ASSESSMENT ON THE COASTAL EROSION AND DEVELOPMENT ALONG THE NORTHERN TERENGGANU COASTLINE

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Assessment on the Coastal Erosion and Development along the Northern Terengganu Coastline

by

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
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Approved by,

(Assoc. Prof. Ahmad Mustafa b. Hashim)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

July 2009

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.

ZAHRATUL AKMAL BINTI IBRAHIM

ABSTRACT

The study is conducted to assess the current status of coastal erosion and development along the northern Terengganu coastline and propose possible coastal protection measures for the critical stage coastline. Based on the National Coastal Erosion Study (NCES 1986), 62.5% of Terengganu coastline which approximately 152.4 km long was found to be eroded. Since 1986, many developments have been constructed along the Terengganu coastline. However no latest overall study to assess the coastal erosion due to the development of new structure along the Terengganu coastline is yet conducted. This study begins on January 2009 and completed on November 2009. The area of study is located starting from the boundary of Terengganu and Kelantan state at Pantai Teluk Bayu, Besut (North 5° 50.286' East 102° 32.727') and end at Pantai Merang, Setiu (North 5° 32.282' East 102° 56.722') near to the Merabang Panjang Village. Due to the time, transportation and cost constraints, focus were given to the coastline which identified to be in the critical stage during the first assessment in March 2009. All data required for this study are obtained from the research done using internet and libraries, site assessment, sieve analysis, and interviews. Aerial photos obtained from Google Earth software are used to estimate the coastal erosion rate. For this study, northern Terengganu coastline is divided into ten reaches. Based on the analysis of the data, three reaches along the northern Terengganu coastline were found to be in the critical stage namely Pantai Teluk Bayu (Reach 1), Pantai Dataran Kuala Besut (Reach 2), and Pantai Merang (Reach 10). The results of this study can be used in future to assist in the planning and development of the northern Terengganu coastline.

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Special thanks go to Coastal Engineering Division, Department of Irrigation and Drainage (DID), Besut for their cooperation in providing information related to the study area and for their willingness to accompany the author during the first site assessment. Besides that, the cooperation from local community in Besut district and Setiu district is also highly appreciated.

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ABBREVIATIONS AND NOMENCLATURES

DID	Department of Irrigation and Drainage
UTP	Universiti Teknologi PETRONAS
GPS	Global Positioning System
EIA	Environmental Impact Assessment
NCES (1986)	National Coastal Erosion Study 1986
FYP	Final Year Project
ASTM	American Society for Testing and Materials
C_u	Uniformity Coefficient
C_k	Gradation Coefficient
PPRT	Projek Perumahan Rakyat Termiskin

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Terengganu, located at the east coast of Peninsular Malaysia is blessed with 244 km long sandy coastline. To the north lies the Kelantan state and looking south lies the Pahang state. Terengganu coastline plays the important roles in ensuring the stability of Terengganu development as the fishing and tourism are the major industries in Terengganu.

One of the major elements that support Terengganu tourism industries is its recreational beaches. "Recreational beaches depend on wide space and good water quality as well as amenities in order for them to be popular with the public" **(Ghazali, 2005)**. However, erosion and degradation of the surrounding environment usually will affect the attractiveness of the beaches. When such beaches loss their popularity, this will eventually give bad impact on the tourism industries.

With that, it is important to monitor and assess the erosion rate of Terengganu coastline so that some preparations can be made and the possible protection measures can be taken. It is essential to install proper protection measures because a wrong structure at the wrong location might lead to undesirable impacts on the coastal environment. So, impact studies on the protection measures are a crucial element in any coastal development to ensure existing resources can be sustainable.

Fleming (1993) pointed out that the forecast of shoreline development following the construction of works that might affect the natural beach processes is considered as one of the interest of coastal engineers. The output from this study is hoped will be able to contribute to the better management along the Terengganu coastline.

1.2 PROBLEM STATEMENT

The coastal erosion is one of the natural phenomenon which resulted by the natural processes and the system. The rate of this coastal erosion process varies with any coastal works done which include jetties, marinas, ports and any activity in the nearshore zone.

Based on the findings from NCES (1986) which was updated recently by Coastal Engineering Division, DID Malaysia in May 2005, Malaysia has a long coastline with a total length of 4809 km. Since 1984, coastal erosion has becomes a serious problem in Malaysia where 29% of the coastline is found to be eroded. Among this, 62.5% of Terengganu coastline which is approximately 152.4 km long is found to be eroded **(Coastal Engineering Division, DID Malaysia, 2005)**. The distribution of coastal erosion areas in Malaysia is shown in **Appendix 1.**

Since 1986, many developments have been constructed along the Terengganu coastline. However no new overall study to assess the coastal erosion due to the development of new structure along the Terengganu coastline is yet conducted. This kind of study is required as erosion can occur not only due to the natural phenomenon but can also be induced by human activity. The main mechanism of coastal erosion is the waves.

Based on **Maged and Shattri (1993)**, the widely accepted hypothesis carried by researcher is that the erosion along Terengganu's coastline is mainly due to the large wave during the north-east monsoon. However, instead of just relying only on this reason, other possible causes that may lead to the increase of number of eroded beach should also considered to mitigate or reduce the coastal erosion problem along the northern Terengganu coastline.

So, in this paper, the author will focus on the coastal assessment and development along the northern Terengganu Coastline.

1.3 OBJECTIVES OF STUDY

The main objectives of this study are to assess the current status of coastal erosion along the northern Terengganu coastline which was due to the natural processes or development along the coastline and propose the possible coastal protection measures for the critical stage coastline.

This study covers the following purpose:

i. To assess the current coastal erosion status on the northern Terengganu coastline
ii. To check the performance of coastal protection work construction (if any) at the assessment area
iii. To check the impact of coastal protection work construction (if any) at the assessment area to the other area of Terengganu coastline.
iv. To recommend the best coastal protection works (if required) at the assessment area.

1.4 SCOPE OF STUDY

This project covered the current environmental issues associated with northern Terengganu coastline especially on the coastal erosion due to the natural processes or development along the coastline. The area of study is located starting from the boundary of Terengganu and Kelantan state at Pantai Teluk Bayu, Besut (North 5° 50.286' East 102° 32.727') and end at Pantai Merang, Setiu (North 5° 32.282' East 102° 56.722') near to the Merabang Panjang Village.

In order to achieve the objective of this project, a few researches, assessment works, and laboratory works were carried out to obtain sufficient information with regard to the study area. Research was done based on internet, journals, books, reports and interviews. Opinion from the nearshore villagers was taken into consideration in completing this study.

The author needs to cover approximately 62 km long coastline. This coastline is divided into ten reaches. However, due to the time constraint, this study is only conducted on the general assessment to identify the highly eroded coastline and focus is given to the identified highly eroded coastline. This study covers two districts in Terengganu which are Besut and Setiu. Besides, the location of the study area is far from UTP and this has limited author's availability to do site assessment frequently. The transportation and cost is also one of the constraints.

During the site assessment, a few sediment samples are taken to check the grain size distribution based on the sieve analysis experiment. This data is used to support all the information gained during the assessment works on coastal erosion analysis. All of this data is compiled and interpreted to meet the study objectives.

Recommendations made during the project are hoped will be able to contribute to the better management of coastal zone in Terengganu.

CHAPTER 2

LITERATURE REVIEW

Review for the study was taken profusely from journals, books, report and the internet. For this project, the spot to be highlighted will cover the coastal waters, erosion and protection measures in order to prevent this problem from spreading and northern Terengganu coastline condition based on NCES (1986). These notes are required to increase author basic knowledge on the topic.

2.1 COASTAL WATERS

Stedman (2005) stated that coastal waters are usually defined as those waters in a zone of the limit of tidal influence namely landward boundary and the edge of the continental shelf namely seaward boundary. The region where the forces from coastal water which occur due to the reaction of wave against the land is typically known as beach or nearshore zone as shown in **Figure 2.1**. Nearshore can be categorized into four zone namely shoaling zone, breaker zone, surf zone and swash zone.

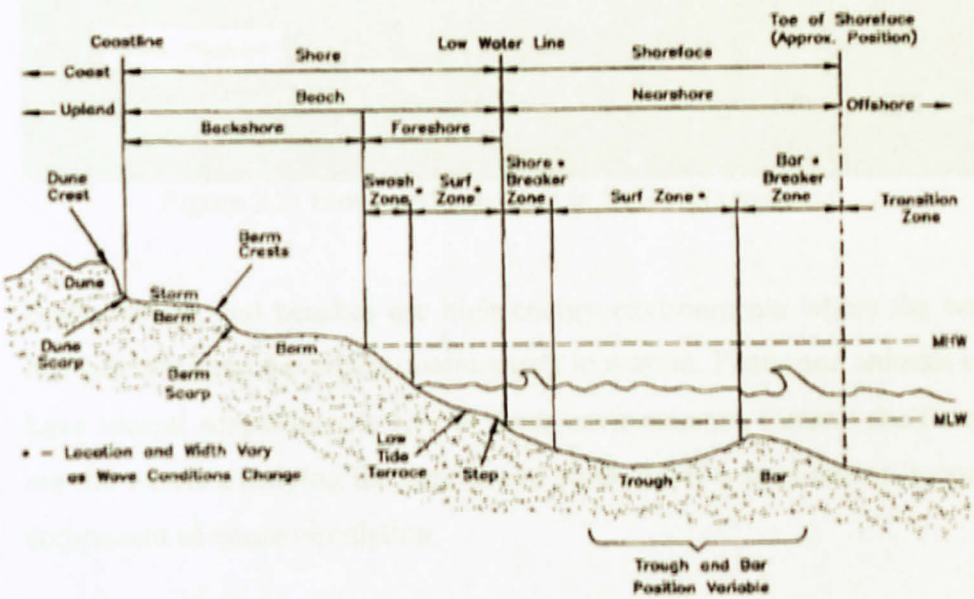

Figure 2.1: Definition of term and features describing the coastal zone **(CEM 2002)**

2.11 Types of Coastal Water

The three types of coastal waters are estuaries and bays, rocky shores and beaches and shelf waters. Estuaries and bays are both the semi-enclosed coastal body of water which has free connection with the open sea, however, the different is, bays is not being associated with the river. There are a lot of estuaries created by spits or bars found in the author's area of study which is in Setiu, Terengganu approximately about 28 km as shown in red circle in **Figure 2.2**. As both estuaries and bays provide protected aquatic environments for marine life, fishermen's consideration should be taken into account throughout this project.

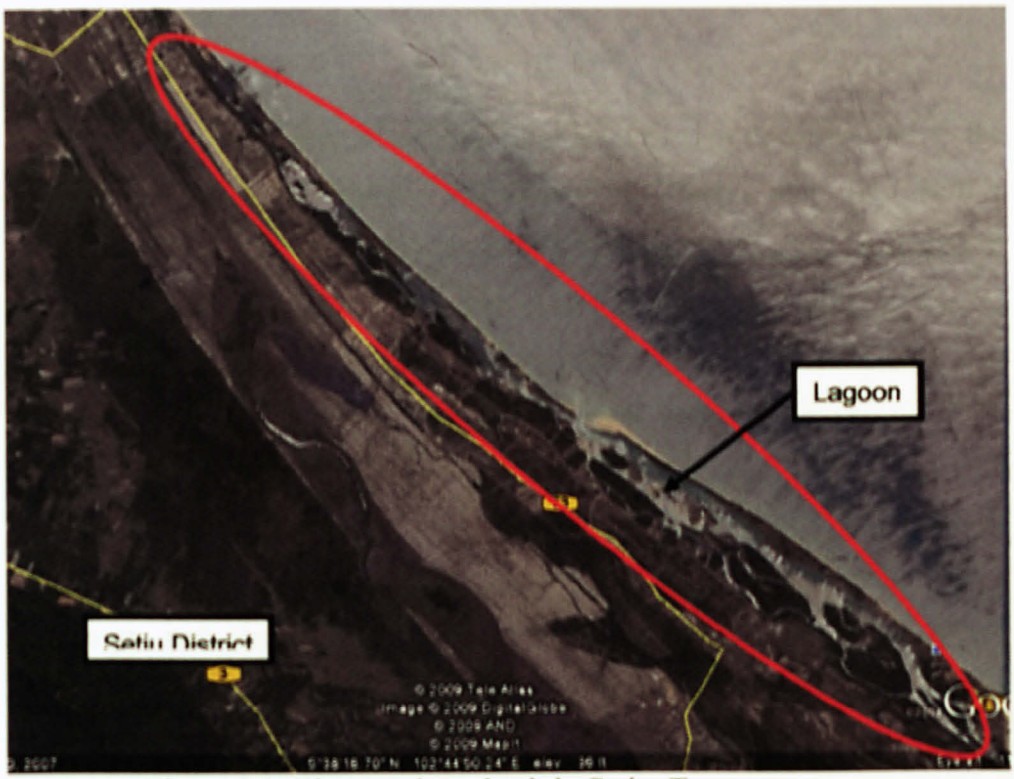

Figure 2.2: Elongated sand spit in Setiu, Terengganu

Rocky shores and beaches are high energy environments where the waves and currents keep the waters continuously in motion. Plants and animals must have special adaptations to live in these environments. Coastal shelf waters are the waters overlying the continental shelf. Shelf waters are an important component of ocean circulation.

2.12 Waves, Tides and Currents

All coastal waters are affected by the waves, tides and currents, to different scales. Waves in coastal are produces by the wind and modified by their interaction with the coastline itself. When generated by the wind, wave will absorb energy from the wind and this energy is transmitted across the water surface by waves. Once waves reach the coastline, waves will break and unleash the energy on the beach. This breaking waves move sediment along the coast which eventually eroding the coast and depositing the sediment to adjacent beach. The action of waves on beaches depends on the type of wave and the beach material. For simplicity, wave types are generally categorized as storm wave or swell waves while the beach material is categorized as sand and mud.

Tides are the phenomenon where the water level rises or decreases due to the complex interactions between astronomical forces and the earth's geomorphology. Tidal cycle transport sediment onto the coast and carry it back into the surf zone. Long term rise in seal level exist resulting in a slow, long-term recession of the coastline partially due to direct flooding and partially as a result of profile adjustment to higher water level.

Currents, generated by waves, tides and winds are the forces that circulate water in the ocean. There are two types of currents which are wind-driven circulation and thermohaline circulation. Wind-driven circulation is the horizontal movement of the upper waters set in motion due to the moving air masses while thermohaline circulation is the slow moving water mass of the deep ocean. When waves reach the coastline, currents parallel to the coastline is created known as longshore current. This current reaches maximum strength in the middle of the surf zone and this strength will reduces as it moves further offshore. This longshore current transported the sediment alongshore to the adjacent beach.

2.2 COASTAL EROSION

In coastal morphology, sediment transport is a natural phenomenon occurring in all coastlines which mean coastlines will continuously undergoing physical changes. Stable coastlines are dynamically stable which means position remain unchanged over a period of time. The sediment transport does not cause erosion because the lost sediment will be replaced by new sediments coming from other parts of the shore. If sediment carrying capacity of longshore current generated by waves exceeds quantity of sediments naturally supplied or the sediment carrying capacity remains the same but quantity of sediments naturally supplied is reduced, beach erosion will occur.

Based on NCES (1986), coastline in Malaysia can be classified into three categories of erosion based on its threat to the existing shore-based facilities in the area as shown in **Appendix 2**.

i. **Category 1 (Critical):** Coastline area currently experiencing erosion and already endangering the shore-based facilities if no action is taken. This will give bad impact on the economic, agricultural, recreational, and transportation value.
ii. **Category 2 (Significant):** Coastline area currently experiencing erosion at the rate where if no action is taken the shore-based facilities are expected to be endangered within five to ten years.
iii. **Category 3 (Acceptable)**: Undeveloped coastline area currently experiencing erosion where if no action is taken, will lead to no or minor loss.

The coastline of Terengganu was reported to experience severe erosion. However, the erosion is limited to only certain sections. Among the areas reported to experience erosion are the areas near the mouth of the Terengganu estuary, Setiu estuary and Chendering **(Loukman et al. 1995).** In addition to this, **Abdullah (2009)** stated that the area reported to experience severe erosion has increased despite protection works being implemented.

As suggested by **Maged and Shattri (1993)**, the widely accepted hypothesis carried by researcher is that the erosion along Terengganu's coastline is mainly due to the large wave during the north-east monsoon. However, **Komar (1976)** stated that the erosion cannot be studied during one season but it should be estimated by the net of the volume transport among the seasons. Instead of just relying only on this reason, other possible causes that may lead to the increase of number of eroded beach should also being considered to mitigate or reduce the coastal erosion problem along the northern Terengganu coastline.

Coastal erosion may occur due to natural phenomenon or man-induced. According to **Seng et al., (2005)**, natural causes of erosion are those which occur as a result of the response of the beach to the effects of nature. Man-induced erosion can be attributed to the lack of understanding or appreciation of coastal processes. Human activities may affect sources of new sediment to the coast and the movement of sediment within the coastal environment. Usually erosion will occurs when development works interfere with the natural sediment transport and cause a deficit in the sediment supply or when the incoming wave pattern is altered to create areas where there is a convergence of waves **(DID, 2001)**. However, good coastal zone management can pre-empt this. So, impact studies on the protection measures are a crucial element in any coastal development to ensure existing resources can be sustainable. **Table 2.1** summarized the possible causes of coastal erosion in Malaysia under two different types.

