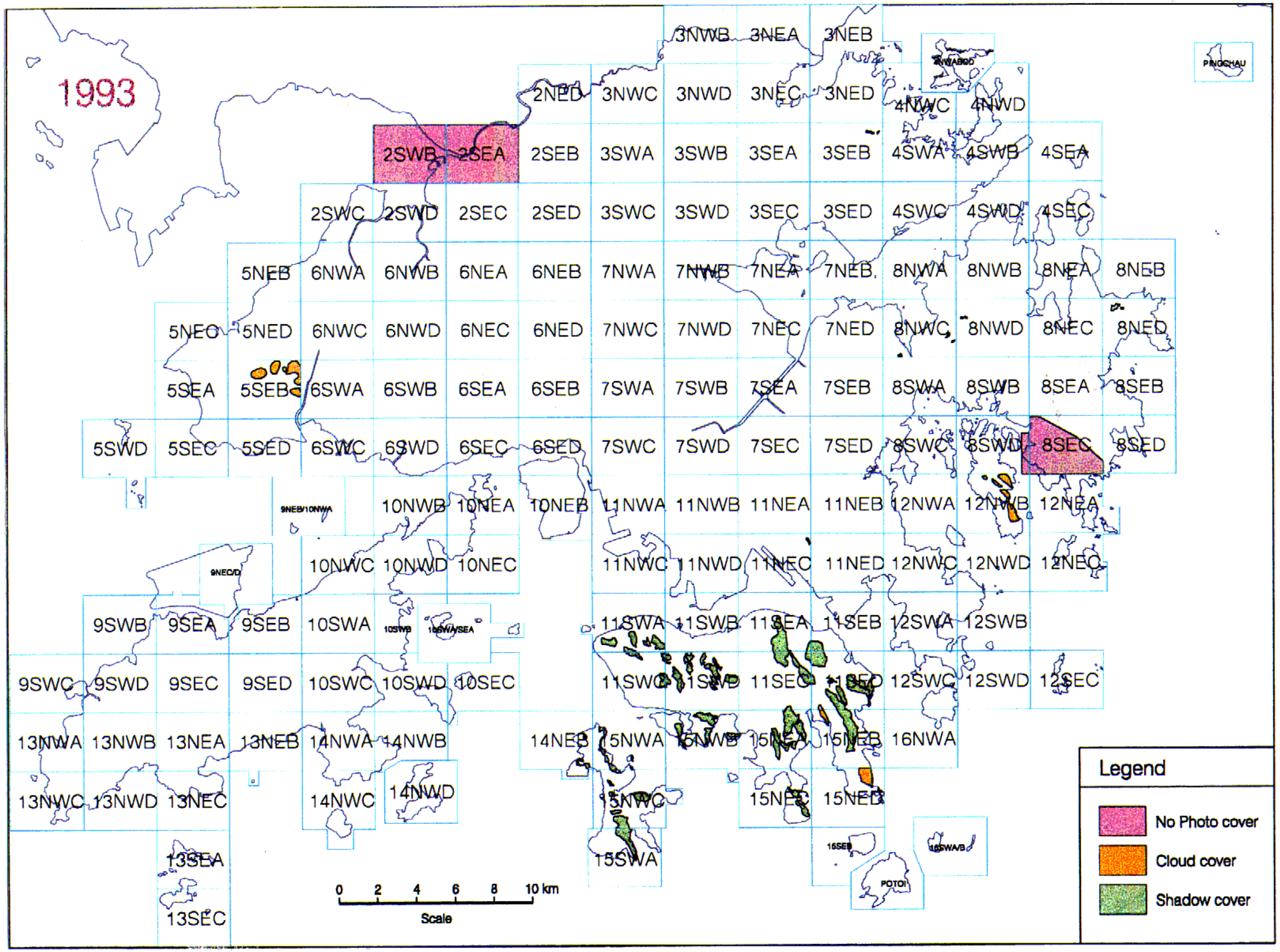


Figure 24 - Aerial Photograph coverage used for 1993 Survey

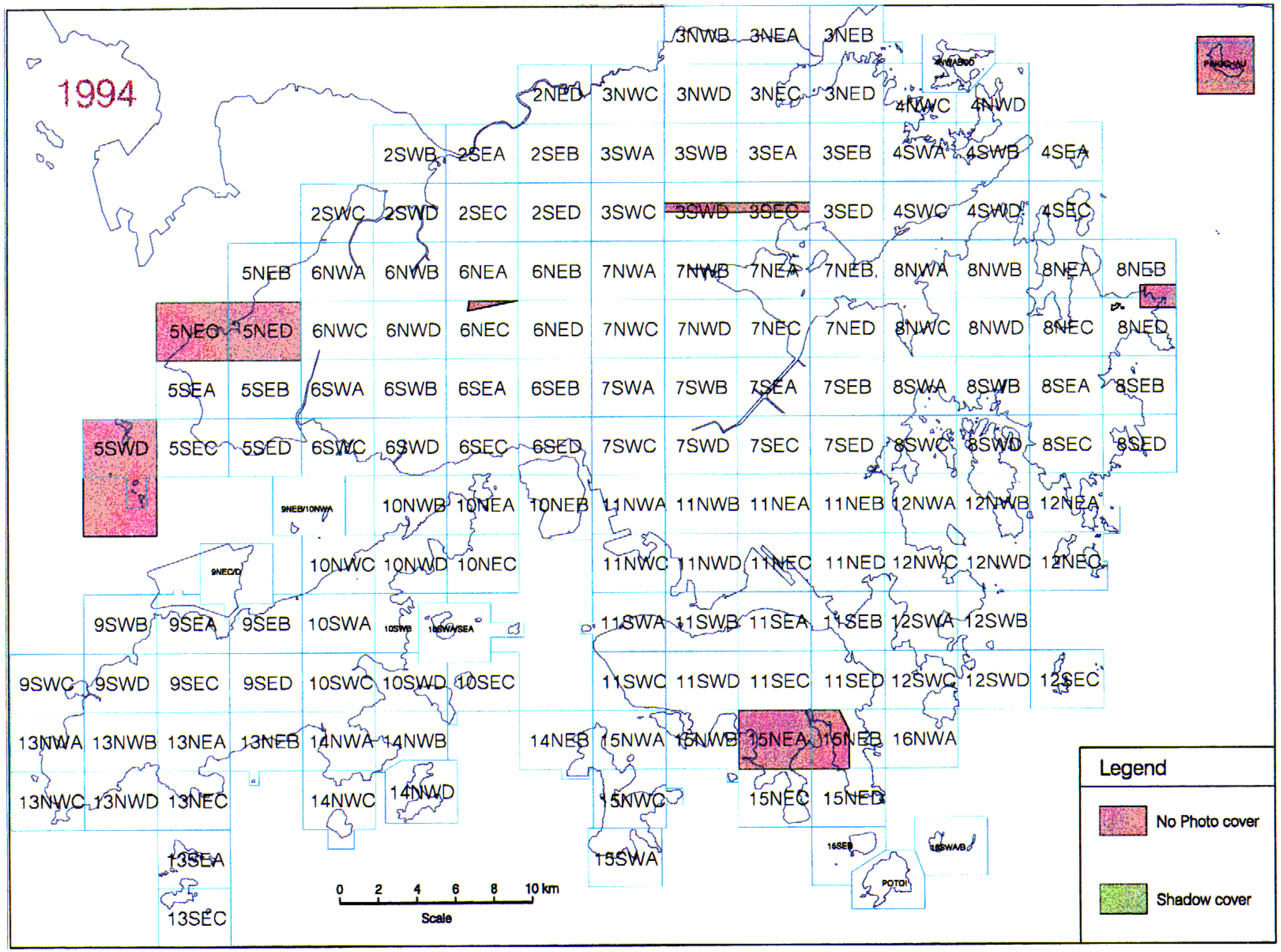


Figure 25 - Aerial Photograph coverage used for 1994 Survey

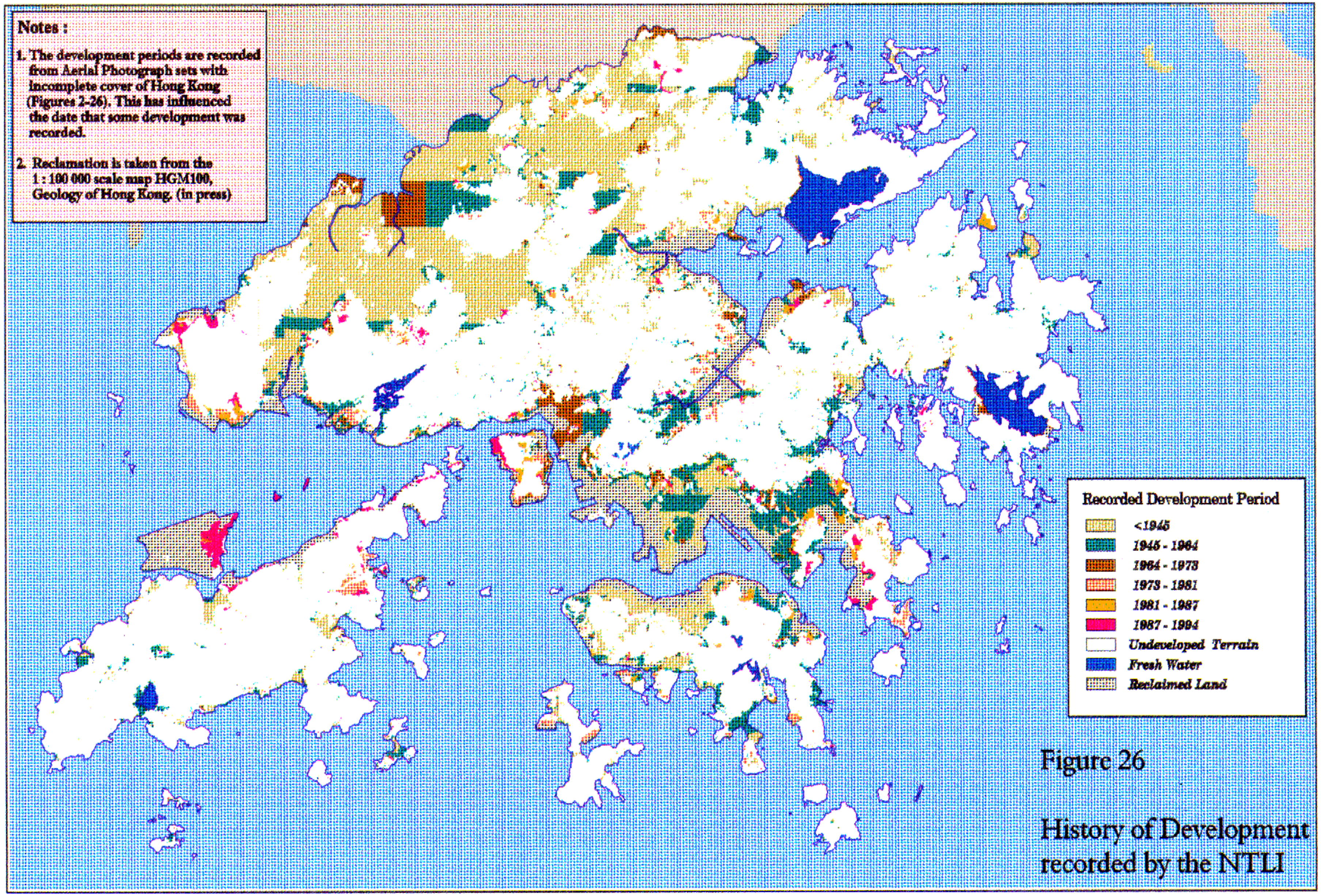


Figure 26

History of Development recorded by the NTLI

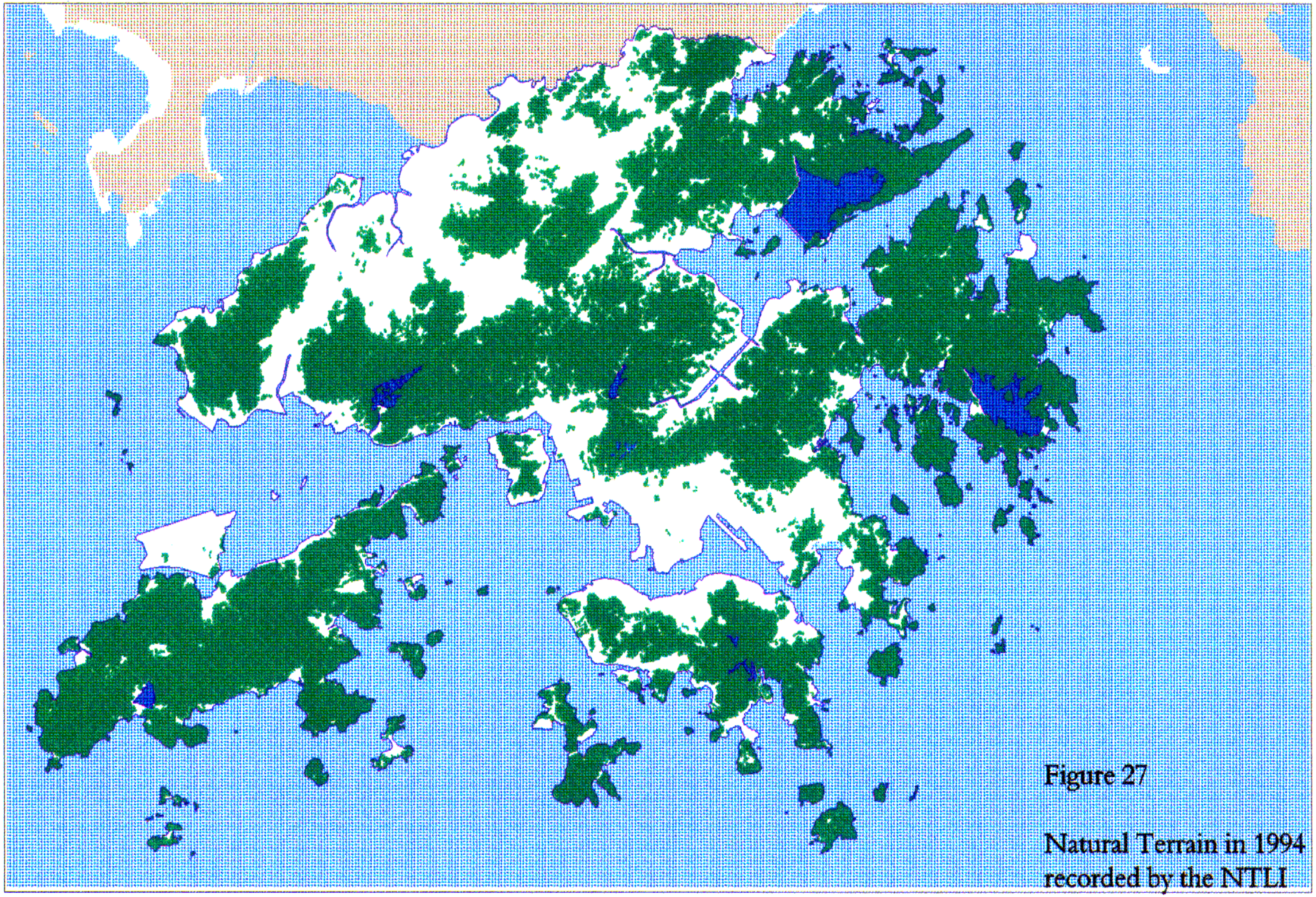


Figure 27

Natural Terrain in 1994 recorded by the NTLI

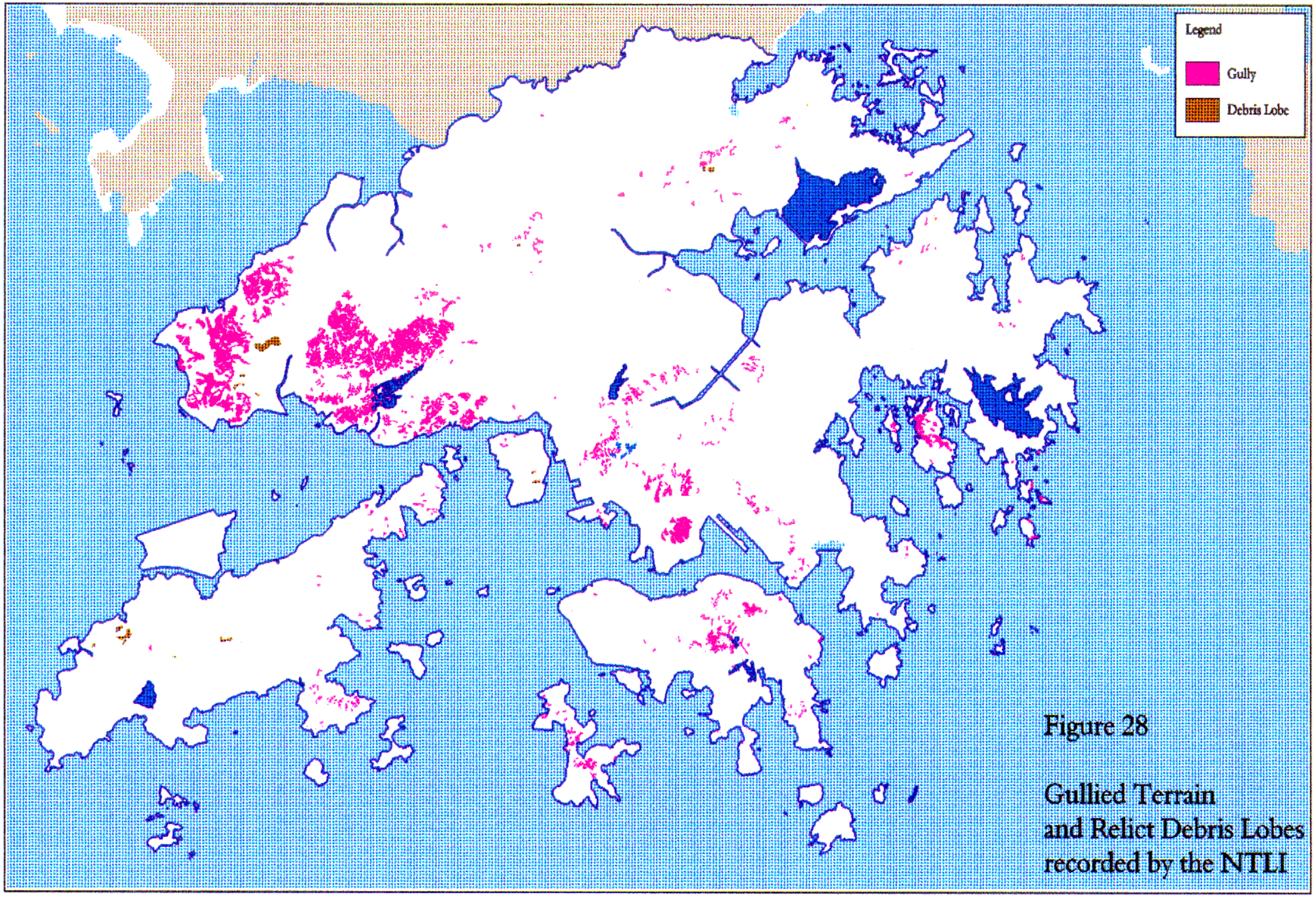


Figure 28

Gullied Terrain and Relict Debris Lobes recorded by the NTLI

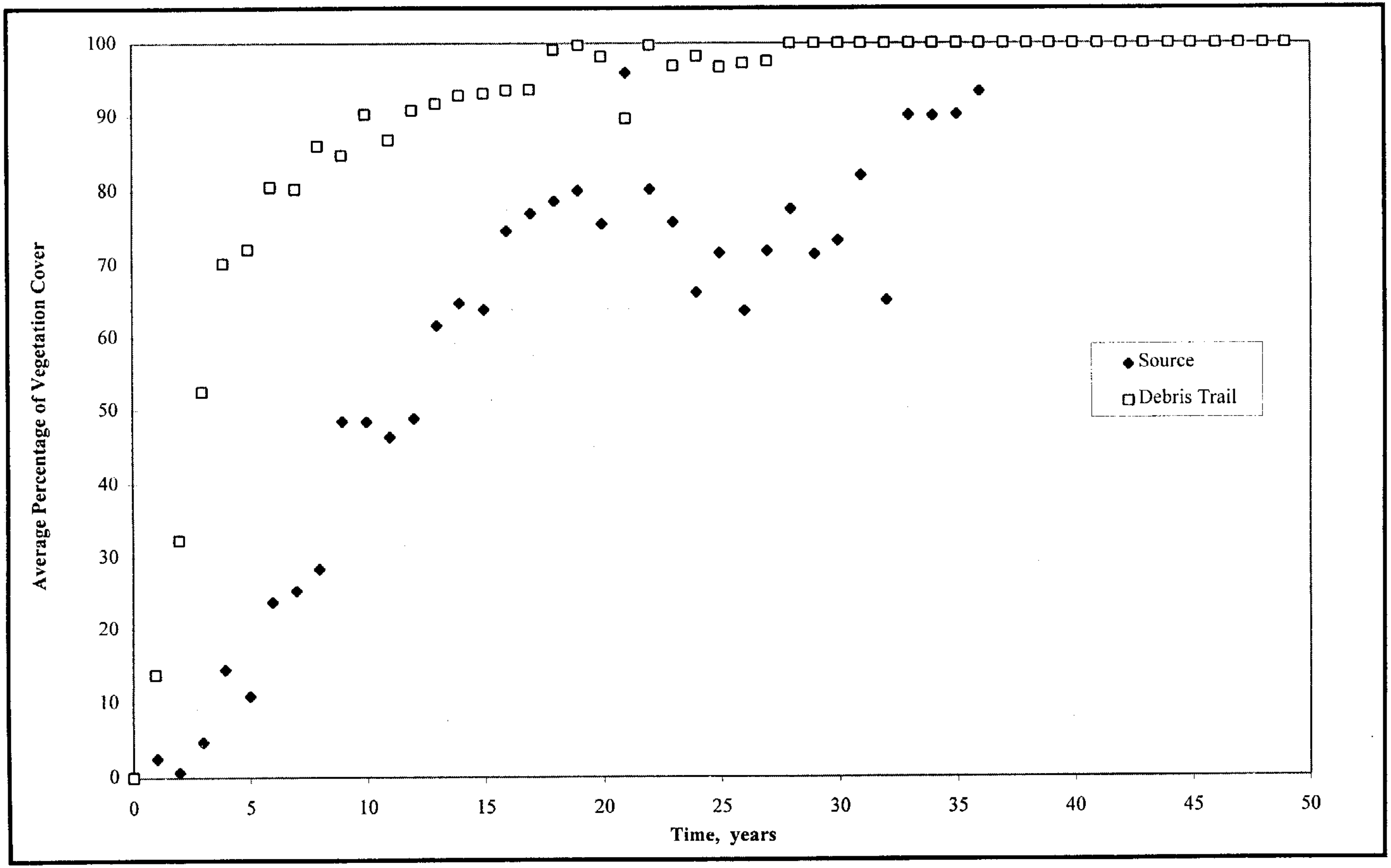


Figure 29 - Revegetation Rate of Landslide Scars

APPENDIX A

WORKING SPECIFICATION FOR THE NATURAL TERRAIN LANDSLIDE INVENTORY

(To avoid repetition Attachment C of the working specification, the example report, is not included. An example map sheet report that includes part of a map is given as Appendix B)

WORKING SPECIFICATION FOR THE NATURAL TERRAIN LANDSLIDE INVENTORY

BACKGROUND

The GEO is undertaking a hazard assessment of natural terrain to identify areas susceptible to landsliding and where, in the event of landsliding, there may be a threat to human life or property. The first step of the assessment is to establish a preliminary inventory of natural terrain landslides. This will be based on landslides which can be recognised from high-level aerial photographs taken during the past 50 years. The landslide mapping is carried out under Agreement No. CE 16/93 by the New South Wales Department of Land and Water Conservation. The terminology used for the project is Attachment A.

METHODOLOGY

The methodology for the study is based on the original consultancy brief, Attachment B. This has been clarified and updated with feedback from the consultant as the mapping progressed. Details of the changes are recorded in the minutes of meetings filed in GCP 2/A1/3-1. Significant developments in the methodology are listed in Attachment B.

High-level aerial photographs of the Territory from 1945 to the present are examined to identify the locations of all significant natural terrain landslides. The base map used is the 1:5000 topographic map which comprises 161 map sheets.

For each map sheet studied a 1:5000 scale Landslide Inventory sheet(s) is produced that shows all identified landslides with reference numbers. The map also shows areas not surveyed in any year due to not being photographed, the non availability of photography, the ground being obscured by cloud or terrain shadows or the presence of development. If the map sheet becomes too crowded, extra sheets are used to show the data.

A brief summary report is produced for each 1:5,000 map sheet. This includes a table of the parameters recorded for each landslide on the sheet and other data as shown on the example report attached as Attachment C (*now presented with map as Appendix B of TN*).

On completion of the survey a brief Final Report will be produced by the consultant on the mapping component of the inventory. The report will include a summary of the work done in the consultancy, a statistical summary of the data collected, and a brief description of the terrain, the occurrence and distribution of mapped features and any unusual features noted.

SURVEY AREA DATA

For each 1:5000 scale map sheet, a list of all aerial photographs examined, giving dates of photographs, photograph numbers and observations regarding image quality is included in the report. A record is also provided of the areas which were not mapped for the following reasons :

- non-availability of aerial photographs for any given year,

- no coverage for any given year due to cloud cover or terrain shadow, and

- non-natural terrain (ie the presence of development) in 1945, 1964, 1973, 1981, 1987, and 1994 .

The limits of development are defined as :-

- linear features e.g. roads and catchwaters and their marginal cut and fill slopes >25 m wide (i.e 5 mm on the map)

- non-linear features >1 hectare (i.e. 2 cm x 2 cm on the map)

Where photography is not available for one of the development years, the photography for either the year before or year after may be used. This is to be recorded in the map sheet report and the year of aerial photography used is marked on the map.

LANDSLIDE DATA

General Information

Natural terrain landslides occur on terrain previously unaffected by development (Appendix A). For example, a landslide is not recorded if its head is located either partly or wholly on cut of filled ground e.g. slopes due to site formation, areas terraced for agriculture, cemeteries or due to squatter habitation.

