GEOLOGY AND TERRAIN ANALYSIS AT RESERVED FOREST GUNUNG RABONG, GUA MUSANG, KELANTAN.

By

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A report submitted in fulfillment of the requirements for the degree of Bachelor of Applied Science (Geoscience) with Honors

FACULTY OF EARTH SCIENCE
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2021

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DECLARATION

I declare that this thesis entitled Geology and Terrain Analysis at Reserved Forest Gunung Rabong, Gua Musang, Kelantan is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : MUHAMMAD SAIFUDIN BIN ISMAIL

Date :

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APPROVAL

I hereby declare that I have read this thesis entitled Geology and Terrain Analysis at Reserved Forest Gunung Rabong, Gua Musang, Kelantan and in my opinion, this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Applied Science (Geoscience) with Honours.

Signature :

Name of Supervisor : Dr. Wani Sofia Binti Udin

Date :

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ACKNOWLEDGEMENT

I am grateful because I managed to complete my final year project and thesis report writing. Special thanks for those who help me throughout this journey directly and indirectly. Throughout the period of two semesters completing this research, I want to take this opportunity to express my utmost gratitude to several parties as they have been supporting me in completing this task. Firstly, I want to thank the Almighty, as I was able to complete the final year project without much difficulty with his graces and blessing. Aside, I would like to express my utmost grateful to my final year project supervisor, Dr Wani Sofia binti Udin for encourage and lead me in doing this project. I would like to thank her for all the guidance and time in helping me to conduct my project. I am deeply grateful for her kindness in explaining the details of the project including the help that was given when I was facing some difficulties while was on this project. Next, I would like to thank my parents and family who always giving me moral supports until the day I manage to complete this project. Thank you for always holding on even though we had to face many difficulties like facing the unpredictable weathers in the study area and exploring the thick forest without any man companion. My special thanks to all my friends especially Muhammad Aqil Bin Mohd Zaki, Muhammad Afnan Iman Bin Kamilan, Mohammad Ameer Farhan Bin Rosli, Mohd Rifqi Bin Goh Yew Hwa, Mohd Haikal Bin Fauzi, Muhammad Naim Bin Yussof and Muhamad Afiq Bin Kahar for all the helps during accomplishment the research. Lastly,I would like to express my appreciation to Encik Muhamad Fatihi bin Abdul Patah and our beloved lecturer, Encik. Arham Muchtar Achmad Bahar for all the time spent during completing the

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research. Despite of their busy schedule, they still taught and shared their knowledge in completing this project especially

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ABSTRACT

This research focused on the geology and terrain analysis in Gunung Rabong forest, Gua Musang Kelantan. Based on the previous research, there was a lack of information on terrain analysis. Furthermore, updating the geological map is required because there are changes in the geological data. The objectives of the research area to produce the geological map of the study area in scales 1: 25000, to produce a terrain classification map and to determine the suitability zone for construction area. In order to achieve the objective, Geographic Information Systems (GIS) is used to produce the result and making interpretation based on cut and fill slope, fill slope, terrain analysis, slope gradient, terrain morphology, activity of slope, erosion and instability and cover & vegetation. The lithology of the study area was granite, interbedded shale, sandstone and quartzite and they included in the Permian to Triassic age. For terrain analysis study, construction suitability map were produced based on terrain classification. In the study area, there were four type of class, which as class I (30.54%), class II (33.9%), class III (27%) and class IV (8.6%). The classes were determined by analyze the slope gradient, terrain code, activity code and erosion & instability. The study area was dominated by class I and class II and the constructions in Class II areas require cutting, filling, and erosion are expected on bared slope when surface runoff is not properly channeled. Construction in these areas was not expected to encounter any major foundation problems. Bedrock may encounter during excavation. From the slope terrain analysis, the site is mainly moderate steep slopes (15° - 25°) to steep slopes (25° - 35°) which cover 26.74% and 45.53% respectively. Flat to gentle slope (0° - 15°) covers 18.9% of the study area. Only 8.6% of the site is covered by very steep slope (>35°).

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ABSTRAK

Penyelidikan ini memfokuskan pada analisis geologi dan medan di hutan Gunung Rabong, Gua Musang Kelantan. Berdasarkan kajian sebelumnya, terdapat kekurangan maklumat mengenai analisis medan. Tambahan pula, mengemas kini peta geologi diperlukan kerana terdapat perubahan dalam data geologi. Objektif kawasan kajian untuk menghasilkan peta geologi kawasan kajian dalam skala 1: 25000, untuk menghasilkan peta klasifikasi medan dan untuk menentukan zon kesesuaian untuk kawasan pembinaan. Untuk mencapai objektif, Sistem Maklumat Geografi (GIS) digunakan untuk menghasilkan hasil dan membuat tafsiran berdasarkan cerun potong dan isi, cerun pengisian, analisis medan, kecerunan cerun, morfologi medan, aktiviti cerun, hakisan dan ketidakstabilan dan penutup & tumbuh-tumbuhan. Litologi kawasan kajian adalah granit, serpihan interbedded, batu pasir dan kuarzit dan mereka termasuk dalam usia Permian hingga Trias. Untuk kajian analisis medan, peta kesesuaian pembinaan dihasilkan berdasarkan klasifikasi medan. Di kawasan kajian, terdapat empat jenis kelas, iaitu kelas I (30.54%), kelas II (33.9%), kelas III (27%) dan kelas IV (8.6%). Kelas ditentukan dengan menganalisis kecerunan cerun, kod medan, kod aktiviti dan hakisan & ketidakstabilan. Kawasan kajian dikuasai oleh kelas I dan kelas II dan pembinaan di kawasan Kelas II memerlukan pemotongan, pengisian, dan hakisan diharapkan pada lereng berduri apabila larian permukaan tidak disalurkan dengan betul. Pembinaan di kawasan-kawasan ini diharapkan tidak akan menghadapi masalah asas. Bedrock mungkin ditemui semasa penggalian. Dari analisis permukaan lereng, laman web ini adalah lereng curam sederhana (15 ° - 25 °) hingga lereng curam (25 ° - 35 °) yang masing-masing merangkumi 26.74% dan 45.53%. Lereng rata hingga lembut (0 ° - 15 °) merangkumi 18.9% kawasan kajian. Hanya 8.6% laman web diliputi oleh cerun yang sangat curam (> 35 °).

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LIST OF ABBREVIATION

CSM	Construction Suitability map
DEM	Digital Elevation Model
DSSM	Department of Survey & Mapping Malaysia
DTM	Digital Terrain Model
E	East
GIS	Geographic Information System
IUGS	International Union of Geological Sciences
JMG	Mineralogy and Geosciences Department (JMG).
Km^2	Kilometer Square
Mm	Millimeter
N	North

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LIST OF SYMBOLS

°	Degree
ʾ,	Minute
"	Second
%	Percent

CHAPTER 1

INTRODUCTION

1.1 Background of study

Gua Musang located in the south of Kelantan state and bordering with Merapoh, Pahang states. It is the largest area in Kelantan. Peninsular Malaysia is dividing into three longitudinal belts, western, central, and eastern belts (Tan 1983). Kelantan were at central belts and is made-up of several formations. Gua Musang also has several formations such as Rabong Formation, Aring formation, Gua Musang formation etc. (Kamal Roslan Mohamed, 2016).

In planning the land use of the area, town planners would need basic information, such as the geology, topography, and land type of the area, as well as other important geotechnical data, such as whether the area is potentially unstable due to landslides or major erosion. Such details can enable engineers to prepare layout plans, design the foundation system and decide on the most suitable style and method of construction. Terrain analysis studies for long linear engineering projects may provide critical engineering geological and geomorphological data that may provide information on project design options, route selection and construction design.

The study of terrain analysis is to evaluate slope gradient based on terrain code such as sideslope, footslope, drainage valley etc. Besides, the erosion and stability can be determined and classified as gully erosion, rill erosion, no

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appreciable erosion etc. These information are very important for the engineering to prevent the hazard such as flood, landslide etc.

Remote Sensing (RS) and Geographic Information Systems (GIS) been embedded in the evaluation of the geo-environmental hazards in recent years. Many research studies have employed DEM analyzed in a GIS environment as the principal information source in the assessment of hazards/disasters, flooding inclusive. This study focused more on geological analysis that conducted at reserved forest Gunung Rabong Gua Musang. Other than that, various derivative maps produced from the mapping activities such as elevation maps, terrain classification map, construction suitability map etc. This information can use in the planning and approval of development projects in the area.

1.2 Study area

1.2.1 Location

The study area is almost 25km^2 (5km × 5km) within Central belt of Peninsular Malaysia. This location is suitable area for the research because of the wide and mountain area. This study area aligned within longitude from 102°07’20”E to 102°09’40”E and latitude from 04°54’20”N to 04°51’40”N. The lowest elevation of the study area is 100m from sea level and the highest elevation of the study area is 420m from sea level. Figure 1.1 shows the base map of study area, which consist coordinate, direction, legend and the scale of the map. Base map have shown the features that are useful for the field and mapping. The accessibility to get to this area are effective because have road in the study area that villager use for the daily

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activity. The road used to collect the product of the palm oil. Mostly the area was cover by palm oil plantation. The study area also has off road that used by villagers to collect the palm.

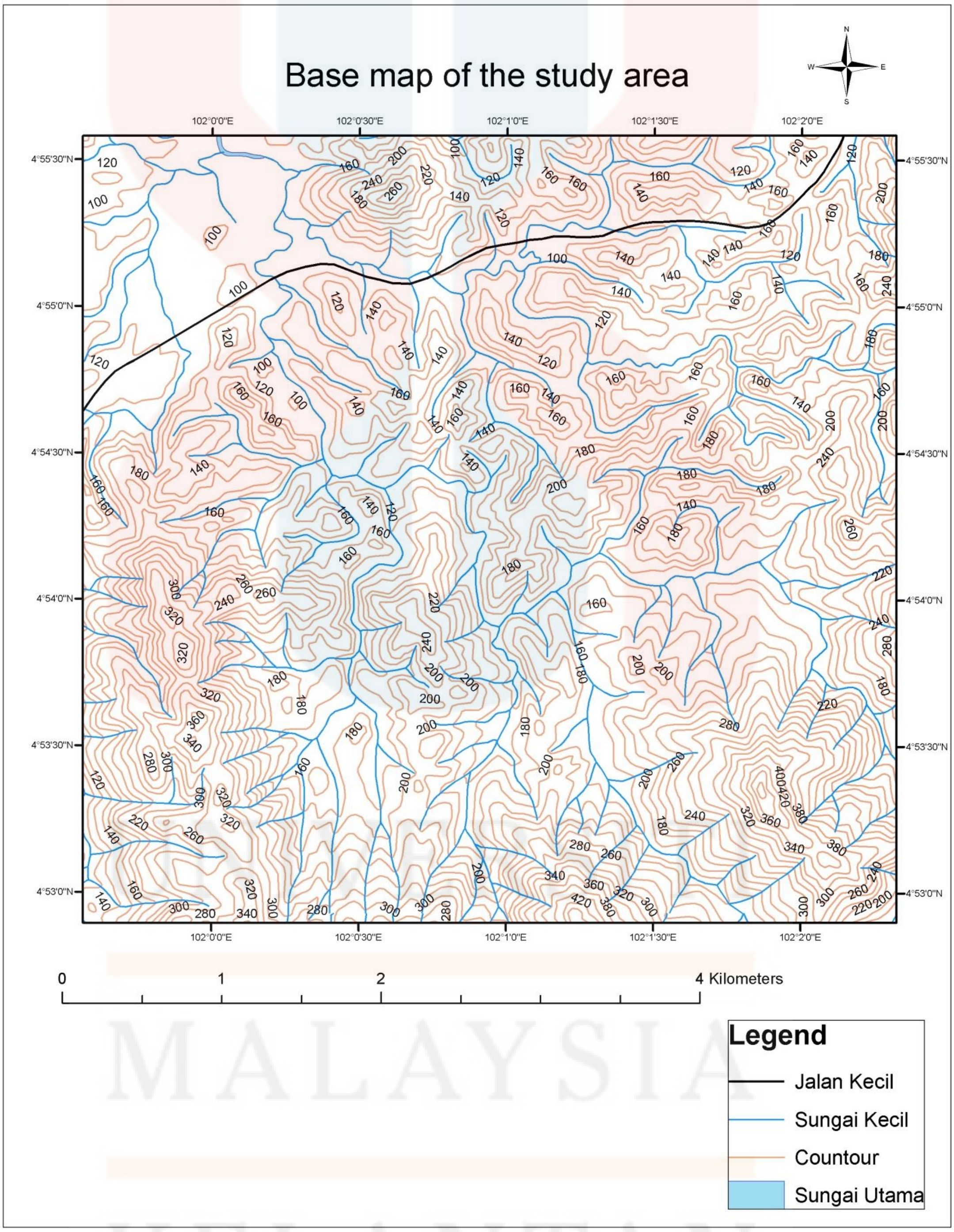

Figure 1.1: Base map of reserved forest Gunung Rabong, Gua Musang, Kelantan in 1:25.000 scales.

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1.2.2 Road connection

In terms of road connection, the study area can be easily access because have a main road Kota Bharu Gua Musang. This main road is the highway that commonly used to go the Pahang and Kuala Lumpur. For the road connection in the study area, it also not too difficult because have small road that were used by villagers to bring the oil palm fruit from the farm. There also have many off-road be access in the study area since many villagers used the main road to go to farm. Time taken for reach at the study area about 1 hour and 45 minutes as show in the Figure 1.2.

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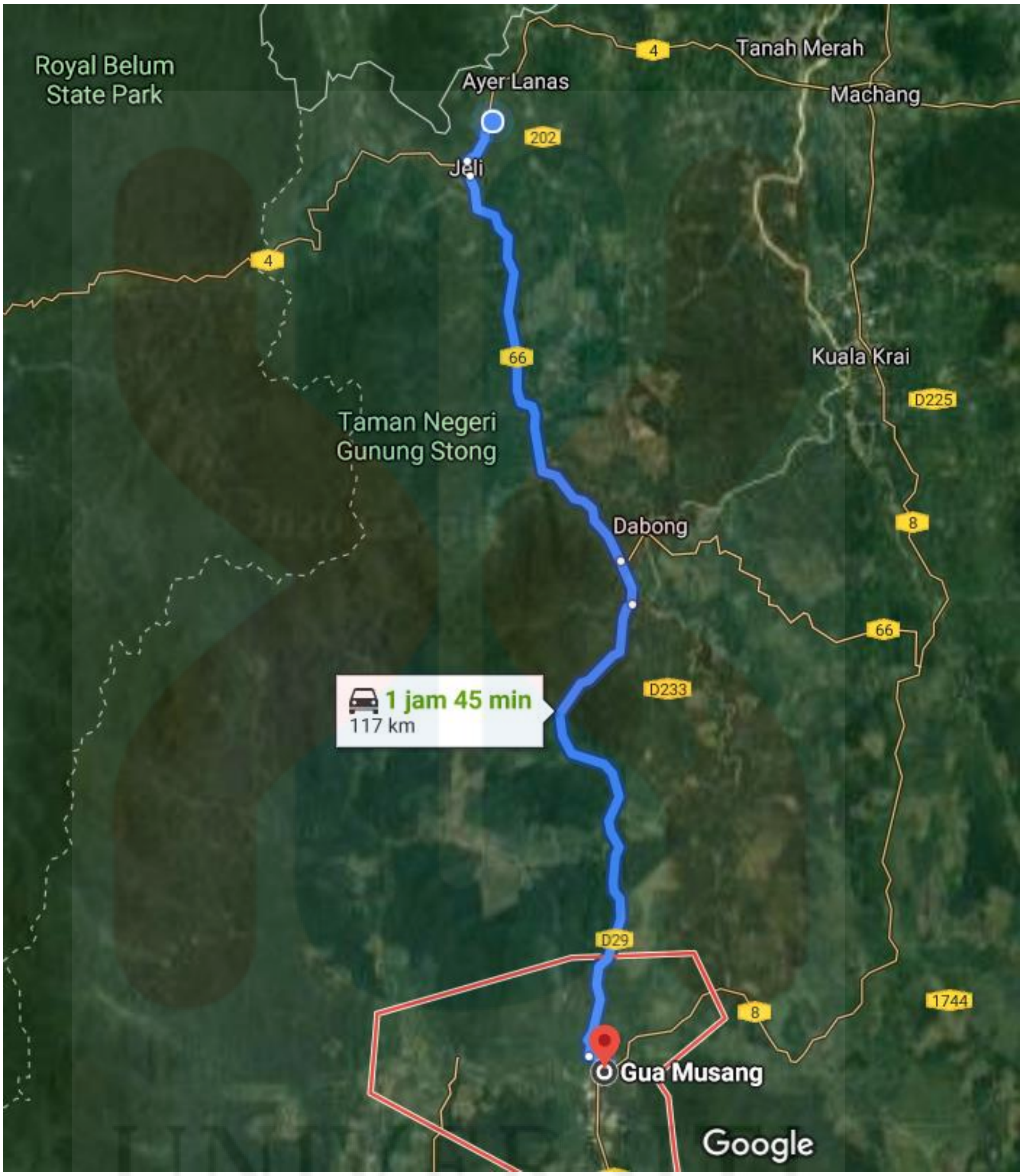

Figure 1.2: Main road accessibility.