Table 2.1: Causes of Coastal Erosion

Types	Natural	Man-Induced
Causes	Sea level rise	Land subsidence from removal of subsurface resources
	Variability in sediment supply to the littoral zone	Interruption of material in transport
	Storm waves	Reduction of sediment supply to the littoral zone
	Wave and surge overwash	Concentration of wave energy on beaches
	Deflation	Increase water level variation
	Longshore sediment transport	Change of natural coastal protection
	Sorting of beach sediment	Removal of material from the beach

Source: DID Malaysia, 2005

The main mechanism of the coastal erosion is the wave. Waves are usually taken into consideration as one of the important measure in assessing the rate of erosion. However, waves usually appear to be irregular in shape and vary in the directions which will constantly changing sea of crests and troughs on the water surface. Due to this, it is difficult to describe the sea surface and the rate of erosion.

According to **Crowell and Buckley (1993)**

> Although most of the techniques used by current researchers to compile erosion rate data are similar, variations in methodologies exist and may strongly influence the accuracy and reliability of the data. Given this, it is quite possible for two different researchers, working independently and in the same study area, to come up with two sets of erosion rates that are significantly different in magnitude, direction, and accuracy.

The wave climates on the east coast of Peninsular Malaysia where Terengganu coastline is located are naturally higher since the fetch lengths over the South China Sea may extend to over 1500 km. Nearshore waves in the east coast may reach 3 m. The study along the northern Terengganu coastline using the McLaren model indicates that the preferred sediment transport direction was northwards. This study suggests that Terengganu River is more important in supplying sediments to the beach than the Setiu River **(Lokman et al. 1998)**.

2.3 COASTAL EROSION PROTECTION MEASURE

When erosion occurs, protection measure is often necessary. Before implementing any protection measures, the cause of erosion and impact on the environment should be taken into consideration. Failure to do so may lead to the undesirable impact to the adjacent beaches. Coastal erosion protection measures can be divided into hard engineering such as revetment, groynes, breakwater, concrete blocks and training wall and soft engineering such as beach nourishment, mangrove replanting and sediment filled geotextile breakwaters **(Seng et al. 2005)**. There are several types of erosion protection measures that can be used for sandy coastlines such as, groynes, gabion, breakwater, revetment and beach nourishment.

2.3.1 Groynes

Based on the environmental impact assessment (EIA) report by **Chemsain Konsultant Sdn. Bhd. (2007),** groynes are permeable to impermeable finger-like structures that are installed perpendicular to the shore. They are generally constructed in groups called groin fields, and their primary purpose is to trap littoral drift. Protecting a beach using these structures may cause erosion to the adjacent beaches as the protected beach will no longer contribute sediment to the local shoreline system.

2.3.2 Gabion

Gabions are wire mesh baskets filled with cobbles or crushed rock. Gabions are flexible and porous and can absorb some wave energy, thereby reducing the scour problems associated with impermeable sea defenses such as concrete seawalls.

2.3.3 Breakwater

Breakwaters are coastal structures used to protect harbor and shore areas by dissipating and reflecting wave energy. They are built to improve maneuvering conditions at river mouth entrances and to help regulate sedimentation by directing currents and by creating areas with different levels of wave disturbance. Breakwaters can be categorized as rubble-mound structures, vertical breakwaters and floating breakwaters. Breakwater can be either constructed attached to the shore or offshore.

2.3.4 Revetment

Revetments are usually composed of thick amour or cover layer directly withstanding the full impact of the waves. The objective of the revetment alternative is to fix or harden the shoreline so as to prevent further retreat to the shoreline. There are several types of revetment such as rock revetment, flex-slab revetment, SAUH revetment and Basalton revetment. **Figure 2.3** shown one example of the revetment.

Figure 2.3: Flex-Slab Revetment at Pantai Dataran Kuala Besut, March 2009 (looking south)

2.3.5 Beach Nourishment

According to **Ghazali (2005)**, beach nourishment is a method of coastal protection which places imported sand onto the beach to create a wider beach and longer slope in order to dissipate wave energy. This method is not a permanent solution as the sand is free to move within the coastal system. Beach nourishment projects implemented by Government of Malaysia are normally targeted at traditionally popular beaches. In Terengganu coastline, Kuala Terengganu to Kuala Ibai is one example of the area protected using this method as this area is classifies as 'critical' under the NCES (1986).

2.4 NORTHERN TERENGGANU COASTLINE

Based on NCES (1986), northern Terengganu coastline extends from Kuala Besut to Bukit Merang is identified to be slightly concaved. Beach slopes are generally mild along this coastline. Rocky beach are located at the entrance of Sungai Keluang and at Kampung Bari Besar. In Setiu district, elongated sand spit can be identified extending between Beting Lintang and Kampung Penarik. Access by car to the sand spit is limited. There is little development within the coastline. Northern Terengganu coastline is considered stable to slightly erosional. Scarps which are typically short and isolated can be found in the area as evidence of erosion.

CHAPTER 3

METHODOLOGY

3.1 PROJECT INITIATION

When the project is initiated, the author needs to identify all the relevant topics and choose the best topic based on interest and feasibility of the project. In this process, FYP lecturer is consulted in order to obtain some general overview of the project.

3.2 RESEARCH

After getting a general overview of the project, investigations on the coastal erosion and solution is conducted. A thorough research is made from the libraries and internet to collect relevant literature and increase author's knowledge on the topic. Besides, information is also obtained from the reports available in DID/consultant office. The report on NCES (1986) is reviewed to obtain past information related to author's study area. The research is focus under these categories:

i. Coastal erosion
ii. Coastal Protection Measure
iii. Northern Terengganu Coastline – coastal erosion status and development

3.3 CRITERIA JUSTIFICATION

Next, the criteria of the study are justified based on the information gathered during the research. In this stage, the number of site assessment and experiment will be discussed and choose properly based on the considered requirements. Any constraints occurred during the study must be taken into consideration to avoid any incomplete scope of study. For better understanding, FYP lecturer needs to be consulted continuously from time to time.

3.4 DATA GATHERING

After justifying the scope of study, site assessment, consultation and experiments were conducted to obtain all the required information.

3.4.1 Site Assessment

To ease the assessment process, assessment form as shown in **Appendix 2** is being used. All required equipment such as compass, portable Global Positioning System (GPS), and measurement tape is provided by Civil Engineering Department, UTP. During the site assessment, the author's used this opportunity to consult with Coastal Engineering Division, DID Besut to obtain more information on northern Terengganu coastline for the past years. Besides personal from DID Besut, villagers and fishermen view is also being taken into consideration. The purposes of site assessment are as follow:

i. To observe the real condition of the site.
ii. To confirm the erosion protection structure (if any) and its location.
iii. To obtain sediment samples at several points in the area of study.
iv. To obtain the beach width and slope at several points in the area of study as shown in **Figure 3.1**.

Figure 3.1: Pantai Teluk Bayu – Beach Measurement

3.4.2 Experiment

Sieve analysis is conducted for this study as shown in **Figure 3.2**. Sediment samples were obtained during the site assessments and labeled accordingly. GRAPHER software is used to plot the grain distribution graph. This experiment will provide some understanding on the beach material distribution along the coastline. This would help in getting possible indication on the beach erosion problem within the assessed area. If the distribution of the sediment size is not evenly distributed and less small particles of sediment observed in the sample, it may be deduced that the beach has possibly eroded because fine particle is easier to be transported.

Figure 3.2: Geotechnical Laboratory – Sieve Experiment

3.5 RECOMMENDATION AND COMPLETION

The data collected is analyzed and the possible causes of erosion are identified. From here, the possible protection measures will be proposed for the highly eroded area to ensure the stability of Terengganu coastline is protected.

Lastly, all data and recommendations will be documented and submitted. At this point, the study is considered to be completed. The flow of the study is simplified in **Appendix 3**. The proposed work programme schedule for FYP is shown in **Appendix 4.**

CHAPTER 4

RESULTS AND DISCUSSION

This project is managed to be completed on scheduled. At justification of criteria stage, the author has considered all the constraints and proposed that this study will be conducted to identify the highly eroded coastline and focus will be given to those areas. For this study, northern Terengganu coastline is divided into ten reaches namely Pantai Teluk Bayu (Reach 1), Pantai Dataran Kuala Besut (Reach 2), Pantai Air Tawar (Reach 3), Pantai Bukit Keluang (Reach 4), Pantai Beting Lintang (Reach 5), Pantai Mangkuk (Reach 6), Pantai Penarik (Reach 7), Pantai Rhu Sepuluh (Reach 8), Pantai Telaga Papan (Reach 9) and Pantai Merang (Reach 10) as shown in **Figure 4.1**. The sand spit along the northern Setiu District will not be considered due to the limitation on access road.

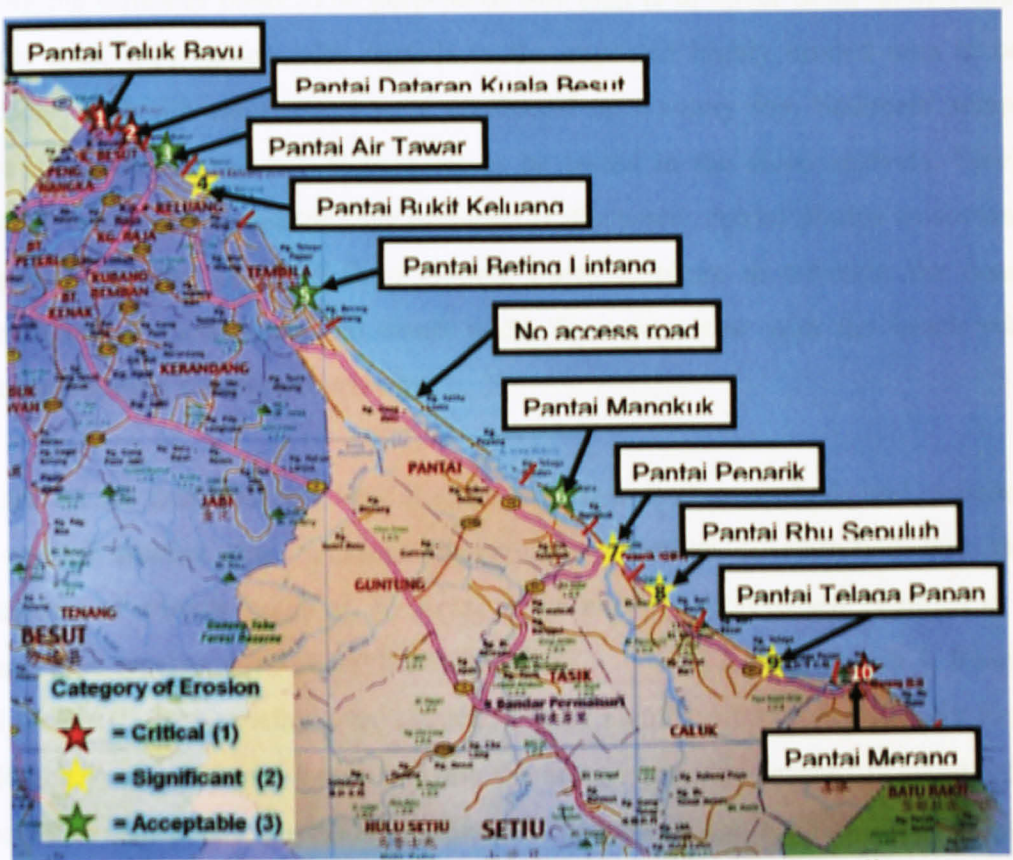

Figure 4.1: Coastal Reaches – Northern Terengganu Coastline

Based on the research, since 1984, coastal erosion has becomes a serious problem in Malaysia where 62.5% of Terengganu coastline is found to be eroded **(Coastal Engineering Division, DID Malaysia, 2005)**. However, only some information was obtained regarding the northern Terengganu coastline. The author needs to seek other sources in addition to the basic information gathered from the internet and library to obtain more information regarding these areas. Additional report such as NCES (1986) report is obtained from DID Malaysia and the important data obtained is highlighted in the chapter two. This shall serve as a good background understanding prior to the site assessment conducted for this study.

The site assessments were conducted twice. First site assessment at northern Terengganu coastline was conducted on 22nd and 23rd March 2009 during the mid-semester break accompanied by Raja Mohd. Ridzuan Raja Idris (Pembantu Teknik) and Hj. Ibrahim Abdullah (Juru Teknik Kanan) from DID, Besut. Due to the time constraint, the author only managed to assess five reaches in Besut District. The author has also took this opportunity to visit DID office in Terengganu. Second site assessment at northern Terengganu coastline was conducted on 7th to 14th July 2009 during the semester break. The purpose of this visit is to cover Setiu district and to obtain more information with regards to the expected highly eroded area in both districts. Both site assessments were conducted on a sunny day. Sediment samples were taken during the site assessment to be tested in the sieve analysis. Sieving process is completed and the data obtained is discussed. Aerial photos as shown in **Appendix 5** were obtained from Google Earth software to estimate the coastal erosion rate by comparing the beach width from past year with the beach width measured during the site assessment.

Based on the data obtained from the site assessment, sieve analysis and estimation of coastal erosion rate, northern Terengganu coastline is classified into three categories of erosion based on its threat to the existing shore-based facilities in the area. Three reaches were classified to be critically eroded namely Reach 1, Reach 2 and Reach 10, four reaches were classified to be significantly eroded namely Reach 4, Reach 7, Reach 8 and Reach 9 while the other remaining reaches is classified as acceptable. So, in this paper, the author will discuss on the finding obtained along the northern Terengganu coastline focusing on Reach 1, Reach 2 and Reach 10.

4.1 SIEVE ANALYSIS RESULT

During the site assessment, nineteen samples of sediment are obtained at 19 different locations depending on the beach condition and length for each reach. The number of samples taken for each reach and its location is shown in **Appendix 6** where nine samples were obtained in Besut District and the remaining samples were taken from Setiu District. Sieve analysis were conducted for three session starting from week 3 and completed on week 6 during the second semester of the project. GRAPHER software is used to plot the grain distribution graph. This experiment will provide some understanding on the beach material distribution along the coastline. This would help in getting possible indication on the beach erosion problem within the assessed area. If the distribution of the sediment size is not evenly distributed and less small particles of sediment observed in the sample, it may be deduced that the beach has possibly eroded because fine particle is easier to be transported. The sieve analysis results for each sediment samples in tabular and graphical order are presented in **Appendix 7**. For the sieve analysis, American Society for Testing and Materials (ASTM) standard is used as reference. The size of the silt and clay, fine sand, medium sand and coarse sand is in the range of 0 mm to 0.08 mm, 0.08 mm to 0.40 mm, 0.4 mm to 2.0 mm and 2.00 mm to 5.00 mm accordingly. Based on this standard, for a well graded sediment sample, the value of uniformity coefficient, C_u is less or equal to 6 while the value of gradation coefficient, C_k is in the range of 1 to 3. If the value of C_k is less than 0.1, the size distribution of sediment sample can be classified as gap graded. The calculation of C_u and C_k is shown below. The average value for D_{50} which showed the size of sediment with 50% finer is obtained from the sieve graph. The summary of sediment size distribution for each reach is shown in **Table 4.1.**

i. Uniformity Coefficient, $C_u = D_{60} / D_{10}$

$= 1.75 / 0.05$

$= 35.00$

ii. Gradation Coefficient, $C_k = D_{30}^2 / (D_{60} \times D_{10})$

$= 0.98^2 / (1.75 \times 0.05)$

$= 10.98$

* Calculation shown only for reach 1 (Pantai Teluk Bayu, Besut)

Table 4.1: Summary of Sediment Size Distribution for each Reach

Reach	% Clay & Silt	% Fine Sand	% Med Sand	% Coarse Sand	D50 (mm)	C_u	C_k	Description
1	5-15	5-25	50-60	15-30	1.600	35.00	10.98	Poorly Graded
2	-	-	-	-	-	-	-	No samples taken
3	80-85	5-10	8-15	0-5	0.038	1.91	1.06	Well Graded
4	50-75	15-25	10-20	0	0.055	3.15	1.30	Well Graded
5	60-75	10-20	10-20	0-5	0.045	2.23	1.12	Well Graded
6	90-98	0-5	0-5	0-5	0.038	2.00	1.16	Well Graded
7	30-50	5-15	25-40	15-25	0.735	40.00	0.06	Gap Graded
8	30-40	5-15	40-50	5-15	0.600	43.33	0.06	Gap Graded
9	50-60	15-30	10-25	0-5	0.063	2.96	0.63	Poorly Graded
10	5-15	5-15	65-75	5-15	1.600	24.29	13.13	Poorly Graded

4.2 REACH 1: PANTAI TELUK BAYU, BESUT

This reach is 2 km long and extends from the boundary of Terangganu and Kelatan state to Kuala Besut. According to the report for coastal erosion protection project at Pantai Teluk Bayu, Besut, the erosion at Pantai Teluk Bayu, Besut is classified under class 1 as currently the sea water is already threatening the shore-based facilities.