The crown of each landslide and the axis of the trail are mapped onto a transparent film copy of the 1:5000 topographic map. Where no trail is observed the downslope direction of the landslide is recorded. Each landslide is given a unique reference number for the sheet and the following parameters are recorded as a table in the sheet report :-

- width of the landslide main scarp, using codes 1= < 20 m and, 2= > 20 m. (For the first 28 sheets studied (listed in appendix B) the width criterion was < 5 m and > 5 m).

- vegetation cover over the landslide head as follows :

Code	Description
A	totally bare of vegetation
B	partially bare of vegetation
C	completely covered in grasses
D	covered in shrubs and/or trees

- ground slope angle across the landslide head, calculated from the distance between the steepest two adjacent contours on the map,

- year of the aerial photograph on which the landslide can be first observed, and

- year of the aerial photograph immediately preceding the photographs on which the landslide is first observed.

Landslide Scars

The landslides recorded in the inventory are divided into two groups: recent if they occurred within the time scale of the available aerial photographs and relict if they occurred earlier.

Recent landslides are generally bare of vegetation. The scars have a distinctive light tone on aerial photographs. Their date of occurrence can be confirmed by reference to earlier aerial photography.

Relict landslides in comparison are covered in grass, shrubs or trees but their shapes still show some clear characteristics of a landslide scar.

Relict landslides are mapped according to the following criteria:

- a spoon-shaped depression of any width and depth;

- a sharp main scarp of any height either visible or inferred from vegetation characteristics;

- relatively sharp, or high relief, boundaries along one or both sides of the depression;

- displaced material may be present downslope of the depression.

Usually the mapped length of the relict landslide is the length of the depression. However, the mapped length should be extended where displaced landslide debris can be recognised downslope of the depression.

Gully erosion downslope of a relict landslide is not included as part of the trail.

The following situations are not mapped as relict landslides:

- broad depressions with no obvious main scarps or sharp edges. The edges are smooth and rounded. These features may have been formed by landslides but are considered to be too degraded;

- depressions that seem to meet the criteria but occur on a slope in shadow in the photography so that the scarp edges cannot be identified reliably. (However, such features may be identified from later photography if clearly visible);

- depressions that meet the criteria but are bounded on all sides by rock at the surface. This will include landslides on and at the crest of sea cliffs;

- areas of severe gully erosion. Although landslides may have initiated, or preceded, the gully activity, this cannot be verified with certainty.

- heads of incised drainage lines.

Each map sheet report is to include a separate paragraph describing in general terms the relict landslide scars observed.

OTHER GEOMORPHOLOGICAL DATA

Gully Erosion

Bare or mostly unvegetated areas of intense gully erosion are to be mapped. Since the edges of these areas are often very irregular, the mapped boundary lines can be generalised.

Relict Debris from Large Landslides

Areas with a morphology that could be interpreted as the relict displaced material from a single large landslide are to be mapped.

SYMBOLOGY ON MAPS

Areas with no Photography

The photographs used to study each sheet are to be listed in the map sheet report. Some years of photography may not cover the whole sheet. Areas not covered by photography in any one year are enclosed by a purple line with triangles pointing towards the area with no photography. The year should also be written in purple within the area.

Areas obscured by Cloud or in Shadow

Areas obscured by cloud or in shadow are enclosed by a brown line with triangles pointing towards the obscured area. The year should also be written in brown within the area. Where cloud and shadow intersect they should both be marked.

