RIVER MORPHOLOGY STUDY IN SUNGAI LEMBING DUE TO IMPACT OF SEDIMENTATIONS AND FLOODS

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Report submitted in fulfillment of the requirements
for the award of the degree of
B. Eng (Hons.) Civil Engineering

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I dedicate this thesis to:

My dearest parents, Muhammad Azman Shah b Ariffin and Zuraila bt Hj Said,
beloved siblings,
without their continuous support, love and care,
I wouldn’t be able to achieve what I have achieved now.

My cherished supervisor, Mdm Nadiatul Adilah bt Ahmad Abdul Ghani,
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My teammates and friends.
Thanks for all your love and encouragement.

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ABSTRACT

A study on river morphology was conducted at Sg. Lembing, Kuantan, Pahang. The major contribution to the depositional process in the river is sediment which is composed by granular materials that have variety size and type. Excess sediment could cause the river level increase that can cause changes of the river morphology. This study focused on changes of river morphology by determine the point of the river that has major changes, sediment grain sizes and types, rainfall data and factors influencing sediment transportation. Three sampling stations have been chosen based on analysing the river changes between in year 2010 to 2015 by using google earth software. Started from upstream Sg. Lembing (Station 1), mid-stream Sg. Lembing (Station 2) and downstream Sg. Lembing (Station 3). Sampling data are collected in two day which is on 16 March 2016 and 23 March 2016. Sample of sediment for every station were sieved to get the sediment grain size. Sediment particles in every station were classified based from United State Army Corps Engineer table (USACE). The data from Department of Irrigation and Drainage and weather station 3930012 Sg. Lembing PCC Mill is used for analysed rainfall pattern. The rainfall data is collected from year 2008 to 2015 to identify the effect of the rainfall to the sediment transportation. Overall, the finding of the study show that the most size of sediment at Sg. Lembing between 2.360mm to 0.425mm. The minimum and maximum total yearly data is 1443mm and 3775.5mm at 2008 and 2011 respectively.

ABSTRAK

Satu kajian mengenai morfologi sungai telah dijalankan di Sg. Lembing, Kuantan, Pahang. Sumbangan utama kepada proses pengenapan di dalam sungai adalah sedimen terdiri dari bahan-bahan berbutir yang mempunyai pelbagai saiz dan jenis. Sedimen yang berlebihan boleh menyebabkan peningkatan paras sungai yang boleh menyebabkan perubahan morfologi sungai. Kajian ini memberi tumpuan kepada perubahan morfologi sungai dengan menentukan titik sungai yang mempunyai perubahan besar. Tiga stesen pensampelan telah dipilih berdasarkan perubahan sungai di antara tahun 2010 sehingga 2015 yang telah dianalisa dengan menggunakan perisian Google Earth. Lokasi kajian adalah di hulu (Stesen 1), pertengahan aliran (Stesen 2) dan hiliran (Stesen 3). Data pensampelan dikumpulkan dalam dua hari iaitu pada 16 Mac 2016 dan 23 Mac 2016. Sampel sedimen bagi setiap stesen telah disaring untuk mendapatkan saiz butir sedimen. Partikel sedimen di setiap stesen diklasifikasikan berdasarkan Jadual United State Army Corps Engineer. Data daripada Jabatan Pengairan dan Saliran dan stesen cuaca 3930012 Sg. Lembing PCC Mill digunakan untuk mengkaji corak hujan. Data hujan dikumpul dari tahun 2008-2015 untuk mengenal pasti faktor utama yang mempengaruhi kepada pengangkutan sedimen. Sebagai kesimpulan, saiz sedimen di Sg. Lembing adalah antara 2.360mm sehingga 0.425mm. Jumlah data hujan tahunan minimum dan maksimum adalah 1443mm dan 3775.5mm masing-masing pada tahun 2008 dan 2011.

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LIST OF SYMBOLS

%	percent
km	kilometre
m	metre
mm	milimeter
µm	micrometer
mg/L	milligram per litre
gm/m^3	gram per metre cube
kg/m^3	kilogram per metre cube
ºC	Celsius

LIST OF ABBREVIATIONS

UMP	Universiti Malaysia Pahang
DID	Department of Irrigation and Drainage
USACE	United States Army Corps Engineer
ARI	Average Recurrence Interval
Sg.	Sungai
SF	Shape Factor

LIST OF EQUATIONS

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Erosion and sedimentation problems are becoming major threats and hazards for the lifespan of man-made surface water reservoirs as well as for the natural water bodies. In Malaysia, due to rapid urbanization and agricultural necessity, land clearing activities and human intervention to natural ecosystem are unavoidable. These land clearing activities may accelerate erosional processes and thus introduce water derived sediment to adjacent water bodies and may affect water quality subsequently. The fact that soil erosion and sedimentation continue to be an environmental problem of significant proportions in the country suggests that additional and more definitive guidelines, and more stringent monitoring and enforcement are required. In addition, proper mitigation measures need to be in place and maintained from time to time.

Erosion and sedimentation are linked to each other and embody the processes of erosion, transportation and deposition mechanism of sediments. In nature, there are two major types of erosion, example by water and wind. For Malaysian environment water is the most significant erosion due to high mean of annual rainfall, storm frequency and density (Department of Irrigation and Drainage, 2001). Sediments which reach streams or watercourses can accelerate bank erosion, clog drainage ditches and stream channels, reduce the depth and capacity of the channels and silt reservoirs. This may cause hydrological deterioration and can lead to severe flooding.

1.2 PROBLEM STATEMENT

Rapid urbanization in Kuantan town has accelerated impact on the catchment hydrology and geomorphology. This rapid development which takes place in river catchment will result in higher sediment yield and affect river morphology and river stability (Chang Chun Kiat et al., 2010). Changes to the land use can decrease permeability, increase fine sediment inputs, impact on water quality and increase runoff. These changes create an unbalance in the natural processes and lead to increased flood events, reduce base flows, decrease habitat diversity and channel erosion.

Several major floods occurred in the last few decades in Kuantan, not only causing extensive damage and inconvenience to the community or the economic, but also the river morphology itself. Over a period of time, the high amount of sediment will settle down and the accumulated sediment will eat up the river bed (Nadiatul Adilah et al., 2013). The sediment also will reduce the function of the river and will cause flooding and brings along the sediments from upstream to downstream when receives heavy rainfall during monsoon time.

1.3 OBJECTIVE OF STUDY

The objectives of this study are:

i. To study the river morphology and identify the area that contributed high sedimentation to the Sg. Lembing downstream catchment by comparisons of satellite images.
ii. To identify the types and characteristics of sediment at Sg. Lembing catchment area.
iii. To determine the factor that affect transportation of sediment within Sungai Lembing catchment area.

1.4 SCOPE OF STUDY

A study area for this project was located in Sg. Lembing in district of Kuantan, Pahang, East Coast of Peninsular Malaysia, about 45km from University Malaysia Pahang (UMP) and 35km from Kuantan town. This study will concentrate on the types of sediment of 3 sample location where the river morphology change. Besides that, the changes of the river cross section due to the sedimentation and flood will be measure.

1.5 SIGNIFICANT OF STUDY

The results of this study provide benefits to the Kuantan area and to the larger scientific community. Locally this study will provide data for educators and help managers implement management strategies to reduce sedimentation. At the end of this study, the river morphology and area that contributes high sedimentation to the downstream of Sg. Lembing could be determined and analyse. Besides that, the sediment characteristics such as grain size and factors influencing sediment transportation also could be determined and known.

CHAPTER 2

LITERATURE REVIEW

2.1 RIVER

Rivers are the most important freshwater resource for mankind. Most commonly rivers flow on the surface but there are many examples of underground rivers where the flow is contained within chambers, caves or caverns. River is very useful and has various functions in human life such as for domestics, economics, connection for one place to others place and many more. The main function of the river is to flow the water to the water storage or sea. River also brings the sediment from upstream or from erosion process. Sediments may affect the characteristics and the rate of the river. As example, the depth of river become shallow if the sedimentation occurred. It also will make the quantity of aquatic life will reduced (Nadiatul Adilah et al., 2013).

River in Malaysia often originated from the highlands. The highlands are often referred to as natural water towers as a significant amount of water from rainfall is captured and accumulated in forest. Upstream areas of a river are characterised by steep V-shaped valleys and waterfalls. In the middle, the river winds its way slowly through the flatter land and continues to widen channel.

2.2 SOIL EROSION

Erosion of soil from the catchments involves the process of detachment of soil from the soil surface and its transport by rainfall and runoff. Water is a very dangerous agent than the wind. Water soluble and will not only run but also erode the nutrients and soil grains break away (Toriman, 2013). The overland flow exerts shear stress on the surface thereby inducing both detachment and transportation of soil particles. Deposition of detached material takes place when the transport capacity of flow is smaller than the quantity of material being transported.

Activities such as deforestation, mining and agriculture that dominantly occurred in the recent past due to developments, resulted in soil on land surfaces exposed directly to the rains. This unprotected soil could be easily removed from the land surfaces by the combined action of rain and the resulting flow (Mahabaleshwara & Nagabhushan, 2014). Soil erosion may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing serious loss of topsoil. The loss of soil from farmland may be reflected in reduced crop production potential, lower surface water quality and damaged drainage networks.

2.3 SEDIMENTATION

Sedimentation is the process of letting the suspended material to settle by gravity. The sediment size can be small, such as sand, small pebbles and silt, or large such as boulders, which are normally found upriver (Nadiatul Adilah et al., 2013). Sediments found in estuaries are mostly fine-grained, such as sand and silt. Sedimentation accomplished by decreasing the velocity of the water, which is treated to a point below. So the particle will not remain in the suspension. If the velocity no longer supports the particle, it will be remove by the gravity.

If the flow velocity is greater than the settling velocity, sediment will be transported downstream as suspended load. As there will always be a range of different particle sizes in the flow, some will have sufficiently large diameters that they settle on the river or streambed, but still move downstream. This is known as bed load and the particles are transported via such mechanism as saltation (jumping up into the flow, being transported short distance then settling again), rolling and sliding.

2.4 TRANSPORTATION

The higher the water velocity, the more capacity a river has for transporting sediment load. There are three different processes in transporting sediment load. They are corrosion, suspension and traction. Corrosion is the process in which stream water corrodes rocks and brings them invisibly into solution. Such fine materials as clay, silt, fine sand and materials lighter than water are transported in the water or on the water surface without contact with the river bed. This process is called suspension, and materials carried in suspension are the suspended loads. Suspended load creates the turbidity of stream water. Gravel of larger diameter slides or rolls, and sand hops or bounds on a river bed. These processes are called traction. Sediment load carried by traction is known as bed load. The amount and size of sediment moving through a river channel are determined by three fundamental controls such as competence, capacity and sediment supply (Hickin, 1995).

2.5 MODES OF SEDIMENT TRANSPORT

The sediment load of a river is transported in several ways, although these distinctions are to some extent arbitrary and not always very practical in the sense that not all of the constituents can be singled out in practice:

2.5.1 Dissolved Load

Dissolved load is material that has gone into solution and is part of the fluid moving through the channel. Since it is dissolved, it does not depend on forces in the flow to keep it in the water column. The amount of material in solution depends on the supply of a solute and the saturation point for the fluid. Obviously, the dissolved load is also very sensitive to water temperature and, other things being equal, tropical rivers carry larger dissolved loads than those in temperate environments (Hickin, 1995).

2.5.2 Suspended sediment load

Suspended-sediment load is the particulate material that moves through the channel in the water column. These materials, mainly silt and sand, are kept in suspension by the upward flux of turbulence generated at the bottom of the channel. The upward currents must equal or exceed the particle fall-velocity (Figure 2.2) for suspended-sediment load to be sustained.

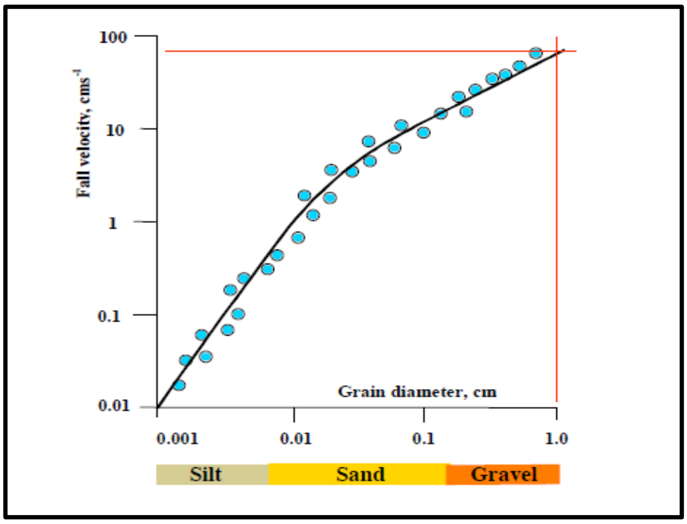

Figure 2.1: Fall velocity in relation to diameter of a spherical grain of quartz

Suspended-sediment concentration is conventionally measured as milligrams per litre (mg/L) which is the same number as gm/m^3. So 1000 mg/L = 1000 gm/m^3 = 1 kg/m^3. The size and concentration of suspended-sediment typically varies logarithmically with height above the bed. That is, concentration and grain size form linear plots with the logarithm of height above the bed. Coarse sand is highly concentrated near the bed and declines with height at a faster rate than doe's fine sand. Fine silt is so easily suspended that it is far more uniformly distributed in a vertical section than is the coarser material. Similarly, the grain-size distribution within a sample of sand displays far more vertical variation than does the vertical distribution of grain size within the silt range. The former is too large for the flow to move much of it into the upper water column and the latter is so small and easily suspended that it is well represented at all levels thus giving rise to a more uniform grain-size profile (Hickin, 1995).

2.5.3 Wash load

Although wash load is part of the suspended-sediment load it is useful here to make a distinction. Unlike most suspended-sediment load, wash load does not rely on the force of mechanical turbulence generated by flowing water to keep it in suspension. It is so fine (in the clay range) that it is maintained in suspension by thermal molecular agitation. Unlike coarser suspended-sediment, wash load tends to be uniformly distributed throughout the water column. That is, it does not vary with height above the bed.

2.5.4 Bed load

Bed load transport is closely associated with inter-granular forces (Chanson, 1999). Bed load is the particulate material that moves through the channel fully supported by the channel bed itself. These materials, mainly sand and gravel, are kept in motion (rolling and sliding) by the shear stress acting at the boundary. Unlike the suspended load, the bed-load component is almost always capacity limited. A distinction is often made between the bed-material load and the bed load.

Bed load, strictly defined, is just that component of the moving sediment that is supported by the bed (and not by the flow). That is, the term “bed load” refers to a mode of transport and not to a source. Bed load is extremely difficult to measure directly because the measuring instrument (bed-load sampler) invariably interferes with the flow.

A commonly practiced type of bed-load sampler is shown in Figure 2.2. In small streams where the sampler can often be placed on the bed so that it is appropriately oriented to the flow, the sample collected may be meaningful, although there is always some bed scour at the inlet that distorts the actual bed-load transport in the vicinity of the instrument. In large rivers where the sampler must be lowered from a boat by a cable to an unseen bed, however, measurements can be highly inaccurate and must be repeated many times before one can have confidence in the results (Hickin, 1995).

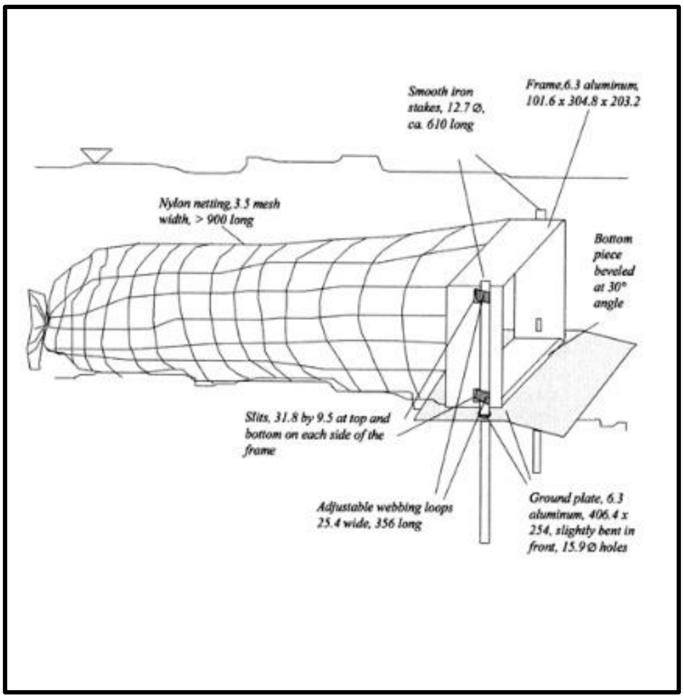

Figure 2.2: A commonly used type of bed-load sampler

2.6 PROPERTIES OF SEDIMENT

Sediment characteristics can influence the rate and the pattern of the river condition. There have some natural factors may affect the condition of the river such as particle size, chemical composition, fall velocity and many more. In this study case, the size of sediment, fall velocity and the sediment density have been choice to determine the characteristics of sediment (Nadiatul Adilah et al., 2013).

2.6.1 Size and shape

Grain size is the most important property affecting transportability of sediment. Natural sediment is of irregular shape and therefore any single diameter used to characterize a certain group of grains must be chosen according to some convenient method of measurement. The usually adopted diameter area:

a) Triaxial diameter: These sizes represent the major, intermediate and minor dimensions of the particle measured along mutually perpendicular axes.

b) Sieve diameter: This size indicates the size of the sieve opening through which the particle will just pass.

c) Sedimentation diameter: This size represents the diameter of a sphere of the same specific weight and fall velocity as the given particle in the same sedimentation fluid with the same temperature. This is also called the fall diameter.

d) Nominal diameter: This represents the diameter of a sphere having the same volume as the given particle.

e) Geometric mean diameter: This is the square root of the product of the maximum and minimum size limits in a range. For example a very coarse and with a size range of 1.00-2.00mm has a geometric mean 1.414mm.

f) Mean diameter: This size is the representative grain size computed from the relation:

$$D_m = (p_1D_1 + p_2D_2 + \ldots p_nD_n)/(p_1 + p_2 + \ldots + p_n) \quad \text{........ (equation 2.1)}$$

Where,
$p_1,p_2,...p_n$ are the grain size fractions associated with size classification 1, 2,.., n
and D_1, $D_2 \ldots D_n$ are the average diameters for size classifications 1, 2,.., n

g) Median diameter: This diameter corresponds to the 50 percent finer by weight or by volume in the size distribution curve called the gradation curve.

2.6.2 Measurement of size distribution

Size determination by means of sieving can in principle be used for particles as small as 50µm, but gives good results for particles down to 75µm. Sieve size openings are made in a geometric series with every sieve being $(2)^{1/4}$ larger in size than the preceding. Taking every other sieve gives a $(2)^{1/2}$ series, whereas taking every fourth gives a ratio of 2 between adjacent sieve sizes.

2.6.3 Grain size distribution

By means of sieving, a grain size distribution of the bed material sample can be obtained, which generally shows a relation between percentages by weight versus grain size, called the gradation curve. Figure 2.4 shows an example of a gradation curve. The cumulative size distribution of most samples can be approximated by a long normal distribution, so by using logarithms probability scale, a more or less straight line is found.

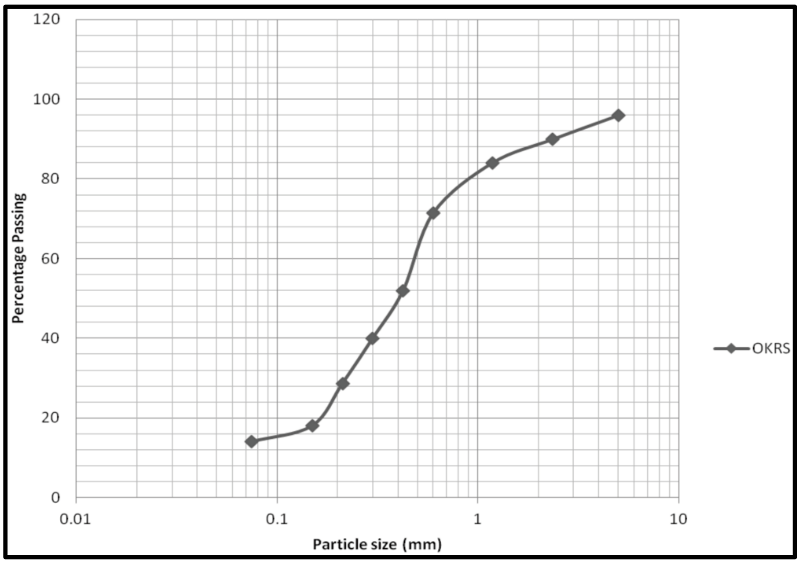

Figure 2.3: Gradation curve for the soil aggregates analysed

In addition to the grain particles distribution, size and shape, the types of the grain is also important. A types describes the form according scale size by United States Army Corps Engineers (USACE, 1991).

Class Name	Millimeters	Feet	PHI Value
Boulders	>256	–	<−8
Cobbles	256–64	–	−8 to −6
Very Coarse Gravel (VCG)	64–32	.148596	−6 to −5
Coarse Gravel (CG)	32–16	.074216	−5 to −4
Medium Gravel (MG)	16–8	.037120	−4 to −3
Fine Gravel (FG)	8–4	.018560	−3 to −2
Very Fine Gravel (VFG)	4–2	.009279	−2 to −1
Very Coarse Sand (VCS)	2.0–1.0	.004639	−1 to 0
Coarse Sand (CS)	1.0–0.50	.002319	0 to +1
Medium Sand (MS)	0.50–0.25	.001160	+1 to +2
Fine Sand (FS)	0.25–0.125	.000580	+2 to +3
Very Fine Sand (VFS)	0.125–0.0625	.00288	+3 to +4
Coarse Silt	0.0625–0.031	.000144	+4 to +5
Medium Silt	0.031–0.016	.000072	+5 to +6
Fine Silt	0.016–0.008	.000036	+6 to +7
Very Fine Silt	0.008–0.004	.000018	+7 to +8
Coarse Clay	0.004–0.0020	.000009	+8 to +9
Medium Clay	0.0020–0.0010	–	+9 to +10
Fine Clay	0.0010–0.0005	–	+10 to +11
Very Fine Clay	0.005–0.00024	–	+11 to +12
Colloids	<0.00024	–	>+12

Figure 2.4: Classification of Sediment Particles (USACE, 1991)

2.6.4 Particle shape

In addition to the diameter of the grain particles, their shape and roundness is also important. Shape describes the form of the particle without reference to the sharpness of its edges, whereas roundness depends on the sharpness or radius of curvature of the edges. For example, a flat particle will have a smaller fall velocity than a sphere, but bed load will be more difficult to transport. Several definitions are used to characterize the shape:

a) Sphericity: The ratio of the surface area of a sphere with the same volume as the particle, to the surface area of that particle.

b) Roundness: The ratio of the average radius of curvature of the edges, to the radius of a circle that can be described within the maximum projected area of the particle.

c) Shape factor: S.F. = $c/(ab)^{1/2}$ with a, b and c being the major, intermediate and minor dimensions of the particle measured along mutually perpendicular axes. For sphere, S.F = 1; for natural sand, S.F = 0.7. Because sphericity and roughness are difficult to determine in practice, the shape factor does have practical applications. As an example, the fall velocity of a particle can be expressed in terms of the nominal diameter, shape factor, and Reynolds number.