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1.2.3 Demography

Based on the statistic from the Department of Statistic Malaysia, the population of Gua Musang District in year 2010 is 90,057 people. The percentage of the Malay people is 76%, Chinese 5%, India 1% and the native people 13%. The distribution of the people is high in Gua Musang town as people are concentrating to work there. Most of people work as farmer and planting the palm.

Table 1.1: People Distribution in Gua Musang

Type Of Nation	**Percentages**
Malay people	76%
Chinese people	5%
Indian people	1%
Native people	13%

(The Department of Statistic Malaysia, 2016)

1.2.4 Landuse

Based on satellite image observations, land use in the study area consisted of palm oil plantations, forests, rubber, cleared land, mixed horticulture, homestead farms and villages. (Senthavy, 2003). The area studied was located at reserved forest Gunung Rabong, Gua Musang, Kelantan. Figure 1.3 show the landuse of the study area.

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Figure 1.3: Landuse of the study area(google map,2015)

1.2.5 Social Economic

Gua Musang areas are mostly depending on the plantation of the palm, rubber and the forest product. The source of the social economic in the Gua Musang areas is palm and rubber product. Based on Abdullah (2012), the farming area practiced subsistence agriculture and agriculture in the form of ordinary farming as a source of income.

1.3 Problem statement

The general geology at reserved forest Gunung Rabong, Gua Musang, Kelantan, have undergoes many process that could change the structure of the earth surface. There are many kind of process that occurs such as tectonic process, weathering process etc. The weathering process effect the composition of rocks and

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it could be altering the rocks physical and chemically. Furthermore, updating geological map update is required because there are changes of the geological data.

Based on the previous research, there was lack information on terrain analysis. Terrain analysis very important because it can prevent the hazard occurs such as flood, earthquake etc. Construction works cannot be executed if lack of terrain information. That information is very useful for planner to design that area. Gua Musang area (study area), it very useful for design a land used, downhill, construction etc. The slope data also useful to ensure the hill are potential to make construction or downhill for prevent landslide or other hazards.

1.4 Objective

1. To update the geological map at reserved forest Gunung Rabong, Gua Musang, Kelantan in scale 1:25,000.
2. To produce a terrain classification map
3. To determine the suitability zone for construction area at reserved forest Gunung Rabong, Gua Musang, Kelantan.

1.5 Scope of Study

The study area covers 25km² (5km X 5km) which included rivers, mountain and surface area. The lithology at the study area mostly covered by sedimentary rocks and has tuff elements. For the study area, the study is focusing on general geology

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and terrain analysis. Furthermore, it also focuses on the geological aspects such as geomorphological, environment, structural geology and lithology at the study area.

Land analysis carried out on topographic maps with a scale of 1:25.000. Basic maps are available in the digital form of the Department of Survey & Mapping Malaysia (DSSM). Using raw digital data, slope gradient maps can be generated using the Arcgis10.8 program. The land classification were based on four attributes. The first is the slope gradient attributes, the second is the morphology attribute, the second is the erosion attributes and the third is the instability attribute. The engineering geology and land use classification maps will guide engineer in planning site investigations, preliminary design of basic systems and project layout.

1.6 Significance of Study

One of the objectives of study is to updates the geological map of reserved forest Gunung Rabong, Gua Musang, Kelantan with 1:25000 scales. It is important to update the geological map for preventing natural hazard, such as flood, landslide etc. The methodology used for the terrain analysis is mapping the subsurface and taking the geomorphology data refers to terrain classification attributes provided by Mineralogy and Geosciences Department (JMG). Terrain analysis study is very important to design the downhill for land use activities such as planting, construction etc.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews on the existing research that is significant to this study especially on geological part and terrain analysis. It is important to carve out a space for every stages of research including research gap, methodologies as well analysis. These establish importance about regional geology and the tectonic setting, sedimentology, stratigraphy, fossil, historical geology and the deposition environment. Besides, literature review can demonstrate familiarity in terms of terrain analysis study.

2.2 Geology and Tectonic Setting

2.2.1 Gua Musang

Yin (1965) mapped the Gua Musang arrangement in South Kelantan-North Pahang to depict Center Permian within the territory of Gua Musang in Late Triassic argillite, carbonate, and pyroclastic/volcanic facies. Currently, the term has been incorrectly used for almost all Permo-Triassic carbonate-argillite-volcanic successions in the northern part of Central Belt Peninsular Malaysia. Widespread

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dispersion of argillite-carbonate-volcanic across northern Central Belt has activated issue with respect to current names relegated.

Peninsular Malaysia is an integral part of Sundaland 's mainland SE Asia core (Metcalfe, 2011). It consists of two tectonic blocks (Sibumasu Terrane, Sukhothai Arc) and can be divided into three western, central and southern bands. The seam zone of Bentong-Raub is the boundary between Sibumasu Terrane (Western Belt) and Sukhothai Arc (Central and Eastern Belts)

2.2.2 Kelantan

Kelantan is located in eastern of Peninsular Malaysia. The Territorial Geography of Kelantan consists of a focal zone of sedimentary stone and metasedimentary rock, which is separate on the west and east by the Main Range and Boundary Range rocks. Heng et al. (2006) claimed that Kelantan consisted of sedimentary and metasedimentary rock in the central zone bordered by granite in the west and east by the Main Range (Titiwangsa Range) and the Boundary Range, respectively. There are granitic intrusive within the Central Zone, such as the Senting batholith, the Kemahang pluton and the Setong Igneous complex. The granite in Boundary Range (east of Kelantan) is overlaid by the coastal alluvial flat of Sungai Kelantan, while the granite belts in the middle and west of the Kelantan continue northward to south Thailand.

The geography of Kelantan can extensively arrange into four kinds of lithology, (1) Unconsolidated silt; (2) Extrusive rocks (volcanic rocks); (3)

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Sedimentary/metasedimentary rocks; and (4) Granitic rocks. For granitic shakes in Kelantan, they can be separate into two principal bodies: the rock bodies inside the Primary Range and the Boundary Range. Kamal Roslan Mohamed et al (1995) clarified that these lateral changes in facies could accumulate within the same group as long as this sediment was deposits in the shallow marine environment of the Gua Musang platform during the Permo-Triassic period.

2.3 Stratigraphy

Topography Peninsular Malaysia was dividing into three belts, which are East, Central and West Malaya belt. Stratigraphy of Western and Central are notable in Peninsular. Stratigraphy of Kelantan was developing by seven arrangements, which those arrangements were Aring Formation, Taku Schist, Gua Musang Formation, Telong Formation, Gunung Rabung Formation, Koh Formation and Badong Conglomerate. Bar of Taku Schist and Aring Formation, which framed during Paleozoic period, the others are shape during Mesozoic time.

Gua Musang Formation is located at the northern piece of the Gua Musang Semantan depocentre that lies east of the Bentong – Raub Suture inside the Central Belt. Gua Musang Formation was making out of the crystalline limestone, interbedded with dainty beds of shale, tuff, chert knobs and subordinate sandstone and volcanic. Gua Musang Formation matured of the Middle Permian to Upper Triassic situated in the south of Kelantan (Mohd Shafeea Leman, 2004). Koh formation is the Jurassic limestone; it also younger than Telong formation based on the sequences. Koh formations are date in Jurassic time base on the geology time

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scale. The formation is dominated by sandstone (arenite, radite), argillite, and interbedded with mudstone. Figure 2.1 shows the Distribution of Gua Musang Group.

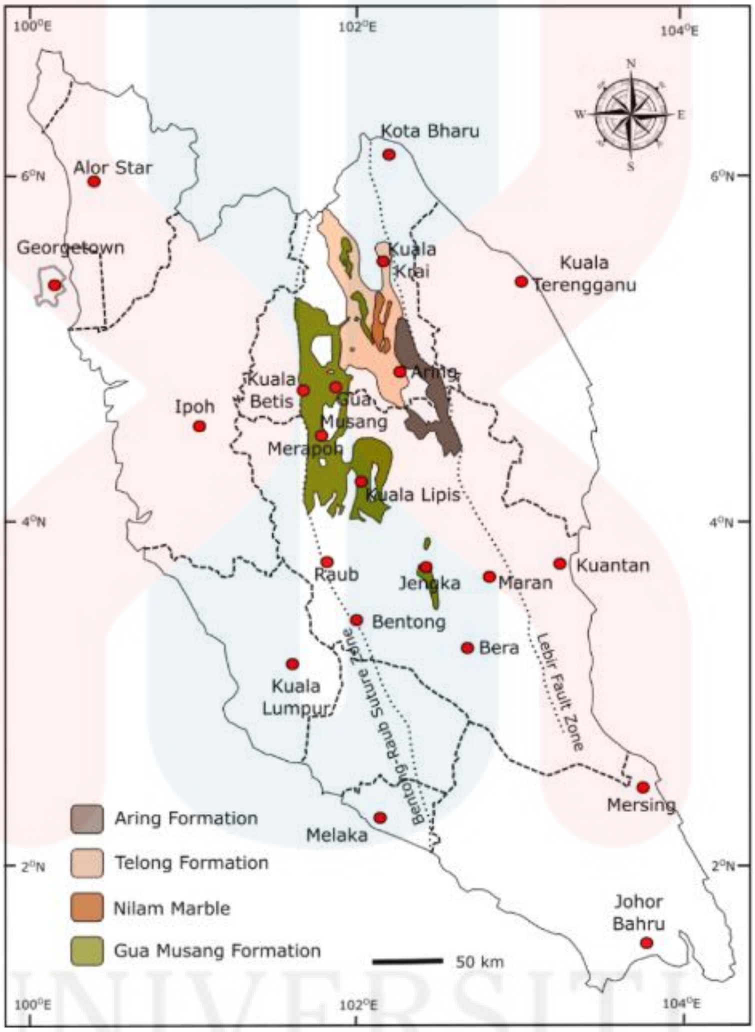

Figure 2.1: Distribution of the Gua Musang Group (source: Mohamed 1995)

2.4 Structural Geology

Gua Musang Formation lies east of Bentong – Raub Suture inside the Central Belt. The structure that has in the Gua Musang is generally dextral opposite deficiency zone (Hutchison, 2009). Based on Noda (2013), The Malay Basin is known as a fault termination basin. At the end of the strike- slip fault, it developed under transnational stress. Along the strike-dip fault, the sediment is supplied into the basin and dominated by rivers. The subsidence of the basin has contributed to both tectonic depression and elevated surface heat flow.

By significant fault along the Bentong-Raub Line on the west and by the Lebir Fault zone on the east, the Central Basin of Peninsular Malaysia is an extensive graben guest. During the Triassic, a significant typical blaming occurred along the Bentong-Raub Line and Lebir Zone, which perhaps began in the Permian, and eventually delivered a graben (Metcalfe, 2013). As per Metcalfe (2013), the Triassic rocks in Central Basin upstanding or delicately plunging fold (both symmetry and non-symmetry) that present in burn collapsing stage. In view of the qualities of other significant flaws of the Peninsular, it is the Lebir Issue Zone may be start as a dextral strike-slip rock formation bouncing deficiency (Hutchison, 2009).

2.5 Historical Geology

Based on Yin (1965), the Gua Musang formation in south Kelantan – North Pahang describe in middle Permian to late Triassic argillic, carbonate. The term been loosely used for nearly all permo – Triassic carbonate – argillite –volcanic sequence in the northern part of central belt peninsular Malaysia.

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In Permian period, strike-slip fault occurs in Malay Basin, which causes expansion of the crustal (Audley-Charles, 1983). As result of deformation, the graben forms and pull apart basin as known as Central Basin. Based on Metcalfe (1989), the sediment from the Triassic period started to be assembled from the basin. The fine grain marine sediment was deposit at the early stages of deposition. Therefore, at Jurassic to cretaceous period it followed by coarse continental sediment.

Aw (1990) related lithology to the Felda Aring Gua Musang Formation is named Aring Formation, while in Sungai Telong it is called Telong Formation. The importance of grouping these formations lies behind the near association observed in terms of sedimentology and paleontological aspect among these formations (Kamal Roslan Mohamed et al, 2016). The use of the informal Gua Musang Formation needs to be re-evaluated for future rank elevation, formalization and clearer understanding of the geology of the Northern Central Belt, particularly with regard to the deposition of different lithostratigraphic units within the Gua Musang platform (Kamal Roslan Mohamed et al, 2016)

The northern border of Gua Musang platform is interfered to bound by low to medium grade metamorphic rocks in carbo – Permian Mangga formation and Taku schists in the north. Kamal Roslan et al. (2016) indicated that Gua Musang proposed the function of distinguishing the central-northern distribution from the adjacent dominantly deep marine of the calcareous series deposited in the permo shallow marine.

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2.6 Terrain Analysis

Terrain Analysis is the investigation and understanding of topographic highlights through geographic data frameworks. Such highlights incorporate incline, viewpoint, viewshed, height, shape lines, stream, up slope flowlines and downslope flowlines. Cataclysmic events happen each year and their effect and recurrence appear to have incredibly expanded in late decades, for the most part because of natural debasement, for example, deforestation, heightened land use, and the expanding populace. The slope failure/ landslide have made significant harm interstates, settlement, farming and business.

Abilities for imagining geology in GIS have developed from 2D raster maps, shapes, and basic 3D networks during the 1980s to intelligent 3D rendered surfaces with concealing and shading maps hung over the surface that got standard during the 1990s. Recently, a few new innovations that consolidate the adaptability of advanced scene portrayal with natural 3D physical models have risen. A model substantial geospatial demonstrating condition in GIS lets clients interface with territory or scene examination and reenactments utilizing an unmistakable physical model, for example, DEM. The terrain analysis coding refers to the JMG schedule as shown in Table 2.1.

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Table 2.1: Terrain classification and land use hazards zonation attributes (Chow and Zakaria, 2002).

Geological Terrain Mapping (GTM) attribute based on JMG (2010)

Slope Gradient		Terrain Code		Activity Code		Erosion and Instability	
>5°	1	Hill Crest/Ridge	A	Natural rock	1	No appreciable erosion	0
				Soil	2		
				Soil and rock	3	Sheet erosion minor	1
5° <15°	2	Side Slope Straight	B			Moderate	2
		Concave	C			Severe	3
15°- < 25°	3	Convex	D	Cut Slope rock	4		
				Soil	5		
25°-< 35°	4	Foot slope straight	E	Soil and rock	6	Rill Erosion minor	4
		Concave	F			Moderate	5
35°-< 60	5	Convex	G	Fill rock	7	Severe	6
				Soil	8		
>-60	6	Drainage valley	H	Soil and rock	9	Gully Erosion minor	7
						Moderate	8
		Floodplain	I	Terraces rock	a	Severe	9
				Soil	b		
		Coastal plain	K	Soil and rock	c	Well defined recent	
						Landslide	
		Littoral zone	L	Reclamation	d	(diameters) <10m	a
						10m-50m	b
		Marshy/swampy	S	Mined – out	e	>50m	c
		Wave cut platform	W	Water body natural stream	f	Development of	n
				Man-made channel	g	General recent	r
		Alluvium plain	X	Water storage	h	Instability relict	
				Pond	i		
		Undulating Hills	Y			Coastal instability	w
				Colluvium	m		
				Excavated platform	p		

The input for terrain mapping is slope, terrain code, activity code and erosion & instability. For the slope gradient, it can be separated into six values that is 0°-5°, 6°-15°, 16°-25°, 26°-35°, 36°-60° and >60°. The value of slope gradient was extract from the topographic map or DEM data. The terrain code also important and can distributed into 12 parts. First is the hillcrest, hillcrest is the top line of the hill. The other terrain code for the terrain mapping is the side slope. Side slope is a slope at given horizontal, vertical ratio or percentage slope that is being traversing across. Side slope can be separate in three that is straight, concave and convex. Third is the foot slope, is the gently inclined hillslope at the foot of the hill. The foot slope also can separate in three such as straight, concave and convex.

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Drainage valley also a part of the terrain codes. Drainage valley is the drainage flow in a valley under calm conditions that built based on the laws on time, momentum and heat conservation. The mass and heat transfer from side slopes is integrated, and the velocity and reactive heat transfers between the valley drainage flow and the valley floor are parameterized (Davidson et all 1963). Flood plain is large patches of land with no dramatic height adjustments. The plain can even be located at any height, but it is generally lower than the surrounding countryside. The plain happens as elevated ground shape sediments including plateau, hill erodes, and washes downhill.

Coastal plain also include in the terrain codes. Coastal plain is adjacent to the ocean a flat, low-lying strip of ground. Coastal plains are separated by nearby landforms like mountains from the rest of the interior (Thomas, 1989) .The coastal plain forms a belt of mixed continental (alluvial, estuarine and aeolian) and marine (chenier, barrier island, tidal delta and deltaic) sediments that flank the sea. Next is the littoral zone, coastal region encompasses backshore, nearshore, and offshore zones, contains a broad range of coastal forms, and is a constantly evolving diverse environment. Swampy terrain is composed of low-resistance soils with plenty of ground shifting and challenging geotechnical properties.