Years of Development

The boundary between natural and developed terrain in 1945 is marked by a black line with 1945 written in black on the developed side of the line. The line may be drawn along a coastline. It may fully enclose a polygon, or the edge of the polygon may include the margin of the map sheet, a line showing non availability of photography or an area obscured by cloud cover or shadow.

The extent of development after 1945 is recorded for 1964, 1973, 1981, 1987 and 1994 by a red line with the date written in red on the developed side of the line. If photographs for any of these years are unavailable, development should be mapped for the next nearest year (either older or younger), in which case this year should also be written in red. Polygons showing development after 1945 may be formed partly from the 1945 black line, the margin of the map sheet, a line showing non availability of photography or an area obscured by cloud cover or shadow.

Landslides

All line work is black. The symbol for the crown is a small cross tagged with a unique sequential landslide reference number for each sheet. The trail, if any, is represented by a single black line. If no trail is observed extending beyond the scar, the downslope direction is indicated by a dot up to 5 mm from the cross.

Where the head of a later landslide is recorded at the same location as an existing head, an additional reference number is written against the original cross. If a head is recorded within an existing trail the cross is marked on the trail. Any trail from later landslides that overlaps an existing trail is represented by a black line drawn parallel to the first.

Where there might be confusion over the link between a cross and several numbers, or between overlapping trails, these are to be circled by an orange line, to clarify the link. For any group of landslides linked by the orange line the landslide reference numbers should increase from oldest to youngest. Where trails overlap, and it is not obvious which trail belongs to which head, the trails should be placed in ascending chronological order, i.e. the trail from the youngest landslide should be the outermost. If it is not possible to draw all the trails on one side of the first trail, the ascending chronological order should be first on the left side (looking down the scar) then right side, etc.

Where trails extend over a map sheet boundary the trail on the second map sheet is marked with the landslide number and map sheet number from where it originates.

Landslides on a slope modified by development, but not mapped as such due to scale limitations, are marked with a cross surrounded by a circle.

Areas of Intensive Gully Erosion

Areas of intensive gully erosion are enclosed by a green line. They may be tagged by the letter "G".

Relict Deposits from large landslides

Areas with a morphology that could be interpreted as relict debris from a single large landslide are enclosed by a blue line.

ATTACHMENT A

Terminology for use with the Natural Terrain Landslide Inventory

Natural Terrain:-

Terrain that has not been modified substantially by human activity such as site formation works, agricultural terraces, cemetery platforms or squatter habitation. In most of the Territory natural terrain has been influenced by deforestation and fire and may have been locally influenced by prehistoric agriculture.
The failure of natural terrain that has been significantly influenced by human activity is not considered to be a natural terrain landslide, e.g.failure immediately above and extending into an excavation or immediately below fill.

Debris:-

A superficial accumulation of loose material consisting of rock fragments, earth, soil material and sometimes organic matter. When qualified by Landslide this becomes a term that describes the displaced material from a specific landslide.

Landslide:-

A general, all-encompassing term used to describe a downslope movement of a discrete mass of soil and/or rock on either natural or artificial slopes.

The term is generally used for failures in soils. Rock failures are more commonly described by specific failure modes such as rockslide or rockfall. Landslide (American) is synonymous with the term Landslip (British) but is more widely used.

Scar:-

The land surface and vegetation disturbed by a landslide. This includes the head and the trail.

Head:-

The upper parts of a landslide between the trail and the crown.

Trail:-

The path of movement of landslide debris. This includes areas of erosion, transportation and deposition.

Crown:-

The undisplaced material adjacent to the highest parts of the main scarp (IAEG 1990).

Main Scarp:-

A steep surface on the undisturbed ground at the upper edge of the landslide, caused by movement of the slide material away from the undisturbed ground (IAEG 1990).

Gully Erosion:-

Creation of incised drainage lines by the removal of soil or decomposed rock by the channelised surface flow of water or a mixture of water and sediment.

ATTACHMENT B

Project Brief for the Preliminary Catalogue of Natural Slope Landslides and Significant Developments to the Mapping Methodology

PROJECT BRIEF

AGREEMENT NO. CE 16/93

PRELIMINARY CATALOGUE OF NATURAL SLOPE LANDSLIDES

OUTLINE BRIEF

BACKGROUND

1. The GEO is undertaking a hazard assessment of natural slopes to identify areas that are susceptible to landsliding and where, in the event of landsliding, there may be a threat to the lives or property of the public. The first step of the assessment will be the establishment of a preliminary catalogue of natural slope landslides that can be recognised from high-level aerial photographs taken during the past 50 years. The catalogue will provide an indication of susceptibility to landsliding on natural terrain and will help to determine those factors contributing to natural slope landslides by relating landslide distribution to rainfall, geology, geomorphology, natural drainage, etc.

METHODOLOGY

2. The task of the Consultants is to carry out a thorough examination of sets of high-level aerial photographs of the Territory, taken in various years during the period 1945 to the present, to identify the locations of all significant natural slope landslides. It is expected that a maximum of 15 sets of aerial photographs will be examined for any one area. The mapping of natural slope landslides is to be carried out at a scale of 1:5,000. There are 171 1:5,000 map sheets covering the whole land area of the Territory.

3. Natural slope landslides are landslides which have occurred on terrain that, prior to the landslide, was unaffected by human activity. Hence, a landslide is not to be recorded if its initial failure scarp is located either partly or wholly on ground that has previously been subject to cutting or filling, including slopes which have been formed in connection with site formation works, areas which have been terraced for agricultural purposes, for burial areas, for squatter habitation, etc.

4. The Consultants shall map the crown of each landslide and the axis of the resulting debris trail. In addition, each landslide shall be given a unique reference number for each 1:5000 sheet and the following parameters recorded :

(i) the width of the landslide scarp, in terms of whether it is greater than or smaller than 5 m,

(ii) the vegetation cover over the landslide scarp (four classes),

(iii) the ground slope angle across the landslide scarp based on the adjacent 2 or 3 contours on the 1:5000 base map,

(iv) the date of the aerial photograph on which the landslide can be first observed, and

(v) the date of the last available aerial photograph (prior to the one on which the landslide is first observed) on which the landslide does not appear.

5. For each 1:5,000 map sheet, the Consultants shall provide a list of all aerial photographs examined, giving dates of photographs, photograph numbers and observations regarding image quality. Also, a record shall be provided of the areas which were not mapped for the following reasons :

(i) no coverage for any given year due to cloud cover,

(ii) non-availability of aerial photographs, and

(iii) the presence of development i.e. non-natural terrain, in 1945, 1964, 1970 (?) and 1980 (?).

DELIVERABLES

6. The Consultants shall provide the following :

(i) A complete set of 1:5000 map sheets that clearly and unambiguously show all identified landslides and trails with their reference numbers and the areas not mapped in each year. If this becomes too crowded, the data shall be recorded on extra sheets.

(ii) A brief summary report for each 1:5000 map sheet on completion of that sheet. This should include a table of the parameters recorded for each landslide on the sheet, and

(iii) A Final Report on completion of the assignment. The report shall provide the following information: a description of the terrain, a discussion of the distribution of the natural landslides, notes on the nature of the landslides e.g. size, location with respect to topography, any unusual features, etc.

Significant Developments to the Mapping Methodology

11/10/95 Standardisation of symbols for landslides on plans and years of development to be used.

18/10/95 Standardisation of colours and linework symbols for plans. Minimum sizes for years of development agreed.

13/11/95 Change width of scar from 5 m to 20 m

Map Sheets using the 5 m criterion

2SE-A, 2SE-C, 2SW-B, 2SW-C, 2SW-D, 5NE-B, 5NE-C, 5NE-D, 5SE-A, 5SE-B, 5SE-C, 5SE-D, 5SW-D, 6NE-A, 6NW-A, 6NW-B, 6SW-C, 6SW-D, 8NE-A, 8NE-B, 8NE-C, 8NE-D, 8NW-D, 8SE-A, 8SE-B, 8SE-C, 8SE-D, 8SW-B, 8SW-D, 9SE-A, 9SE-C, 9SE-D, 9SW-B, 9SW-C, 9SW-D, 13NE-B, 13NE-C.

21/11/95 Use of a dot to indicate downslope direction for a landslide with no observed trail.

18/12/95 Title changed from catalogue to Inventory

APPENDIX B

EXAMPLE MAP SHEET REPORT, PART OF A MAP AND LEGEND

INVENTORY OF NATURAL SLOPE LANDSLIDES

Map sheet Report

Map Sheet Reference Number :	8-NW-D
Date of Assessment :	24 November 1997
API Consultant:	P.A.Spiers API(Consultant)/17 Produced under Agreement No.CE 16/93 for CED
Description of Terrain :	Seep to very steep hills and foothills on volcanic parent material. Vegetation cover is mainly grass with scattered areas of shrub occurring in the sheltered valleys.
Land Use :	The area is sparsely populated. Agricultural terracing is practised in the valleys and low footslopes.
Extent of Land Modifications :	Pak Tam and Hoi Ha roads completed in 1973. Weirs constructed in drainage lines south east of Tai Che Leng Tun and north east of Ngau Yee Shek Shan.
Land Area of Map Sheet :	1120 ha
Time Involved :	46 hours
No. of Aerial Photo. Sets Examined:	23
AP's Showing Recent Landslide activity:	New landslide features were observed in 1964, 1973, 1974, 1975, 1976, 1978, 1979, 1981, 1983, 1985, 1988, 1992, 1993 and 1994.
Years for which Aerial Photographs are not Available:	1977 No photographic coverage available 1980 No photographic coverage available. 1984 No photographic coverage available
Years for which Ground Coverage is obscured by Cloud:	1989

Years and Localities in which Natural Terrain was Modified:

Pak Tam and Hoi Ha roads completed in 1973. Weirs constructed in drainage lines south east of Tai Che Leng Tun and north east of Ngau Yee Shek Shan.

List of Aerial Photographs Used

Year	Height (ft)	Photograph Number	Date	Coverage
1945	20 000	3153-57 4197-99	10.11.45 10.11.45	B B
1964	12 500	2647-49 2688-90		A A
1972	13 000	2262-63	3.10.64	B
1973	12 500	7945-47	20.12.73	A
1974	12 500	8236-38 9847-49	28.02.74 21.11.74	A A
1975	12 500	11717-19	19.12.75	A
1976	12 500	16475-77	23.11.76	A
1978	12 500	20655-57	6.1.78	A
1979	10 000	28227-29 28213-14	29.11.79 29.11.79	B B
1981	10 000	39237-39 39223-25	27.10.81 27.10.81	A A
1982	10 000	44649-51	10.10.82	B
1983	10 000	52261-64 52206-08	22.12.83 22.12.83	A A
1985	10 000	67295-97 67281-83	1.10.85 1.10.85	A A
1986	10 000	A08034-36 A08087-89	21.12.86 21.12.86	A A
1987	20 000	A08445-46 A08433-34	5.01.87 5.01.87	A A
1988	10 000	A15109-12 A15056-59	3.11.88 3.11.88	A A
1989	10 000	A19340-42 A19136-38	20.11.89 13.11.89	B B
1990	10 000	A24272-73 A24308-10	3.12.90 3.12.90	B B
1991	10 000	A28742-44 A28270-73	29.10.91 19.10.91	A A
1992	10 000	A32887-90 A32870-73	11.11.92 11.11.92	A A
1993	10 000	CN5550-53 CN5611-14	6.12.93 6.12.93	A A
1994	10 000	A39438-40 A39394-96	21.10.94 21.10.94	A A

A = full stereoscopic coverage
B = partial stereoscopic coverage

MAP SHEET NUMBER: 8-NW-D						
TAG NO.	SLOPE	YEAR	COVER	WIDTH	CROSS TAG NO.	LAST YR
0001	34	83	B	2		82
0002	24	83	B	2		82
0003	30	83	B	2		82
0004	30	83	B	2	555	82
0005	39	83	B	2		82
0006	27	83	B	2		82
0007	39	83	B	2	125	82
0008	30	85	B	2	256	83
0009	34	85	B	2		83
0010	34	85	B	2		83
0011	20	85	B	2		83
0012	34	85	B	2		83
0013	30	85	B	2		83
0014	30	85	B	2	22	83
0017	34	89	B	2	593	88

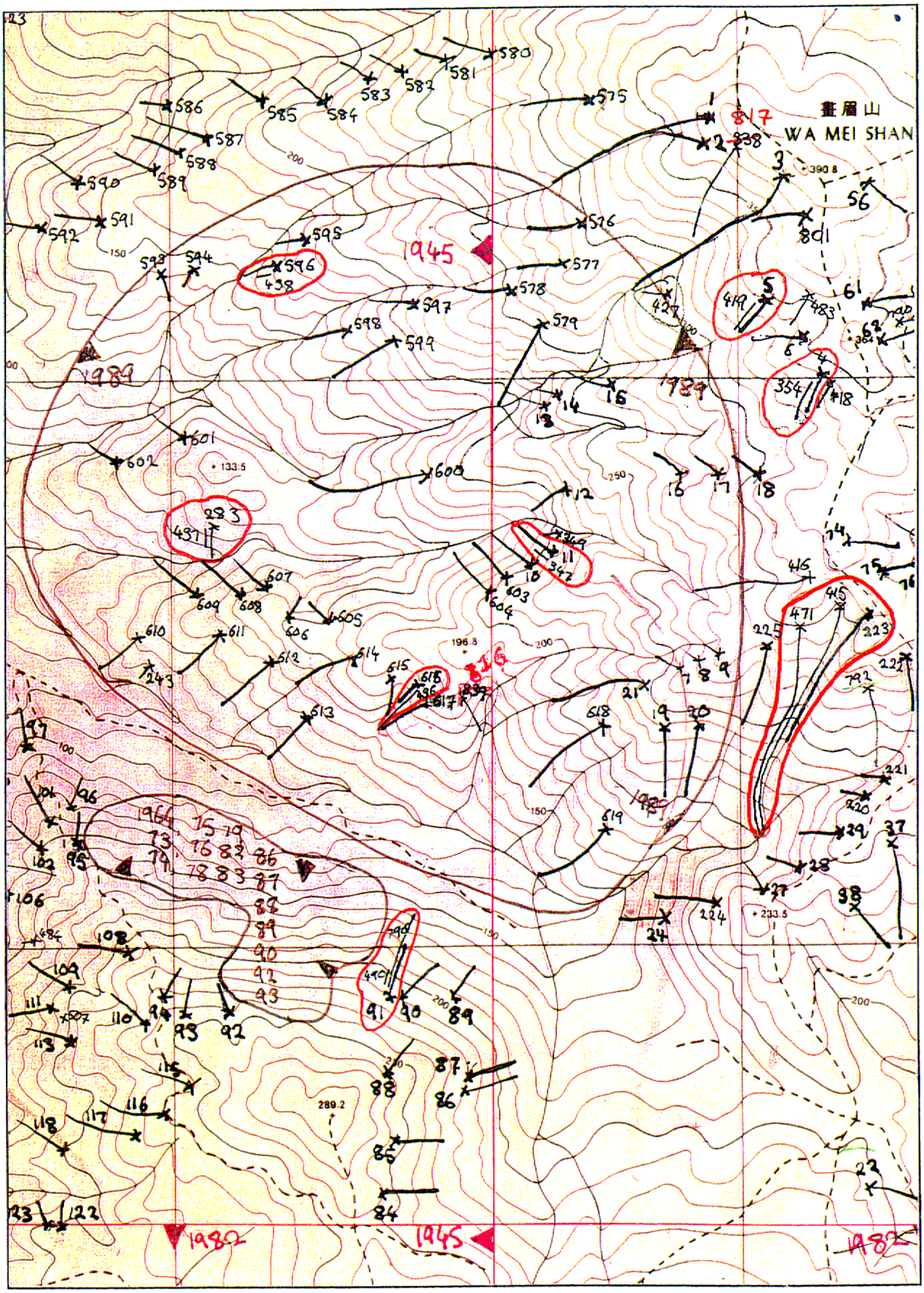
Natural Terrain Landslide Catalogue, Summary Sheet for Sheet No. 8 NW-D

