# THE EVALUATION OF RESERVOIR ELEMENTS IN EASTERN KELANTAN DELTA DEPOSITIONAL ENVIRONMENT

By

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13924

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**CERTIFICATION OF APPROVAL**

The Evaluation of Reservoir Elements in Eastern Kelantan Delta Depositional Environment

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A project dissertation submitted to the
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Approved by,

_____

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UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
May 2014

## CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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**NUR 'IZZATI BINTI BABA**

## ABSTRACT

The project explores and describes the reservoir elements in the Eastern Kelantan Delta in Malaysia. The project is to analyze the relationship between the lithology, porosity, and thermal conductivity in the study area. Soil samples are taken in two locations in the Eastern Kelantan Delta which are Kampung Kor and Pantai Mek Mas to observe the sediment distribution and lithology of the study area.

Soil analysis is done by using particle sieving method to determine the particle size distribution. Generally, the Eastern Kelantan Delta is covered with silty clay and sands is found dominated going to the beach. The lithology, porosity and thermal conductivity profiling is producedby using Petromod software in order to determine the reservoir quality in the study area. The projectcould be served as general guide for typical deltaic environment.

## ACKNOWLEDGEMENT

First and foremost, praise to God for all His guidance and blessings for the accomplishment of this Final Year Project and to whom I owe my very existence. This would not have been possible without the support of many people. I would like to express my deepest appreciation to all those who provided me the possibility to complete this project.Also, I would like to express my gratitude towards my parents for their endless love, support and motivation through all my ups and downs.

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# CHAPTER 1
# INTRODUCTION

## 1.0 INTRODUCTION

## 1.1 Background of study

A review of the porosity, lithology and thermal conductivity relationship is carried out in East Peninsular Malaysia located in Kelantan Delta. The variety morphology in Eastern Kelantan Delta is observed. The project is focused on the reservoir elements in Kelantan Delta that emphasizes between porosity, lithology, and thermal conductivitywith depth relationship.

The soil analysis, log analysis and borehole analysis are used to identify the reservoir elements in the study area. For the shallow depths, soil analysis is preferred while the log analysis and boreholeanalysis is done for the deeper depths. A vertical profiling of porosity, lithology and thermal conductivity areanalyzed. The expectation of the project is to evaluate the reservoir elements in Kelantan Delta as analog to Malay Basin. The data presented could serve as a general guide for further research in the Kelantan Delta.

## 1.2 Problem Statement

Kelantan Delta is a typical delta having various morphology to study.In Malaysia, only few researches done to investigate the development of Kelantan Delta in geological term. In response to this problem, the project is to generally study the geology of Kelantan Delta and produce basic geological profiles. The project is to correlate the relationship between porosity, lithology, and thermal conductivity in Eastern Kelantan Delta.

## 1.3 Title & Objectives

The title of the project is *"The Evaluation of Reservoir elements in Eastern Kelantan Delta Depositional Environment".* The objectives of the project are:

- To identify the porosity vs.depth profiling in the study area.
- To analyze the lithology vs. depth profiling in the study area.
- To investigate the relationship between thermal conductivity and depth in the study area.
- To describe the morphology features of Kelantan Delta based on the studied profiles.

## 1.4 Scope of Study

The scope of this project is in Kelantan Delta which requires the foundation of geology and petrophysical knowledge. The project is to evaluate the reservoir elements in the study area. The soilanalysis, log analysis and borehole analysis method are chosen for this project.The reservoir elements investigated in the project are:

- The relationship between porosity and depth.
- The relationship between lithology and depth.
- The relationship between thermal conductivity and depth.

## 1.5 Feasibility of the Project within the Scope and Time Frame

The project could be completed within the time frame since all the data needed are possible to be gathered and analyzed.The required skills to complete the project are as follow:

- The Petrophysical Skills: Producing vertical profiling of porosity, lithology and thermal conductivity.
- Depositional Environment Interpretation.
- Log Interpretation of lithology for various morphologic features.

# CHAPTER 2
# LITERATURE REVIEW

## 2.0 LITERATURE REVIEW

## 2.1 General Statement of the Study Area

Kelantan Delta is located on the East Coast of Peninsular Malaysia (FIGURE 1) having a latitude between 06°11.00'N to 06°13.00'N and longitude of 102°10.00'E to 102°14.00'E(Ibrahim, 2003). Kelantan Delta has a complex variety landscape with two major regions observed on either sides of the Kelantan Delta; the mainland area and the marine area (Zakaria, 1975). The observable structures in the mainland area located in the western partof Kelantan Delta are three parallelridges and two distinct parallel depressions. An assemblage of parallel bars and spits are detected in the eastern part of Kelantan Delta which is known as the marine area. The depression running from west to east in the eastern part is controlled by the existing and abandoned streams with levee developed on both banks.

The Kelantan River is coming from Kuala Krai to Tumpat (FIGURE 2). Koopmans(1972) claimed that the northeast monsoon is influencing the strong westward beach drift which causes the mouth of the Kelantan River to gradually shifted westward. The sand in this area is transported along the beach which is indicated from the shifting position of a spit that encloses the Bay of Tumpat. The morphology of the Kelantan Delta is mainly due to the process of erosion and deposition which is strongly influenced by the northeast and southeast monsoons. These processes are different for both in the mainland area and marine area, depending on the time, space, and the seasonal climatic conditions. The project focuses on the Eastern part of the Kelantan Delta (APPENDIX 1).

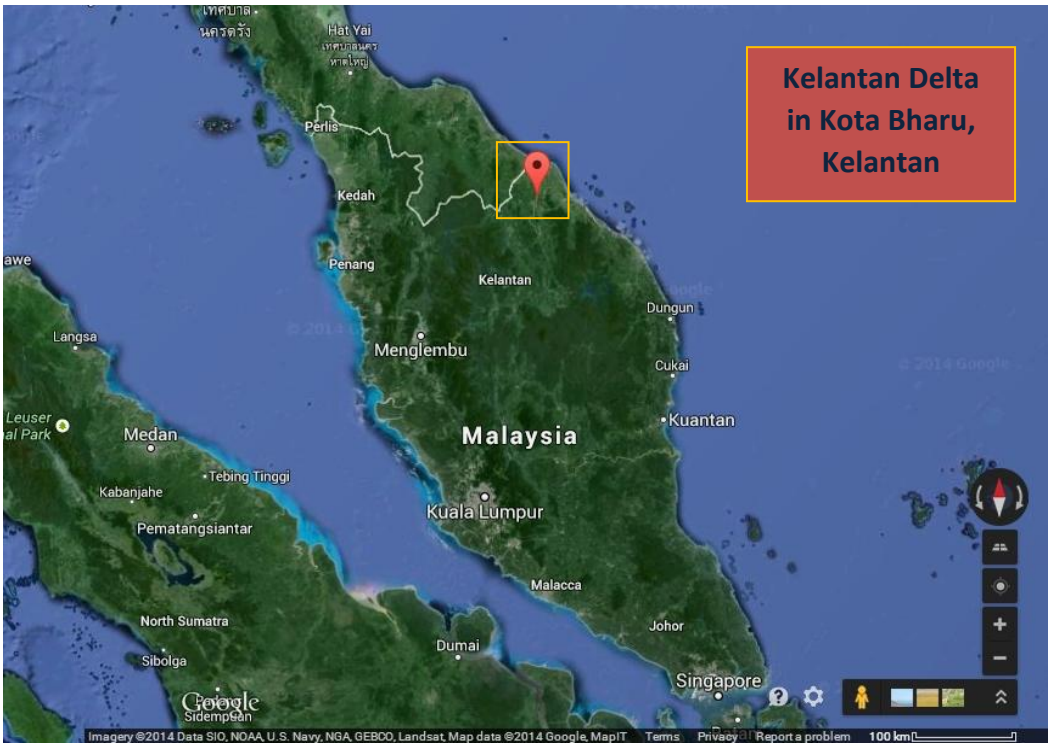



FIGURE 1: Location of Kelantan Delta in east coast Peninsular Malaysia (modified from Google Map)

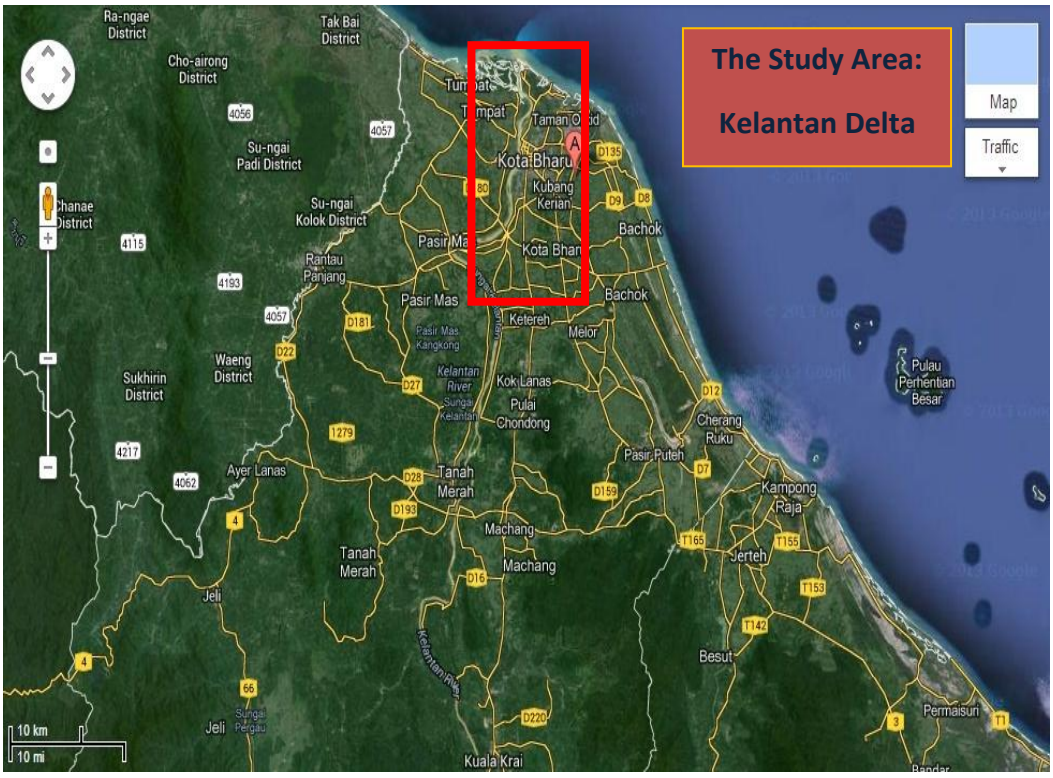



FIGURE 2: Location of the study area in Kelantan Delta (modified from Google Map)

## 2.2 Geological Setting

Peninsular Malaysia is separated into four domains; Northwest, West, Central and East Domain. It is elongated in north-northwest direction parallel to its main structural trend which is superimposed by structures with northeast and east strikes. In a Late Triassic-Early Jurassic deformational period, the main NNW trend is developed.

Kelantan Delta is located in the East Domain of Peninsular Malaysia. According to The Petroleum Geology and Resources of Malaysia, a published book by PETRONAS (1999), the East Domain is separated by Lepar Fault. According to Rishworth (1974), the volcanic activity and faulting are in the Late Jurassic to Early Cretaceous period in the southern part of the East Domain.

Going to the north of the Lepar fault zone, the oldest known rocks are Carboniferous with abundance of coalified plant remains in some intervals that indicate possibility of coastal or continental setting. It is shown that these rocks are intruded by Permian granitoids. On the other hand, the oldest strata to the south of the Lepar fault zone are Permian, supported by the fossiliferous limestone at Sumalayang Mountain. It is believed that all the Upper Paleozoic strata have been metamorphosed and might have at least three deformational episodes.At the Permian-Triassic boundary, acid volcanism occurred in the southern part of the East Domain.

Hutchison(1977)deduced that there are extensive outcrops found in East Domain of dominantly Upper Triassic granitic rocks which are mostly equigranular with some porphyritic varieties. From the base map of Peninsular Malaysia which has been simplified after the Geological Survey of Malaysia (1985), Kelantan area is mainly comprised of granitic to pre-granitic metasedimentary rocks. The sediments in the Kelantan area are shown as Quaternary sediments.

