# Sustainable Urban Drainage System (SUDS) – Malaysian Experiences

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## ABSTRACT
Sustainable Urban Drainage Systems (SUDS) have been used widely in USA, Europe, Japan and Australia to name a few developed countries. SUDS are currently the recommended techniques towards solving three major problems in Malaysia which are flash flood, water scarcity and water pollution. Previously, most of the stormwater runoff especially in urban areas is catered by conventional drainage systems that carry runoff to the downstream by rapid disposal concept. In order to manage these three major problems, SUDS provide long term solutions to urban drainage management. A number of recently completed SUDS projects in Malaysia will be discussed

## KEYWORDS
Stormwater management; SUDS; BMPs; swales; detention pond; wetland

## INTRODUCTION
Sustainable drainage is a concept that includes long term environmental and social factors in decisions about drainage. It takes account of the quantity and quality of runoff, and the amenity value of surface water in the urban environment (CIRIA, 2007). With the particular design and right combination of SUDS techniques, the systems will operate holistically. From the aspect of quantity control, these integrated designs become as a runoff controller and flood protector by attenuation of runoff using components such as swale, bio-retention dry ponds, dry detention basins, ponds and constructed wetlands.

From the aspect of quality, with a treatment train, it will minimize the amount of pollution entering the downstream waterways. The SUDS systems will allow sedimentation, pollutant removal, and purification process which occur in the grass swale, bio-filtration basins, ponds, wetlands and etc. Finally, for the amenity aspect, the systems will blend the landscapes and surrounding areas to be more relax, rejuvenate, leisure and environmentally friendly.

This paper will describe Malaysian experience in handling several projects based on Malaysian drainage manual known as Urban Stormwater Management Manual (MSMA) which is effective on 2001. This manual has been launched by Department of Irrigation and Drainage Malaysia, which is responsible for water resources in Malaysia. Basically the manual comprises all the Best Management Practices (BMPs) and SUDS techniques suitable for Malaysian condition based on experience overseas. The applicability of the suggested techniques are being tested initially with the national pilot project at Engineering Campus, Universiti Sains Malaysia (USM) with the construction of Bio-Ecological Drainage Systems (BIOECODS) completed at the end of the year 2002. BIOECODS (Zakaria et al. 2003; Ab Ghani et al., 2004) offers an exemplary model for urban stormwater management under tropical climates. BIOECODS consists of three components namely ecological swales, biofiltration storage, and ecological ponds made up of a wet pond, a detention pond, a constructed wetland, a wading river and a recreational pond. Another newly constructed projects (Zakaria et al., 2007) utilizing several components of SUDS includes the Taiping Town Clinic, and DID Mechanical Ipoh (Chang et al. 2008).

## BIO-ECOLOGICAL DRAINAGE SYSTEM (BIOECODS)

The USM Engineering Campus project has taken a series of measures to reduce runoff rates, runoff volumes and pollutant loads by implementing a source control approach (Figure 1) for stormwater management as suggested in the Stormwater Management Manual for Malaysia. This includes a series of components namely ecological swale (Figure 2), on-line underground storage, and dry ponds as part of the Bio-ecological drainage systems that contribute to the treatment of the stormwater before it leaves the campus. This system was designed to combine infiltration, delayed flow, storage and purification as pre-treatment of stormwater before discharging to constructed wetlands In addition to source controls; these measures include integrating large-scale landscapes into the development as a major element of the stormwater management system. The detention pond provides the function of a stormwater detention, solids settling, and biological treatment. Finally, wetlands provide both stormwater detention and biological treatment prior to the runoff entering the recreational pond (Figure 3). All of these benefits help to ensure that the final discharge from a sustainable urban drainage system will not pollute rivers, nor create flooding downstream.

