1 MALAYSIAN PERSPECTIVE

1.1 GENERAL

Malaysia is part of the South East Asian community. It occupies a total area of approximately 330,000 sq. km and is divided by the South China Sea into West Malaysia (the Peninsula) and East Malaysia (Sabah and Sarawak), about 1000 km apart. Being located between longitudes 1^o - 7^o North and latitudes 100^o - 120^o East, Malaysia is influenced by the equatorial environment and is well outside volcanic, tornado, and severe drought belts. Strategically, the country is located central to various international air and sea transport and communication routes.

Malaysia is moving towards achieving a developed nation status by the year 2020. This is evidenced by its rapid socio-economic growth in the last two decades. Urban and industrial areas have grown in many parts of the country, especially in the West Coast of the Peninsula. The pressures have caused significant consequences to the environment, such as hydrological and ecological changes.

Malaysia, like many other developing tropical countries, is striding to upgrade the social well-being of its urban citizens by alleviating ever-increasing flash food, water and pollution problems. The particular issues being focused upon are stormwater management (SWM) and drainage practices.

1.2 GEOGRAPHY

1.2.1 Socio-Economics and Politics

Malaysia is formed by 13 states varying in size from 244 sq. km. (Federal Territory Kuala Lumpur) to 124,449 sq. km. (Sarawak). With a present estimated total of 21 million people, the Malaysian population is becoming more concentrated into cities, towns, and industrial zones (over 50%), with the highest figure in Kuala Lumpur at 1.4 million. Kuala Lumpur started as a village in 1860, became capital of the United Malay States in 1896, and was turned into the capital of Malaysia in 1963. It was subsequently upgraded to a city status in 1974 and now stands as the most urbanised and populated zone in Malaysia with a projected population of 1.85 and 2.4 million in 2020 and 2050, respectively (EPU, 2000).

The increase in the total population is not only from births within the country but also from immigrants across its borders. From the viewpoint of urban stormwater management/water resources, this situation means that planning for the future in Malaysia must envisage a continued increase in population growth in urban areas. Internal migration grows annually. Migration takes place from rural areas to established urban centres and industrial zones where there are good infrastructural facilities. Most urban areas are normally found on alluvium plain and coastal/estuarine zones. In the year 2020, the Malaysian population is expected to escalate to 30 million and, with further urban and industrial growth, cities and towns may reach 55-60% of the total population. Urban citizens, while making their daily life more prosperous, will increasingly be subject to environmental consequences.

1.2.2 Landform and Water Resource

Malaysia is generally formed by highland, floodplain, and coastal zones (Figure 1.**Error! Reference source not found.**). In the Peninsula, the Banjaran Titiwangsa stretched from north to south, divides the West Coast and East Coast states, while in Sarawak the Banjaran Kapuas Hulu and Banjaran Iran border Indonesia. All of these ranges are governed by virgin forest.

Most rivers in the Peninsula are short and steep, especially along the West Coast. Sg. Pahang (330 km) is the longest in the Peninsula, while Sg. Rajang in Sarawak (563 km) is the longest in Malaysia.