ID_MAX, Total number of landslides 802 Unused Numbers between 0 and ID_MAX 0

Aerial Photograph Cover

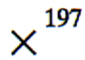
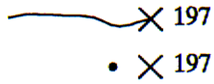
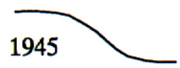
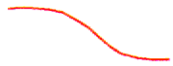
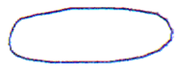
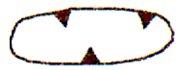
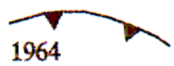
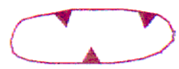
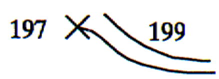
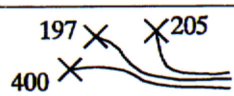
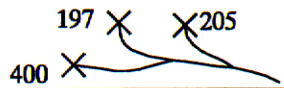
YEAR	Coverage
1945	PC
1964	FC
1972	PC
1973	FC
1974	FC
1975	FC
1976	FC
1977	NF
1978	FC
1979	PC
1980	NF
1981	FC
1982	PC
1983	FC
1984	NF
1985	FC
1986	FC
1987	FC
1988	FC
1989	FC
1990	PC
1991	FC
1992	FC
1993	FC
1994	FC

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



Part of N.T.L.I. 1:5,000 Scale Master Plan. Sheet 8-NW-D

NATURAL TERRAIN LANDSLIDES - MAP SYMBOLS

Feature Name	Feature Type	Hard Copy
Landslide Crown	point	black cross 
Landslide ID	text	black text 
Landslide trail	line	black line or black dot* 
1945 Development Area	area	black line with black text 
Later Development	area	red line 
Date of Later Development	text	red text 
Gully Erosion	area	green line 
Relict Deposit	area	blue line 
Cloud or Shadow	area	brown line 
Cloud Date	text	brown text 
No Photograph	area	purple line 
No Photograph Date	text	purple text 
Linked Crowns		
Linked Trails from different years		
Trails that join in the same year		

* The dot is the downslope direction of a landslide with no observed trails : to be digitised with a standard trail length of 5m.

APPENDIX C

FINALISED CONTRACT BRIEF FOR DIGITISATION OF THE NATURAL TERRAIN LANDSLIDE INVENTORY

1. The design file symbology shown as Table 1 of Appendix 1 has been updated to show the final structure of the 1:5000 map sheet .dgn files rather than the more limited symbology shown on the original document.

2. Appendix 2, the symbology on maps, has been deleted as it is included in the Working specification for the NTLI which forms Appendix A of this Technical Note.

Contract Brief for Digitisation of the Natural Terrain Landslide Inventory

The GEO is establishing a preliminary catalogue of natural terrain landslides. This will be based on landslides which can be recognised from high-level aerial photographs taken during the past 50 years.

The study comprises analysis of twenty-five sets of high level aerial-photographs (dated 1945, 1964, and then annually from 1972 to 1994). The area covered by aerial photographs in each year is identified, areas of non-natural terrain ("development") are excluded and the remaining area surveyed for landslides and related geomorphology. The base map used for the project is the 1:5000 topographic map of the Territory which comprises 161 map sheets. The symbology used for the mapping is given in Appendix 2.

One hundred and sixty one 1:5000 scale map sheets of data for the Natural Terrain Landslide Catalogue are to be digitised by the contractor.

The sheets will be passed to the contractor in batches of about 20 sheets at a time.

For each batch of maps the contractor will receive:

- One sepia/film base-map for every sheet in the batch. Each base-map will be marked up with landslide database features as defined in Appendix 1 (Digital Output - Technical Specification).

- One MicroStation (.dgn) seed file with map boundaries and labels for each map sheet in the batch as described in Appendix 1.

- A MicroStation Colour Table and Pen Table

- A summary sheet for each map in the batch, listing:

  ID_MAX: the number of landslides in the sheet;
  The number of unused landslide numbers between 0 and ID_MAX;
  Years for which there is no aerial photograph (AP) cover;
  Years for which there is partial AP cover;
  Years for which there is full AP cover.

Within 2 working days of receiving each batch the contractor shall notify GEO if there is any mismatch between the hard-copy maps and the seed file.

Within 30 days of receipt of each batch the contractor shall deliver the following to GEO:

- the original marked-up base maps, in good condition

- a single design file (.dgn), based on the provided seed file, containing digitised and validated data from each of the sheets in the batch. Design file elements shall be digitised and validated according to the specifications, standards and procedures described in Appendix 1.

- a 1:5000-scale, colour, validation plot, on clear film, for each sheet in the batch (the plot format is also described in Appendix 1)

If digitisation is not completed to specification, the GEO may return the deliverables to the contractor for correction at any time within 14 days of receipt of the last batch of deliverables.

In addition to the requirements for each batch, the contractor shall deliver to GEO, before the completion of the project, an MDL program for placing graphic elements, of the specified symbology, for landslide crown, ID and trail. The program shall be in source code format. All rights to the program are to be the property of GEO.

APPENDIX 1 Digital Output - Technical Specification

1. Introduction

This appendix describes the technical specification for the digital output of the project: **"Digitisation of the Natural Terrain Landslide Catalogue"**.

2. Media

All digital data exchanged between GEO and the contractor will be by 3.5" High Density floppy disk. All files will be in MicroStation design file format (Version 5).

3. Seed file elements

A seed file (.dgn) will be provided with each batch of maps for digitisation. Levels 1, 2 and 3 are used for linestrings defining the outer boundary of contiguous maps, inner boundaries of maps and labels for all the map sheets respectively (see summary in table 1).

The seed file linework provided will be topologically clean and will not require further processing. However, levels 1 and/or 2 may be used in other line cleaning processes (as defined in each section below). Linework for levels 1 and 2 should not be altered during this line cleaning.

4. Specification

4.1 Photographed Area by Year

For each annual set of photographs, the photographed area is defined by actual air-photo coverage minus any area of cloud or deep shadow for which observations cannot be made.

Each set of photographs is assigned a separate design file level, in which boundaries to air-photograph coverage and any cloud cover for that year are digitised as linestrings. The specification for their digitisation is summarised in Table 1.

Areas of deep shadow have the same map symbology as cloud, only differing in that multiple dates lie within the polygon. Linework and text (one text element for each date) are digitised into two further levels (ie, not into the "annual" levels) also shown in Table 1.

Following line cleaning and validation (see below), a single text element (comprising the appropriate date) should be placed in each area of no-photography or cloud within the outer boundary defined on level 1.

Accuracy & digitising specification

No-photograph lines should only have vertices at changes of direction and map boundaries (inner and outer). Vertex placement should be accurate to 10 m.

Validation

Check that map sheets having partial coverage of photography for any year (as listed in summary sheet) have no-photograph linework in the appropriate level.

Each level (13 to 39) should be line-cleaned separately but always in conjunction with level 1 (outer boundary). This should effectively edge-match within the area covered by contiguous map sheets.

Check that map sheets having no coverage of photography for any tear (as listed in summary sheet) lie within polygons defined in the above process.

Unresolved problems in the photography-cover should be flagged at the level for the appropriate year, or, if the year is not obvious, at level 9.

4.2 Development Areas

Areas of "development" (areas that have been photographed but are excluded from the area surveyed because they are not natural terrain) are delineated by polygons enclosing a date. Two styles are used: black lines and dates for development recorded in the 1945 aerial photographs and red lines and dates for areas of later development. These should be digitised as linestrings and text according to symbology in Table 1.

Accuracy & digitising specification

Boundaries to development areas should be accurate to approximately 10 m. However, vertex spacing should be no closer than 20 m (ie 4 mm on the maps). Some smoothing may be required to achieve this requirement, with associated reduction in accuracy.

Validation

Line clean level 41 (1945 development) with level 13 (1945 photographed area), level 1 and level 2 (outer and inner map boundaries).

Line clean levels 42 (later development), 1 and 2 separately but do not resolve free end problems. Free end flags are to be placed on level 44.

4.3 <u>Landslide Crown/ID/Trail</u>

Each landslide has a crown (marked by a cross), an ID (adjacent integer), and a trail (usually a black line).

Because of a dual requirement of database loading and graphical representation, there are three components of data conversion of the landslide data:

- Crown/ID data for database loading
- Crown/ID data for graphic display
- Trail (database and graphic)

To ensure that this is done consistently, the contractor is required to write an MDL program (or equivalent) to semi-automate this procedure.

The MDL will prompt for:

- entry of the ID (or increment of previous ID)
- data point to mark crown position
- further data points either to indicate downslope direction, or further vertices on the trail axis.

The MDL will produce:

For Crown/ID (DB)	:	A text node with value = ID
For Crown/ID (G)	:	An oriented cell (orthogonal to downslope direction), and label (= ID)
For Trail (DB/G)	:	A line string, minimum 2 vertices, first vertex at crown location, second vertex 5 m in immediate downslope direction, subsequent vertices as placed. The line string element will hold a TAG DATA value = ID.

A number of special cases occur in the map representation of landslide data. Digitising instructions for these follow:

Trail marked with a dot	Enter minimum length (5 m) trail (2 vertices only)
X-circle	Circled landslide crowns are NOT to be entered

Where a group of landslides overlap, an orange line is drawn around them to indicate that they are linked. In any linked group the landslide ID No.s increase from oldest to youngest.

Linked Crowns	A single crown symbol with multiple labels (IDs) represents multiple landslides at the same location. In the digitising, enter each landslide separately (resulting in overlapping elements).
Linked Trails (diff. years)	Where trails from landslides in different years overlap, then the trails are drawn parallel to the oldest (lowest ID No.) trail. Later trails (higher ID Nos) are offset successively. In some cases it is not possible to offset all trails on the same side and in this case trails are first offset to the left (looking downslope) and then the right.
Linked trails (same year)	Where trails from a number of landslides in the same year coalesce, it is not possible to distinguish the actual extent of any one of them. In this case digitise each trail linestring to the maximum extent of the coalescing trails.

At map edges only, two further cases arise

Truncated trails	Where a trail runs into a map boundary.
Orphan trails	Where trails come into a sheet from another map

Where a truncated trail can be matched with an orphan trail across an inner boundary (level 2), then the resultant digitised landslide should be resolved.

Where a truncated trail occurs at an outer boundary, digitise the landslide as normal (ie, complete with text node, cell, label and trail) stopping the trail at the outer boundary. Then mark the landslide with a flag in level 54.

In any other cases of uncertainty, also place a flag at level 54

Accuracy & digitising specification

- Crown position should be accurate to 5 m
- Trail vertices should be accurate to 5 m
- Angular relationship of crown position to first downhill point should be accurate to 10 degrees

Validation

- Every ID to be checked

- ID sequence within any one map sheet to be unbroken sequence of integers 1 ... ID_MAX. (Excluding unused numbers listed in the summary sheet).

- Check: text node = cell = linestrings = ID_MAX - unused numbers

- NO TOPOLOGY CLEANING SHOULD BE UNDERTAKEN ON LANDSLIDE DATA

4.4 <u>Gully Erosion / Relict Deposits</u>

Areas of gully erosion and relict deposits are to be digitised as linestrings on levels 45 and 47 respectively.

Following line cleaning and validation, a centroid of appropriate symbology (see Table 1) should be placed within each polygon.

Accuracy & digitising specification

Bounding linework should be accurate to 10 m. Vertex spacing should not be less than 20 m.

Validation

Levels 45 and 47 can be cleaned together with level 1.

5. <u>Error Flags</u>

"Error Flags" mentioned in the preceding account will comprise of a shape (MicroStation element type 6, co=3, wt=10) at the specified levels below:

- Problems with survey areas are flagged at the level for the year in which the problem occurs, or, if that is not known, at level 9.

- Problems with development areas are flagged at level 44.

- Problems with landslides are flagged at level 54.

- Problems with gullied areas are flagged at level 45.
- Problems with relict deposits are flagged at level 47.

6. Plotting Specification

A validation plot of each 1:5000 scale sheet is required as a deliverable along with the design file for the whole batch of sheets.

Plotting will be in colour, on foil (transparent, permanent plotting medium).

Each 1:5000 scale sheet in the batch should be plotted from a fence (clip inside lock on), using colour table and pen table (or equivalent) delivered with the seed file.