Next is the alluvial plain, described as a plain composed of alluvium, the word alluvial plain is used in both a restricted and a general context. Bates and Jackson (1980) define The AGI Glossary restrictively as "a level or a slightly sloping tract or a slightly undulating land surface resulting from extensive alluvial deposition”. The wave cut platform also a part of the terrain code. Formed by a

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combination of wave erosion and dropping mud. When wave moves on to sever under a cliff of rock, overhanging rock may collapse, causing the cliff to gradually recess. Top of the line cliff notch shows the height waves can hit during storms. The excavated platform is the platform also important in determine terrain code. Lastly is the undulating hill, a general category for lowland landscapes in which the topography has no well-developed grain or distinctive platforms, plateau or escarpments

For the activity code, it can classify into natural slope, cut slope, fill, terrace, reclamation, mined out, colluvial and water body. The erosion and instability also an important attributes for the terrain analysis, such as gully erosion, no appreciable erosion, rill erosion, sheet erosion, well-defined landslip, diameter, development of general instability, development of general instability and coastal instability. In order to define the classes of terrain, steepness of the terrain, the morphology of the slope; the activities on the slope and the degree of erosion or instability on that slope have to identify.

The form of the landscape can exemplify by the steepness, the angle of the slope and the curvature of the earth. Biophysical processes at the subsurface. Surface layer Forms are also characterize by primary locality attributes to terrain (Moore et al., 1991). Wood (1998) analyzed measurements of slope and found that their values differ according to the scale of the area considered. In computing derivatives from DEMs, Wolock and McCabe (2000) examined the cause of scale dependence and distinguished between the effects of land-discretization (or cell-subdivision) and smoothing (or loss of detail) effects (Schneider, 2001).

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Topographic position typically has explicit or implicit environmental meanings, and is often defined in GIS as referring to a biophysical process or characteristic. Examples may include upslope contributing area depending on flow routing, hill shading involving incoming solar radiation, and distance to the nearest ridge. Therefore, the distinction between the topographical location and the shape of the terrain is that the former can be considered primarily point-based, but must use its characterisation.

Elevation mainly affects surface temperature and precipitation (Geiger, 1965; Hutchinson, 2007) and commonly demonstrated by an empiric approach based on the elevation relationship of direct observations (Mc Cutchan Mouse, 1986).

2.7 Geographic Information System (GIS)

ArcMap is the software that is going to invest much of the effort. It is working like a portal to records, access and modifies maps. ArcMap also has a style feature where completed maps can be created for export or printing. It is special which its ability to store, capture, and manage spatial data like vector and raster data models such as points, lines, polygons and continuous field respectively. GIS in terrain analysis can be dividing into three aspects, which are analysis data, data handling and data modelling. Then, all the data collected from secondary and primary data of the study area have compiled together in order to run the process. Next, the landslide susceptibility also needs to always updated and ongoing process as required. This software also contains Digital Elevation Models (DEMs) and

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triangulated irregular networks (TINs). The DEMs and TINs are able to derive information like slope angle and aspect using a specific function in GIS Software.

2.8 Slope Analysis

This study also takes part in slope analysis in order to complete terrain analysis. The size of the slope and direction of the slope will affect the suitability for construction. The slope angle plays the main role in providing the construction suitability map (CSM). Slope angle can classify into four classes based on the Department of Mineral and Geoscience Malaysia. For the first slope is less than 15̊. Second is 15̊-20̊. Third is 25̊-35̊ and lastly is more than 35̊ (Chow and Zakaria, 2002).

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CHAPTER 3

MATERIALS AND METHOD

3.1 Introduction

This chapter explained about the material and methodologies that were used during research. Geological tools and material were list to conduct during this research such as software ArcGis 10.8, USGS website, Google Earth Pro, and google Map. While for methodologies part included interpretation refers to slope analysis, weathering class, erosion class, type of contour and type of elevation.

3.2 Materials

Table 3.1 represents list of materials used in this reseach.

Table 3.1: List of materials

Materials	Uses
Software Arcgis10.8	To process all the data and produce maps such as geological map, slope map and etc.
Website: USGS	Collect the secondary data like satellite imagery data.
Google earth pro	To know the structure of the study area.

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3.3 Methodology

3.3.1 Preliminary studies

The research was conducted to summarize and identify the terrain analysis. Firstly, all the related journal book and article on terrain analysis and about the geology of the study area were referring. Next, remote sensing method, which is able to capture geomorphological ground motion and can spot deformations related to tectonic movement and slope in the large range is studied. Then, the base map of the study area was generated using GIS software (ArcMap10.8). Based on the topographic map, information such as lineament map, drainage pattern and vegetation can extracted.

3.3.2 Data Collection

The data were collected from the USGS website such as contour and river. For the highway, village and vegetation were collected from google earth and google map. Furthermore, the information about geomorphology, lithology, and structure of rock can be determine by analyzing through contour and google earth.

a) Land cover

Landsat 8 images dated 5.12.2014 (-path127, row 057) and Landsat 8 images dated 19.12.2019 (-path 127, row 057) were used to determine the land cover variations for reserved forest Gunung Rabong, Gua Musang, Kelantan. Table 3.2 shows the characteristics of satellite imagery used for determining land cover changes.

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Table 3.2: Landsat data for land cover year 2019

Technical properties	**Data type** **Landsat 8 satellite images**
Sources	USGS
Spatial resolution	30 meter
Path/row	127/056
Projection	UTM
Datum	WGS84

(Source: United States Geological Survey, 2019)

b) Digital Elevation Model (DEM)

DEM data are used to create slope, aspect and drainage density. This data downloaded from the USGS website, so it has to build from raw data like contour data and elevation, which is not directly from the existing map. This data able to create a landform map and identify the occurrence site to make construction. The DEM may be obtained using techniques such as Photogrammetry, Lidar, If SAR, Land Survey, etc. (Li et al. 2005). DEMs are usually designed using data obtained using remote sensing techniques, but can also construct by surveying the ground. In GIS, DEMs are frequently used and are the most common basis for digitally generated relief maps. Table 3.3 shows the DEM data in Gua Musang, Kelantan.

Digital Elevation Model (DEM) and Triangulate Irregular Network (TIN) are two common types of input data for land mapping and analysis. The DEM is a regular array of points of elevation. It converted by placing each elevation point in the center of the cell into an elevation raster. TIN approximates the surface of the land with a series of non-overlapping triangles. DEM can convert to TIN using either

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the maximum z-tolerance algorithm or the VIP (very important point) algorithm. TIN can converted into a DEM by using local first-order polynomial interpolation.

Table 3.3: DEM data year 2019

Technical properties	**Data type Digital elevation model (DEM) year 2019**
Source	USGS
Spatial resolution	30 meter
Area	Gua Musang, Kelantan.

(Source: United State Geological Survey, 2019)

3.3.3 Data Analysis

a) Fill slopes

Land clearance for new development area may involve the practice of cutting the side slopes or the ridges of the hills. The excavated material dumped on the steep slopes adjacent to the cut platforms. Such fill slopes inevitably have instability and pollution problems. These fill slopes are quite loose and lack the cohesion of the original residual soil. The intense rainfall in the highland regions will results in the occurrence of severe sheet, rill and gully erosion on the unprotected fill slopes. Fill slopes are generally unstable and landslides are often present on such slopes. The modes of failure include slump to planar failure that always accompanied by severe gully and rill erosion.

b) Weathering Profile

The weathering profile of the original bedrock is characterized by lateral and vertical variations in the level of preservation of the minerals, texture and structure. The variations allow morphological zones and horizons to be recognized, which can be correlated with the weathering grade of rock mass.For analysis, the weathering

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should know to estimate the rate of erosion in the study area. The type of lithology in the study area also gives the information about weathering profile. In addition, the weather in Malaysia give a huge impact on weathering. The hot and humid weather cause the biological and chemical weathering occurs quickly. The rain also effect the weathering cause the rain can react with the environment (mineral in rocks). . Table 3.4 refers to classification of weathered rock for engineering purposes.

3.3.4 Data Processing and Interpretation

GIS was use to process, store, handle and view spatial data as well as all forms of geographic data such as line and polygon. GIS Software would then be able to generate all types of maps required, such as base maps, drainage maps and geological maps. Remote sensing is a complementary tool for data collection to field observation since it helps to map geological features of regions without interaction with the regions being explore. Upon completing the geological mapping, polygons need to be digitized and analysis the data using GIS ArcMap10.3 software. The product in the form of a geological terrain map and construction suitability map were produce.

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Table 3.4: Classification of weathered rock for engineering purposes (after Attewell 1993).

Weathering grade	Description	Definition	Likely engineering characteristics
VI	Residual soil	Rock is discoloured, and completely degraded to a soil in which none of the original fabric remains; there is a resultant large volume change; the soil has not been significantly transported.	Unsuitable for most foundations; any stability on slopes relies upon vegetation rooting and there will be substantial erosion without the presence of any hardcap or preventive measures; careful selection and purpose of use knowledge are needed before it can be adopted as a fill.
V	Completely weathered	Rock is substantially discoloured and has broken down to a soil, but with the original fabric still largely intact; the soil properties are a function of the composition of the parent rock.	Can be excavated by hand or ripped relatively easily; the rock is not suitable as a foundation for substantial structures, but may be appropriate for lightly-loaded structures; weathered rocks may be used as a fill; new discontinuities may have formed in the as yet unweathered fraction; may be unstable in steep cuttings and will require continuous support in tunnels; exposed surfaces will require erosion protection.
IV	Highly weathered	Rock is substantially discolored and more than half the material is in a degraded soil condition; the original fabric near to the discontinuity surfaces will have been altered to a greater depth; a deeply weathered, originally strong, rock may show evidence of fresh rock as a discontinuous framework or as a corestone; an originally weak rock will have been substantially altered, with perhaps small relict blocks but little evidence of the original structure.	As in V above
III	Moderately weathered	Rock is significantly discolored; discontinuities will tend to have been opened by the weathering process and the discoloration will have penetrated inwards from the	Can sometimes be excavated without blasting or cutting (i.e. by block leverage at the discontinuities); will be relatively easily crushed by construction

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		discontinuity surfaces; less than half the rock material is decomposed or disintegrated to a soil; samples of rock containing discoloration are noticeably weaker than the fresh undiscoloured rock; an original weak rock will comprise relict blocks of substantially weathered material.	plant moving over it in situ, but with care is suitable as a foundation rock; suitable as a low permeability fill; joints may have acquired lower friction characteristics, so rendering side slopes and tunnel roofs unstable.
II	Slightly weathered	Some discoloration on and adjacent to discontinuity surfaces; discolored rock is not significantly weaker than undiscoloured fresh rock; weak (soft) parent rock may show penetration of discolouration.	Normally requires blasting or cutting for excavation; suitable as a foundation rock but with open jointing will tend to be very permeable; not suitable as an aggregate rock.
I	Fresh	No visible sign of rock material weathering; no internal discoloration or disintegration.	Normally requires blasting or cutting for excavation: may be self-supporting in excavations, but may sometimes require support in tunnels if closely jointed.

a) Topographic map/ contour map

The topographic map was produce using DEM data. Development of contours involves several steps which determine how contours are produced and where the class of features is stored. It must specify the name of the contour feature class that generates the contour interval and the database in which the contour layer is stored. Some attributes are added and automatically populated when a contour feature class is created, based on the fields specified using the Contour Field Options tool. These include fields containing a code of a feature, a type of contour, and an attribute of elevation value.

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b) Slope Gradient Map

The Slope method may use to trace the slope by defining the slope from each cell of the raster sheet. Contour lines are typically view as line features in a shapefile or a function class (vector data). Nonetheless, a slope chart cannot generate directly from the contour lines, because the Slope method does not accept vector data as input.

c) Elevation Map

Elevation layers can assist with 3D visualization by providing relaxation in your 3D environment. Elevation layers are composed of data contour sources. The raster elevation model that you build from elevation data sources can then use to publish the elevation map. Elevation layers may use as a surface that offers base heights layers in your scenes.

d) Geological Map

The geological map at the study area was produced in scale 1:25 000 and it cover all element in the geology. For example are the lithology, contour, Main River, rocks boundary, creek, geological structure, strike and dip, and coordinate of the study area. The geological map also has a cross section between two points in the study area. ArcMap operates with two separate 'views' – the view of the data and the structure view.

e) Terrain Classification

A collection of geoprocessing software for building field datasets is included in the 3D Analyst toolbox. Geoprocessing resources suggested for data automation,

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scripting, and simulation purposes. In order to create a field dataset interactively, use the Latest Terrain wizard. The New Terrain wizard can reach either in the Arc Catalog or Catalog window from the Dataset app shortcut screen. The step to produce terrain classification map are classify into four which are create terrain, add terrain pyramid level, add feature class to terrain and build terrain. Lastly, insert the legend, scale, tittle, north arrow and name at the layout, then the geological map are produce.

After terrain classification map was produced have to create a polygon in order to differentiate the type and value of coding based on Terrain classification and land use hazards zonation attributes (Chow and Zakaria, 2002). In order to create the polygon, ArcMap10.8 software be used. The polygon is creating based on Terrain classification and land use hazards zonation attributes. Terrain code is classified base on the type of slope, for example, hillcrest ridge, side slope, foot slope and drainage valley.

f) Construction Suitability Map

The suitability of the site for development and construction is evaluates from the terrain attributes and surface engineering geology, following recommended procedures of the Minerals and Geosciences Department. The construction suitability classified into four classes and the type of soil investigation required based on the construction suitability (Table 3.5).

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Table 3.5: Construction Suitability Classification System based on Geoscience and Mineral Department.

Class Charecteristics	Class 1	Class II	Class III	Class IV
Geotechnical Limitations	Low	Moderate	High	Extreme
Suitability for Development	High	Moderate	Low	Probably Unsuitable
Engineering Costs for Development	Low	Normal	High	Very high
Intensity of Site Investigation Required	Normal	Normal	Intensive	Very Intensive
Examples of Terrain	1.Insitu terrain <15° minor erosion 2.Cut platforms in insitu terrain	1.Insitu terrain 15° - 25°, no instability or severe erosion 2.Insitu terrain <15°, severe erosion 3.Colluvium <15°, no instability or severe erosion	1.Insitu terrain 25° - 35° no instability or severe erosion 2.Insitu terrain 15° - 25°, history of landslips 3.Colluvium 15° - 25°, general instability	1.Insitu terrain >35° 2.Insitu terrain 25° - 35°, instability or severe erosion 3.Colluvium 25° - 35°, moderate erosion

(Geoscience and Mineral Department, 2010)

Creating a map of suitability makes it possible to obtain an appropriate value for each location on the map. The required dataset layers are in position (in this case, land use, slope, distance to recreation places, and distance to schools) for study. As is the case for this illustration, all of the measurement units for the suitability scales are synthetic. No matter what measures of measurement is used for the scale of suitability, of is a rated metric of suitability or choice, from the best to the worst. The ranking of inputs, once your various inputs have been prepared, they need to transform into a common scale. Reclassify method is to evaluate a chart describing land-use types. As it is better to construct on other forms of land use regardless of the costs associated, you need to consider whether to rate the values.

Ranking the areas on relatively flat land, to prevent steep hills and locate places that are level to construct on, you need to learn the slope of the ground. The Slope tool will create such a map, identifying the maximum rate of change of value

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from each cell to its neighbors for each cell. The resulting raster reports the slope as constantly shifting floating-point values. Because preferences are consider varying directly with changes in the value of the slope, the Rescale by function tool is use to rank this map by applying the linear function. Combining the maps of suitability, the last step in the suitability model is to integrate transformed outputs (maps of suitability) of land-use forms, hills, distances to recreation areas and distances to schools. Verifying the outcome once, you have the result of any spatial analysis, check that it is correct. This can achieve by visiting prospective locations in the area, if necessary. The suitability of the site for development and construction is evaluates from the terrain attributes and surface engineering geology, following recommended procedures of the Minerals and Geosciences Department and construction suitability map can be produced. Figure 3.1 represents flowchart of overall research methodology.

