CHAPTER 1

Introduction.

1.1: Background and issue.

Nibong Tebal town used to be one of the more backward areas in Penang state. Since early this century, it is regarded as a district capital and a small commercial centre serving the surrounding agricultural area. However, the development pace was slow in the late 70's, and since the early 90's the pace could be considered rapid especially under the Penang Master Plan, which destines this town and it's peripheral to be a new growth centre.

This area is situated in the Krian River flood plain. A network of levees, irrigation canals had been built since the 50's mainly to secure the town and largely plantation areas from flooding due to high tides and high river discharges.

However, of late flash flood had been more frequent and extensive (especially during high rainfall and high tides) in the town area. This is possibly due to urbanization, poor drainage and inefficient flood management. Flash floods, disrupt commercial activities, schooling and daily lives of residents in effected areas.

There is a possibility that the occurrence of flash flood will increase in frequency, severity and extent, as urbanization continues without better drainage system and long term planning.

1.2: Aim and Objectives.

The aim of this study is to predict the potential present and future floods by relating estimated design peak discharges from the drainage systems over a period of time. In this study, the current flood control measures will be examined. A flood management plan will be recommended based on the evaluations. This will be invaluable to the planners who will need the information for their planning purposeses.

The main objectives are:

1- to identify the rate and spatial trend of urbanization in the study area.

2- to relate this trend to occurrence of flash flood at present and predict future scenarios.

3- to demarcate flash flood boundaries with reference to objective b.

4- to suggest flood mitigation and preventive measures for the present and future.

1.3: Significance, interdisciplinary aspect and contribution.

This research assesses the current flood situation and forecasts the future flood conditions. It will assist local planners in producing better mitigation and preventive measures, by giving an academic opinion of the flood situation.

This research is interdisciplinary. Flash flood studies have usually been approached within the framework of integrated studies. This study also follows this trend. Starting from an understanding of the spatial land unit where flood flows occur in an open system with natural boundary, the complex web of interactions between biotic and abiotic components that aggravate the floods were observed. Thus, in observing these interactions, an interdisciplinary approach is fundamental. However, in any research, there is limitation to the study. Firstly, not all components within a system have equal importance to the subject matter, and the interdisciplinary aspect of this research is to confine itself to related disciplines such as geomorphology, hydrology and hydraulics, meteorology and climatology, pedalogy (soil science), human geography and plant ecology. Secondly, flash flood is often thought of as a civil engineering problem. As a result, structural measures had always been given emphasis in any mitigation plans. Whilst, this is important, flash flood is also an environmental problem requiring an environmental approach. Structural measures will always be an important component but long term solutions will have to include the environmental approach.

This research will approach the flood issue from an environmental viewpoint (while employing engineering as well) to identify cause, potential problems and possible solutions. Thus, giving another dimension for planners for their deliberations.

1.4: Literature review.

Floods in Malaysia have been thoroughly reviewed by Leigh C.H and Low, K.S, 1973 and Sooryanarayana V, 1995, who gave accounts of major floods in Peninsular Malaysia (since the first record was made during the British era) for the year 1886, 1926, 1967, 1971, 1986. According to them, flood was an annual problem for the east coast states of Kelantan, Trengganu and Pahang. Early records of 1886 and 1926 were scanty and not well documented. In 1886, hurricane force winds caused severe floods in Kelantan. However, the extend of the flooded area was not recorded. The Great Flood of 1926, so far was considered the biggest ever occurred in our Malaysian history, causing extensive damage in Pahang, Trengganu, Kelantan and Perak. Generally, the most severe floods effected Kelantan, Trengganu and Perak. In 1967, 20% of Kelantan was flooded and 84% of its population were affected. The flood damages amounted to RM30 million. Following the 1967 flood, the government had taken steps to improve and expand flood forecasting and warning system. In January 1971, most parts of Peninsular Malaysia were flooded, causing destruction estimated to be RM 300 million. Kuala Lumpur suffered RM 50 million losses and Pahang valley, RM 38 million. In 1986, Trengganu was severely flooded.

The State of Penang was severely affected by floods in 1971, 1976, 1980, 1988, 1991 and 1995 (DID in Chan N.W, 1998). In 1998 and 1995, Georgetown and other parts of Penang suffered a total flood damage of RM 1.3 million and RM 4.844 million.

Floods in the east coast were mainly caused by prolonged rainfall, typically ranging from three to nine days. Episodes of intense rainfall were triggered off by converging cold surges interacting with the northeast monsoon disturbances or quasi stationary near equatorial troughs occurring in the vicinity (Sooryanarayana, 1995). While the northeast monsoon (November to March) was largely responsible for the extensive floods on the east coast, the occurrence of floods on the west coast were more localized and associated with the southwest monsoon season (May to September) and two relatively short inter-monsoon periods (April and October) (Chan, 1997).