TABLE 1

Title : NATURAL TERRAIN LANDSLIDE INVENTORY : DESIGN FILE SYMBOLOGY Client : GEO/PLANNING/PTE

LV	CO	WT	LC	DESCRIPTION	COLOR	LINE STYLE	DESCRIPTION
1	0	0	0	OUTER BOUNDARY (LINESTRING)	WHITE	SOLID	
2	0	0	0	1:5000 GRID LINES (LINESTRING)	WHITE	SOLID	
3	3	0	0	MAP NAME (TEXT)	RED	SOLID	TX=25
4							
5							
6							
7							
8							
9							
10	22	5	C	SHADOW BOUNDARY (LINESTRING)	BROWN	SOLID	
11	22	0	0	SHADOW LABELS (TEXT)	BROWN	SOLID	TX=15
12							
13				1945 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)			)
14				1964 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)			)
15				1972 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)			)
16				1973 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)	) PINK	) SOLID	)NO-PHOTO
17				1974 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)	FOR	FOR	)CO=19, WT=5, LC=C
18				1975 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)	NO-PHOTO LINESTRING		)
19				1976 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)			)
20				1977 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)			)
21				1978 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)	BROWN	DASH	)
22				1979 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)	FOR	FOR	)
23				1980 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)	CLOUD LINESTRING		)
24				1981 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)			)
25				1982 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)			)CLOUD LINESTRING
26				1983 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)	) ORANGE	) SOLID	)CO=22, WT=5, LC=C
27				1984 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)	FOR	FOR	)
28				1985 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)	NO-PHOTO & CLOUD TEXT		)
29				1986 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)			)
30				1987 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)			)
31				1967 NO-PHOTO (CUSTOM LINESTRING AND TEXT)			)OCCURED AT MAP
32							
33				1988 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)			)
34				1989 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)			)LABEL TEXT
35				1990 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)			)CO=22, WT=0, LC=0,
36				1991 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)			)
37				1992 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)			)
38				1993 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)			)
39				1994 NO-PHOTO AND CLOUD (CUSTOM LINESTRING AND TEXT)			)
40							
41	17	5	C	DEVELOPMENT UP TO 1945 (CUSTOM LINESTRING)	BLUE	SOLID	
42	3	5	C	DEVELOPMENT 1964 TO 1994 (CUSTOM LINESTRING)	ORANGE	SOLID	
43		0	0	DEVELOPMENT LABELS (TEXT)			TX=20, 1945 CO=17,
44							
45	2	5	C	GULLY EROSION (LINESTRING)	GREEN	SOLID	
46	2	0	0	GULLY EROSION CENTROID (TEXT='G')	GREEN	SOLID	TX=15
47	1	5	C	RELICT DEPOSIT (LINESTRING)	PURPLE	SOLID	
48	1	0	0	RELICT DEPOSIT CENTROID (TEXT='R')	PURPLE	SOLID	TX=15
49							
50				RESERVED FOR DATABASE LOADING TEXT NODE			
51							
52	0	0	0	CROWN TEXT LABEL	WHITE	SOLID	TX=10
53	0	3	C	TRAIL CUSTOM LINESTRING	WHITE	SOLID	
54	6	10	0	LINKED CROWN POLYGONS (LINESTRING)	ORANGE	SOLID	
55							
56							
57							
58							
59							
60				ERROR FLAGES	RED	SOLID	
61	3	0	0	INSET	RED	SOLID	
62	3/71	0	10	POLYGONS OF BULTI TRAILS OF SINGLE CROWN *	RED/BLUE	SOLID	
63							

*Color Tbl. \usr\ip32\mstation\date\geoslide1.tbl (PACT) PRINT / PLOT / IPLOT Scale / Size 1:5,000 Output Device v8900 Source:\user5\resource\ndi*dgn (PACT)*

* ***Only Sheets 03SEA, 03SEB, 03SEC, 04SWA, 06SEA, 06SWA, 06SWB, 08NWA, 08SWB, 09SEB, 10NEB, 10SWC, 11SWA, 13NWB, 14NWA (Total 15 Map Sheets)***

APPENDIX D

PROCEDURES FOR HANDLING AND VALIDATION OF NTLI DATA WITH EXAMPLES OF PROBLEM REPORTS AND DATA CAPTURE VALIDATION SHEETS

NTLI 24.4.96

Program for Handling and Validation of Data

1. Receive Original mapping and report from DLWC.

2. Check of general conformity to specification by GE/PTE1.

3. STO/PTE copy map and report. Original and copy map stored in vertical plan chest, report original and copy stored in two sets of lever arch files.

4. Original map sheet and summary sheet from the report given to digitising contractor (ABI) in groups of 20 to 30 maps. (Pilot, Lantau, Hong Kong, NT1, NT2, NT3, NT4, NT5, NT6, NT7)

5. ABI return group of original maps and :-

   (i) 08NEA.dgn file
   (ii) paper print of .dgn file
   (iii) summary report and problem report.

6. STO/PTE

   (i) makes 2 copies of the summary report and problem report and files them together in a lever arch file group validation file. The originals are filed in map sheet order in the master Validation File (VF).

   (ii) checks the paper print against the original (grid square by grid square) and marks all differences with a red sticker except those of missing landslide lines inside a linked crown marker.

   (iii) stores O8NEA.dgn file in PACT /usr6/pte/abi with a sub-directory for each group (eg /pilot, /lantau, /hk, /NT1 etc.), checks each .dgn file against the digitisation spec as defined in Attachment 1, and produces a brief report on any non-conformity, or reports correct digitisation, on a Data Capture Validation Sheet (DCVS) which is a blank level table with the sheet number marked. The DCVS is stored in map sheet order in the group VF.

7. GE/PTE 1

   (i) Checks the marked up paper print, summary and problem reports for accurate digitisation and any problems arising from the DLWC mapping not being within specification, indicates these on the problem report filed in the group VF (see attached examples) and on the paper sheet.

(ii) Indicates on the problem report and paper plan all problems that will need to be fixed in the .dgn file. This should include a note of any edge matching problems that will need to be resolved when sheets are merged.

(checks for i and ii) should first consider each problem annotated on the problem report, then check summary report against problem report, then check each red dot on the map).

(iii) Checks DVCS for conformity with digitisation spec. Accepts digitisation or returns .dgn file to ABI for adjustment. Steps 5. to 8. are repeated as necessary until .dgn file is accepted. Each time the .dgn file is resubmitted it is over written on the file in /abi (the original transmitted data on floppy disc forms a backup held be PTE 1). The accepted file may still have some minor non conformity to the spec that is documented on the DCVS in the group VF. When the .dgn file is accepted the final DVCS is signed off by GE/PTE1, then all earlier versions are deleted and the .dgn file is transferred to /usr6/pte/pdabi.

(iv) Returns the maps and reports to DLWC for checking and rectification where necessary. (This will mainly be unclear script on the map, landslides with no numbers, duplicate landslides and data table entries with no landslide on the map.)

8. DLWC

(i) Rectifies data by marking in red on the original and paper maps corrections/additions, producing a separate correction sheet (attachment 2) for additional information and by marking any other corrections in the original report in red. Brief notes showing the solution of all problems indicated for DLWC on the problem report (including confirmation of data queried as unclear) should be written on the problem report.

9. GE/PTE 1 checks and confirms the DLWC rectifications and sends data tables from the photocopy sheet reports (making check against the original table and including correction sheets) to the Typing Pool for entering into Wordperfect. The sheet reports are returned from the typing pool, in Wordperfect as 08NEA.LST. These are checked and corrected by STO/PTE, converted to asci files as 08NEA.DAT and stored in /usr5/resource/ntli/asci. Hard copy of the final asci files are stored in map sheet order in the NTLI Data file.

10. STO/PTE corrects the 08NEA.dgn file in /pdabi for all problems marked on the problem report. Checks corrections are complete by creating a summary report and prints out a summary report and paper print for the corrected map sheet. These are

checked by GE/PTE1, signed if accepted and filed in the group VF, the corrected .dgn file is then transferred to /usr5/resource/ntli/dgn. A permanent backup is made of these .dgn files.

List of NTLI Files

1. Map Sheet Report Files, a) Originals
   b) Photocopies

   Contain 1:5000 map sheet reports submitted by DLWC and photocopies of them.

2. Summary Sheet File

   Copies of summary sheets for all map sheets that are sent to ABI

3. Vertical Plan Chest

   Contains original film copies and paper prints of the original NTLI map sheets. To these are added the paper plots of the .dgn files submitted by ABI and the final proof prints from the validated sheets.

4. Master Validation File

   The original problem and summary reports submitted by ABI

5. Group Validation File.

   Starts with two photocopies of the ABI problem and summary reports for each group. To this are added all copies of the DVCS up to the finally signed off copy. The problem reports become marked up with the solution to all problems. The last entry is a signed off summary report for each fixed sheet.

6. Data File

   Checked hard copy of the asci files of the data tables.

7. An informal progress file is held by GE/PTE1 to record the progress of the digitisation project.

<u>Data Capture Validation Specification (ATTACHMENT 1)</u>

Log in to PACT as TRAIN (Password TRAIN) so that files examined are read only.

1. Check level use and record all levels in use on the data capture validation sheet (DCVS). This is a blank level table on which the sheet number, name of the checker and date should be recorded, example attached. Record all levels used. Check that only levels specified in Table 1, Design File Symbology, (12/3/96) are in use, investigate any other level use and report it on DCVS.

2. Using Table 1, Design File Symbology, (12/3/96) check levels sequentially for appropriate entry. Record any differences on DCVS. In general check the following as appropriate when each level is checked:-

   (a) Check boundary lines are custom linestyle (analyse) and that triangles and text are on the no photo side.

   (b) Check all data labels are in the appropriate polygon.

   (c) If any data looks odd check colour, weight, thickness etc.

Sequence of checking

(i) Check levels 1, 2, and 3.

(ii) Check levels 10, and 11;

(iii) Check level 13 and level 41. 1945 Development should all be in the photographed area.

(iv) Check levels 13 to 49 that are in use on at a time.

(v) Check levels 41, 42, 43. Development areas should not overlap and text labels should be centred in the polygons.

(vi) Check levels 45 and 46.

(vii) Check levels 47 and 48.

(viii) Check levels 52, 53, 54, check <u>all</u> shared crown landslides are two+ elements (use the move command and the reject button) of the correct lengths. List problems on back of the DVSC and mark the paper print of the map.

(ix) Check number of elements in levels 52 and 53, they should be the same.

(x) Check co-ordinates of map sheet corners.

Summary Report
Maximum Slide Serial Number is 78

Total Number of Duplicated Slide Texts in c:\slide\c\07nec.dgn = 9

Number	Map Sheet	Color	Weight	Style	Level
47	07NEC	0	0	0	52
48	07NEC	0	0	0	52
49	07NEC	0	0	0	52
50	07NEC	0	0	0	52
61	07NEC	0	0	0	52
62	07NEC	0	0	0	52
63	07NEC	0	0	0	52
64	07NEC	0	0	0	52
46	07NEC	0	0	0	52

Total Number of Duplicated Slide in c:\slide\c\07nec.dgn = 9

Number	Map Sheet	Color	Weight	Style	Level
47	07NEC	0	3	(slide)	53
48	07NEC	0	3	(slide)	53
49	07NEC	0	3	(slide)	53
50	07NEC	0	3	(slide)	53
61	07NEC	0	3	(slide)	53
62	07NEC	0	3	(slide)	53
63	07NEC	0	3	(slide)	53
64	07NEC	0	3	(slide)	53
46	07NEC	0	3	(slide)	53

Slides in Validation File but missed in Design File.

======================

52
53
54
55
56
65
66
67
68

======================

Total Number of Slides in C:\slide\c\07nec.dgn = 69

Number	Map Sheet	Color	Weight	Style	Level	Text
1	07NEC	0	3	(slide)	53	Y
2	07NEC	0	3	(slide)	53	Y
3	07NEC	0	3	(slide)	53	Y
4	07NEC	0	3	(slide)	53	Y
5	07NEC	0	3	(slide)	53	Y
6	07NEC	0	3	(slide)	53	Y
7	07NEC	0	3	(slide)	53	Y
8	07NEC	0	3	(slide)	53	Y
9	07NEC	0	3	(slide)	53	Y
10	07NEC	0	3	(slide)	53	Y
11	07NEC	0	3	(slide)	53	Y
12	07NEC	0	3	(slide)	53	Y
13	07NEC	0	3	(slide)	53	Y
14	07NEC	0	3	(slide)	53	Y
15	07NEC	0	3	(slide)	53	Y

16	07NEC	0	3	(slide)	53	Y
17	07NEC	0	3	(slide)	53	Y
18	07NEC	0	3	(slide)	53	Y
19	07NEC	0	3	(slide)	53	Y
20	07NEC	0	3	(slide)	53	Y
21	07NEC	0	3	(slide)	53	Y
22	07NEC	0	3	(slide)	53	Y
23	07NEC	0	3	(slide)	53	Y
24	07NEC	0	3	(slide)	53	Y
25	07NEC	0	3	(slide)	53	Y
26	07NEC	0	3	(slide)	53	Y
27	07NEC	0	3	(slide)	53	Y
28	07NEC	0	3	(slide)	53	Y
29	07NEC	0	3	(slide)	53	Y
30	07NEC	0	3	(slide)	53	Y
31	07NEC	0	3	(slide)	53	Y
32	07NEC	0	3	(slide)	53	Y
33	07NEC	0	3	(slide)	53	Y
34	07NEC	0	3	(slide)	53	Y
35	07NEC	0	3	(slide)	53	Y
36	07NEC	0	3	(slide)	53	Y
37	07NEC	0	3	(slide)	53	Y
38	07NEC	0	3	(slide)	53	Y
39	07NEC	0	3	(slide)	53	Y
40	07NEC	0	3	(slide)	53	Y
41	07NEC	0	3	(slide)	53	Y
42	07NEC	0	3	(slide)	53	Y
43	07NEC	0	3	(slide)	53	Y
44	07NEC	0	3	(slide)	53	Y
45	07NEC	0	3	(slide)	53	Y
46	07NEC	0	3	(slide)	53	Y
47	07NEC	0	3	(slide)	53	Y
48	07NEC	0	3	(slide)	53	Y
49	07NEC	0	3	(slide)	53	Y
50	07NEC	0	3	(slide)	53	Y
51	07NEC	0	3	(slide)	53	Y
57	07NEC	0	3	(slide)	53	Y
58	07NEC	0	3	(slide)	53	Y
59	07NEC	0	3	(slide)	53	Y
60	07NEC	0	3	(slide)	53	Y
61	07NEC	0	3	(slide)	53	Y
62	07NEC	0	3	(slide)	53	Y
63	07NEC	0	3	(slide)	53	Y
64	07NEC	0	3	(slide)	53	Y
69	07NEC	0	3	(slide)	53	Y
70	07NEC	0	3	(slide)	53	Y
71	07NEC	0	3	(slide)	53	Y
72	07NEC	0	3	(slide)	53	Y
73	07NEC	0	3	(slide)	53	Y
74	07NEC	0	3	(slide)	53	Y
75	07NEC	0	3	(slide)	53	Y
76	07NEC	0	3	(slide)	53	Y
77	07NEC	0	3	(slide)	53	Y
78	07NEC	0	3	(slide)	53	Y

Problem Report
Project : Digitisation of the Natural Terrain Landslide Catalogue

Sheet No. : **7NE-C**

Problem No.	ABI	DOWC	Problem Description	Adjusted Dgn
A			Slide no. 46, 47, 48, 49, 50 duplicate	
B			Slide no. 61, 62, 63, 64 duplicate	
C			Slide no. 52, 53, 54, 55, 56,65, 66, 67, 68 are in validation file bu missed in design file	
D				
E				
F				
G				
H				
I				
J				
K				
L				
M				
N				
O				
P				
Q				

Date : ______________ ______________

Drawn by : ______________ **Verified by:** ______________

DATA CAPTURE VALIDATION SHEET (DCVS)

Name of Microstation File : (dgn) 07NEC.DGN

☑ 2D File ☐ 3D File

File checked by : Yu Chiu [signature]

Objective :

Date : 16 - 7 - 96

Level	Use	Description	Colour	Weight	Style
1					
2					
3					
4					
5					
6		No Problem			
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					
41					
42					
43					
44					
45					
46					
47					
48					
49					
50					
51					
52		No. of element = 78 } ok.			
53		No. of element = 78 } ok.			
54	ff	Linked Conn Polygon			
55					
56					
57					
58					
59					
60	ff	Error flags			
61					
62					
63					

File saved on :

CMSDCV_IFO.WB2

[initials] Checked OK 1-8-96

APPENDIX E

LANDSLIDE DATA CAPTURE MODULE FOR THE NTLI

Natural Terrain Landslide Data Capture MDL Module

(As at January 23, 1996)

A MicroStation MDL module is developed for capturing Natural Terrain Landslide and other area features. There 10 commands (icon) in the current verion of data capture module.

