BIO-ECOLOGICAL DRAINAGE SYSTEM

CONCEPT & DESIGN

UNIVERSITI SAINS MALAYSIA

REDAC
RIVER ENGINEERING AND URBAN DRAINAGE RESEARCH CENTRE

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1.0 Introduction

1.1 Drainage issues in Malaysia

Rapid urbanization in Malaysia has been accompanied by dramatic hydrologic changes. The detrimental effect of urbanization on hydrological cycle such as infiltration and groundwater recharge decreases, pattern of surface and river runoff is changed imposing high peak flows, large runoff volumes and increased transport of pollutants and sediment from urban areas. Thus, the urban area influences the runoff pattern and the state of the ecological systems not only within the urban area but also in and around a whole river system downstream. The effect of the urbanization on runoff has resulted in producing significantly more runoff volume than predevelopment, and flow peaks are increased. Study by Drainage and Irrigation Department (DID, 2000) showed that 9% of the country's land mass is prone to floods which affect about 12% of the population. As a result, frequent occurrences of flash flood occur at downstream of new development areas resulting in an average loss of RM 100 million annually.

Traditionally, the objective of stormwater management has been to transport runoff as quickly as possible (rapid disposal) through the drainage system in order to prevent flooding and protect lives and property. This is referred to as quantity control. Although public health and safety are still the most important goals, other objectives must now be met as well, such as the preservation of water quality and natural habitat. Historical flood and quantity control methods are not always suitable under current conditions, because it can cause problems of flooding, water shortage and pollution or damage to the environment. It also proving quantity control methods are not to be sustainable. Therefore there is a need to seek holistic and sustainable solutions not only to mitigate existing flood problems but also to prevent the occurrences of such problems in new areas to be developed. Known that urban stormwater management system needs to change, all new development area must fulfil new urban stormwater manual since 1 January 2001 by government.

1.2 Stormwater Management Manual (MSMA)

First urban stormwater manual titled Planning and Design Procedures NO. 1: Urban Drainage Design Standard and Procedures for Peninsular Malaysia was published by Department of Irrigation and Drainage Malaysia (DID) in 1975. This manual became a guideline to engineers in order to design the urban drainage and also as a reference to others government agencies. This manual was used as guideline for more than 25 years without any amendment even there are a lot of new technologies regarding on urban drainage system and stormwater management.

Thus, a proactive step was made to integrate runoff management for new development area with enforcement of Stormwater Management Manual for Malaysia, MSMA on 1 January 2001. The new MSMA promote control at source concept. This new approach applies integrated process of infiltration, detention, self-cleansing to control quantity and quality of runoff from developing area remains as before the development. Consequently, the natural of rivers' corridor and its ecosystem can be protected even rapid developments occur in surrounding area.

Benefits of Control-At-Source:

- Decrease flash flood to minimum level
- Treatment of rainfall water to good quality before its flow to the river
- Stabilize groundwater through infiltration process
- Conserve the flora and fauna in rivers ecosystem

1.3 Memorandum of Understanding USM-DID

Memorandum of Understanding was signed on **1st October 1999** with objective to create a smart partnership in developing of latest technology in management of river basin, urban drainage and hydrological engineering. Establishment of Centre of Excellent known as **River Engineering and Urban Drainage Research Centre (REDAC)** as stated in media by General Director of DID Malaysia and YAB Ministry of Agriculture Malaysia, is purposely to transform USM as regional centre of river engineering and urban drainage especially in developing of environmental friendly urban drainage in order to solve the current problems.

The networking between USM and DID via REDAC are focusing on:

- Developing of latest technology in management of river basin, urban drainage and hydrological engineering;
- Distribution of information and research finding in related field;
- Transform the better quality of life in urban area through new system of urban drainage.

The benefits that USM will gain are research development and teaching curriculum which improve the quality of graduate students. USM is enthusiastic to be excellent in research and development in River Engineering and Urban Drainage and also become a reference and information centre in the field especially in Malaysia and Southeast Asia.

2.0 Bio-Ecological Drainage System (BIOECODS)

2.1 Introduction

Rapid development in Malaysia need a new paradigm changes especially the concept of infrastructure preparation in urban drainage. The transformation of stromwater runoff management in urban area can be referred in Stormwater Management Manual for Malaysia, MSMA. This guideline is implementing the integrated concept where quantity and quality of runoff has been control equally and became a main agenda in design and construction of drainage developing area.