2.6.5 Fall velocity

Fall velocity is the velocity at which a sediment particle falls through a fluid. This velocity reflects the particle size, pattern, and weight, as considerably as the fluid characteristics. Consider a sphere of diameter D that is released at zero velocity in a quiescent fluid (water). As the fall velocity W increase, fluid resistance reduces the acceleration to an equilibrium. At equilibrium, the gravitational attraction force is in equilibrium with the drag force and a terminal velocity W_T exists.

2.7 IMPACTS ON FLOODS

Floods are the natural calamity which results in huge losses in the human lives and the property. In India occurrence of floods are very frequent, many existing example proves its severity. A flood is relatively high stream flow that overtops the natural or artificial banks in any reach of a stream. The overtopping of the banks results in spreading of water flow, the flood plains and generally comes into conflicts with men and his activities. Usually no overflow of the banks during high discharges and the problem is confined to bank erosion, rise of bed level due to sedimentation. Occurrence of floods due to excessive precipitation, combined with inadequate channel capacity. Over spilling can also occur due to obstruction in or aggradation of the river bed.

Erosion leads for carrying of silt along with river water, part of which gets accumulated at the bed also along the banks, thereby rise in the bed level and congestion in the water flow will occur. The erosion of soil due to cultivation practices in the encroached river course results to flooding situation (Mahabaleshwara & Nagabhushan, 2014).

2.8 RAINFALL

Rainfall is a component in the hydrologic cycle, which is a continuous process that happens on the earth. Rainfall is the amount of water that falls on the land from precipitation process. Precipitation occurs when the vapours in the atmosphere having a condensation process and change into droplets that cannot be suspended in the air. There a few factors for the occurrence of rainfall. Ground elevation, wind direction and location within a continental mass would give a big impact for the precipitation to occur. By knowing the nature of the rainfall, we can make a prediction on how it affect the surface runoff, infiltration, evaporation and water yield.

2.9 RAINFALL ESTIMATIONS

Rainfall data and characteristics are the driving force behind all storm water studies and designs. Adequacy and significance of the rainfall design is a necessary pre-requisite for preparing satisfactory urban drainage and storm water management projects. The estimation involves frequency, duration and intensity analyses of rainfall data.

2.9.1 Average recurrence interval (ARI)

Average recurrence interval or annual recurrence interval is the average period or expected value of period between exceedances of a given rainfall total accumulated over a given duration. In this definition, periods between exceedances are random. Average Recurrence Interval is also known as return period is an estimate of the interval of time between events like earthquake, flood or river discharge flow of a certain intensity or size. Return period is the statistical measurement denoting the average recurrence interval over an extended period of time, and is usually required to dimension structures so that they are capable of withstanding an event of a certain return period with its associated intensity.

Rainfall and subsequent discharge estimate is based on the selected value of frequency or return period, termed as the Average Recurrence Interval (ARI) which is used throughout this Manual. ARI is the average length of time between rain events that exceeds the same magnitude, volume or duration.

2.10 RIVER MORPHOLOGY

The terms river morphology and its synonym fluvial geomorphology are used to describe the shapes of river channels and how they change in shape and direction over time. Fluvial geomorphology is the study of the interactions between river channel forms and processes at a range of space and time scales. The morphology of a river channel is a function of a number of processes and environmental conditions, including the composition and erodibility of the bed and banks such as sand, clay and bedrock. Erosion comes from the power and consistency of the current and can effects the formation of the river's path.

Rivers and streams continuously shape and reform their channels through erosion of the channel boundary (bed and banks) and the reworking and deposition of sediments. For example, erosion and undermining of the banks can lead to channel widening. Scouring of the channel bed deepens the channel, while sediment deposition reduces the depth and can lead to the formation of channel bars. These are just some of the ways in which channel adjustment takes place (Charlton, 2008).

Channel processes are driven by flow and sediment supply, although the range of channel adjustments that are possible are often restricted by the valley setting. The influence of channel substrate and vegetation on bank erosion and channel migration have already been mentioned. The valley slope is also significant, affecting the steepness of the channel, which, together with discharge, determines stream power. Channels that flow over very gentle gradients can be extremely restricted in the adjustments because the energy that available are little. While some channels are able to migrate freely across a wide floodplain, others are confined to a greater or lesser extent by the valley walls.

2.11 THE FORM OF A CHANNEL

2.11.1 Alluvial Channel Form

Four main types of alluvial channels are generally recognised such as straight, meandering, braided and anabranching.

a) Straight Channel

Straight channels are relatively static, with rates of channel migration limited by a combination of low energy availability and high bank strength. This is especially true where the channel banks are formed from more resistant material, such as cohesive silts and clays.

b) Meandering Channel

Meanders form in a variety of bedrock and alluvial substrates. Associated with moderate stream powers, alluvial meanders may develop in gravels, sands, or fine-grained silts and clays. An interesting characteristic of meanders is that they are scaled to the size of the channel, being more widely spaced for larger channels.

c) Braided Channel

Braided rivers are characterised by wide, relatively shallow, channels in which the flow divides and rejoins around bars and islands. The appearance of a braided channel varies with changing flow conditions. During high flows, many of the bars become partly or wholly submerged, giving the appearance of a single wide channel. At low flows, extensive areas of bar surface may be exposed.

d) Anabranching Channel

Anabranching channels, where the flow is divided into two or more separate channels, are relatively rare in comparison to braided and meandering channels. The separate channels called anabranches, are typically cut into the floodplain, dividing it up into a number of large islands. Individual anabranches can themselves be straight, meandering or braided.

2.11.2 Bedrock channels Form

Bedrock channels also show a wide diversity of form. In comparison with alluvial channels, bedrock and mixed bedrock–alluvial rivers have received relatively little attention until recently. These channels often behave in a different way to alluvial channels, being strongly influenced by the resistant nature of their substrate. Structural controls, such as joints, bedding planes and the underlying geological strata can all have a significant effect on flow processes and river morphology.

CHAPTER 3

STUDY AREA

3.1 INTRODUCTION

A study area was selected for the data collection. The study area is located at Sg. Lembing which is located in the district of Kuantan, Pahang, East-Coast of Peninsular Malaysia. The location is about 45km from Universiti Malaysia Pahang (UMP) and 42km from Kuantan town. Figure 3.1 shows the locations of the study area located at Sg. Lembing town area. The area was selected based on major changes of the river and also the conditions of the river.

Nearby Sg. Lembing is located Bukit Panorama which place to watch sunrise and Kuantan town. The place also suitable for the peoples who like to do an outdoor activities. 10km from Sg. Lembing is Pelangi Waterfall, where peoples can do trekking, fishing or others outdoor activities. On the way to Sg. Lembing, theres have Sg. Pandan Waterfall and a temple cave that is popular among tourist calling Gua Charas.

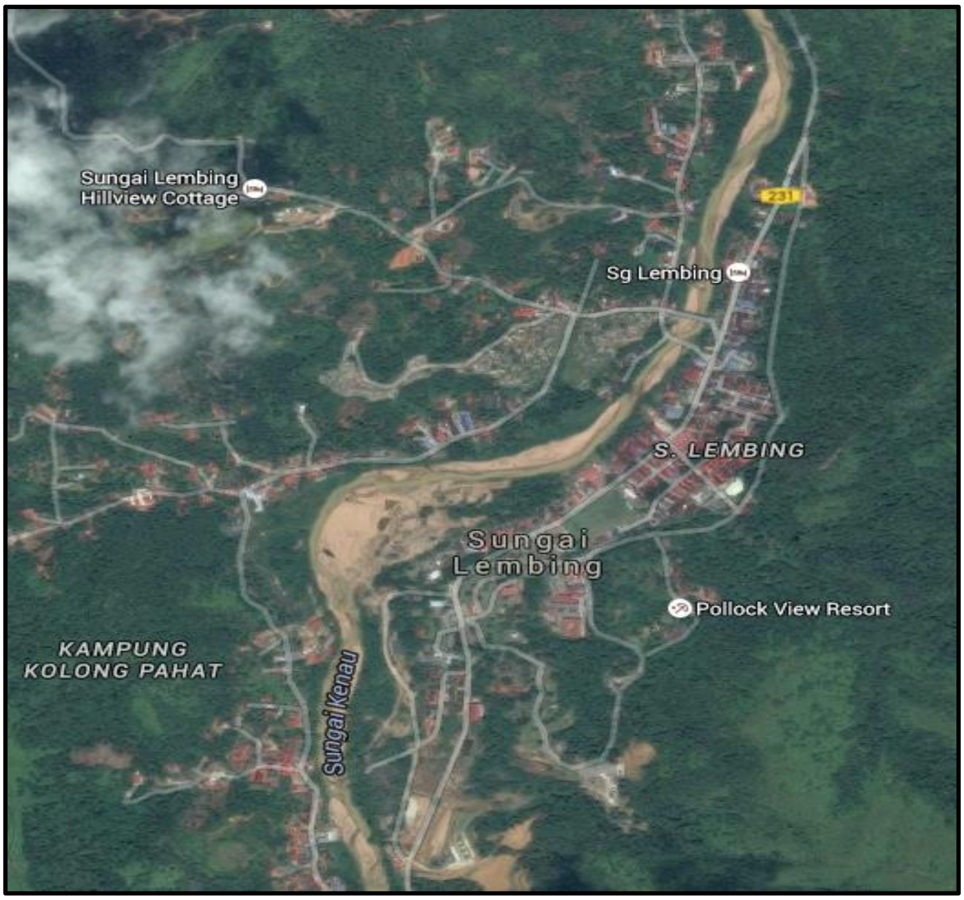

Figure 3.1: The study area from the satellite

3.2 LOCATION OF STATION

There are 3 sampling station at Sg. Lembing that had been choosen. Each of the stations was in 500m distance. These stations were selected base on major morphology changes and their safety for doing the study. Averagely, all of the stations have the acceptable depth which not exceed 1.5m and not too dangerous to do the research. These 3 sampling location are shown in Figure 3.2, the study start from Station 1 which is can be recognized as upstream zone and finish at Station 3 which is the downstream zone.

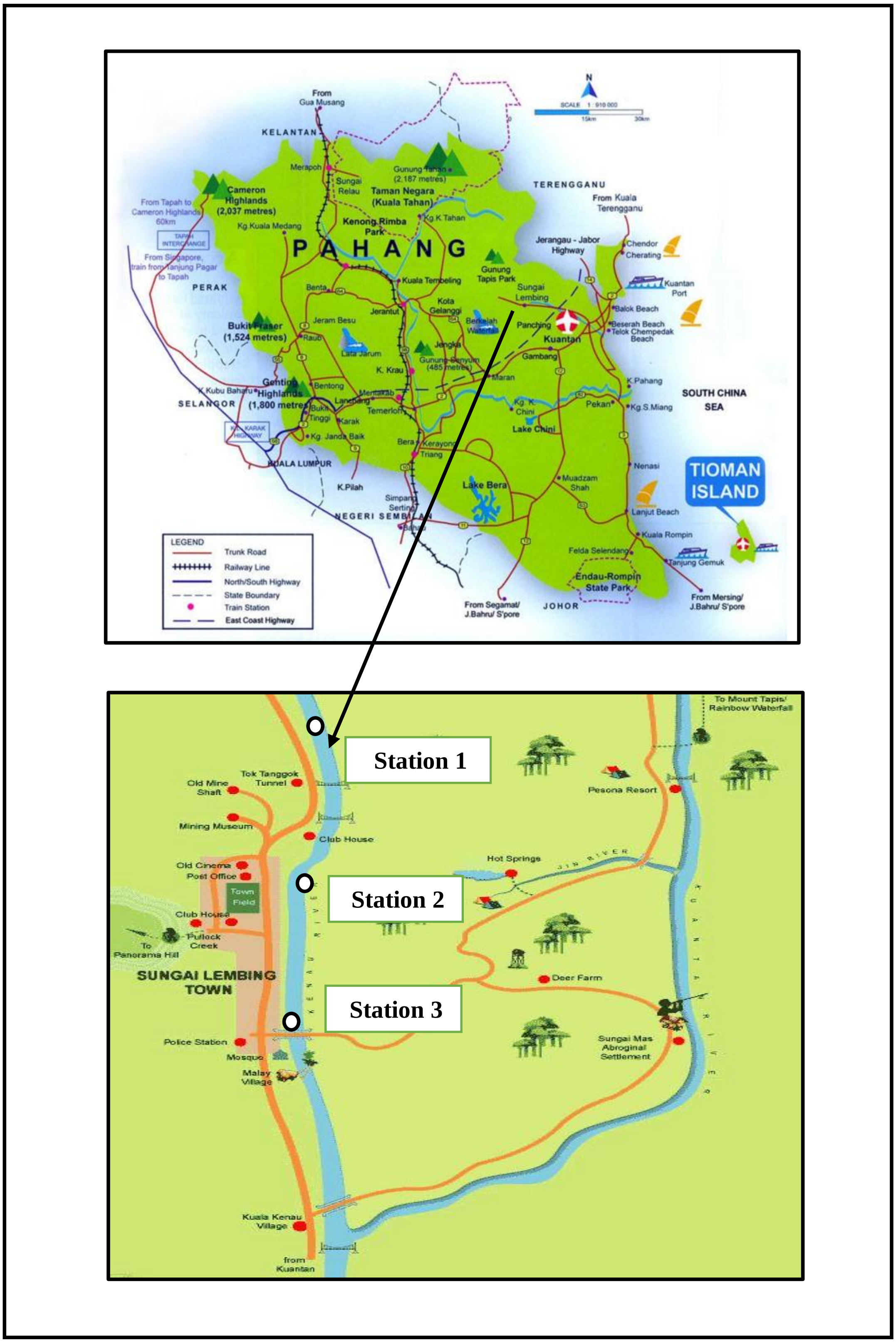

Figure 3.2: Location of all station study area

3.2.1 Location of Station 1

Station 1 is located at the upstream with coordinate N 03˚54.329' E 103˚01.821' which is nearby Kg. Kolong Pahat. This area are famous and became a centre for tourist rent a chalet or resort that ore provided by the villagers. This section has a width of stream of 16.32m, meanwhile width of sediment besides of the stream is 40.1m. The depth of the stream is between 0.2m to 0.4m (Refer Figure 3.3).

Figure 3.3: Location of Station 1

3.2.2 Location of Station 2

Station 2 is located at the upstream with coordinate N 03˚54.647' E 103˚01.756' which is in front of the Muzium Sg. Lembing. This section has a width of stream of 16.70m, meanwhile width of sediment besides of the stream is 26.40m. The depth of the stream is between 0.1m to 0.5m (Refer Figure 3.4).

Figure 3.4: Location of Station 2

3.2.3 Location of Station 3

Station 3 is located at the upstream with coordinate N 03˚54.986' E 103˚01.995' which is nearby the food court. This section has a width of stream of 19.14m, meanwhile width of sediment besides of the stream is 116m and 27.70m. The depth of the stream is between 0.1m to 0.5m (Refer Figure 3.5).

Figure 3.5: Location of Station 3

CHAPTER 4

METHODOLOGY

4.1 OVERVIEW METHODOLOGY

This chapter will discuss about methodology applied in this particular research. The research requires combination of fieldwork and laboratory work. In the early stage of the research, the point of the river that has a major changes in morphology has to identify by using google earth software. Then, fieldwork has to carry out to collect samples from Sg. Lembing to determine flow rate, cross section of the river and sample of the sediment. After that, laboratory works need to be done to the samples from Sg. Lembing. The size and characteristic of sediment that deposited at study area can be determined by using sieve analysis. The rainfall data also has to collect from Department of Irrigation and Drainage Department to analyse rainfall pattern.

Finally, the relationship between the types of sediment and flow rate in Sg. Lembing. can be analysed and draw to conclusion. Figure 4.1 show the flow chart of the methodology of the research.

4.2 METHODOLOGY FLOW CHART

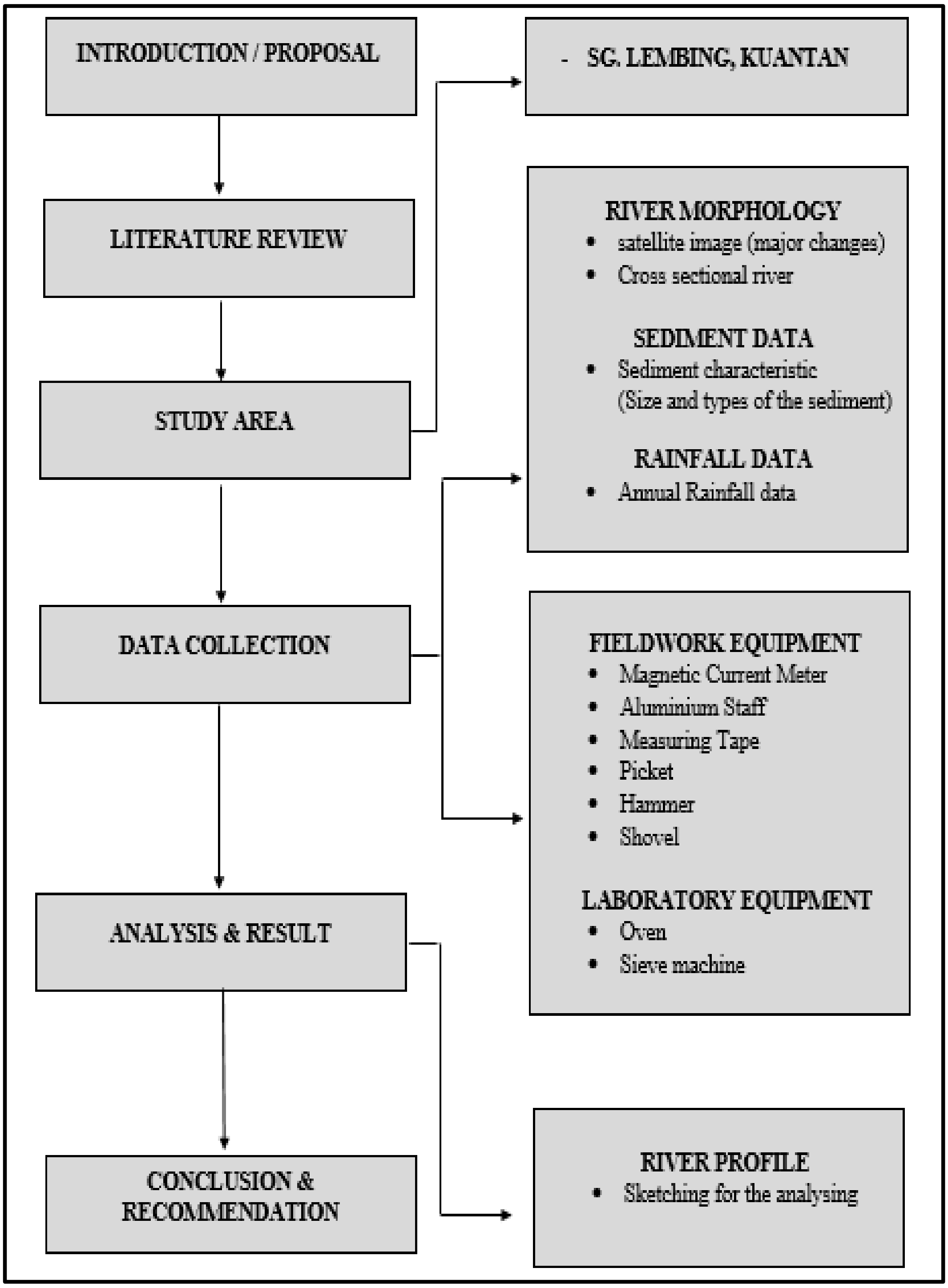

Figure 4.1: Flow Chart of the Research

4.3 FIELD MEASUREMENT

River surveys, flow measurement and field data collection provide the basic physical information such as sediment characteristics, discharge, water surface slope, which is needed for the planning and design of river engineering (River et al., 2010). Parameters such as the flow velocity, width and the depth of the river were determine in-situ and used for purposes of measuring specific discharge values and sediment sampling. The field measurement is divided into three works:

i. River characteristics: In determining the sediment in river, some of river characteristic have been investigated such as distance between stations, shape of bed channel, cross section of river, width of river, type of channel, type of meandering, depth of flow, sediment characteristics and distribution of soil particles (Musa & Manan, 2008).

ii. Velocity: The velocities of river were determined by three levels based on the depth of water.

iii. Soil sampling: A grab sampler has been used to collect samples of soil in the channel to determine the soil characteristics.

Parameters such as the flow velocity, width and depth of the river were determine in-situ. All the data obtain from the field and laboratory are important in computing sediment discharge. To calculate sediment discharge, sediment transport function has been used.

4.4 CHANNEL MORPHOLOGY

Water and sediment transport through the Sg. Lembing increase with time due to the reduction of river capacity that resulted from reclamation and sedimentation along the river. River bank erosion, river bed degradation, river buffer zone encroachment and deterioration of river water quality cause a serious and regular hazard in urban settlements at the area. The powerful water currents wear away at the edges of these settlements during the wet periods and sometimes entire settlements established near the bank are washed away. Figure 4.2 shows the channel planform modification along Sg. Lembing.

a) Year 2010 b) Year 2015

Figure 4.2: The channel planform modification along Sg. lembing in a year 2010 and 2015

The changes in the channel can be observed in many locations along the river. From these results of cross section changes, it's shown that steep slope in Sg. Lembing has induced higher discharge, and it was associated with the spatial variation in sediment transport and sediment size. The changes in river bed profile may be attributed to the erosion or deposition along the banks or the channel width.

4.4.1 Station 1

Station 1 is located at the upstream with coordinate N 03˚54.329' E 103˚01.821'. Figure 4.3 below shows the morphology changes of river at Station 1, Sg. Lembing in year 2010 and 2015.

a) Year 2010 b) Year 2015

Figure 4.3: The changes of the river at Station 1 in year 2010 and 2015

4.4.2 Station 2

Station 2 is located at the upstream with coordinate N 03˚54.647’ E 103˚01.756’. Figure 4.4 below shows the morphology changes of river at Station 2, Sg. Lembing in year 2010 and 2015.

a) Year 2010 b) Year 2015

Figure 4.4: The changes of the river at Station 2 in year 2010 and 2015

4.4.3 Station 3

Station 3 is located at the upstream with coordinate N 03˚54.986' E 103˚01.995'. Figure 4.5 below shows the morphology changes of river at Station 3, Sg. Lembing in year 2010 and 2015.

a) Year 2010

b) Year 2015

Figure 4.5: The changes of the river at station 3 in year 2010 and 2015

4.5 FLOW RATE MEASUREMENT

The flow rate measurement is obtained by the velocities of the water collected in every station. The velocities is collected at least 5 readings in every station to get the mean velocity for the reading accuracy.