## 2.3 Porosity, Lithology and Depth

Porosity is defined by the percentage of pore volume or void space, or that volume within rock that can contain fluids. Porosity can develop from deposition when there are spaces between grains that are not completely compacted or through alteration of the rock. Porosity is essential in Oil and Gas industry as burial depth is related to porosity due to the effects of increasing overburden and temperature for compaction and cementation process (Ehrenberg, Nadeau, & Steen, 2009).

Lithology of a rock unit is defined as the description of its physical characteristics which is visible at outcrop or soil sample depending on the grain composition. Lithology is dependent on the porosity where the compaction is a function of both burial depth and lithology (Kominz, Patterson, & Odette, 2011). The first approximation for the vertical profile of porosity vs. depth is illustrating the general decline in porosity with depth.

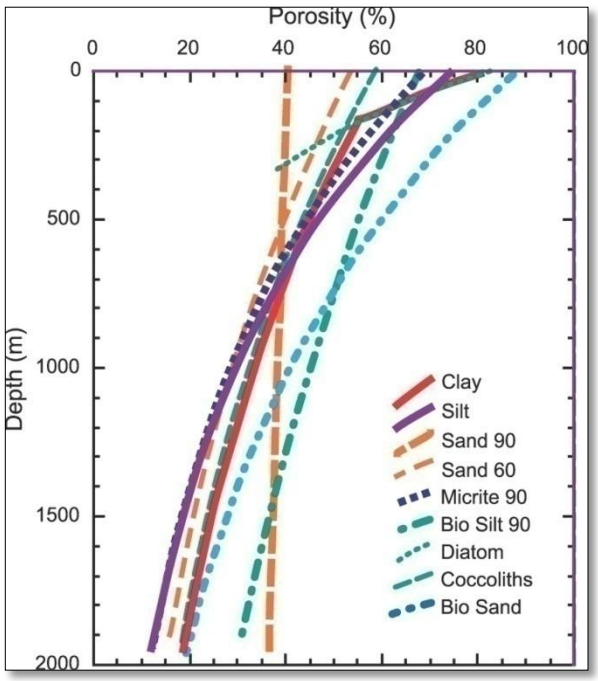



FIGURE 3: The porosity vs. depth plot related to lithology (Michelle A. Kominz, Kyle Patterson, and Danielle Odette, 2001)

## 2.4 Thermal Conductivity, Porosity and Depth

Thermal Conductivity (k) is the property of a material to conduct heat. Thermal conductivity is temperature dependent since it involves heat transfer from high thermal conductivity to low thermal conductivity material. The thermal conductivity of rocks is highly dependent on porosity (Stefansson, 1997) and the thermal conductivity measurements for different rock types are mainly due to the porosity variation (Cermák and Rybach, 1982).

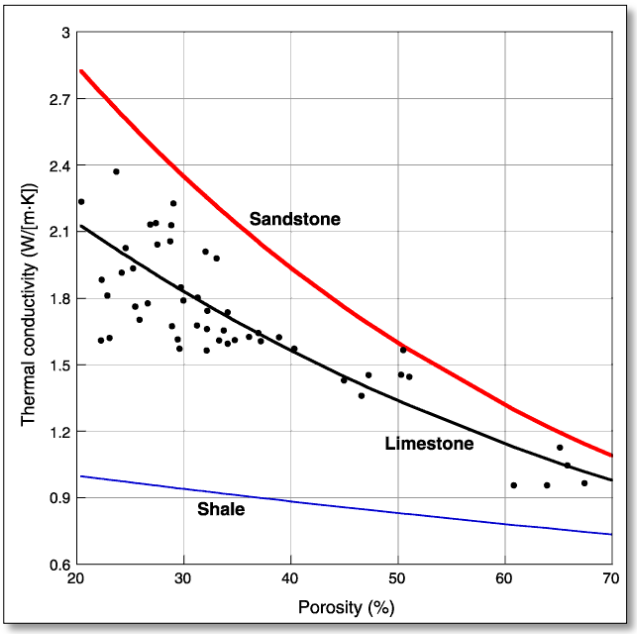



FIGURE 4: The relationship of thermal conductivity vs. porosity

# CHAPTER 3
# METHODOLOGY

## 3.0 METHODOLOGY

## 3.1 RESEARCH METHODOLOGY

The project will focus onsoil analysis to evaluate the reservoir elements in the Eastern Kelantan Delta. The log analysis is done to compare the result from the soil analysis.

### 3. 1.1 Soil Analysis for Lithology

Soils are generally called gravel, sand, silt, or clay, depending on the size of particles within the soil. The particle sizes vary with the biggest is gravel and the smallest size is clay. In order to separate these particles, soil analysis is done using sieves in the laboratory(APPENDIX 2).

Sieve analysis involves shaking the soil sample through a set of sieves that have various sizes of openings. To conduct the sieve analysis, the soil sample must first be oven-dried, and the lumps will be broken into small particles. Then the soil is shaken through a stack of sieves with openings of decreasing size from top to bottom and a pan is placed below the stack to collect the smallest particles. After that, the mass of the soil on each sieve is weighted and recorded through the calculation procedure:

1) Determine the mass of soil retained on each sieve and in the pan(i.e., M1, M2…Mn).
2) Determine the total mass of the soil: M1+M2+…..+Mn=$\sum M$.
3) Determine the cumulative mass of soil retained above each sieve (*i*th sieve = M1+M2+…+M*i*).
4) The mass of soil passing the *i*th sieve is $\sum M$- (M1+M2+…+M*i*).

5) The percent of soil passing the *i*th sieve is

$$F = \frac{\sum M - (\mathrm{M1} + \mathrm{M2} + \cdots + \mathrm{M}i)}{\sum M} \times 100$$

6) Plot the calculations as the particle-size distribution curve.

### 3.1.2 Borehole Analysis using Petromod1D Express

With PetroMod 1D Express, simulated 1D models (input and output) could be viewed which have been generated with a licensed 1D version.

- **Input:** The clear tree structure enables calibration wells to be easily added to a model, activated and deactivated for simulation.
- **Simulation:** Simulation is started similar to 2D and 3D by setting simulator options first and then clicking a Run button. A simulation log provides details of the simulation.
- **Output:** PetroMod 1D Express comes with a predefined set of output plots; depth and time plots and burial history Data shown in depth plots as lines (e.g. temperature) can be combined with overlays (e.g. maturity). It is also easy to compare the simulation output of several models either by viewing several parallel output windows, or by displaying the output of several models in one plot.

The PetroMod 1D Express is used to produce the basic "porosity vs. depth" and "thermal conductivity vs. depth" profiles based on the Hotel Perdana and JMG data. These profiles are used to compare the values received from the experiments on the samples taken from Kampung Kor and Pantai Mek Mas.

## 3.2 Workflow/ Key Milestone

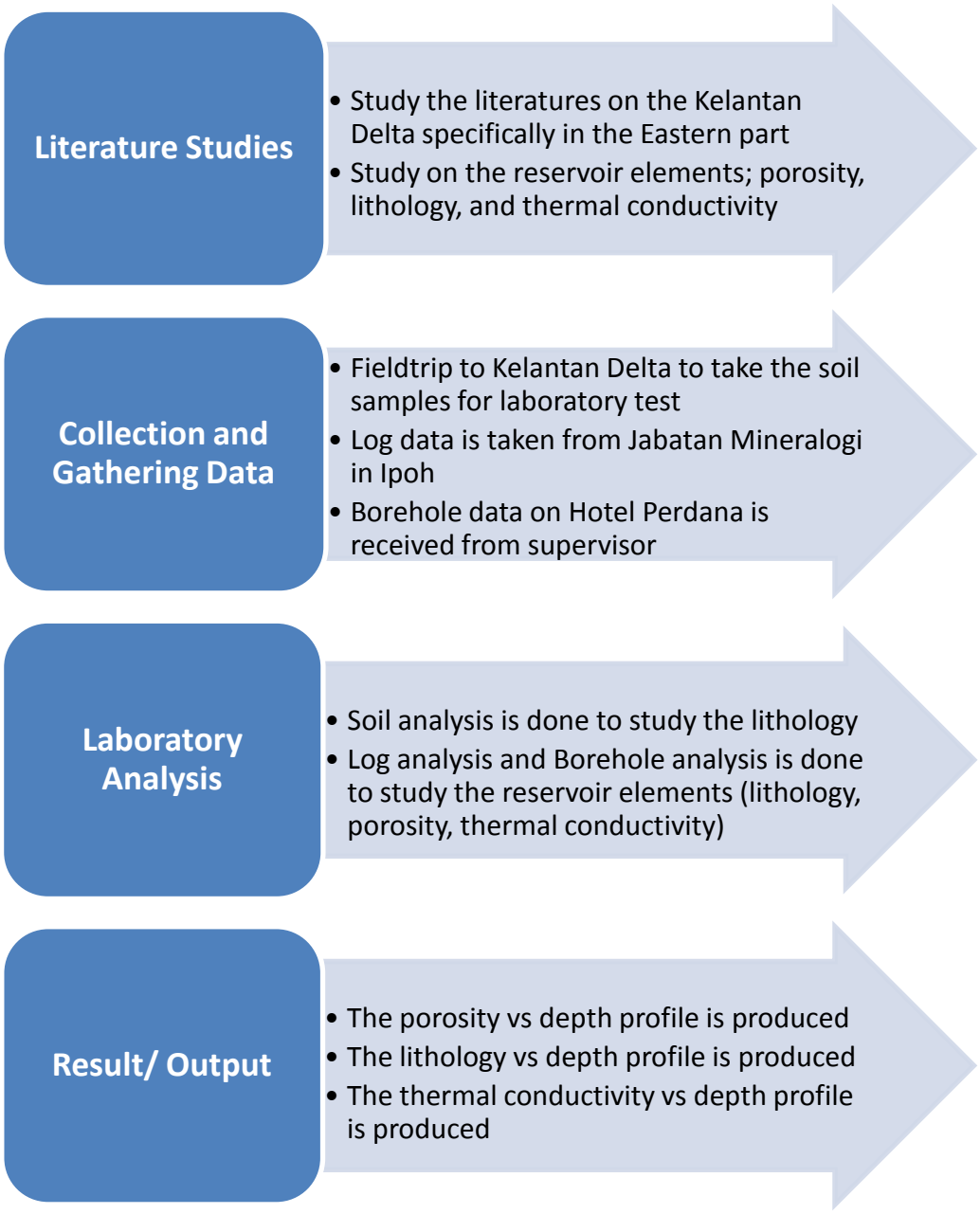



FIGURE 5: The Project Workflow

## 3.3 Gantt Chart

The Gantt Chart for both the first semester (FYP I) and second semester (FYP II) are attached in the APPENDIX 3.

# CHAPTER 4
# RESULT & DISCUSSION

## 4.0 RESULT AND DISCUSSION

### 4.1 Geomorphology Map

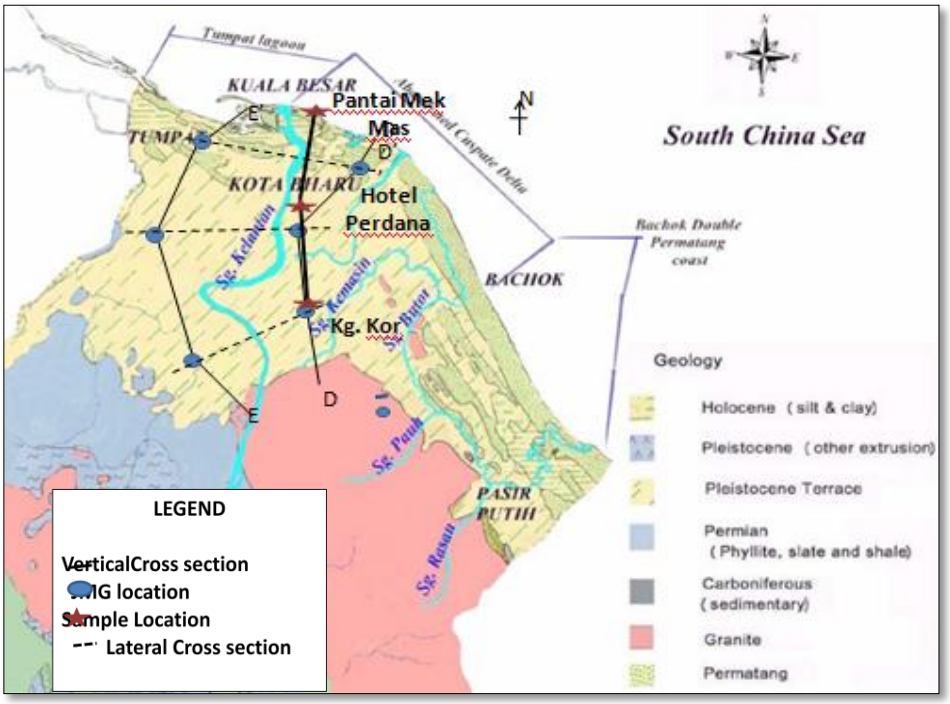



FIGURE 6: The geomorphology map with JMG cross-section of Kelantan Delta (modified from Geostudies, 2011).