Based on the NCES (1986) report, Pulau Perhentian Kecil and Pulau Perhentian Besar which located approximately 19 km offshore provide partial sheltering along this reach from the predominant Northeast Monsoon wave as evidenced by the accretional delta formation.

Based on the Aerial photo taken in year 2003, delta formation can still be observed but as shown in **Appendix 5** in year 2005, the delta formation is reduced and the beach width is shorten. The length of erosion is identified to be approximately 1.5 km. Beach slope are generally mild along this reach with measured beach width found to be in between 30 m to 40 m. Based on the Aerial photo in year 2003, the beach width is in between 70 m to 80 m and this has reduced in year 2005 which is in between 40 m to 50 m. The beach is estimated to be eroded at 3.0 m/year. During the monsoon season, wave overtopping problem occurred and affected the nearby houses in Kampung Pengkalan Atap as shown in **Figure 4.2**.

Based on **Abdullah (2009)**, this area is already coded with red by DID and not suitable for village. Due to the existence of many facilities in the area such as houses, shop house and hall, this beach must be protected to ensure the safety of the villagers. Projek Perumahan Rakyat Termiskin (PPRT) can be found along the beach.

Figure 4.2: Wave Overtopping Threatening Villager's House

The existing protection measures observed along the area are coastal bund, groynes and breakwater. The purpose of the coastal bund is to protect the villager's house from the wave. However, due to the distance between villager's house and coastline is short, sea water still managed to reach villager's house during the monsoon

season. One of the possible causes of erosion is due to breakwater built in Kuala Besut which eventually led to the accumulation of sediment in Kuala Besut. Due to this, the total sediment transported to reach 1 is reduced. Scarp formation can be observed along the beach. The plan view of Pantai Teluk Bayu is shown in **Figure 4.3.**

Figure 4.3: The Plan View of Pantai Teluk Bayu, Besut in 2005

Three sediment samples were taken to be analyzed. Based on the sieve analysis, the sediment size distribution can be concluded to be poorly graded as the value of C_u and C_k is 35 and 10.98 accordingly. The percentage of medium and coarse sediment is high which are 50% to 60% and 15% to 30% accordingly. Compared to other reach, the percentage of clay and silt is low in between 5% to 15%. The average value of D_{50} is found to be 1.6 mm which falls under medium sand size.

In order to mitigate this problem, a wider beach is required. Beach nourishment works can be done to compensate for the lack of natural supply of beach material. Besides beach nourishment, the design of the existing groynes can be altered to optimize the function of the groynes. The length of the existing groynes can be increased to allow it to trap more sediment and increased the beach width.

4.3 REACH 2: PANTAI DATARAN KUALA BESUT, BESUT

This reach is 2 km long and extends from Kuala Besut to Kampung Pengkalan Kubur. According to the report for erosion protection structure improvement project at Pantai Dataran Kuala Besut, Besut, the erosion at Pantai Dataran Kuala Besut, Besut is classified under class 1 as currently the sea water is already threatening the shore-based facilities as shown in **Figure 4.4**.

Figure 4.4: Existing Flex-Slab is Damaged due to the Wave – looking south

Based on the Aerial photo, in year 2003, the amount of sand trap at the longer breakwater is approximately 70 m and increase to 95 m in year 2005 (Refer **Appendix 5**). Due to the sand is trapped at the south, northern beach is experiencing erosion. The length of erosion is identified to be approximately 1 km. Two protection measures available in the area are flex-slab revetment and breakwater. Dataran Kuala Besut always received direct impact from the wave. During the monsoon, wave overtopping occurred and damaging the existing flex-slab revetment (Refer **Figure 4.4**). The facilities available in the area are bus station, shop, recrational park and restaurant. Besides, Dataran Kuala Besut is the gate for the tourist from Pulau Perhentian. If no improvement action taken, the existing flex-slab will damage more severely.

Other problem occurred in the area is the accumulation of sediment in Kuala Besut. As the sediment accumulated, the depth of Kuala Besut is decresed and due to this, bigger boat cannot pass under Kuala Besut bridge. Based on the observation, the amount of sand trapped by the breakwater at the south part is probably already exceeding the breakwater design capacity and due to this, the exceed sediments is transported and accumulated in Kuala Besut. Based on **Abdullah (2009)**, the sediment accumulated in Kuala Besut have been excavated three years ago. However, as shown in **Figure 4.5** taken during the first assessment, sediments can still be seen accumulated in Kuala Besut. During the second assessment, dredging activity can be observed as shown in **Figure 4.6**.

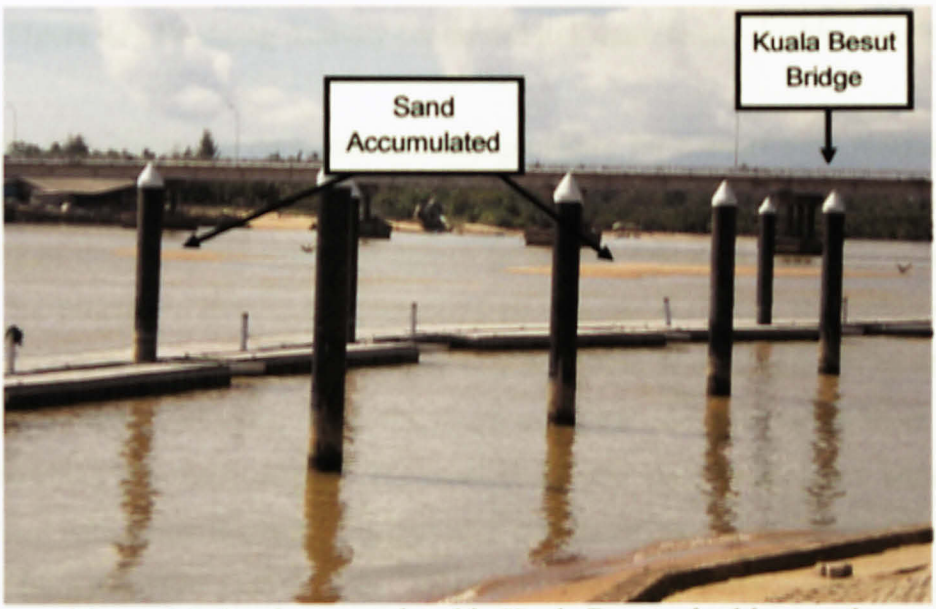

Figure 4.5: Sand Accumulated in Kuala Besut – looking south

No sediment sample is taken along reach 2 because the sediment found in the area is not the origin material. The sediments are obtained from the river and being used as the base material to construct the flex -slab revetment.

Figure 4.6: Dredging Activity conducted in Kuala Besut – looking south

In order to mitigate the damaged flex-slab problem, for a short term measure, the flex-slab should be repaired sooner to avoid the damage flex-slab from affecting the stability of the whole flex-slab. As shown in **Figure 4.4**, steel sheet pile is already being constructed to protect the unsecured river bank. However, this solution will perhaps contribute to worsening the flex-slab condition as the toe might be affected due to the reaction of wave (reflection) with the steel sheet pile as the sheet pile is not absorbing the wave energy. The steel sheet pile cans be replaced with other revetment with better flexibility such as rock revetment because it can sustains more impact from the wave. Due to its flexibility, rock revetment will have stronger toe.

As mentioned above, Kuala Besut always received direct impact from the wave. So, for a long term solution, redesigning the breakwater by accounting the current wave data can be conducted to solve the problem. By doing this, the direct wave impact due to the Northeast Monsoon may be reduced or blocked by the new breakwater. Besides, this solution may also solve the sedimentation problem in this area. The new design of breakwater may be able to sustain the additional sediment transported from the south and avoid it from accumulating in Besut River.

4.4 REACH 3: PANTAI AIR TAWAR, BESUT

This reach is 3.5 km long and extends from Kampung Pengkalan Kubur to Pantai Bukit Keluang. Based on the site assessment, no prove of erosion occur in the area. Based on the Aerial photo taken in year 2003 and year 2005, there is no much changes occur in the beach width. In year 2003, the beach width is in between 50 m to 55 m and in year 2005 the beach width is in between 50 m to 55 m. The beach width measured during the site assessment is in between 45 m to 55 m. The beach is estimated to be eroded at 0.4 m/year. However, due to the traditional event usually conducted here for example Pekan Budaya and Expo Pembangunan, the beach stability need to be concerned and preserved. This area is mostly covered with rhu tree. To the north, breakwater at Kuala Besut can be observed. **Figure 4.7** shows the picture taken during the site assessment at Reach 3.

Two sediment samples were taken to be analyzed. Based on the sieve analysis, the sediment size distribution can be concluded to be well graded as the value of C_u and C_k is 1.91 and 1.06 accordingly. The percentage of medium and coarse sediment is low which are 8% to 15% and 0% to 5% accordingly. Compared to other reach, the percentage of clay and silt is high in between 80% to 85%. The average value of D_{50} is small which is 0.038 mm and fall under silt and clay sand size. Based on the site assessment, sieve analysis and estimated erosion rate this reach can be classified as acceptable.

Figure 4.7: Pantai Air Tawar, Besut – looking south

4.5 REACH 4: PANTAI BUKIT KELUANG, BESUT

This reach is 4.5 km long. Rocky beach are located at the entrance of Sungai Keluang. Based on the data obtained from DID, Kuala Terengganu, Pantai Bukit Keluang, Besut is not classified under highly eroded beach. However, according to one of the villagers, during monsoon season, wave overtopping still occured. Short scarp formation can be observed as a proof of severe erosion along the Pantai Bukit Keluang as shown in **Figure 4.8**. This reach is one of the famous recrational beach in Terengganu. Small cave can be observed at Bukit Keluang. Due to that, the author classified this reach as significant. The length of erosion is identified to be approximatley 0.5 km.This reach is mostly covered with rhu tree and coconut tree. No protection measure was found in the area. No Aerial photo is found for this area. Without photo from past years, the rate of erosion cannot be estimated. The beach width measured during the site assessment is in between 40 m to 50 m. . Two sediment samples were taken to be analyzed. Based on the sieve analysis, the sediment size distribution can be concluded to be well graded as the value of C_u and C_k is 3.15 and 1.30 accordingly. The percentage of medium and coarse sediment is low which are 10% to 20% and 0% accordingly. However, the percentage of clay and silt is not so high in between 50% to 75%. The average value of D_{50} is small which is 0.055 mm and fall under silt and clay sand size.

Figure 4.8: Scarp Formation at Pantai Bukit Keluang – looking north

4.6 REACH 5: PANTAI BETING LINTANG, BESUT

This reach is 5.7 km long and extends from Pantai Bukit Keluang to Kampung Beting Lintang. This reach is mostly covered with rhu tree and coconut tree. Coastline tree plantation project activity can be observed in the area. Besides, fishing activity also can be observed in Pantai Benting Lintang, Besut. No prove of serious erosion can be observed in the area. No protection measure was found in the area. No Aerial photo is found for this area. Without photo from past year, it is hard to estimate the erosion rate. The beach width measured during the site assessment is in between 30 m to 33 m. .

Two sediment samples were taken and analyzed. Based on the sieve analysis, the sediment size distribution can be concluded to be well graded as the value of C_u and C_k is 2.23 and 1.12 accordingly. The percentage of medium and coarse sediment is low which are 10% to 20% and 0% to 5% accordingly. The percentage of clay and silt is in between 60% to 75%. The average value of D_{50} is small which is 0.045 mm and fall under silt and clay sand size. Based on the site assessment, sieve analysis and estimated erosion rate this reach can be classified as acceptable erosion category. **Figure 4.9** shows the current condition of this reach.

Figure 4.9: Current condition of Pantai Beting Lintang – looking south

4.7 REACH 6: PANTAI MANGKUK, SETIU

The length of the reach is approximately 4 km. There is no proper access road to the beach. Pantai Mangkuk, Setiu is mostly coverd with Rhu trees and grass. There are scarp formation can be observed along the beach as shown in **Figure 4.10**. Based on the beach slope measured at four different points along the beach, this beach can be classified as steep where the measured slope is in the range of 1:10 to 1:15. This beach can be considered experiencing erosion however due to the less number of facilities nearby and due to its location at the rural area, no protection measure is constructed in the area. People usually come to this area to fish. Based on the Aerial photo taken in year 2002 and year 2007, there is no much changes occur in the beach width. In year 2002, the beach width is in between 30 m to 35 m and in year 2007 the beach width is in between 28 m to 33 m. The beach width measured during the site assessment is in between 25 m to 30 m. The beach is estimated to be eroded at 0.6 m/year. Two sediment samples were taken to be analyzed. Based on the sieve analysis, the sediment size distribution can be concluded to be well graded as the value of C_u and C_k is 2.00 and 1.16 accordingly. Both percentage of medium and coarse sediment is low while the percentage of clay and silt is high compare to other reach where it is in between 90% to 98%. The average value of D_{50} is small which is 0.038 mm and fall under silt and clay sand size. Based on the site assessment, sieve analysis and estimated erosion rate this reach can be classified as acceptable.

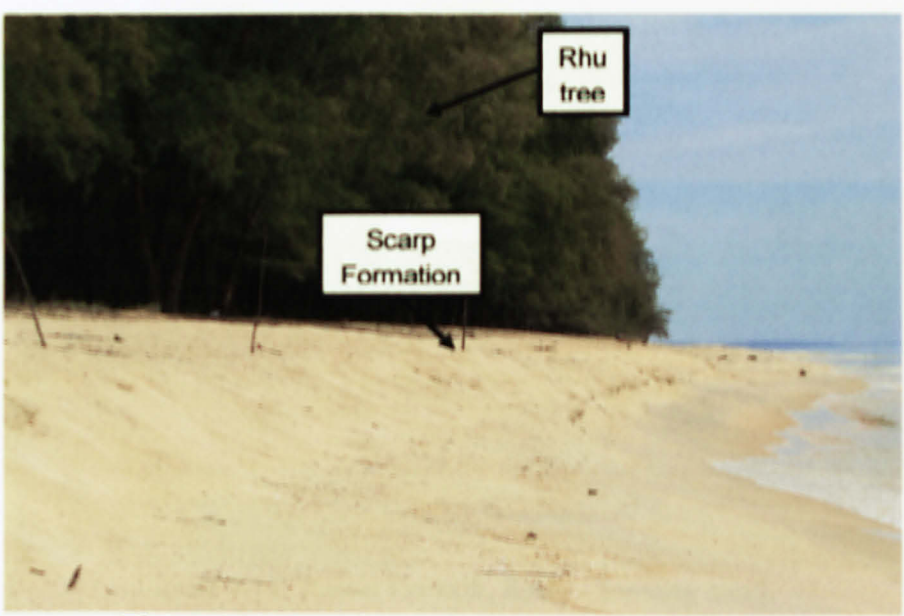

Figure 4.10: Pantai Mangkuk, Setiu – looking north

4.8 REACH 7: PANTAI PENARIK, SETIU

The reach is approximately 4 km long and extends from Kampung Mangkuk to Kampung Penarik. The beach is beautiful and suitable for tourism industry. This reach is mostly covered with coconut tree. No protection measure was found in the area. However, as tourism is one of the biggest industry in Terengganu, the beach stability still need to be preserved and maintained. **Figure 4.11** shows the picture taken at Pantai Penarik, Setiu. Many shore-based facilities observed in the area such as school, police station, Kampung Penarik and cemetary areas. Based on the Aerial photo taken in year 2002, the beach width is in between 40 m to 50 m. The beach width measured during the site assessment is in between 25 m to 30 m. The beach is estimated to be eroded at 2.8 m/year.

Three sediment samples were taken and analyzed. Based on the sieve analysis, the sediment size distribution can be concluded to be gap graded as the value of C_u and C_k is 40.00 and 0.06 accordingly. The percentage of medium and coarse sediment is 25% to 40% and 15% to 25% accordingly. The percentage of clay and silt is in between 30% to 50%. The average value of D_{50} is high which is 0.735 mm and fall under medium sand size. Based on the site assessment, sieve analysis and estimated erosion rate this reach can be classified as significant. The extent of erosion is approximately 1 km.

