Establishment of Enviromental Geological Database on Slope Land in Taiwan

Central Geological Survey
Chi Chung-Chi
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Taiwan Topography

Over 75% of highlands

Initiative

- Overdeveloped slopeland usually causes landslide or slope failure during typhoon season or earthquake.
- To identify potential problem area in order to prevent from future disaster.
- The Central Geological Survey (CGS) has commenced the geological hazard investigation program on sloping land since 2002 .

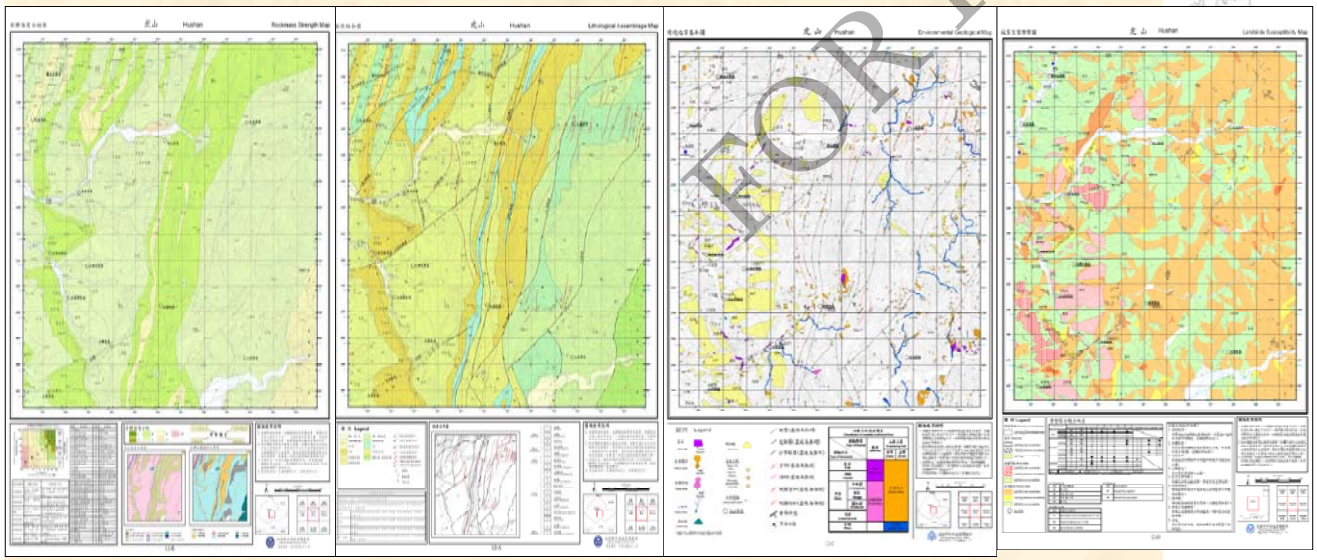
Introduction

The goal of this project :

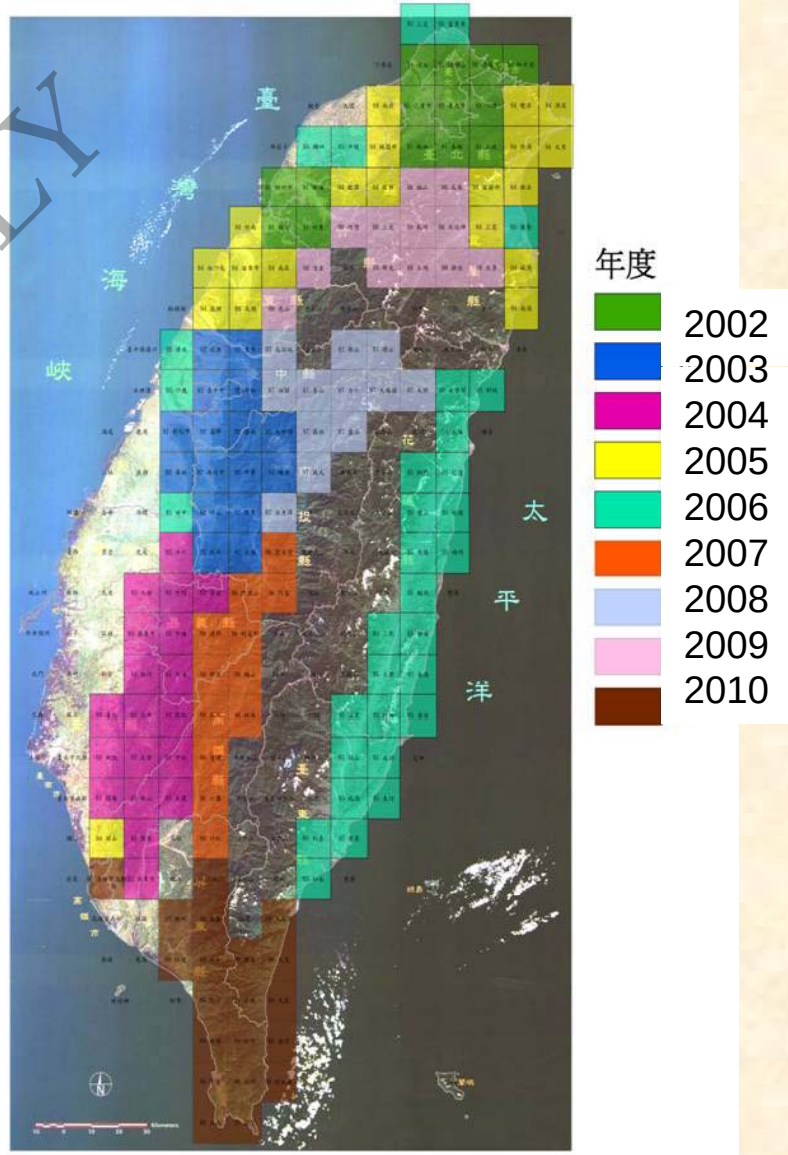
1. Identify hazard area for slope area.
2. Establish an integrated geological database for hazard prevention.
3. Gelological hazard evaluation for villages.
4. Provide real-time geological hazard information.
5. Promotion and education for hazard prevention.

The Contents of Database

- Lithological Map
- Rock Mass Strength Map
- Environmenta lGeological Basic Map
- Landslide Susceptibility Map