The geomorphology map describes the relief of the Earth's surface according to its morphology and also its origin and age. The geomorphology map of the Kelantan Delta is modified from Geostudies (2001) (FIGURE 6).

Three locations are being investigated in the Eastern part to analyze the lithology, porosity and thermal conductivity properties. The locations are:

a) Kampung Kor – coordinate (6.015583, 102.236152)
b) Hotel Perdana in Khota Bharu
c) Pantai Mek Mas – coordinate (6.213962, 102.245978)

Kampung Kor and Hotel Perdana is in the Pleistocene Terrance while Pantai Mek Mas is located on the Permatang. Different sediment distribution is detected in these locationswhere sand is dominating the beach area (Pantai Mek Mas) and abundance of silty clay in the other two locations.

Two cross-sections are taken from the Jabatan Mineralogi dan Geosains (JMG) named D-D' in the Eastern part and E-E' in the Western part (FIGURE 6). The lithostratigraphic section is analyzed in the Eastern part.

The lithostratigraphic section from the JMG cross-section is used as the basis to determine the lithology in the sample locations. Offset presence between the sample locations and the JMP cross-section is being identified. For Hotel Perdana and Pantai Mek Mas, it is about 1.5 km and 8km away from the cross-section (D-D') respectively. The lithostratigraphic section is modified based on the offset (FIGURE 7).

## 4.2 Lithostratigraphic Section

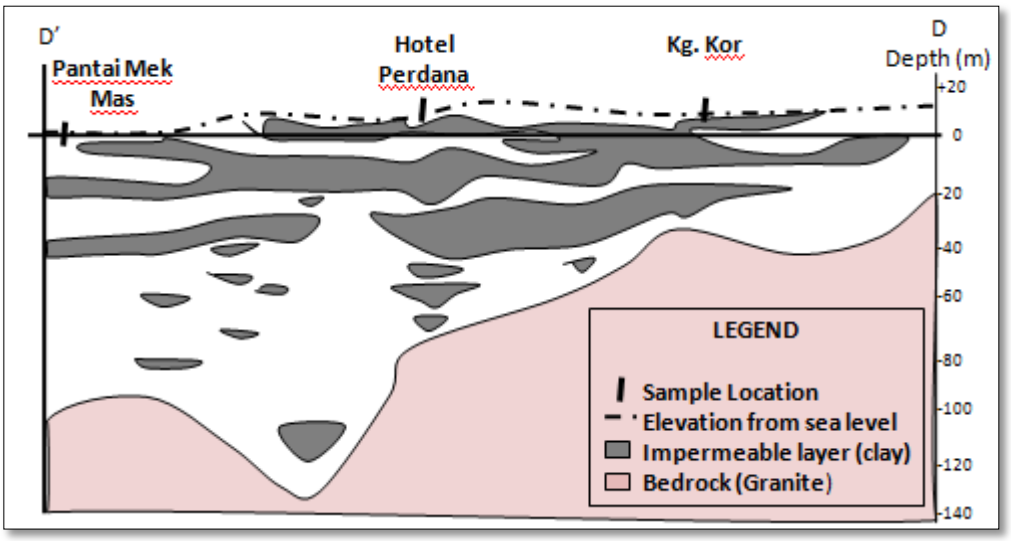



FIGURE 7: The lithostratigraphic section of the cross-section D-D' (modified from the Geostudies, 2011)

The lithostratigraphic section is a stratigraphic column divided on the basis of lithology. The D-D’ cross-section is done in the Eastern part along Kota Bharu with 27 well from hydrology.

Two locations are selected for soil analysis; Pantai Mek Mas and Kg. Kor withdepth about 3 km from the surface. The sea level is at 0m depth. The elevations taken along thesample locations are represented by the dotted line.

The elevation of Pantai Mek Mas is 0m which means that the area is in the same level as the sea. The second location, Kg. Kor is 16m from the sea level. The elevation trend concluded that the land surface is decreasing towards the beach from D to D’ where the difference in the elevation is related to the sea level.The slope might also indicate presence of basin development. If having similar trend, it could served as analog to Malay Basin.

The lithostratigrahic section shows the lithology for Pantai Mek Mas is sand while Hotel Perdana and Kg. Kor is located on the impermeable layer which could be clay or siltstone. The sand sieving analysis is done to differentiate the particle size distribution in order to confirm the lithology.

### 4.3 Sample Locations

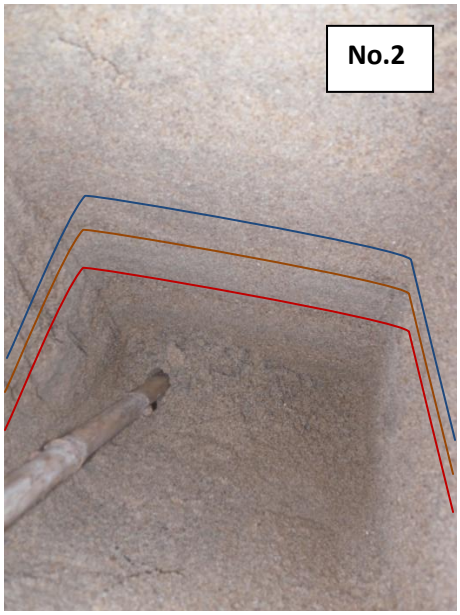
#### 4.3.1 Kampung Kor


Kampung Kor sample is taken in an area like a trench to analyze the layer below the surface (Picture No.1). The sample is not taken on the surface due to disturbance from human activities and climate factor. The exact location where the sample is taken using hammer is represented by Picture No.2. The sample is easy to takeout, and it is easily molded which looks like a clay. However, Picture No.3 looks more like silt, based on the grain size.

Silt tends to have larger particle size than clays, but there is some overlap in both particle size and other physical properties that make them hard to be differentiated. Geologists usually consider the separation between silt and clay is at a particle size of 2μm where clay is finer than silt. But the geotechnical engineers differentiate them based on the plasticity properties of the soil which is measured by the soils' Atterberg Limits.

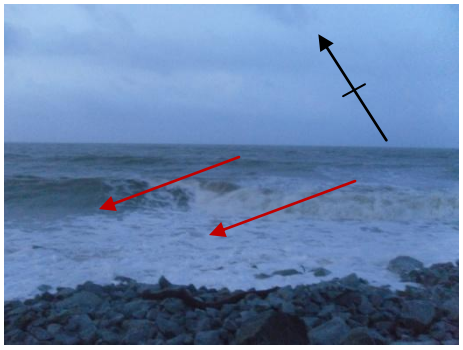
Therefore, Kampung Kor is concluded to have silty clay. However, the laboratory analysis will determined the exact type of sediment in the location.

### 4.3.2 Pantai Mek Mas


Picture No.1 is the location of the sample taken in Pantai Mek Mas. It could clearly be seen that the sediment type is sand since the sample is taken at a beach. Three strata are identified in the sample location (Picture No.2). The strata mean that there are sea level changes that occur in the area making a distinct layer of sedimentary rock.

### 4.3.3 Pantai Cahaya Bulan



In Pantai Cahaya Bulan, no sample is taken due to the high wave current. The wave direction is observed. The long-shore is going to the West of Kelantan Delta where the sediment then will be deposited in the area of Tumpat. The sediment is transported by going to the wave direction.

### 4.4 Grain Size Distribution

#### 4.4.1 KampungKor

TABLE1: Results from particle sieving for Kampung Kor

| Sieve aperture (mm) | Weight retained (g) | Weight retained (%) | Cumulative weight retained (g) | Cumulative percent retained (%) | Grain size (phi) |
|---|---|---|---|---|---|
| 2 | 129.24 | 64.69 | 129.24 | 64.69 | -1 |
| 1 | 27.93 | 13.98 | 157.17 | 78.67 | 0 |
| 600µm | 18.28 | 9.15 | 175.45 | 87.82 | 0.74 |
| 425µm | 6.23 | 3.12 | 181.68 | 90.94 | 1.23 |
| 300µm | 4.7 | 2.35 | 186.38 | 93.29 | 1.74 |
| 150µm | 5.41 | 2.71 | 191.79 | 96.00 | 2.74 |
| 63µm | 4.73 | 2.37 | 196.52 | 98.36 | 3.99 |
| 44µm | 3.27 | 1.64 | 199.79 | 100.00 | 4.51 |

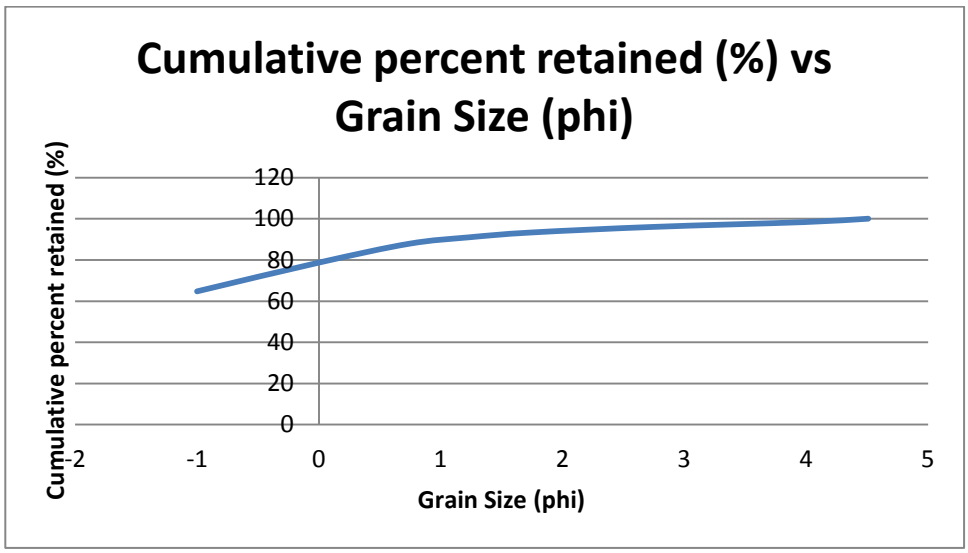



FIGURE 8: Graph of Cumulative percent retained (%) vs Grain size (phi) in Kampung Kor

The calculation states that the mean is 0.79 phi where it falls under coarse grained (APPENDIX 4). But, the grain size is not really representing the true lithology because it is already compacted and thus showing bigger size than the actual uncompacted sediment.