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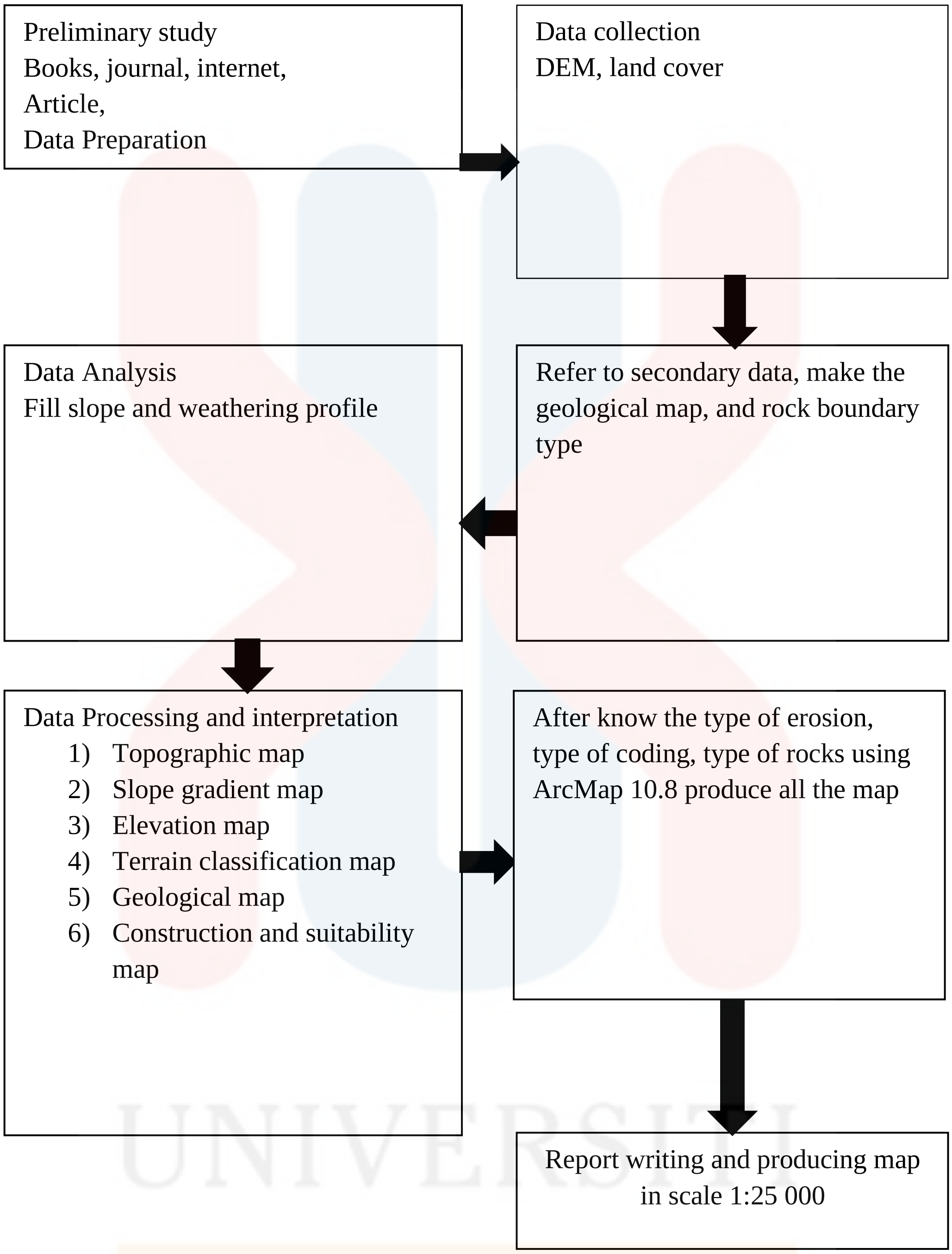

Figure 3.1: Flowchart of research study

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CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter discusses the discovery of the geomorphology process, stratigraphy, historical geology and structural geology. The study area (25 km^2) located at reserved forest Gunung Rabong, Gua Musang, Kelantan. This research started with preliminary studies by referring to previous research, books, journal and article about the study area. The main source of secondary data was from USGS website and Google Earth pro software. The Arcgis10.3 software was use to design the topographic map and create the contour by overlay with the satellite imagery. The topography of the study area is low lying until mountain area. It can define as mountain area because the highest elevation at the study area was 440 meter from sea level.

In terms of accessibility, the study area can be reach using road crosses where villagers use the roads for the daily activities. The road was mainly use to collect the product of the palm oil. Mostly the area was covers by palm oil plantation. Besides, villagers also use off road to collect the palm. Figure 4.1 show the road (Kota Bharu

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– Gua Musang) and Figure 4.2 shows the road that used by villager to go palm oil plantation.

Figure 4.1: Main road (Kota Bharu – Gua Musang). (Source:google map, 2016)

Figure 4.2: Road for palm oil plantation. Sources from google map.(source: google map, 2016)

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Gua Musang actually the largest district in Kelantan, but due to its undeveloped process the population was quite low compared to other districts. Table 4.1 shows the population in Kelantan.

Table 4.1: Population distribution in Kelantan.

DISTRICT	AREA(HECTARE)	PERCENTAGE (%)
Gua Musang	817,595	48.54 %

(Sources: Department of Statistics, Malaysia 2010)

As the study area was mainly included in reserved forest of Gunung Rabong, so most of the land was cover by mountain with elevation 360m to 420m. Certain land areas land belong to private property because owned by the local villagers. Figure 4.3 shows the topography of the study area.

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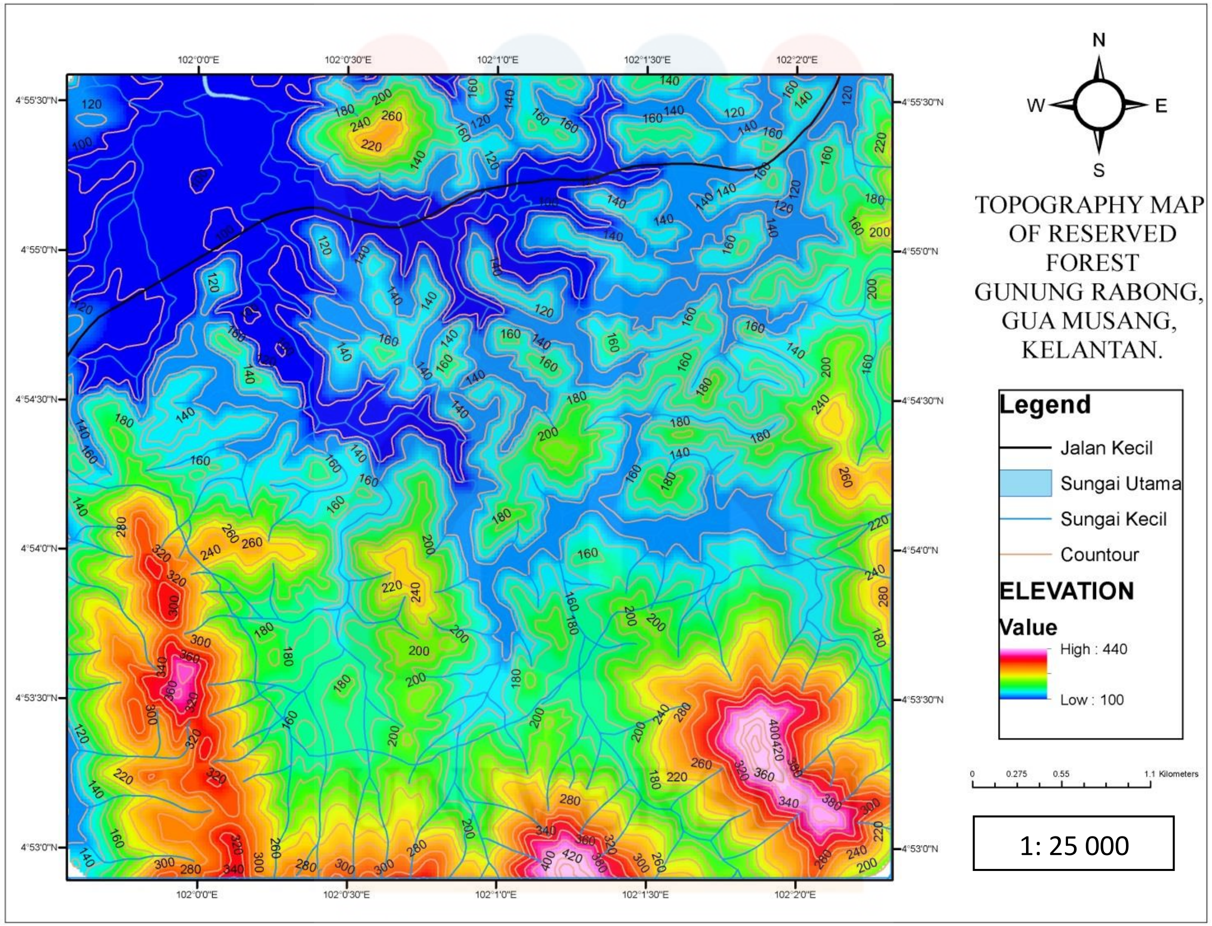

Figure 4.3: Topography map of the study area

4.2 Geomorphology

The study of landforms is geomorphology and its processes that related to the origin and elevation. Earth landform is affected by endogenic and exogenic measure. Geomorphological cycle is the cycle that prompts the progressions on the Earth surface incorporates physical, substance and natural cycle. The specialists engaged with this cycle are water, wind, ice sheet. In this part, water and wind are the regular specialists for enduring cycle. This geomorphological cycle is imperative to seeing more insights concerning the Earth landform. The geomorphological cycle, which related to topography, enduring cycle and waste example were discuss in this section. The nature and rate of geomorphic process change with time and some landform were produce under various environment conditions, surviving today a relict feature (Hugget, 2007). As indicated by Hutchinson and Tan (2009), in spite of the fact that the Peninsular is considered to be generally steady structurally, it has still been impact by local occasions of Sundaland. Its present-day landforms hence result in part from its delayed sub-elevated introduction all through the Tertiary period, with transcendence of enduring and disintegration. Larger part geomorphology at study zone is undulating until hilly on the grounds that have height 76m-420m. Figure 4.4 shows geomorphological map of the study area and 3D map of the study area indicated in Figure 4.5.

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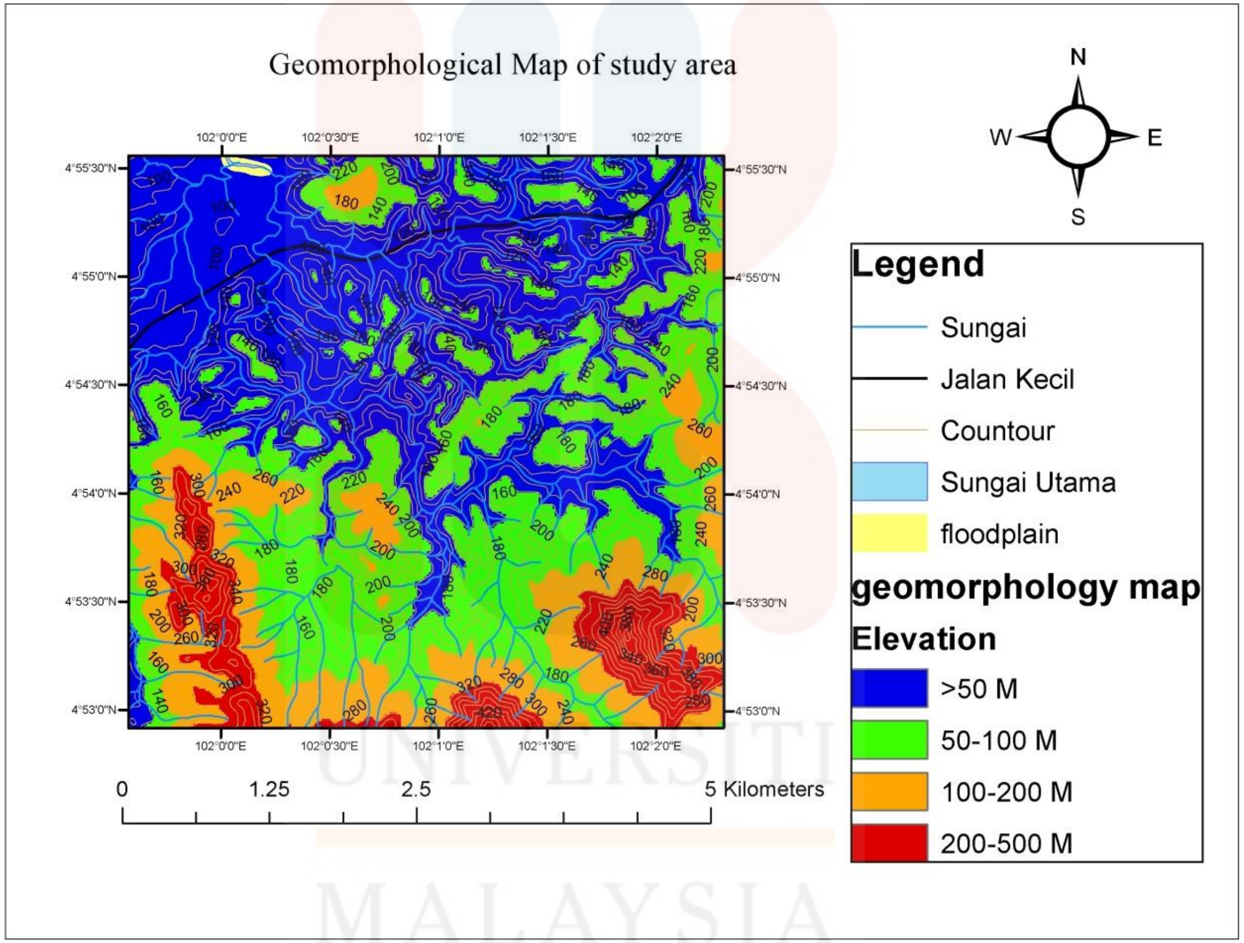

Figure 4.4 Geomorphological map of the study area.

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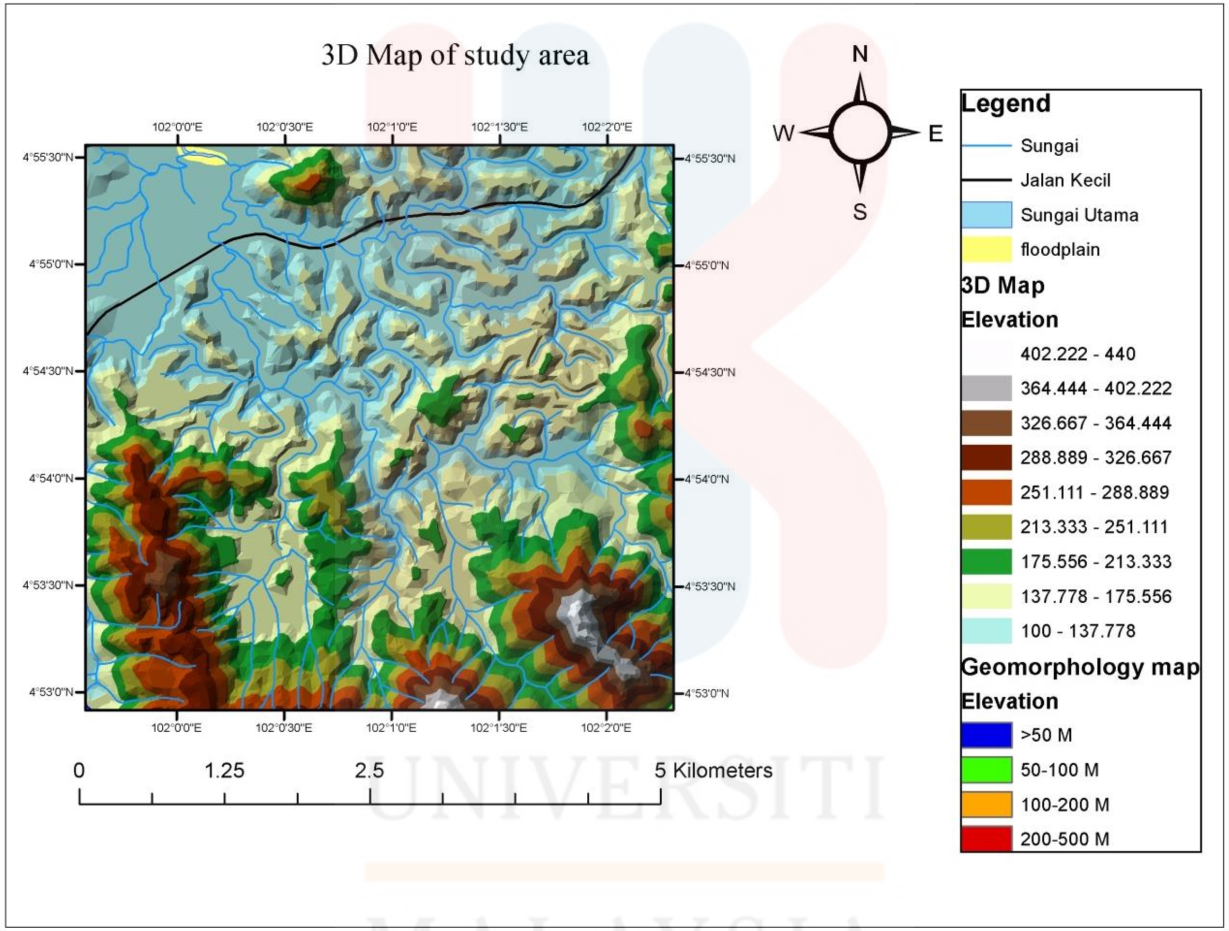

Figure 4.5: 3D map of the study area

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4.2.1 Geomorphology classification

The higher landform may cause the hill formed by the erosion or the deposition of sediment that brought by the geomorphological agent such as wind or maybe faulting. The transportation occurs at the sandstone part because it downs the elevation. The transportation down the slope and slow down to deposition because it the lowest part in the study area. This process occurs at the high elevation and transport to the lowest elevation support by stream/channel.