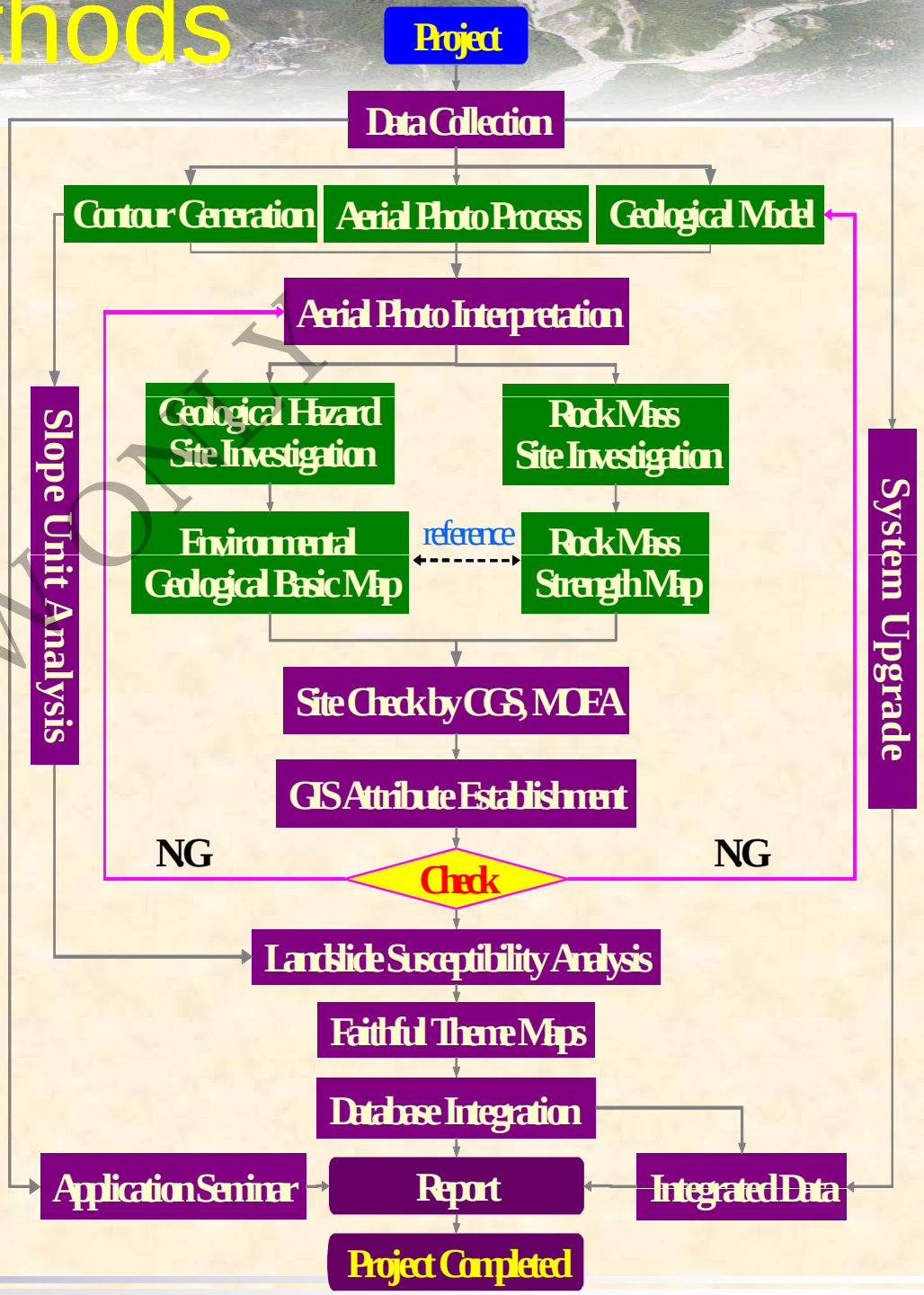


臺灣坡地環境地質圖91-99調查範圍

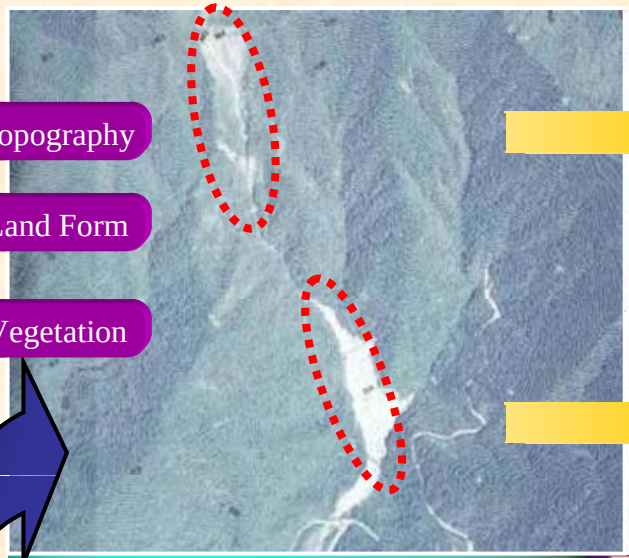


Methods

- ✓ Contour generation
- ✓ Aerial photo process
- ✓ Aerial photo interpretation
- ✓ Filed investigation
- ✓ GIS database establishing
- ✓ Landslide susceptibility analysis
- ✓ Susceptibility evaluation for high mountain villages
- ✓ Query System Upgrade
- ✓ Inquiry and Application Seminar



Aerial Photo Interpretation

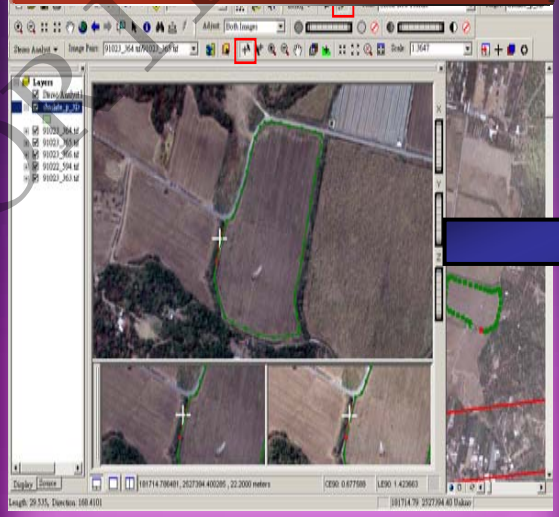


- Interpreted and digitized with GIS application
- Minimized the inaccuracy during digitization
- Integrated data layers overlap for check / print

Aerial Photo Interpretation

ArcGIS+Stereo Analyst

Digitization

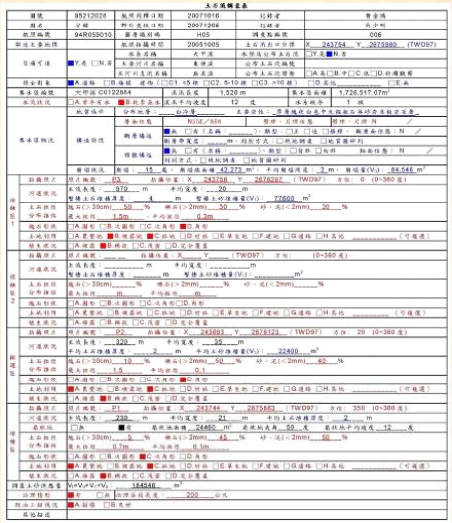


Field Base Map

Site Investigation

- Recording by using PDA / UMPC to minimized typing error.
- Schmidt hammer, geological hammer and knife were used for strength determination.
- Photograph all surveyed outcrops with GPS to record the coordinate.
- 13,262 geological hazards, of which 2,692 were surveyed. Besides, 1,818 rock mass engineering outcrops were studied and 1,331 rock strength tests were conducted.

Check tables



Field strength test

S1(0.25)甚軟黏土：	手掌易於插入
S2(0.25-0.5)軟黏土：	大拇指易插入
S3(0.5-1)實黏土：	大拇指用力可插入
S4(1-2.5)硬黏土：	大拇指易於壓出凹痕但難插入
S5(2.5-5)甚硬黏土：	大拇指甲易於壓出凹痕
S6(5)甚硬黏土：	大拇指甲難於壓出凹痕
R0(2.5-10)極弱岩石：	大拇指甲僅能壓出凹痕
R1(10-50)甚弱岩石：	可以地質錘細端敲碎，可以小刀切削之
R2(50-250)弱岩：	小刀難於切割；地質錘細端敲出淺痕
R3(250-500)中強岩石：	小刀無法切削；地質錘敲擊一次可裂
R4(500-1000)強岩：	地質錘敲擊一次以上始裂
R5(1000-2500)甚強岩石	地質錘敲擊多次始裂
R6(2500)極強岩石：	地質錘猛敲擊僅見小碎片跳出，極難於敲裂