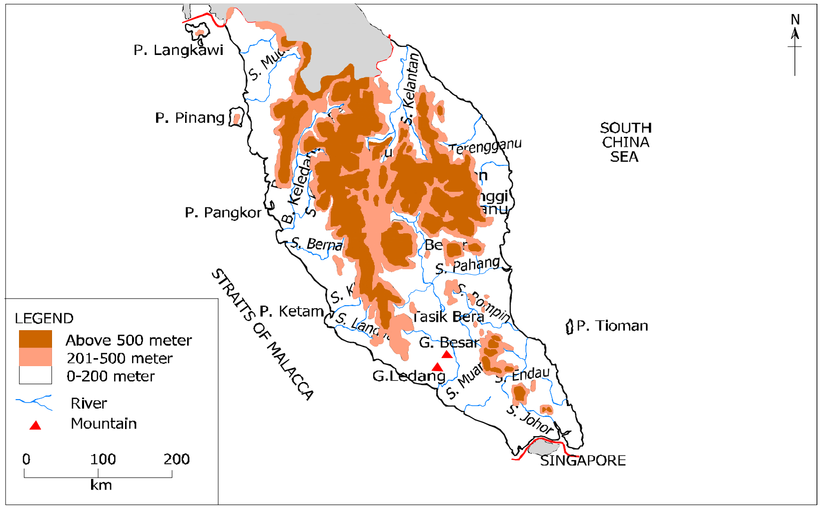
Open water bodies comprise man-made lakes such as dam reservoirs and ex-mining ponds (mostly found in the Klang and Kinta Basins), and natural lakes such as Tasek Bera and Chini in Pahang. These water sources are used for power generation, flood control, water supply, recreation, aquaculture, and tourism.

Most cities and large towns in the Peninsula are located over limestone and granite with a thin surface alluvium. These include Kuala Lumpur, Seremban, Ipoh, and Penang. Kota Bharu, Kuala Terengganu, Kuantan, Johor Bahru, and Alor Setar are resting on coastal alluvium. Similarly, in Sarawak and Sabah, most primary urban towns such as Kuching, Sibu, Miri, and Kota Kinabalu are situated on coastal alluvium. Kota Bharu is known to have the largest groundwater aquifers in Malaysia.

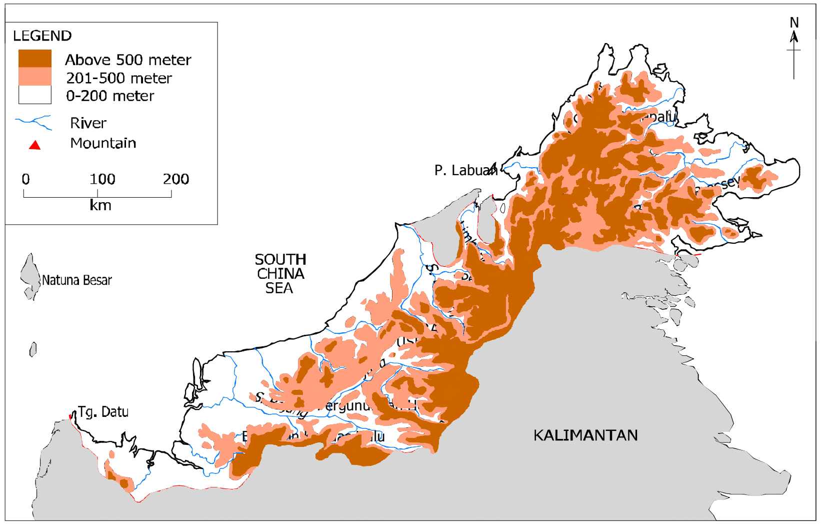
Limestone and granite rock associated with the Banjaran Titiwangsa and Tanah Tinggi Terengganu dominate the inland area of the Peninsula while the majority of Sarawak and Sabah are geologically underlained by limestone.

1.2.3 Climate

Malaysia is warm and humid throughout the year, as characterised by the equatorial climate. It has an average annual rainfall of more than 2500 mm with monthly variations for selected cities and towns, as shown in Figure 1.**Error! Reference source not found.**. The West Coast of the Peninsula is subject to localised and convective storms generated by the inter monsoon seasons/Sumatra wind system in the months of April/May and October/November. The highest monthly rainfalls in Kuala Lumpur are recorded in April and October. Storms mainly occur in the late afternoon and early evening. Intense short duration rainfall has frequently caused flash floods in many localities in the Klang Valley.