Bio-ecological Drainage System (BIOECODS) become an alternative, environmental friendly and sustainable in stormwater management and follow the concept of quantity and quality control of runoff. BIOECODS as a pilot project of MSMA was constructed in Engineering Campus, UniversitiSains Malaysia, NibongTebal, Pulau Pinang via smart partnership between UniversitiSains Malaysia and Department of Irrigation and Drainage Malaysia (DID).

The concept of quantity control in stormwater runoff is implementing the control at source concepts which apply engineering elements like infiltration, storage and flow attenuation. Components of infiltration and storage can attenuate the flow runoff and increase the quality of runoff water through the treatment process. So, the quality control of runoff water can be achieved. Pollutants removal in stormwater runoff can be achieve through the terrain of best management practices from the source until to the river. Treated runoff also can be stored and detain in designed pond like wetpond and recreational pond for domestic use.

The objectives of BIOECODS based on Stormwater Management Manual for Malaysia, MSMA in order to create a sustainable urban drainage system are:

- To introduce infiltration concept that recycle water naturally
- To attenuate the stormwater runoff
- To introduce the concept of stormwater runoff treatment
- To create green and better landscape

2.2 BIOECODS Concept

BIOECODS as environmental friendly drainage system consist of infiltration, storage at source and flow attenuation in order to fulfil quantity and quality control of stormwater runoff. The concept of BIOECODS can be referred in Figure 1.

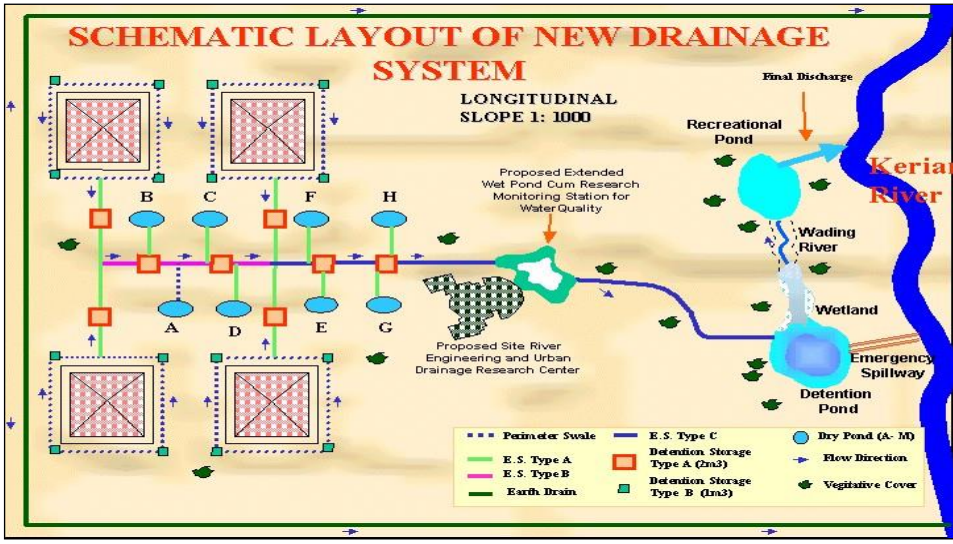
Basically, BIOECODS components consist of swale, which is designed to convey runoff flow and dry pond as a temporary storage to detain stormwater runoff as it designed. Both components are capable in attenuate runoff flow and as a result, the peak flow of runoff can be reduced. Swale is a grass channel with a shallow design also plays a role in treating stormwater runoff. Stormwater runoff infiltrates to sub-surface module through river sand which located underneath of the swale for further water quality treatment.

Stormwater runoff in Engineering Campus area will convey to bio-ecological ponds namely wet pond, detention pond, constructed wetland and recreational pond. Detention pond is a final component that controls the quantity of stormwater runoff. Whereas constructed wetland is designed as further water quality treatment facility. The end product of stormwater runoff that flows via BIOCODS is considering high quality of water and can be recycled for domestic use.