PDA / UMPC recording

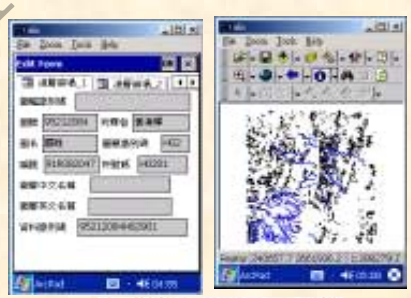


Photo with GPS data

Landslide

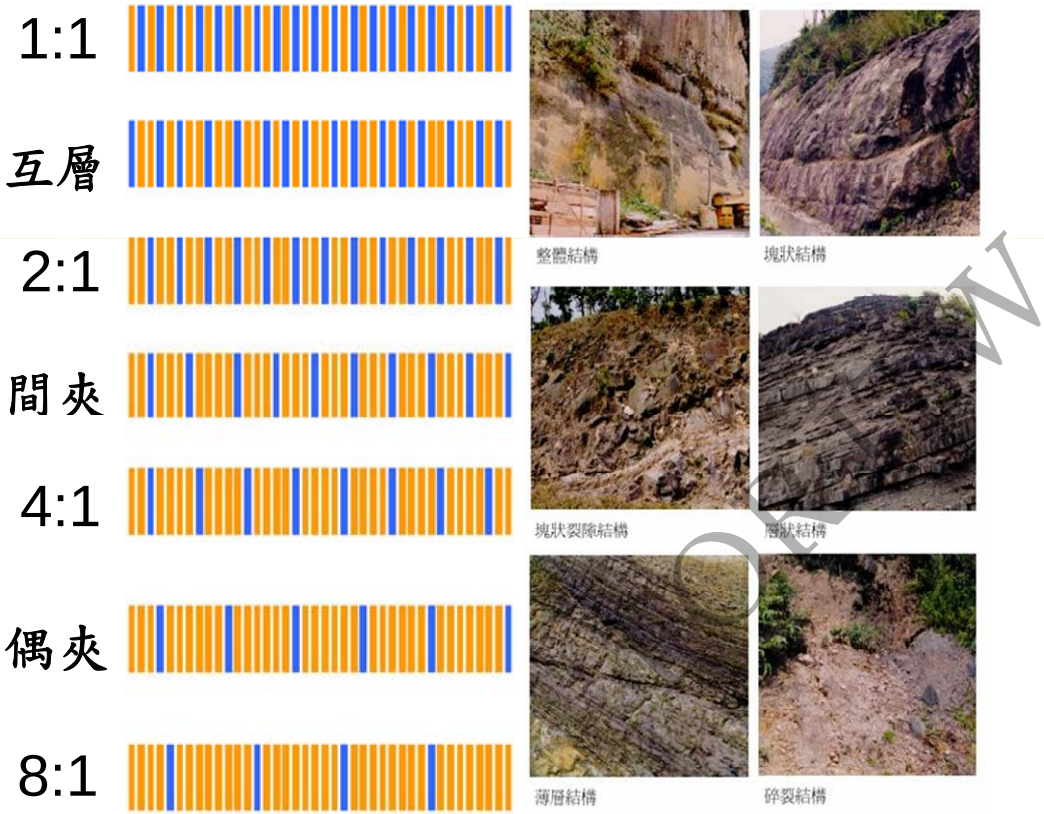
Rock slide

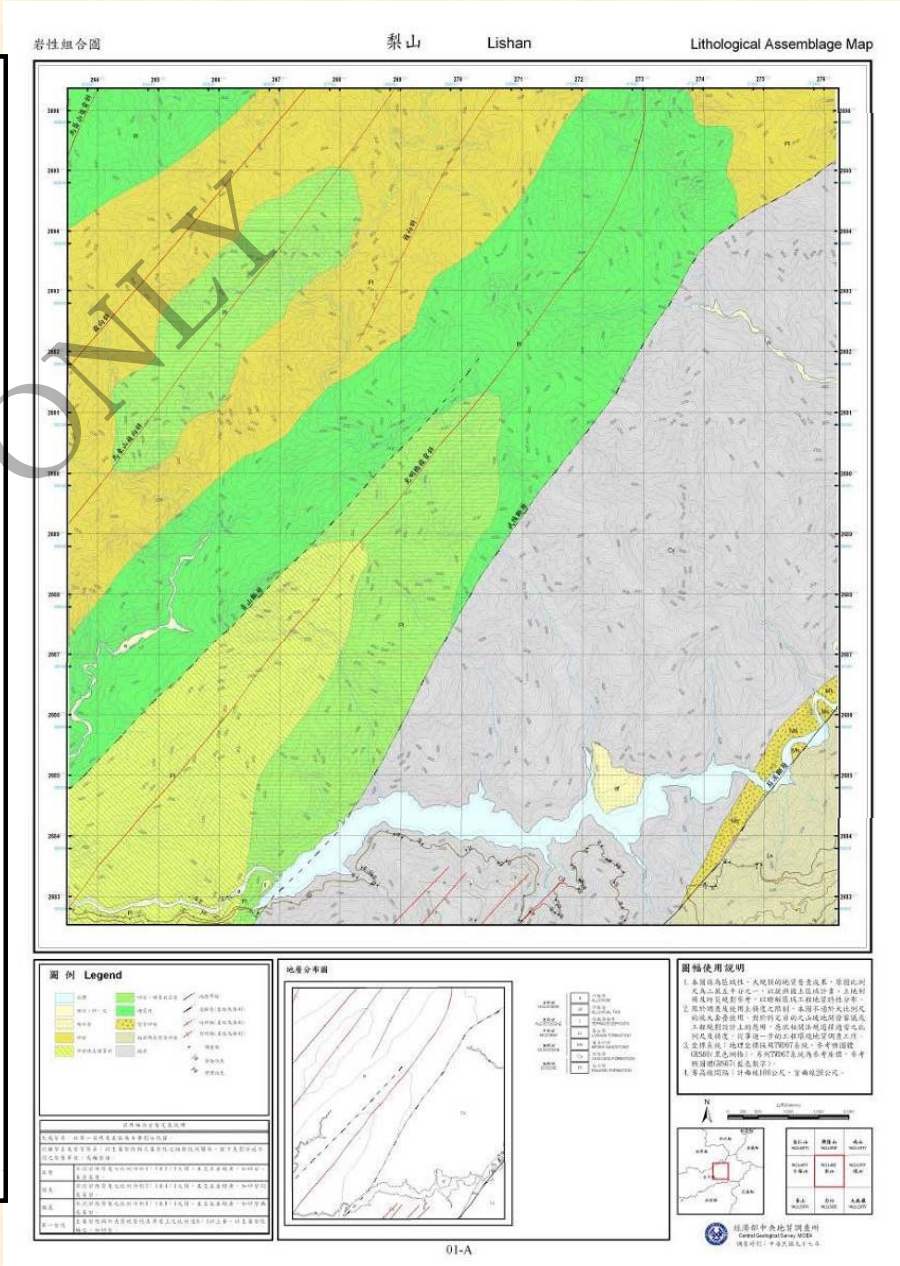
Debris flow

Rock Mass Engineering Maps

- To Establish Lithological Assemblage Map
  - ✓Classified the geological formation according to its engineering characters such as lithology, thickness and structure, etc.
- To Establish Rock Mass Strength Map
  - ✓Classified the geological formation according to rock mass strength
  - ✓Field tests including point loads, Schmidt-hammer were conducted at site for evaluating the rock mass strength