### 4.4.2 Pantai Mek Mas

TABLE2: Results from particle sieving for Pantai Mek Mas

| Sieve aperture (mm) | Weight retained (g) | Weight retained (%) | Cumulative weight retained (g) | Cumulative percent retained (%) | Grain size (phi) |
|---|---|---|---|---|---|
| 2 | 0.5 | 0.25 | 0.5 | 0.25 | -1 |
| 1 | 14.39 | 7.20 | 14.89 | 7.45 | 0 |
| 600µm | 41.2 | 20.62 | 56.09 | 28.07 | 0.74 |
| 425µm | 42.44 | 21.24 | 98.53 | 49.32 | 1.23 |
| 300µm | 53.84 | 26.95 | 152.37 | 76.27 | 1.74 |
| 150µm | 42.99 | 21.52 | 195.36 | 97.78 | 2.74 |
| 63µm | 4.12 | 2.06 | 199.48 | 99.84 | 3.99 |
| 44µm | 0.02 | 0.01 | 199.5 | 99.85 | 4.51 |

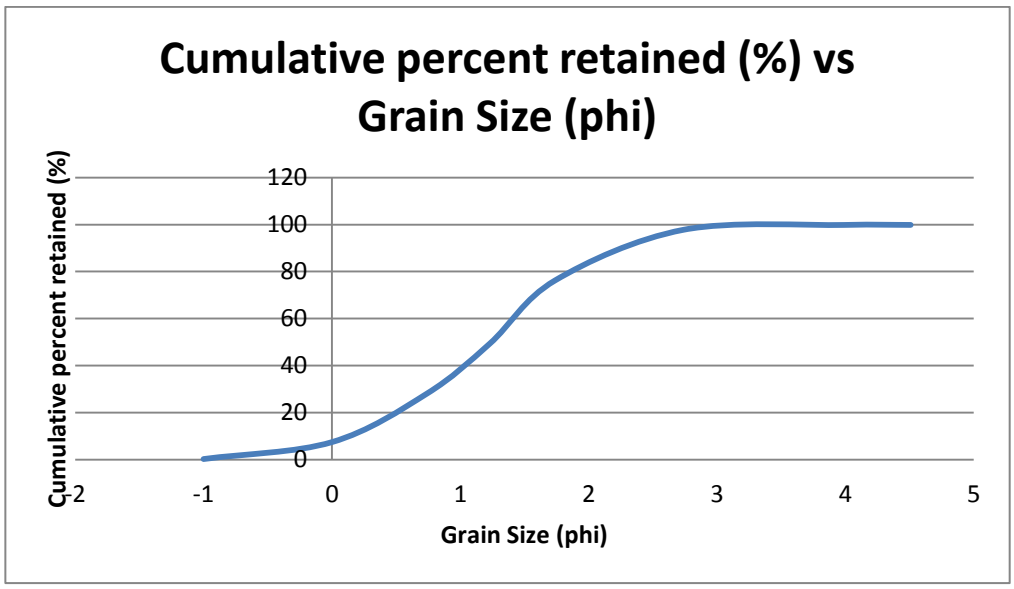
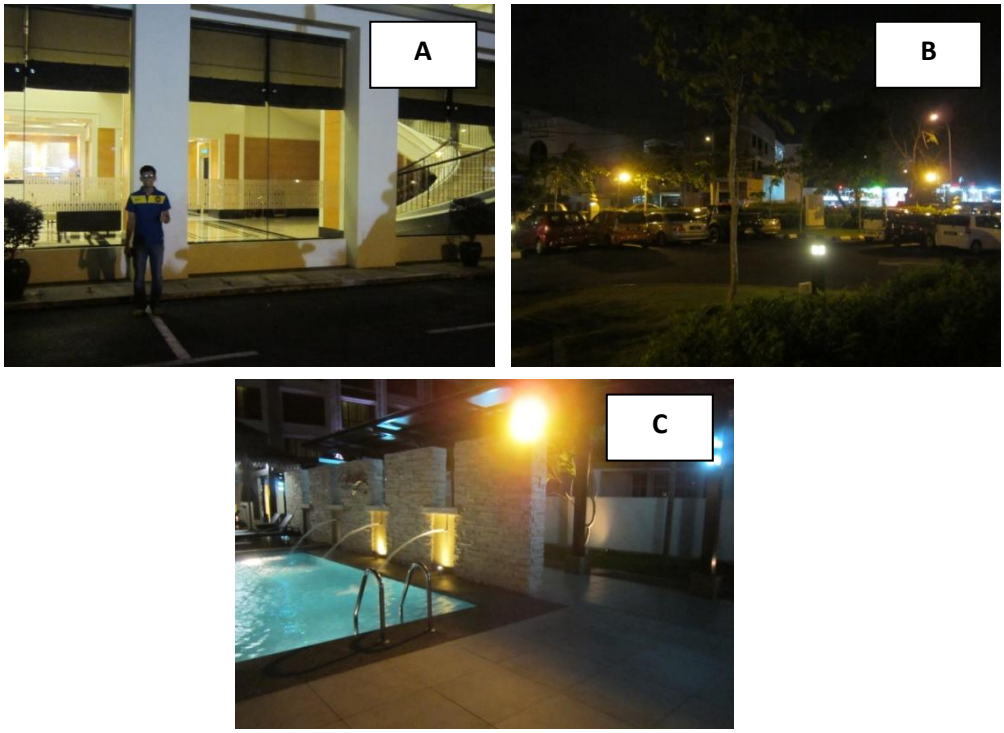



FIGURE 9: Graph of Cumulative percent retained (%) vs Grain size (phi) in Pantai Mek Mas

The calculation states that the mean is 1.13 phi where it falls under medium grained (APPENDIX 4).The lithology in Pantai Mek Mas is confirmed to have sand dominating with medium sand transported by wave.

### 4.5 Borehole Analysis (Hotel Perdana)

Hotel Perdana is observed to correlate the lithology with the other two sample locations; Kampung Kor and Pantai Mek Mas because it is located in between the two locations. The analysis done is based on the reportdata entitled “The soil Investigation Works for the Proposed Upgrading and Renovation Works of Hotel Perdana, Kota Bharu, Kelantan” (2008).




Three Nos. Borehole are being observed located in A, B and C with depth up to 5m. The coordinates and elevations are:

A. Coordinate (6.120742, 102.241468); elevation is 12m
B. Coordinate (6.121283, 102.241517); elevation is 10m
C. Coordinate (6.12113, 102.24186); elevation is 8m

#### 4.5.1 Location A

The soil description is silt with little fine sand at the top and clay with little fine sand at deeper depth about 3m and below. The Atterberg Limits analysis shows that the area is silty clay with very high plasticity. The particle size distribution shows that the content of clay is 44%, silt 52%, sand 3% and gravel 1% which indicates that in this area, the most dominant are silt, followed by clay.

TABLE 3: The main input of Location A for Petromod

| Layer | Top (m) | Base (m) | Thick (m) | Depo. from (Ma) | Depo. to (Ma) | Lithology |
|---|---|---|---|---|---|---|
| Top Soil | 0 | 1.2 | 1.2 | 0.0117 | 0 | SANDsilty |
| Silty clay | 1.2 | 8.6 | 7.4 | 0.126 | 0.0117 | SILTshaly |
| Silty sand | 8.6 | 11.6 | 3 | 0.781 | 0.126 | Siltsandy |
| Clayey silt | 11.6 | 44.7 | 33.1 | 1.5 | 0.781 | SILTshaly |
| Silty sand | 44.7 | 50.1 | 5.4 | 1.8 | 1.5 | Siltsandy |
| | | | | | 1.8 | |

Hotel Perdana data are used to produce reservoir element profiles using Petromod software (TABLE 3). Kelantan Delta is Quarternary in age, and due to limited information on the age, the depositional age is estimated in between the Quarternary. Petromod is used to produce typical profile of "porosity vs. depth" and "thermal conductivity vs. depth" based on its lithology.

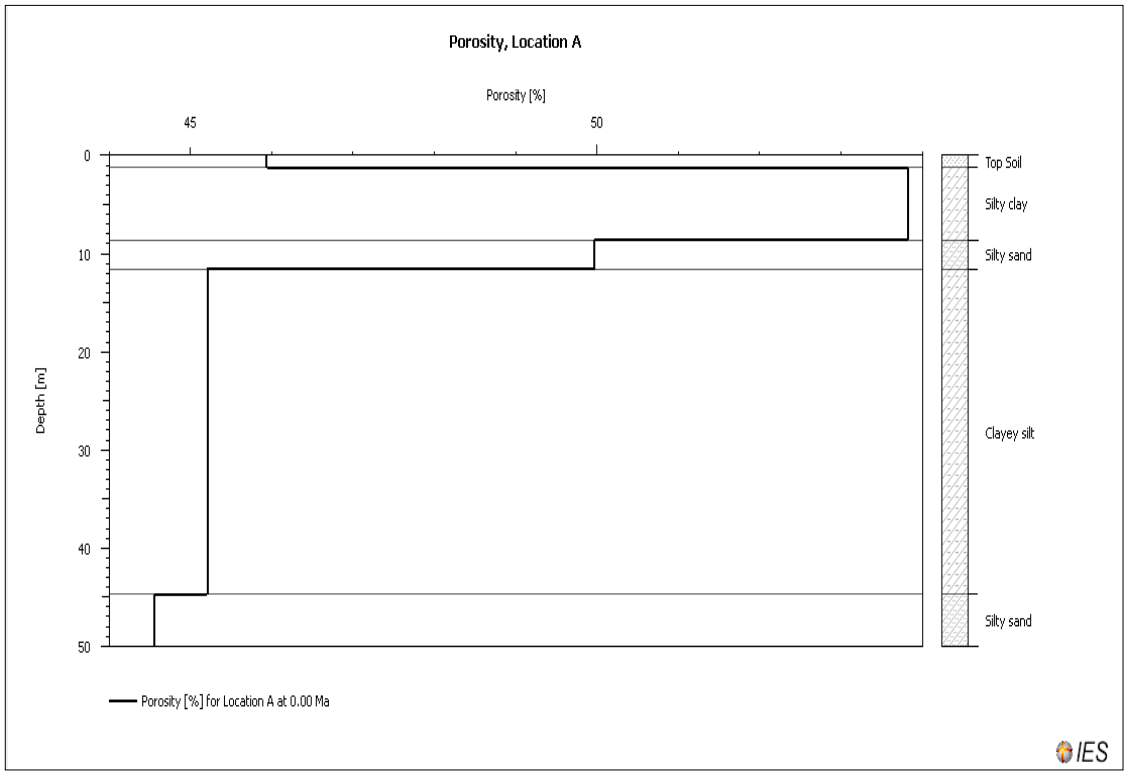



FIGURE 10: Porosity for Location A (depth plot)

Location A shows that silty clay is having the highest porosity in between 53-54% and silty sand is the lowest in between 44-45% (FIGURE 10). This is due to the size of particles in silty clay is much smaller than in silty sand, which makes the pore in between the particles increases.When pore increases, the porosity will also increase. High porosity in silty clay might also due to uncompacted sediment in the shallow depth about 1-9m. However, the efficiency of the porosity depends on the permeability to determine a good reservoir.