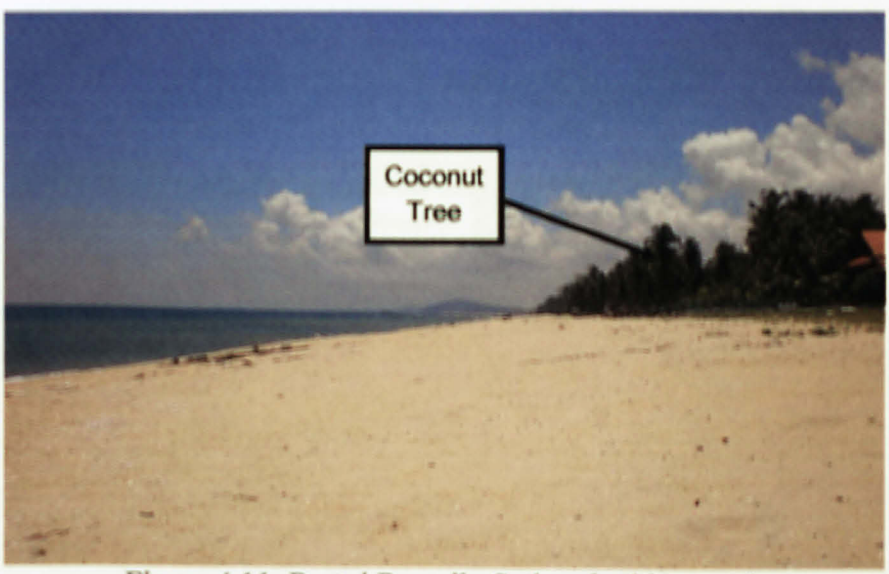

Figure 4.11: Pantai Penarik, Setiu – looking south

4.9 REACH 8: PANTAI RHU SEPULUH, SETIU

The reach is approximately 6 km long and extends from Kampung Penarik to Kampung Bari Kecil. The beach is beautiful and suitable for tourism industry. This reach is mostly covered with grass and rhu tree. Scarp formation as a proof of erosion can be observed during the site visit. No protection measure was found in the area. However, as tourism is one of the biggest industry in Terengganu, the beach stability still need to be preserved and maintained. **Figure 4.12** shows the picture taken at Pantai Rhu Sepuluh, Setiu. The condition of the beach is basically the same as Pantai Penarik.The beach is located near to the Rhu Sepuluh village house, motivational camp area and road. Based on the Aerial photo taken in year 2002, the beach width is in between 30 m to 35 m. The beach width measured during the site assessment is in between 20 m to 35 m. The beach is estimated to be eroded at 1.5 m/year. One sediment sample was taken to be analyzed. Based on the sieve analysis, the sediment size distribution can be concluded to be gap graded as the value of C_u and C_k is 43.33 and 0.06 accordingly. The percentage of medium and coarse sediment is 40% to 50% and 5% to 15% accordingly. The percentage of clay and silt is in between 30% to 40%. The average value of D_{50} is high which is 0.6 mm and fall under medium sand size. Based on the site assessment, sieve analysis and estimated erosion rate this reach can be classified as significant. The extent of erosion is approximately 1 km.

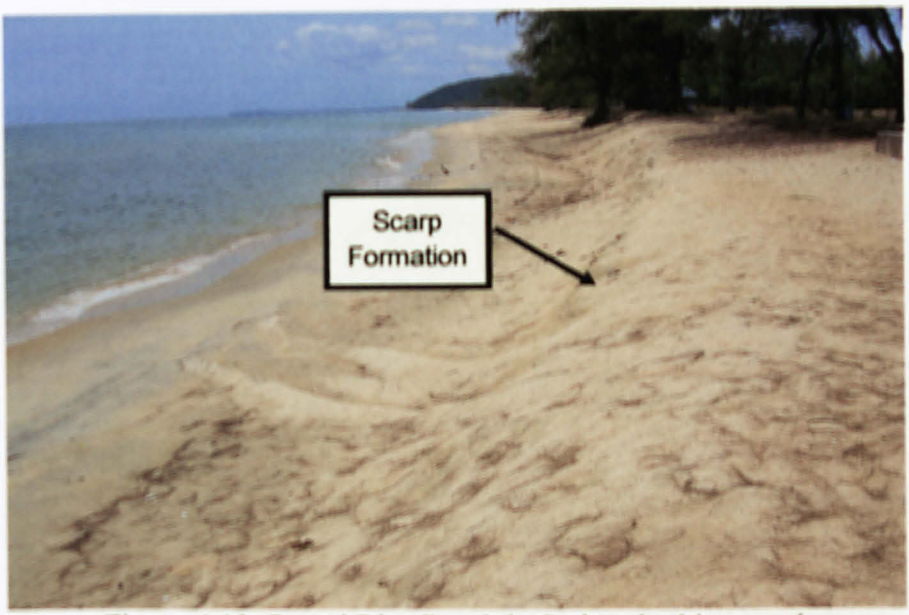

Figure 4.12: Pantai Rhu Sepuluh, Setiu – looking south

4.10 REACH 9: PANTAI TELAGA PAPAN, SETIU

The reach is approximately 9 km long and extends from Kampung Bari Besar to Bukit Merang. This reach is mostly covered with grass, rhu tree and coconut tree. Scarp formation as a proof of erosion can be observed during the site visit. No protection measure was found in the area. However, as tourism is one of the biggest industry in Terengganu, the beach stability still need to be preserved and maintained. **Figure 4.13** shows the rip current occurrence due to the shape of the coastline along Pantai Telaga Papan, Setiu. Shore-based facilities that can be observed along the beach is mostly villager's house. Based on the Aerial photo taken in year 2007, the beach width is in between 30 m to 35 m. The beach width measured during the site assessment is in between 20 m to 30 m. The beach is estimated to be eroded at 3.0 m/year. Two sediment samples were taken to be analyzed. Based on the sieve analysis, the sediment size distribution can be concluded to be poorly graded as the value of C_u and C_k is 2.96 and 0.63 accordingly. The percentage of medium and coarse sediment is 10% to 25% and 0% to 5% accordingly. The percentage of clay and silt is in between 50% to 60%. However, the average value of D_{50} is low which is 0.063 mm and fall under silt and clay sand size. Based on the site assessment, sieve analysis and estimated erosion rate this reach can be classified as significant because currently the erosion does not threatening the nearby facility yet but the rate of erosion is high. The extent of erosion is approximately 3 km.

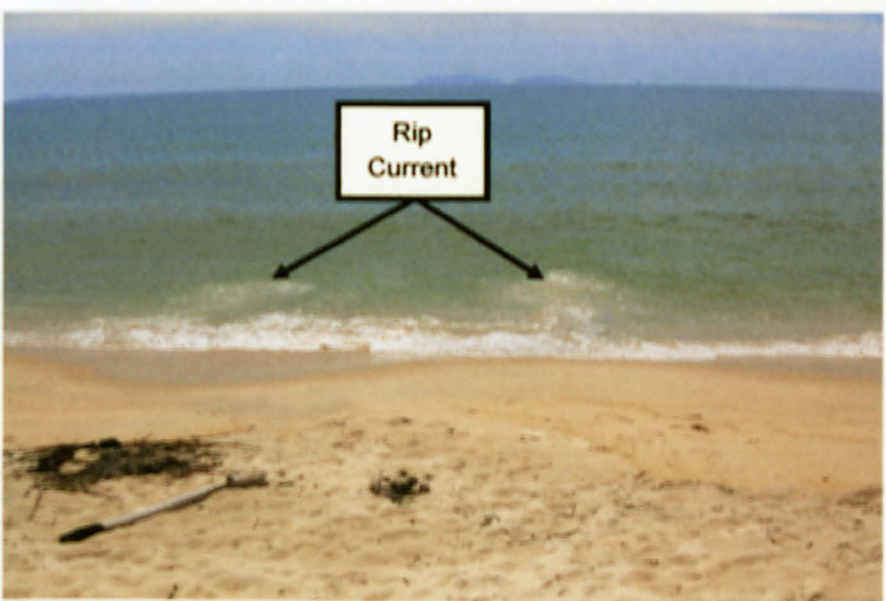

Figure 4.13: Rip Current occurrence due to the shape of the coastline

4.11 REACH 10: PANTAI MERANG, SETIU

This reach is approximately 7 km long and extends from Bukit Merang to the boundary of Kuala Terengganu and Setiu District. Shore-based structure such as Botanical Course Camp Resort is available in the area which considered as one of the location that contributes to tourism industry in Terengganu. Breakwater can be observed looking from south in the area **(Refer Figure 4.14)**.

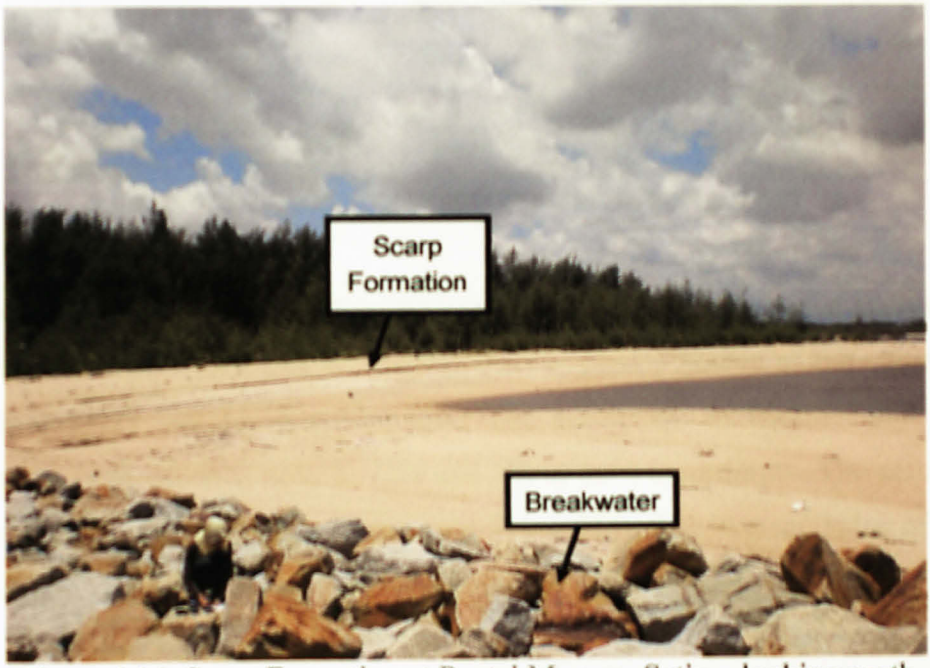

Figure 4.14: Scarp Formation at Pantai Merang, Setiu – looking north

Based on the information obtained from DID, Kuala Terengganu, erosion at Pantai Merang, Setiu is classified under class 1. The extent of erosion is approximately 1 km. The erosion occurs possibly due to the construction of breakwater at the south which traps the sediment from moving to the north. Scarp can be observed to the north of the beach. This beach is mostly covered with Rhu tree. The plan view of Pantai Merang, Setiu is shown in **Figure 4.15.**

Figure 4.15: The Plan View of Pantai Merang, Setiu

Two sediment samples were taken to be analyzed. Based on the sieve analysis, the sediment size distribution can be concluded to be poorly graded as the value of C_u and C_k is 24.29 and 13.13 accordingly. The percentage of medium and coarse sediment is high which is 65% to 75% and 5% to 15% accordingly. The percentage of clay and silt is low which is in between 5% to 15%. The average value of D_{50} is high which is 1.6 mm and fall under medium sand size.

CHAPTER 5

CONCLUSION

This study is conducted to assess the current status of coastal erosion along the northern Terengganu coastline which due to the natural process or development along the coastline and propose the possible coastal protection measures for the critical stage coastline. For this study, northern Terengganu coastline is divided into ten reaches namely Pantai Teluk Bayu (Reach 1), Pantai Dataran Kuala Besut (Reach 2), Pantai Air Tawar (Reach 3), Pantai Bukit Keluang (Reach 4), Pantai Beting Lintang (Reach 5), Pantai Mangkuk (Reach 6), Pantai Penarik (Reach 7), Pantai Rhu Sepuluh (Reach 8), Pantai Telaga Papan (Reach 9) and Pantai Merang (Reach 10). Reach 1 to Reach 5 is located in Besut District while Reach 6 to Reach 10 is located in Setiu District.

Two site assessments were conducted in March 2009 and July 2009 to observe the current condition of the coastline and identify any shore-based facilities along the coastline. During the first site assessment, the author only managed to focus on Besut District due to the time constraint. During the second visit the author managed to visit all the assessible locations in Setiu District. The elongated sand spit along the northern Setiu District as shown in chapter 4 is not being considered in this study due to the limitation on the access road.

Nineteen sediment samples were taken during the site assessment. The number of sediment samples required is decided based on the condition of the coast and its length. Sieve analysis were conducted for three sessions starting from week 3 and completed on week 6 during the second semester of the project. GRAPHER software is used to plot the grain distribution graph. Aerial photos obtained from Google Earth software were used to compare the beach width with the current beach width measured during the site assessment. The difference in measurement is considered as the possible indication to estimate the coastal erosion rate.

Based on the data obtained from the site assessment, sieve analysis and estimation of coastal erosion rate, the northern Terengganu coastline is classified into three categories of erosion based on its threat to the existing shore-based facilities in the area. Three reaches were classified to be critically eroded namely Reach 1, Reach 2 and Reach 10, four reaches were classified to be significantly eroded namely Reach 4, Reach 7, Reach 8 and Reach 9 while the other remaining reaches is classified as acceptable.

Focus is given to the critically eroded area where the possible causes of erosion were discussed as shown in chapter four. Based on this, the possible protection measure is recommended to ensure the stability of Terengganu coastline. However, the recommendations made were only on the conceptual. This is due to the lack of data obtained from the site. In order to properly design a coastal protection measure, details data on the wave, current, wind, sea slope, sea depth and etc are required. For the future FYP, it is recommended that a thorough research should be conducted to collect details information related to coastal erosion on the identified critically eroded study area so that possible coastal protection measure can be properly design.

The results of this study are hoped will be able to contribute to the better management of coastal zone in Terengganu and can be used in future to assist in the planning and development of the northern Terengganu coastline.

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APPENDIXES

Appendix 1

Table A1: Distribution of Coastal Erosion Areas in Malaysia

State	Length of Coastline (km)	Length of Coastline Having Erosion			Total Length of Coastline Having Erosion	
		Category 1 CRITICAL EROSION (km)	Category 2 SIGNIFICANT EROSION (km)	Category 3 ACCEPTABLE EROSION (km)	(km)	(%)
Perlis	20	4.4 (3)	3.7 (1)	0.4 (4)	14.5 (8)	72.5%
Kedah	149	31.4 (10)	2.2 (1)	9.9 (3)	43.5 (29)	29.4%
Pulau Pinang	152	42.4 (9)	19.7 (5)	1.1 (1)	63.2 (15)	41.6%
Perak	230	28.3 (4)	18.8 (2)	93.1 (4)	140.2 (10)	61.0%
Selangor	213	63.5 (10)	22.3 (7)	66.1 (3)	151.9 (20)	71.3%
N. Sembilan	58	3.9 (2)	7.7 (4)	12.9 (1)	24.5 (7)	42.2%
Melaka	73	15.6 (5)	15.1 (2)	0.0 (2)	36.7 (9)	50.3%
Johor	492	28.9 (9)	50.3 (9)	155.6 (11)	234.8 (29)	47.7%
Pahang	271	12.4 (11)	5.2 (3)	107.6 (8)	125.4 (22)	46.3%
Terengganu	244	20.0 (6)	10.0 (6)	122.4 (10)	152.4 (22)	62.5%
Kelantan	71	5.0 (3)	9.5 (3)	37.6 (5)	52.1 (11)	73.4%
W.P. Labuan	59	2.5 (2)	3.0 (2)	25.1 (2)	30.6 (6)	51.9%
Sarawak	1,035	17.3 (5)	22.3 (10)	9.6 (7)	49.2 (25)	4.8%
Sabah	1,743	12.8 (5)	3.5 (2)	279.2 (12)	295.5 (19)	17.0%
TOTAL	4,809	288.4 (93)	193.3 (57)	932.8 (73)	1,414.5 (223)	29.4%

Source: Coastal Engineering Division, DID Malaysia, 2005

Appendix 2

Table A2: Site Assessment Form

Location			
Date/Day/Time			
Oceanography Meteorology	Sunny/ Rainy		
	Tide		
	Wind (speed, direction)		
	Wave (height , period type)		
Coastal Land Use	Agriculture	Padi	
		Coconut	
		Others	
	Urban/ Roads		
	Recreation		
	Forestry		
	Undeveloped		
Local Community/ Activity	Fisherman		
	Agriculture/ Kampung		
	Industry		
	Mixed		
	Others		
Shoreline condition	Advanced		
	Retreat		
	Stable		
	Seasonal change		
	Other		
	Beach Slope		
Shoreline Grain Material			
Shoreline vegetation cover	None		
	Pasture/ Grass		
	Coconut		
	Trees		
	Mangrove		
Category of Coastal Erosion	Beach Length		
	Extent of erosion damage		
	Erosion category		
	Existing Protection Measures		
	Performance of the Existing Protection Measures		