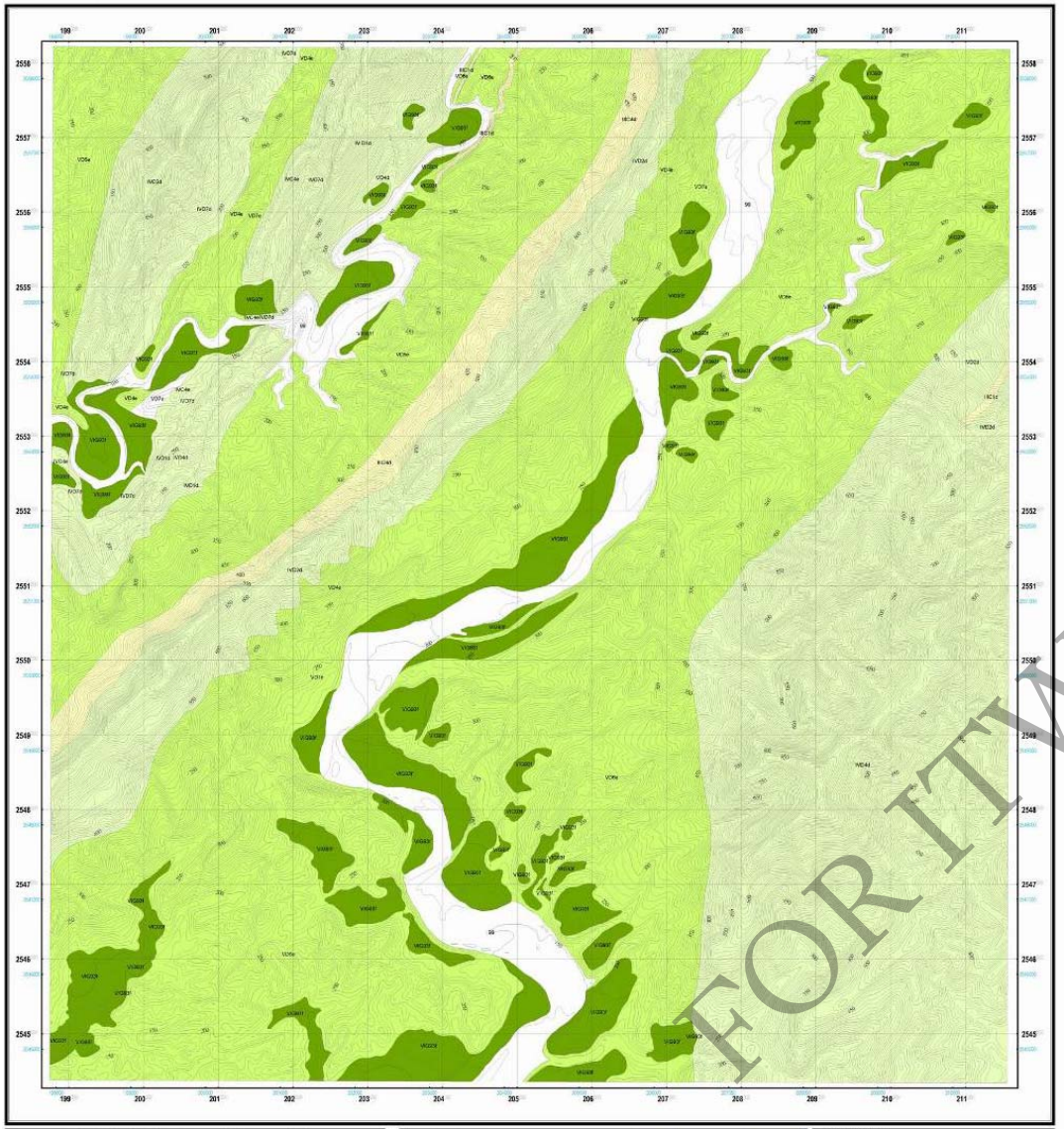
Lithological Assemblage Map

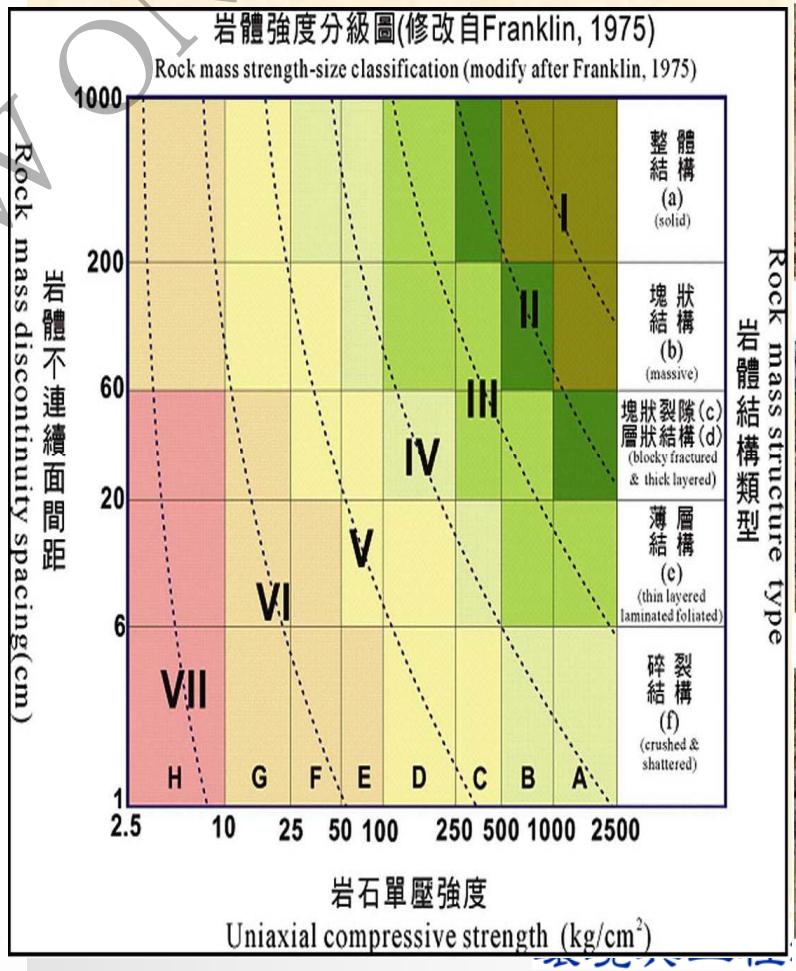


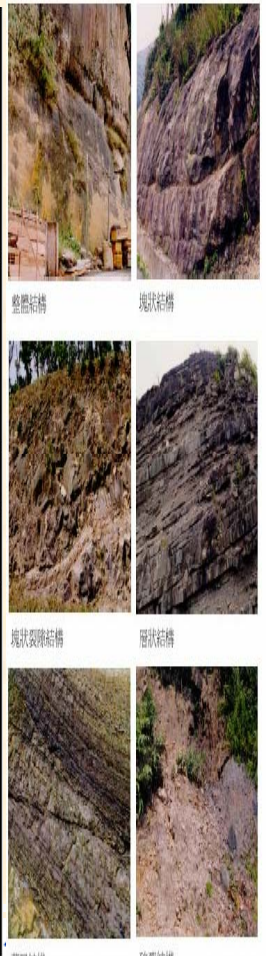


Rock mass Strength Map

1. Lithological Type
2. Rock fracture conditions
3. Rock strength



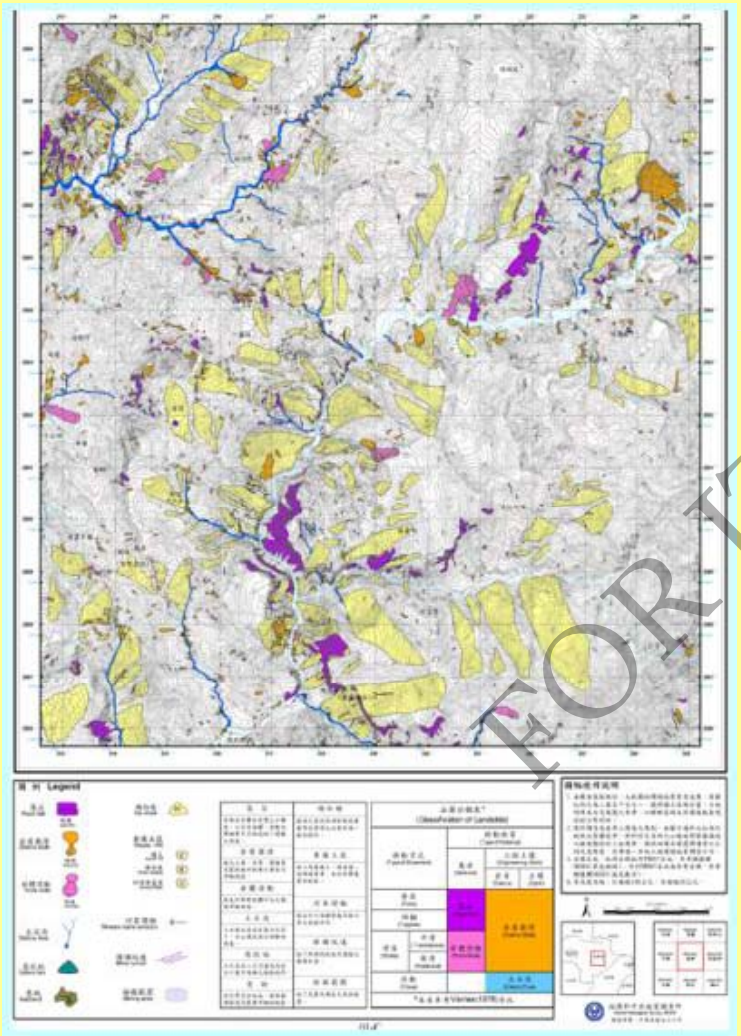




Environmental Geological Maps

- To Establish Environmental Geological Maps
  - ✓ The identified geological hazards in Taiwan, including landslide, rock fall, debris flow, etc.
  - ✓ The induced geological hazard factors such as erosion, dip slope, mined deposit, badlands, etc.
- To Establish Landslide Susceptibility Maps
  - ✓ Analyzed existing environmental condition, gradient, rock properties, etc.
  - ✓ To identify potential geological hazards

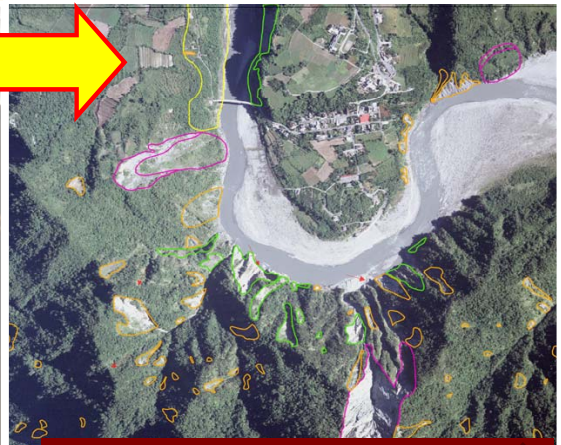
Environmental Geological Maps



- Landslide & Deposits
- Debris flow
- Dip slope
- Debris fan
- Badland
- Waste/Fill
- Stream bank erosion
- Headward erosion