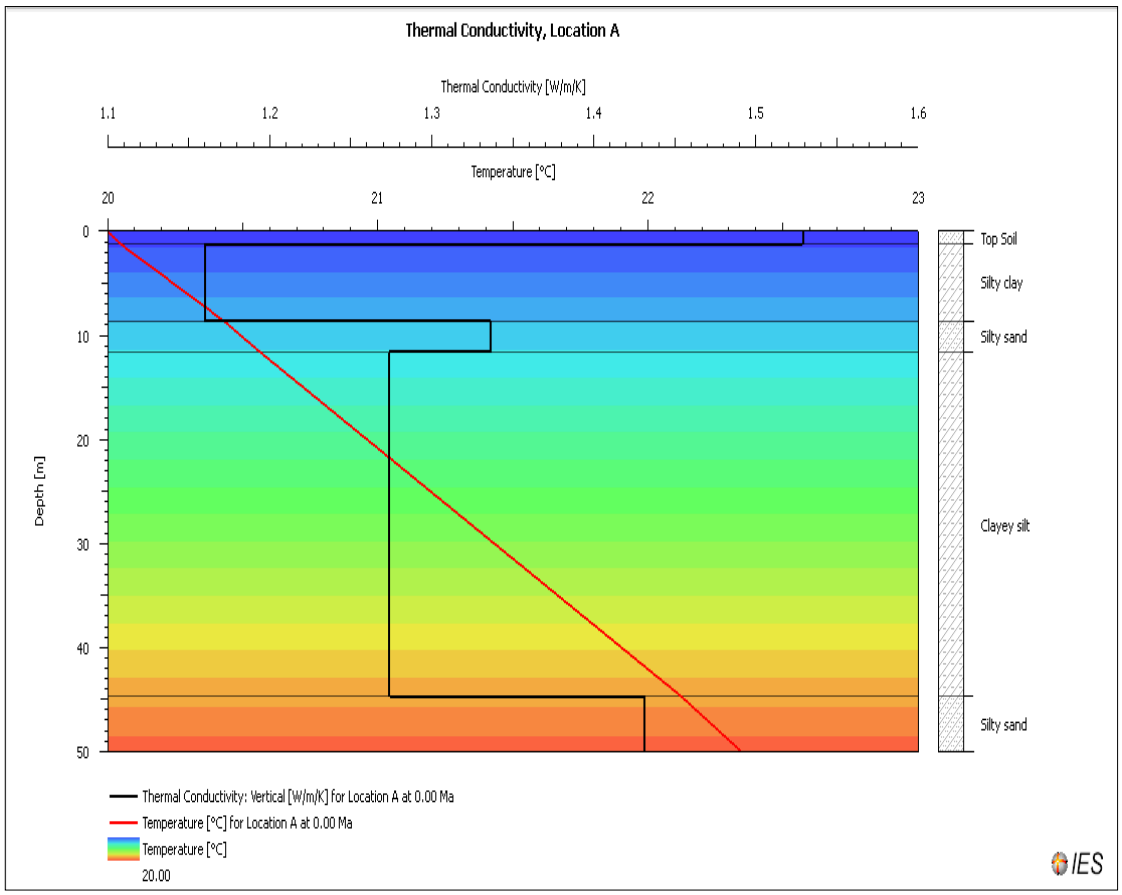



FIGURE 11: Thermal Conductivity (depth plot)

Thehighest value for thermal conductivity is in the sand silty at the top which is in between 1.5-1.55 W/mK and the lowest is in the silty clay in between 1.15-1.2 W/mK (FIGURE 11). The temperature (represented by the red line) increases with depth due to compaction and as it goes deeper, it is closer to the heat source from the core. The colour range shows the different temperature where the highest value is represented in red and the lowest in blue.

### 4.5.2 Location B

The soil description is silty clay with little gravel at the top and silty clay at the bottom. The Atterberg Limits analysis shows that the area is silty clay of high plasticity. The particle size distribution shows that the content of clay is 52%, silt 47%, and sand 1%. Thus in Location B, the most dominant are clay, followed by silt.

Silty clay is having the highest porosity in between 48-49% and sand is the lowest in between 40-41% (FIGURE 12).The highest value for thermal conductivity is in the sand which is in between 1.7-1.75 W/mK and the lowest is in the silty clay in between 1.2-1.25 W/mK (FIGURE 13).

### 4.5.3 Location C

The soil description are silty clay at the top and sandy clay at deeper depth. The Atterberg Limits analysis shows that the area is silty clay of high plasticity. The particle size distribution shows that the content of clay is 52%, silt 38%, and sand 10%. In this area, the most dominant are clay and followed by silt.

Silty clay is having the highest porosity in between 52-53% and clayey silt is the lowest in between 44-45% (FIGURE14).The highest value for thermal conductivity is in the sand silty which is in between 1.5-1.55 W/mK and the lowest is in the silty clay in between 1.15-1.2 W/mK (FIGURE15).

All these three locations conclude that the dominant sediment type in Hotel Perdana is silty clay. The sediment type is expected to be the same in Kampung Kor since these two areas are quite close.

TABLE 4: Main input for location B

| Layer | Top (m) | Base (m) | Thick (m) | Depo. from (Ma) | Depo. to (Ma) | Lithology |
|---|---|---|---|---|---|---|
| Top Soil | 0 | 1.2 | 1.2 | 0.0117 | 0 | SANDsilty |
| Silty clay | 1.2 | 29.7 | 28.5 | 0.126 | 0.0117 | SILTshaly |
| Silty sand | 29.7 | 47.6 | 17.9 | 0.5 | 0.126 | Siltsandy |
| Sand | 47.6 | 50.7 | 3.1 | 0.7 | 0.5 | Sandstone |
| Sandy clay | 50.7 | 55 | 4.3 | 1.5 | 0.7 | SANDshaly |
| Silty sand | 55 | 60.45 | 5.45 | 1.8 | 1.5 | Siltsandy |
| | | | | | 1.8 | |

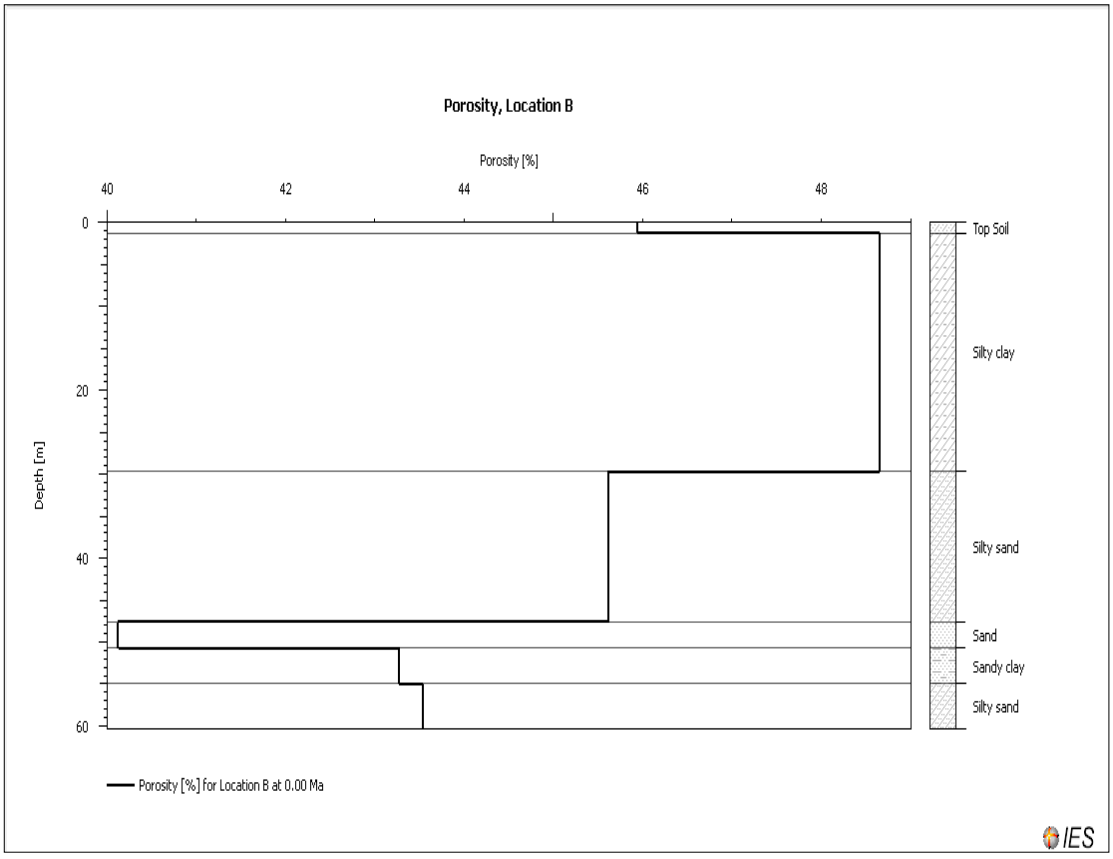



FIGURE 12: Porosity (depth plot) for Location B

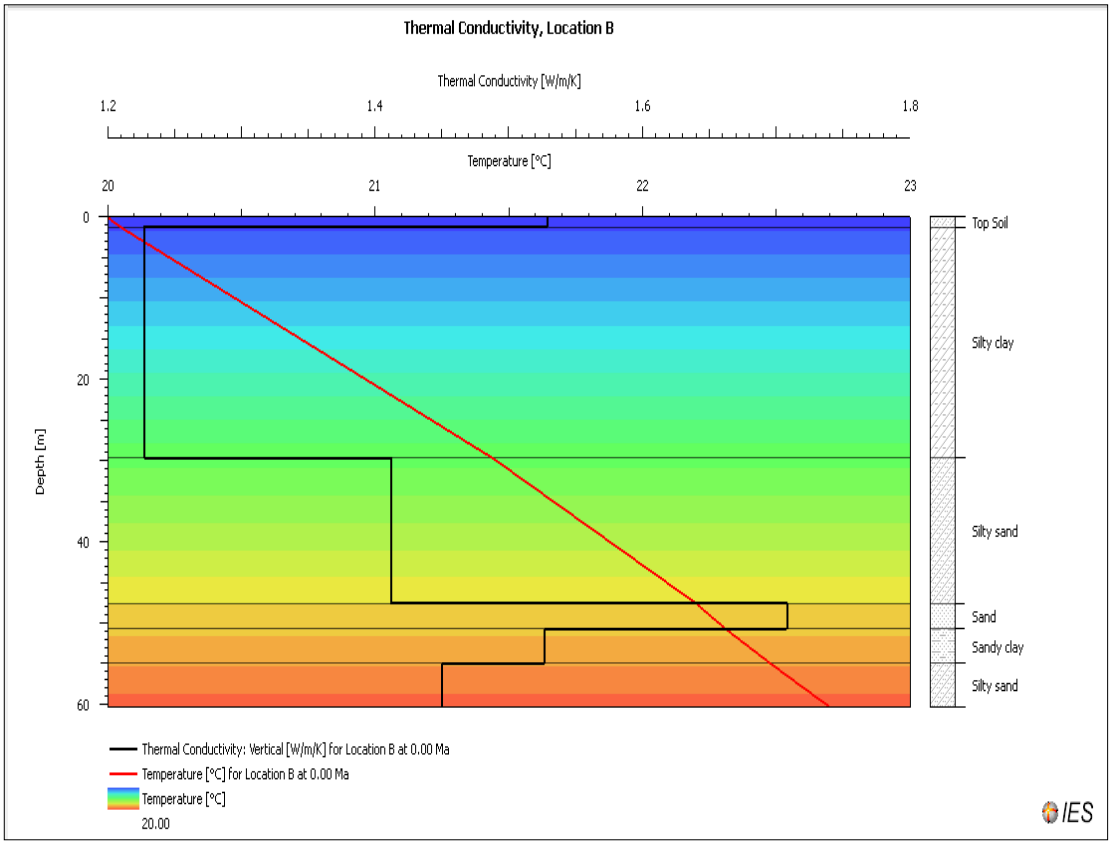



FIGURE 13: Thermal conductivity (depth plot) for Location B

TABLE 5: Main Input for Location C

| Layer | Top (m) | Base (m) | Thick (m) | Depo. from (Ma) | Depo. to (Ma) | Lithology |
|---|---|---|---|---|---|---|
| Top soil | 0 | 1.1 | 1.1 | 0.0117 | 0 | SANDsilty |
| Silty clay | 1.1 | 13.2 | 12.1 | 0.126 | 0.0117 | SILTshaly |
| Sandy clay | 13.2 | 19.1 | 5.9 | 0.5 | 0.126 | SANDshaly |
| Silty sand | 19.1 | 28.2 | 9.1 | 0.7 | 0.5 | Siltsandy |
| Clayey silt | 28.2 | 32.7 | 4.5 | 1.5 | 0.7 | SILTshaly |
| Silty sand | 32.7 | 45.45 | 12.75 | 1.8 | 1.5 | Siltsandy |
| | | | | | 1.8 | |