4.6 FLOW RATE MEASUREMENT EQUIPMENT

The equipment for the flow rate below as shown in Figure 4.6 and Figure 4.7. It is important to have an electromagnetic current meter equipment for the flow rate data collection. During take the velocity measurement, some precautions must be alert in order to get the precise reading. The area to measure the velocity should not be no obstruction and the propeller should be faced the flow of the stream flow.

Figure 4.6: Electromagnetic Current Meter

Figure 4.7: Measuring the velocity

4.7 RIVER AREA MEASUREMENT

The measurement of the river area is important to determine the profile of the river. The measurement is done to get the width and depth for the section in the study area and the cross sectional area. The width of every section of the Sg. Lembing study area is determined by using the measuring tape while for the depth of every section is determined by using the aluminium staff.

The shape varies with position in the stream and discharge. The deepest part of the channel occurs when the stream velocity is the highest. Both width and depth increase downstream because the discharge increases at downstream. As discharge increases, the cross sectional shape will change, with the stream becoming deeper and wider.

Figure 4.8: Aluminium Staff

Figure 4.9: Measuring tape

Figure 4.10: Measuring work to determine width of the section

4.8 CROSS SECTIONAL AREA

The cross sectional area of the flow is determined from a level measurement by using the staf. It is important to do the level measurement and the flow measurement at the same location.

4.9 CROSS SECTIONAL AREA PROCEDURE

These propose of the procedure to determine the flow rate for each station. It is important to do the multiple measurement of current velocity and depth in order to get an accurate value to measure the discharge. In this study, the flow measurement can be measure by using Mean Section Method. The velocity and the depth of the river will be getting from the current meter and depth measurement. All data are important to calculate the flow stream of the water.

Table 4.1: Flow rate data calculation by using Mean Section Method

Station	Depth (m)	Width, w_1 (m)	Velocity (m/s)	Average Velocity, v_1	Average Depth, d_1	Flow rate $= w_1 v_1 d_1$ (m^3/s)
1a	0	0	0			
				0.193	0.145	0.114
1b	0.310	4.080	0.385			
				0.436	0.335	1.192
1c	0.380	8.160	0.487			
				0.417	0.345	1.760
1d	0.290	12.240	0.347			
				0.174	0.155	0.440
1e	0	16.320	0			

The total stream width is divided to the five points. The distance between the points should be approximately same or close in order to make the calculation become easy. The interval width and the water depth at the every point should be recorded as shown in Figure 4.11.

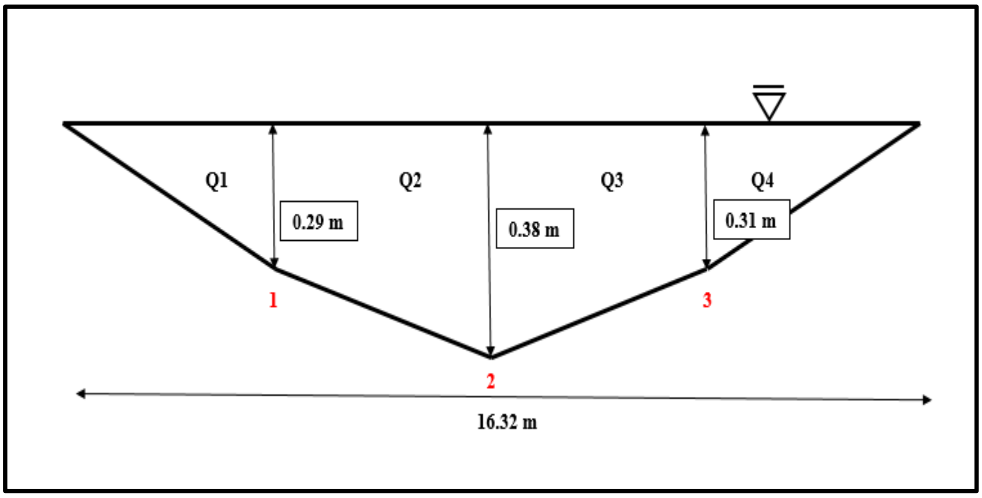

Figure 4.11 Example of illustration of the cross section at the station

Flow, Q at each section divided is calculated by mean section method:

w_1 = width

$v_1 = (V_1 – V_{2+n}) /2$ (n = 1, 2, 3, 4, …..)

d_1 = depth

Thus, $Q = w_1 \times v_1 \times d_1$ ……………….. (equation 4.1)

From the calculation the Q:

Q1 = 0.114m^3/s

Q2 = 1.192m^3/s

Q3 = 1.760m^3/s

Q4 = 0.440m^3/s

Q_{total} = 0.114 + 1.192 + 1.760 + 0.440

= 3.506m^3/s

4.10 COLLECTING SAMPLE

Sg. Lembing is a shallow river, so the sediment sample can be collected by using a shovel. The sample will be collected from each of the station and every station has 2 types of sediment which is sediment in the river (bed load) and sediment besides the river. The sample of sediment will be keep in the plastic and will be bring to the laboratory for the purpose of analysis.

4.11 LABORATORY TEST

After collecting samples from Sg. Lembing, the sample will be sent to the laboratory for the purpose of analysis. The laboratory test that needs to be done is sieve analysis.

Sieve analysis is used to determine the distribution of the larger grain sizes. The soil is passed through a series of sieves with the mesh size, reducing progressively, and the proportion by weight of the soil retained on each sieved are measured. There are a ranged of sieve sizes that can be used, and the finest is usually a 63µm sieve. Sieving can be performed either wet or dry. Because of the tendency of particles to clump together, wet sieving is often required with fine grained soils.

The sieving method was done by spreading the sediments on a tray and dry with oven by 105° c to 110° c for about 24hours. The soil sample was sieved about 10 to 15minutes with a mechanical shaker. The size of sieve tray used in this research are 10mm, 5mm, 2mm, 1mm, 0.425mm, 63µm and pan. Once all soil samples had been categorized and separated according to size, they are transfer to petri dishes to weight on an electronic weighing machine to the nearest two-point decimal. The weight of each sample size represent a percentage size of the soil.

4.12 RAINFALL DATA

Data of rainfall intensity will be obtained from JPS (Jabatan Pengairan dan Saliran). S. Lembing of rainfall station will be needed to get a rainfall intensity and to approach the coefficient value used in rainfall intensity equation. The site station is Station 3930012 - Sg. Lembing PCC Mill.

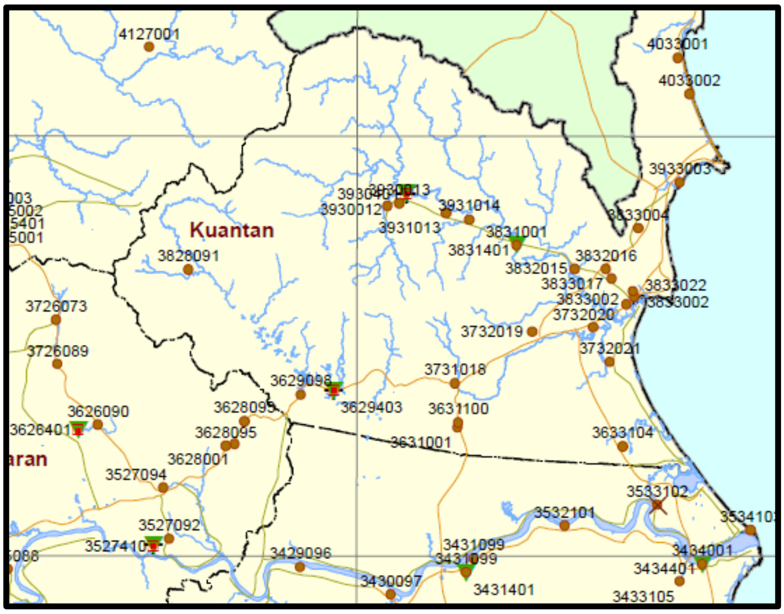

Figure 4.12: Station 3930012 - Sg. Lembing PCC Mill

CHAPTER 5

RESULT AND ANALYSIS

5.1 INTRODUCTION

This chapter will discuss about the total of rainfall at Sg. Lembing and flow rate that happens in each station at that have majority changes in morphology. It is important to know the relationship between flooding and sedimentation occurred that cause the changes in morphology at Sg. Lembing. Besides that, this chapter also will discuss about the analysis of the pattern or grain size of bed form or sediment that form in every 3 station. From the analysis, the explanation on how the sedimentation and flooding affected changes of the stream.

The sediment transportation is affected by the flow velocity of the river. The rainfall will cause the water level increase and also increasing the velocity of the river. It will make the sediment can easily being transport to others place and finally can effects the river morphology.

5.2 FLOW RATE RESULT

The flow rate is obtained from data velocity of the river and the cross section area of every station. The flow rate result is collected on 13/3/2016. The flow rate result and cross-section for Station 1 are shown in Table 5.1 below:

Table 5.1: Flow Rate Data for Station 1

Station	Depth (m)	Width, w_1 (m)	Velocity (m/s)	Average Velocity, v_1	Average Depth, d_1	Flow rate = $w_1 v_1 d_1$ (m^3/s)
1a	0	0	0			
				0.193	0.145	0.114
1b	0.310	4.080	0.385			
				0.436	0.335	1.192
1c	0.380	8.160	0.487			
				0.417	0.345	1.760
1d	0.290	12.240	0.347			
				0.174	0.155	0.440
1e	0	16.320	0			

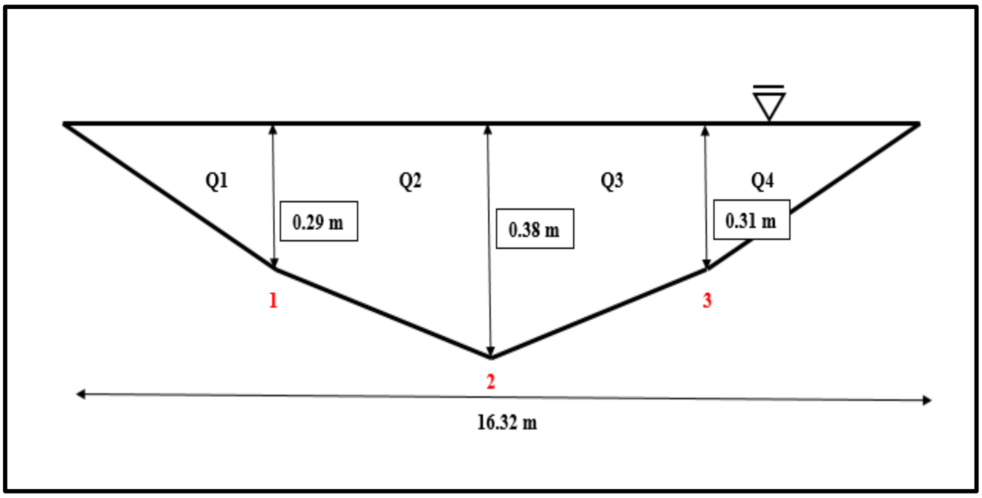

Figure 5.1: Cross-section of the river at Station 1

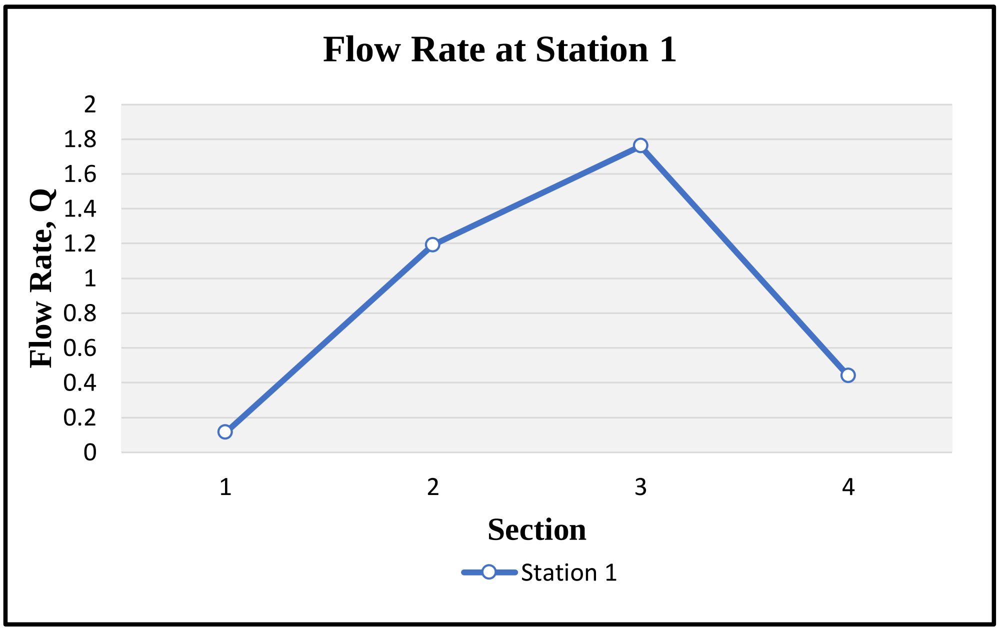

Figure 5.2: Result of Flow Rate at Station 1

Figure 5.1 and Figure 5.2 show the cross-section of the river and data of flow rate at Station 1. The total flow rate is recorded the maximum flow with 3.506m^3/s. For this particular section, section Q3 was recorded highest flow with 1.760m^3/s. The average flow is 0.878m^3/s.

The flow rate result and cross-section for Station 2 are shown in Table 5.2 below:

Table 5.2: Flow Rate Data for Station 2

Station	Depth (m)	Width, w_1 (m)	Velocity (m/s)	Average Velocity, v_1	Average Depth, d_1	Flow rate = w_1 v_1 d_1 (m^3/s)
2a	0	0	0			
				0.178	0.083	0.062
2b	0.165	4.175	0.355			
				0.497	0.3303	1.257
2c	0.440	8.350	0.638			
				0.492	0.365	2.249
2d	0.290	12.525	0.346			
				0.173	0.145	0.419
2e	0	16.700	0			

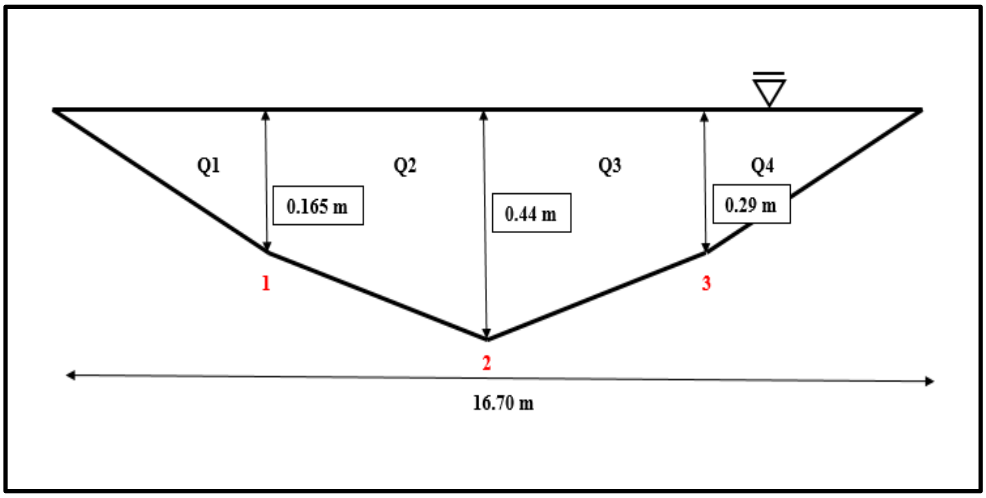

Figure 5.3: Cross-section of the river at Station 2

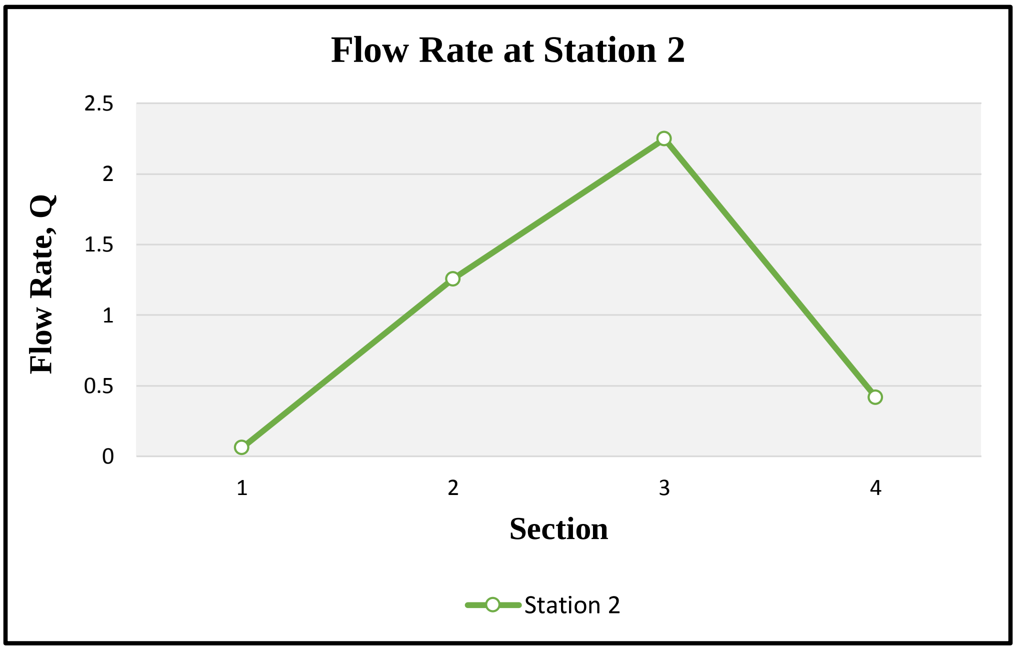

Figure 5.4: Result of Flow Rate at Station 2

Figure 5.3 and Figure 5.4 show the cross-section of the river and data of flow rate at Station 2. The total flow rate is recorded the maximum flow with 3.987m^3/s. For this particular section, section Q3 was recorded highest flow with 2.249m^3/s. The average flow is 0.998m^3/s.

The flow rate result and cross-section for Station 3 are shown in Table 5.3 below:

Table 5.3: Flow Rate Data for Station 3

Station	**Depth (m)**	**Width, w_1 (m)**	**Velocity (m/s)**	**Average Velocity, v_1**	**Average Depth, d_1**	**Flow rate = $w_1 v_1 d_1$ (m^3/s)**
3a	0	0	0			
				0.167	0.088	0.070
3b	0.175	4.785	0.334			
				0.377	0.213	0.768
3c	0.250	9.570	0.420			
				0.439	0.340	2.143
3d	0.430	14.355	0.457			
				0.229	0.215	0.942
3e	0	19.140	0			

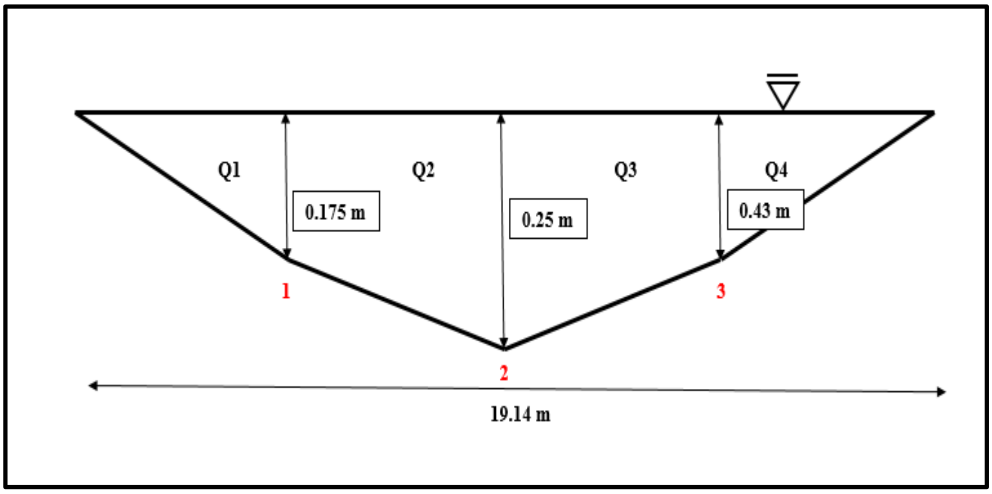

Figure 5.5 Cross-section of the river at Station 3

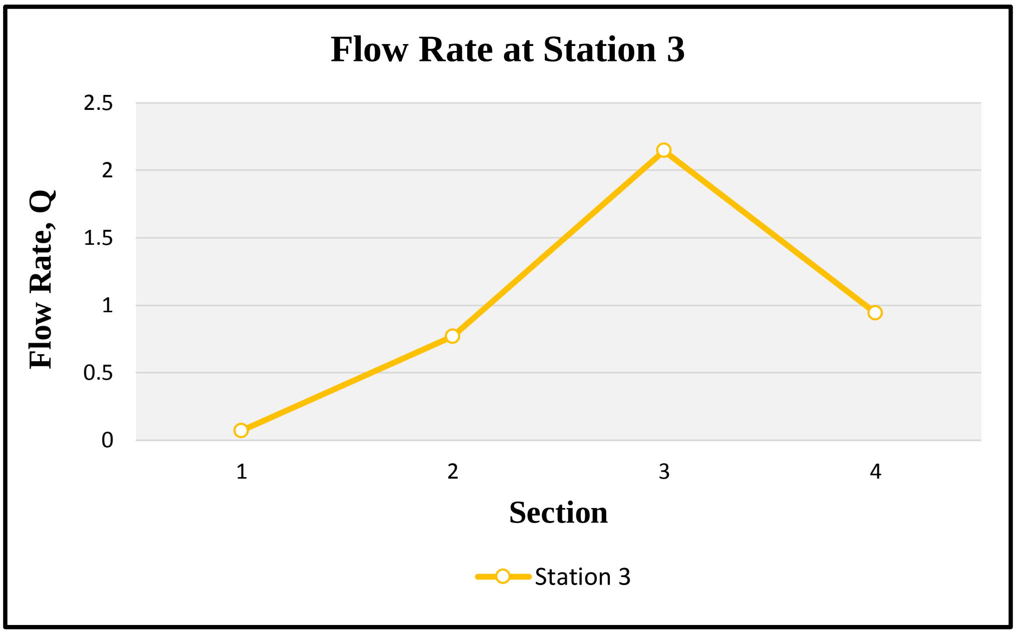

Figure 5.6: Result of Flow Rate at Station 3

Figure 5.5 and Figure 5.6 show the cross-section of the river and data of flow rate at Station 3. The total flow rate is recorded the maximum flow with 3.923m^3/s. For this particular section, section Q3 was recorded highest flow with 2.143m^3/s. The average flow is 0.981m^3/s.