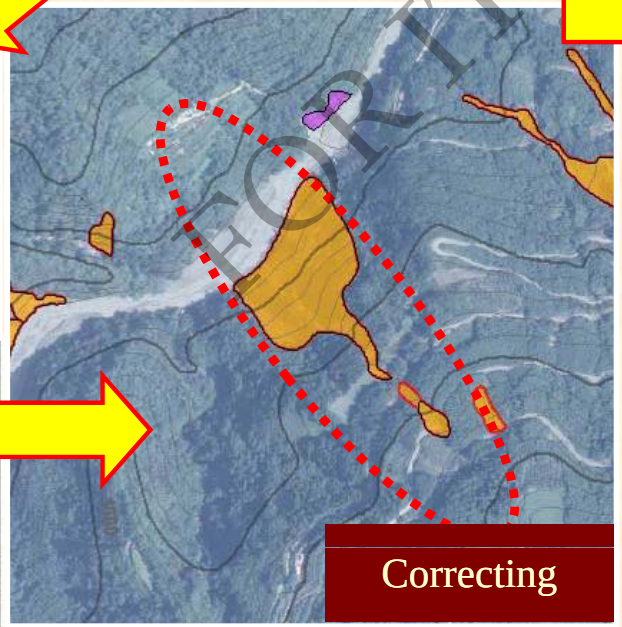
Environmental Geological Map

Aerial Photo Interpretation

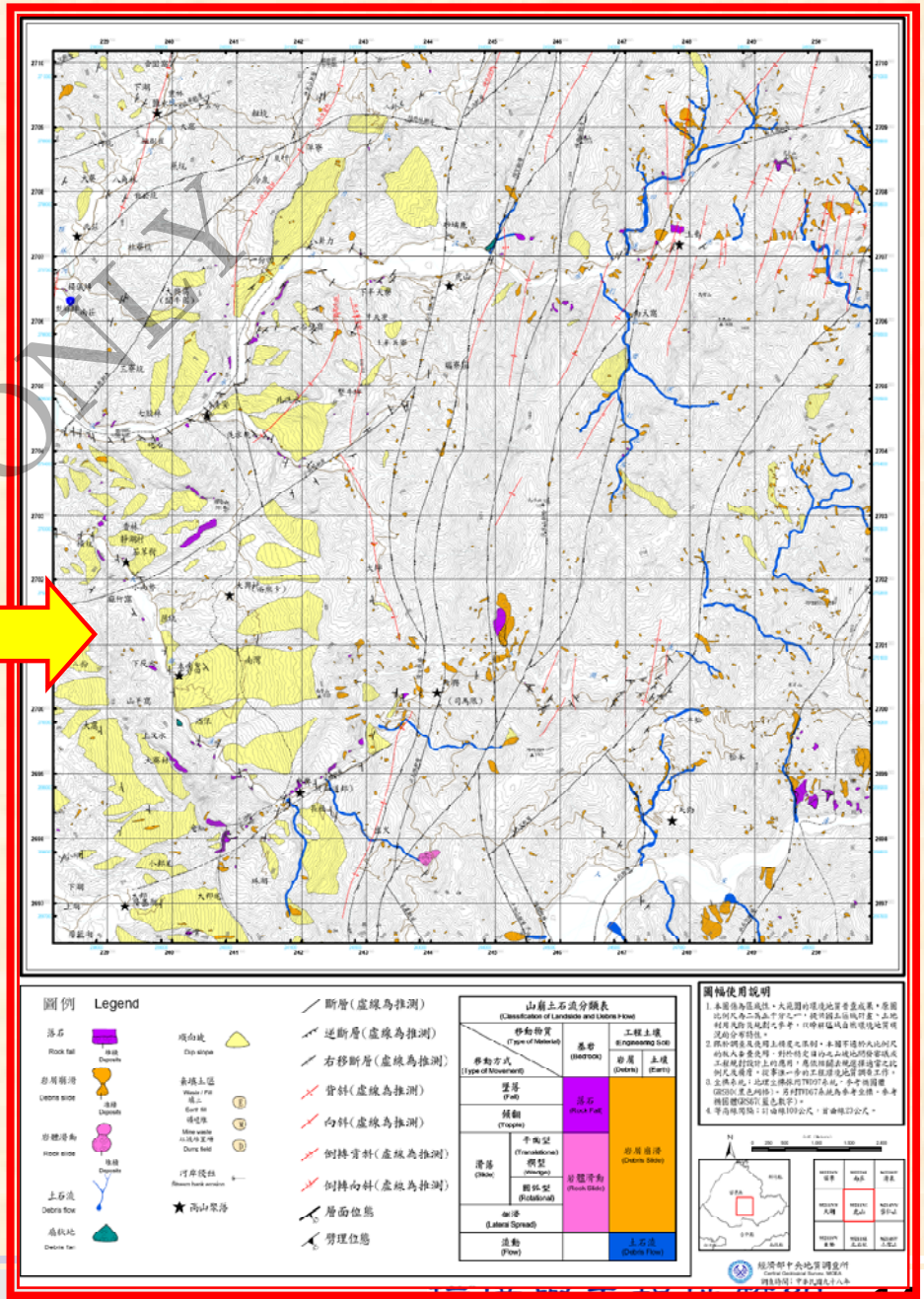


Overlapping with Ortho-image

Site Verification



Correcting



Classification of landslide

Rock Fall

Type of Material / Type of Movement		Bedrock	Engineering Soil	
			Debris	Earth
Falls		Rock fall	Debris Slide	
Topples				
Slides	Translational Wedge	Rock Slide		
	Rotational			
Lateral Spread				
Flow			Debris Flow	

Debris Slide

Rock Slide

Debris Flow

- Dip Slope
- Disposable filling
- Erosion
- Badlands

落石(Rock fall)

定義

落石為發生在陡峻岩石峭壁之鬆動岩塊、岩體，其自岩壁上分離後，以自由落體、滾動或彈跳等方式快速向下運動，運動過程中甚少與坡面接觸。

判定準則

由塊狀或互層狀堅硬岩層組成之陡直崩崖

（Ⅰ）崩崖面光凸。
（Ⅱ）崖錐堆積塊石。
（Ⅲ）密集節理。
（Ⅳ）崖面有不利方位節理。
（Ⅴ）具坡面突石。

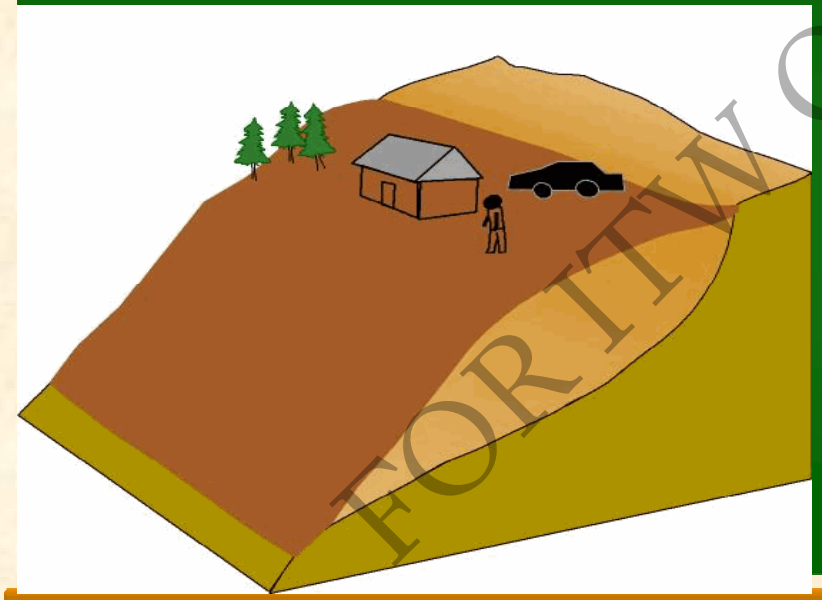
岩體滑動 (Rock slide)