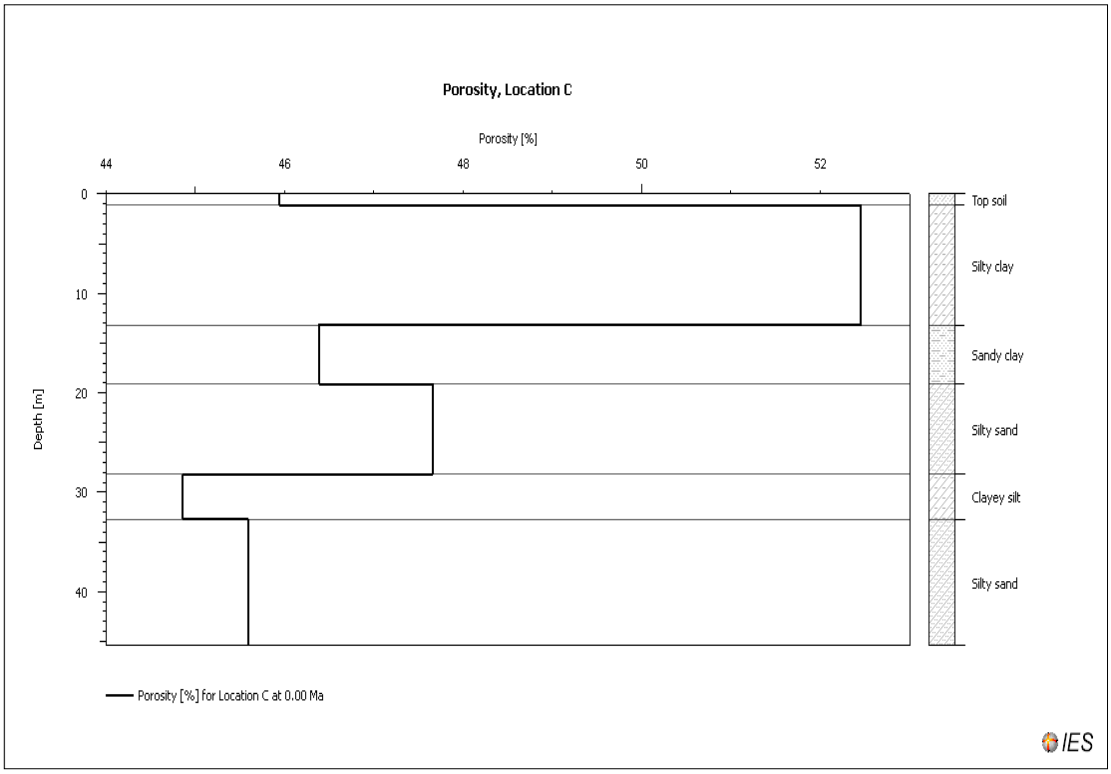



FIGURE 14: Porosity (depth plot) for Location C

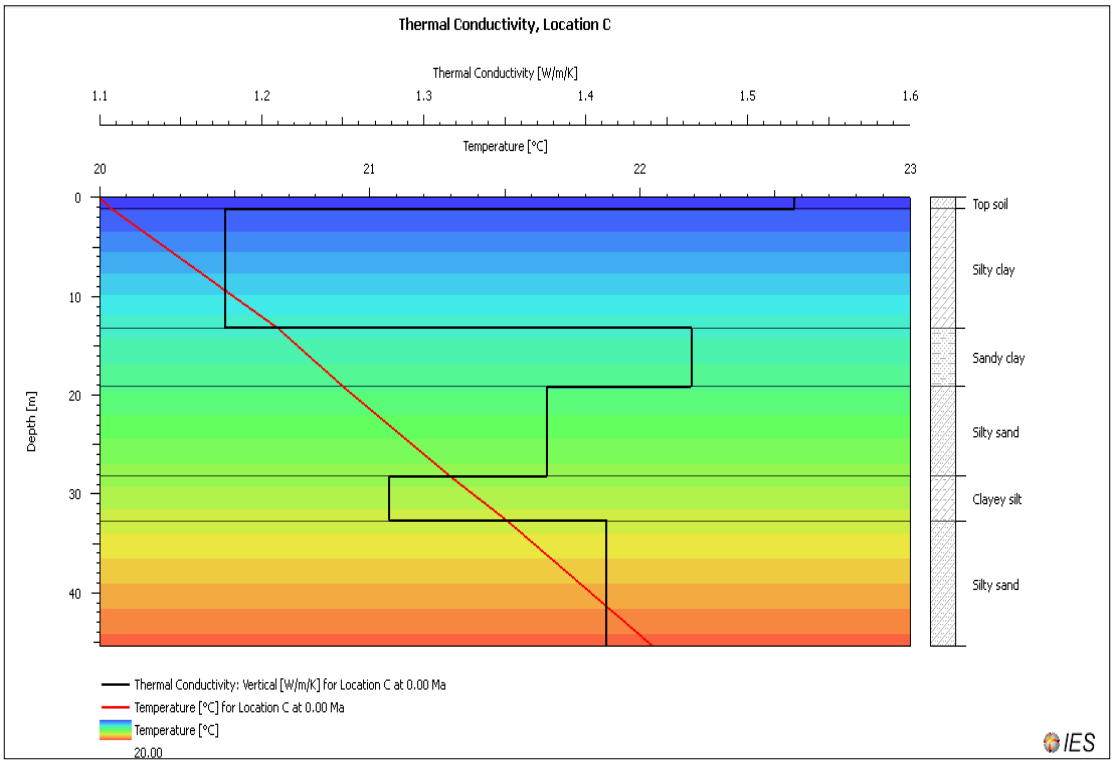



FIGURE 15: Thermal Conductivity (depth plot) for Location C

### 4.6 Logs Reference

Apart from the the samples taken in Kg. Kor and Pantai Mek Mas, the analysis are also based on the available logs data taken from JMG in the area nearby the cross-section for comparison which are Kampung Putih and Kampung Pasir Tumboh. All these data is to determine the reservoir elements in the Eastern Kelantan Delta.


FIGURE 16: Location of Kampung Putih and Kampung PasirTumboh in the Google Map

#### 4.6.1 Kampung Putih

The report data from JMG entitled “Projek Bekalan Air Kelantan Utara, 1993” is analyzed. The sediment description from the borehole analysis is yellowish brown silty clay at shallow part and traces of sand in the silty clayat deeper part (APPENDIX 5). Kg. Putih is near to Hotel Perdana, the sediments are being compared in these two locations, where both locations are showing silty clay.

Silty clay is having the highest porosity in between 55-56% and coarse sand is the lowest in between 41-42% (FIGURE 17).The highest value for thermal conductivity is in the coarse sand which is in between 1.65-1.7 W/mK and the lowest is in the silty clay in between 1.1-1.15 W/mK (FIGURE 18).

TABLE 6: Main input for Kampung Putih

| Layer | Top (m) | Base (m) | Thick (m) | Depo. from (Ma) | Depo. to (Ma) | Lithology |
|---|---|---|---|---|---|---|
| Silty clay | 0 | 5 | 5 | 0.0117 | 0 | SILTshaly |
| Coarse sand | 5 | 15.2 | 10.2 | 1.5 | 0.0117 | Sandstone |
| Silty clay | 15.2 | 18 | 2.8 | 1.7 | 1.5 | SILTshaly |
| | | | | | 1.7 | |

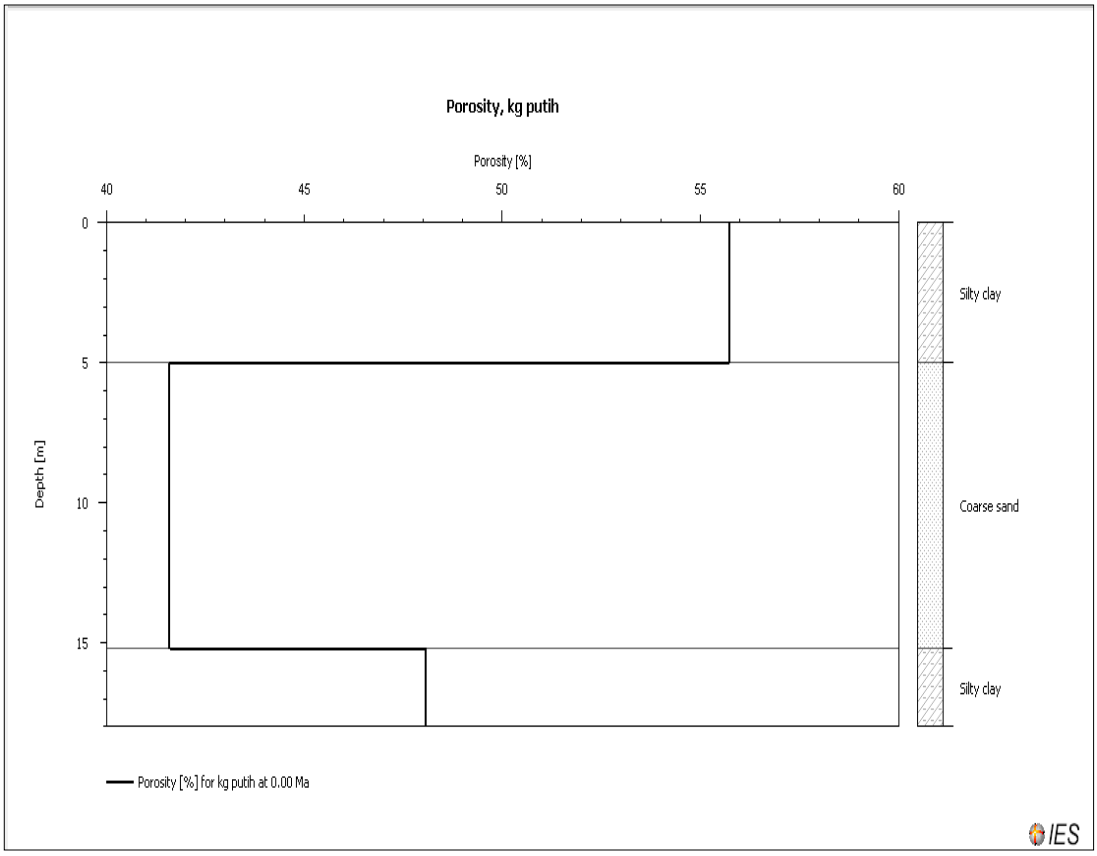



FIGURE 17: Porosity (depth plot) for Kampung Putih

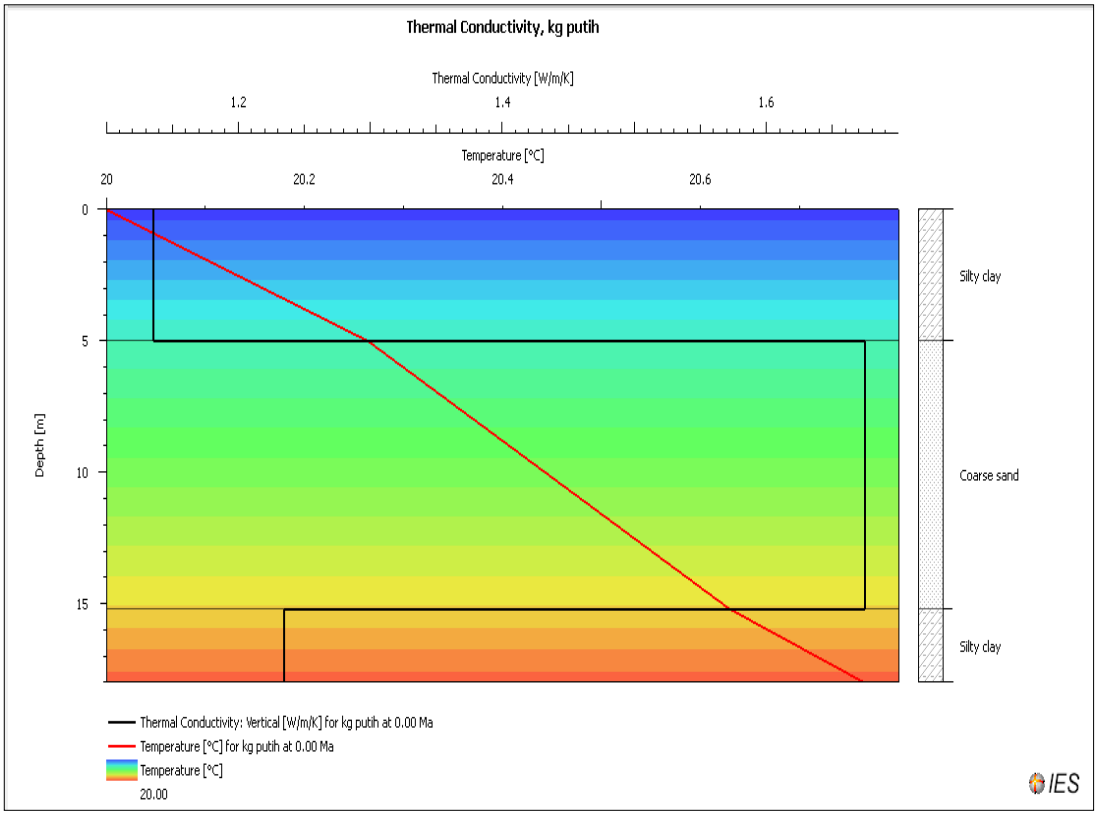



FIGURE 18: Thermal conductivity (depth plot) for Kampung Putih

### 4.6.2 KampungPasirTumboh

The sediment description from the borehole analysis is dark brownish silty clay and going deeper sand is dominated. The JMP cross-section D-D' shown that in Hotel Perdana, the top is dominated with silty clay, but going deeper, it is dominated with sands. The cross-section is having the same result as the gamma ray log in Kampung Pasir Tumboh where the sand is dominated starting from depth 20m to below(APPENDIX 5).