Appendix 3

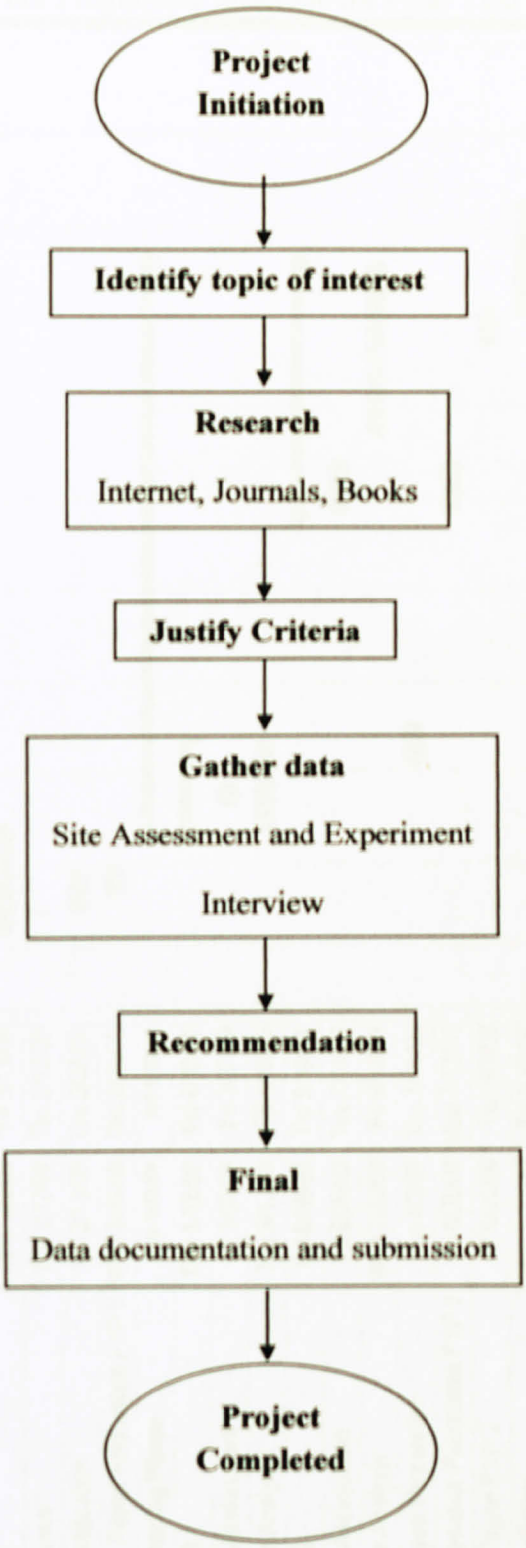
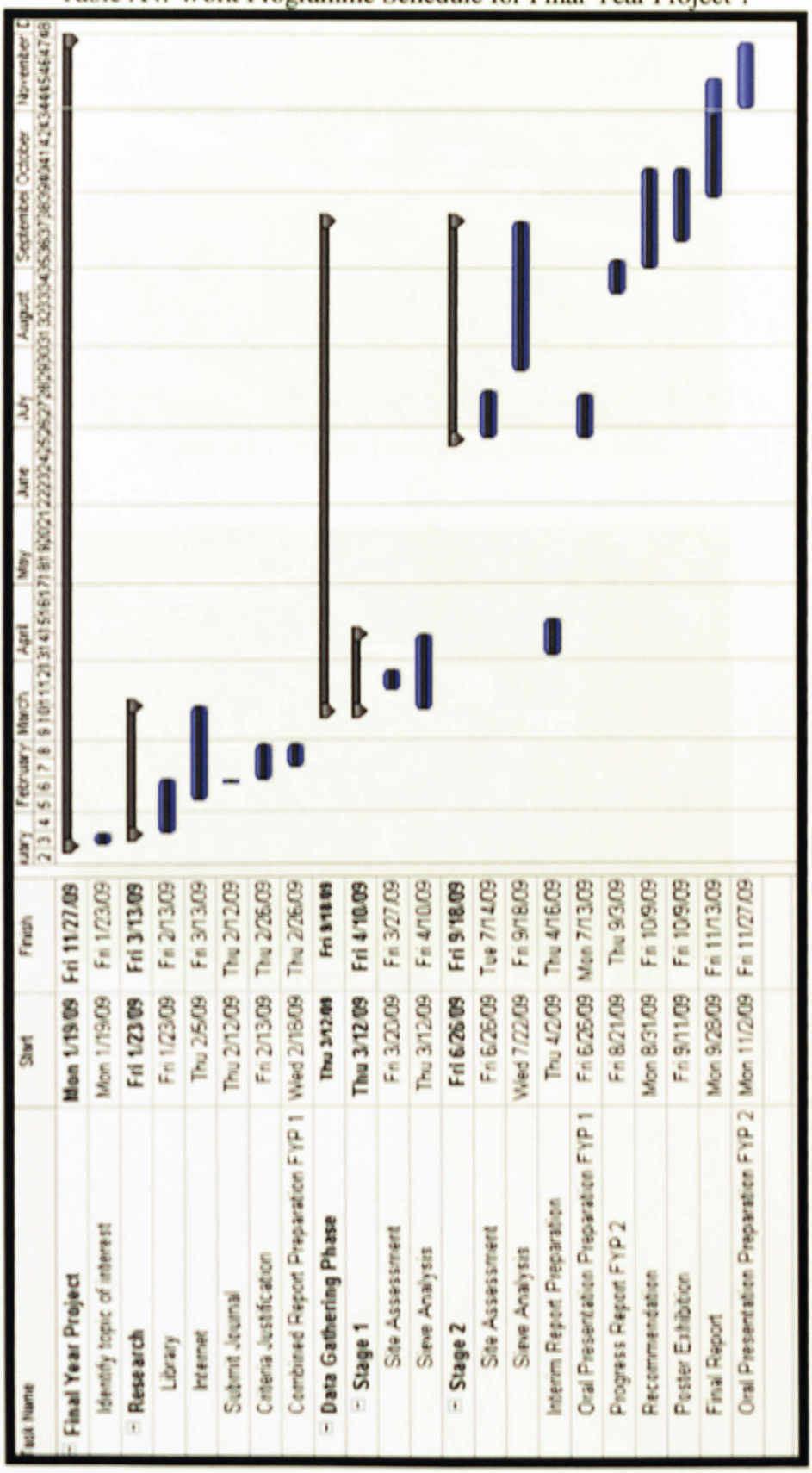


Figure A3: Methodology of the Study

Appendix 4

Table A4: Work Programme Schedule for Final Year Project 1



Task Name	Start	Finish
Final Year Project	**Mon 1/19/09**	**Fri 11/27/09**
Identify topic of interest	Mon 1/19/09	Fri 1/23/09
Research	**Fri 1/23/09**	**Fri 3/13/09**
Library	Fri 1/23/09	Fri 2/13/09
Internet	Thu 2/5/09	Fri 3/13/09
Submit Journal	Thu 2/12/09	Thu 2/12/09
Criteria Justification	Fri 2/13/09	Thu 2/26/09
Combined Report Preparation FYP 1	Wed 2/18/09	Thu 2/26/09
Data Gathering Phase	**Thu 3/12/09**	**Fri 9/18/09**
Stage 1	**Thu 3/12/09**	**Fri 4/10/09**
Site Assessment	Fri 3/20/09	Fri 3/27/09
Sieve Analysis	Thu 3/12/09	Fri 4/10/09
Stage 2	**Fri 6/26/09**	**Fri 9/18/09**
Site Assessment	Fri 6/26/09	Tue 7/14/09
Sieve Analysis	Wed 7/22/09	Fri 9/18/09
Interim Report Preparation	Thu 4/2/09	Thu 4/16/09
Oral Presentation Preparation FYP 1	Fri 6/26/09	Mon 7/13/09
Progress Report FYP 2	Fri 8/21/09	Thu 9/3/09
Recommendation	Mon 8/31/09	Fri 10/9/09
Poster Exhibition	Fri 9/11/09	Fri 10/9/09
Final Report	Mon 9/28/09	Fri 11/13/09
Oral Presentation Preparation FYP 2	Mon 11/2/09	Fri 11/27/09