5.3 SEDIMENT SIZE AND TYPES ANALYSIS

The size and types data is important in order to know the distribution of sediment in every station. The sediment is collected randomly in river and besides the river at every station and is sieved at the laboratory for the classification of their sizes. For the classification of their types, the reference from USACE table is used.

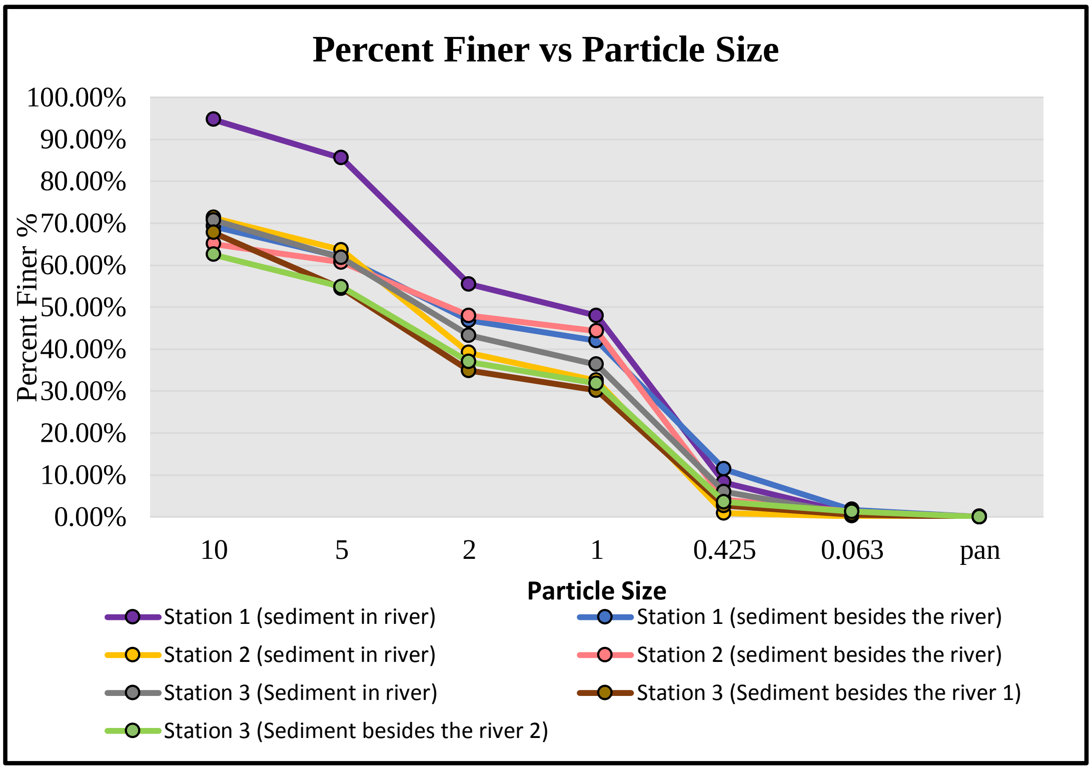

Figure 5.7: Result of sieve analysis

Figure 5.7 shows the percentage of particle size distribution from Station 1 to Station 3. The sediment collection is done 0n 13 March 2016. The result was obtained from the sieve analysis to get the percentage of mass retained at every sieve size used.

5.3.1 Station 1

The result types of sediment at Station 1 as shown in Figure 5.8 and Figure 5.9:

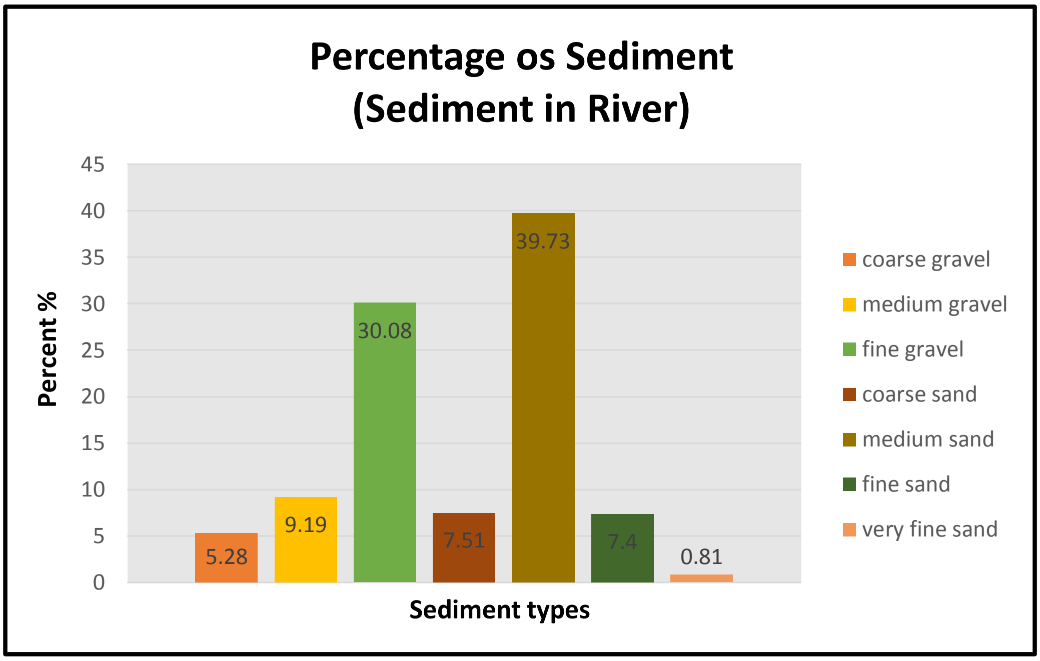

Figure 5.8: Types of sediment in river at Station1

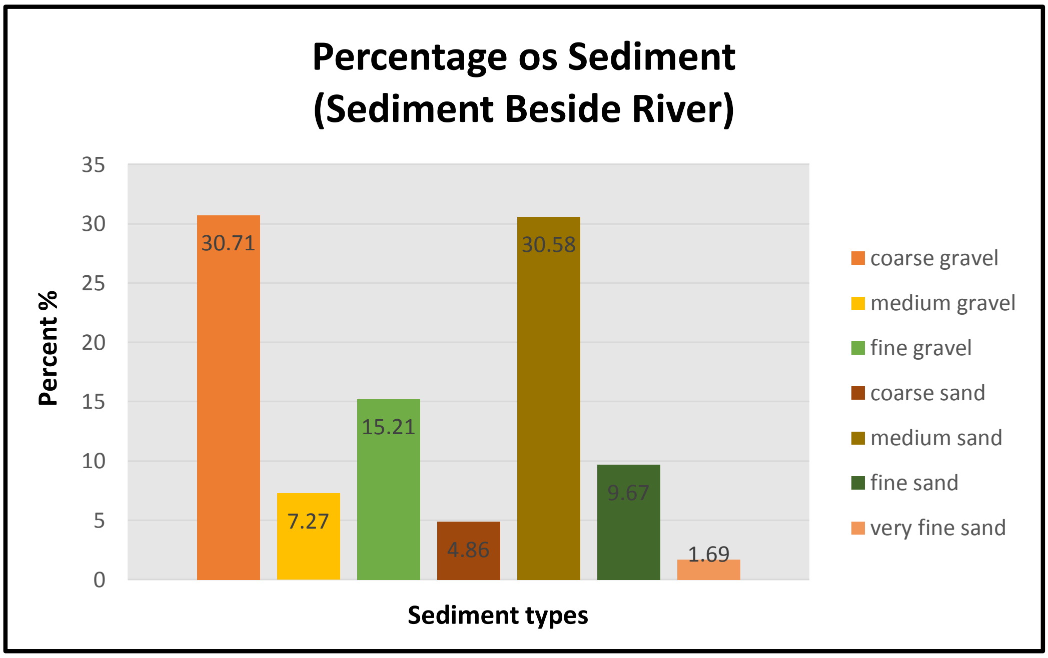

Figure 5.9: Types of sediment besides the river at Station 1

Figure 5.8 and Figure 5.9 shows the types of sediment in river and besides river at Station 1. The most type of sediment in river is medium sand and coarse gravel for sediment beside the river. It shows that at Station 1, the sediment types is contained mostly by the medium sand and coarse gravel followed by fine gravel.

5.3.2 Station 2

The result types of sediment at Station 2 as shown in Figure 5.10 and Figure 5.11:

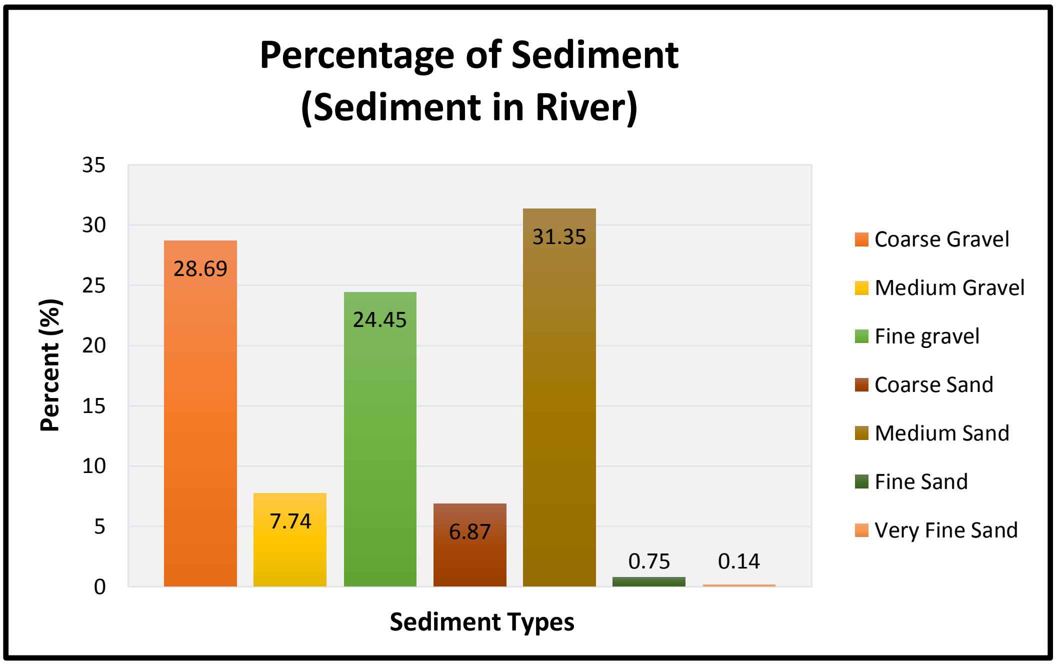

Figure 5.10: Types of sediment in river at Station 2

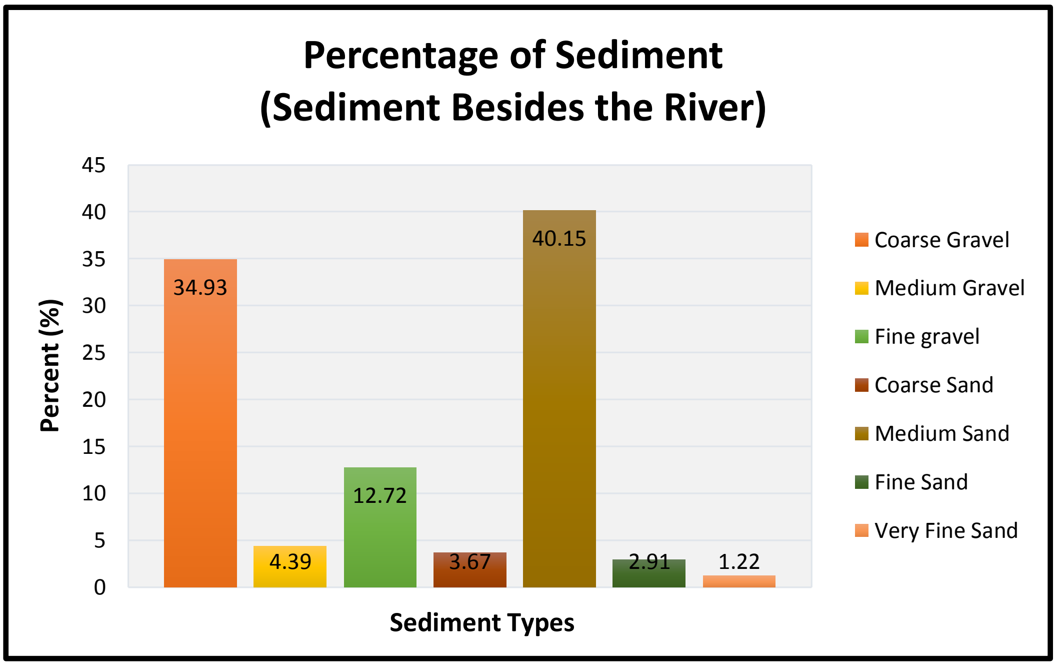

Figure 5.11: Types of sediment besides the river at Station 2

Figure 5.10 and Figure 5.11 shows the types of sediment in river and besides river at Station 2. The most type of sediment is medium sand. It shows that the distribution of sand sediment is high. The second higher distribution is coarse gravel followed by fine gravel.

5.3.3 Station 3

The result types of sediment at Station 3 as shown in Figure 5.12, Figure 5.13 and Figure 5.14:

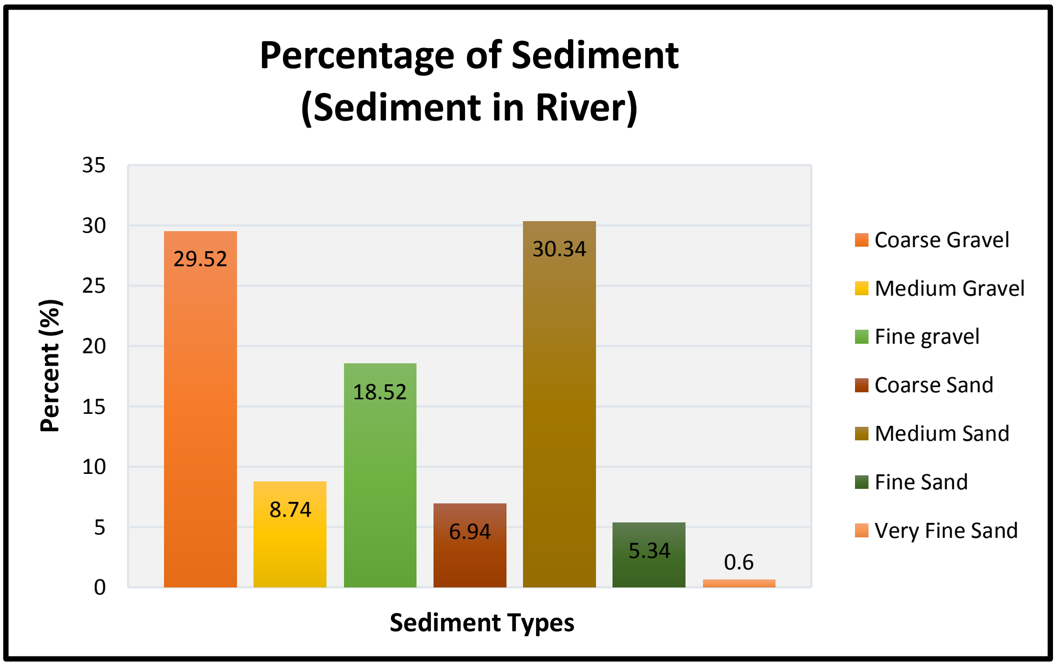

Figure 5.12: Types of sediment in river at Station 3

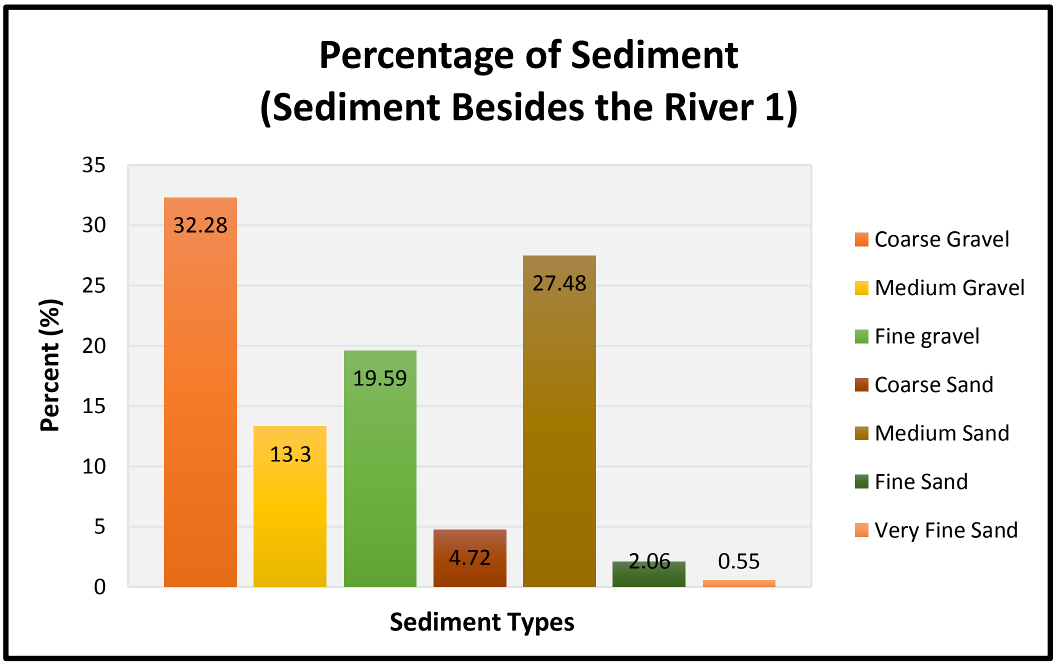

Figure 5.13: Types of sediment besides the river at Station 3

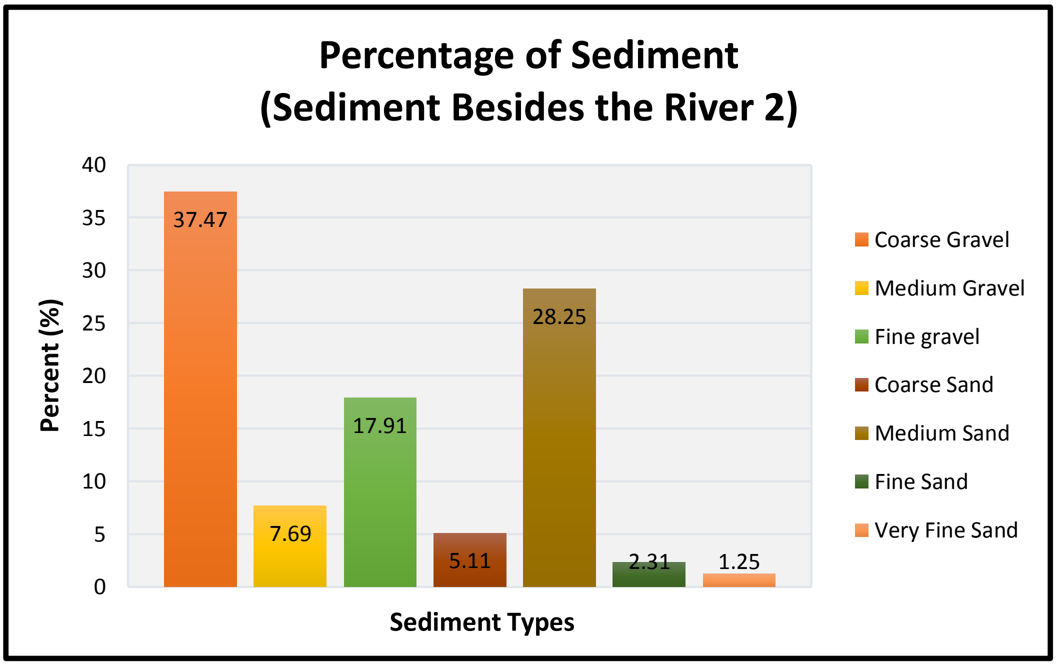

Figure 5.14: Types of sediment besides the river at Station 3

Figure 5.12, Figure 5.13 and also Figure 5.14 shows the types of sediment in river and besides river at Station 3. For sediment in the river the most type of sediment is medium sand. It shows that the distribution of sand sediment is high. The second higher distribution is coarse gravel followed by fine gravel. But for both sediment besides the river the most type of sediment is coarse gravel. The second higher distribution is coarse gravel followed by fine gravel.

5.3.4 The relationship between Flow Rate and Types of Sediment

Figure 5.15 shows the relationship between coarse gravel and flow rate at every station. The coarse gravel (16mm – 32mm) is less deposited at Station 1 with low flow rate. At Station 2 and Station 3, where the flow is recorded high, the coarse gravel distribution at the station has high percentage.

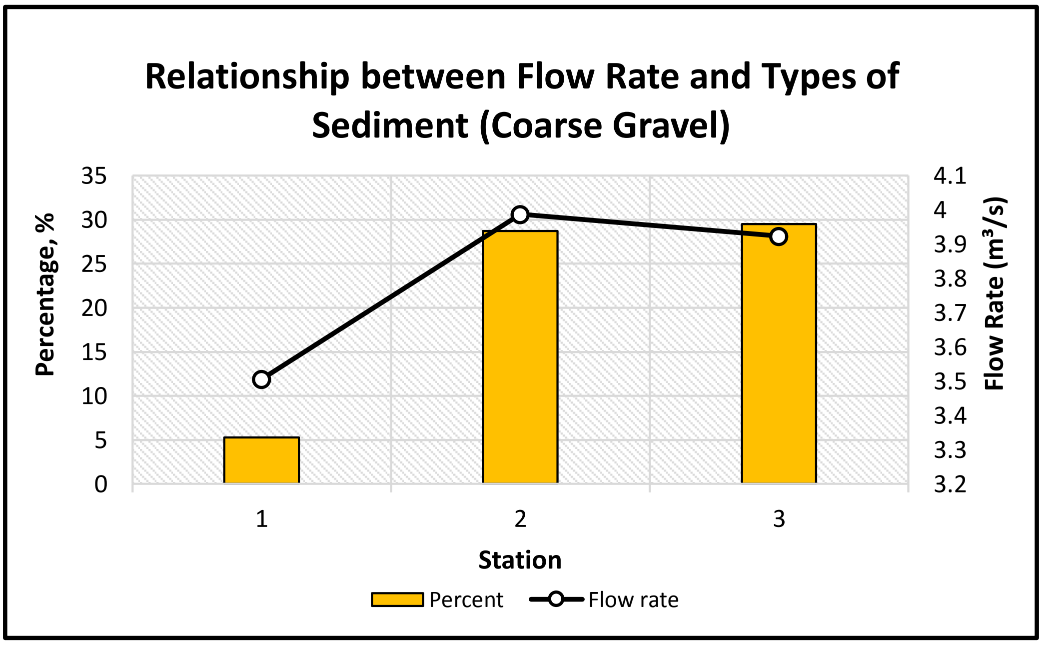

Figure 5.15: Relationship between flow rate and types of sediment (coarse gravel)

Figure 5.16 shows the relationship between flow rate and fine gravel at every station. Fine gravel sediment (4mm – 8mm) is much deposited at Station 1 but in the other hand, the flow rate is recorded low. At Station 2 and Station 3 where the flow is recorded high, the fine gravel distribution at each station has average low percentage.