=================== To Compile This Program ============================

All the source codes should be resided in a directory, says c:\mdl\slide

(1). Modify the variable "slide", in slide.mke, to point to the directory

    slide   = c:/mdl/slide/

(2). Make sure variable MS points to the directory where ustn resides.

    $ set MS=c:\ustation

(3). Modify all the default symbologies setting in file "slide.mc" to fit your need.

```
/*==========================================================================
                 Modify following constants to change the default
                 settings of elements' symbologies.
==========================================================================*/
#define     TEXTHEIGHT      3.0    /* The text height of slide text */
#define     TEXTWIDTH       2.0    /* The text width of slide text */
#define     TEXTCOLOR         0    /* The text color of slide text */
#define     TEXTWEIGHT        0    /* The text weight of slide text */
#define     TEXTSTYLE         0    /* The text style of slide text */
#define     TEXTLEVEL         1    /* The text level of slide text */
#define     TEXTFONT          2    /* The text font of slide text */

#define     LINESLIDECOLOR    5    /* The color of line slide */
#define     LINESLIDEWEIGHT   0    /* The weight of line slide */
#define     LINESLIDELEVEL    2    /* The style of line slide */

#define     DOTSLIDECOLOR     4    /* The color of dot slide */
#define     DOTSLIDEWEIGHT    0    /* The weight of dot slide */
#define     DOTSLIDELEVEL     3    /* The level of dot slide */
```

```
/*=======================================================================
  Following are the symbologies of error mark. The program will create a buffer
  zone around the invalid/duplicated slides.
  where invalid means the slide number can't be found in the check file,
        duplicate means the slide number is identical with that of existing
slide.
=======================================================================*/

#define     ERRORBUFFER       2.5  /* The width of buffer zoning created when
error occurs */

#define     INVALIDCOLOR       3   /* The color of error mark of invalid slide */
#define     INVALIDWEIGHT      0   /* The weight of error mark of invalid slide
*/
#define     INVALIDSTYLE       0   /* The style of error mark of invalid slide */
#define     INVALIDLEVEL      61   /* The level of error mark of invalid slide */

#define     DUPLICATECOLOR     3   /* The color of error mark of duplicated slide
*/
#define     DUPLICATEWEIGHT    0   /* The weight of error mark of duplicated
slide */
#define     DUPLICATESTYLE     0   /* The style of error mark of duplicated slide
*/
#define     DUPLICATELEVEL    61   /* The level of error mark of duplicated slide
*/

#define     DEVEL1945COLOR           0
#define     DEVEL1945WEIGHT          0
#define     DEVEL1945STYLE           0
#define     DEVEL1945LEVEL          30

#define     DEVEL1945TEXTCOLOR       0
#define     DEVEL1945TEXTWEIGHT      0
#define     DEVEL1945TEXTLEVEL      31
#define     DEVEL1945TEXTFONT        2
#define     DEVEL1945TEXTHEIGHT    3.0
#define     DEVEL1945TEXTWIDTH     2.0

#define     LATERDEVELCOLOR          3
#define     LATERDEVELWEIGHT         0
#define     LATERDEVELSTYLE          0
#define     LATERDEVELLEVEL         32

#define     LATERDEVELTEXTCOLOR      3
#define     LATERDEVELTEXTWEIGHT     0
#define     LATERDEVELTEXTLEVEL     33
#define     LATERDEVELTEXTFONT       2
#define     LATERDEVELTEXTHEIGHT   3.0
#define     LATERDEVELTEXTWIDTH    2.0

#define     GULLEYCOLOR              2
#define     GULLEYWEIGHT             0
#define     GULLEYSTYLE              0
#define     GULLEYLEVEL             34

#define     GULLEYTEXTCOLOR          2
#define     GULLEYTEXTWEIGHT         0
```

```
#define     GULLEYTEXTLEVEL         35
#define     GULLEYTEXTFONT           2
#define     GULLEYTEXTHEIGHT       3.0
#define     GULLEYTEXTWIDTH        2.0

#define     RELICTCOLOR              1
#define     RELICTWEIGHT             0
#define     RELICTSTYLE              0
#define     RELICTLEVEL             36

#define     CLOUDCOLOR               6
#define     CLOUDWEIGHT              0
#define     CLOUDSTYLE               0
#define     CLOUDLEVEL              37

#define     CLOUDTEXTCOLOR           6
#define     CLOUDTEXTWEIGHT          0
#define     CLOUDTEXTLEVEL          38
#define     CLOUDTEXTFONT            2
#define     CLOUDTEXTHEIGHT        3.0
#define     CLOUDTEXTWIDTH         2.0

#define     NOPHOTOCOLOR             5
#define     NOPHOTOWEIGHT            0
#define     NOPHOTOSTYLE             0
#define     NOPHOTOLEVEL            39

#define     NOPHOTOTEXTCOLOR         5
#define     NOPHOTOTEXTWEIGHT        0
#define     NOPHOTOTEXTLEVEL        40
#define     NOPHOTOTEXTFONT          2
#define     NOPHOTOTEXTHEIGHT      3.0
#define     NOPHOTOTEXTWIDTH       2.0

/*======================================================================*/
```

(4). Compile the source codes to application by following command.

```
$ bmake slide (For DOS)
$ bamkewin slide (For NT)
```

================== To Execute SLIDE CAPTURE ==========================

(1). Copy slide.rsc to \ustation\wsmod\default\symb, the slide.rsc is a symbology file which contains the definition of customer line style (slide).

(2). Open a design file to perform slide capture. The design file must reference the hkgrid2d.dgn which contains the grid of HK. You may want to create a seed file which have the working unit properly set and reference attached.

(3). MDL LOAD SLIDE
There will come out a dialog box to allow the user to keyin the directory and 5000 map sheet number. The map sheet number should looks like 5SWA or 15NWB. For example, if I keyin C:\SLIDE\ as the directory and 6NWD as the 5000 map sheet number, then, the program will try to open c:\slide\6nwd.vid as the slide number validation file, and c:\slide\6nwd.dup as the duplicated slide number file.

Both files have following format:

```
slide number
     :
     :
     :
```

For Examples,

```
124
125
100
101
102
103
```

The .vid file should come from the database which contains the valid slide number in unit of 5000 map sheet.

The .dup file is created automatically by program which contains all the slide been captured.

(4). After the program loaded all the files necessary for checking, there will come out a dialog box contains 10 icons.

(1) The 1st icon is used to digitize line slide.

You can keyin the slide no. in the Command field of MicroStation Command Window. After <Reset> to end the line slide, you need to <Data> to identify the location of slide text.
Program will check the validation and duplication automatically and creates buffer zoning using specified symbologies to indicate error occurance when necessary.

(2) The 2nd icon is used to digitize part of line slide. (slides having part of its lstring at other map sheet.

The beginning part of slide should be digitized using 1st icon while this command is use to digitize end part (without slide crown) of slide.
Program will append a userdata to this element in order to be reconized when performing edge-matching.

(3).The 3rd icon is used to digitize Dot slide (with fixed length of 5 M).

You can keyin the slide no. in the Command field of MicroStation Command Window. After 2nd <Data> to identify the orientation of slide, you need to <Data> to identify the location of slide text.
Program will check the validation and duplication automatically and creates buffer zoning using specified symbologies to indicate error occurance when necessary.

(4).The 4th icon is used to duplicate slide.

You can keyin the slide no. in the Command field of MicroStation Command Window. You need first identify a existing slide, and then use <Data> to identify the location of slide text.
Program will check the validation and duplication automatically and creates buffer zoning using specified symbologies to indicate error occurance when necessary.

(5).The 5th icon is used to query the attribute of slide.

Identify a existing slide and accept it, program will show up a dialog box showing the 5000 map sheet number, slide number and slide type of the selected slide. Keyin the desired value in the corresponding field and tap <Update> button will cause the program to update the attribute of the slide. If you update the slide text, program will update automatically the slide as well, and vice-vesa.

(6).The 6th icon is use to check the validation of slide (both text and string element).

The validation process will begin with the checking of text first. It will point out the conflict between the text string and userdata. Once the program find any confliction inbetween, there will come out a dialogbox containing all the texts with confliction, the numbers show in listbox are the slide numbers extracted from userdata. Double clicks the number will cause the program to zoom-in the text element.

If the text validation process is passed, program will cross-check the text and slide, and generates a report on the slide using follow format.

Total Number of Slides in c:\mail\mdltrain\slide\slide.dgn = 4

Number	Map Sheet	Color	Weight	Style	Level	Text
123	10SWA	5	0	{slide}	2	Y
124	10SWA	5	0	{slide}	2	Y
125	10SWA	5	0	{slide}	2	Y
126	10SWA	5	0	{slide}	2	Y

(7).The 7th icon is use to generate text, 5000 map sheet no. and slide serial number, at the begining point of slide.

Click the icon to issue the command and press <Data> to begin the process. You can fill in the symbology settings necessary to create the text elements.

(8).The 8th icon is use to digitize incomplete area feature.

incomplete area feature is defined as an area feature having part of its graphic at other map sheet. You need to choose the correct feature type from the option button. The symbologies of element been placed is decided by the feature type.

(9).The 9th icon is use to digitize area feature.

You need to choose the correct feature type from the option button. The symbologies of element been placed is decided by the feature type. For feature types other than RELICT DEPOSIT, you will need to keyin a string (Date) for the program to place. After digitized the area, You need to identify the text location.

(10).The 10th icon is use to place a date text for area feature.

You need to choose the correct feature type from the option button. The symbologies of text been placed is decided by the feature type.

Try it and let me know if you encounter any problem. I will keep enhansing this program and make you up to date by email.

APPENDIX F

LIST OF NTLI DATA FILES WITH COVERAGE OF ALL HONG KONG AND DRAFT SPECIFICATION FOR THE NTLI GIS IN THE GEO SCIENCE DATABASE

Draft Specification prepared by Lorraine Chu, Advanced Business Inc, consultant for Agreement No. CE 42/95 "Development of the Geoscience Database (Incorporation of ACP Ground Investigation Data into the Geoscience Database).

Natural Terrain Landslide Inventory Data Files with coverage of all Hong Kong

File Name	Description	Status(11/97)
abihk.ntl	landslide scars	original file from ABI, renamed from hk.ntl as original developed.
abihk.ntt	landslide text labels	original file from ABI, renamed from hk.ntt as original developed.
c_hkgul.dgn	gullied areas	cleaned, NDC, filled, with 1:100,000 coastline.
hkqda2.fea	development boundaries	linestring cleaned, NDC, problem with 1945 boundary on HK island
hkrelict.dgn	relict deposits	cleaned, NDC
hk.ntl	landslide scars	relict and recent separated, (hkrr2.ntl renamed)
hk.ntt	landslide text labels	relict and recent separated (hkrr2.ntt renamed)
hongkong1.sha	shadow areas	not cleaned, NDC
npc_final.fea	no photo and cloud areas	cleaned, NDC
hkrr2.ntl	landslide scars	relict and recent separated
hkrr2.ntt	landslide text	relict and recent separated
den100b2d.dgn	landslide isopleths	
udvp.dgn	undeveloped terrain	filled, without 100,000 coastline
hp5c_grid.dgn	NTLI 1:5000 sheets grid	
coast.fea	100,000 scale coastline	linestring cleaned
HK1 to HK16 .ttn	TIN model for DTM	1 for each 1:20,000 scale map
BASIC.DB	Basic slide data	Renamed from SLIDE0003.DB)
DERIVED.DB	Derived slide data	
PHOTO_D (or NTLIDATE.XLS)	Dates of photography used for each sheet	

NDC = No duplicate centroids

1. Introduction

The Natural Terrain Landslide Inventory (NTLI) data are provided by the Planning and Terrain Evaluation (PTE) section in the following files and reside under /usr3/prj/gsdb2/dgn/ntli:

BASIC.TXT	Oracle SQL*Loader data file for the basic attributes
DERIVED.TXT	Oracle SQL*Loader data file for the derived attributes
HBASIC.TXT	Oracle SQL*Loader control file for loading of BASIC.TXT
HDERIVED.TXT	Oracle SQL*Loader control file for loading of DERIVED.TXT
HK.TNL	MicroStation design file with all the slides
HK.NTT	MicroStation design file with slide_id labels at head of slides
SLIDETAG.DGN	MicroStation design file with slide_id labels at head and tail of slides

The consultant had uploaded and integrated the above data into GSDB2 for future analysis.

2. New Oracle Table & MGE Features

New database tables and MGE features were created in GSDB2 to maintain the dataset.

2.1 MGE Features

The following MGE features and labels were defined in MGE Feature Schema Builder and Label Manager.

Feature Name: Feature Code: Feature Type: Feature Category: Level: Style: Weight: Color: Attribute Table:	Slide (recent) SLIDE_RECENT line NTLI FEATURES 2 0 3 0 slide_basic
Feature Name: Feature Code: Feature Type: Feature Category: Level: Style: Weight: Color: Attribute Table:	Slide (relict) SLIDE_RELICT line NTLI FEATURES 62 0 3 3 slide_basic
Feature Name: Feature Code: Feature Type: Feature Category: Level: Style: Weight: Color: Attribute Table: Label Content: Label Placement: Label Type:	Slide Label (head) SLIDE_L_HEAD label NTLI FEATURES 3 0 0 3 slide_basic ?slide_id? x Offset: 0 m y Offset: 0 m Text

Feature Name:	Slide Label (tail)
Feature Code:	SLIDE_L_TAIL
Feature Type:	label
Feature Category:	NTLI FEATURES
Level:	4
Style:	0
Weight:	0
Color:	3
Attribute Table:	slide_basic
Label Content:	?slide_id?
Label Placement:	x Offset: 0 m y Offset: 0 m
Label Type:	Text

2.2 Oracle Tables

2.2.1 slide_basic

Description: To store basic attributes loaded from BASIC.TXT.

SLIDE_BASIC		
Column Name	***MGE Data Type***	***Oracle Data Type***
1. SLIDE_ID	character(9)	varchar2(9)
2. MSLINK	integer	number(10)
3. MAPID	integer	number(10)
4. SLOPE	integer	number(10)
5. COVER	character(1)	varchar2(1)
6. WIDTH	integer	number(10)
7. YEAR	integer	number(10)
8. XTAG	character(9)	varchar2(9)
9. YEAR_2	integer	number(10)
10. HEADELEV	integer	number(10)
11. TAILELEV	integer	number(10)

2.2.2 slide_derived

Description: To store derived attributes loaded from DERIVED.TXT.