Appendix 5

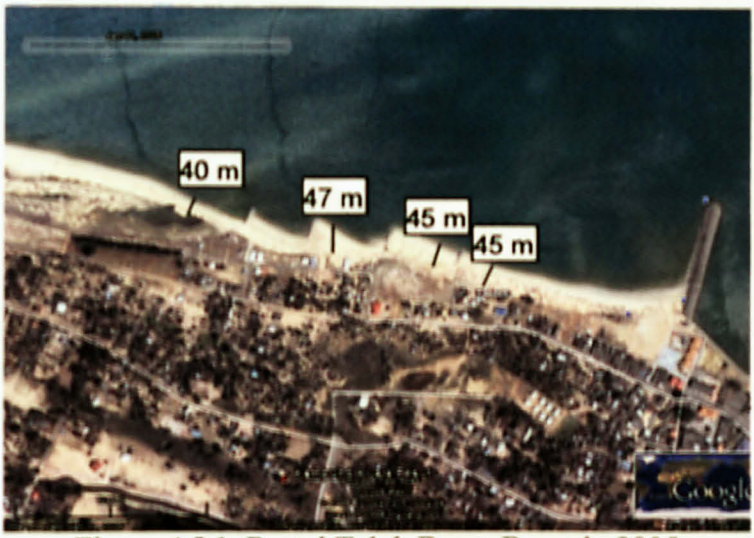


Figure A5.1: Pantai Teluk Bayu, Besut in 2005

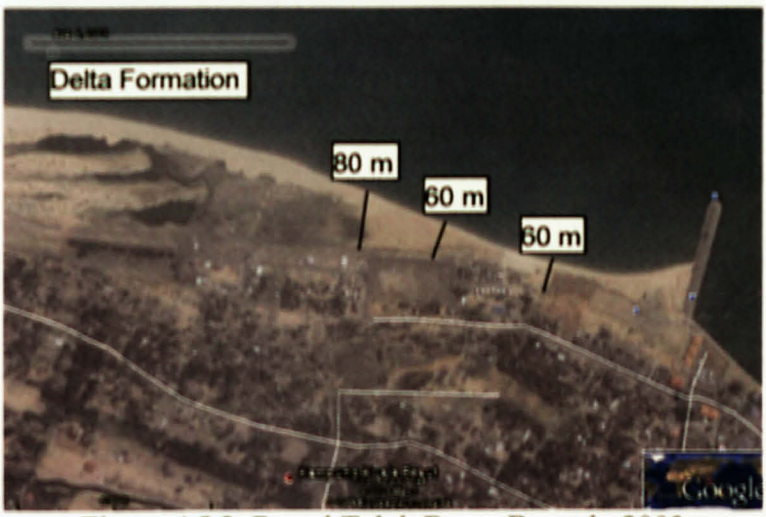


Figure A5.2: Pantai Teluk Bayu, Besut in 2003

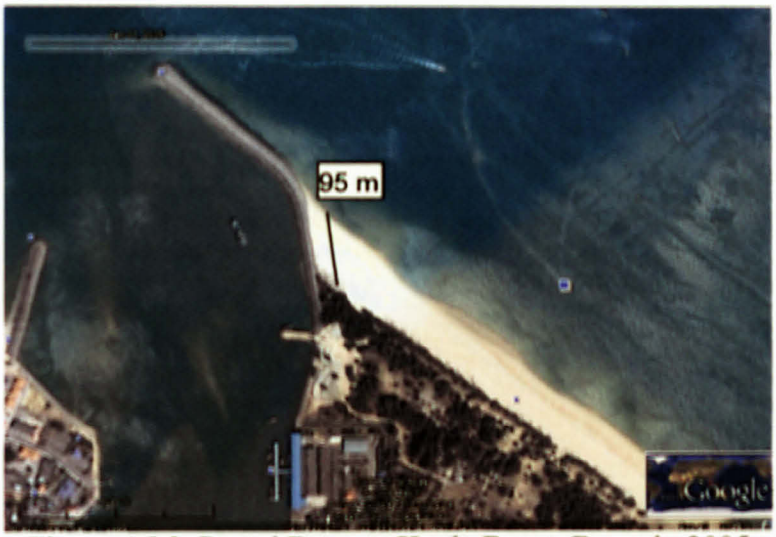


Figure A5.3: Pantai Dataran Kuala Besut, Besut in 2005

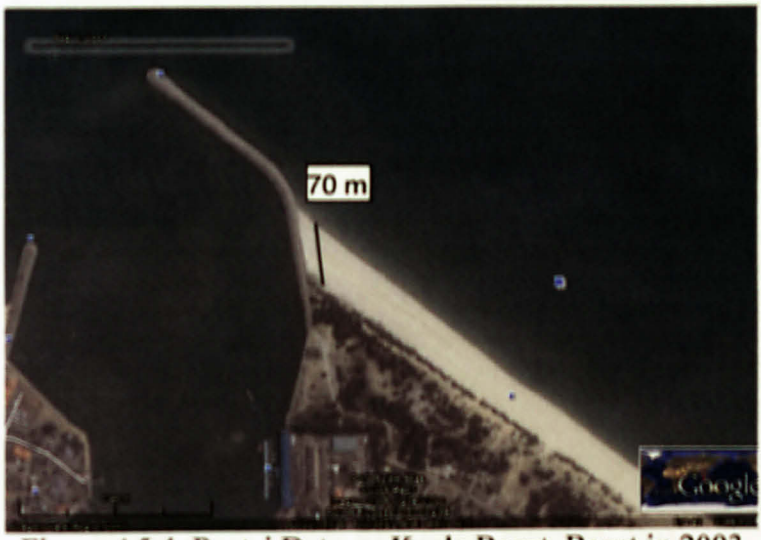


Figure A5.4: Pantai Dataran Kuala Besut, Besut in 2003

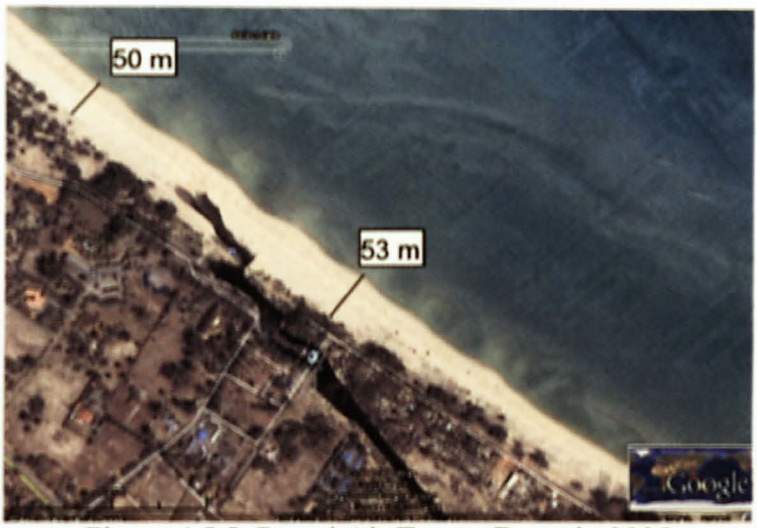


Figure A5.5: Pantai Air Tawar, Besut in 2005

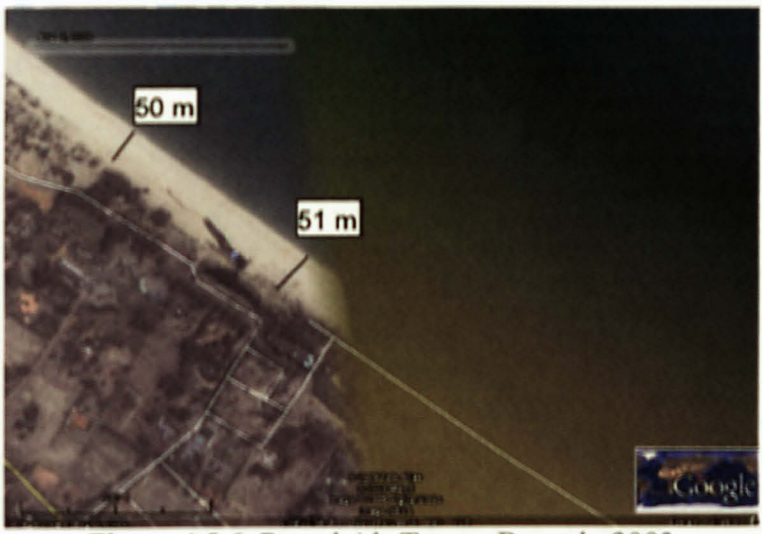


Figure A5.6: Pantai Air Tawar, Besut in 2003

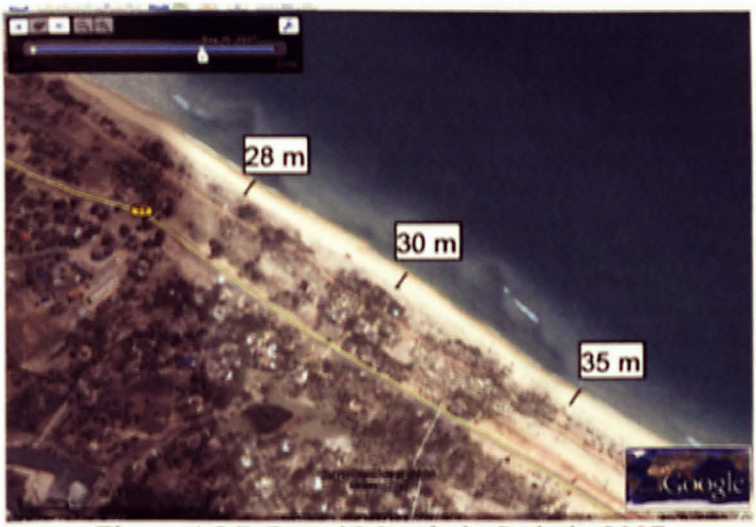


Figure A5.7: Pantai Mangkuk, Setiu in 2007

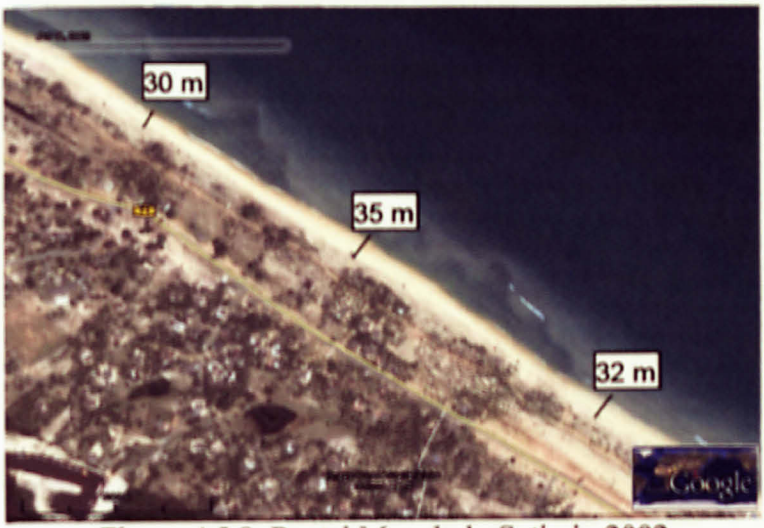


Figure A5.8: Pantai Mangkuk, Setiu in 2002

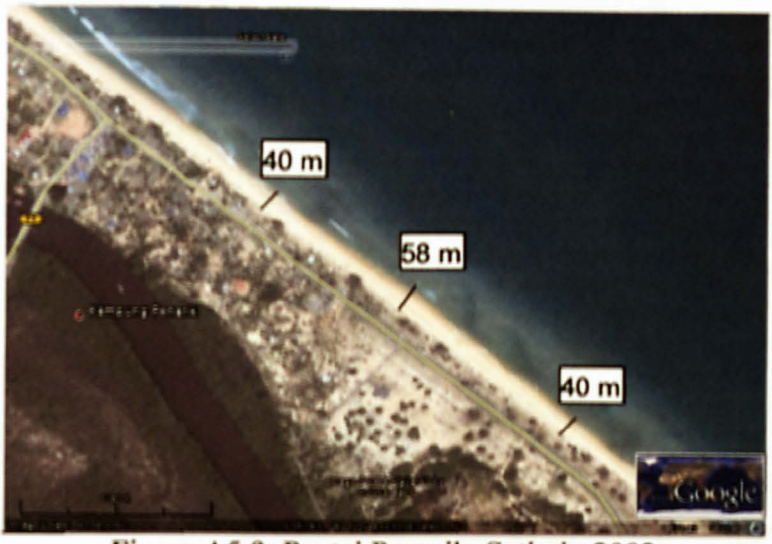


Figure A5.9: Pantai Penarik, Setiu in 2002

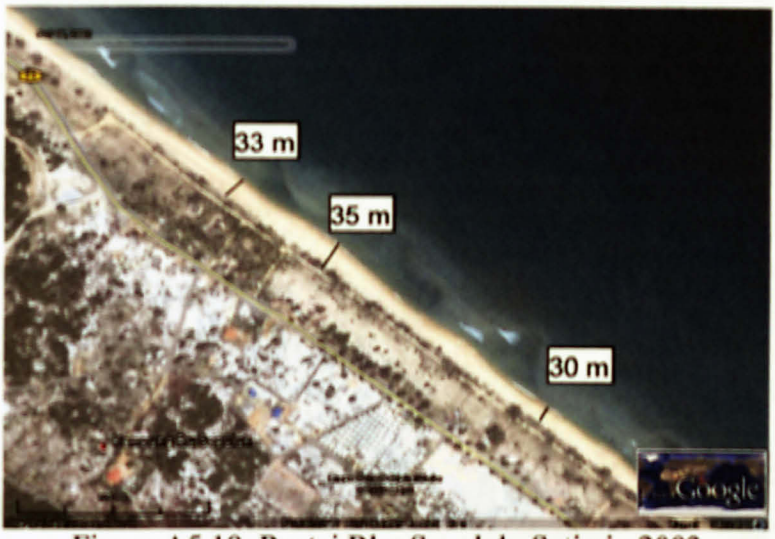


Figure A5.10: Pantai Rhu Sepuluh, Setiu in 2002

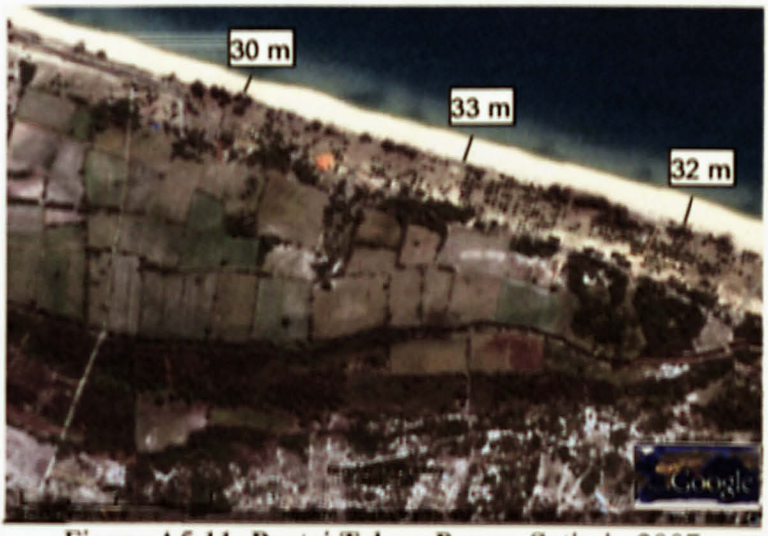


Figure A5.11: Pantai Telaga Papan, Setiu in 2007

Appendix 6

Table A6: Sediment Sample Location

Reach	No. of Sample	Location	
		North	East
1 (Pantai Teluk Bayu, Besut)	3	5° 50.25′	102° 32.85′
		5° 50.15′	102° 33.07′
		5° 50.12′	102° 33.27′
2 (Pantai Dataran Kuala Besut)	0	-	-
3 (Pantai Air Tawar)	2	5° 49.49′	102° 34.5′
		5° 48.50′	102° 35.35′
4 (Pantai Bukit Keluang)	2	5°48.35′	102° 36.60′
		5°48.13′	102° 36.22′
5 (Pantai Benting Lintang)	2	5°45.05′	102° 39.07′
		5° 44.24′	102° 39.57′
6 (Pantai Mangkuk)	2	5° 38.33′	102° 46.08′
		5° 38.09′	102° 47.10′
7(Pantai Penarik)	3	5° 37.10′	102° 48.38′
		5° 36.51′	102° 48.86′
		5° 36.30′	102° 48.96′
8 (Pantai Rhu Sepuluh)	1	5° 35.53′	102° 49.78′
9 (Pantai Telaga Papan)	2	5° 32.78′	102° 53.90′
		5° 32.37′	102° 54.69′
10 (Pantai Merang)	2	5° 32.15′	102° 56.66′
		5° 32.10′	102° 56.79′

Appendix 7

Table A7.1: Result of Sieve Analysis for Reach 1

BS Sieve Size (mm)	Location 1		Location 2		Location 3	
	Percentage Retained (%)	Total Passing (%)	Percentage Retained (%)	Total Passing (%)	Percentage Retained (%)	Total Passing (%)
2.26	4.59	95.41	11.54	88.46	13.44	86.56
2	4.02	91.39	9.08	79.38	16.59	69.97
1.18	35.58	55.81	51.35	28.03	41.66	28.31
600µ	49.57	6.24	16.54	11.48	10.92	17.38
425µ	1.54	4.70	1.05	10.43	7.27	10.12
212µ	1.30	3.40	0.22	10.22	8.26	1.86
150µ	1.70	1.70	0.02	10.20	1.56	0.30
63µ	1.68	0.02	10.16	0.04	0.25	0.05
pan	0.02	0.00	0.04	0.00	0.05	0.00

Table A7.2: Result of Sieve Analysis for Reach 3

BS Sieve Size (mm)	Location 1		Location 2	
	Percentage Retained (%)	Total Passing (%)	Percentage Retained (%)	Total Passing (%)
2.26	0.58	99.42	0.01	99.99
2	0.01	99.41	0.05	99.94
1.18	0.16	99.25	2.86	97.08
600µ	6.73	92.52	19.47	77.61
425µ	15.42	77.11	17.92	59.69
212µ	60.08	17.02	44.43	15.26
150µ	10.95	6.07	9.06	6.20
63µ	6.03	0.04	6.16	0.04
pan	0.04	0.00	0.04	0.00

Table A7.3: Result of Sieve Analysis for Reach 4

BS Sieve Size (mm)	Location 1		Location 2	
	Percentage Retained (%)	Total Passing (%)	Percentage Retained (%)	Total Passing (%)
2.26	0.00	100.00	0.08	99.92
2	0.10	99.90	0.00	99.92
1.18	2.98	96.92	1.79	98.13
600µ	48.04	48.88	34.16	63.98
425µ	32.81	16.07	29.01	34.97
212µ	7.63	8.44	25.58	9.38
150µ	5.07	3.36	1.54	7.84
63µ	3.36	0.00	7.78	0.06
pan	0.00	0.00	0.06	0.00

Table A7.4: Result of Sieve Analysis for Reach 5

BS Sieve Size (mm)	Location 1		Location 2	
	Percentage Retained (%)	Total Passing (%)	Percentage Retained (%)	Total Passing (%)
2.26	0.82	99.18	0.58	99.42
2	1.13	98.05	0.52	98.90
1.18	7.00	91.05	4.55	94.35
600μ	22.22	68.83	35.28	59.07
425μ	13.73	55.09	29.29	29.78
212μ	46.04	9.05	23.08	6.70
150μ	8.41	0.64	1.76	4.95
63μ	0.58	0.06	4.94	0.00
pan	0.06	0.00	0.00	0.00

Table A7.5: Result of Sieve Analysis for Reach 6

BS Sieve Size (mm)	Location 1		Location 2	
	Percentage Retained (%)	Total Passing (%)	Percentage Retained (%)	Total Passing (%)
2.26	0.12	99.88	0.27	99.73
2	0.05	99.84	0.28	99.45
1.18	0.60	99.24	1.49	97.96
600μ	8.53	90.71	9.57	88.39
425μ	20.07	70.64	22.30	66.09
212μ	58.93	11.71	55.20	10.89
150μ	6.29	5.42	5.45	5.44
63μ	5.35	0.07	5.34	0.10
pan	0.07	0.00	0.10	0.00

Table A7.6: Result of Sieve Analysis for Reach 7

BS Sieve Size (mm)	Location 1		Location 2		Location 3	
	Percentage Retained (%)	Total Passing (%)	Percentage Retained (%)	Total Passing (%)	Percentage Retained (%)	Total Passing (%)
2.26	0.04	99.96	10.38	89.62	10.98	89.02
2	0.17	99.79	7.01	82.61	5.27	83.75
1.18	1.10	98.69	34.33	48.28	20.38	63.37
600μ	9.94	88.75	21.78	26.50	22.93	40.44
425μ	21.44	67.32	16.10	10.40	13.57	26.87
212μ	64.07	3.25	10.19	0.21	19.24	7.64
150μ	1.33	1.93	0.20	0.02	2.45	5.18
63μ	1.92	0.01	0.01	0.00	5.12	0.06
pan	0.01	0.00	0.00	0.00	0.06	0.00

Table A7.7: Result of Sieve Analysis for Reach 8

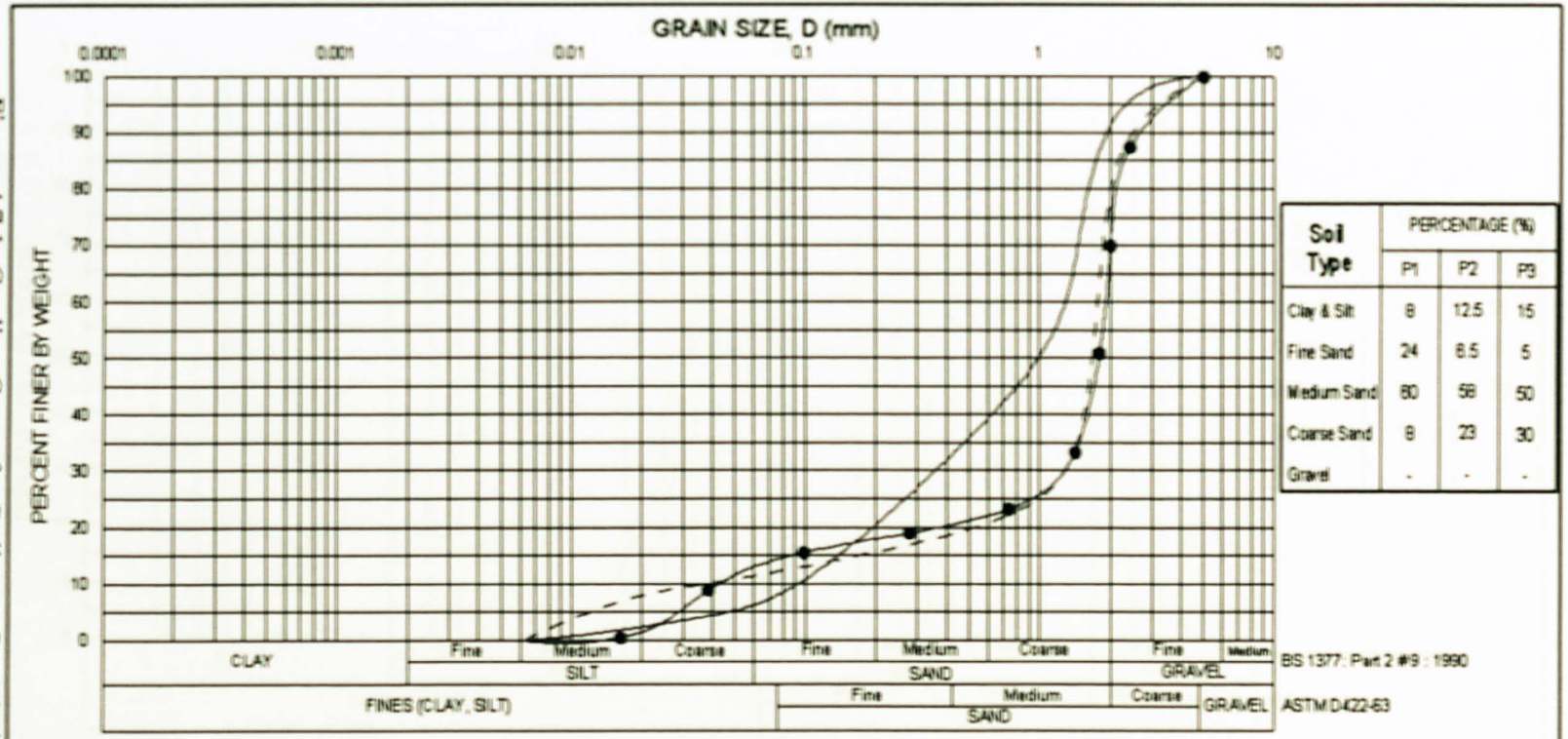
BS Sieve Size (mm)	Location 1	
	Percentage Retained (%)	Total Passing (%)
2.26	0.56	99.44
2	8.06	91.38
1.18	33.85	57.53
600μ	22.95	34.58
425μ	19.90	14.67
212μ	12.43	2.24
150μ	2.03	0.21
63μ	0.19	0.02
pan	0.02	0.00

Table A7.8: Result of Sieve Analysis for Reach 9

BS Sieve Size (mm)	Location 1		Location 2	
	Percentage Retained (%)	Total Passing (%)	Percentage Retained (%)	Total Passing (%)
2.26	1.46	98.54	5.22	94.78
2	0.88	97.67	2.59	92.19
1.18	4.81	92.86	8.14	84.05
600μ	49.24	43.62	31.71	52.35
425μ	35.43	8.19	25.48	26.86
212μ	7.97	0.22	21.83	5.04
150μ	0.16	0.06	4.96	0.07
63μ	0.04	0.03	0.06	0.01
pan	0.03	0.00	0.01	0.00

Table A7.9: Result of Sieve Analysis for Reach 10

BS Sieve Size (mm)	Location 1		Location 2	
	Percentage Retained (%)	Total Passing (%)	Percentage Retained (%)	Total Passing (%)
2.26	2.05	97.96	2.25	97.75
2	7.72	90.23	1.87	95.88
1.18	62.12	28.12	65.98	29.90
600μ	20.49	7.63	16.58	13.32
425μ	1.68	5.95	6.58	6.73
212μ	1.02	4.93	1.82	4.91
150μ	1.05	3.88	0.85	4.06
63μ	1.72	2.17	4.06	0.00
pan	2.17	0.00	0.00	0.00