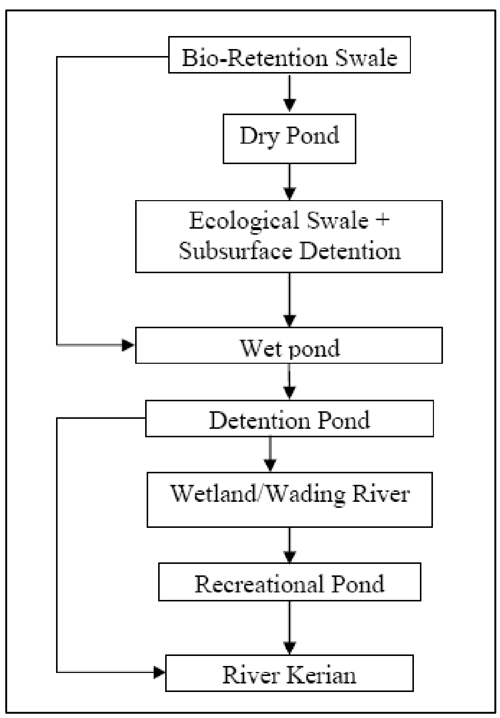


**Figure 1**. Schematic diagram of BIOECODS.

**Figure 2**. An ecological swale with river gravels making up the low flow channel.

**Figure 3**. A meandering wading river upstream of the recreational pond.

The dry swales are designed for 10-year flood with a slope of 1 in 1000. The wet pond is designed for 10-year flood and detention pond 50-year flood. The wetland purifies stormwater for up to 2-year flood. Details of the design criteria and construction experience could be found in Zakaria et al. (2003) and Ab Ghani et al. (2004). The recent results on peak flow attenuation and stormwater treatment throughout the system are given in Table 1 and Figure 4.

**Table 1.** Stormwater quality in swale assessment – 19th April 2006.

| Sampling Station | Parameter | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH | Temperature | DO | $BOD_5$ | COD | Turbidity | TSS | TS | TP | $NH_3$-N | Grease & Oil |
| | | (°C) | (mg/L) | (mg/L) | (mg/L) | (NTU) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) |
| GS 3 | 7.7 | 24 | 5 | 2 | 6 | 10 | 0 | 0.0 | 0.1 | 0.0 | 0.1 |
| GS 4 | 9.0 | 23 | 5 | 3 | 5 | 23 | 0 | 0.0 | 0.2 | 0.0 | 0.0 |
| GS 5 | 7.0 | 25 | 5 | 2 | 8 | 14 | 0 | 0.0 | 0.2 | 0.0 | 0.0 |
| GS 6 | 7.8 | 25 | 7 | 2 | 2 | 20 | 0 | 0.0 | 0.4 | 0.1 | 0.0 |
| GS 7 | 8.3 | 28 | 6 | 2 | 34 | 14 | 0 | 0.0 | 0.1 | 0.1 | 0.5 |
| GS 10 | 9.4 | 25 | 6 | 2 | 13 | 23 | 0 | 0.0 | 0.2 | 0.0 | 0.0 |
| GS 9 | 8.7 | 29 | 7 | 2 | 5 | 6 | 0 | 0.0 | 0.1 | 0.1 | 0.0 |
| GS 8 | 6.9 | 28 | 8 | 2 | 6 | 17 | 0 | 0.0 | 0.3 | 0.1 | 0.0 |
| **Average** | **8.1** | **26** | **6** | **2** | **10** | **16** | **0** | **0.0** | **0.2** | **0.1** | **0.1** |
| **Median** | **8.0** | **25** | **6** | **2** | **6** | **16** | **0** | **0.0** | **0.2** | **0.1** | **0.0** |
| **Standard Deviation** | **0.9** | **2** | **1** | **1** | **10** | **6** | **0** | **0.0** | **0.1** | **0.0** | **0.1** |
| **Class IIB, Malaysia Standard** | **6 - 9** | **-** | **5 - 7** | **3** | **25** | **50** | **50** | **-** | **-** | **0.3** | **-** |