Floods can be classified in terms of duration and spatial coverage. Causes of flood were mentioned by Leigh, C. H, Low K. S, 1973, Chan N W, 1992 and Sooryanarayana V, 1995. The causes were torrential rainfall lasting for few days, causing discharge to be more than channel capacity which was a result of haphazard urbanization that increased runoff , reducing time lag and channel capacity and loss of natural retention. High tides and backwater effects coinciding with heavy rainfall and sedimentation reducing channel capacity, blockage of river channel by rubbish and logs and natural terrain features - low lying areas (some are below mean sea level) and excessive improvement of upstream trunk drainage aggravated the situation.

Flash flood was charactèrized by its "sudden" occurrence after a short but intense rainfall or storm compared to gradual flooding that results from a prolong period of rainfall. The term urban flood was usually used to refer to flash flood. Rasid H, 1982, defined urban flood as any abnormally high water stage or flow over urban streets that results in significant detrimental effects.

In ESCAP, 1990, it was reported that flash floods were common in South East Asean cities namely Kuala Lumpur, Bangkok, Jakarta and Manila. Rapid urbanization was also one of the key factors of flash floods in these cities. Manila and Bangkok were partly influenced by tides. Flash floods are mainly the result of human activities in altering the drainage system and hydrological components. These activities were more intense in urban area as mentioned by Chow V. T, 1969.

In urban areas, there are two systems of drainage and different hydrological components compared to a natural system as mentioned by Hall M. J, 1980, Douglas I, 1984 and Musaike K, 1991. Hall (1980) described the two systems as internal and external drainage. Internal drainage refers to sewer network and external drainage to land drainage or river. Once the internal drainage is constructed, this sewerage system is instrumental in changing the hydrological regime of the urban catchment area.

Douglas (1984) described this as a dual water system or double hydrological cycle consisting of a modified natural drainage system of streams and rivers and man induced water supply and waste water system. This two usually converge where water is discharged into the modified natural channels within or downstream system of cities.

Musaike (1991) included municipal water supply as a major component in urban hydrology which eventually effects the stream network.

They identified two common features in urban drainage. These were higher peak flows and shorter time lag resulting from large impervious surface typical of urban areas.

The effects of land use change (natural to either urban or agriculture) and rainfall and runoff relationship had been reviewed by Goh K. C. (1972), who had made a comparative study of rainfall and runoff relationship characteristics of a developed and forested catchment. In his analysis of twenty storm events, he had identified three important hydrometeorological variables. They were rainfall amount, rainfall duration and antecedent condition of the catchment for the forested catchment. However, no relationship could be traced between these variables and runoff for a developed catchment. Runoff volume over long and short term period was found to be consistently higher in the developed catchment. The greater storm runoff in the developed catchment was a reflection of its developed nature that retards infiltration but enhances overland flow.

Low K. S. and Goh K. C. (1972) made a comparative water balance study of five catchments in Selangor. Significant difference in the runoff totals between four forested catchments and a semi forested catchment was identified. The former catchments had lower runoffs as a result of higher losses through evapotranspiration and interception. The latter (Damansara catchment) had higher runoffs that could be attributed to changes in the nature of land use from forest to agriculture, roads, settlements and an airport which retards infiltration but encouraged surface flow.

Leigh C. H. and Low K. S. (1973) in an appraisal of West Malaysia flood situation had attributed process of urbanization such as creation of impervious surface, loss of mining pools (which act as retention ponds), deforestation (resulting in siltation) and inadequate artificial drainage to occurrence of flood.

Goh K. S. and Toebes C. (1975) made a general review of some hydrological effects of land use changes in Peninsular Malaysia. They identified similar factors from available data and literatures relating land use to floods.

DeVries J. J. (1980) conducted a study on the effects of flood plain encroachments on peak flow. He concluded that when land development was permitted on river flood plains, the magnitude of the flood peak discharge would increase due to removal of flood plain storage. If the activity was limited, the study results indicated that the increase of flood peak was usually small, generally less than 10%. Flood plain storage was an important factor in the attenuation of flood peak flows and in reducing flood levels. It was found that the effects of encroachment were less on steeper rivers than on flatter ones. Greatest increases in peak flow were those with the flattest slopes, largest storage reduction and with hydrograph peak early in the flood event.

Rasid H. (1982) in his study on urban flood problems of an expanding Benin city in Nigeria had identified three sets of factors responsible for accumulation of flood waters on the city's street. They were urban impervious land which reduced ground infiltration and allowed abundance of surface runoff, eroded street pavements, depressions that provided for localized basin for runoff accumulation, the lack of adequate drainage structures along streets and blockages of existing drains with sediments and municipal refuse that inhibit efficient or quick disposal of these waters.