According to Van Zuidam 1985, there are four type of morphography that can be classified by the elevation in the study area. First is below 50meter is identified as lowlands. Second is the 50 meters to 100meter were categorized as inland lowlands. Third, is the 100meter to 200 meters are considered low hills and lastly 200meter to 500 meter is in hills category. Figure 4.6 represents geomorphological map of the study area and Table 4.2 shows indicator of elevation based on Van Zuidam classification.

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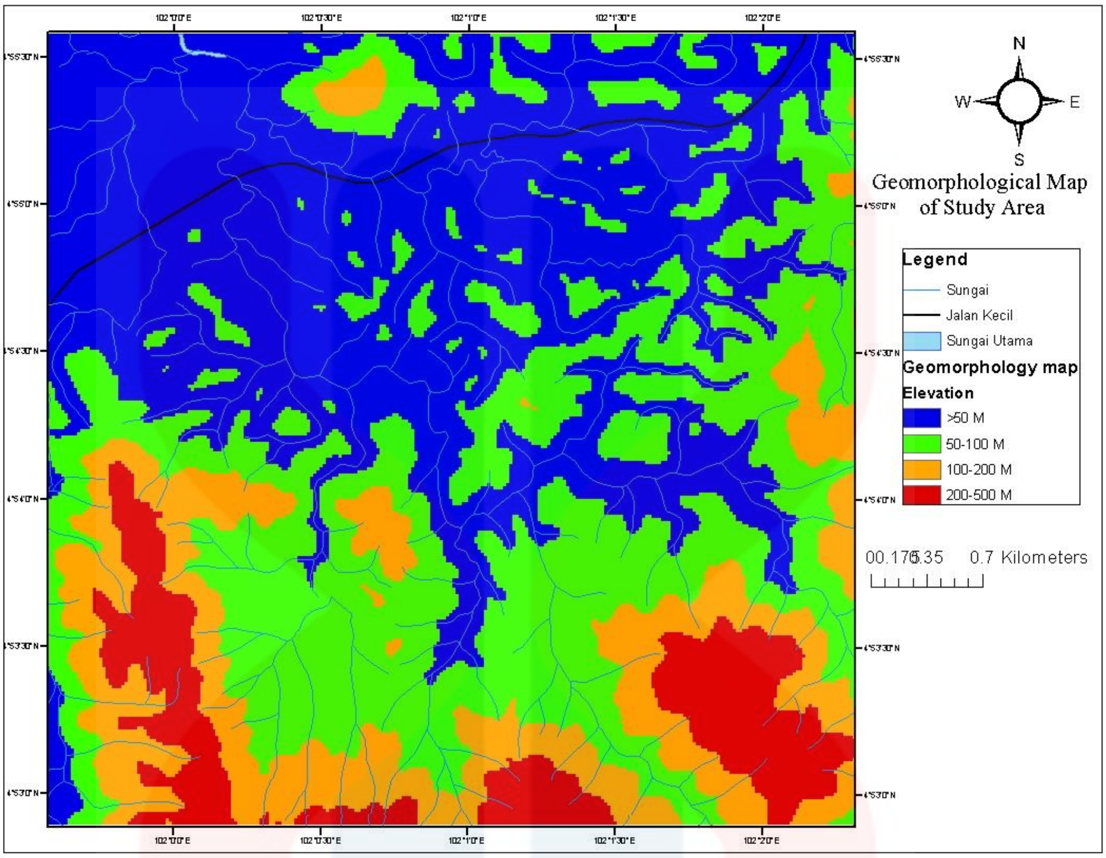

Figure 4.6: Geomorphological map of the study area.

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Table 4.2: Type of elevation type based on Van Zuidam, 2010

KETINGGIAN ABSOLUT	UNSUR MORFOGRAFI
< 50 meter	Dataran rendah
50 meter - 100 meter	Dataran rendah pedalaman
100 meter - 200 meter	Perbukitan rendah
200 meter - 500 meter	Perbukitan
500 meter - 1.500 meter	Perbukitan tinggi
1.500 meter - 3.000 meter	Pegunungan
> 3.000 meter	Pegunungan tinggi

4.2.2 Drainage Pattern

The drainage system pattern in the drainage basin consists of streams, rivers and lakes (Ling Zhang, 2012). A seepage framework accomplishes a specific seepage design where its organization of stream channels and feeders is resolved by nearby geologic elements. The drainage pattern can classify based on their form and texture according to slope and structure. Drainage pattern in the study area is important to assume types of rock and the watershed of the area. The geomorphology of the landform is one of the causes of the drainage pattern are different pattern with each other. Many types of drainage pattern that are commonly found in the field, but in the study, area only have two types drainage pattern which is dendritic and parallel.

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Firstly, a dendritic drainage pattern is common form like a branch of tree root. There is no straight dendritic drainage and there are contributing streams that then join the main river tributaries together. Drainage pattern are developed when the river channel follows the slope of the terrain in study area. Dendritic stream pattern is commonly the rock type is impervious and non-porous. The study area mostly consists of a dendritic drainage pattern and some parts in the study area are parallel drainage pattern. The dendritic pattern tends to develop on surfaces that erode uniformly on gentle to moderate slope. The evolution of the dendritic pattern is guided by lithological features, mainly the permeability of the underlying rock, the rainfall quantity and regime, the resulting surface runoff and the time factor. In a dendritic river system, tributaries of a main river join in a shape analogous to the twigs of a tree (Lambert, 1998). Figure 4.7 shows the watershed of the study area while Figure 4.8 represents stream map. Drainage pattern map is shown in Figure 4.10.

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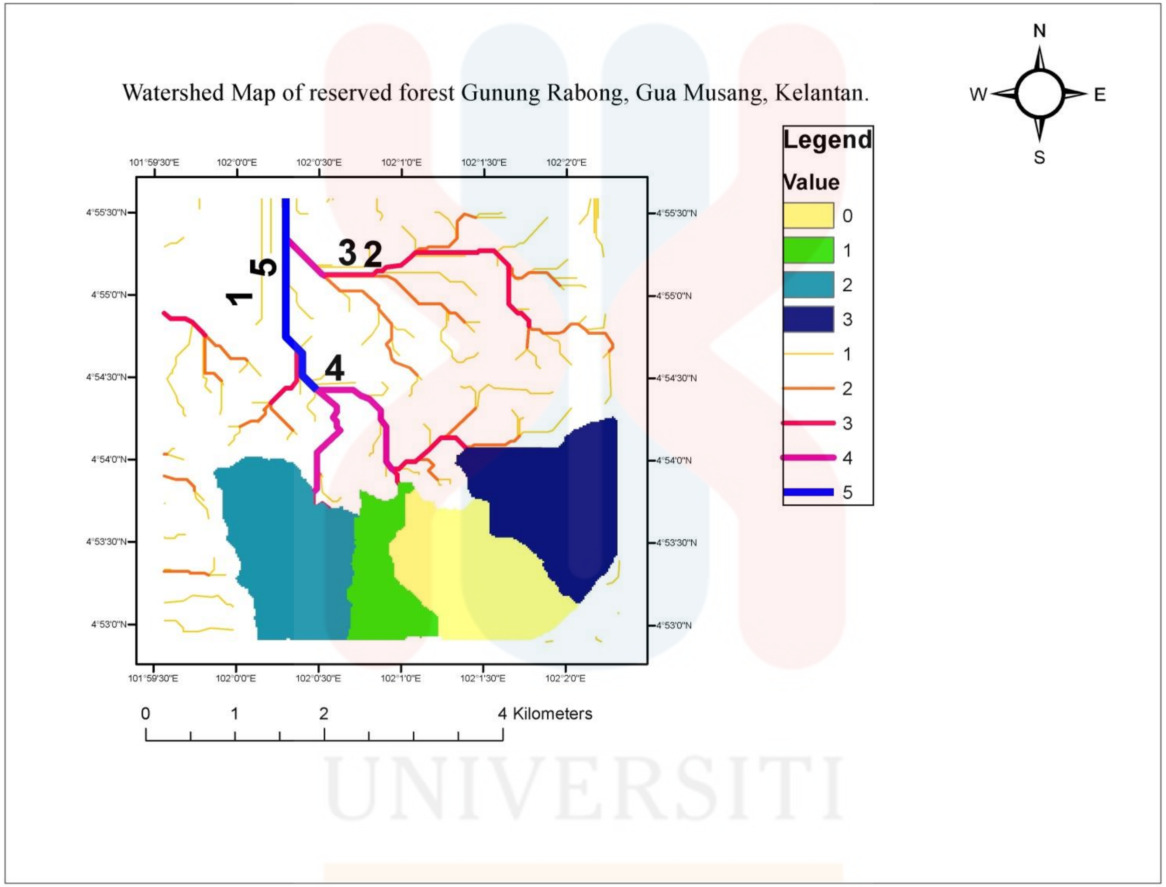

Figure 4.7: watershed of the study area.

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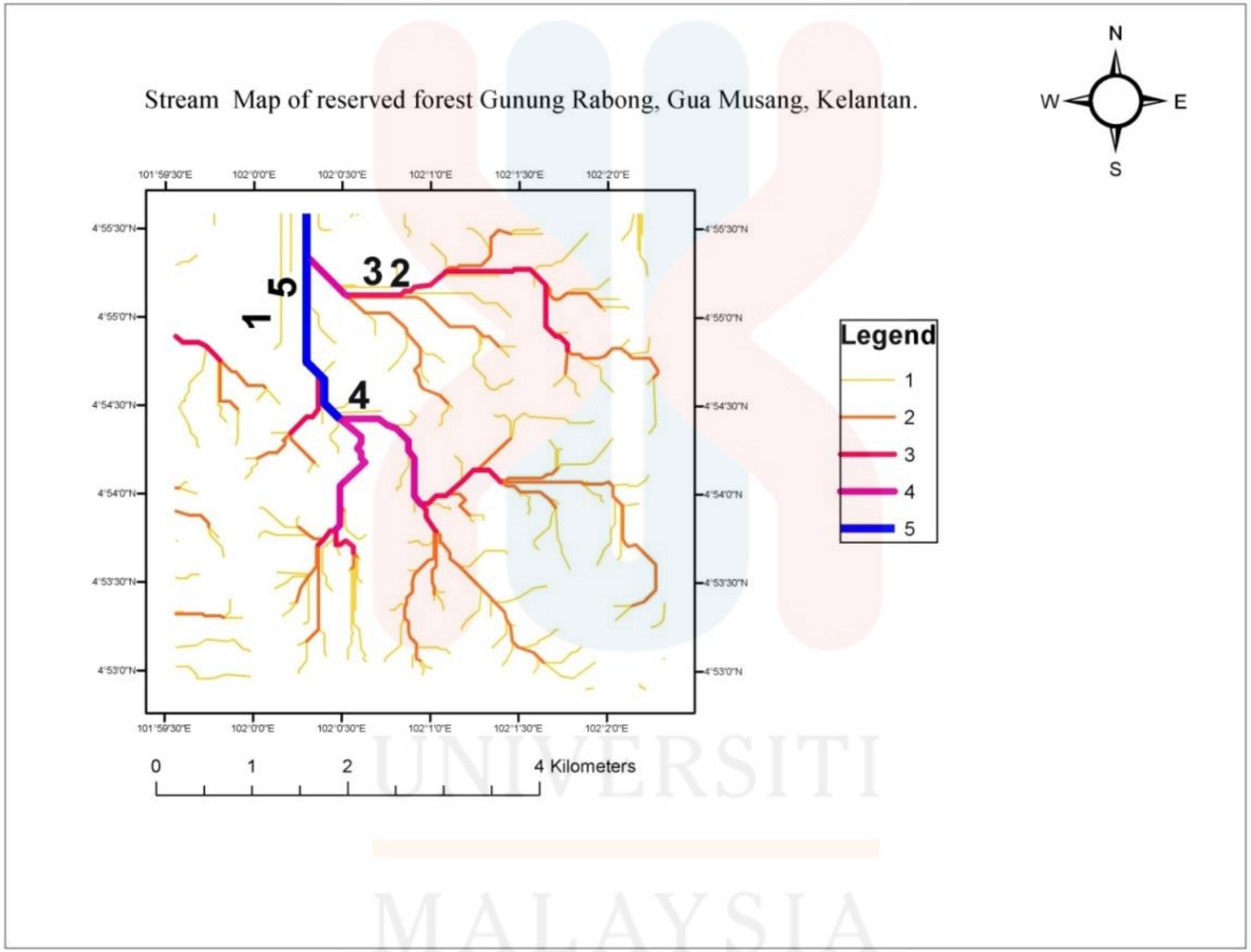

Figure 4.8: stream map of the study area

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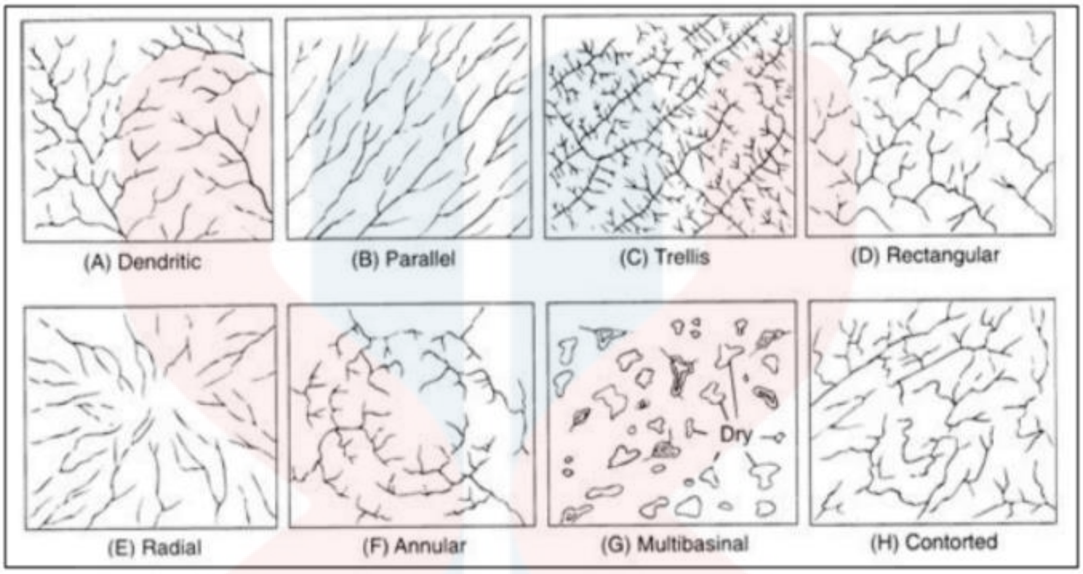

Figure 4.9: type of drainage pattern by Howard 1967

Table 4.3: drainage pattern characteristic by Ling Zhang (2012).