Silty clay is having the highest porosity in between 56-58% and medium sand is the lowest in between 41-42% (FIGURE 19).The highest value for thermal conductivity is in the medium sand which is in between 1.65-1.7 W/mK and the lowest is in the silty clay in between 1.1-1.15 W/mK (FIGURE 20).

TABLE 7: Main input for Pasir Tumboh

| Layer | Top (m) | Base (m) | Thick (m) | Depo. from (Ma) | Depo. to (Ma) | Lithology |
|---|---|---|---|---|---|---|
| Silty clay | 0 | 2 | 2 | 0.0117 | 0 | SILTshaly |
| Coarse sand | 2 | 6.5 | 4.5 | 0.126 | 0.0117 | Sandstone |
| Silty clay | 6.5 | 15 | 8.5 | 0.4 | 0.126 | SILTshaly |
| Medium sand | 15 | 16.5 | 1.5 | 0.78 | 0.4 | Sandstone |
| Silty clay | 16.5 | 22 | 5.5 | 1.5 | 0.78 | SILTshaly |
| Clayey silt | 22 | 27 | 5 | 1.8 | 1.5 | SHALEsilt |
| | | | | | 1.8 | |

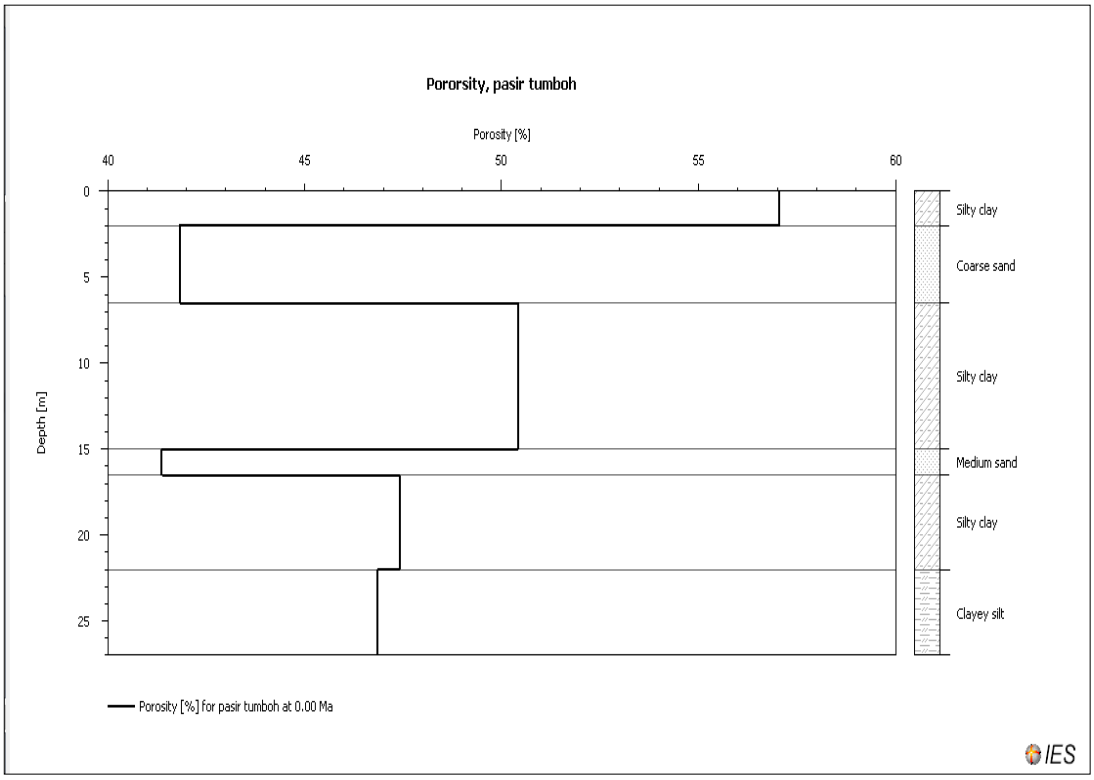



FIGURE 19: Porosity (depth plot) for Pasir Tumboh

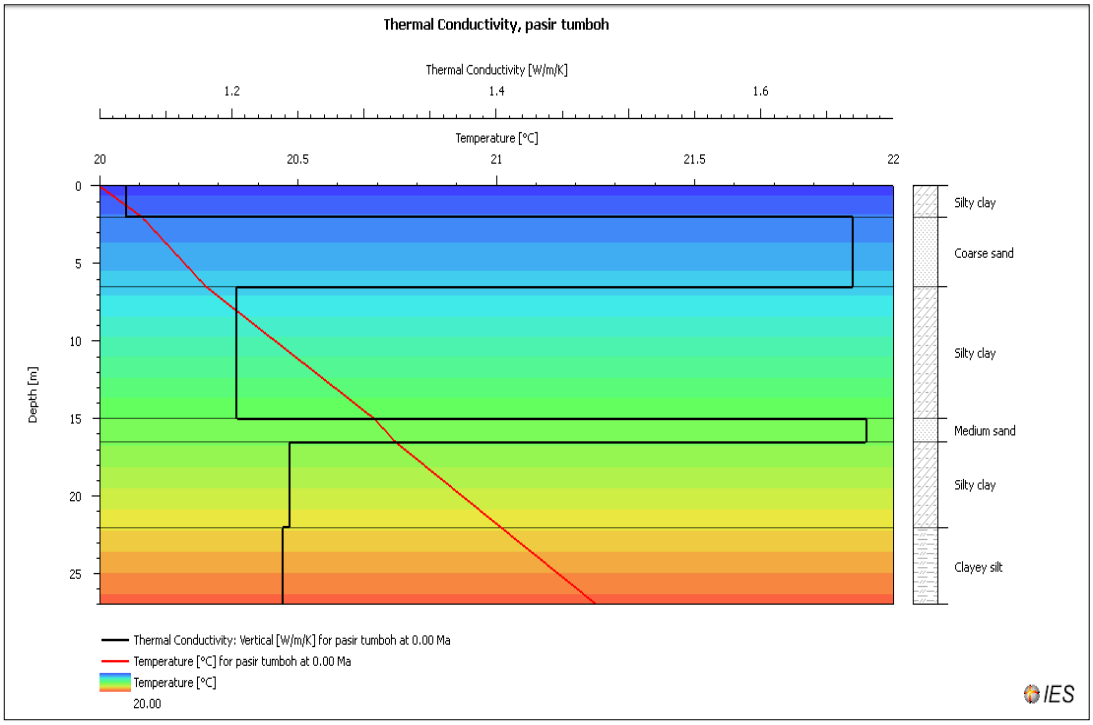



FIGURE 20: Thermal Conductivity (depth plot) for Pasir Tumboh

TABLE 8: Summary of reservoir elements from petromod

| **Sample location** | **Porosity highest (%)** | **Porosity lowest (%)** | **Thermal conductivity highest (W/mK)** | **Thermal conductivity lowest (W/mK)** |
|---|---|---|---|---|
| Location A | 53-54<br>Silty clay | 44-45<br>Silty sand | 1.5-1.55<br>Sand silty | 1.15-1.2<br>Silty clay |
| Location B | 48-49<br>Silty clay | 40-41<br>Sand | 1.7-1.75<br>Sand | 1.2-1.25<br>Silty clay |
| Location C | 52-53<br>Silty clay | 44-45<br>Clayey silt | 1.5-1.55<br>Sand silty | 1.15-1.2<br>Silty clay |
| Kampung Putih | 55-56<br>Silty clay | 41-42<br>Coarse sand | 1.65-1.7<br>Coarse sand | 1.1-1.15<br>Silty clay |
| Kampung Pasir Tumboh | 56-58<br>Silty clay | 41-42<br>Medium sand | 1.65-1.7<br>Medium sand | 1.1-1.15<br>Silty clay |

The summary concluded that in Eastern Kelantan Delta, it is abundant with silty clay. Kelantan Delta development is depending on the monsoon season, and the sediments transported are depending on the wave direction. This climate changes is the main reason for different sediment distribution in the Kelantan Delta.

The results only focus on the surface with highest depth of 60 m. The porosity for silty clay is high which indicate good porosity for estimation of reservoir quality in the area. The porosity result is only representing the shallow depth, where the high porosity could be due to the low compaction in the area. As it goes deeper, it is more compacted and the pore between the grain sizes is decreasing. Thus the porosity will decrease in deeper depth. Silty clay is common in deltaic environment due to the change of sea level.

The porosity profile and thermal conductivity profile is vice versa; as porosity increase, the thermal conductivity decrease. This is because when porosity increases the pore between the grain sizes also increases. Thermal conductivity is dependent on the heat flow, and medium is needed for heat to flow. If the pore is increasing, the particles are moving apart and no medium is presence for heat flow. Thus in this condition, the thermal conductivity will be lower.

The lithostratigraphic section (FIGURE 7) suggested that the trend of Kelantan Delta could be related to Malay Basin. If the bed rock is extrapolated towards basinward, it might represent a channel where similar basin development with Malay Basin could be predicted. The gamma ray log data is only for shallow depth, further research on deeper log data will be useful. Then reservoir quality could be estimated.

## 4.7 Lithology Map

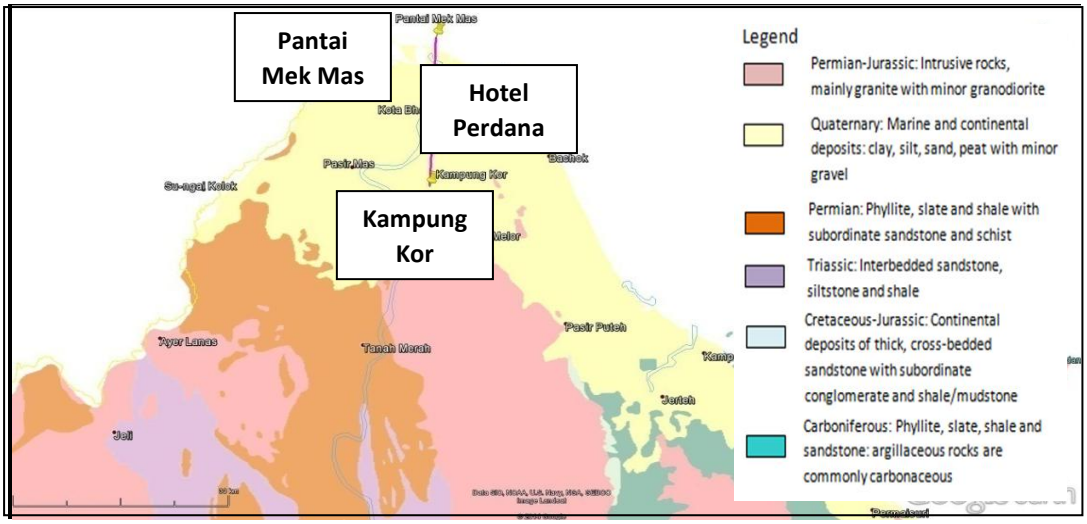



FIGURE 21: The lithology map done using OneGeology

The lithology map is done using OneGeology software. In Kelantan Delta, it is shown that the area is Quaternary in age. The sediments are marine and continental deposits with clay, silt, sand, and peat with minor gravel. There is basalt of Early Pleistocene age in the Kuantan Area.


FIGURE 22: The overlaid lithology map with Google Map

The lithology map is overlaid with Google Map to show the exact coordinate of the locations in the Google Map.