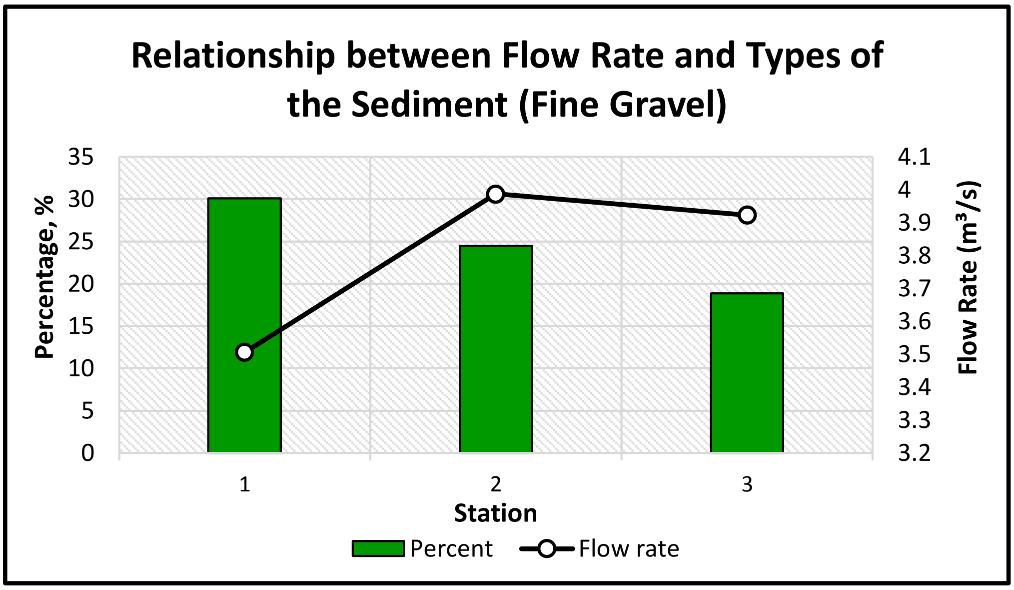

Figure 5.16: Relationship between flow rate and types of sediment (fine gravel)

Figure 5.17 shows the relationship between medium sand and flow rate at every station. Medium sand (0.25mm – 0.50mm) is also much deposited at Station 1 but the flow rate recorded is low. At Station 2 and Station 3, where the flow is recorded higher, the medium sand distribution has the low percentage than the Station 1.

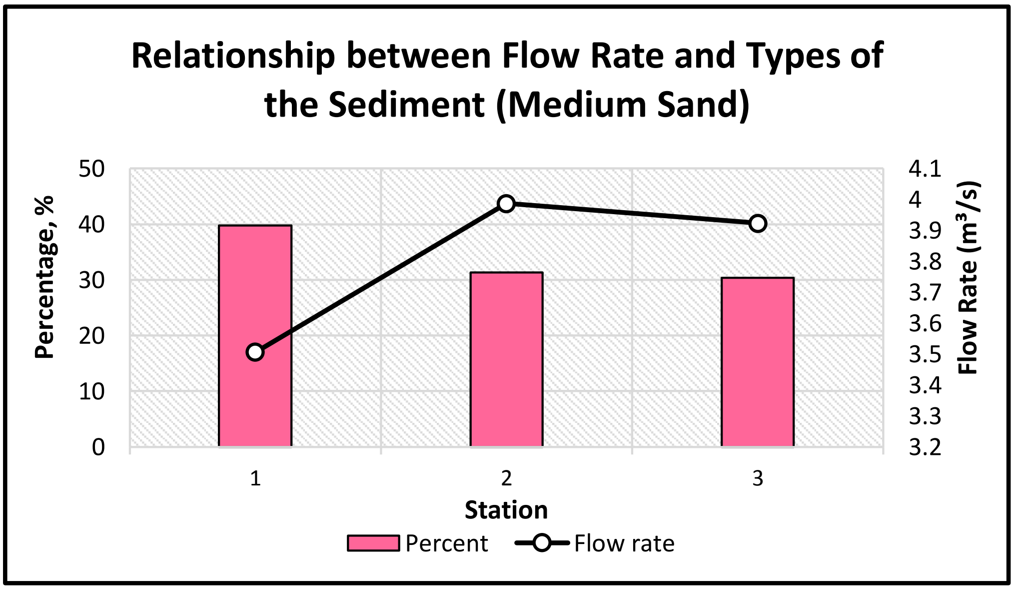

Figure 5.17: Relationship between flow rate and types of sediment (Medium Sand)

5.3.5 Discussion

From the result of the types of sediment distribution at Station 2 and Station 3, it shows that the sediment size is tends to decrease and so that the sediment types which from coarser to finer from the upstream to the downstream. Compare to coarse gravel percentage, it was recorded low distribution at Station 1 and it was because the flow at Station 1 is low than other Station. The finer gravel and medium sand is averagely deposited at each Stations because it is lighter than coarse gravel and easily transported together with the flow of the river.

5.4 RAINFALL ANALYSIS

Data rainfall that be used in this study are data rainfall from Station 3930012 - Sg. Lembing PCC Mill. This station is selected because located near to the study area and the data is important in order to make assumption for annual rainfall.

5.4.1 Total Monthly Rainfall

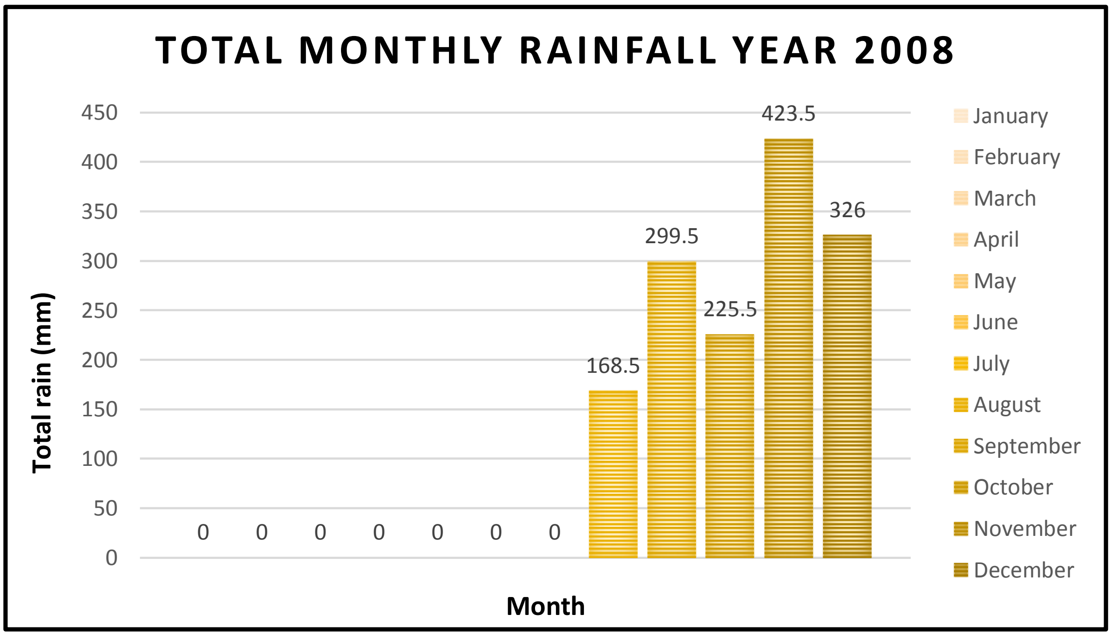

Figure 5.18: Total monthly rainfall year 2008

From the graph shown in Figure 5.18 above, it show that distribution of rainfall in year 2008. It shows that the distribution of rainfall is high in November followed by distribution rainfall in September. Rainfall data for January to June are not recorded because cannot be generate from sources Department of Irrigation and Drainage.

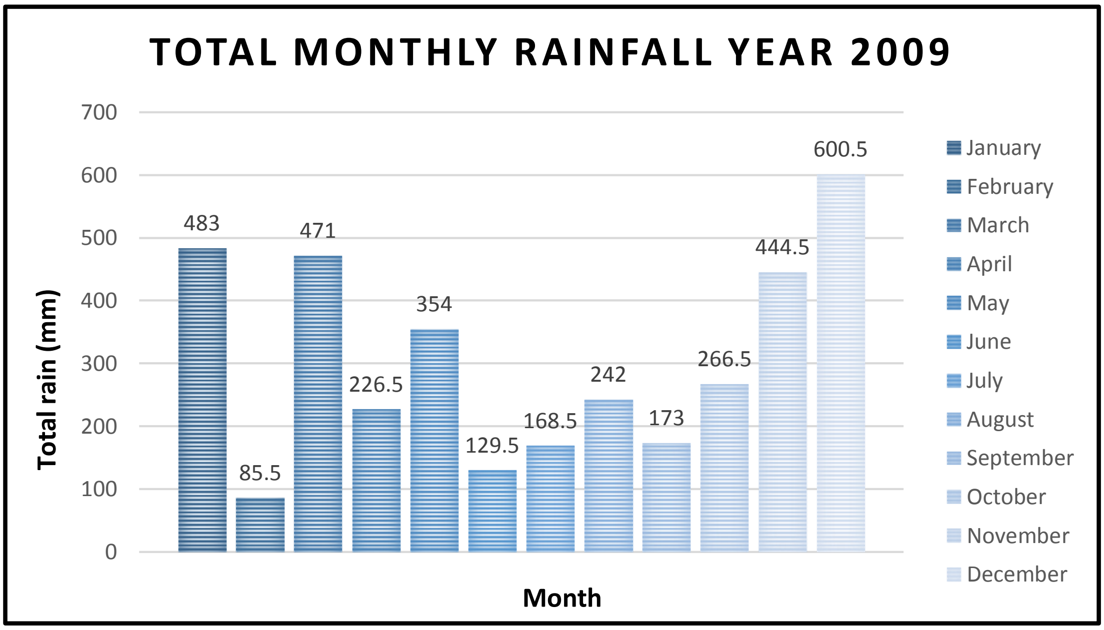

Figure 5.19: Total monthly rainfall year 2009

From the graph shown in Figure 5.19 above, it show that distribution of rainfall in year 2009. It shows that the distribution of rainfall is high in December which is followed by distribution rainfall in January, February also in November.

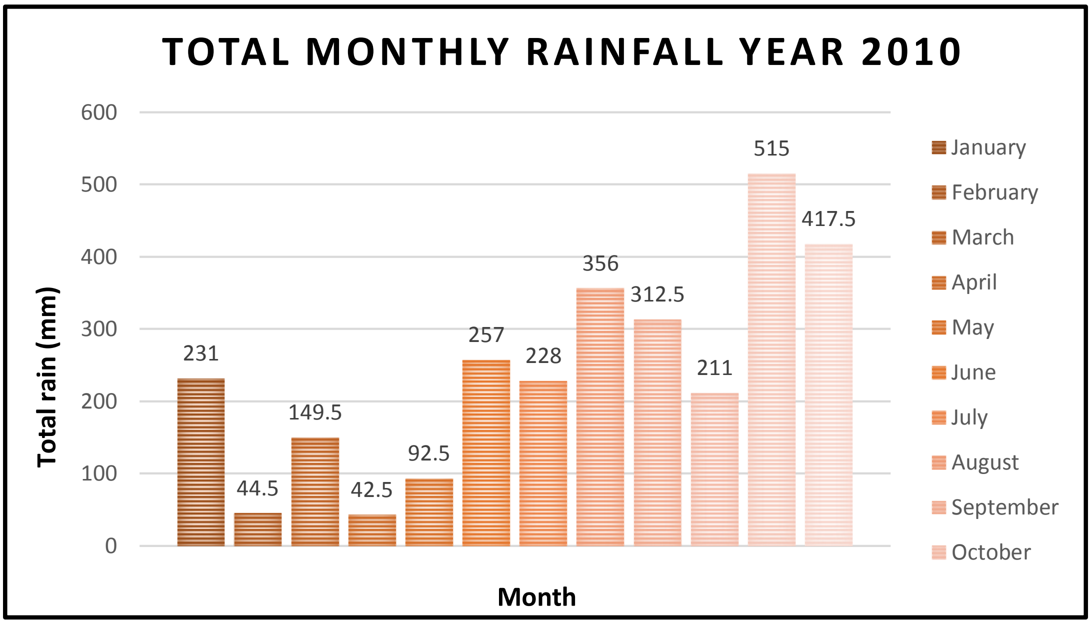

Figure 5.20: Total monthly rainfall year 2010

From the graph shown in Figure 5.20 above, it show that distribution of rainfall in year 2010. It shows that the distribution of rainfall is high in November and also in December.

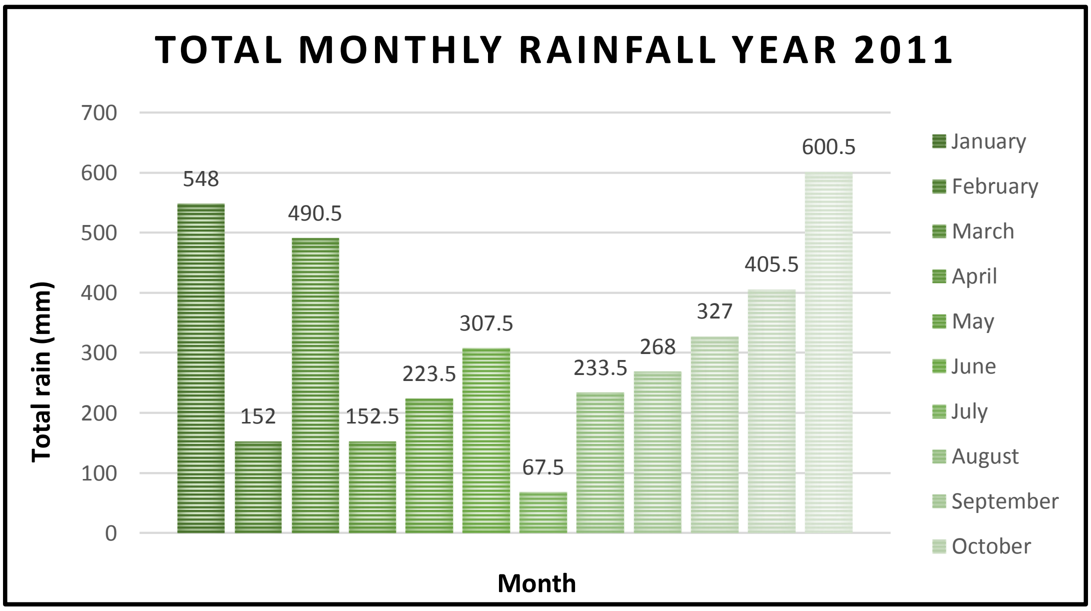

Figure 5.21: Total monthly rainfall year 2011

From the graph shown in Figure 5.21 above, it show that distribution of rainfall in year 2011. It shows that the distribution of rainfall is high in December which is followed by distribution rainfall in January, February also in November.

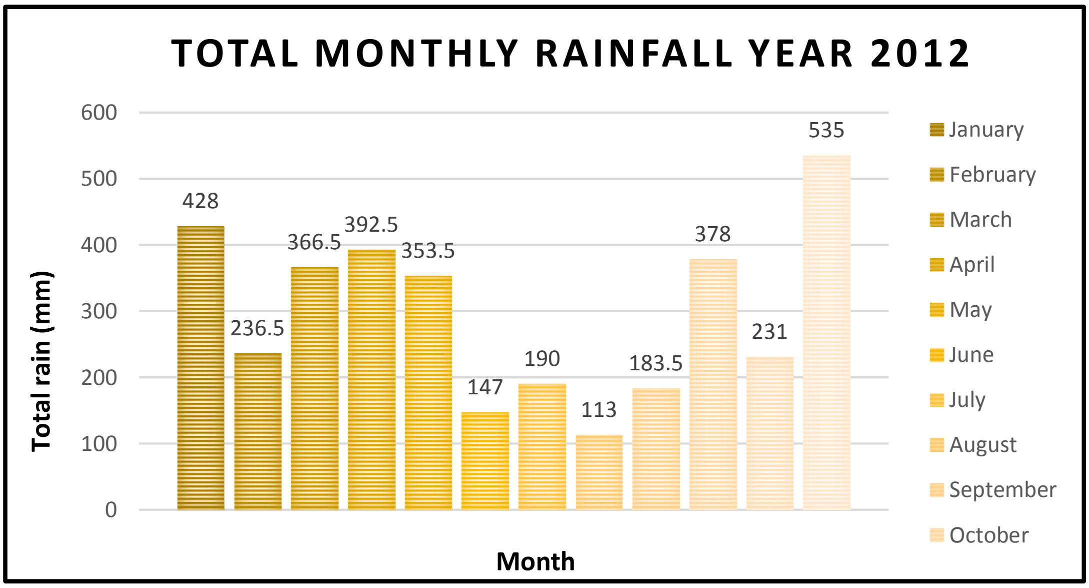

Figure 5.22: Total monthly rainfall year 2012

From the graph shown in Figure 5.22 above, it show that distribution of rainfall in year 2012. It shows that the distribution of rainfall is high in December followed by distribution rainfall in January and April.

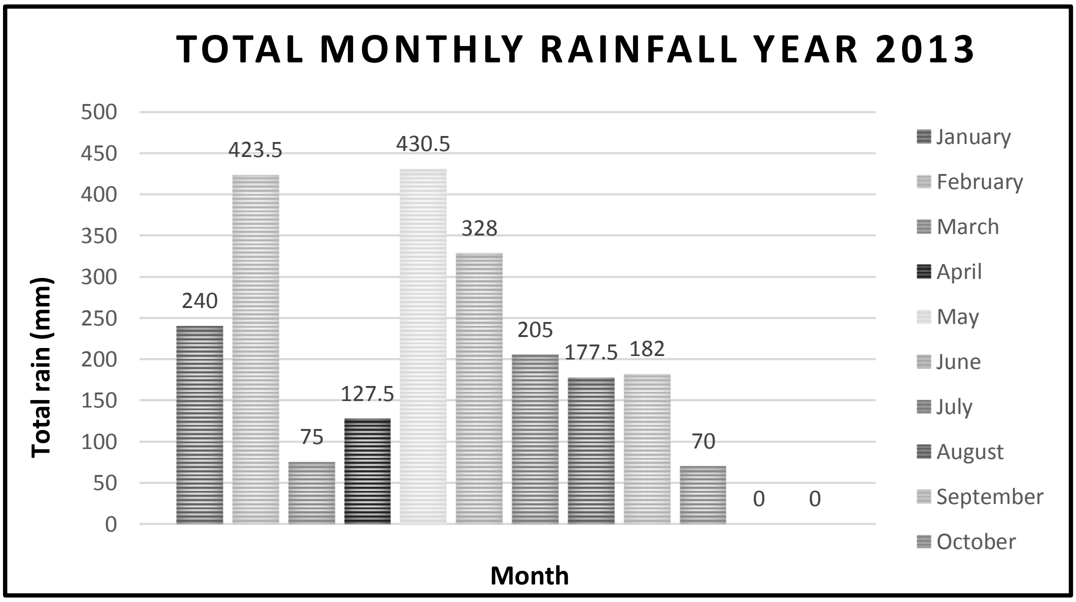

Figure 5.23: Total monthly rainfall year 2013

From the graph shown in Figure 5.23 above, it show that distribution of rainfall in year 2013. The rainfall distribution high in May and in February. According Department of Irrigation and Drainage staff, Mr. Hafiz Reza the data cannot be recorded in November and December because the rainfall gauge has been stolen.

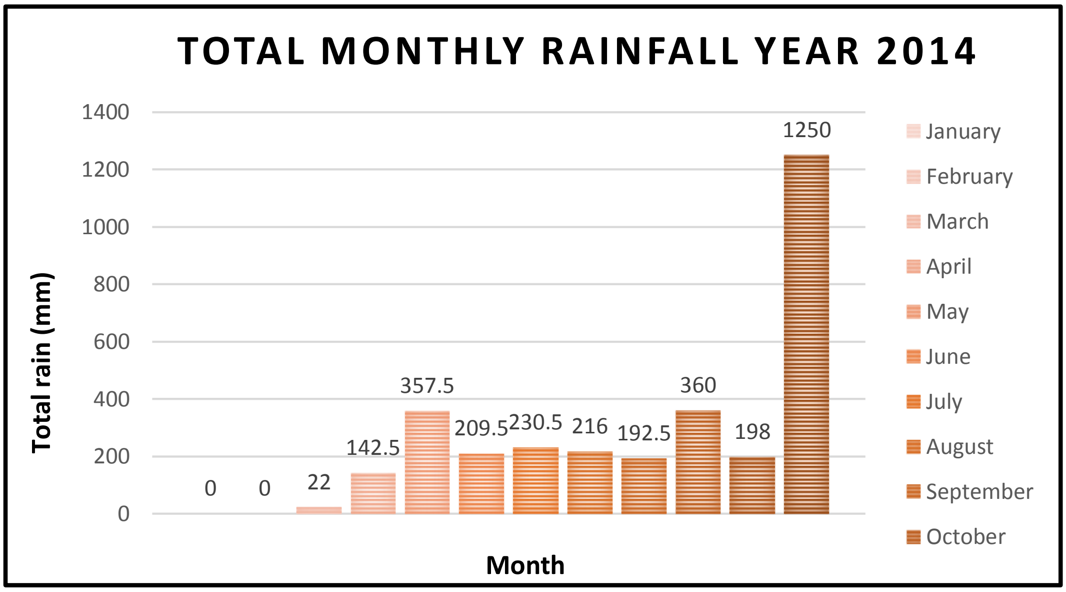

Figure 5.24: Total monthly rainfall year 2014

From the graph shown in Figure 5.24 above, it show that distribution of rainfall in year 2014. The rainfall distribution high in December. The rainfall gauge has been renewed started in March.