Drainage pattern	**Geometric & Topologic characteristic**
Dendritic	- Tributaries joining at acute angle. - Parallel like
Parallel	- Elongated catchment - Long straight tributaries - Tributaries joining at small acute angle
Trellis	- Short straight tributaries - Tributaries joining at almost right angle
Rectangular	- Tributary bends - Tributaries joining at almost right angle
Reticulate	- Tributaries cross together forming a cycle

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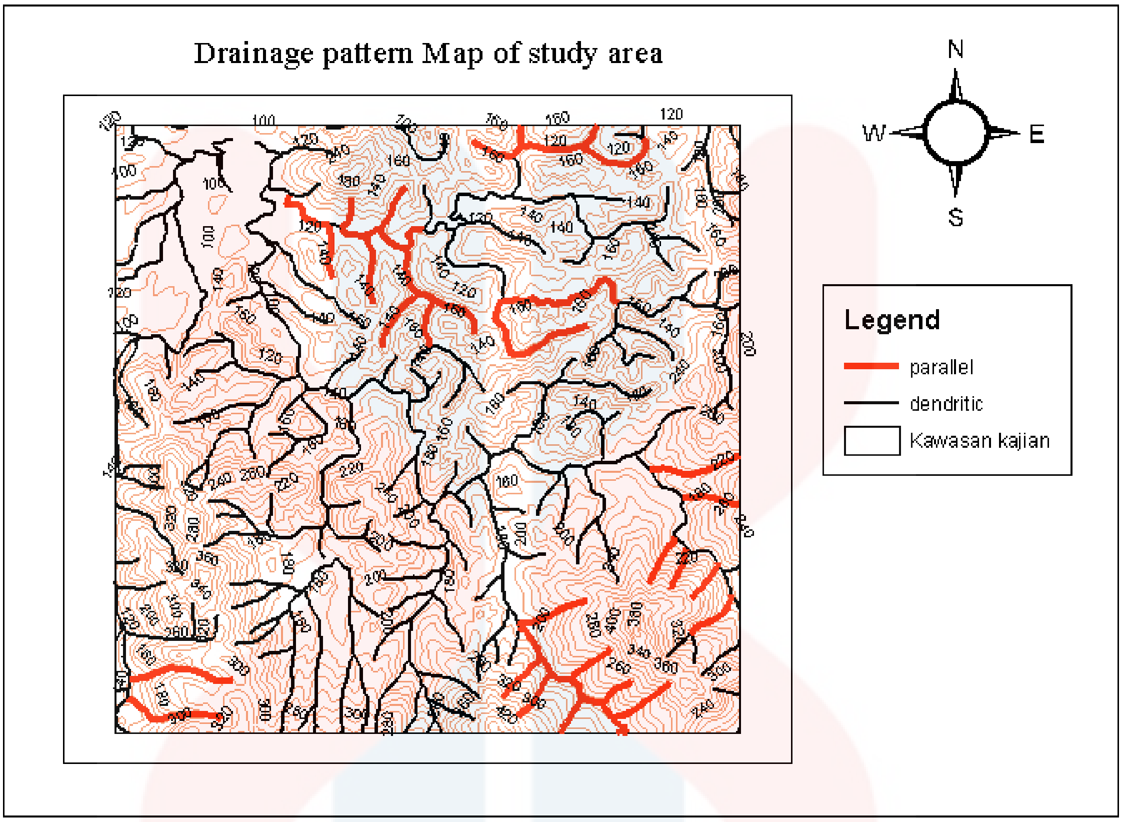

Figure 4.10: Drainage pattern in the study area

4.3 Lithostratigraphy

Stratigraphy is a branch of geology, which is study about strata, and layering of earth. Stratigraphy is a part of topography, which is, learns two, which are lithology and lithostratigraphy, partitioned about layers and layering (stratification) . Lithology is investigation of the actual relationship among rock units. While lithostratigraphy is a sub-order of stratigraphy, the geographical science related with the investigation of layers or rock layers. There also has alluvium soil a study area. The different lithological unit had their own depositional process.

The study area composed on four lithological units, which are granite, quartzite, sandstone and interbedded shale. The oldest rocks is interbedded shale

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because it from Permian period. Second is the sandstone also in Permian period. The younger lithology is the granite from Triassic period and the youngest lithology is quartzite that is form due to heat and pressure of granite intrusion. The study areas are included in the Gua Musang formation and Rabong formation.

4.3.1 Stratigraphic position

The oldest rocks in the study area were interbedded shale (sediment rock) from Gua Musang formation. The period for this rock unit are Permian and it located north – east at the study area. The second oldest lithology units are sandstone (sedimentary rock) also from Gua Musang formation and it included in Permian period. The lithological unit were located in south – west at the study area. Third oldest are granite (igneous rocks) and included in Gua Musang formation. The period time for this lithology are from Triassic and it located at south – east in the study area. Lastly, are quartzite (metamorphic rocks), from Rabong Formation and included in Triassic period. This lithology unit located at north of map at the study area. Figure 4.11 shows stratigraphic column for lithology in the study area.

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Stratigraphy column

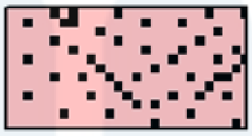
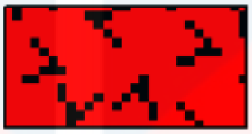
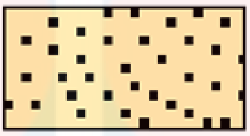
Formation	Period	Name of lithology	Lithology	Description
Rabong Formation	Triassic	Quartzite		White in colour and composed of quartz.
Gua Musang Formation		Granite		Composed of quartz, plagioclase and alkaline feldspar.
	Permian	sandstone		White, reddish in colour, composed of volcanic fragment and quartz.
		Shale		Black in colour, fissile and laminated.

Figure 4.11: Stratigraphic column for lithology in the study area.

4.3.2 Unit Explanation

a) Granite

Based on the stratigraphy of Gua Musang that related with the study area, granitoid rock is the youngest rock unit in study area with Cretaceous age. The granite was located in the hilly to mountainous landform of study area in both rubber tree plantation and palm tree plantation. According to Kamal Roslan Mohamed et al (2016), pink granite seem to be much more older compared to grey granite but both of them still in Triassic age. The texture of the granite that been found was

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phaneritic, coarse texture as huge scale of ortoclase minerals are found on pink granite outcrops.

b) Interbedded shale

The oldest rocks in the study area were interbedded shale (sediment rock) from Gua Musang formation. The period for this rock unit are Permian and it located north – east at the study area. The characteristic of shale was black in colour, fissile and laminated.

c) Sandstone

The second oldest lithology units are sandstone (sedimentary rock) also from Gua Musang formation and it included in Permian period. The lithological unit were located in south – west at the study area. The physical characteristic of sandstone was white/ reddish in color composed of volcanic fragment and quartz.

d) Quartzite

The youngest lithology in the study area was quartzite. It forms due to metamorphism process during intrusion of granite. After exposed to high temperature and pressure during granite intrusion, sandstone that was compose from quartz mineral change to quartzite. The physical characteristic of quartzite was white in color and it totally composed of quartz mineral.

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4.4 Structural Geology

Structural geology is one of the fundamental piece of general topography that geologist need to know as should be obvious the historical backdrop of the spot dependent on its geographical structure that have been uncovered in the examination region. In view of the topography structures of the research territory, numerous information of the spot acquired like its geomorphology landform, its structural setting, the periods of the stones dependent on its bedding and numerous others. Subsequently, land structures are truly significant as a rule geography as it gave the geologist trace of how the minerals, shakes and earth misshaping dependent on their cycle.

Lineament is any parallel line that we have on the topographic map. The lineament indicated the geological structures based on the location of lineament line that plotted in the map. Lineament analysis can be separate in two types that are positive lineament and negative lineament. Positive lineament can identify by ridge and valley of the strata. Negative also can identify by river. The entire lineament is important and useful in interpretation of fault zone. After make, an interpretation and analysis the rose diagram, the type of faulting can be decided. Figure 4.12 shows the negative lineament analysis in the study area and Figure 4.13 show the positive lineament analysis in the study area.

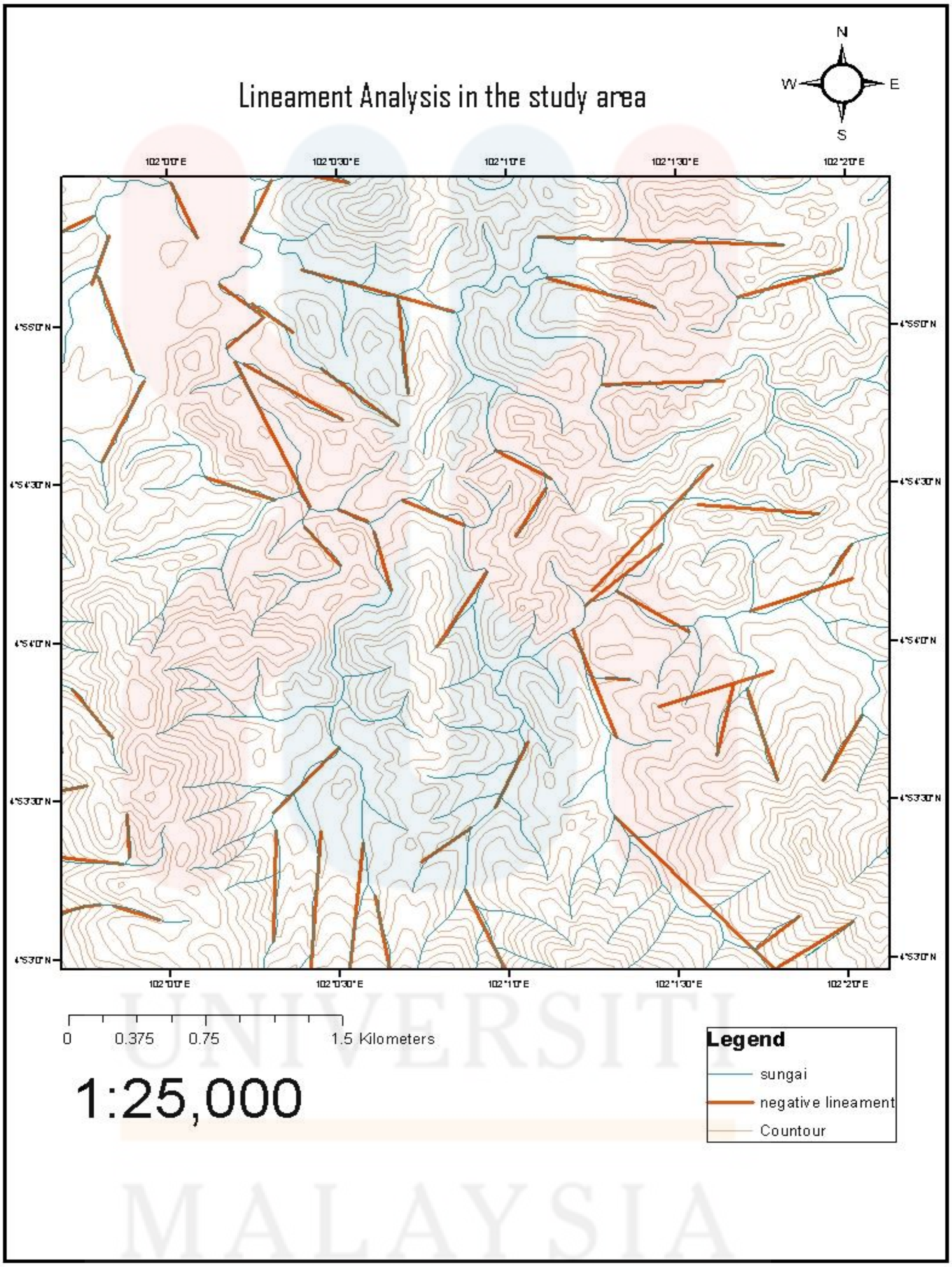

Figure 4.12: Negative lineament analysis in the study area

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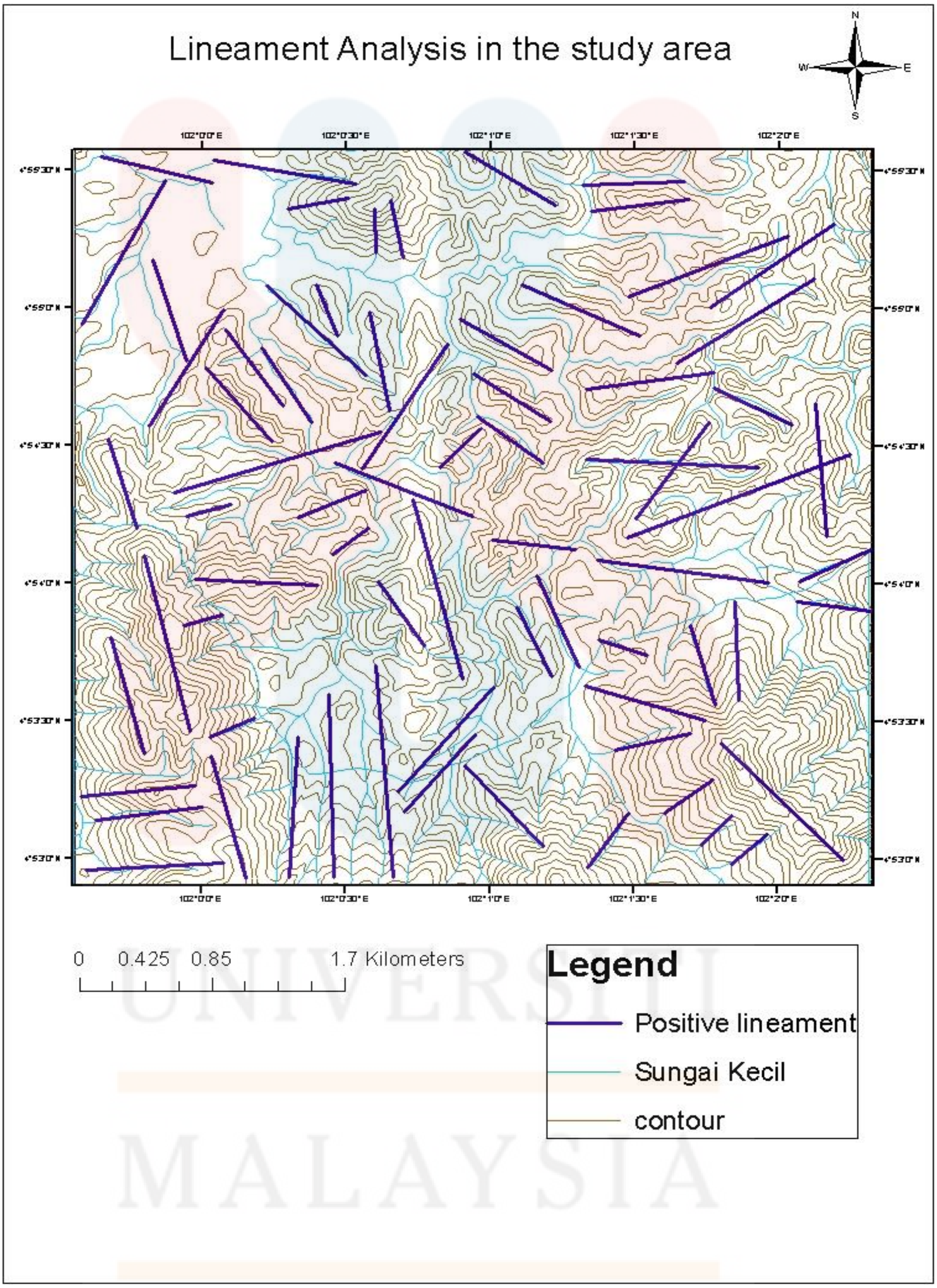

Figure 4.13: Positive lineament analysis in the study area

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4.4.1 Fault

Due to horizontal compression, the strike-slip fault occurred and the energy release in a horizontal direction almost parallel to the compression force by rock displacement. The fault plane is vertical, and along the plane, the relative slip is lateral. These faults are widely spread and most of strike-slip fault founded at the boundary between obliquely converging oceanic and continental tectonic plates (Alexandra E. Hatem et al, 2017). In the research area, strike-slip fault are identified based on the geomorphology landform. This is due to the stike-slip fault cannot be found anywhere in the study area so lineament map above are used to identify the strike-slip fault.

In the study area, the fault was target at the granite landform and in Meta - sediment unit landform. Based on interpretation, the dextral strike slip faults were found in the study area. This interpretation was doing using lineament analysis using contour and straightened feature in the study area. The value of lineament extracted from the google earth and topographic map.

4.4.2 Fold

A fold is defined a bend in the rock strata. While folding is a type of earth movement resulting from the horizontal compression of rock layers by internal forces of the earth along plate boundaries. Fold was a secondary structure that occurred in planar featured or rock strata. The analysis was done by plotting strike and dip by

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using stereo net software. This analysis was conduct to determine the fold axis, plunge and the direction of the stress acting on the layer.

4.4.3 Mechanism of structure

In the study area, there were several mechanisms of structure such as erosion and tectonic movement. There were four stages of erosion in the study area that were analyzed using google earth such as no erosion, minor erosion, moderate erosion and severe erosion. Tectonic movement also identified with the structure of contour and the lineament analysis. The lineament analysis was separate into two such as positive lineament and negative lineament. All the mechanism of structure was estimate by analyzing in the google earth.

4.5 Historical geology

Historical geology is a field that reconstructs and understands the geological history of the Earth using ideologies and methods of geology. It focuses on geological processes which alter the surface and subsurface of the Earth. Stratigraphy, structural geology and paleontology information describe the sequence of these events.

According to Yin (1965), Gua Musang Formation is in Middle Permian to Upper Triassic. In Gua Musang Formation, the lithology that can be found were limestone interbedded with shale, tuff, chert and some part of sandstone and extrusive rock. The Middle Permian to Upper Triassic Gua Musang Formation was

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plan by Yin (1965) in south Kelantan. The development was assessed to be 650 m thick, comprised of glasslike limestone, interbedded with slender beds of shale,tuff, chert nodul es and subordinate sandstone and volcanics. Inadequately protected fusulines including Verbeekina from Gua Musang give a Permian age to parts of the limestone and Lower Triassic (Scythian) ammonoids have additionally been depict from the limestone close by. The slender had relations with, overlaid and fissile shale is generally dark in shading however is dark when carbonaceous (Hutchinson and Tan, 2009). The argillaceous sandstone is fine to medium grained with precise quartz in a lattice of limonitic or carbonaceous dirt. The arrangement is what might compare to the pyroclastic Aring Formation and is inseparable from the Telong Formation of in south Kelantan (Aw, 1974).

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CHAPTER 5

TERRAIN ANALYSIS

5.1 Introduction

This chapter discuss about terrain analysis using Geological Terrain Mapping (GTM) attribute based on JMG 2010. This chapter also explained more on the terrain code, slope gradient, activities code, erosion, and instability. This analysis is conducted based on the parameter used such as cut and fill slope, fill slope, terrain analysis, terrain morphology, slope gradient, activity of slope, erosion and instability, cover & vegetation and potential geo hazard.