(a) Peninsular Malaysia



(b) Sabah and Sarawak

Figure 1.1 Landform and Major Rivers

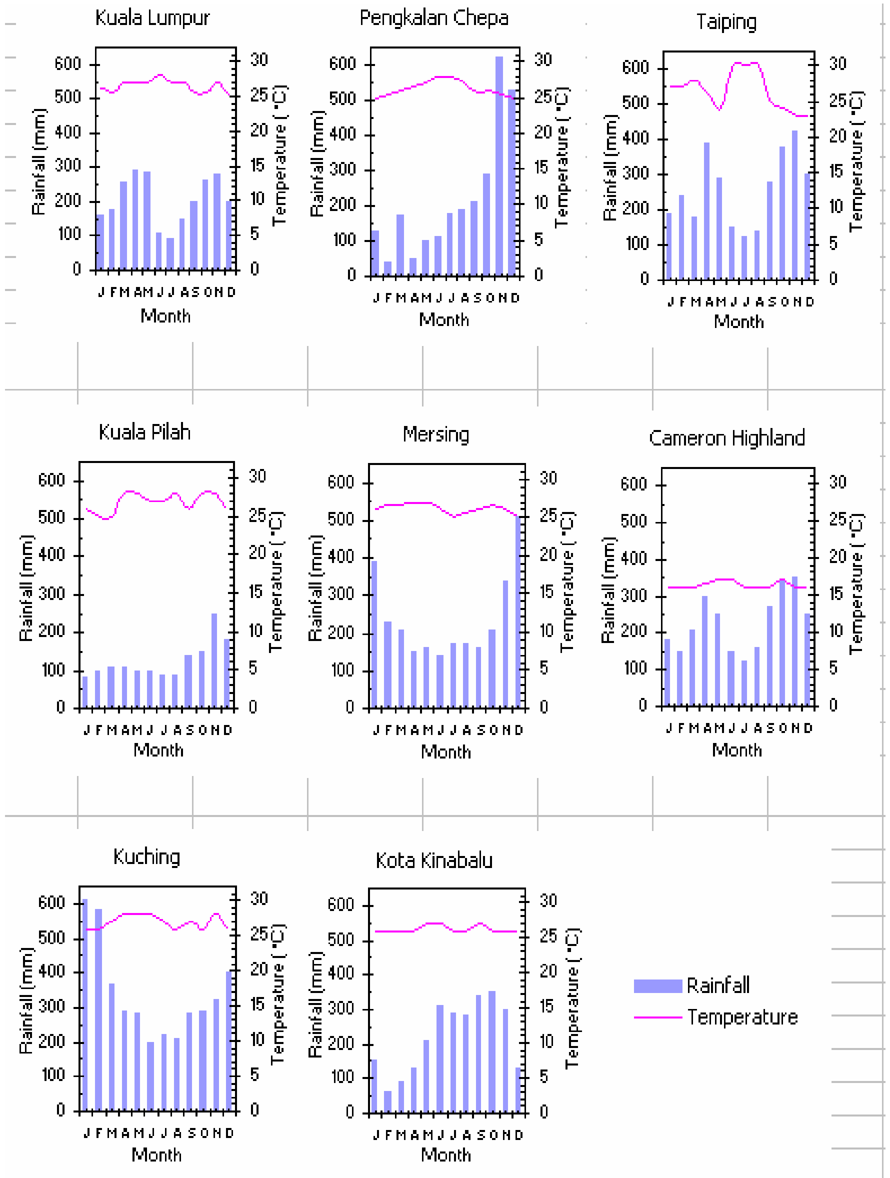


Figure 1.2 Monthly Rainfall and Temperature Variations

The South-West Monsoon (normally from May to September) produces less rain in the West Coast of the Peninsula whilst the North-East Monsoon, from November to March, carries longer and heavier rains to the East Coast of the Peninsula, North Sabah, and inland Sarawak (Figure 1.**Error! Reference source not found.**). In the Peninsula the wettest area is Taiping in Perak whilst the driest is Kuala Pilah in Negeri Sembilan (Figure 1.**Error! Reference source not found.**). Average daily temperatures range from a minimum of 25^{o} C to a maximum of 33^{o} C. Relative humidity is high, sometimes exceeding 80%. Daytime cloudy hours are also high while haze lately is a frequent occurrence that has contributed to acid rains.