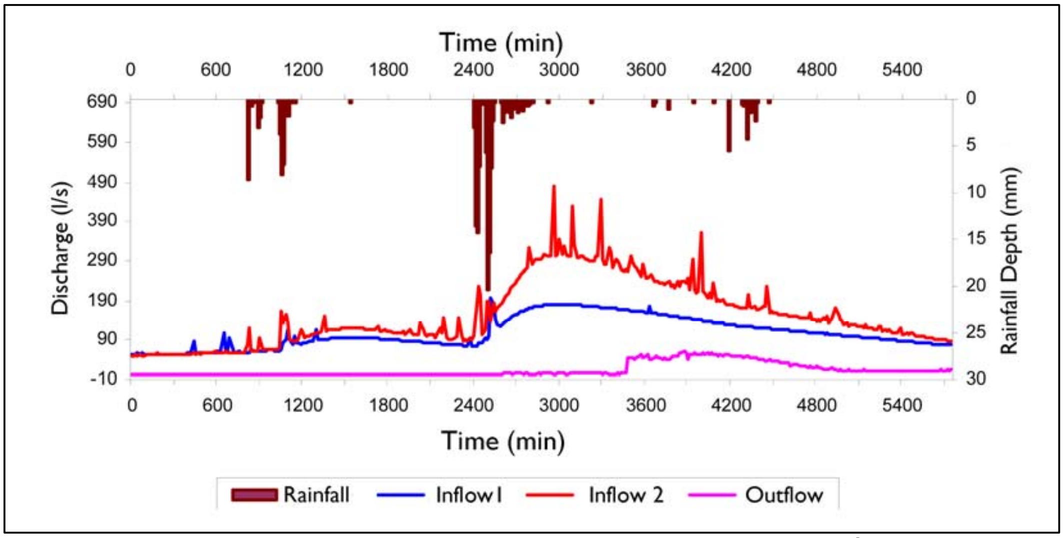


**Figure 4.** Peak flow attenuation during a 100-year event (21st - 24th July 2007).

Another recently completed BIOECODS project involved the construction of Taiping Health Clinic. The Government of Malaysia via Public Work Department (JKR) Malaysia has planned to construct a new building for the Taiping Health Clinic and its infrastructure on the area approximately 7 acres in Larut & Matang District in Perak. This project consists of the construction of a double storey building block, chemical store, condenser block, TNB block, store and garage, security guard house, sewerage treatment plant, pavilion and car park. The soil profile for overall project area is consistent from silty sand at the first 10m depth to hard layer of silty clay. Ground water level is observed at 0.95m to 1.35m depth from original ground surface.

The proposed drainage system has one main and few minor runoff control facilities to regulate the runoff from the site as shown in Figure 5. The drainage improvement that has been proposed at outside boundary are mainly consist of covered concrete lined drains as per directed by the local council.

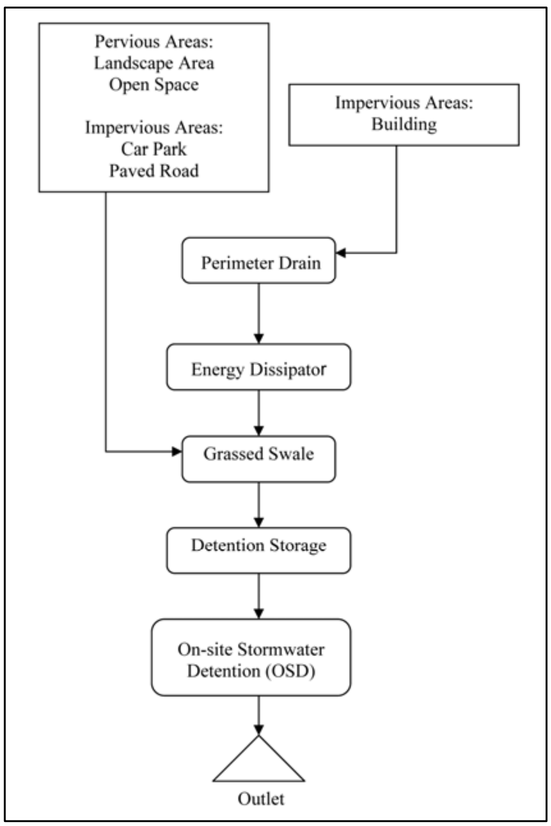


**Figure 5.** Design Concept of Proposed Drainage System for Taiping Health Clinic.

a) Grassed Swale (Figure 6)

Grassed swale is designed to cater any excess water from perimeter drain (for individual building) whilst the flow from pervious and impermeable surface will be directed to the grassed swale. The grassed swale is defined as grass earth channel combined with subsurface module which enclosed within a permeable geotextile. Grassed swale has the ability to reduce on-site peak flow rates by increasing the roughness of the channel and infiltration rates. These vegetated systems also provide runoff quality treatment by removing low concentrations and quantities of TSS, heavy metals, hydrocarbons and nutrients from stormwater. The vegetated systems remove pollutants by means of sedimentation, filtration, soil absorption and plant uptake.