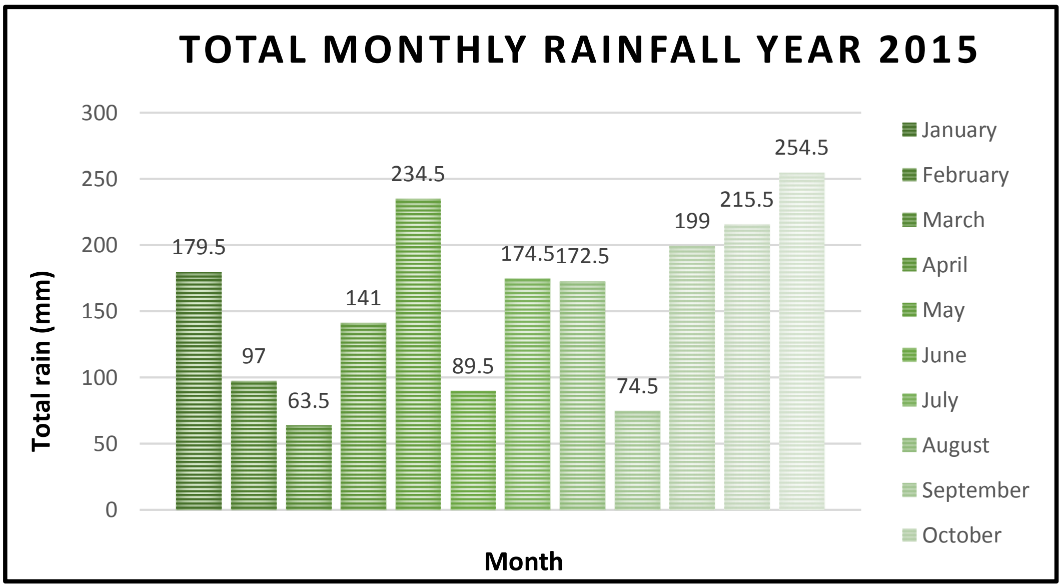

Figure 5.25: Total monthly rainfall year 2015

From the graph shown in Figure 5.25 above, it show that distribution of rainfall in year 2015. It shows that the distribution of rainfall is high in December which is followed by distribution rainfall in May and also in November.

5.4.2 Average Monthly Rainfall

The rainfall averages are based on the daily rainfall measurements. Daily rainfall is defined as the 24-hour accumulated amount of rain from 8:00 am on a given day until 8:00 am the following day. Monthly rainfall is obtained by summing over the individual monthly rainfalls between years 2008 to 2015.

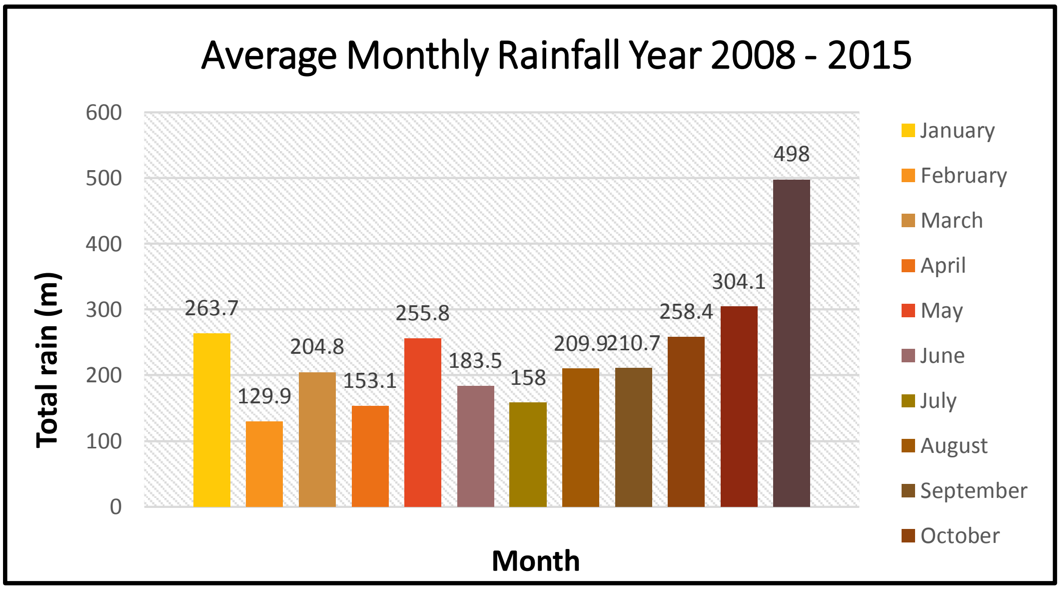

Figure 5.26: Average monthly rainfall year 2008-2015

Figure 5.26 shows the average monthly rainfall for year 2008-2015. It shows that the month receives the least number of rainfalls is on February where amount of 129.9mm is recorded. In contrast, the wettest month is on December, records 498mm. The rainfall pattern for 8 years is not constant. During 8 years period, most of the driest month is on February and the wettest month is on December.

5.4.3 Annual Rainfall Distribution

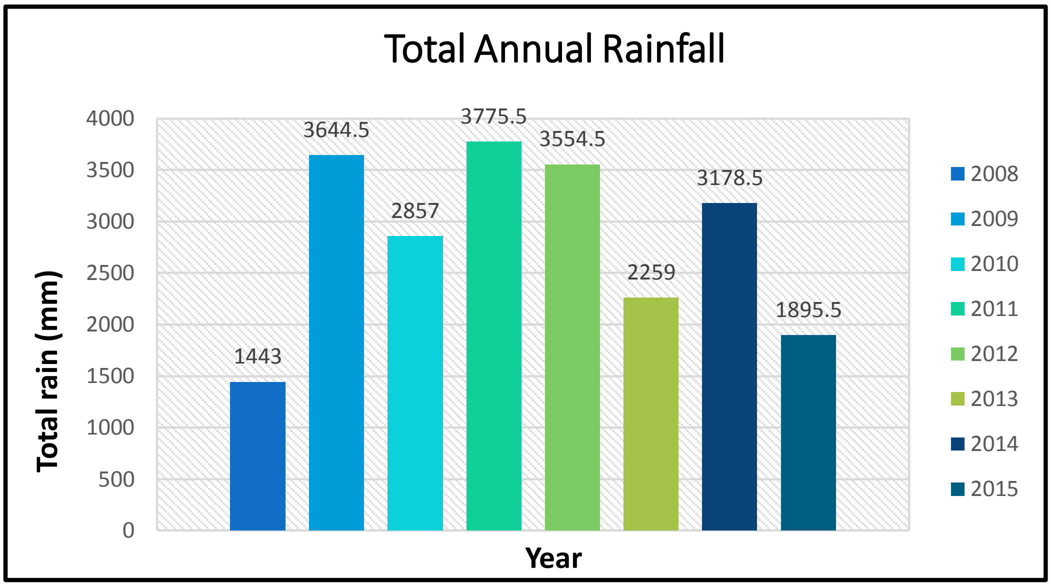

Figure 5.27: Annual rainfall distribution

Figure 5.27 shows the annual rainfall distribution between years 2008 to 2015. As stated in graph, the highest that received rainfall distribution is in 2011 which is 3775.5mm. The second higher rainfall distribution is in 2009, 3644.5mm and followed by 2012 and 2014 which is 3554.5mm and 3178.5mm.

5.4.4 Discussion

Rainfall in the river catchment area are the primary sources of water discharge, the local water level are also determined in the state of the river bed. Factor influencing sediment transportation was covered by acquiring the flow rate of the river. Total of rainfall genuinely affects the flow rate. Sudden changes in velocity can result in deposition by streams. Within a stream the velocity varies with position and if sediment gets move to the lower velocity part of the stream the sediment will come out of suspension and be deposited.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

Sedimentation and flooding can give an effects to river morphology. The flood problem that happen every year in Sg. Lembing gives the big impact to the river system. During floods sediment is transported in the main channel. The sediment is carried onto the floodplain either by diffusion or convection and as the flow velocities on the floodplain are generally low, it is deposited. The rate of sediment deposition normally reduces rapidly as one moves away from the main channel. Sediment deposition on floodplains is normally largest where there is an exchange of water between the main channel and the floodplain, commonly at bend (Roger Betters, 2008).

In order to carry out the analysis of sedimentation pattern at Sg. Lembing, samples are collected from the study area and sieve analysis graph is used to determine the size of sediment while the types of sediment is determine by reference using USACE table. From the research, it can be concluded that the sediment and flood give an impacts to the flow or river morphology. The relationship between the flow and the types of sediment deposited and also rainfall distribution can be shown by the graph.

From the study, it can be concluded that the sediment and flood give an impacts to the flow or river morphology. The relationship between the flow and the types of sediment deposited and also rainfall distribution can be shown by the graph. The types of sediment at Sg. Lembing are different from upstream to the downstream. Most of the types of sediments at the area are coarse gravel, fine gravel and medium sand. At Sg. Lembing, the types of sediment can be found at the area are 7 types according U.S.Army Corps of Engineer (USACE) size classification., the percentage of coarse gravel that have size between 32mm - 16mm is high among the other types. The medium sand recorded second high which is 0.50mm - 0.25mm followed by fine gravel which have size between 8mm - 4mm. The percentage other types of sediment is below than 10%.

At Sg. Lembing, the area that has the highest velocity is Station 2 that consisted of larger sediments. Most of the types of the sediments at the area are coarse gravel, fine gravel. The other types of sediments are only few at the area because has been wash into the downstream that had a lower velocity. At Station 1, the velocity at this area is the lowest among other station at the study area. There are still larger sediment like coarse gravel and fine gravel, but increasing of the finer particles such as medium sand can be found at this Station. It shows that, the types of the sediment will flow with the velocity and discharge of the river. The larger sediment will move when there are high velocities while the finer types will settled at the area when flow cannot transport the sediment anymore.

Based on rainfall distribution graph, Sg. Lembing catchment area faced frequently flooding and overflow during the river monsoon. Environmental factors such as flooding were also contributed to the increasing levels of sediment in the river. Generally, water velocity influences the rate of erosion and deposition of sediments along river stretches and river mouth.(C. River, 2009). The observed values flow rate and discharge at Sg. Lembing were among the primary factors that affected sediment mobility in the area. As such, a higher discharge value and water velocity would result in higher amounts of sediment. The data size sediment is quite important because researcher can know the size of material submerged in the bottom of the river. If the size of sediment is bigger, the depth of the river becomes shallow and as a result will occurred in high rate and also can changes the river morphology.

This study had identified the area that contributed high sedimentation to the Sg. Lembing catchment. Also, this study had gained sediment information at Sg. Lembing. The sediment grain size and factors influencing sediment transport are determined. The relationship between size of sediment, rainfall, flow rate, cross section of the river are correlation with each other that can changes the river morphology (Nadiatul Adilah & Nor Farahin, 2016).

6.2 RECOMMENDATIONS

There are some recommendations that can be done by the readers and future researchers for the river morphology study.

i. The appropriate equipment should be used for collecting samples. The equipment can collect the same amount of sample every time. This is to make sure the analysis of the sample is more accurate.

ii. The length time for doing this research must lengthening more. The suitable duration for doing this research is 1 year. The studies of sedimentation take some time for at least a year for the accurate data of the sediments.

iii. The sample data that use for this research should be taken more. This is to get the accurate data of sedimentation and also for rainfall distribution.

REFERENCES

Chang Chun Kiat, Aminuddin Ab Ghani, Rozi Abdullah & Nor Azazi Zakaria. 2010. Sediment transport modeling for Kulim River e A case study, *2*(October 2003).

Department of Irrigation and Drainage. 2012. Urban Stormwater Management Manual for Malaya Estimation. Chapter2, 1-5.

Edward J. Hickin. 1995. River geomorphology. River Geomorphology, 44(2), 255.

Hubert Chanson. 1999. Sediment transport: new approach and analysis. The Hydraulics of Open Channel Flow, 195–209.

H. Mahabaleshwara & H.M. Nagabhushan. 2014. A Study on Soil Erosion and Its Impacts on Floods and Sedimentation. International Journal of Research in Engineering and Technology, 3(3), 443–451.

Mohd Ekhwan Toriman, Mohd Khairul Amri Kamarudin, Mushrifah Hj Idris, Nor Rohaizah Jamil, Muhammad Barzani Gazim & Nor Azlina Abd Aziz. 2009. Sediment Concentration and Load Analyses at, *1*(2), 43–50.

Nadiatul Adilah Ahmad Abdul Ghani, Fatin Adnin & Mohamad Prim Nasir. 2013. Preliminary study on sediment load at Sungai Galing , Kuantan , Pahang.

Nadiatul Adilah Ahmad Abdul Ghani, Norasman Othman & Mohd Khairun Hafiz Baharudin. 2013. Study on Characteristics of Sediment and Sedimentation Rate at Sungai Lembing, Kuantan, Pahang. Procedia Engineering, 53, 81–92.

Nadiatul Adilah Ahmad Abdul Ghani & Nor Farahin Azman Shah. 2016. Effect of Sg Lembing Morphology Due To Sedimentation and Extreme Flood Event. Journal Teknologi (In Review).

Ro Charlton. 2008. Fundamental of Fluvial Geomorphology.

Roger Betters. 2008. Sediment transport & alluvial resistance in rivers.

Sabariah Musa, Ismail Abd Manan, Zarina Md. Ali, Dwi Tjahjanto, Nazahiyah Rahmat & Mohd Idrus Mohd Masirin. 2008. A Study of Sediment Load : Case Study At Parit Botak Channel , Batu Pahat , Johor , Malaysia, *2008*(Icenv), 1–8.

Toriman. 2013. Bed-Load Sediment Profile and Effect of River Bank Erosion on River Cross-Section. American Journal of Environmental Sciences, *9*(4), 292–300.

U.S Army Corps of Engineer.1991. Scour and Deposition in River and Reservoir, User Manual, Hydrologic Engineering Center, Davis, California.

APPENDIX A

RAINFALL DATA YEAR 2008 TO 2015

JPS Ampang

24 hour periods ending at 8:00:00am each day.
Year 2008 Site 3930012 SG. LEMBING PCCL MILL
Daily totals rain (mm)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	?	?	?	?	?	?	?	?	0.0	40.5	24.0	4.5
2	?	?	?	?	?	?	?	?	6.5	0.5	91.0	3.0
3	?	?	?	?	?	?	?	?	91.0	3.5	0.0	3.0
4	?	?	?	?	?	?	?	?	21.0	5.5	0.5	1.5
5	?	?	?	?	?	?	?	?	25.0	12.5	50.5	1.0
6	?	?	?	?	?	?	?	?	5.0	22.0	0.0	15.0
7	?	?	?	?	?	?	?	?	60.5	0.5	5.0	26.0
8	?	?	?	?	?	?	?	15.0	4.0	0.5	9.0	79.0
9	?	?	?	?	?	?	?	0.0	1.5	0.5	6.0	21.5
10	?	?	?	?	?	?	?	43.5	0.0	3.0	0.0	0.5
11	?	?	?	?	?	?	?	18.5	0.0	0.0	29.0	0.0
12	?	?	?	?	?	?	?	6.0	0.0	0.0	2.0	0.0
13	?	?	?	?	?	?	?	0.5	0.0	10.5	4.5	0.0
14	?	?	?	?	?	?	?	0.0	29.0	13.5	0.5	4.0
15	?	?	?	?	?	?	?	0.0	0.0	0.0	0.0	8.5
16	?	?	?	?	?	?	?	39.0	5.5	2.0	0.0	2.0
17	?	?	?	?	?	?	?	20.5	0.0	0.0	0.0	3.5
18	?	?	?	?	?	?	?	0.0	0.0	0.0	8.0	0.0
19	?	?	?	?	?	?	?	0.5	5.0	36.5	11.0	2.5
20	?	?	?	?	?	?	?	0.0	0.0	15.5	83.5	0.0
21	?	?	?	?	?	?	?	3.0	0.0	3.0	11.5	4.0
22	?	?	?	?	?	?	?	0.0	6.0	3.0	0.5	3.0
23	?	?	?	?	?	?	?	0.0	0.0	8.0	2.0	0.5
24	?	?	?	?	?	?	?	2.0	0.0	26.0	42.5	0.0
25	?	?	?	?	?	?	?	0.0	7.0	0.0	0.0	7.0
26	?	?	?	?	?	?	?	7.5	0.0	0.0	6.0	2.5
27	?	?	?	?	?	?	?	0.0	19.0	1.0	31.5	9.5
28	?	?	?	?	?	?	?	3.5	0.0	4.0	0.0	38.5
29	?	?	?	?	?	?	?	2.5	1.5	13.5	0.0	69.0
30	?		?	?	?	?	?	5.0	12.0	0.0	5.0	0.0
31	?		?		?		?	1.2		0.0		16.5
Min	?	?	?	?	?	?	?	0.0	0.0	0.0	0.0	0.0
Tot	?	?	?	?	?	?	?	168.5	299.5	225.5	423.5	326.0
Max	?	?	?	?	?	?	?	43.5	91.0	40.5	91.0	79.0

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24 hour periods ending at 8:00:00am each day.
Year 2009 Site 3930012 SG. LEMBING PCCL MILL
Daily totals rain (mm)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	16.5	0.0	4.5	1.5	2.0	0.0	0.0	0.0	0.0	6.5	0.0	6.5
2	126.2	1.0	25.0	2.5	1.5	9.0	9.0	25.5	2.0	7.5	0.0	2.0
3	149.0	0.0	10.5	0.0	1.5	0.0	51.0	0.0	0.0	4.5	1.5	55.5
4	130.0	0.0	12.0	5.5	0.0	0.0	6.0	0.0	13.0	7.0	15.5	58.5
5	12.5	2.0	3.0	2.5	1.0	0.0	3.0	0.0	0.0	4.0	86.0	115.5
6	12.5	0.0	55.5	1.0	4.5	4.0	0.0	0.0	2.5	7.5	65.0	14.0
7	0.0	0.0	23.0	3.5	0.5	0.0	0.0	0.0	0.0	0.0	5.0	4.5
8	0.0	0.0	50.0	84.0	0.0	2.5	4.0	3.0	0.0	0.0	0.0	1.5
9	0.0	0.0	13.0	19.5	116.5	0.0	13.0	0.0	0.0	4.5	4.0	15.0
10	0.0	0.0	4.5	29.0	0.5	0.0	2.0	51.5	6.0	5.0	11.5	4.5
11	0.0	0.0	0.5	2.0	2.5	0.0	21.0	0.0	0.0	3.5	7.0	0.0
12	0.0	9.5	0.0	2.5	4.5	5.5	0.0	0.0	6.0	12.5	0.0	0.0
13	4.5	0.0	0.0	2.0	6.0	0.0	0.0	14.5	19.0	0.0	2.0	0.0
14	6.0	0.0	3.5	17.5	11.0	2.0	0.0	0.0	0.0	2.5	11.0	2.0
15	3.0	0.5	7.0	2.0	0.0	11.0	0.0	0.0	0.0	0.0	0.0	4.0
16	0.0	2.5	69.0	32.5	25.5	0.0	0.0	0.0	0.0	1.5	2.5	2.0
17	0.0	35.5	0.5	0.0	7.5	0.0	0.0	0.0	0.0	18.0	0.0	0.0
18	0.0	0.0	0.5	0.0	84.0	0.0	0.0	13.5	84.0	43.5	0.0	61.5
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	18.0	68.0
20	0.0	0.0	47.0	4.0	0.0	0.0	0.0	0.0	8.0	0.0	22.0	65.0
21	0.0	6.0	22.0	10.5	0.0	0.0	0.0	9.5	0.5	32.5	44.0	25.5
22	0.0	3.0	20.0	0.0	15.5	1.5	?19.0	6.0	9.0	14.0	72.0	4.5
23	0.0	1.5	0.0	0.0	17.0	7.5	14.5	32.5	0.0	1.5	12.5	33.5
24	0.0	13.5	3.5	0.0	7.5	53.5	0.0	34.0	14.5	20.5	11.5	7.0
25	8.5	0.0	17.5	4.5	0.0	0.0	0.0	4.5	0.0	9.5	2.0	0.5
26	24.0	0.0	1.0	0.0	0.0	0.0	0.0	0.5	0.0	13.5	13.5	3.5
27	0.0	10.5	5.5	0.0	20.5	10.0	2.5	21.0	0.0	14.0	24.5	39.5
28	0.0	0.0	0.5	0.0	7.5	0.0	13.5	15.5	0.0	30.0	13.5	6.5
29	0.0		16.0	0.0	16.5	6.5	10.0	0.0	8.5	3.0	0.0	0.0
30	0.0		53.0	0.0	0.5	16.5	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0		3.0		0.0		0.0	10.0		0.0		0.0
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot	483.0	85.5	471	226.5	354.0	129.5	168.5	242.0	173.0	266.5	444.5	600.5
Max	149.0	35.5	69.0	84.0	116.5	53.5	51.0	51.5	84.0	43.5	86.0	115.5

JPS Ampang

24 hour periods ending at 8:00:00am each day.
Year 20010 Site 3930012 SG. LEMBING PCCL MILL
Daily totals rain (mm)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	24.0	0.0	0.0	1.0
2	14.0	0.0	0.0	0.0	0.0	0.0	8.0	0.0	0.5	1.0	0.0	16.0
3	20.5	0.0	0.0	0.0	0.0	0.0	7.5	0.0	1.5	0.5	0.0	4.5
4	71.5	0.0	0.0	4.5	0.0	15.0	46.5	0.0	0.5	0.0	1.0	0.0
5	10.0	0.0	0.0	32.0	0.0	40.0	0.0	3.5	21.5	22.5	0.0	29.5
6	1.5	0.0	0.0	6.0	2.5	0.0	0.0	0.0	1.5	0.0	47.5	0.0
7	8.0	18.5	0.0	0.0	0.0	28.0	0.0	0.0	41.0	38.0	22.5	80.5
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	0.5	1.5	0.0
9	8.5	0.0	0.0	0.0	0.0	0.0	54.5	0.0	0.0	0.0	1.0	6.0
10	0.0	0.0	0.0	0.0	36.5	1.0	5.0	0.0	21.0	17.0	7.0	12.0
11	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0
12	0.0	0.0	1.5	0.0	0.0	0.0	0.0	7.5	23.5	0.0	101.0	14.5
13	0.0	0.0	23.5	0.0	5.0	5.5	0.0	0.0	0.0	0.0	40.0	10.0
14	0.5	0.0	18.5	0.0	0.0	0.0	0.0	8.0	23.0	18.5	36.5	25.0
15	5.0	0.0	9.5	0.0	19.0	0.0	0.0	9.0	12.0	0.0	0.0	2.5
16	5.5	0.0	0.0	0.0	0.0	11.5	0.0	21.0	0.0	0.0	3.0	34.5
17	0.0	1.0	0.0	0.0	2.0	0.0	4.0	6.0	6.0	0.5	1.0	4.5
18	0.0	7.5	14.0	0.0	0.0	0.0	0.0	12.5	1.0	0.0	12.5	26.0
19	0.0	0.5	13.0	0.0	20.5	0.0	1.0	23.5	3.0	0.0	51.0	4.0
20	0.0	0.0	21.5	0.0	0.5	0.0	26.0	8.5	0.5	0.0	36.0	14.5
21	17.0	0.0	5.0	0.0	1.0	55.5	14.0	0.0	1.0	1.0	4.5	6.0
22	3.5	16.5	14.0	0.0	0.0	0.5	0.5	0.0	1.5	0.0	65.5	0.5
23	0.0	0.0	0.0	0.0	3.5	0.0	0.5	0.0	0.0	1.5	1.0	32.5
24	6.5	0.0	14.5	0.0	0.0	21.5	0.0	39.5	0.0	1.0	7.0	10.5
25	0.0	0.0	0.0	0.0	0.0	46.5	0.5	0.0	0.0	38.5	18.5	0.0
26	0.0	0.0	0.0	0.0	0.5	0.0	34.0	0.0	0.0	13.0	1.0	0.0
27	39.0	0.0	0.0	0.0	0.0	18.0	0.0	0.0	0.0	25.5	15.0	0.0
28	13.5	0.0	1.0	0.0	0.0	1.5	0.0	20.0	0.0	7.5	38.0	3.5
29	0.0		0.5	0.0	0.0	7.0	0.0	43.0	80.0	6.5	1.0	12.0
30	0.0		13.0	0.0	0.0	5.5	22.5	52.0	48.0	11.0	2.0	49.5
31	6.5		0.0		1.5		3.5	37.0		7.0		18.0
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot	231.0	44.5	149.5	42.5	92.5	257.0	228.0	356.0	312.5	211.0	515.0	417.5
Max	71.5	18.5	23.5	32.0	36.5	55.5	54.5	52.0	80.0	38.5	101.0	80.5