1.2.4 Urbanisation

Urbanisation results in the growth and spread of impervious areas and a diversification of urban landuse practices with respect to the hydrologic and environmental terms. Urban and industrial areas in Malaysia typically comprise the following (Figure 1.1);

- residential
- commercial/business
- industrial
- institutional
- construction
- resort/golf link
- parks and greenways
- market places
- roads, streets and highways

Urbanisation poles are formed in many different ways. They are configured:

- centrally in dense arrangements such as towns, cities, ports, commercial/business centres, and new development areas
- linearly along road, highway, railway, river, estuary, and coastal area
- randomly including villages and high class residential areas

A well-planned settlement, in a Malaysian planning perspective, is one that is facilitated by adequate infrastructure and utilities, such as the new town of Shah Alam in Selangor.

The main functions within an urban area can be classified as administrative, industrial, and business. Factors that contribute to urban growth are locality and socio-economic development.

In some river basins, development pressures on the water environment are now at an alarming level. Of significance are Sg. Klang, Sg. Langat and Sg. Buloh (Selangor), Sg. Linggi (Negeri Sembilan), Sg. Melaka (Melaka), Sg. Skudai (Johor), Sg. Juru and Sg. Dondang (Pulau Pinang), and Upper Sg. Kinta (Perak).

1.3 CURRENT DEVELOPMENT ISSUES AND DRAINAGE PRACTICE

1.3.1 Development Consequences and Needs

It is widely recognised that landuse changes from rural to urban or industrial areas cause local runoff impacts on receiving water flow, quality, and ecology. Apart from erosion and sedimentation problems associated with development, it has become increasingly apparent that stormwater runoff contributes to receiving waters a significant part of total loads of such pollutants as nutrients (including phosphorus and nitrogen), heavy metals, oil and grease, bacteria, etc. Over the years, flood damage and adverse impacts on water quality, fisheries, scenic river areas, and wildlife habitats have been recognised as shortcomings of long-accepted approaches to the planning, design, and management of storm drainage facilities in urban areas.

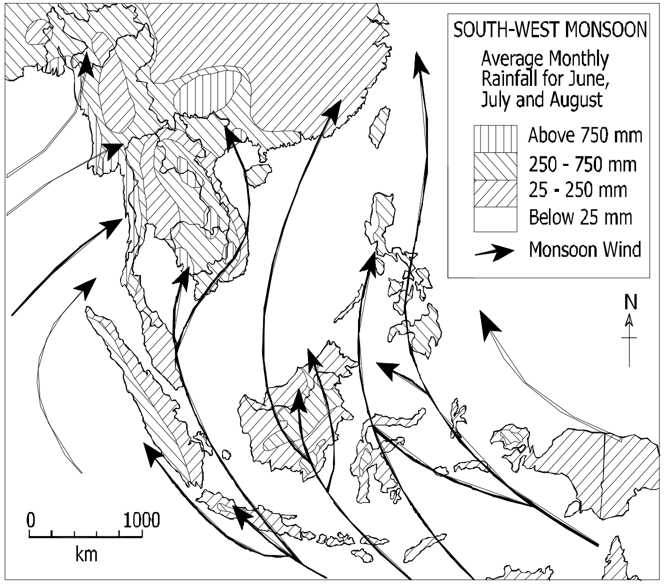
As a result rivers, lakes, ponds, reservoirs, and estuarine and coastal waters, have become sensitive to increased rates and volumes of runoff and pollutant discharges. These discharges have posed major issues to many urban and residential centres, particularly in the western states of the Peninsula. The problems have become even more aggravated by frequent intense rainfalls, the physiological nature of basins, and the pattern of urbanisation with relatively poor urban services.

Conventional storm drainage has long been in practice in many countries including Malaysia. Local decision-makers and professionals have just begun to recognise the need for a new and broader approach, urban stormwater management (SWM) in the light of development in the country progressing at a tremendous pace.