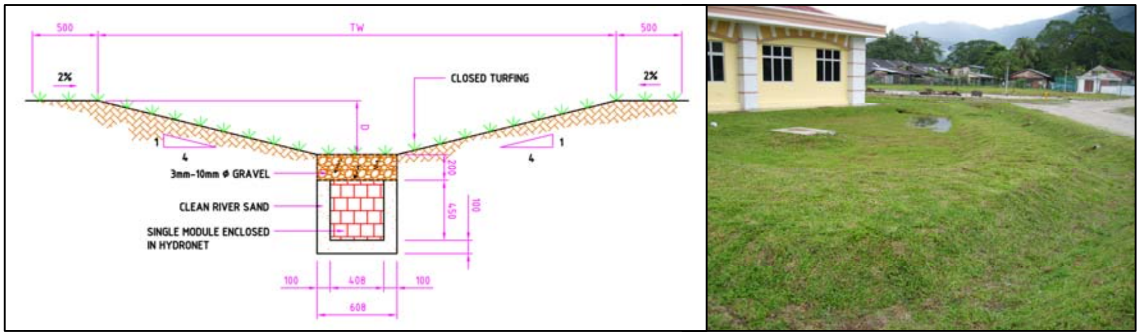


**Figure 6.** Grassed Swale.

b) Detention Storage (Figure 7)

The excess stormwater is stored in the subsurface detention storage. The storage modules have been designed to be places at the connecting points, junction and critical point of the system. These detention storages are provided to reduce flows from the building, regulating flow velocity which causes the gravity settling of particulates and increase the infiltration process where all these mechanisms will control the quality and quantity of stormwater runoff.

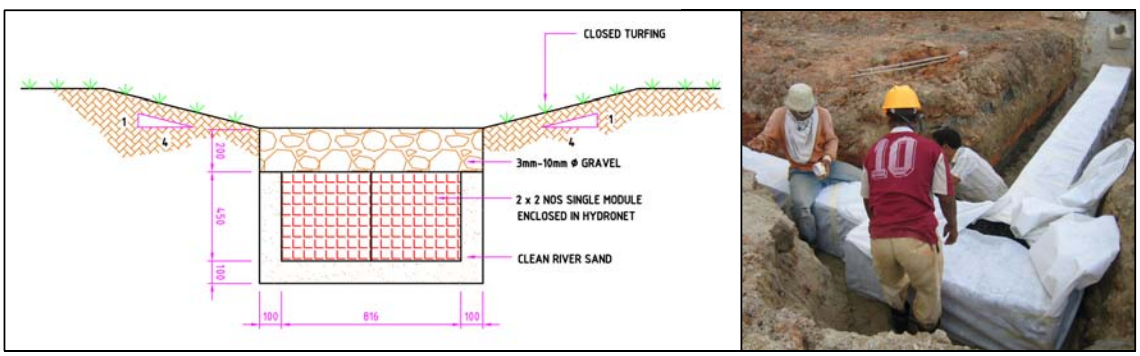


**Figure 7.** Underground Detention Storage.

c) On-site Stormwater Detention (OSD)

The excess stormwater is also stored in the dry pond constructed (Figure 8) with a storage function. The dry pond is a detention basin with the purpose to temporary store the stormwater runoff. This detention basin is design to store to the surface of 600mm of the excess rainfall under design average recurrent interval of 10-year and blend with the surrounding landscape. The outflow path is controlled by orifices in order to drain the dry pond system in less than 24 hours. Therefore, the quantity and quality of the runoff from developed areas can be maintained to be the same as pre-development condition. OSD is normally dry or empty when not in operation. It will be utilized for multi-purpose use to incorporate passive and active recreational areas such as public parks and open space or sporting facilities.


**Figure 8.** Dry pond.

## EX-MINING POND REHABILITATION AS A STORMWATER MANAGEMENT FACILITY

Department of Irrigation and Drainage (DID) Malaysia has appointed REDAC to carry out a "Rehabilitation of Ex-Mining Ponds and Existing Wetland for Integrated Storm water Facilities" at DID Mechanical Section, Ipoh. In line with the implementation OF MSMA, the Study will be a showcase for development of ex-mining ponds as storm water facilities in Perak and throughout Malaysia. The study is a pilot project that rehabilitates the ex-mining pond into multi-functional uses, which include recreational, water reuse and storm water retention purposes.

The study area consists of DID Mechanical Section covering an area of 88 acres. The area is located on Lot 40367 Sg Kinta, Kinta District. The study area is situated on a former ex-mining land which consists of sandy soil and largely sparsely vegetated. The main feature of the site is the two ex-mining ponds which are located in the vicinity of the buildings. There are also swampy areas which stretched along the eastern border of the site and some parts of the swampy area may extend outside the study area. Drainage system in the Study area is based on rapid disposal approach which disposes the surface runoff to the roadside concrete drain prior to discharging into River Kinta via the pump station located near by. The surface runoff from the open area flows into the two main ex-mining ponds which are connected to the River Kinta by earth drain. The ex-mining pond and the existing wetland (swampy areas) shall be rehabilitated and restored into ecological ponds with multi-functional uses. The planning and design into the restoration and rehabilitation of the ecological ponds shall be based on the MSMA and fulfill the requirement of water quantity and quality control.