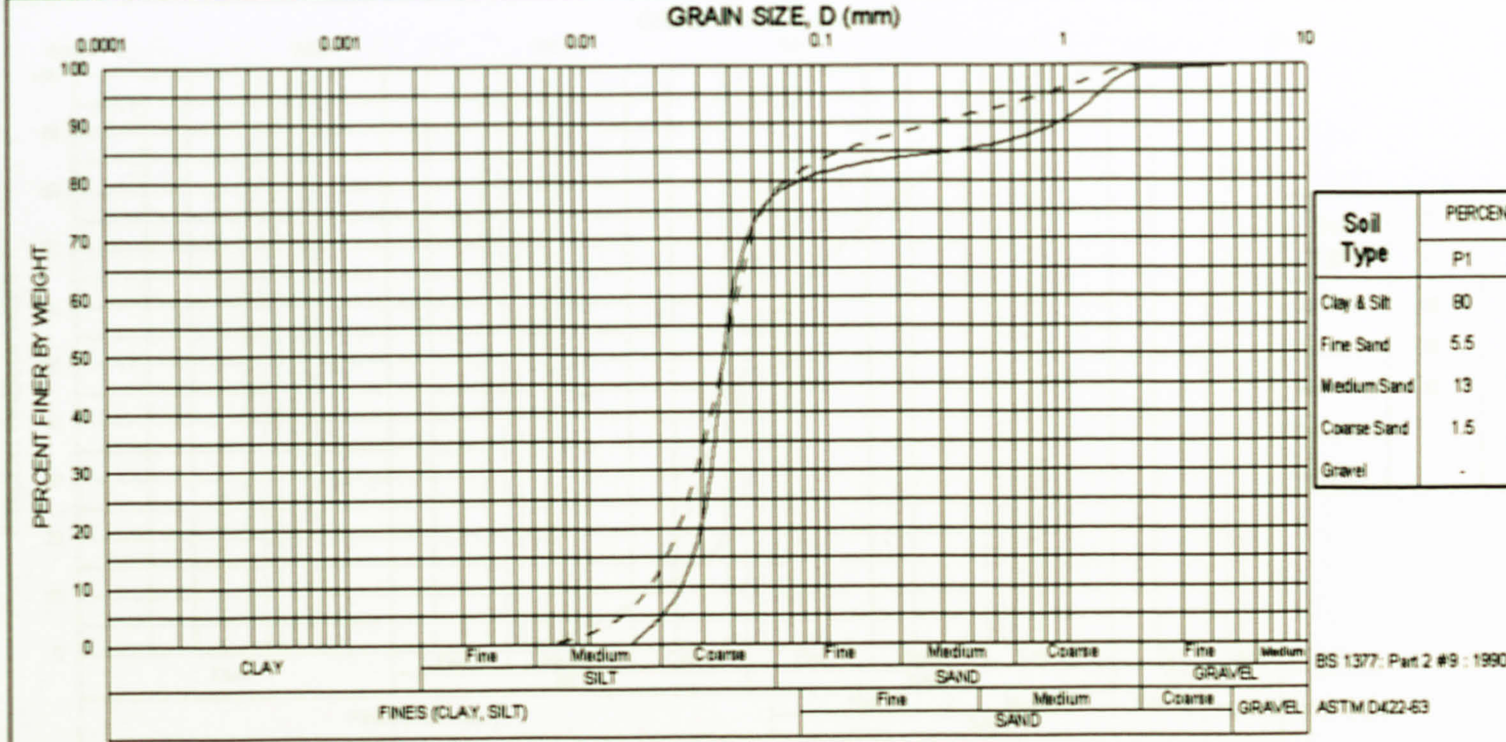


Soil Type	PERCENTAGE (%)		
	P1	P2	P3
Clay & Silt	8	12.5	15
Fine Sand	24	8.5	5
Medium Sand	60	56	50
Coarse Sand	8	23	30
Gravel	-	-	-

SAMPLE	LOCATION	CURVE	DISCUSSION	GRAIN SIZE DISTRIBUTION CURVE
Point 1 Point 2 Point 3	N 5° 50.25' E 102° 32.85' N 5° 50.15' E 102° 33.07' N 5° 50.12' E 102° 33.27'	—— - - - - - —•—•—	Poorly Graded Sample	**NORTHERN TERENGGANU COASTLINE** **Reach 1: Pantai Teluk Bayu, Besut**

Prepared by : Zahratul Akmal binti Ibrahim

Figure A7.1: Grading Curve for Sediment Sample in Reach 1

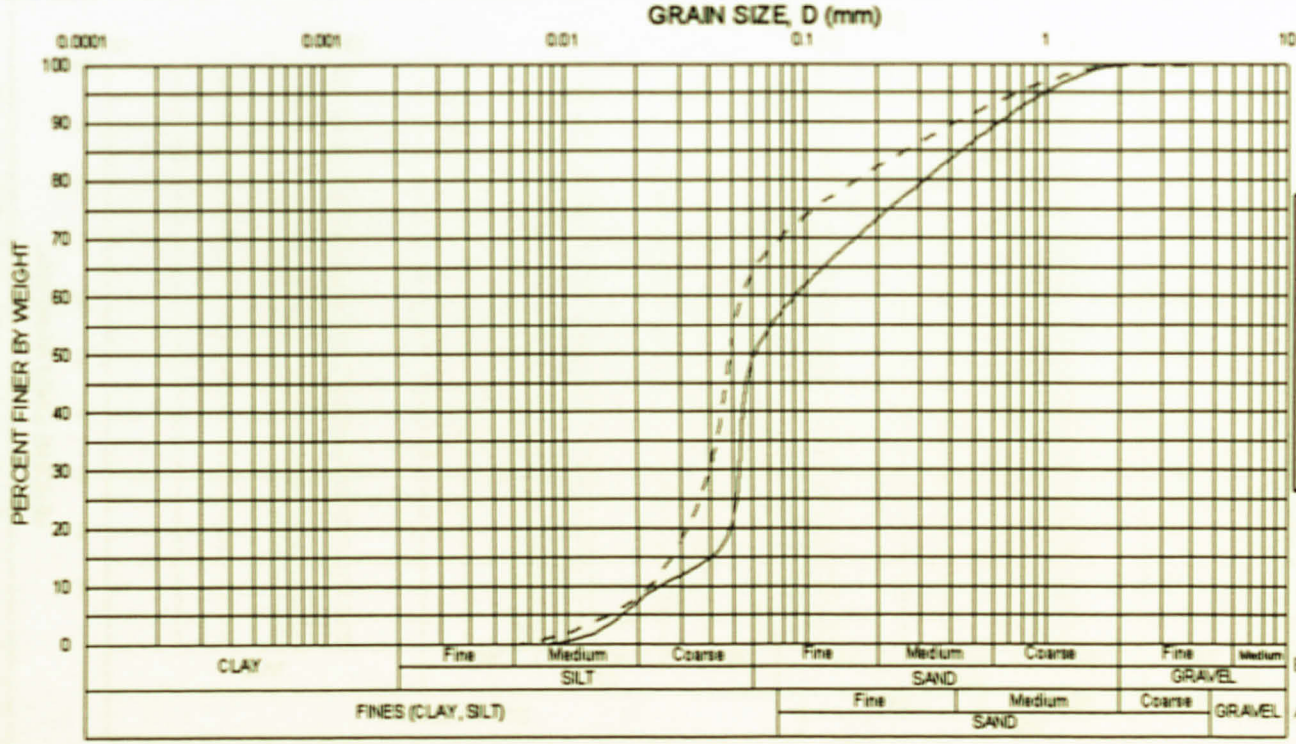


Soil Type	PERCENTAGE (%)	
	P1	P2
Clay & Silt	80	82.5
Fine Sand	5.5	9
Medium Sand	13	8.5
Coarse Sand	1.5	-
Gravel	-	-

SAMPLE	LOCATION	CURVE	DISCUSSION	GRAIN SIZE DISTRIBUTION CURVE
Point 1 Point 2	N 5° 49.49' E 102° 34.50' N 5° 48.50' E 102° 35.35'	———— - - - - - -	Well Graded Sample	**NORTHERN TERENGGANU COASTLINE** **Reach 3: Pantai Air Tawar, Besut**

Prepared by : Zahratul Akmal binti Ibrahim

Figure A7.2: Grading Curve for Sediment Sample in Reach 3

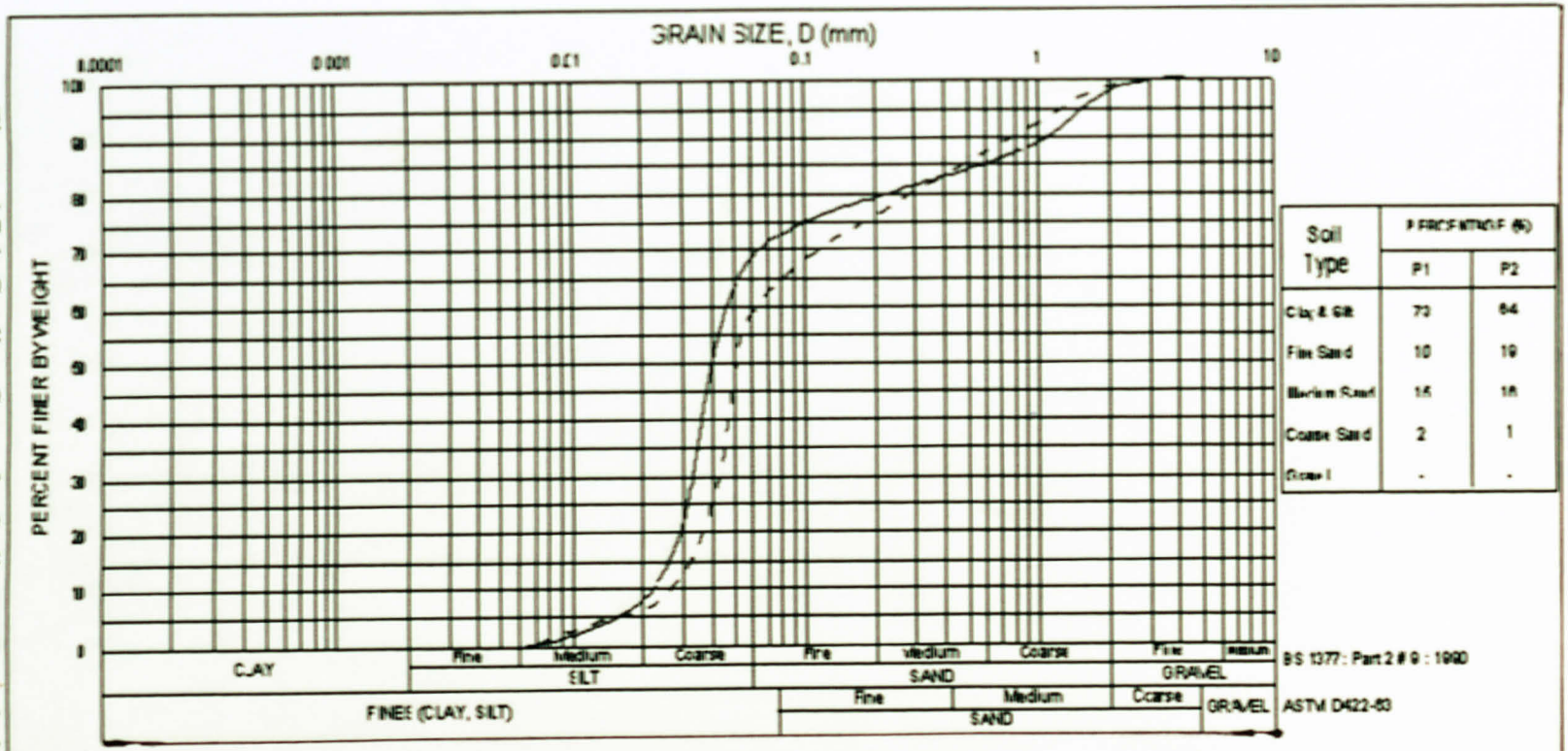


Soil Type	PERCENTAGE (%)	
	P1	P2
Clay & Silt	58	71
Fine Sand	25	18
Medium Sand	17	11
Coarse Sand	-	-
Gravel	-	-

SAMPLE	LOCATION	CURVE	DISCUSSION	GRAIN SIZE DISTRIBUTION CURVE
Point 1 Point 2	N 5° 48.35' E 102° 36.60' N 5° 48.13' E 102° 36.22'	—— - - - - - -	Well Graded Sample	**NORTHERN TERENGGANU COASTLINE** **Reach 4: Pantai Bukit Keluang, Besut**

Prepared by : Zahratul Akmal binti Ibrahim

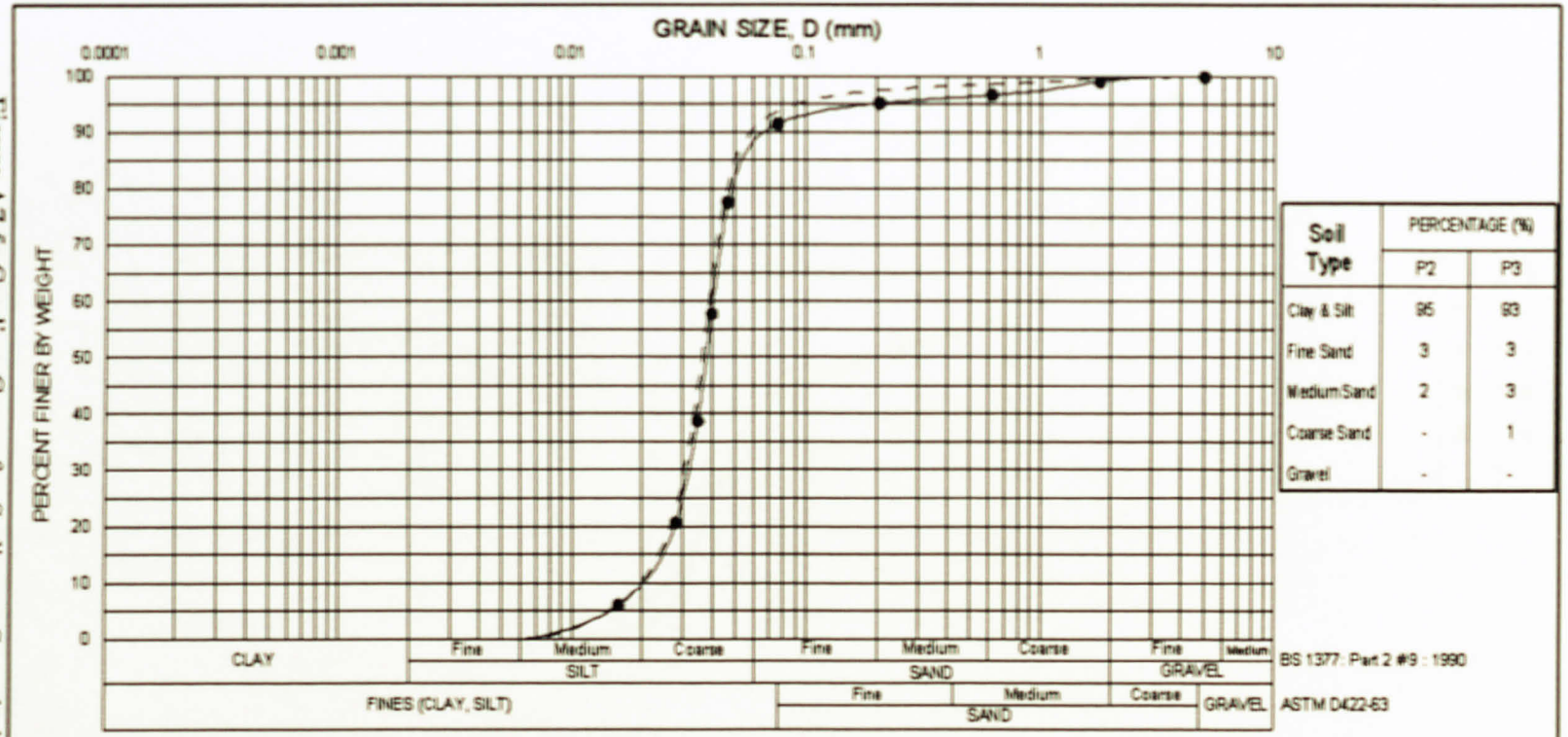
Figure A7.3: Grading Curve for Sediment Sample in Reach 4



SAMPLE	LOCATION	CURVE	DISCUSSION	GRAIN SIZE DISTRIBUTION CURVE
Point 1 Point 2	N 5° 45.05' E 102° 39.07' N 5° 44.24' E 102° 39.57'	- - - - - -	Well Graded Sample	NORTHERN TERENGGANU COASTLINE Reach 5: Pantai Betil Lintang, Besut