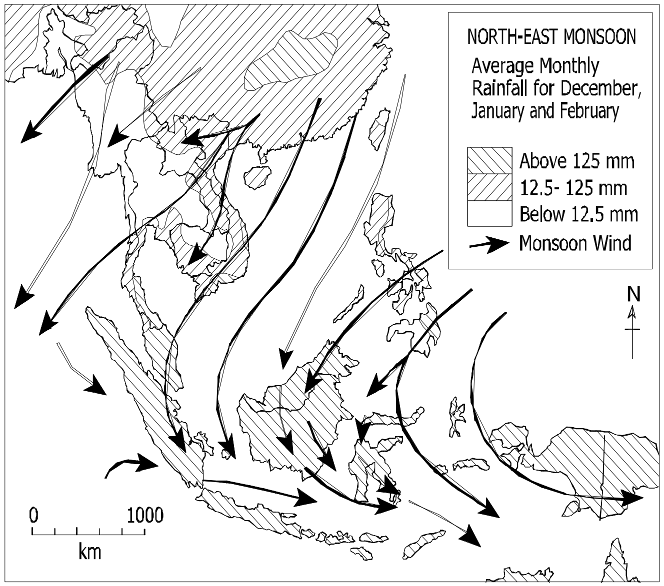
Every professional currently engaged in such development (engineers, planners, and environmentalists in particular) should therefore accept the new concept and challenging roles of not only designing satisfactory flood protection facilities but also of controlling and reducing stormwater pollution in urban catchments and receiving waters. The level of technical know-how of our practising engineers and the quality of stormwater data, in terms of sufficiency and reliability, need to be upgraded in readiness to develop and achieve sound design practice and operational procedures to deal effectively with the existing and future stormwater systems.

1.3.2 Existing Drainage Practices

Present experience indicates that rapid disposal, localised, reactive, and mono-functional drainage concepts have been widely practised in Malaysia.