JPS Ampang

24 hour periods ending at 8:00:00am each day.
Year 2011 Site 3930012 SG. LEMBING PCCL MILL
Daily totals rain (mm)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	108.5	13.5	0.0	17.5	45.0	26.0	0.0	0.0	0.0	0.0	1.5	0.5
2	69.5	12.5	0.3	4.0	35.5	1.0	0.0	0.0	0.0	25.0	6.0	0.0
3	2.5	4.0	2.7	4.5	4.0	43.5	0.0	0.0	62.5	23.0	1.0	0.0
4	0.0	1.0	1.5	10.5	10.5	10.0	0.0	0.0	5.0	1.0	2.5	0.0
5	0.0	0.0	0.0	3.0	4.5	15.0	0.0	2.0	61.5	0.0	26.0	68.0
6	33.0	0.0	0.0	30.0	4.5	58.0	0.0	0.0	0.0	16.5	4.5	0.0
7	25.0	0.0	42.5	0.5	0.0	0.0	0.0	0.0	0.0	9.0	0.0	0.0
8	27.5	0.0	6.0	0.0	0.0	0.0	0.0	10.5	5.0	52.5	0.0	0.5
9	1.5	0.0	20.5	0.0	0.0	47.0	0.0	6.5	0.0	2.5	0.0	0.0
10	2.5	0.0	21.5	4.5	0.0	0.5	0.0	0.0	13.5	9.5	0.0	0.0
11	9.5	0.0	46.0	14.0	1.0	2.0	0.0	46.0	0.0	10.0	33.0	72.0
12	0.0	0.0	130.0	5.5	1.0	0.0	0.0	0.0	0.0	0.0	1.5	97.5
13	1.5	0.0	6.0	0.0	3.0	3.0	0.0	2.0	0.0	2.0	54.0	6.0
14	0.0	0.0	1.5	0.0	0.0	1.0	0.0	4.5	1.0	0.0	11.5	59.5
15	7.0	0.0	11.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	7.0	0.0
16	10.0	30.5	1.5	0.0	0.0	97.5	4.0	0.0	0.0	20.5	2.0	0.0
17	3.0	25.5	0.5	0.0	0.0	0.0	0.0	0.0	0.5	4.5	0.0	43.5
18	0.5	0.0	0.0	0.5	0.0	0.0	0.0	0.0	13.5	11.5	2.0	36.5
19	0.0	1.5	1.5	4.5	14.0	0.0	0.0	0.0	71.0	19.5	0.0	23.5
20	0.0	0.0	14.5	45.5	0.5	1.0	0.0	0.0	0.0	6.5	0.0	5.5
21	0.0	0.0	41.0	0.0	56.0	0.0	0.0	39.5	7.0	33.0	8.5	5.0
22	0.0	0.0	0.0	0.0	9.0	0.0	0.0	0.0	14.5	0.0	24.5	55.5
23	0.0	34.0	2.5	0.0	0.0	0.5	42.5	32.5	0.0	14.0	32.5	65.0
24	0.0	0.5	19.0	0.0	0.0	0.0	2.0	0.0	0.0	0.5	99.0	32.5
25	6.5	27.5	21.5	0.0	11.0	0.0	9.5	13.0	2.5	0.0	32.0	14.5
26	30.0	1.5	2.5	0.0	14.5	0.0	0.0	0.0	1.0	0.0	2.0	1.0
27	35.5	0.0	0.0	8.0	2.0	0.0	7.5	0.0	9.5	38.5	10.5	0.0
28	32.5	0.0	33.5	0.0	0.0	0.0	0.0	0.0	0.0	1.0	29.0	3.5
29	14.0		51.0	0.0	7.5	0.0	0.0	75.5	0.0	16.5	4.5	5.0
30	68.0		12.0	0.0	0.0	1.0	2.0	1.5	0.0	8.0	10.0	1.5
31	60.0		0.0		0.0		0.0	0.0		2.0		4.0
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot	548.0	152.0	490.5	152.5	223.5	307.5	67.5	233.5	268.0	327.0	405.0	600.5
Max	108.5	34.0	130.0	45.5	56.0	97.5	42.5	75.5	71.0	52.5	99.0	97.5

JPS Ampang

24 hour periods ending at 8:00:00am each day.
Year 2012 Site 3930012 SG. LEMBING PCCL MILL
Daily totals rain (mm)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3.5	6.0	2.0	0.0	0.0	19.5	0.0	0.0	0.0	56.0	4.0	16.0
2	2.0	4.5	7. 5	1.5	0.0	43.5	19.0	0.0	0.0	0.0	5.0	0.0
3	47.5	0.5	29.5	8.0	35.0	18.0	0.5	0.0	0.0	44.0	17.5	1.5
4	2.5	21.0	8.5	5.5	0.0	0.0	0.0	0.0	0.0	0.0	15.0	3.5
5	0.0	0.5	0.0	42.5	102.5	0.0	0.0	0.0	5.5	4.0	10.0	23.0
6	0.0	0.0	5.5	21.0	0.0	29.5	2.0	0.0	0.0	1.5	16.0	2.0
7	0.0	2.5	38.0	0.5	94.0	0.5	0.0	4.0	0.0	46.5	0.5	23.0
8	0.5	0.0	5.5	0.0	0.5	0.0	48.5	1.0	0.0	0.0	0.0	0.0
9	5.0	0.0	7.5	4.5	10.0	1.0	11.0	0.0	18.0	0.0	2.5	0.5
10	2.0	0.0	49.5	0.0	0.0	0.0	0.0	0.0	10	0.0	25.0	1.5
11	9.0	0.0	11.0	0.0	7.0	0.0	7.5	0.0	18.5	25.5	7.0	7.0
12	61.0	1.5	2.5	87.5	1.0	0.0	0.0	0.0	54.5	0.0	18.0	0.0
13	164.0	2.0	27.5	6.5	9.5	0.0	0.0	43.5	3.0	2.5	0.0	29.0
14	27.5	6.0	18.0	45.0	3.5	0.0	0.0	0.5	22.0	60.0	6.0	4.5
15	4.5	0.0	7.0	0.5	45.0	0.0	0.0	0.0	0.0	21.0	0.0	6.5
16	0.0	0.0	5.5	5.0	0.0	0.0	18.0	0.0	0.0	19.5	0.0	14.5
17	0.0	0.5	0.0	5.5	0.0	0.0	1.0	3.0	0.0	2.0	3.5	32.5
18	0.5	0.0	0.0	18.5	0.0	0.0	22.5	2.5	24.0	6.5	5.5	28.5
19	10.5	157.5	0.0	11.0	0.0	0.0	9.5	10.5	0.0	9.5	0.0	31.5
20	0.5	12.5	5.5	64.5	0.0	0.5	50.0	5.5	3.5	2.0	17.0	7.0
21	18.5	19.0	0.5	11.5	1.0	6.5	0.0	10.0	7.5	1.5	0.0	11.0
22	61.0	0.5	6.5	0.5	0.0	0.0	0.0	0.0	1.5	34.0	0.0	4.0
23	0.0	0.0	16.0	9.0	15.0	0.0	0.0	8.5	0.0	1.5	49.5	85.5
24	0.0	0.0	4.0	0.0	16.0	0.0	0.5	0.0	0.5	0.0	4.0	87.0
25	0.0	0.0	1.0	0.5	2.5	20.5	0.0	10.0	15.5	0.0	3.0	51.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	16.0	16.5	14.5
27	0.0	0.0	9.0	36.5	0.0	7.5	0.0	0.0	1.0	23.0	0.0	5.0
28	6.5	0.5	4.5	0.0	1.5	0.0	0.0	1.5	0.0	0.0	1.0	11.0
29	0.5	1.5	0.0	0.0	7.5	0.0	0.0	0.5	0.0	0.0	0.0	0.0
30	0.0		15.5	7.0	1.0	0.0	0.0	0.0	0.0	0.0	4.5	18.0
31	1.0		79.0		1.0		0.0	12.0		1.5		0.0
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot	428.0	236.5	366.5	392.5	353.5	147.0	190.0	113.0	183.5	378.0	231.0	535.0
Max	164.0	157.5	79.0	87.5	102.5	43.5	50.0	43.5	54.5	60.0	49.5	87.0

JPS Ampang

24 hour periods ending at 8:00:00am each day.
Year 2013 Site 3930012 SG. LEMBING PCCL MILL
Daily totals rain (mm)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	60.5	6.0	5.5	0.0	0.0	23.0	0.5	0.0	1.5	0.0	?	?
2	1.0	0.0	9.0	0.0	0.0	5.5	0.0	0.0	1.0	?	?	?
3	10.0	4.0	4.5	0.0	78.5	0.5	20.5	0.0	?0.0	2.0	?	?
4	0.5	51.0	0.0	1.0	52.5	29.5	245	0.0	8.5	0.0	?	?
5	0.0	48.5	0.0	12.5	0.0	21.0	3.5	0.5	14.5	36.0	?	?
6	0.0	9.0	0.0	15.5	7.0	112.0	0.0	?	12.0	0.0	?	?
7	0.0	39.0	11.0	11.5	16.5	0.0	0.5	8.5	29.0	0.0	?	?
8	0.0	1.0	4.0	0.0	29.5	26.0	?	0.0	13.0	0.0	?	?
9	0.0	20.5	14.0	0.0	0.0	18.0	5.0	0.5	10.0	2.5	?	?
10	1.5	0.0	0.5	0.0	3.0	0.0	15.5	0.0	0.0	0.5	?	?
11	0.0	51.0	0.0	1.5	5.0	0.0	82.0	19.0	3.0	29.0	?	?
12	2.0	0.5	0.0	0.5	0.0	1.0	2.5	1.5	11.0	?	?	?
13	0.0	27.0	0.0	9.0	0.0	0.0	0.0	0.0	7.0	?	?	?
14	1.5	13.5	0.0	0.0	0.0	0.0	12.0	0.0	11.0	?	?	?
15	0.5	14.5	0.0	0.0	6.0	0.0	0.5	0.0	0.0	?	?	?
16	0.5	51.0	0.0	4.5	84.0	0.0	0.0	3.5	0.0	?	?	?
17	0.0	15.0	12.0	0.0	58.0	0.0	9.0	2.0	19.5	?	?	?
18	0.0	2.0	0.0	21.5	0.0	0.0	18.0	0.5	1.0	?	?	?
19	45.5	0.0	0.0	27.5	5.5	0.0	0.0	11.0	0.0	?	?	?
20	5.5	0.5	0.0	1.0	25.0	0.0	0.0	15.2	0.0	?	?	?
21	24.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	?	?	?
22	55.0	0.0	5.5	0.0	13.0	0.0	0.0	0.0	0.0	?	?	?
23	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	?	?	?
24	7.5	2.0	0.0	8.5	3.0	0.0	0.0	1.0	0.0	?	?	?
25	21.0	4.5	0.0	0.0	10.0	0.0	0.0	0.0	0.0	?	?	?
26	0.0	4.0	9.0	7.0	0.0	6.5	3.5	0.0	0.0	?	?	?
27	0.0	21.0	0.0	3.0	1.5	0.0	7.5	6.0	0.0	?	?	?
28	0.0	38.0	0.0	0.5	30.5	4.0	0.0	0.0	28.5	?	?	?
29	0.0		0.0	1.5	0.0	20.0	0.0	63.5	7.0	?	?	?
30	0.0		0.0	1.0	0.0	61.0	0.0	34.0	4.5	?	?	?
31	0.0		0.0		0.5		0.0	10.5		?		?
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	?	?
Tot	240.0	423.5	75.0	127.5	430.5	328.0	205.0	177.5	182.0	70.0	?	?
Max	60.5	51.0	14.0	27.5	84.0	112.0	82.0	63.5	29.0	36.0	?	?

JPS Ampang

24 hour periods ending at 8:00:00am each day.
Year 2014 Site 3930012 SG. LEMBING PCCL MILL
Daily totals rain (mm)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	?	?	?	0.0	68.0	0.0	10.0	2.0	0.0	0.0	0.0	?
2	?	?	?	?0.0	0.0	12.0	?	0.0	?	36.0	14.0	0.0
3	?	?	?	0.0	10.5	0.0	55.5	20.5	9.0	0.5	0.0	11.5
4	?	?	?	7.5	0.0	1.0	0.0	20.5	5.0	8.0	0.0	4.0
5	?	?	?	0.0	0.0	39.0	3.5	0.0	31.5	68.0	?	19.5
6	?	?	?	0.0	?	0.0	0.0	?	43.5	0.0	0.0	2.0
7	?	?	?	0.0	?	2.5	0.0	1.5	1.5	0.0	2.0	0.0
8	?	?	?	0.0	37.5	0.0	9.0	0.0	0.0	?	2.5	10.5
9	?	?	?	0.0	0.5	?	0.0	0.0	0.0	0.5	18.5	6.5
10	?	?	?	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	?	?	?	42.5	30.5	3.0	18.5	0.0	0.0	50.5	0.0	0.0
12	?	?	?	40.5	5.0	24.5	67.0	0.0	20.5	2.5	0.0	0.0
13	?	?	0.0	0.0	1.0	0.5	0.0	28.5	0.0	3.0	8.0	0.0
14	?	?	0.0	0.0	0.5	9.0	0.0	29.5	0.0	18.5	8.5	0.0
15	?	?	0.0	0.0	2.5	0.0	0.0	16.0	1.5	0.5	23.5	10.0
16	?	?	0.0	0.0	8.0	0.0	0.0	2.0	0.0	0.0	0.0	22.5
17	?	?	0.0	0.0	8.0	0.0	0.0	0.0	0.0	0.5	11.5	134.0
18	?	?	0.0	0.5	4.5	8.0	13.5	0.0	0.0	1.0	35.0	80.0
19	?	?	0.0	46.0	20.5	0.0	0.0	52.5	0.0	76.5	43.5	34.0
20	?	?	0.0	0.0	48.5	0.0	0.0	2.5	0.0	0.0	0.5	5.0
21	?	?	0.0	0.5	3.5	0.0	0.0	0.5	49.5	0.5	0.0	5.0
22	?	?	0.0	0.0	26.5	0.0	0.0	0.0	0.0	2.5	0.0	191.0
23	?	?	0.0	0.0	21.5	0.0	19.5	0.0	0.0	46.5	0.0	184.5
24	?	?	0.0	0.0	15.0	0.0	0.0	33.0	0.0	2.0	10.5	170.0
25	?	?	0.0	0.0	0.0	0.0	0.0	2.0	0.0	6.5	6.0	43.5
26	?	?	8.0	0.0	0.0	0.0	0.0	0.0	27.5	1.0	0.0	41.5
27	?	?	2.5	3.5	0.0	3.5	21.0	0.0	2.0	10.5	0.0	88.5
28	?	?	0.0	0.0	0.0	80.0	0.5	0.0	0.0	7.5	0.0	4.5
29	?		6.5	1.5	42.5	15.0	0.5	0.0	0.0	0.0	10.0	110.5
30	?		2.5	0.0	1.0	11.5	12.5	0.0	1.0	12.5	4.0	71.5
31	?		2.5		2.0		0.0	5.0		4.5		0.0
Min	?	?	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot	?	?	22.0	142.5	357.5	209.5	230.5	216.0	192.5	360.0	198.0	1250.0
Max	?	?	8.0	46.0	68.0	80.0	67.0	52.5	49.5	76.5	43.5	191.0

JPS Ampang

24 hour periods ending at 8:00:00am each day.
Year 2015 Site 3930012 SG. LEMBING PCCL MILL
Daily totals rain (mm)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.0	0.0	29.0	11.0	?	3.5	16.0	4.5	26.0	1.0	0.0
2	0.0	0.0	11.5	35.0	25.5	0.0	0.0	0.0	0.0	0.0	5.5	?
3	0.5	1.0	0.0	6.0	6.5	6.0	1.5	?	0.0	1.5	?	0.0
4	0.0	60.5	0.0	0.0	0.0	0.0	8.5	25.0	0.0	0.0	?	0.0
5	0.0	13.0	?	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	21.5
6	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	14.0	3.5
7	26.5	4.0	0.0	14.0	0.0	0.0	?	0.0	0.0	4.0	19.0	23.5
8	28.5	0.0	0.0	0.0	?	0.0	0.0	0.5	?	?	3.0	12.0
9	92.5	0.0	0.0	0.0	12.5	36.5	0.0	21.0	14.5	0.0	0.5	1.0
10	14.5	0.5	0.0	2.5	0.0	2.0	0.0	0.0	7.0	2.0	0.0	1.0
11	3.0	?	0.0	1.5	19.5	0.0	0.0	21.0	0.0	0.0	0.0	15.5
12	1.5	0.0	0.0	0.0	0.0	6.5	0.0	32.0	0.0	29.5	0.0	2.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	42.5
14	0.0	0.0	0.0	?	9.0	38.5	0.0	0.0	0.0	0.0	7.5	0.5
15	2.0	0.0	0.0	12.0	3.5	0.0	0.0	0.0	0.0	9.0	12.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	9.5	0.0
17	0.0	0.0	0.0	0.0	2.0	0.0	14.5	0.0	2.5	6.0	2.0	0.5
18	0.0	0.0	0.0	0.0	31.0	0.0	8.0	0.0	14.5	0.0	0.0	20.0
19	0.0	0.0	0.0	0.0	8.0	0.0	0.0	0.0	0.0	8.0	0.0	1.5
20	0.0	18.0	0.0	0.5	23.0	0.0	11.0	14.5	0.0	0.0	0.5	0.0
21	?	0.0	0.0	2.0	1.0	0.0	0.0	0.5	1.5	0.0	20.0	0.0
22	?	0.0	0.0	15.5	5.0	0.0	1.0	3.0	10.5	0.0	6.0	0.0
23	0.0	0.0	0.0	0.0	34.0	0.0	0.0	0.0	13.0	0.0	12.5	0.0
24	2.5	0.0	0.0	0.0	1.5	0.0	0.0	29.5	0.0	0.0	0.0	36.0
25	1.0	0.0	4.5	5.0	0.0	0.0	31.5	0.0	0.0	0.0	26.0	5.5
26	0.0	0.0	25.0	14.5	26.0	0.0	0.0	0.0	0.0	5.0	3.5	0.0
27	0.0	0.0	0.0	2.0	5.5	0.0	2.0	0.0	0.0	56.5	14.0	0.0
28	0.0	0.0	0.5	1.5	2.0	0.0	93.0	0.0	0.0	3.5	9.5	26.5
29	0.0		0.0	0.0	0.5	0.0	0.0	0.0	5.0	15.5	49.0	41.0
30	4.5		16.5	0.0	0.0	0.0	0.0	6.5	0.5	12.5	0.5	0.5
31	0.0		5.5		1.5		0.0	0.5		20.0		0.5
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot	179.5	97.0	63.5	141.0	234.5	89.5	174.5	172.5	74.5	199.0	215.5	254.5
Max	92.5	60.5	25.0	35.0	34.0	38.5	93.0	32.0	14.5	56.5	49.0	42.5

APPENDIX B

SIEVE TEST RESULT

STATION 1 (SEDIMENT IN RIVER)

Sieve size (mm)	Mass of sieve (g)	Mass retained + sieve (g)	Mass retained (g)	Percent retained (%)	Percent passing (%)	Cumulative percent retained (%)
10.000	599.14	625.37	26.23	5.28	94.72	5.28
5.000	526.24	574.89	45.65	9.19	85.53	14.47
2.000	538.88	688.30	149.42	30.08	55.45	44.55
1.000	502.28	539.60	37.32	7.51	47.94	52.06
0.425	436.21	633.58	197.37	39.73	8.21	91.79
0.063	328.48	365.24	36.76	7.40	0.81	99.19
Pan	377.38	381.42	4.04	0.81	0.00	100
			$\sum = 496.79$			

STATION 1 (SEDIMENT BESIDES RIVER)

Sieve size (mm)	Mass of sieve (g)	Mass retained + sieve (g)	Mass retained (g)	Percent retained (%)	Percent passing (%)	Cumulative percent retained (%)
10.000	599.14	750.14	151.09	30.71	69.29	30.71
5.000	526.24	561.98	35.74	7.27	62.02	37.98
2.000	538.88	613.70	74.82	15.21	46.81	53.19
1.000	502.28	526.21	23.93	4.86	41.95	58.05
0.425	436.21	586.65	150.44	30.58	11.37	88.63
0.063	328.48	376.06	47.58	9.67	1.70	98.3
Pan	377.38	385.71	8.33	1.69	0.01	100
			$\sum = 491.93$			

STATION 2 (SEDIMENT IN RIVER)

Sieve size (mm)	Mass of sieve (g)	Mass retained + sieve (g)	Mass retained (g)	Percent retained (%)	Percent passing (%)	Cumulative percent retained (%)
10.000	599.14	740.56	141.42	28.69	71.31	28.69
5.000	526.24	564.40	38.16	7.74	63.57	36.43
2.000	538.88	659.41	120.53	24.45	39.12	60.88
1.000	502.28	536.15	33.87	6.87	32.25	67.75
0.425	436.21	590.75	154.54	31.35	0.90	99.10
0.063	328.48	332.18	3.70	0.75	0.15	99.85
Pan	377.38	378.09	0.71	0.14	0.01	99.99
			$\sum = 492.93$			

STATION 2 (SEDIMENT BESIDES THE RIVER)