定義

規模較大的山崩，滑動面深度約在5~10公尺以上，單一滑動規模在1公頃以上。滑動面通常切入岩層以下數公尺。

判定準則

Rotational Slide D/L 0.15-0.33
Compound Slide D/L 0.1-0.3

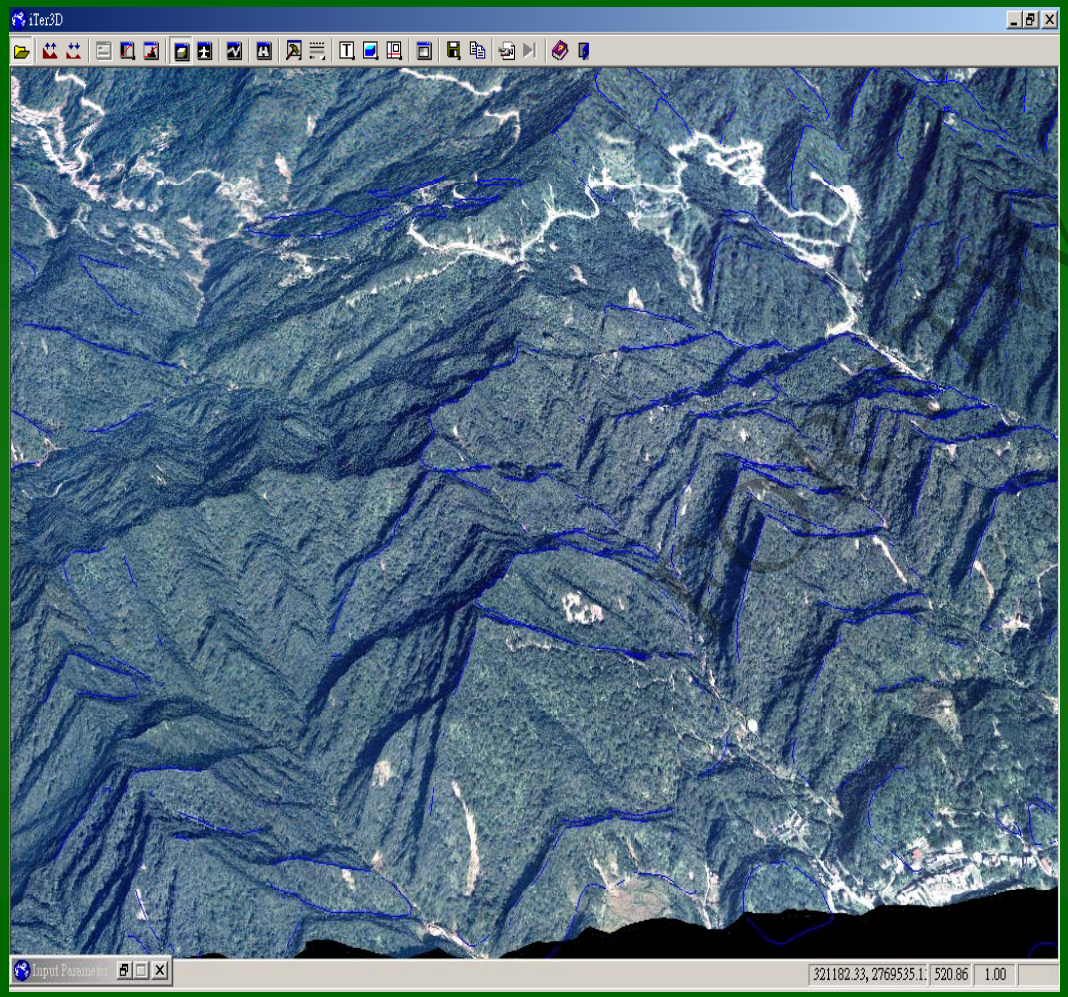


圈繪範圍

圈繪符合上述室內判釋或野外具岩體滑動地貌特徵的地區。岩體滑動之圈繪範圍包含崩崖、崩積層(滑動體)。

Dip slope

順向坡係指坡面地形單元之坡向與坡角，與所構成之地層層面或劈理面之走向與傾角約為一致之坡面地形單元。

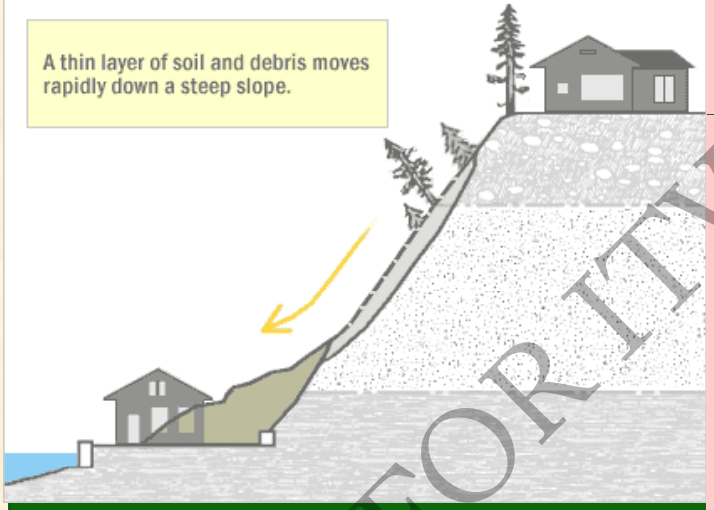


岩屑崩滑(Debris slide)

定義

發生於坡面淺部(5公尺以內)單一滑動範圍在1公頃以下，之風化土層岩屑、 崩積層或鬆軟、破碎地層等材料之崩落、滑動。

判定準則



Debris Slide low D/L 0.05以下
深度 寬度小 high L/B 5-10以上

圈繪範圍

岩屑崩滑圈繪範圍包含崩崖、移動區及崩積層(堆積區)。

Dip Slope Interpretation

Geological Data Layers

- Attitude
- Stratigraphy
- DEM

Average Strike / Dips Layer

Slope Aspect Layer

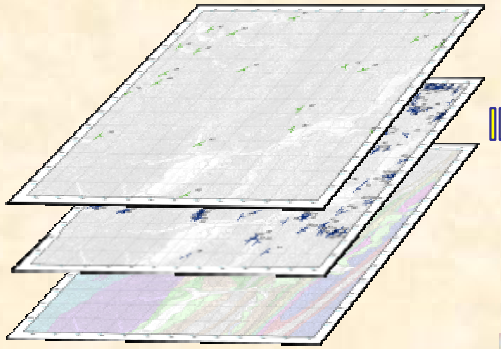
Reference

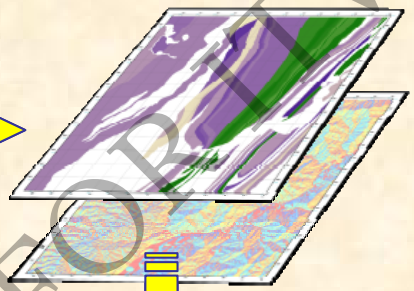
Dip Slope Analysis Program

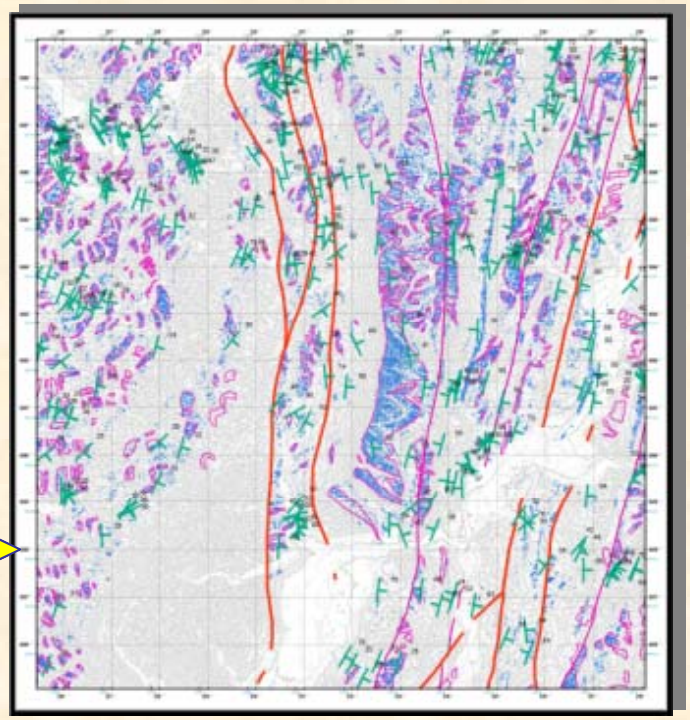
Overlap with Geology Data

Manual Interpretation

- Check the terrain of cuesta, hogback with aerial photo







Environmental Geological Data

TYPE / YEAR	Rock Fall	Debris Slide	Rock Slide	Debris Flow	Dip Slope	Bad Land	Erosion	Deposit	SUM
2002	568	5,911	59	118	3,726	0	797	287	11,466
2003	1,051	12,538	62	393	3,700	0	1,135	67	18,946
2004	195	9,366	30	143	3,835	6,636	1,018	54	21,277
2005	704	5,313	62	130	3,423	104	586	181	10,503
2006	3,200	15,406	35	303	1,079	310	931	41	21,305
2007	2,283	18,082	70	333	1,768	0	288	5	22,829
2008	6,771	20,572	42	284	1,277	0	154	6	29,106
SUM	14,772	87,188	360	1,704	18,808	7,050	4,909	641	135,432