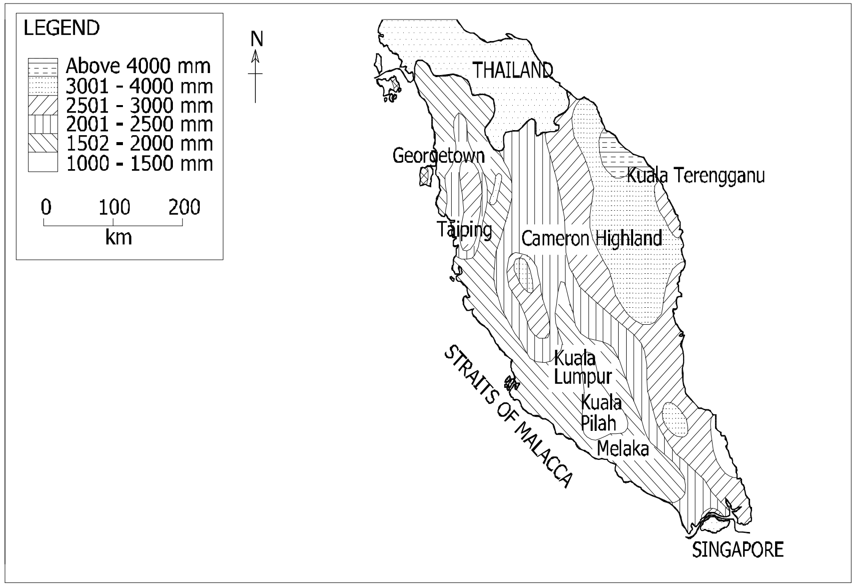


(a) South West Monsoon

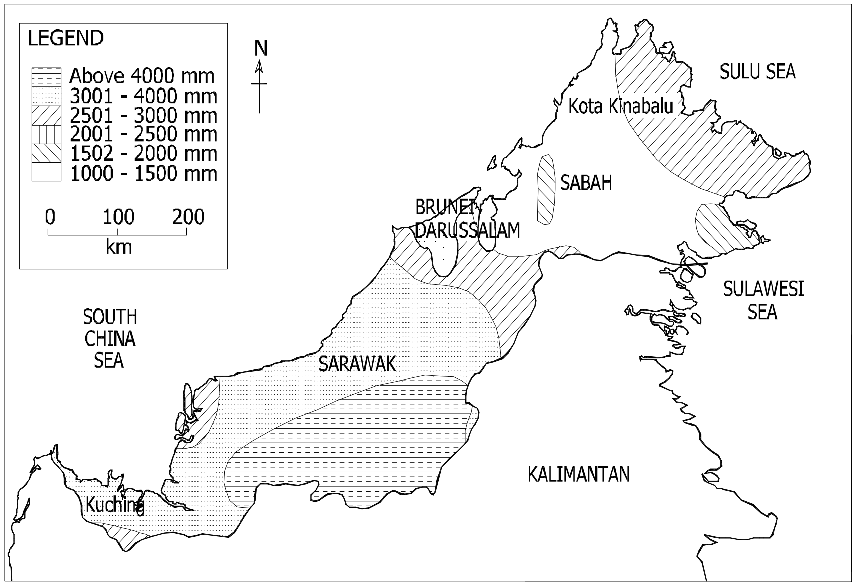


(b) North East Monsoon

Figure 1.3 Monsoon Influences



(a) Peninsular Malaysia

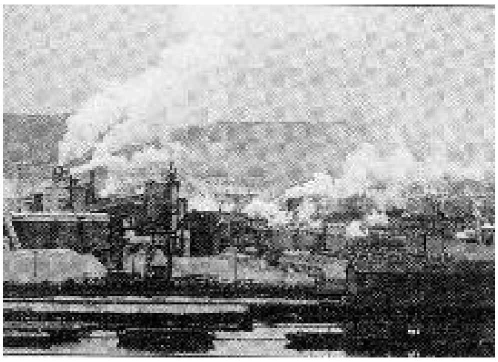


(b) East Malaysia

Figure 1.4 Spatial Distribution of Annual Rainfall

(a) Residential Area

(b) Commercial/Business Centre



(c) Industrial Zone

Figure 1.1 Type of Urbanisation

Although situation may differ from one country to another or even in regions with regard to development, the Rational Method is adopted for sizing most drainage structures. While standard design procedures have been available since the early 1970s, the peak discharge estimation method has been freely used, even for large and complex hydraulic structures in large catchment and tidal areas. As a result, cost-effective design and construction has seldom been realised. Practices in Malaysia have thus far relied very much on slight adaptation or even direct use of temperate region-based urban rainfall/runoff design procedures and computer models.

Research on the characteristics of urbanised and urbanising catchment areas is relatively scarce within Malaysia and continues to be frustrated by a lack of data, in terms of quantity/quality/length of record, from which meaningful design information may be deduced sufficiently and reliably.

In Malaysia, urban drainage practice has been largely based on the 1975 DID Urban Drainage Design Manual that covers essentially the following;

- planning
- basis of design
- flood estimation
- hydraulic design of open channels
- structures
- storm drainage design for urban streets
- detention storage
- erosion and sediment control
- information to be submitted with design

The approaches to the design procedure, in terms of methods and techniques employed, have not been reviewed and upgraded although advances in urban drainage and stormwater management technology are continuing and circumstances changing as evidenced by the increased frequency of flash floods and water quality problems occurring in many urbanising areas in Malaysian towns and cities.

In relation to the contents of the former manual, some recognised weaknesses are associated with institutional and legal issues, strategic/masterplanning concepts, discharge estimation, minor and major drainage facilities, computer simulation, and runoff quantity and quality controls. These were either inadequately covered or not included in the manual.