5.2 Terrain Analysis

5.2.1 Topographic map

For the specification on terrain analysis, the size of contour map used is 5meter. The reason of using 5-meter gap contour is to analyze the specific elevation and determine the type of elevation. If using the large contour size, the slope gradient the detail size is hard to get and encounter problem in terms of the accuracy of the map. The size of contour is important thing to consider since it contributes to the result of slope gradient.

5.2.2. Cut and Fill Slope

The presence part of study area requires the use of heavy machinery to cut and bulldoze the hill slopes to form flat platforms and to make access road. Cut slopes that were not protecting are subject to varying degree of sheet, rill and sometimes gully erosion. Erosion on cut slopes is not so severe as compared with fill slopes, as the soil is still cohesive and can withstand erosion resulting from the percolating rainwater. To gain access to project area, track has to be prepared at the foot and along the side slopes of the hills in the study area, which may lead to instability problems. Cut and fill slopes along such new access tracks are often unstable and are very susceptible to rill and gully erosions. Sheet erosion of fill materials dumped by the side of cut platforms can also be very severe if not protects or covered by vegetation.

5.2.3 Weathering Profile

The weathering profile characterized by lateral and vertical variations in the level of preservation of the original bedrock's minerals, texture, and structure. These variations allow morphological zones and horizons to recognize that correlate with grades of rock mass weathering. The weathering generally separated into three type, which are, physical weathering, biological weathering and chemical weathering.

This research area dominated by four type of lithology, which are granite, sandstone, interbedded shale, and quartzite. The weathering zones are developed approximately parallel to overlying ground surfaces and thicker below the ridge crest

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and summits, but thin towards valley floor. The thickness varies dependent upon several factors including the mineralogy and texture of the original bedrock, the regional and local topographic settings as well as site geomorphic history. In the study area, it can be defined as weathering grade 3, which was moderately weathered.

Rock is significantly discolored; discontinuities tend to have been opened by the weathering process and the discoloration have penetrated inwards from the discontinuity surfaces; less than half the rock material is decomposed or disintegrated to a soil; samples of rock containing discoloration are noticeably weaker than the fresh unicolored rock; an original weak rock comprises relict blocks of substantially weathered material.

For the geological engineering, it can sometimes be excavated without blasting or cutting (i.e. by block leverage at the discontinuities); relatively easily crushed by construction plant moving over it in situ, but with care is suitable as a foundation rock; suitable as a low permeability fill; joints may have acquired lower friction characteristics, so rendering side slopes and tunnel roofs unstable. Table 5.1 shows the classification of rock material weathering grade (Attewell. 1993).

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Table 5.1: Weathering grade refer to JMG, 2010

Weathering grade	Description	Definition	Likely engineering characteristics
VI	Residual soil	Rock is discoloured, and completely degraded to a soil in which none of the original fabric remains; there is a resultant large volume change; the soil has not been significantly transported.	Unsuitable for most foundations; any stability on slopes relies upon vegetation rooting and there will be substantial erosion without the presence of any hardcap or preventive measures; careful selection and purpose of use knowledge are needed before it can be adopted as a fill.
V	Completely weathered	Rock is substantially discoloured and has broken down to a soil, but with the original fabric still largely intact; the soil properties are a function of the composition of the parent rock.	Can be excavated by hand or ripped relatively easily; the rock is not suitable as a foundation for substantial structures, but may be appropriate for lightly-loaded structures; weathered rocks may be used as a fill; new discontinuities may have formed in the as yet unweathered fraction; may be unstable in steep cuttings and will require continuous support in tunnels; exposed surfaces will require erosion protection.
IV	Highly weathered	Rock is substantially discolored and more than half the material is in a degraded soil condition; the original fabric near to the discontinuity surfaces will have been altered to a greater depth; a deeply weathered, originally strong, rock may show evidence of fresh rock as a discontinuous framework or as a corestone; an originally weak rock will have been substantially altered, with perhaps small relict blocks but little evidence of the original structure.	As in V above
III	Moderately weathered	Rock is significantly discolored; discontinuities will tend to have been opened by the weathering process and the discoloration will have penetrated inwards from the	Can sometimes be excavated without blasting or cutting (i.e. by block leverage at the discontinuities); will be relatively easily crushed by construction

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		discontinuity surfaces; less than half the rock material is decomposed or disintegrated to a soil; samples of rock containing discoloration are noticeably weaker than the fresh undiscoloured rock; an original weak rock will comprise relict blocks of substantially weathered material.	plant moving over it in situ, but with care is suitable as a foundation rock; suitable as a low permeability fill; joints may have acquired lower friction characteristics, so rendering side slopes and tunnel roofs unstable.
II	Slightly weathered	Some discoloration on and adjacent to discontinuity surfaces; discolored rock is not significantly weaker than undiscoloured fresh rock; weak (soft) parent rock may show penetration of discolouration.	Normally requires blasting or cutting for excavation; suitable as a foundation rock but with open jointing will tend to be very permeable; not suitable as an aggregate rock.
I	Fresh	No visible sign of rock material weathering; no internal discoloration or disintegration.	Normally requires blasting or cutting for excavation: may be self-supporting in excavations, but may sometimes require support in tunnels if closely jointed.

5.2.4 Fill Slope

Land clearance for new development area may involve the practice of cutting the side slopes or the ridges of the hills. The excavated material dumped on the steep slopes adjacent to the cut platforms. Such fill slopes inevitably have instability and pollution problems. These fill slopes are quite loose and lack the cohesion of the original residual soil. The intense rainfall in the highland regions will results in the occurrence of severe sheet, rill and gully erosion on the unprotected fill slopes. Fill slopes are generally unstable and landslides are often present on such slopes. The modes of failure include slump to planar failure that are always accompany by severe gully and rill erosion.

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5.2.5 Terrain Classification

Land surface information including slope gradient, erosion and instability, as well as land cover and vegetation used to evaluate the potential geohazards of the site and their physical constraints for development. In the study area, all the information analyzed and differentiate based on slope degree. The information about geology also included to set up the terrain analysis. Figure 5.1 shows the terrain classification in the study area.

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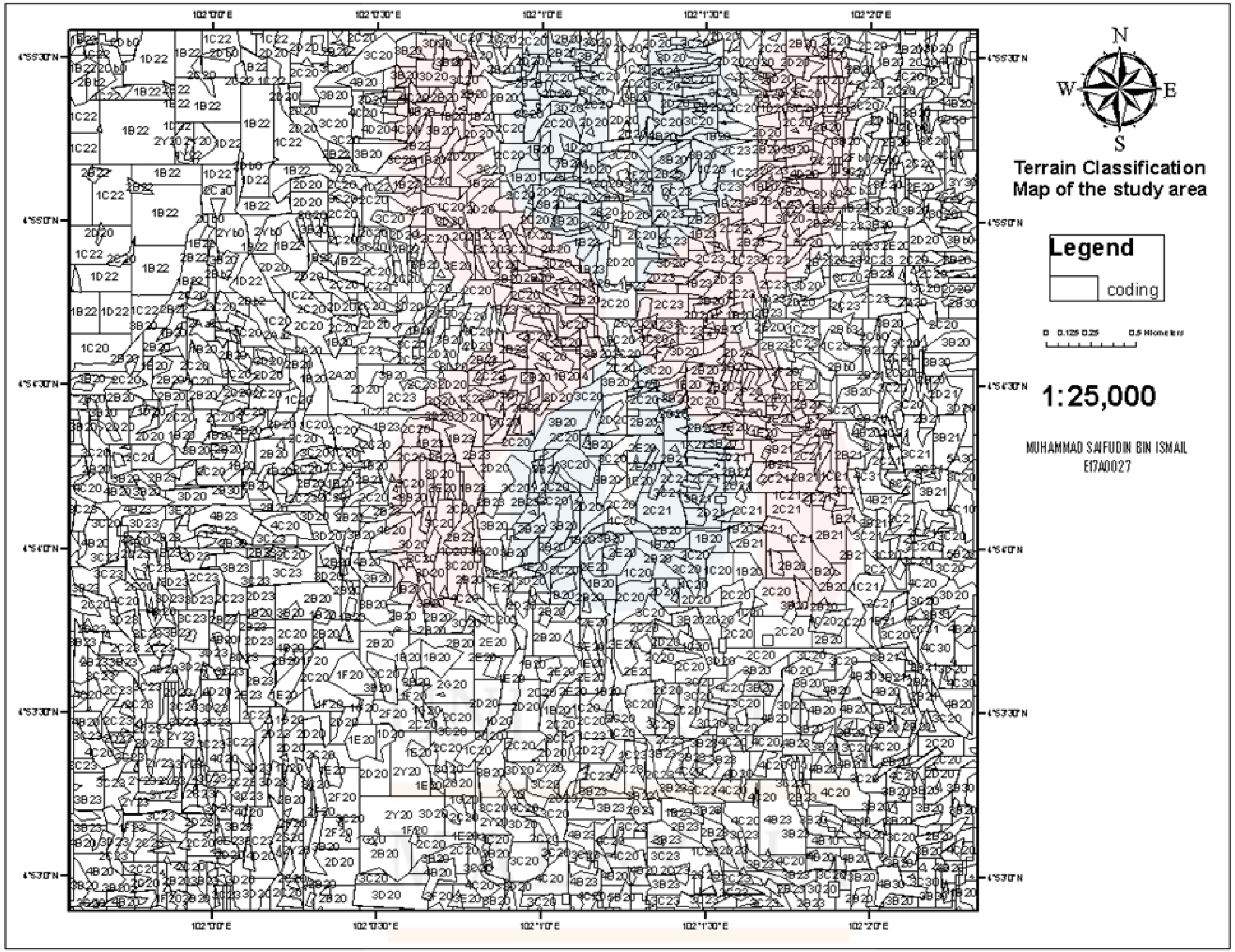

Figure 5.1: Terrain classification map of the study area.

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a) Slope Gradient

The slope gradient of the site shown in Figure 5. 2. The site is mainly flat to gently sloping area (0° - 5°) covered 18.9% of the project site. The gently slope are (5° - 15°) covered 45.53%. The moderately steep (15° - 25°) which covered 26.74% of the site where else 8.6 % of the site is steep slope (25° - 35°). Only 0.22 % of the site is covered by very steep slope (>35°) where most of it contributed by the cut slopes along the main road which traverse across the study area.

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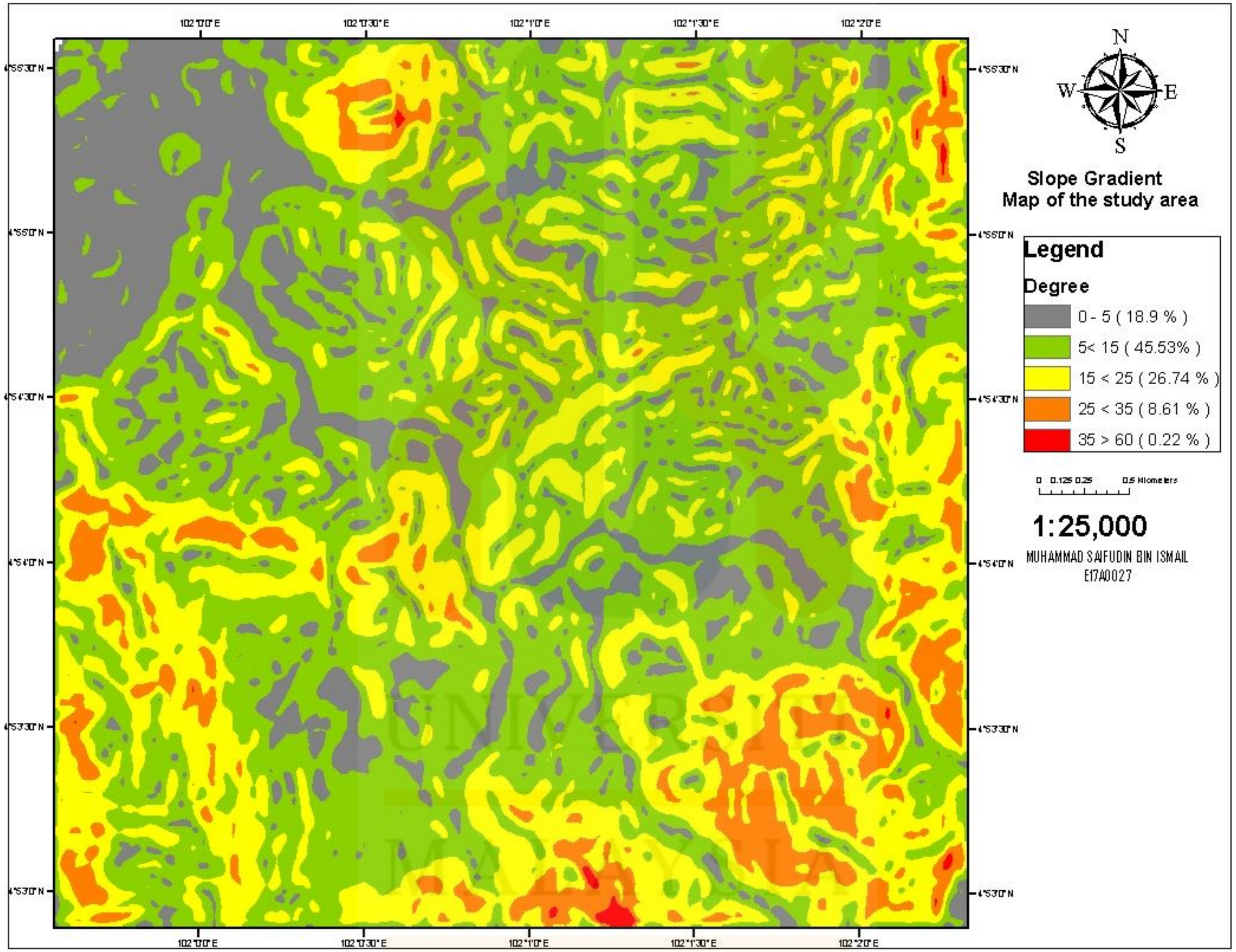

Figure 5.2: Slope Gradient of the study area

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b) Terrain Morphology

The site is mainly consisting of crest, concave side slopes, straight side slopes, convex side slopes and foot slope. A drainage valley which is a tributary of lake at the central west of the study area traverse from central south towards northwest of the project site. The terrain morphology of the site shown in Figure 5.3

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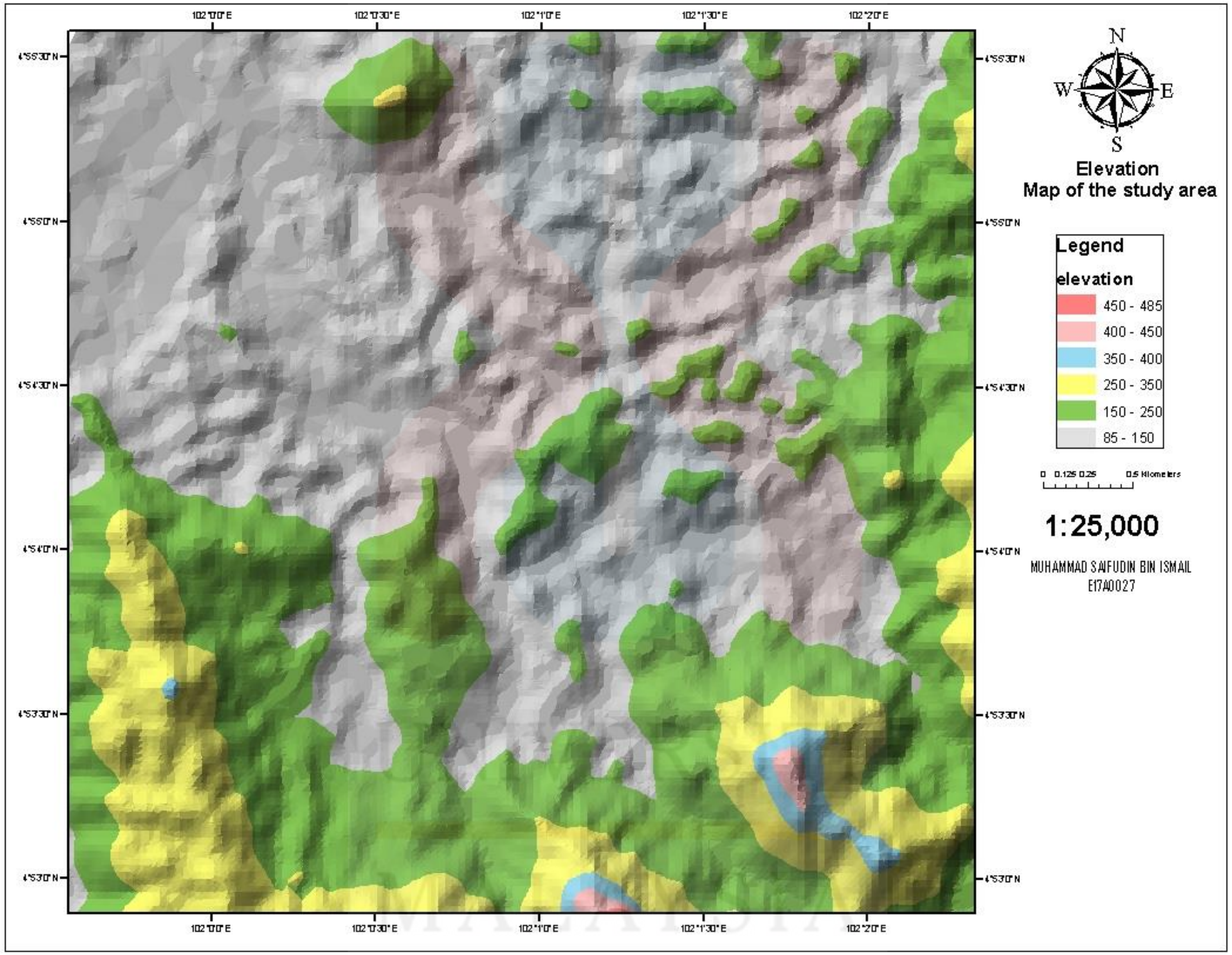

Figure 5.3: The elevation map of the study area

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c) Activity of Slope

Natural soil slopes with secondary forest cover almost the entire site. The activity code in the study area was natural, cut slope, fill, terrace and colluvium. The stage of the activity code can separated into three code, which are, rock (1), soil (2) and soil and rock (3). For the cut slope code, also separate into three, which was code 4 for rocks, code 5 for soil and code 6 for soil and rocks. Next, is fill activity, also separated into three and code 7 for rocks, codes 8 for soil and codes 9 for rocks and soil. The terrace activity also occurs in the study area, the activity codes for terraces is a, b, and C and it also represent as rocks, soil, soil and rock. The last activity in the study area was colluvium and the codes were m. All the activity code was codding in terrain classification map.