SLIDE_DERIVED		
Column Name	***MGE Data Type***	***Oracle Data Type***
1. MSLINK	integer	number(10)
2. MAPID	integer	number(10)
3. SLIDE_ID	character(9)	varchar2(9)
4. H	real	float(21)
5. L	real	float(21)
6. HL	real	float(21)
7. GCODE	character(5)	varchar2(5)
8. GGROUP	character(5)	varchar2(5)
9. VEG	character(5)	varchar2(5)
10. L_FORM	character(2)	varchar2(2)
11. ERO	character(2)	varchar2(2)
12. WIDTH	integer	number(10)
13. STATUS	character(6)	varchar2(6)

2.3 MGE Joins and Views

To facilitate the viewing of the derived attributes on top of the basic attributes, MGE joins and views were created to link *slide_basic* and *slide_derived* by column: *slide_id.*

2.3.1 slide_all

Description: Relational view created by joining *slide_basic* and *slide_derived* on *slide_id.*

SLIDE_ALL		
Table	*Column*	*Alias*
1. slide_basic	slide_id	slide_id
2. slide_basic	slope	slope
3. slide_basic	cover	cover
4. slide_basic	width	basic_width
5. slide_basic	year	year
6. slide_basic	xtag	xtag
7. slide_basic	year_2	year_2
8. slide_basic	headelev	headelev
9. slide_basic	tailelev	tailelev
10. slide_derived	h	h
11. slide_derived	l	l
12. slide_derived	hl	hl
13. slide_derived	gcode	gcode
14. slide_derived	ggroup	ggroup
15. slide_derived	veg	veg
16. slide_derived	l_form	l_form
17. slide_derived	ero	ero
18. slide_derived	width	derived_width
19. slide_derived	status	derived_status

3. Loading Workflow

a) Attributes from the source data are tagged with Oracle linkage mode. In order to read the data in MGE, environment variable: MS_LINKTYPE has to include Oracle.

MS_LINKTYPE=DMRS:RIS:ORACLE
export MS_LINKTYPE

Update the following files with an editor:

$/usr/ip32/mge/cfg/command.env
$/usr/ip32/mge/cfg/graphics.env
$/usr/ip32/mge/cfg/alpha.env

b) Define the new MGE features and Oracle tables in *MGE Setup -> MGE Basic Administrator... -> Feature/Schema Builder.*

c) Define the relational join in *MGE Setup -> MGE Basic Administrator... -> Join Manager.*

Table 1	*Table 2*	*Join Relationship*
slide_basic	slide_derived	slide_basic.slide_id=slide_derived.slide_id

d) Define the relational view: slide_all in *MGE Setup -> MGE Basic Administrator... -> View Manager.*

Primary Table	*Joined Table*	*Join Relationship*
slide_basic	slide_derived	slide_basic.slide_id=slide_derived.slide_id

e) Bulk load data from the ASCII data files into Oracle by using Oracle SQL*Loader. The following control files are used accordingly:

HBASIC.TXT	Load 26,901 records from BASIC.TXT into Oracle table: slide_basic
HDERIVED.TXT	Load 26,901 records from DERIVED.TXT into Oracle table: slide_derived

f) The source design files are tagged with table linkages of entity number: 101. The MGE table: *mscatalog* should be checked to see if any existing table is having the same entity number.

h) If none of the existing table is having 101 as the entity number, run SQL command to update *mscatalog*:
SQL> update mscatalog set entitynum = 101 where tablename = 'slide_basic';

i) To speed up querying and searching in MGE GeoDatabase Locate (GDL), the following Oracle indexes need to be created:
SQL> create index slide_mslink on slide_basic (mslink);
SQL> create index slide_basic_id on slide_basic (slide_id);
SQL> create index slide_derived_id on slide_derived (slide_id);

j) The original design files do not have MCSO coordinate system defined. In GSDB2, create new design file (e.g. ntli_src.dgn) base on geoseed.dgn, and then copy all of the elements from HK.NTL and SLIDETAG.DGN into the file. To copy:
- start MicroStation with ntli_src.dgn as active design file;
- running MERGE utility inside MicroStation (*ustn> mdl load merge*);
- merge HK.NTL inoto ntli_src.dgn (*ustn> merge /usr3/prj/gsdb2/dgn/ntli/HK.NTL*);
- merge SLIDETAG.DGN into ntli_src.dgn (*ustn> merge /usr3/prj/gsdb2/dgn/ntli/SLIDETAG.DGN*).

The features are resided in the following levels:
- level 2 - relict slides;
- level 3 - slide head labels;
- level 4 - slide tail labels;
- level 62 - recent slides.

k) By running the following MGE batch commands, all of the features are tagged with the appropriate feature linkages, and reformatted with DMRS rather than Oracle attribute linkages:

- *mge -u -p gsdb2*
- *ulfbldr -I ntli_src.dgn -E relict.ulf -l 2*
- *featmkr -v -U relict.ulf -D ntli1.dgn -f SLIDE_RELICT*
- *ulfbldr -I ntli1.dgn -E recent.ulf -l 62*
- *featmkr -v -U recent.ulf -D ntli2.dgn -f SLIDE_RECENT*
- *ulfbldr -I ntli2.dgn -E head.ulf -l 3*
- *featmkr -v -U head.ulf -D ntli3.dgn -f SLIDE_L_HEAD*
- *ulfbldr -I ntli3.dgn -E tail.ulf -l 4*
- *featmkr -v -U tail.ulf -D ntli4.dgn -f SLIDE_L_TAIL*
- *ulfbldr -I ntli4.dgn -E ntli4.ulf -l 2-4,62*
- *linkdtr -U ntli4.ulf -D ntli.dgn -x*

l) (Optional) Run *MGE Base Mapper -> Attribute Processing Modules.... -> Map ID Loader* to load mapids into column: *mapid* of table: *slide_basic.*

4. Appendices

File: HBASIC.TXT

```
LOAD DATA
INFILE BASIC.TXT
INTO TABLE SLIDE_BASIC
REPLACE
FIELDS TERMINATED BY '|' OPTIONALLY ENCLOSED '"'
TRAILING NULLCOLS
(slide_id,mslink,slope,cover,width,year,xtag,year_2,headelev,tailelev)
BEGINDATA
```

File: HDERIVED.TXT

```
LOAD DATA
INFILE DERIVED.TXT
INTO TABLE SLIDE_DERIVED
REPLACE
FIELDS TERMINATED BY '|' OPTIONALLY ENCLOSED '"'
TRAILING NULLCOLS
(mslink,slide_id,H,L,HL,Gcode,Ggroup,Veg,L_form,Ero,width,status)
BEGINDATA
```

APPENDIX G

STUDY BRIEF, METHODOLOGY AND EXAMPLE DATA SHEET FROM THE RECOGNITION FACTOR SURVEY

The original survey data is stored in Planning Division file GCP 2/A1/3-1. Maps showing the areas resurveyed each year are stored in the NTLI vertical plan chest with the original 1:5,000 scale NTLI maps.

PROJECT BRIEF

Project Title: Determining a Recognition Factor for Landslides Identified in the Natural Terrain Landslide Inventory.

Aim: To determine the percentage of natural slope landslides misclassified or unclassified in the Natural Terrain Landslide Inventory.

Methodology: Compare the number of natural terrain landslides identified from low altitude aerial photographs against those mapped from the high altitude aerial photographs and recorded within the Natural Terrain Landslide Inventory.

Comparisons will involve:

(i) landslides not identified from high altitude aerial photographs;
(ii) landslides wrongly identified as natural terrain landslides in high altitude aerial photographs. This includes:

  * features which are not natural terrain landslides;
  * landslides which originate within artificial slopes.

The method will be restricted to a comparison of data sets where low and high altitude aerial photographs are available for the same year. Low altitude aerial photographs must have been taken within 12 months of the date of the high altitude aerial photographs. In many cases, this will restrict comparisons between low and high altitude aerial photography dating from the late 1970's or early 1980's to 1994.

Part or all of ten (10) 1:5 000 map sheets have been selected on different geological units across the Territory to ensure that a complete coverage of differing densities of recent landslides is achieved. The sheets have been selected to ensure that they fulfil a number of criteria:

1. part of the map sheet has been affected by major landslide activity since 1981;
2. low altitude aerial photographs are available for part or all of the map sheet in the same year as the major landslide activity;
3. aerial photographs cover part or all of the map sheet for a number of other years where landslide activity was not observed in the high altitude aerial photographs;
4. the sheets include all major geological units in the Territory.

The selected sheets are:

3NW-D (volcanics)
4SW-A (sediments)
parts of 6SE-C & 6SE-D (fine and medium grained granites)
6SW-A (fine and fine to medium grained granites)

7NW-A (volcanics)
8NW-A (tuffs)
9SW-D (volcanics and sediments)
9SE-D (volcanics)
13NE-A (volcanics).

Procedure:

1. From the natural terrain landslide data base for the ten selected 1:5 000 topographic map sheets, GEO is to plot on film or paper, all landslides that have a land cover class of Class A or Class B for nominated years. Different colours should be used to indicate the year in which each landslide crown and trail was identified. Each landslide is to be annotated with its correct landslide number.
2. Interpret the low altitude aerial photographs for the years selected and on these same 1:5 000 map sheets:

   * identify on the low altitude aerial photographs all the natural terrain landslides mapped in the Natural Terrain Landslide Inventory;
   * record new landslides not identified from high altitude aerial photographs;
   * mark those landslides incorrectly identified as natural terrain landslides including those which are not landslides, and those which are associated with artificial slopes;
   * for features already classified correctly, assess if more than one active head is located within the landslide.

<u>Note:</u> No assessment will be made of the recognition factor associated with the lengths of the debris trails.

Estimated Time:

240 hours (6 weeks) for API work
40 hours (1 week) for report writing and editing

Report:

The consultant will prepare a brief report on the results obtained from the project. It will comprise

1. A Summary Table for each map sheet listing:
   * aerial photograph sets used;
   * landslides not identified from the high altitude aerial photographs;
   * landslides misclassified as natural terrain landslides;
   * landslides classified as natural terrain landslides but originating within disturbed terrain;
   * percentage of natural terrain landslides missed because they cannot be identified from the high altitude aerial photographs.

2. General Conclusions.

Consultant's Duties:	1.	Select the aerial photograph sets to be used.
	2.	Undertake the API assessment.
	3.	Write Report.
GEO's Input:	1.	Technical Officer assistance to retrieve the aerial photographs.
	2.	Plots of 1:5 000 topographic maps showing all fresh (i.e. land cover classes A and B) dating from 1972 with (i) landslide number attached (ii) year of identification, using different colours for each year.
	3.	Order in low altitude aerial photographs to cover the following map sheets:

6SW-A:	1973, 1976, 1977, 1981, 1982, 1983, 1985, 1989, 1991, 1992
7NW-A:	1976, 1980, 1982, 1985, 1989, 1991
9SE-D:	1973, 1990
9SW-D:	1973, 1985
13NE-A:	1982, 1983, 1990.

API STUDY: DETERMINING THE RECOGNITION FACTOR FOR LANDSLIDES IDENTIFIED IN THE NATURAL TERRAIN LANDSLIDE INVENTORY

Study Brief

The aim of the study was to determine the percentage of natural landslides misclassified or unclassified in the Natural Terrain Landslide Inventory (NTLI).

Study Area

Part or all of ten (10) 1:5000 map sheets were studied to reflect the differing geologies across the Territory.

These sheets were:

3NW-D (volcanics)
4SW-A (sediments)
parts of 6SE-C & 6SE-D (fine and medium grained granites)
6SW-A (fine and fine to medium grained granites)
7NW-A (volcanics)
8NW-A (tuffs)
9SW-D (volcanics and sediments)
9SE-D (volcanics)
13NE-A (volcanics)

Methodology

The methodology was set in the brief as follows:

Compare the number of natural terrain landslides identified from low altitude aerial photographs against those mapped from the high altitude aerial photographs and recorded within the Natural Terrain Landslide Inventory.

Comparisons involved:

(i) landslides not identified from high altitude aerial photographs;
(ii) landslides wrongly identified as natural terrain landslides in high altitude aerial photographs. This included:

- * features which are not natural terrain landslides;
- * landslides which originate within artificial slopes;
- * landslides that have been recorded with the wrong dates.

The method is restricted to a comparison of data sets where low and high altitude aerial photographs are available for the same year. Low altitude aerial photographs must have been taken within 12 months of the date of the high altitude aerial photographs. In many cases, this restricts comparisons between low and high altitude aerial photography dating from the late 1970's or early 1980's to 1994.

Part or all of ten (10) 1:5 000 map sheets have been selected on different geological units across the Territory to ensure that a complete coverage of differing densities of recent landslides is achieved. The sheets have been selected to ensure that they fulfil a number of criteria:

1. part of the map sheet has been affected by major landslide activity since 1981;

2. low altitude aerial photographs are available for part or all of the map sheet in the same year as the major landslide activity;

3. aerial photographs cover part or all of the map sheet for a number of other years where landslide activity was not observed in the high altitude aerial photographs;

4. the sheets include all major geological units in the Territory.

A data sheet was drawn up to record all the information for each observation. A copy of a completed record is attached as Appendix 1.

Procedure

Landslides originally recorded in the NTLI were located on the low altitude aerial photographs. They were checked for the dates in which they could be first observed and for the number of heads in each landslide feature. Any discrepancies in the dates were recorded.

Additional landslides identified from the low altitude aerial photographs were mapped as linear features, in the same way as was done for the NTLI study, and details recorded of the year in which they were first observed and their vegetation cover. They were given a four digit, unique reference number commencing with the number '2'. This ensured that the these additional landslides were totally distinct from those recorded by the NTLI.

For each set of low altitude aerial photographs examined, the area covered by the stereoscopic image was drawn on the base map.

For each map sheet, a summary sheet was prepared detailing the years for which landslides were resampled, the number of landslides resampled, those landslides that were wrongly dated, those that were misclassified and the number of heads in each landslide. Additional landslides were recorded in the year they were first observed, together with the number of heads identified.

No comparisons were made from low altitude aerial photographs which were taken more than 12 months apart from the date of the high altitude aerial photographs.

General Observations:

1. The low altitude aerial photographs generally covered the lower and more intensively used sections of the valleys. As a consequence, higher elevated areas were not covered.

2. Poor coverage of low altitude aerial photographs restricted the number of NTLI landslides that could be resampled.

3. Approximately 2.7% of all landslides had more than one head per landslide feature.

4. The majority of the additional landslides were identified only from the low altitude aerial photographs.

5. Recently constructed graves on steep hill sides were the main features misclassified as natural terrain landslides from the high altitude aerial photographs.

6. On the ten 1:5 000 map sheets examined, no examples were found of small, partially displaced landslides. Characteristics of a partially displaced landslide include the downward displacement of a soil mass over a small distance so that it largely overlies the surface of rupture. With the displaced material still carrying its original vegetation cover intact, these features cannot be recognised easily in the smaller scaled aerial photographs.