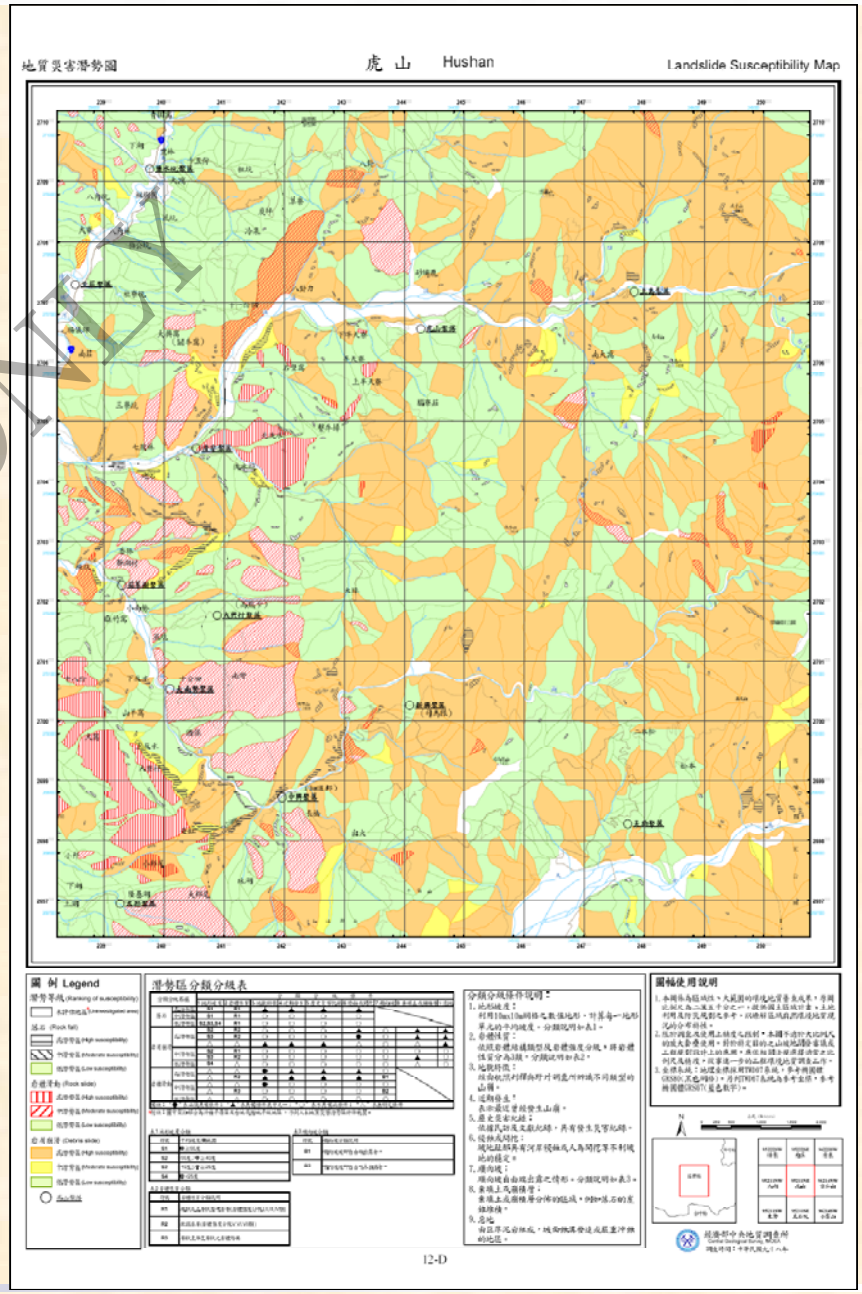
Landslide Susceptibility Map

Classification

- Susceptibility of Rock Fall
- Susceptibility of Debris Slide
- Susceptibility of Rock Slide

Analysis Factors

- Landslide History
- Rock Mass Properties
- Slope Gradient
- Hydrology & Erosion Conditions