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d) Erosion and Instability

The erosion and instability in the study area were separate into four types that were no erosion, minor erosion, moderate erosion and severe erosion. The erosion identified by makes analysis on elevation map, lithology map and slope map. The percentage of no appreciable erosion was 69.9 %, the minor erosion was 5.62 %, for the moderate erosion was 21.8% and the severe erosion was 21.8 %. Figure 5.4 shows the percentage of erosion map.

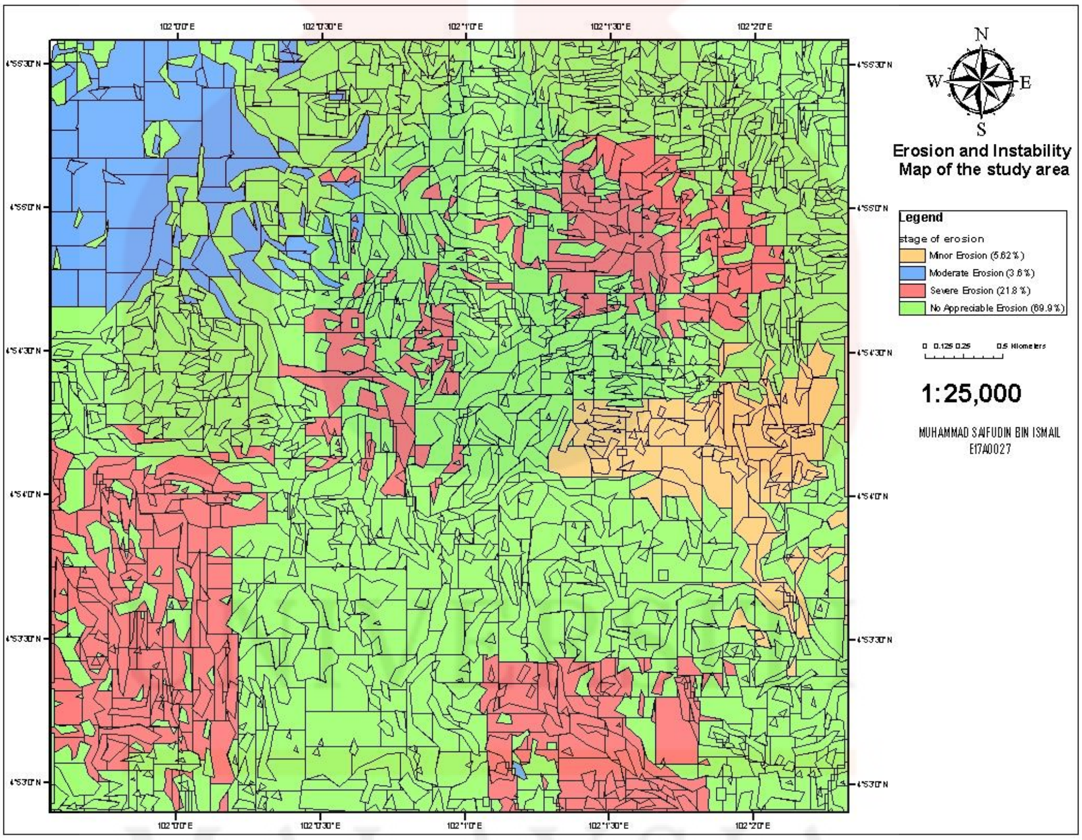

Figure 5.4: The erosion and instability map of the study area

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e) Cover and Vegetation

The entire site largely covered by shrubs and dense secondary vegetation. This vegetation protects the study area from major erosion. The plantations of the study area were rubber, oil palm and forest.

5.2.6 Construction Suitability

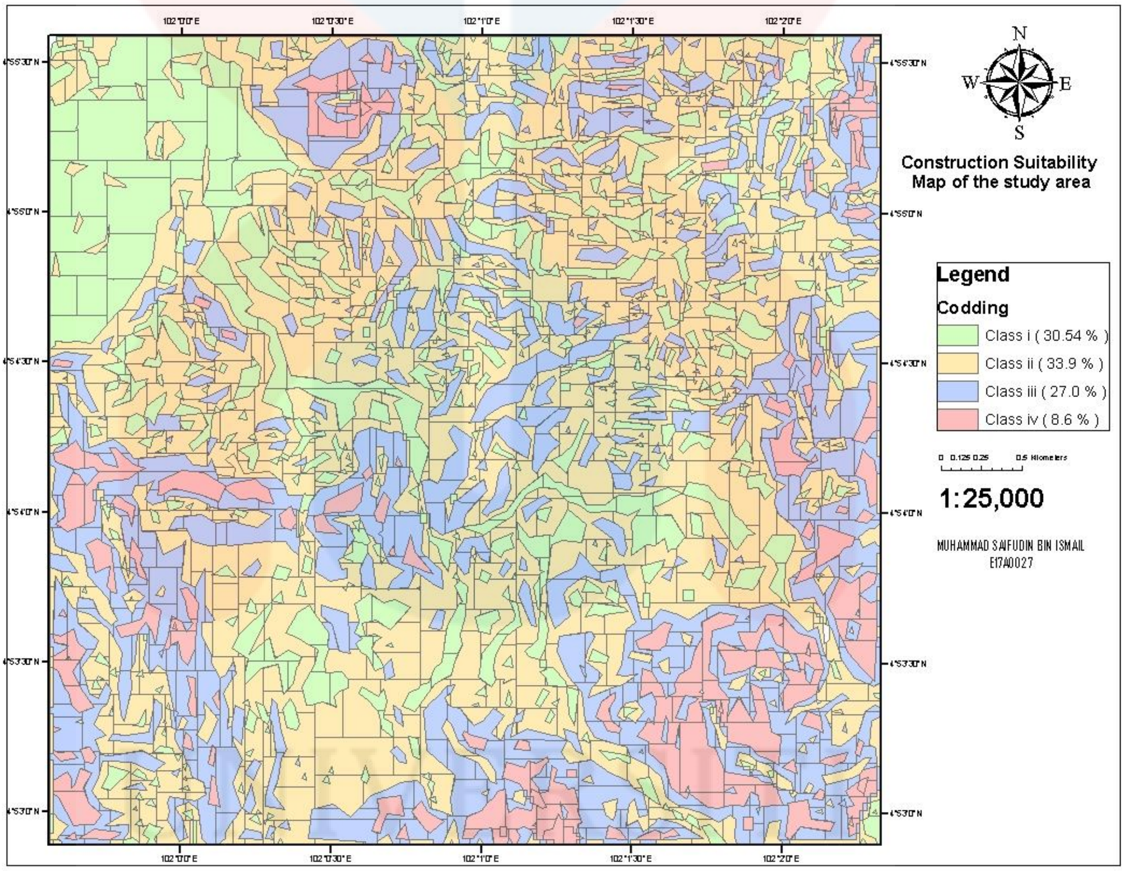

Figure 5.5: Construction suitability map of the study area (CSM)

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Table 5.2: The result of construction suitability map of the study area (CSM)

Class	Description	Percent (%)
i	Suitable for development	30.54%
ii	Suitable for development	33.9%
iii	Suitable for Development with detailed geotechnical and geological studies	27.0%
iv	Not Suitable for Development (green area recommended)	8.6%

The suitability of the site for development and construction is evaluated from the terrain attributes and surface engineering geology, following recommended procedures of the Minerals and Geosciences Department. The construction suitability was classified into four classes refers to Table 5.4 and the type of soil investigation required based on the construction suitability (Table5.3.)

Table 5.3: Construction suitability classification system

Class Charecteristics	Class 1	Class II	Class III	Class IV
Geotechnical Limitations	Low	Moderate	High	Extreme
Suitability for Development	High	Moderate	Low	Probably Unsuitable
Engineering Costs for Development	Low	Normal	High	Very high
Intensity of Site Investigation Required	Normal	Normal	Intensive	Very Intensive
Examples of Terrain	1.Insitu terrain <15° minor erosion 2.Cut platforms in insitu terrain	1.Insitu terrain 15° - 25°, no instability or severe erosion 2.Insitu terrain <15°, severe erosion 3.Colluvium <15°, no instability or severe erosion	1.Insitu terrain 25° - 35° no instability or severe erosion 2.Insitu terrain 15° - 25°, history of landslips 3.Colluvium 15° - 25°, general instability	1.Insitu terrain >35° 2.Insitu terrain 25° - 35°, instability or severe erosion 3.Colluvium 25° - 35°, moderate erosion

(Sources: JMG,2010)

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Table 5.4: Construction Suitability classes and type of site investigation required

Risk Category		Description of Site Investigation		
		Classes I,II	Class III	Class IV
Category	a. Loss of life b. Economic loss			
Negligible	a. None expected (no occupied premises) b. Minimal structural damage. Loss of access on minor roads	Assessment of surrounding geology and topography for indication of stability. Visual examination of soil and rock forming the site or to be used for the embankment. Specialist Advice – Requirement (A)	As for Class I and II. More detailed geology and topography survey. For the steeper slopes, information on soil and rock joint strength parameters. Survey of hydrological features affecting the site. Specialist Advice – Requirement (B)	As for Class I and II. Area outside confines of site to be examined for instability of soil, rock and boulders above the site. Specialist Advice – Requirement (B)
Low	a. Few (only small occupied premises threatened). b. Appreciable structural damage. Loss of access on sole access roads.	Geology and topography survey of site and surroundings area. Soil and rock joint strength parameters for foundation and cut slopes. For embankments steeper than 1 on 3, recompacted strength parameters of fill. For cut, information on groundwater level. Specialist Advice – Requirement (B)	As for Class I and II. Survey of hydrogical features affecting the site.	As for Class I and II. Extend outside limits of site to permit analyses of slopes above and below the site.
High	a. More than a few b. Excessive structural damage to residential and industrial structures. Loss of access on regional trunk routes.	Detailed geology and topography survey of site and surrounding area. Soil and rock joint strength parameters for foundation and cut slopes. Recompacted strength parameters for fill. For cut, information on ground water level. Specialist Advice – (B)	Specialist Advice – Requirement (B) As for Class I and II. Survey of hydrological features affecting the site. Extend investigations locally outside limits of the site to permit analyses of slopes above and below the site. Specialist Advice – Requirement (C)	Specialist Advice – Requirement (C) As for Class I and II. Extend investigations more widely outside limits of site to permit analyses of stability of slopes above and below the site. Specialist Advice – Requirement (C)
Note : Requirement for Specialist Advice: A) Services for an experienced geotechnical engineer or engineering geologist not necessary B) Services for an experienced geotechnical engineer or engineering geologist to depend on location relative to developed or developable land C) Services for an experienced geotechnical engineer or engineering geologist essential				

(Sources: JMG,2010)

Class I areas have low geological limitations and highly suitable for construction. There are about 30.54% of Class I areas cover the site. All these areas are flat to gently sloping (<15°) without erosion or instability. Some cutting and filling of slopes are not expected to be difficult as they generally not high. These areas are not expected to face foundation problems.

Class II areas have moderate geotechnical limitations and are moderately suitable for construction. These areas are moderate slopes (15° - 25°) with several erosion or instability. This class covers about 33.9% of the study area. Constructions in Class II areas will require cutting, filling, and erosion are expected on bared slope when surface runoff is not properly channeled. Construction in these areas is not

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expected to encounter any major foundation problems. Bedrock may be encountered during excavation.

Class III areas have high geotechnical limitations and low suitability for construction. The Class III slope is generally steep (25° - 35°) and covers about 27% of the site. Construction in these areas will involve significant cut and fill. Severe erosion may occur, and the stability of the slopes can be a problem if they are not properly attended. Excavation in these areas is likely to encountered bedrock. The cost of development in these areas is expected to be high. A detailed site investigation and geotechnical study should be carried out in Class III areas.

Class IV that is very steep hill slope (>35°) represented by cut slopes has extreme geotechnical limitations and is unsuitable for development occurs in less than 8.68% of the site. Most cut slopes are located along earth tracks that traverse all over the study area.

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a) Potential Geohazard

No major geohazards expected to occur in the study area. The potential environment impact predicted is mechanical and chemical evolution process, which may result in soil erosion caused by surface run-off water if proper drainage system is not constructed. The scale of erosion varies with different gradient and occurrence of vegetation covered. The geomorphic process is more active at slope gradient more than 35° where the mass movement (e.g., localized circular failure, slump, etc.). At gentle slope (gradient <35°) the process of transportation and deposition took place where the material of the top surface usually contains lots of clay and silt, which might cause siltation and sedimentation problem.

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CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The proposed site was situated on a hilly undulating terrain, with natural slopes forming the lowest elevation about 85 meters at the south – east part of study area and the highest level of about 485 meters in the west of study area. This study area composed of four lithologies, which were granite, sandstone, interbedded shale and quartzite. In the study area, faulting can find. The type of faulting is dextral slip fault.

The faulting was identifying by lineament analysis. From the topographic map, the positive and negative lineament can be identifying. Form the lineament interpretation of faulting zone in the study area made.

From the slope terrain analysis, the site is mainly moderate steep slopes (15° - 25°) to steep slopes (25° - 35°) which cover 26.74% and 45.53% respectively. Flat to gentle slope (0° - 15°) covers 18.9% of the study area. Only 8.6% of the site is covered by very steep slope (>35°). The site is consisting mainly of crest and side slopes that are concave, straight, and convex, and hillcrest ridge.

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The suite is largely classified as Class I (30.54%), which has low geotechnical limitations and highly suitable for development. Some cutting and filling of slopes not expected to be difficult as generally not high. These areas not expected to face foundation problems. Class II which has moderately geotechnical limitations and moderate suitability for development covered 33.9% of the study area. Constructions in Class II areas require cutting, filling, and erosion on bared slope when surface runoff not properly channeled. Construction in these areas not expected to encounter any major foundation problems. Bedrock encountered during excavation.

Class III that has high geotechnical limitations and low suitability for development covers about 27% of the site. Construction in these areas will involve significant cut and fill. Severe erosion may occur, and the stability of the slopes can face problem if not properly attended. Excavation in these areas is likely to encountered bedrock. The cost of development in these areas expected to be high. A detailed site investigation and geotechnical study carried out in Class III areas. Less than 8.6% is Class IV which has extreme geotechnical limitations and probably not suitable for development. Most cut slopes are located along earth tracks that traverse all over the study area.

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6.2 Suggestion

The primary data from the field observation were required to identify and update the type of erosion occurs in the study area. The research study would be accurate if using the primary data. For the future researcher, the structure analysis must confirm in the fieldwork because the structure of earth changes due to the erosion, weathering, and landslide. In addition, the lithology boundary must determine by fieldworks to get the exact zone for rock boundary.

It is also suggested doing a thin section instead of interpretation of rocks types. Naming and identify the type of rocks and determine their mineral also easier rather than interpretation. Some part of the Rabong Mountain area, Gua musang is inaccessible due to heavy vegetation. Mapping using some modern technology, such as digital mapping and drones or unmanned aerial vehicles, is recommended (UAV). The digital mapping software has improved its function and is capable of geologically assessing the facies and examining the rock's geological characteristics.

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