Chan N. W. (1995) had made a contextual analysis of flood hazard management in Peninsular Malaysia. The socio-political, institutional and individual context in either alleviating or perpetuating flood hazards were studied. Flood hazard models were generated, consisting of a composite flood hazard response for Peninsular Malaysia and a model of flood hazard creation via interaction of the natural and human systems. These models take into account the human perception of flood hazard. Institutional policies were examined also. This study gave a conceptual view for flood management concerning Peninsular Malaysia.

Previous flood studies were conducted by Syed Muhammad, Hooi and Binnie (1988) and Chrison Konsultant (1996) for the study area. They related the occurance of floods to a combination of poor drainage, high tides and heavy rainfalls. In addition to these studies, there were flood reports made by DID Penang (1990 to 1995), which provided informations concerning the extent of floods. However, these studies and reports did not provide detailed informations concerning the flood situations in the study area. Hence, the above reviews gave a good background understanding on flood events, flood classifications, causes of floods, rainfall-runoff relations and urban hydrologic systems which provided important insights into the flood situations in the study area.

In this study, an integrated approach was employed. The study area was divided into drainage units. Each of them is a complex system by itself. Their components such as soil, drainage, weather and climate, vegetation cover and built up structures were studied to model their rainfall-runoff relations using the Modified Rational Method and other mathematical models. Both the present and future potential conditions were modeled. Based on the obtained results, potential flood boundaries were demarcated for this area for the present and future conditions. Recommendations on flood mitigation and preventive measures were also made. The methods employed in this study and the recommendations that were forwarded are not uncommon as indicated in the literature reviewed below.

Wright R. L. (1972) brought forward an integrated approach in land use studies. The complexities of land as a system and spatial unit were considered in its various interacting biophysical components. This spatial unit was a system with a definite natural boundary. This boundary was defined by the geomorphologic characteristic of a particular area. It contributed an important perspective in studies concerning land system. Hydrology was shown by Wright to be intimately linked to the components of this complex system. Aerial photography was employed to demarcate land units or system within the almost flat Fitzroy flood plains. They formed the basic spatial unit of for his study.

The rational method was widely used for estimation of peak flow in small catchment area. Fricke T. J and Lewis K. V (1976) recommended this method with an addition of storage function coefficient (included a suitable storage delay time constant for Malaysia was suggested) to DID for flood estimation in urban areas. This method was suggested in a number of applied hydrological publications, for example in Chow V. T, et. al. (1988) and Hall M. J. (1980). This method was also employed by JICA in the Penang flood mitigation studies.

Morris E. M. (1981) gave a brief review on the range of surface water flow models. Mathematical models ranged from full analysis of the physics of shallow water flow to very much simpler "black box" models that describe mathematically the relation between precipitation and runoff without describing the physical processes that relate both. The choice of models depended on the intended applications. Physics based models were most useful when flow data for calibration were not available, for example if the catchment investigated was ungauged or if the effect of a hypothetical land use change was to be investigated. When data for calibration was available, then the so called "lumped conceptual" model was more useful. "Black box" models was mainly used for real time forecasting.

Literature on flood prevention and mitigation were reviewed in Sheafer J.R, et. al. (1982), Whipple W, et. al. (1983), ESCAP (1990), Musiake K, Yoshino F, Leong K. K, Kaneko Y. (1991). Basically they were divided into structural (civil engineering measures) and non-structural measures. Most of the literature had suggested a combination of both. Non-structural measures included methods of reducing surface runoff by encouraging infiltration, interception and reducing flood hazards on flood plain dwellers by better urban planning. The conventional structural method included construction of dams, flood retention ponds, bypass drains, drainage improvements and levee construction.

The master plan for flood mitigation and drainage in Penang Island was reviewed. The plan was drafted by the JICA Study Team lead by Kaneko Y (1991). This master plan included floods and flood runoff analysis, flood damage analysis, structural and non-structural measures. As flood mitigation and prevention were expensive, a suitable or realistic protection level was recommended by them. For Penang Island, a 50 years return period flood protection was recommended based on comparison of construction cost including land acquisition, existing flow capacity of the rivers, existing riverine land use conditions, scale of catchment and scale of experienced floods. Non-structural measures that were suggested include soil erosion and runoff control, removal of floating logs and debris from drains, formulation of design criteria for river and related structures and instituting a flood forecasting and warning system.

Low K.S. (1972) had conducted studies on vegetation interception for forested area and Teoh T. S. (1973) for rubber plantations. Soepadmo E. (1984) gave a general review of the role of vegetation in urban ecology that include their hydrological functions in urban areas. Their studies had shown that vegetation can intercept more than 30% of the rainfall depending on the intensity of rainfall and foliage density. These studies had an important implication in creating urban green areas for the purpose of flood prevention and mitigation.