7. For one map sheet, 6SW-A, eleven additional landslides were identified within the areas mapped as gully eroded lands. Many of these gully systems have characteristics suggesting that landslides were either a prominent factor in their formation or part of the on-going erosion process after the gully had formed. Because of the difficulty of resolving the chronological order of the processes, landslides were not mapped within these gullied areas. Instead, the affected areas were identified as gully eroded lands and excluded from further assessment.

Observations for Each Map Sheet

3NWD **Chueng Shan (Dog Hill)**

Poor coverage of low altitude aerial photographs with only 5 NTLI landslides resampled and 3 additional landslides recorded.

4SWA **Yan Chau Tong (Double Haven)**

Very poor coverage of low altitude aerial photographs with only 2 years able to be examined (1986 & 1987). Eight (8) NTLI landslides were assessed and 4 additional landslides added.

6SEC **Sham Tseng/Tuen Mun Road**

There was reasonable coverage of low altitude aerial photographs with the majority of NTLI landslides resampled in 1982 (39) from a total of 46. Six (6) additional landslides were identified from the low altitude aerial photographs.

4

6SED **Tsuen Wan/Tuen Mun Road**

There were only 3 years for which landslides were recorded on the NTLI (1973, 1976, 1982). Tsing Yi Island had the majority of these landslides. However, it also had very poor coverage of low altitude aerial photographs. There were only 4 landslides resampled and no additional landslides were found.

6SWA **East of Tuen Mun**

There was a good selection of low altitude aerial photographs but with most runs covering the urban areas leaving poor coverage of the eastern half of the map sheet. There were 46 additional landslides recorded from the low altitude aerial photographs. Of the 153 NTLI landslides resampled, only 4 were identified as non-landslides as they were mainly eroded gully features. Eleven (11) landslides were also identified as originally within the areas mapped as gully eroded areas. Under the criteria for mapping of landslides within the NTLI, these were not included in the NTLI.

7NWA **Lam Tsuen Valley**

There was a reasonable coverage of low altitude aerial photographs with the majority of these orientated in the NE to SE direction (associated with more densely populated areas). 81 NTLI landslides were resampled of which 4 were identified as non-landslides. Fifteen (15) additional landslides were recorded from the low altitude aerial photographs.

8NWA **Shek Nga Tau/Kai Ma Tung**

Poor coverage of low altitude aerial photographs during the 1970's with photos only available for 1973. This year had the majority of additional landslides identified from the low altitude aerial photographs. Only 6 NTLI landslides were resampled in 1985 & 1987.

9SED **Sunset Peak, Lantau Island**

Good coverage of low altitude aerial photographs. The majority (47) of the NTLI landslides resampled were in 1992, of which 10 had been reclassified as non-landslides (7 of these were gravesites). Nine (9) additional landslides were recorded and of these two could be seen on the high altitude aerial photographs.

9SWD **Tai O / Sham Wat Road**

Two landslide years had full coverage of low altitude aerial photographs (1973, 1993) and part coverage for 2 other years. There were a large number of additional landslides found in 1973 but not identifiable on the high altitude aerial photographs for that year. In 1976, 19 NTLI landslides were wrongly dated, being visible in 1973 low altitudes but not visible on the high altitude aerial photographs because of poor resolution. As a result they could only first be identified in 1976. 1993 landslide year had a large number of NTLI landslides resampled (94) with only 2 identified as non-landslide features and 3 additional landslides found on the low altitude aerial photographs.

13NEA **Shek Pik Reservoir, Lantau Island**

Poor coverage of low altitude aerial photographs during the 1970's with no NTLI landslides able to be resampled until 1982. 83 NTLI landslides were then resampled of which 6 were determined to be non-landslide features. 18 additional landslides were recorded.

Project Time: 9.10.1996 - 24.10.1996
104 hours

Project Consultant: G.I.Short
API Consultant/5
Produced under Agreement No.CE 16/93 for CED

APPENDIX

Page 1: **Example of the summary sheet prepared for each 1:5 000 map sheet (7NW-A) assessed during the API Study.**

Page 2: **Example of the data sheet used for the API Study (1:5 000 map sheet 9SW-D).**

Recognition Factor for Landslides

Sheet No: 7NWA........ Date: 17.10.96.... APPENDIX 1

* Refer to data sheets for comments

Year	Area ha	Resampled Landslides				New Landslides			
		No. Resampled	Non L/S NTLI No.	Wrong date * NTLI No.	Multi heads NTLI No.	Low flt only L/S No.	High & low L/S No.	High only L/S No.	No. of heads L/S No.
1973		15	56			2447			1
			34			2448			1
							2449		1
1976		1				2450			1
1975		2							
1982		28	186	246	185	2457			1
				262	166		2458		1
						2459			1
						2460			1
						2461			1
						2462			1
						2463			1
						2464			1
1989		35	308		295	2453			1
					299	2454			1
					315				
1994		NIL				2465			1
1992		NIL							
1993		NIL							

Recognition Factor for Landslides

Sheet No: 9SWD Date: 23.10.96 pg 2.

Old No.	New Slide No.	Yr of Slide. High Flt	Photo Yr. Low Flt	No. of Heads	Veg. cover	Incorrectly Identified - Comments
	2739	—	73	1	B	
	2740	—	73	1	B	
	2741	—	73	1	B	
495		76	73	1		Not visible on 73 high (shadow)
498		76	73	1		
499		76	73	1		
500		76	73	1		
496		76	73	1		
497		76	73	1		
	2742	—	73	2	B	Obscured in 73 high
	2743	—	73	1	B	
	2744	—	73	2	B	
	2745	—	73	1	B	
	2746	—	73	1	B	
	2747	73	73	2	A	
462		76	73	1		Not visible on 73 high
463		76	73	1		
464		76	73	1		
465		76	73	1		
	2748	—	73	1	A	
	2749	—	73	1	A	
	2750	—	73	1	A	
	2751	—	73	1	B	
	2752	—	73	1	A	In shadow on 73 high
444		73	73	1		
445		73	73	1		
446		73	73	1		
447		73	73	1		
449		73	—	—		Not found on 73 high or low
448		73	—	—		
450		73	—	—		
560		73	73	1		
509		73	73	1		
508		73	—	—		Not found on high or low 73
507		73	—	—		

APPENDIX H

PROJECT BRIEF, METHODOLOGY AND EXAMPLE DATA SHEET FROM THE REVEGETATION SURVEY

The original survey data is stored in Planning Division file GCP 2/A1/3-1.

PROJECT BRIEF

Project Title: An assessment of the rate of reestablishment of vegetation cover on natural terrain landslides.

Aim: To determine the rate at which natural terrain landslides become stable with vegetation cover.

Methodology: Approximately 100 natural terrain landslide events which occurred between 1964 and 1989 will be selected for assessment. Aerial photographs from the date of the landslide event will be interpreted. In most cases, the aerial photographs will need to be interpreted from the date of the high level aerial photographs immediately preceding the set on which the landslide was first observed. This is because the landslide may have been initiated some years before it was first observed in the high altitude aerial photographs.

For each successive pass of aerial photographs (both high and low level aerial photographs), the vegetation cover for the landslide crown and the landslide trail will be recorded into one of four classes. The classes to be used are:

Class A	totally bare of vegetation
Class B	partially bare of vegetation
Class C	completely covered in grasses or vines
Class D	covered in shrubs and/or trees.

Procedure:

1. From the natural terrain landslide data, the landslides for study will be selected and reviewed by SGE/PTE. Information will be provided on the map sheet number, the year in which the landslide was first observed and the vegetation cover category.
2. Aerial photographs retrieved from the system by a Technical Officer.
3. API for vegetation cover to be undertaken by the Consultant.
4. Observations to be recorded on data sheets by Consultant.
5. Report written by Consultant.

Estimated Time: 40 hours (1 week) for API work
8 hours (1 day) for report writing

Report: The consultant will prepare a brief report on the methodology used for the project. It will comprise

1. A Summary Table listing the aerial photographs used;
2. A description of the methodology used for the project.

The report will not provide any analysis of the data obtained from the project.

Consultant's Duties:

1. Select the aerial photograph sets to be used.
2. In combination with staff of PTE Section, nominate the landslides to be studied, ensuring that they cover a wide range of geological and land form units.
2. Undertake the API assessment.
3. Write Report.

GEO's Input:

1. Technical Officer assistance to retrieve the aerial photographs.
2. Order in additional aerial photographs where requested for use in the API assessment.

PROJECT TITLE: THE RATE OF REVEGETATION OF NATURAL SLOPE LANDSLIDES

Project Aim

Determine the rate at which natural slope landslides are revegetated.

Project Objectives

Interpret all aerial photographs available within the PTE Section to determine the changes in ground cover conditions for two sections of a natural terrain landslide:

1. the exposed part of the surface of rupture;
2. the disturbed mass of material within the landslide debris trail.

Project Methodology

It was important to ensure that a number of variables were considered when selecting the landslides for individual assessment. These variables were:

1. locality
2. the year in which the landslides were first observed
3. rock type
4. aspect
5. topographic location
6. vegetation cover around the crown of the landslide at the time the landslide occurred
7. characteristics of the landslide: size of surface of rupture, length and width of debris trail, depth of failure
8. aerial photograph coverage.

A data sheet was drawn up to record specific information for each landslide assessed. The data sets were of two types: background information concerning the landslide and the direct observations of ground cover conditions made from the aerial photographs.

a. Background Information

This comprised data from the Natural Terrain Landslide Inventory (NTLI), the 1:20 000 geological maps and observations from aerial photographs. From the NTLI, the relevant information extracted was:

1. the 1:5 000 map sheet number
2. NTLI landslide number
3. year and month in which the landslide was first observed by the NTLI
4. aspect.

Other information from the NTLI digital data to be added at a later stage includes:

5. length of debris trail
6. co-ordinates of the landslide crown.

From the 1:20 000 geological maps of the Territory, the map symbol for the geological unit on which the landslide crown occurred was recorded.

From the aerial photographs, two further sets of data were added. These were:

7. the width of the landslide at its widest point, measured directly from the aerial photographs. The scale of an aerial photograph was determined from its nominal flying height. For example, a flying height of 10 000 ft gives an approximate scale of 1:20 000.

8. a general description of the characteristics of the landslide, including its topographic location, previous landslide events on the site, ground cover conditions and significant characteristics of the debris trail.

b. Observations from Aerial Photographs

For each set of high and/or low aerial photographs the following data were recorded:

* year, month and day of photography
* aerial photograph index numbers
* percentage bare ground on the landslide crown (including the exposed part of the surface of rupture)
* percentage bare ground of the debris trail.

Eighty-nine sets of records were prepared for 95 landslide features, and covering eighteen 1:5 000 map sheets. For each 1:5 000 map sheet, the numbers of features examined were:

3NE-B(2)	3NE-C(12)	3NE-D(5)
3SE-A(12)	3SE-C(5)	4SW-A(7)
6NE-B(1)	6SW-B(7)	6SW-D(5)
7NW-A(9)	7NW-C(2)	9SE-C(6)
9SE-D(7)	11SW-A(3)	11SW-C(3)
13NE-A(4)	13NW-A(3)	15NW-B(2).

Limitations of the Methodology

In some of the aerial photographs, observations of ground cover conditions around the crown of the landslide and along the debris trail were not possible because of specific problems. Problems included:

1. lack of aerial photography. This is a particularly critical issue for all areas outside the major urban centres. Over isolated parts of the Territory, only

one or two sets of low altitude aerial photographs may be available for some landslide features;

2. poor resolution in some high altitude aerial photographs, restricting the ability to identify if bare areas are being colonized by grasses or low shrubs. In the dry seasons, when the grasses have dried out and are light brown in colour, their reflectance characteristics can be very similar to bare soil;
3. shadowing of sections of the landslide because of the time of photography or the camera angles;
4. obscuring of the landslides caused by overhanging terrain and the angle of the photography.

Observations from the Project

Revegetation Characteristics

1. The trail of a landslide revegetates more quickly than the landslide head, which includes the exposed part of the surface of rupture.

   In many cases, the landslide trail was completely, or almost completely, covered by vegetation five to eight years after the initial failure. In those situations where the trail comprised only a thin deposit of material or a thin incision into the slope, the rate of revegetation was quicker, whereas if the debris deposits were thicker, or the depth of incision greater, complete revegetation of the trail took longer than eight years.

2. The head and crown of the landslide, which included the exposed part of the surface of rupture, revegetated more slowly because of the absence of a suitable growing medium. The rate of revegetation of the landslide head can be 10 or 15 years longer than for the trail of the same landslide.

3. For both the head and trail of the landslide, once the proportion of bare ground falls below 50%, further revegetation increased quickly because of the presence of pioneer plants.

4. Revegetation of landslides on north-facing slopes **seemed** to occur more quickly, possibly due to a number of factors, including:

   * milder temperature regimes
   * lower incoming solar radiation levels
   * higher moisture levels because of lower evapotranspiration rates.

   Conversely, the south-facing slopes **seemed** to revegetate more slowly because of the opposite factors:

   * higher temperature regimes
   * higher incoming solar radiation levels
   * lower moisture levels because of higher evapotranspiration rates.

5. The influence of geology, climate and topographic location on the rates of revegetation, as single issues or in combination with each other and with aspect, could not be assessed within the time allowed for this project.

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SHEET NUMBER: 3NE-C LANDSLIDE NUMBER: 14				
YEAR AND MONTH LANDSLIDE FIRST OBSERVED: 1964.12				
Co-ordinates of Landslide Crown:				
1:20 000 Geology Map Symbol: JSM Aspect: S-SSW				
Approximate Width (m) of Landslide: 20m				
Approximate Length (m) of Landslide:				
Ground Slope Angle (°) across Landslide Crown: 34°				
Year	Month and Day	Aerial Photo Numbers	Landslide Crown % Bare Ground	Landslide Trail % Bare Ground
1964	12.14	Y13070-1	100	80
1973		stereoscopic image not available		
1974	11.25	10025-6	50	0
1975	12.24	11844-5	40	0
1976	11.23	16299-300	40	0
1978	12.15	24451-2	20	0
1979	11.30	28463-4	10	0
1981	10.28	39473-4	10	0
1983	1.24	47059-60	0	0
1985	10.1	67350-1	50[1]	0
1986	8.3	A 5544-5	0	0
1987	1.5	A 8488-9	0	0
1988	1.16	A 11850-1	0	0
1990	12.3	A 24203-4	0	0

[1] new period of sheet/rill erosion on site.

Description of Landslide: Located within an old landslide scar below a prominent ridge. Part of the debris comprises displaced blocks of weathered material with the vegetation intact. Appears as though it comprises two separate landslides, one below the other. Original vegetation is grass.

saved as: d:\emery\landslide\tab.lsl

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7.11.1996