The main components of the proposed integrated storm water facilities (Figure 9) include Ex-mining pond 1 designed as a regional pond to control both water quantity and quality from the study site and the surrounding areas (Figure 10). The conveyance system is made of an engineered waterway with features those of natural rivers. Storm water runoff from the botanical garden is conveyed to the engineered waterway via swale. Further treatment of storm water runoff is provided through a constructed wetland connected to the Ex-Mining Pond 1 via the engineered waterway. The existing wetland will treat runoff from the nearby surrounding areas located outside of the study area. The Ex-Mining Pond 2 is designed as a community pond to control both water quantity and quality from the study site only. An automatic tidal gate is provided at the downstream end before the runoff is discharged to River Kinta.

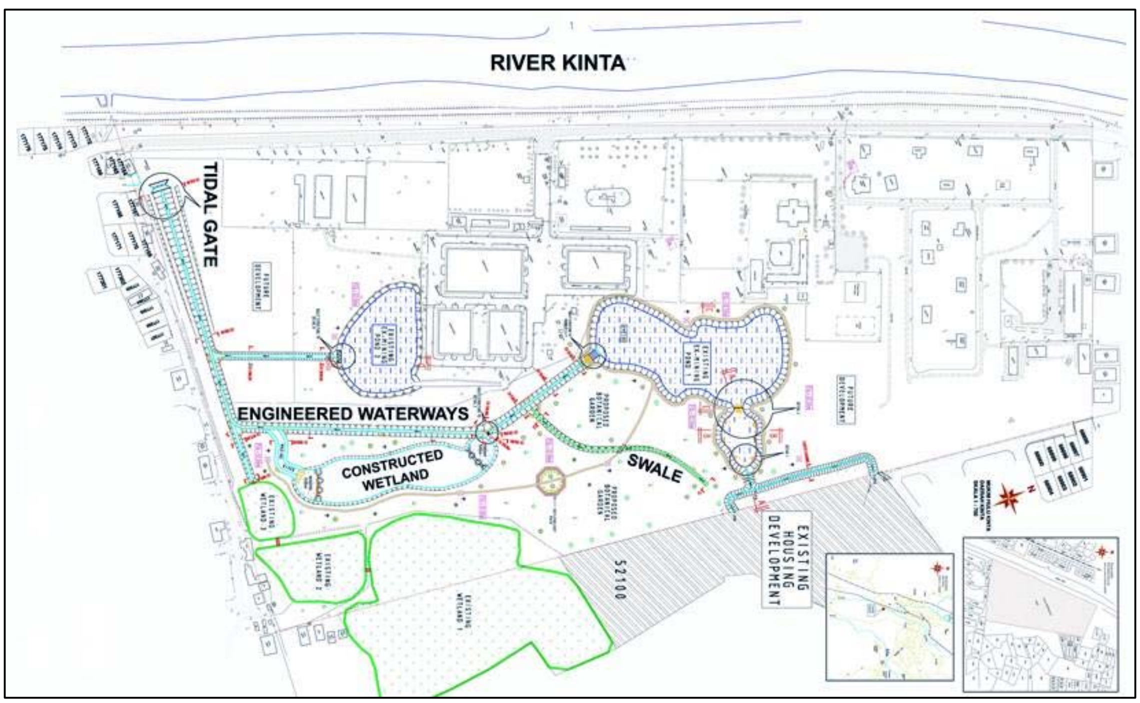


**Figure 9**. Layout of Rehabilitated Ex-Mining Ponds.

(a) Ex-Mining Pond 1

(b) Outflow of Ex-Mining Pond 1

(c) Built Hard Landscape

Figure 10 Rehabilitated Ex-Mining Pond 1

## CONCLUSIONS

The applications of SUDS will help solving not only flash flood problems but also water quality degradation at urbanized catchments. Several projects that apply components of SUDS in Malaysia has proven other benefits that can be achieved namely beautiful green landscape surrounding the drainage area together with clear water proving the ability of SUDS components to purify stormwater pollutants.

## NOTATIONS

| | |
|---|---|
| DO | Dissolved Oxygen |
| $BOD_5$ | Biochemical Oxygen Demand |
| COD | Chemical Oxygen Demand |
| TSS | Total Suspended Solids |
| TS | Total Sulfur |
| TP | Total Phosphorus |
| $NH_3$-N | Ammoniacal Nitrogen |

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