Prepared by : Zahratul Akmal binti Ibrahim

Figure A7.4: Grading Curve for Sediment Sample in Reach 5

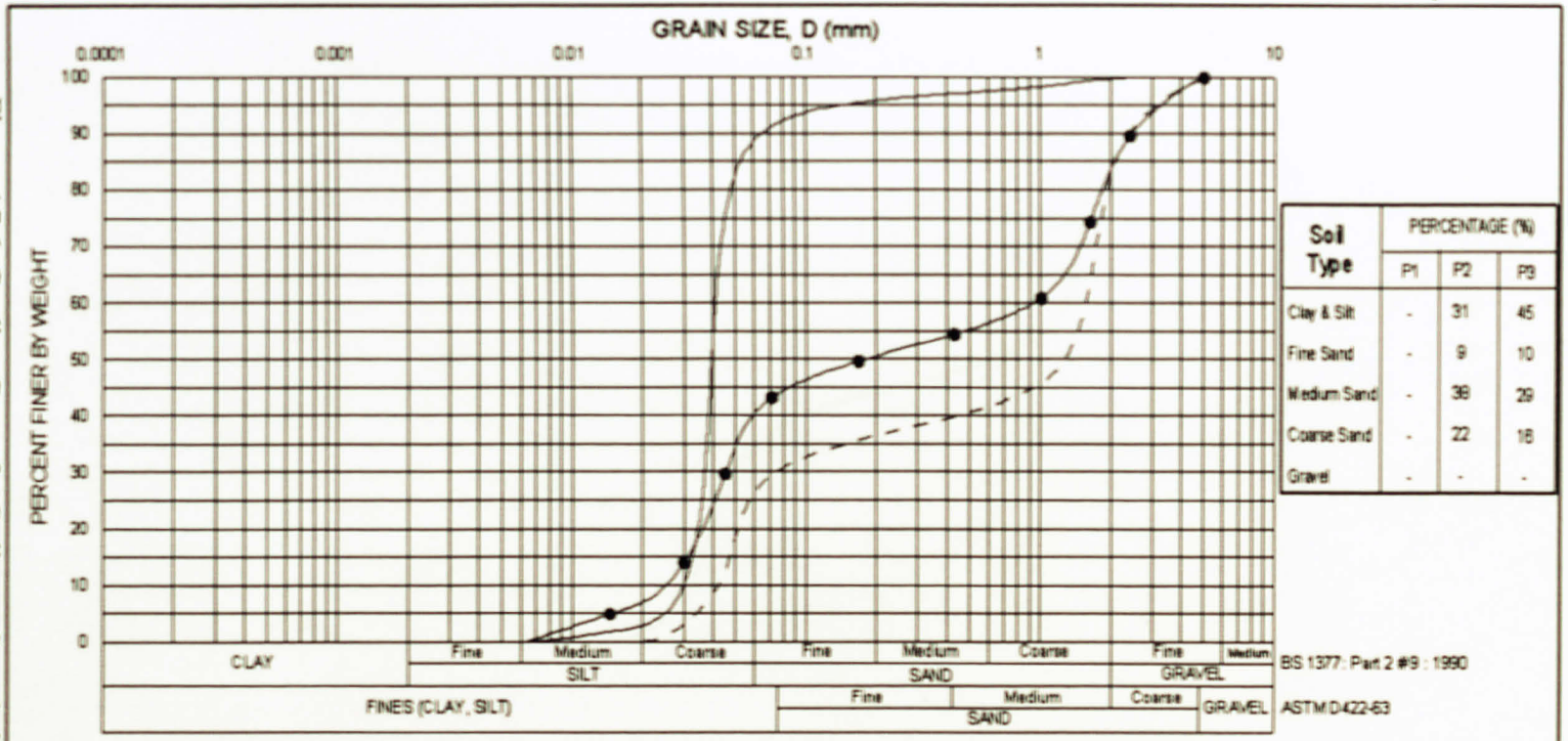


Soil Type	PERCENTAGE (%)	
	P2	P3
Clay & Silt	95	93
Fine Sand	3	3
Medium Sand	2	3
Coarse Sand	-	1
Gravel	-	-

SAMPLE	LOCATION	CURVE	DISCUSSION	GRAIN SIZE DISTRIBUTION CURVE
Point 2 Point 3	N 5° 38.33' E 102° 46.08' N 5° 38.09' E 102° 47.10'		Well Graded Sample	**NORTHERN TERENGGANU COASTLINE** **Reach 6: Pantai Mangkuk, Setiu**

Prepared by : Zahratul Akmal binti Ibrahim

Figure A7.5: Grading Curve for Sediment Sample in Reach 6



Soil Type	PERCENTAGE (%)		
	P1	P2	P3
Clay & Silt	-	31	45
Fine Sand	-	9	10
Medium Sand	-	38	29
Coarse Sand	-	22	16
Gravel	-	-	-

SAMPLE	LOCATION	CURVE	DISCUSSION	GRAIN SIZE DISTRIBUTION CURVE
Point 1	N 5° 37.10' E 102° 48.38'	———	Not to be considered	NORTHERN TERENGGANU COASTLINE
Point 2	N 5° 36.51' E 102° 48.86'	- - - - -		Reach 7: Pantai Penarik, Setiu
Point 3	N 5° 36.30' E 102° 48.96'	—•—•—	Gap Graded Sample	

Prepared by : Zahratul Akmal binti Ibrahim

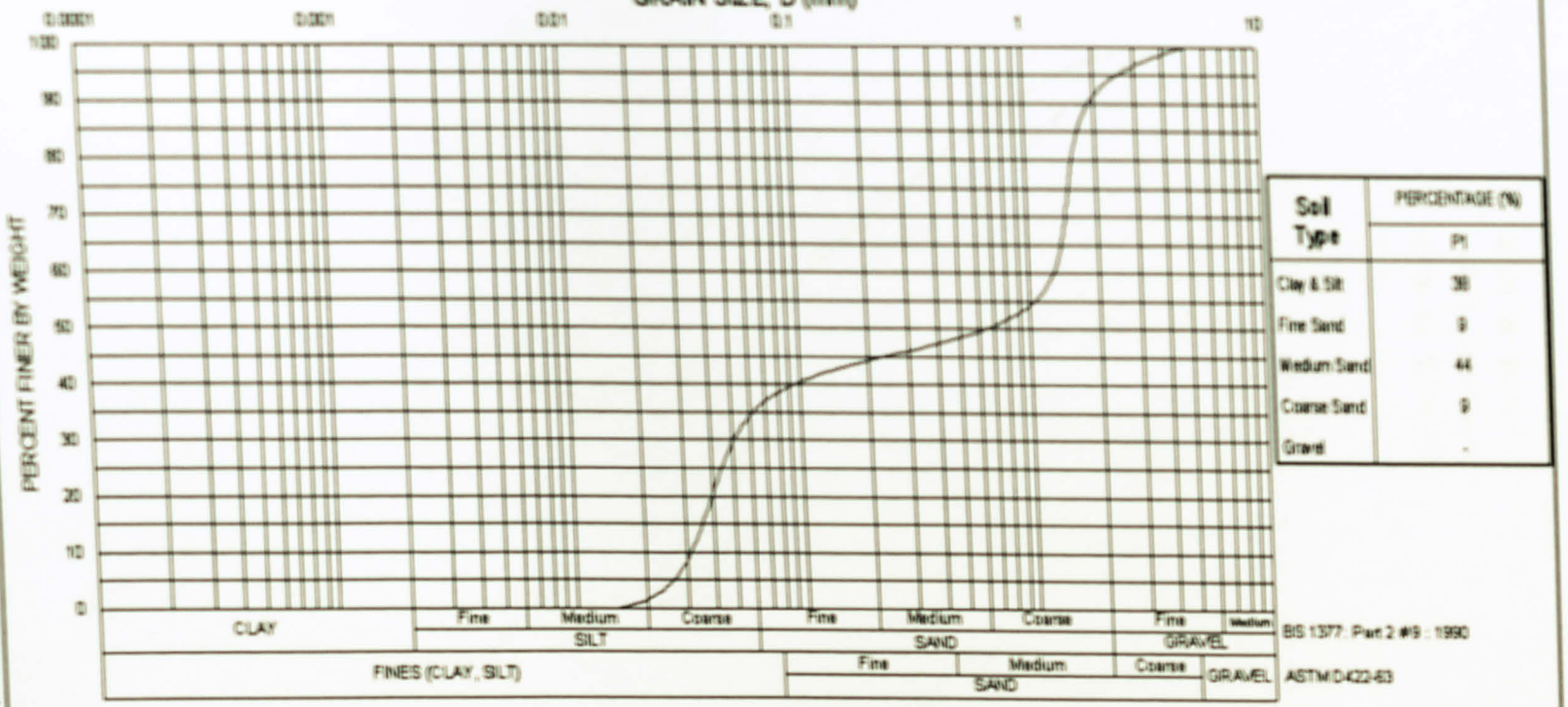
Figure A7.6: Grading Curve for Sediment Sample in Reach 7

Sample in Reach 8

CLAY	SILT	SAND			GRAVEL	ASTM D422-63
		Fine	Medium	Coarse		
FINES (CLAY, SILT)		SAND				

SAMPLE	LOCATION	CURVE	DISCUSSION	GRAIN SIZE DISTRIBUTION CURVE
Point 1	N 5° 35.53' E 102° 49.78'	_____	Gap Graded Sample	**NORTHERN TERENGGANU COASTLINE** **Reach 8: Pantai Rhu Sepuluh, Setiu**

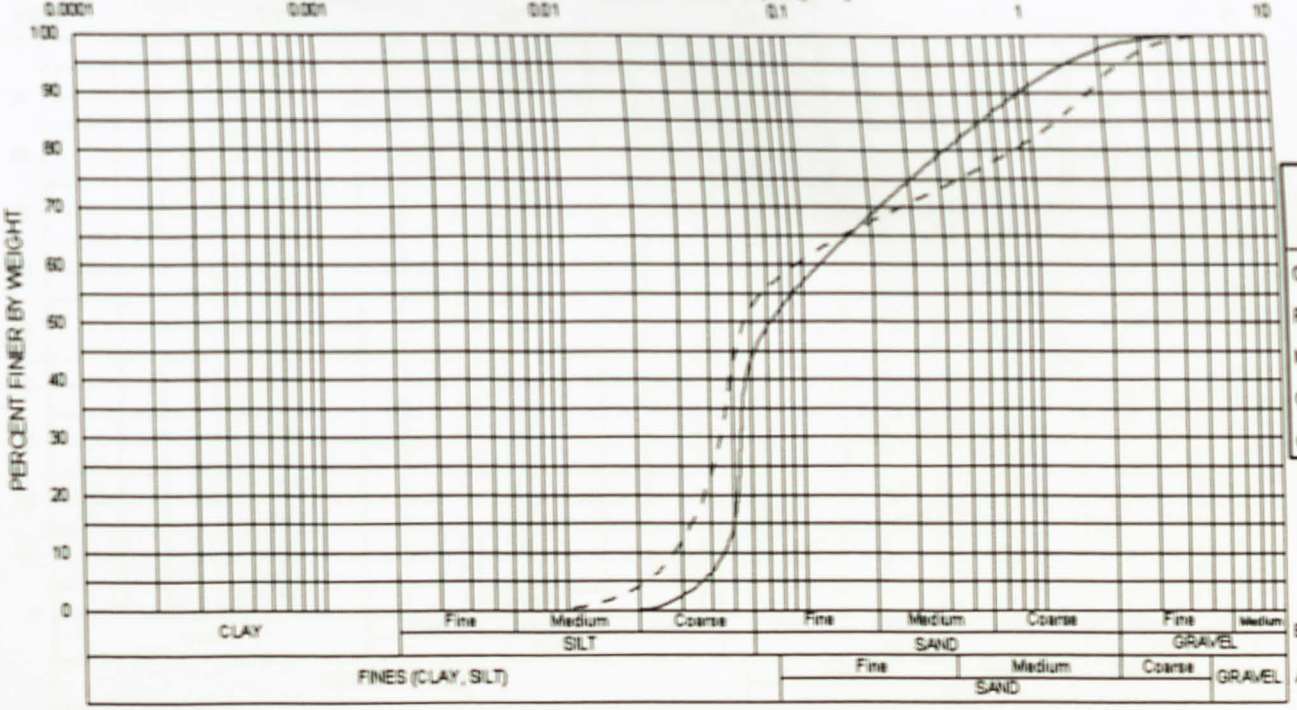
Prepared by : Zahratul Akmal binti Ibrahim



SAMPLE	LOCATION	CURVE	DISCUSSION	GRAIN SIZE DISTRIBUTION CURVE
Point 1	N 5° 35.53' E 102° 49.78'	———	Gap Graded Sample	**NORTHERN TERENGGANU COASTLINE** **Reach 8: Pantai Rhu Sepuluh, Setiu**

Prepared by : Zahratul Akmal binti Ibrahim

Figure A7.7: Grading Curve for Sediment Sample in Reach 8

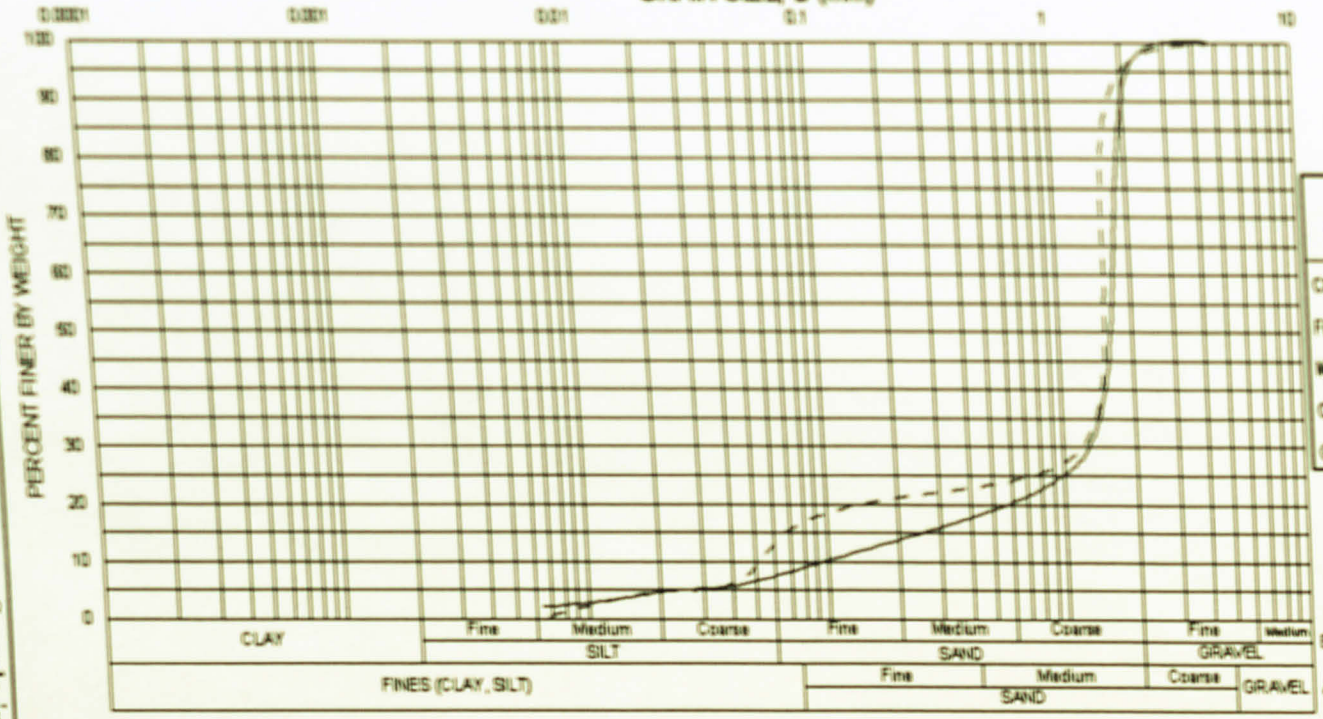


Soil Type	PERCENTAGE (%)	
	P1	P2
Clay & Silt	53	55
Fine Sand	27	18
Medium Sand	17	20
Coarse Sand	3	7
Gravel	-	-

Figure A7.8: Grading Curve for Sediment Sample in Reach 9

SAMPLE	LOCATION	CURVE	DISCUSSION	GRAIN SIZE DISTRIBUTION CURVE
Point 1 Point 2	N 5° 32.78' E 102° 53.90' N 5° 32.37' E 102° 54.69'	—————— – – – – – –	Poorly Graded Sample	**NORTHERN TERENGGANU COASTLINE** **Reach 9: Pantai Telaga Papan, Setiu**

Prepared by : Zahratul Akmal binti Ibrahim



Soil Type	PERCENTAGE (%)	
	P1	P2
Clay & Silt	8	15
Fine Sand	11	8
Medium Sand	71	72
Coarse Sand	10	5
Gravel	-	-

Figure A7.9: Grading Curve for Sediment Sample in Reach 10

SAMPLE	LOCATION	CURVE	DISCUSSION	GRAIN SIZE DISTRIBUTION CURVE
Point 1 Point 2	N 5° 32.15' E 102° 56.66' N 5° 32.10' E 102° 56.79'	—————— – – – – – –	Poorly Graded Sample	**NORTHERN TERENGGANU COASTLINE** **Reach 10: Pantai Merang, Setiu**

Prepared by : Zahratul Akmal binti Ibrahim