Mapping of Susceptible Zones

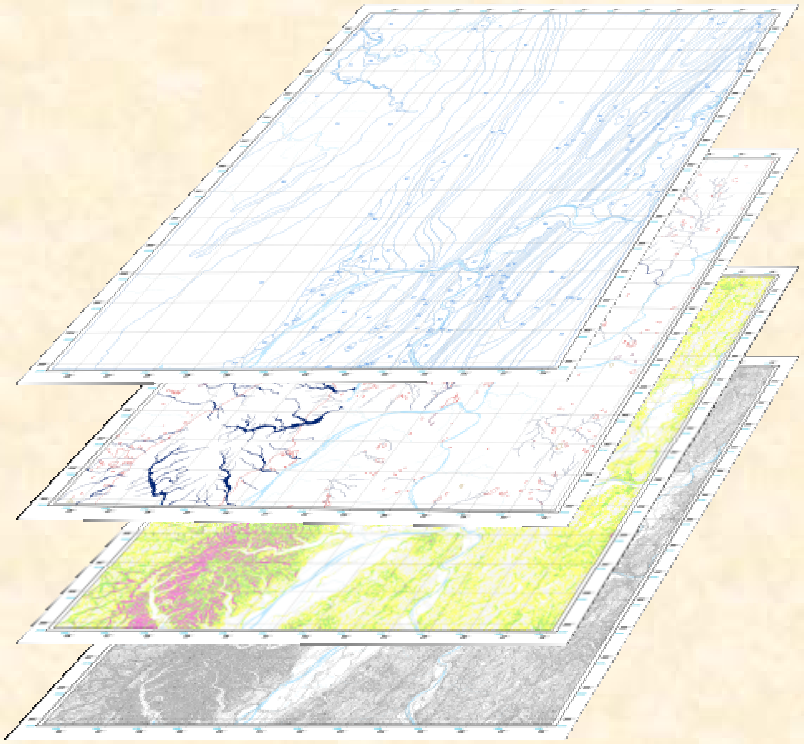
Susceptible Zone of Rock Fall

Susceptible Zone of Debris Slide

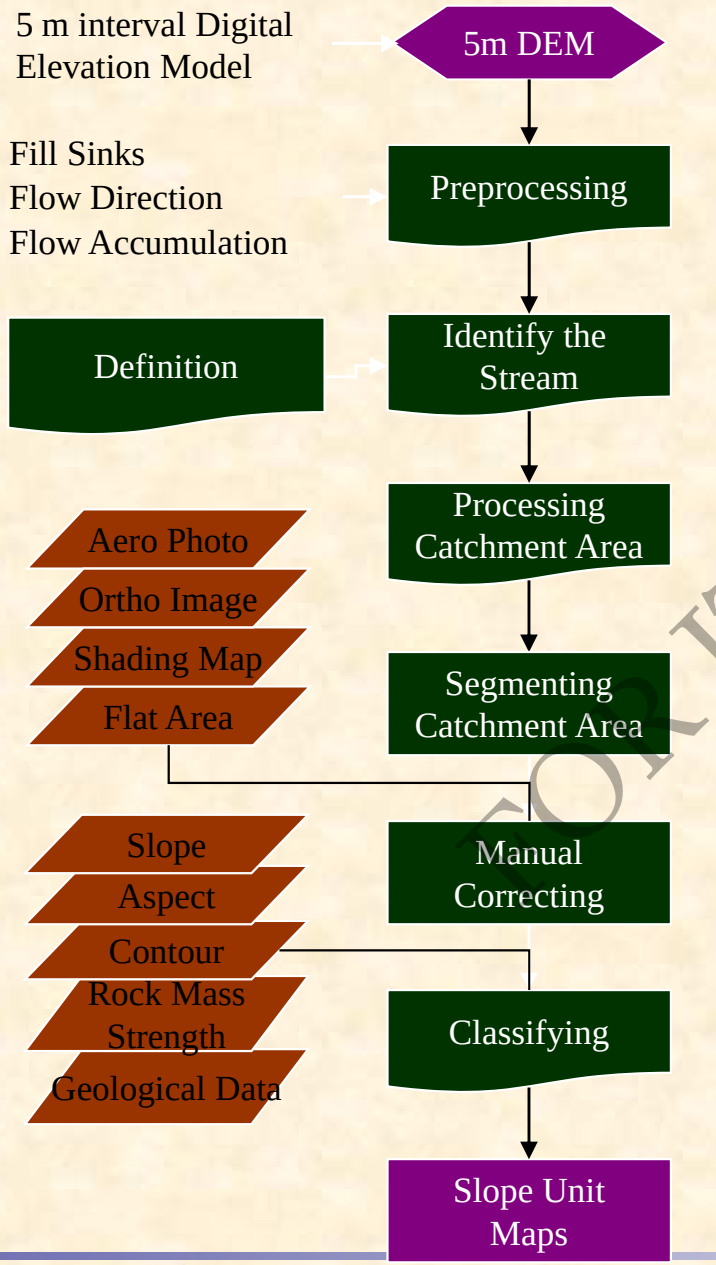
Susceptible Zone of Rock Slide

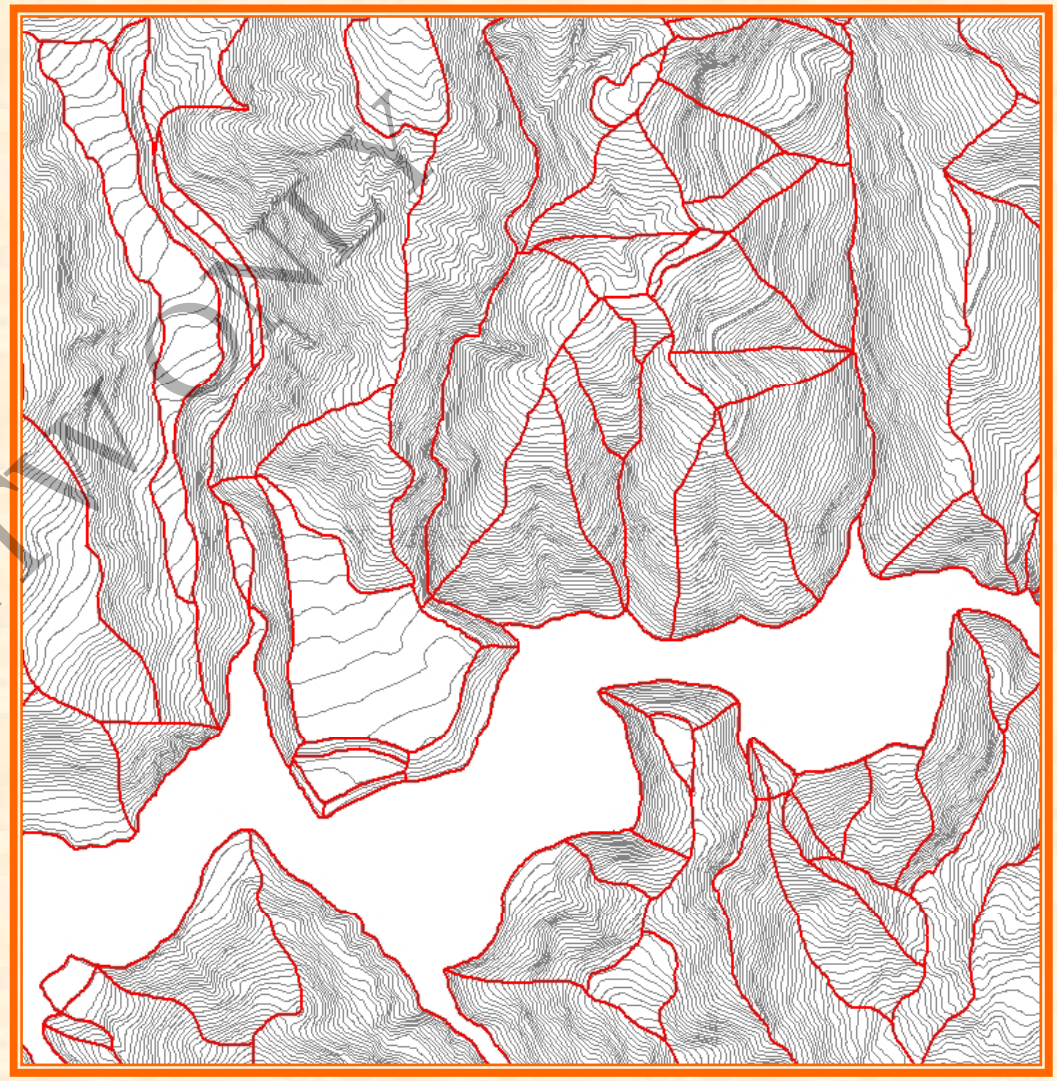
Analysis Factors

- Landslide History
- Rock Mass Properties
- Slope Gradient
- Hydrology & Erosion Conditions

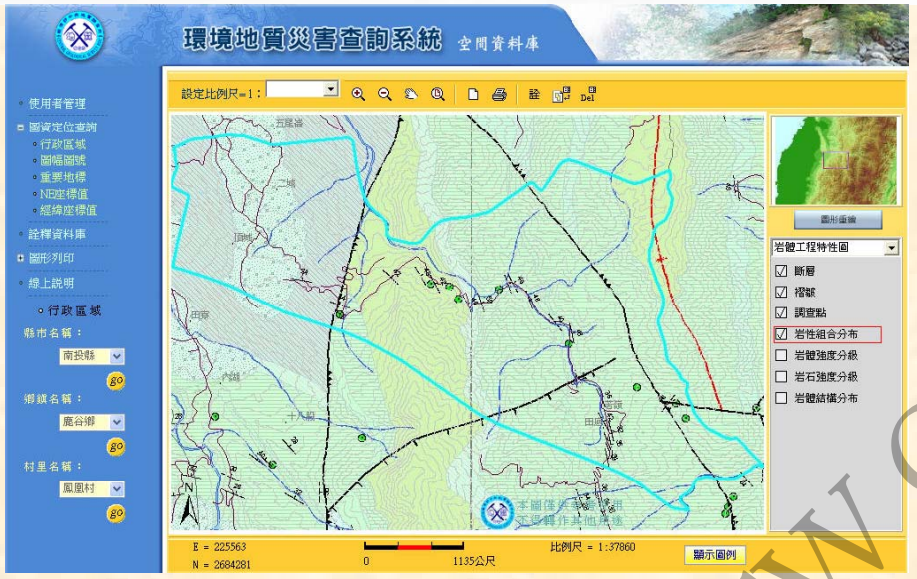


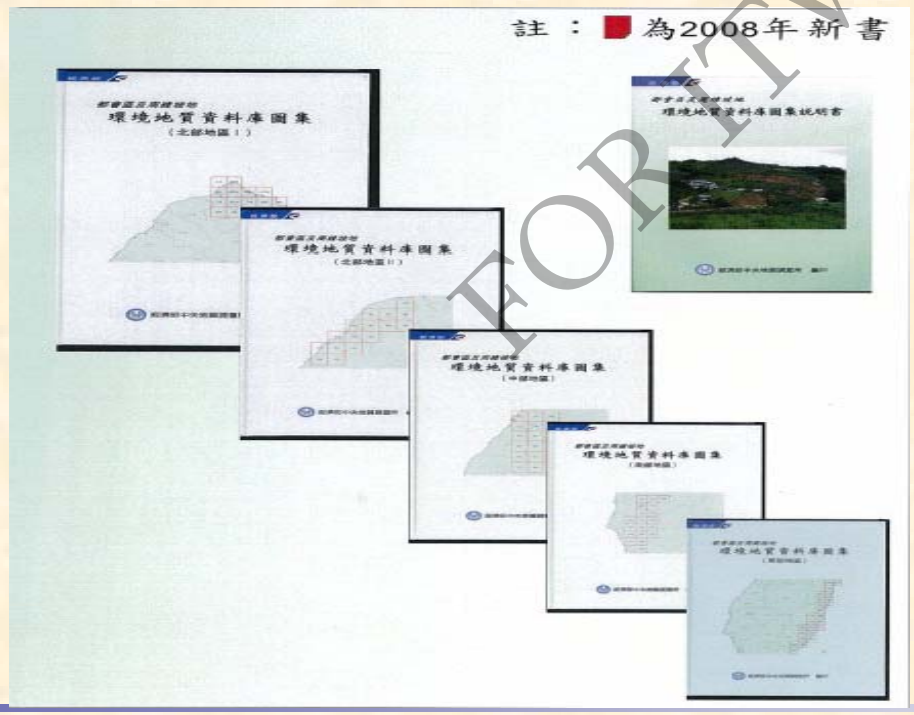
Slope Unit Processing





Application






謝謝各位
Thank you
for your attention
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