1.3.3 Local Problems

Some of the stormwater-associated problems being encountered in Malaysia are (Figure 1.2);

- construction activities and mud flows
- flash flooding
- water pollution and ecological damage
- urban slope failures
- traffic disruption and accidents
- surcharges and overflows from wastewater facilities
- garbage and floating litters
- sedimentation

Major zones that are prone to these problems include urbanised and urbanising centres in the Klang Valley, MSC/KLIA region, Upper Kinta Valley, Penang, Linggi Basin, Melaka Basin, and other new socio-economic growth areas in the West Coast of the Peninsula. Inland localities normally experience short flash floods while coastal towns face larger, longer duration floods due to expanded basin runoff contributions, flattened floodplains, and tidal influences. Many urban rivers, lakes, and ponds are rendered unfit for use, either in-stream or off-stream, as they are flooded and overloaded with non-point source (NPS) pollutants in wet periods and their water bodies experience more concentrated point sources (PS) due to reduced baseflow contribution in dry periods. An interpretative evaluation of river water quality has revealed that increasing proportions (more than 60%) of the Malaysian inland waters are failing due to pollution contributions from the NPS or storm-generated activities, particularly in urban areas (W Mokhtar, 1998).

(a) Flash Flooding

(b) Pollution of Receiving Waters

Figure 1.2 Flash Flood and Pollution from Stormwater

1.4 NEW DIRECTION

It should be appreciated that the engineer concerned with the drainage of urban areas is, by necessity, working in a dynamic situation. The very presence of urban and industrial areas would normally cause a disruption of the local water balance and the natural environment, which is often unanticipated and difficult to predict. Nevertheless, the minimisation and control of flooding and pollution risks are necessarily compatible with maximising wildlife habitats and enhancing landscape values or minimising the long term effects of development on the ecology of the area.

Contribution of flow and pollutants to our waterways are provided mainly from spatially distributed land sources such as residential areas of various densities, city and urban centres, industries, golf courses, and streets and highways. With such complexities being experienced in our catchment development activities, the approaches to the current urban drainage codes of practice are seen to be no longer adequate. New, comprehensive, and integrated SWM strategies are now needed to be in line with the government's drive to achieve a sustainable developed nation status in the early 21st century. Such new strategies will incorporate interalia, runoff source control, management and delayed disposal on a catchment wide, proactive, and multi-functional basis. This should result in flood flow reduction, water quality improvement, and ecological enhancement in downstream receiving waters. To some extent, it should also contribute to improved urban amenity through the application of wetlands, landscape for recreation, potential beneficial reuse of stormwater (especially as a non-potable supply source), and recharge of depleted urban groundwater aquifers to enhance stream baseflow during dry seasons.

1.4.1 Catchment Management

There is evidence in many developed countries of an increasing interest in the use of SWM practice in adaptive, strategic level approaches to achieve integrated catchment planning (ICP) and sustainable urban river corridor environment. ICP is strategically applied for sustaining catchment outflow and replenishment of nearby water bodies by reducing runoff discharge magnitude and NPS pollutants during wet weather and enhancing longer outflow contribution through the implementation of SWM practices. Controlled drainage of wastewater (domestic, municipal, and industrial) and augmentation of baseflow should form an important ICP measure. On a larger scale, many recent implementation studies were carried out based on this catchment approach (Hassel, 1997; Smission, 1991; Murray & Cave, 1997 and Richards, 1997).

Holistic catchment plans for urban drainage, SWM, and the water environment will need to be based on cost-effective new technology. They will provide both the forward planning frameworks for liaison with local authorities in the preparation of structure and local district development plans, and the catchment-scale assessment of investment needs in terms of function and location. It is essential that hydrologic, hydraulic, and water quality models be used to provide not only a better representation of the present situation, but also a predictive and adaptive management tool for the future.

The uses and constraints of catchment receiving water bodies are usually defined by relevant and suitable environmental quality/flow standards specified by the DOE and DID. By evaluating the current monitored performance against these standards, priorities for pollution abatement and flow reduction can be identified. Modelling and monitoring can be used to assess the impacts of various sources of pollutants on receiving water bodies.