# CHAPTER 5
# CONCLUSION & RECOMMENDATION

## 5.0 CONCLUSION& RECOMMENDATION

## 5.1 Conclusion

The project is significantas only few studies have been done previously in the study area but Kelantan Delta have various different morphology to be studied and analyzed. The reservoir element profiles are developed in the results; porosity versus depth profile and thermal conductivity versus depth profile. Both profiles can be used for reservoir quality estimation in Oil and Gas industry. The result also can be used as new data reference since surface porosity and thermal conductivity data can be extrapolated and matched with the data in deeper depth.

In summary, the Eastern Kelantan Delta is covered with silty clay and sands is found dominated going to the beach. The result from the project could be served as general guide for typical deltaic environment.

## 5.1 Recommendation

For further recommendation, it is suggested to obtain more data availability such as pore pressure, geothermal gradient and heat flow to be used in reservoir quality estimation. Secondly, experiment should be conducted on thermal conductivity and porosity since raw data could give better prediction in reservoir quality.

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## APPENDICES

## APPENDIX 1

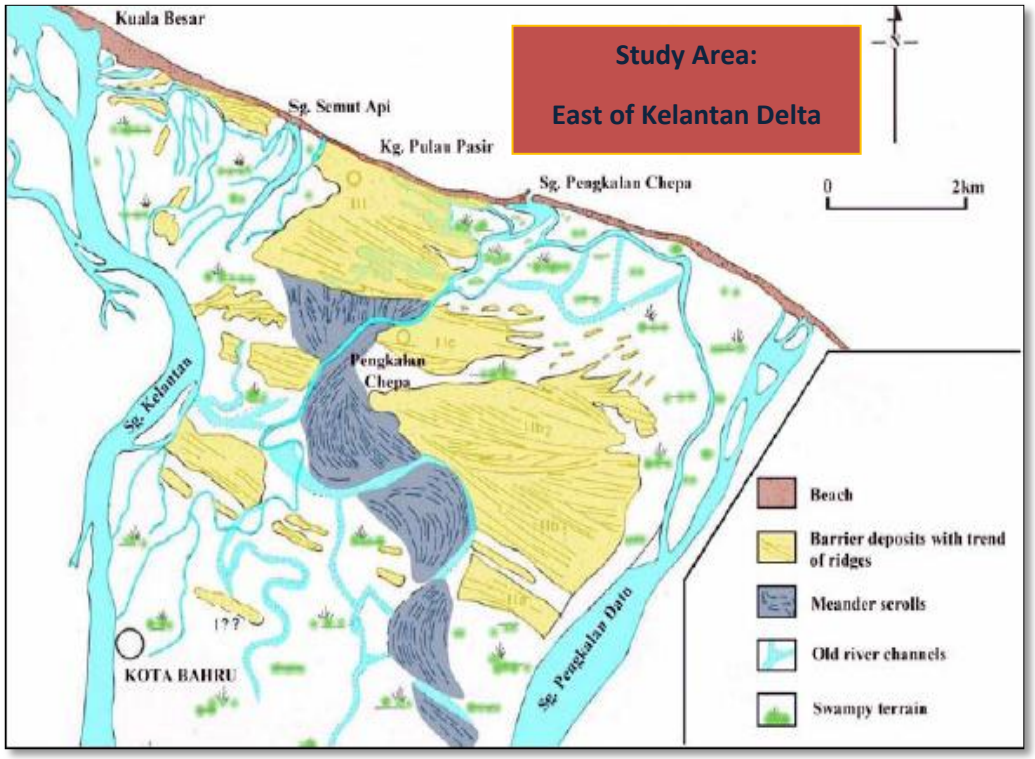


FIGURE 23: The morphology of the study area; Eastern Kelantan Delta

## APPENDIX2


FIGURE 24: The Particle Sieving Equipment

## APPENDIX3

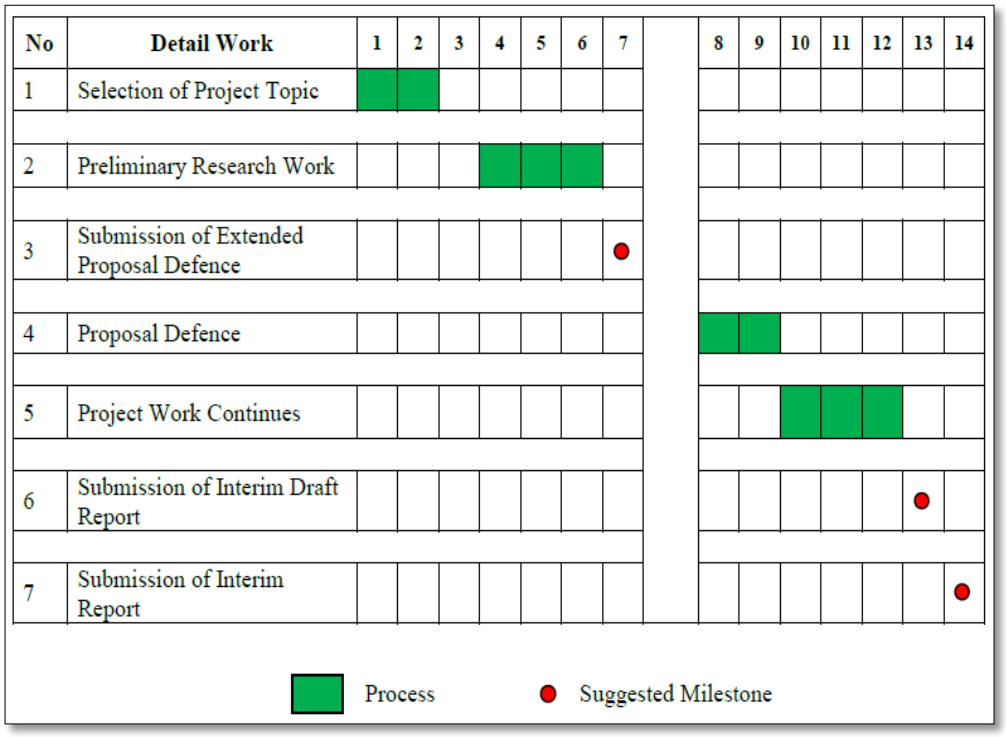


FIGURE 25: Gantt Chart for Semester 1 FYP I

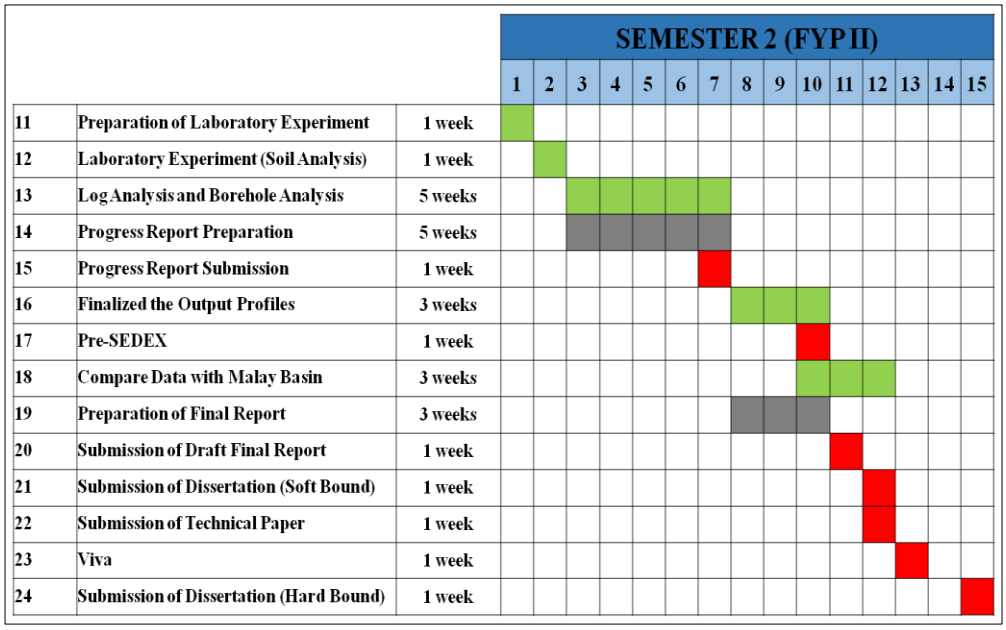


FIGURE 26: Gantt Chart for Semester 2 FYP II

**APPENDIX4**

TABLE 9: The grain size distribution based on the mean

| | |
|---|---|
| Boulder | -12 to -8 phi |
| Cobble | -8 to -6 phi |
| Pebble | -6 to -2 phi |
| Granular | -2 to -1 phi |
| Very coarse grained | -1 to 0.0 phi |
| Coarse grained | 0.0 to 1.0 phi |
| Medium grained | 1.0 to 2.0 phi |
| Fine grained | 2.0 to 3.0 phi |
| Very fine grained | 3.0 to 4.0 phi |
| Coarse silt | 4.0 to 5.0 phi |
| Medium silt | 5.0 to 6.0 phi |
| Fine silt | 6.0 to 7.0 phi |
| Very fine silt | 7.0 to 8.0 phi |
| Clay | 8.0 and smaller |

## APPENDIX 5

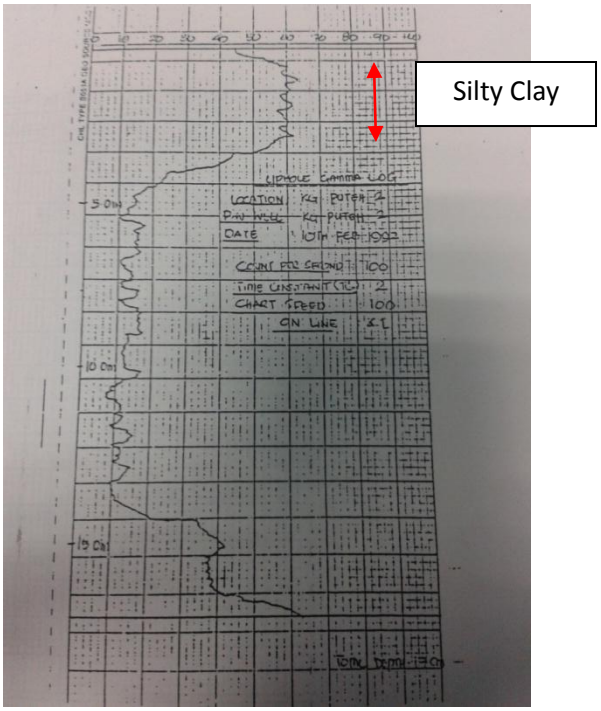


FIGURE 27: The Gamma Ray Log for Kampung Putih

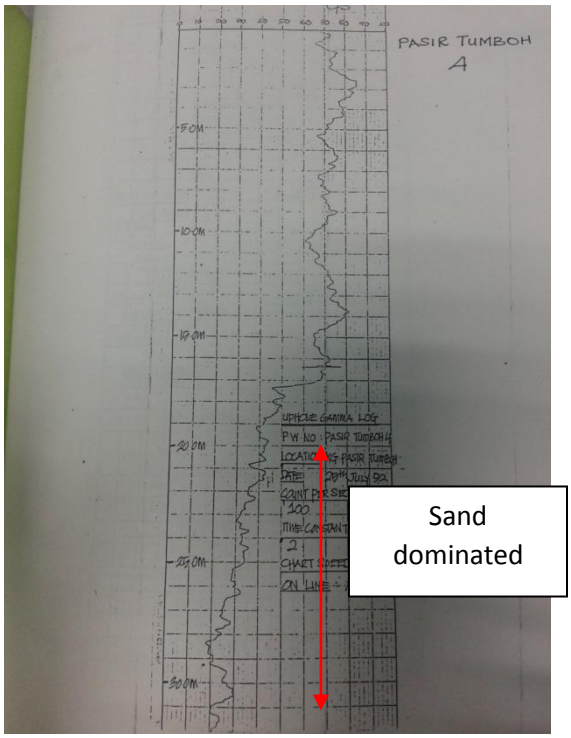


FIGURE 28: The Gamma Ray Log for Kampung Pasir Tumboh