Sieve size (mm)	Mass of sieve (g)	Mass retained + sieve (g)	Mass retained (g)	Percent retained (%)	Percent passing (%)	Cumulative percent retained (%)
10.000	599.14	770.58	171.54	34.93	65.07	34.93
5.000	526.24	547.82	21.58	4.39	60.68	39.32
2.000	538.88	601.36	62.48	12.72	47.96	52.04
1.000	502.28	520.32	18.04	3.67	44.29	55.71
0.425	436.21	633.41	197.20	40.15	4.14	95.86
0.063	328.48	342.77	14.29	2.91	1.23	98.77
Pan	377.38	383.35	5.97	1.22	0.01	99.99
			$\sum = 491.10$			

STATION 3 (SEDIMENT INSIDE RIVER)

Sieve size (mm)	Mass of sieve (g)	Mass retained + sieve (g)	Mass retained (g)	Percent retained (%)	Percent passing (%)	Cumulative percent retained (%)
10.000	599.14	744.41	145.27	29.52	70.48	29.52
5.000	526.24	569.25	43.01	8.74	61.74	38.26
2.000	538.88	630.02	91.14	18.52	43.22	56.78
1.000	502.28	536.42	34.14	6.94	36.28	63.72
0.425	436.21	585.54	149.33	30.34	5.94	94.06
0.063	328.48	354.76	26.28	5.34	0.60	99.40
Pan	377.38	380.38	3.00	0.60	0.00	100
			$\sum = 492.17$			

STATION 3 (SEDIMENT BESIDES THE RIVER 1)

Sieve size (mm)	Mass of sieve (g)	Mass retained + sieve (g)	Mass retained (g)	Percent retained (%)	Percent passing (%)	Cumulative percent retained (%)
10.000	599.14	758.95	159.81	32.28	67.72	32.28
5.000	526.24	592.10	65.86	13.30	54.42	45.58
2.000	538.88	635.87	96.99	19.59	34.83	65.17
1.000	502.28	525.65	23.37	4.72	30.11	69.89
0.425	436.21	572.25	136.04	27.48	2.63	97.37
0.063	328.48	338.70	10.22	2.06	0.57	99.43
Pan	377.38	380.11	2.73	0.55	0.02	99.98
			$\sum = 495.02$			

STATION 3 (SEDIMENT BESIDES THE RIVER 2)

Sieve size (mm)	Mass of sieve (g)	Mass retained + sieve (g)	Mass retained (g)	Percent retained (%)	Percent passing (%)	Cumulative percent retained (%)
10.000	599.14	784.32	185.18	37.47	62.53	37.47
5.000	526.24	564.24	38.03	7.69	54.84	45.16
2.000	538.88	627.41	88.53	17.91	36.93	63.07
1.000	502.28	527.55	25.27	5.11	31.82	68.18
0.425	436.21	575.82	139.61	28.25	3.57	96.43
0.063	328.48	339.91	11.43	2.31	1.26	98.74
Pan	377.38	383.58	6.20	1.25	0.01	99.99
			$\sum = 494.25$			

APPENDIX C

JURNAL TEKNOLOGI

(EFFECT OF SG. LEMBING MORPHOLOGY DUE TO SEDIMENTATIONS AND EXTREME FLOOD EVENT)

Jurnal Teknologi

Full Paper

Effect of Sg. Lembing Morphology due to Sedimentation and Extreme Flood Event

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Abstract

A study on river morphology was conducted at Sg. Lembing, Kuantan, Pahang. The major contribution to the depositional process in the river is the sediment which is composed by granular materials that have variety size and type. Excess sediment could cause the river level increase that can cause changes of the river morphology. This study focused on changes of river morphology by determines the point of the river that has major changes. Three sampling Stations have been chosen based on the river changes between in year 2010 to 2015 which had been analyzing using Google Earth software. The locations of study area are in upstream (Station 1), mid-stream (Station 2) and downstream (Station 3). Sampling data are collected in two day which is on 16 March 2016 and 23 March 2016. Sediment particles in every station were classified based from United State Army Corps Engineer [1] table. The data from Department of Irrigation and Drainage and Malaysian Meteorological Department are used for analysed rainfall pattern. As the conclusion, sediment sizes at Sg. Lembing are between 2.360mm to 0.425mm. The minimum and maximum total yearly rainfall data is 1443mm and 3775.5mm at 2008 and 2011 respectively.

Keywords: Sg. Lembing, Rainfall pattern, River morphology, Sediment classification

Abstrak

Satu kajian mengenai morfologi sungai telah dijalankan di Sg. Lembing, Kuantan, Pahang. Sumbangan utama kepada proses pengenapan di dalam sungai adalah sedimen yang terdiri dari bahan-bahan berbutir yang mempunyai pelbagai saiz dan jenis. Sedimen yang berlebihan boleh menyebabkan peningkatan paras sungai yang boleh menyebabkan perubahan morfologi sungai. Kajian ini memberi tumpuan kepada perubahan morfologi sungai dengan menetukan titik sungai yang mempunya perubahan besar. Tiga stesen pensampelan telah dipilih berdasarkan perubahan sungai di antara tahun 2010 sehingga 2015 yang telah dianalisa dengan menggunakan perisian Google Earth. Lokasi kajian adalah di hulu (Stesen 1), pertengahan aliran (Stesen 2) dan hiliran (Stesen 3). Data pensampelan dikumpulkan dalam dua hari iaitu pada 16 Mac 2016 dan 23 Mac 2016. Partikal sedimen di setiap stesen diklasifikasikan berdasarkan Jadual United State Corps Army Engineer [1]. Data daripada Jabatan Pengairan dan Saliran dan Jabatan Meteorologi digunakan untuk menganalisa corak hujan. Sebagai kesimpulan, saiz sedimen di Sg. Lembing adalah antara 2.360mm sehingga 0.425mm. Jumlah data hujan tahunan minimum dan maksimum adalah 1443mm dan 3775.5mm masing-masing pada 2008 dan 2011.

Kata kunci: Sg. Lembing, corak hujan, morfologi sungai, klasifikasi sedimen

1.0 INTRODUCTION

Rivers are the most important freshwater resource for mankind. Most commonly rivers flow on the surface but there are many examples of underground rivers where the flow is contained within chambers, caves or caverns. River is very useful and has various functions in human life such as for domestics, economics, connection for one place to others place and many more. The main function of the river is to flow the water to the water storage or sea. River also brings the sediment from upstream or from erosion process. Sediments may affect the characteristics and the rate of the river. As example, the depth of river become shallow if the sedimentation occurred. It also will make the quantity of aquatic life will reduced [2] .

Sediment is the nonpoint source pollutants come from a number of sources and washed into our waterways by surface runoff. When land disturbing activities occur, soil particles are transported by surface water movement. Soil particles transported by water are often deposited in streams, lakes and wetlands that can changes the cross section; increase the bed load also changes the morphology itself. The process of sediment deposition is also dependent on river discharge and speed of river flow. As such, the higher value of water velocity would result in higher amount of sediment.

Erosion of soil from the catchments involves the process of detachment of soil from the soil surface and its transport by rainfall and runoff. Water is a very dangerous agent than the wind. Water soluble and will not only run but also erode the nutrients and soil grains break away [3]. The overland flow exerts shear stress on the surface thereby inducing both detachment and transportation of soil particles. Deposition of detached material takes place when the transport capacity of flow is smaller than the quantity of material being transported.

Sedimentation is the process of letting the suspended material to settle by gravity. The sediment size can be small, such as sand, small pebbles and silt, or large such as boulders, which are normally found upriver [2]. Sediments found in estuaries are mostly fine-grained, such as sand and silt. Sedimentation accomplished by decreasing the velocity of the water, which is treated to a point below. So the particle will not remain in the suspension. If the velocity no longer supports the particle, it will be remove by the gravity.

Erosion and sedimentation are linked to each other and embody the processes of erosion, transportation and deposition mechanism of sediments. In nature, there are two major types of erosion, example by water and wind. For Malaysian environment water is the most significant erosion due to high mean of annual rainfall, storm frequency and density [4]. Sediments which reach streams or watercourses can accelerate bank erosion, clog drainage ditches and stream channels, reduce the depth and capacity of the channels and silt reservoirs. This may cause hydrological deterioration and can lead to severe flooding.

The pressures of urban development have large scale in Kuantan town impacts to the natural environment and in particular aquatic resources and their natural corridors. Changes to the land use can decrease permeability, increase fine sediment inputs, impact on water quality and increase runoff. These changes create an unbalance in the natural processes and lead to increased flood events, reduce base flows, decrease habitat diversity and channel erosion.

Several major floods occurred in the last few decades in Kuantan, not only causing extensive damage and inconvenience to the community or the economic, but also the river morphology itself. The sediment will reduce the function of the river and will cause flooding and brings along the sediments from upstream to downstream when receives heavy rainfall during monsoon time.

There are three main objectives for this study which are:

i. to study the river morphology and identify the area that contributed high sedimentation to the Sg. Lembing catchment.
ii. to identify the types and characteristics of sediment at Sg. Lembing catchment area.
iii. to determine the factor that affect transportation of sediment within Sg. Lembing catchment area.

The study was conducted at Sg. Lembing, Kuantan, Pahang. It was concentrate on the types of sediment of 3 sample location where the river morphology change. Additional sources of rainfall data are obtained from Malaysian Department of Irrigation and Drainage to analyse the rainfall pattern. The changes of the river cross section due to the sedimentation and flood event were determined.

2.0 METHODOLOGY

Three sampling point representing the length of Sg. Lembing which is about 2km has been selected; Station 1 (S1) upstream Sg. Lembing, Station 2 (S2) mid-stream Sg. Lembing and Station 3 (S3) downstream Sg. Lembing. Sediment sample were collected by using the shovel. The samples collected were analyzed in the laboratory.

The sieving method was done by spreading sediments on a tray and dry with 105 $^{\circ}$C for about 24 hours. The soil sample was divided into 500 grams samples and sieved about 15 minutes with a mechanical shaker. The sizes of sieve tray used in this research were 10.0mm, 5.00mm, 2.00mm, 1.00mm, 0.425mm, and 63µm. Each type of the sediment represents the different size that characterized from the United State Army Corps Engineer [1] table as reference of sediment particles classification.

Parameters, such as the flow velocity, width and depth of the river were determined in-situ. All the data obtained from laboratory and in-situ measurement are important in computing the stream discharge. In this study, the flow measurement can be measure by using Mean Section Method. Other than the stream data, the rainfall data from Department of Irrigation and Drainage is collected. The data is collected to observe the pattern of the rainfall. After all, the data was analyzed.

3.0 RESULTS AND DISCUSSION

River geometric give effects on the river's flow rate where steeper, wider and deeper as goes down from upper stream to downstream. In the meantime, higher flow rate tends to sweep and erode the soil more and much more at the area with less vegetal cover. Also, high flow rate is able to carry large sediment discharge. Smaller size of sediment is easy to be carried out along the river instead of larger size of sediment.

Sediment deposition on floodplains is normally largest where there is an exchange of water between the main channel and the floodplain, commonly at bend [5]. After all, the relationships between sediment grain sizes, rainfall pattern, river flow rate, Q are discussed.

Flow rate or stream discharge, Q for each Station was calculated by using mean section method is presented in Table 1, Table 2 and Table 3 and sieve analysis data for each Station as in Figure 1, Figure 2 and Figure 3. Besides that, rainfall data within year 2008 to 2015 is also presented in Figure 4

Table 1 Flow rate and cross section data for Station 1[a]

Station	Depth (m)	Width (m)	Velocity (m/s)	Average velocity	Average Depth	Flow rate $= w_i d_i v_i$ (m^3/s)
1a	0	0	0			
				0.193	0.145	0.114
1b	0.310	4.080	0.385			
				0.436	0.335	1.192
1c	0.380	8.160	0.487			
				0.417	0.345	1.760
1d	0.290	12.240	0.347			
				0.174	0.155	0.440
1e	0	16.320	0			

Table 2 Flow rate and cross section data for Station 2[a]

Station	Depth (m)	Width (m)	Velocity (m/s)	Average velocity	Average Depth	Flow rate $= w_i d_i v_i$ (m^3/s)
2a	0	0	0			
				0.178	0.083	0.062
2b	0.165	4.175	0.355			
				0.497	0.3303	1.257
2c	0.440	8.350	0.638			
				0.492	0.365	2.249
2d	0.290	12.525	0.346			
				0.173	0.145	0.419
2e	0	16.700	0			

Table 3 Flow rate and cross section data for Station 3

Station	Depth (m)	Width (m)	Velocity (m/s)	Average velocity	Average Depth	Flow rate $= w_i d_i v_i$ (m^3/s)
3a	0	0	0			
				0.167	0.088	0.070
3b	0.175	4.785	0.334			
				0.377	0.213	0.768
3c	0.250	9.570	0.420			
				0.439	0.340	2.143
3d	0.430	14.355	0.457			
				0.229	0.215	0.942
3e	0	19.140	0			

3.1 Flow Rate, Q

The flow rate is obtained from data velocity of the river and the cross section area of every Station. The flow rate result is collected on 13/3/2016. Table 1 until Table 3 shows the cross section and flow rate data for Station 1, Station 2 and Station 3.

3.2 Sediment Grain Size

The finding of this study, for grain size sediment it shows that sediment in river (bed load) and sediment besides the river at all Station are most retained at 0.425mm followed by 10.00mm and 2.00mm. Bed load is the particulate material that moves through the channel fully supported by the channel bed itself [6]. According to [1], the most sediment can be classified as medium sand, medium coarse gravel and fine gravel.

Figure 1 until Figure 3 shows the percentage of particle size distribution from Station 1 to Station 3. The sediment collection is done on 13 March 2016. The result was obtained from the sieve analysis to get the percentage of mass retained at every sieve size used.

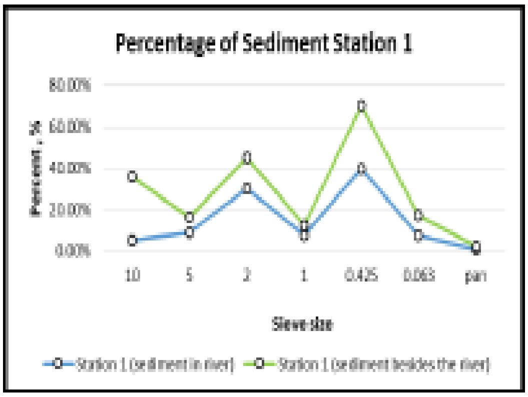

Figure 1 Percentage of Sediment at Station 1

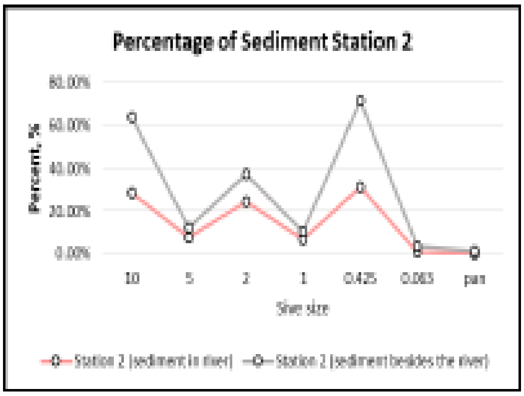

Figure 2 Percentage of Sediment at Station 2

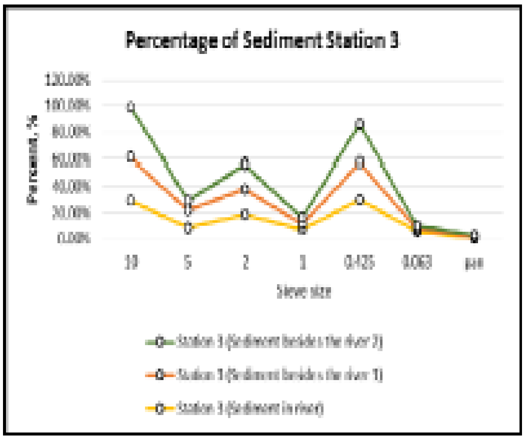

Figure 3 Percentage of Sediment at Station 3

3.3 Analysis Rainfall

Factors influencing sediment transportation was covered by acquiring the flow rate of the river. Total of rainfall genuinely affects the flow rate. From Figure 5, the year receives the least number of rainfalls is in 2008 where amount of 1443mm was recorded. In contrast, the wettest month is in year 2011, records 3775.5mm.

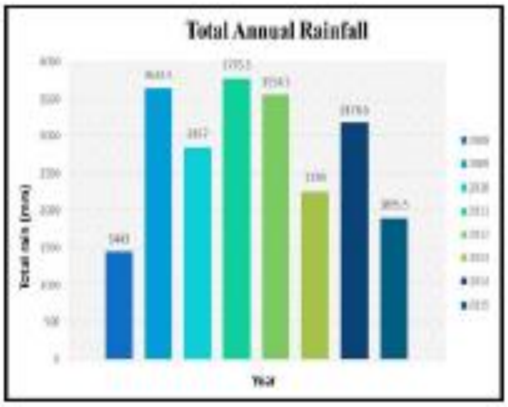

Figure 5 Total Annual Rainfall (2008-2015)

Rainfall in the river catchment area are the primary sources of water discharge, the local water level are also determined in the state of the river bed. Sudden changes in velocity can result in deposition by streams. Within a stream the velocity varies with position and if sediment gets move to the lower velocity part of the stream the sediment will come out of suspension and be deposited.

For example, if the discharge is suddenly increases, as it might be during a flood, the stream will overtop its banks and flow onto the floodplain where the velocity will then suddenly decrease. This results in deposition of such features as levees and floods.

3.4 River Morphology

Water and sediment transport through the Sg. Lembing increase with time due to the reduction of river capacity that resulted from reclamation and sedimentation along the river.

River bank erosion, river bed degradation, river buffer zone encroachment and deterioration of river water quality cause a serious and regular hazard in urban settlements at the area. The powerful water currents wear away at the edges of these settlements during the wet periods and sometimes entire settlements established near the bank are washed away. Figure 6 shows the channel planform modification along Sg. Lembing.

The changes in the channel can be observed in many locations along the river. From these results of cross section changes, it's shown that steep slope in Sg. Lembing has induced higher discharge, and it was associated with the spatial variation in sediment transport and sediment size. The changes in river bed profile may be attributed to the erosion or deposition along the banks or the channel width.

a) Year 2010 b) Year 2015

Figure 6 The channel platforms modification along Sg. Lembing in year 2010 and year 2015

Station 1 is located at the upstream with coordinate N 03 ˚ 54.329' E 103 ˚ 01.821' which is nearby Kg. Kolong Pahat. This area is famous and became a centre for tourist rent a chalet or resort that ore provided by the villagers. This section has a width of stream of 16.32 m, meanwhile width of sediment besides of the stream is 40.1 m. The depth of the stream is between 0.2 m to 0.4 m. Figure 7 below shows the morphology changes of river at Station 1, Sg. Lembing in year 2010 and 2016.

Station 2 is located at the upstream with coordinate N 03 ˚ 54.647' E 103 ˚ 01.756' which is in front of the Muzium Sg. Lembing. This section has a width of stream of 16.70 m, meanwhile width of sediment besides of the stream is 26.40 m. The depth of the stream is between 0.1 m to 0.5 m. Figure 8 below shows the morphology changes of river at Station 2, Sg. Lembing in year 2010 and 2016.

Station 3 is located at the upstream with coordinate N 03 ˚ 54.986' E 103 ˚ 01.995' which is nearby the food court. This section has a width of stream of 19.14 m, meanwhile width of sediment besides of the stream is 116 m and 27.70 m. The depth of the stream is between 0.1 m to 0.5 m. Figure 9 below shows the morphology changes of river at Station 3, Sg. Lembing in year 2010 and 2016.

a) Year 2010 b) Year 2015

Figure 7 The changes of the river at Station 1 in year 2010 and 2015

a) Year 2010 b) Year 2015

Figure 8 The changes of the river at Station 2 in year 2010 and 2015

1

a) Year 2010 b) Year 2015

Figure 9 The changes of the river at Station 3 in year 2010 and 2015

4.0 CONCLUSION

Sedimentation and flooding can give an effect to river morphology. The flood problem that happens every year in Sg. Lembing gives the big impact to the river system. During floods sediment is transported in the main channel. The sediment is carried onto the floodplain either by diffusion or convection and, as the flow velocities on the floodplain are generally low, it is deposited. The rate of sediment deposition normally reduces rapidly as one move away from the main channel. Sediment deposition on floodplains is normally largest where there is an exchange of water between the main channel and the floodplain, commonly at bend [5].

In order to carry out the analysis of sedimentation pattern at Sg. Lembing, samples are collected from the study area and sieve analysis graph is used to determine the size of sediment while the types of sediment is determine by reference using USACE table.

From the study, it can be concluded that the sediment and flood give an impacts to the flow or river morphology. The relationship between the flow and the types of sediment deposited and also rainfall distribution can be shown by the graph. The types of sediment at Sg. Lembing are different from upstream to the downstream. Most of the types of sediments at the area are coarse gravel, fine gravel and medium sand. At Sg. Lembing, the types of sediment can be found at the area are 7 types according U.S.Army Corps of Engineer (USACE) size classification., the percentage of coarse gravel that have size between 32-16 mm is high among the other types. The medium sand recorded second high which is 0.50-0.25 mm followed by fine gravel which has size between 8-4 mm. The percentage other types of sediment is below than 10%.

At Sg. Lembing, the area that has the highest velocity is Station 2 that consisted of larger sediments. Most of the types of the sediments at the area are coarse gravel, fine gravel. The other types of sediments are only few at the area because has been wash into the downstream that had a lower velocity.

At Station 1, the velocity at this area is the lowest among other station at the study area. There are still larger sediment like coarse gravel and fine gravel, but increasing of the finer particles such as medium sand can be found at this station.

It shows that, the types of the sediment will flow with the velocity and discharge of the river. The larger sediment will move when there are high velocities while the finer types will settled at the area when flow cannot transport the sediment anymore.

This study had identified the area that contributed high sedimentation to the Sg. Lembing catchment. Also, this study had gained sediment information at Sg. Lembing. The sediment grain size and factors influencing sediment transport are determined. The relationships between size of sediment, rainfall, flow rate, cross section of the river are correlation with each other that can changes the river morphology itself.

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References

[1] U.S Army Corps of Engineer. 1991. *Scour and Deposition in River and Reservoirs,* User Manual, Hydrologic Engineering Center, Davis, California.

[2] Nadiatul Adilah Ahmad Abdul Ghani, Norasman Othman & Mohd Khairun Hafiz Baharudin. 2013. *Study on Characteristics of Sediment and Sedimentation Rate at Sungai Lembing, Kuantan, Pahang.* Procedia Engineering, 53, 81–92.

[3] Toriman. 2013. *Bed-Load Sediment Profile and Effect of River Bank Erosion on River Cross-Section.* American Journal of Environmental Sciences, 9(4), 292–300.

[4] Department of Irrigation and Drainage. 2012. *Urban Stormwater Management Manual for Malaysia Estimation.* Chapter 2, 1-5.

[5] Roger Betters. 2008. *Sediment transport & alluvial resistance in rivers.*

[6] Chanson, H. 1999. *Sediment transport: new approach and analysis.* The Hydraulics of Open Channel Flow, 195–209.