Review of dischargers' design methods, operation and maintenance procedures, upgrading works, and data collection and planning capabilities are also important. An evaluation report should be presented, in qualitative and quantitative terms, describing what information exists on the catchment and what investigations are required to produce catchment management plan (CMP). To evaluate such issues, it is necessary to complement existing catchment information with baseline studies. This can be efficiently handled using Geographic Information System (GIS) software and relational databases linked to water and environmental parameters and flow/transport models (W Mokhtar, 1993). These modelling components can be integrated with catchment policies on stormwater disposal, landuse, and environmental protection in order to provide an indication of reductions in pollutants loading required to achieve receiving water quality goals. The authority can build these into forward planning of its capital works programme and disposal strategies with other pollution control measures. Dischargers will then be required to implement appropriate construction and operational programmes while regulators can audit these programmes, give compliance consent, and assess the resulting effects on the environment through 'Environmental Monitoring'. Whenever necessary, the CMP shall be updated upon the issue of new directives.

1.4.2 Stormwater Resources

Local urban water resources are often neglected and left to degrade and run to waste. As socio-economic growth continues, stormwater may be used increasingly to augment water supplies, recharge aquifers, improve inland fisheries, and provide public recreation. After the 1998 water crisis in Selangor and Kuala Lumpur, interest has been growing in the government and private sectors to use these vital resources, and efforts to restore their depleted conditions are developing. Experience elsewhere has shown that PS pollutants are readily treated while NPS pollutants are highly uncertain, random, and much more difficult to control.

Most developed countries have made good use of urban stormwater, which has helped to harmonise the distorted hydrologic and environmental system due to urbanisation. Within the KLIA at Sepang, stormwater is being used for landscape irrigation. It appears that a more comprehensive approach to stormwater use will be implemented soon at Putrajaya, as some BMPs are already in place for sustaining its lake water resources. Use of rainwater and stormwater runoff in a systematic way is still scarce, even in a tight water demand and supply crisis area such as the Klang Valley. In view of runoff control, water shortage/emergencies, and aquifer enhancement, local water resource uses should be mandated in the region. A comprehensive stormwater source management system has successfully been implemented for a house lot in Bangi, Selangor.

Natural recharge is extremely slow in urban groundwater aquifers and this can restrict withdrawal and reduce baseflow in nearby streams and water bodies. Apart from combating land subsidence due to overdrafts, stormwater (pretreated) can be diverted from streams, drains, ponds and lakes into aquifers. This can augment water resource availability in dry periods and help reduce persistent stormwater flooding in wet periods. These types of schemes are most applicable in areas such as Kota Bharu (where groundwater is heavily used) and Kuala Lumpur (where flooding and water crisis is at issue).

1.4.3 Initial Efforts

Despite being relatively new in this country, some forms of SWM have been practised to some extent, albeit in an ad hoc manner. SWM practices for controlling NPS pollutants are still in their infancy in Malaysia. The DID and Local Authorities are now beginning to focus on controlling runoff peak discharge, volume, and associated sediments while supporting data and research are relatively scarce.

Promotion of SWM was initiated in 1989. The first Stormwater Symposium was held in Kuala Lumpur in May 1990 with selected papers published in its proceedings (W Mokhtar, 1991). The event was well attended by world experts and local practitioners and researchers. The ongoing efforts made by the DID include the development of this SWM Manual, seminar/training activities, and R&D collaboration with local universities. Published scientific papers so far have touched on stormwater modelling (Abustan, 1998), infiltration trench sizing (W Mokhtar, 1999), and stormwater BMPs (Yu & W Mokhtar, 1991). Earlier research efforts that were started in Universiti Teknologi Malaysia include runoff study for a small residential catchment, stormwater reuse, highway runoff characterisation, and laboratory investigation of porous pavement (W Mokhtar & Satri, 1993).