2.3 Benefits of BIOECODS

Several benefits of Bio-ecological drainage system are:

- Attenuation of peak flow
- Stormwater runoff treatment
- Increase concentration of dissolve oxygen
- Increase the population of aquatic life
- Alternative water resource for domestic use
- Increase groundwater
- Aesthetic value added and green the surrounding area



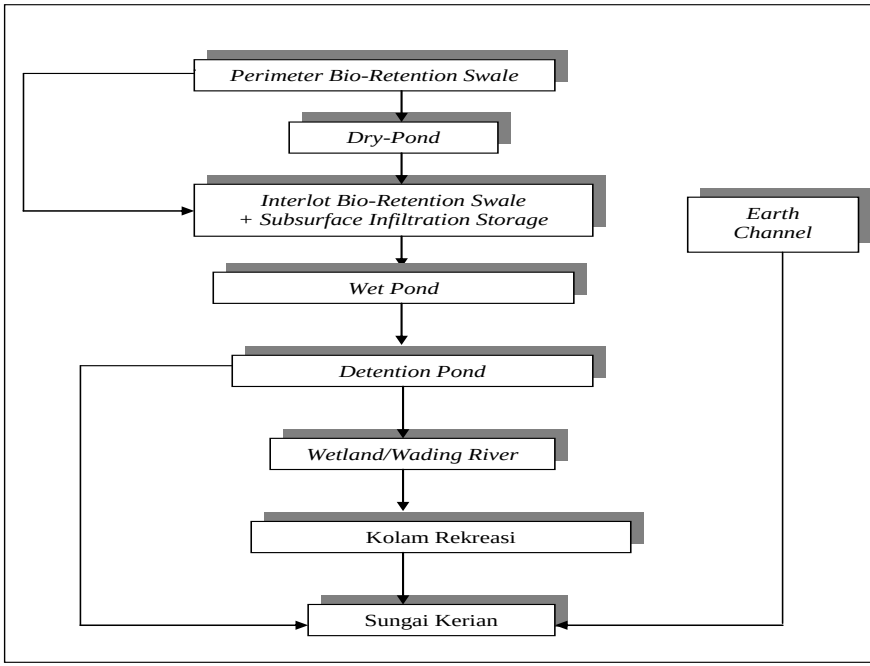


Figure 1 BIOECODS Concept

2.4 BIOECODS Components

BIOECODS components that were implemented in this pilot project are:

i. Ecological Swale

a) Perimeter swale (Figure 2) *is used to cater for any excess water from individual buildings for 10 years ARI, whilst the flow from impermeable surface will be directed to the individual swale*. Perimeter swale was constructed surrounding building (building perimeter swale) and parking (interlot parking swale).

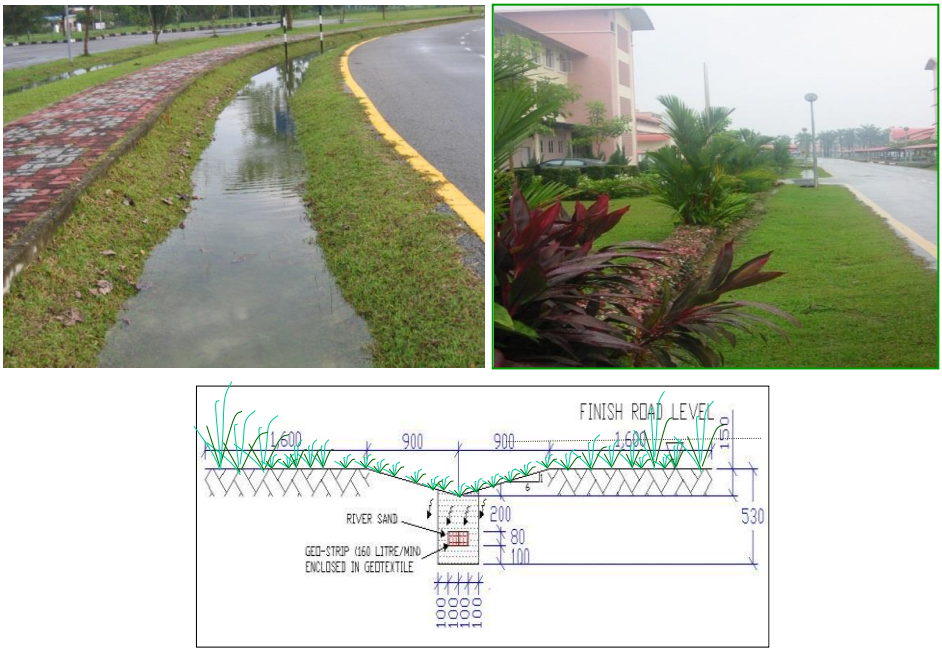


Figure 2 Perimeter Swale

b) *The flow from an individual swale (perimeter swale) will be conveyed to an inter-lot swale (ecological swale)* as a main conveyor. The ecological swale is a grass-earthen channel, combined with a subsurface module enclosed within a permeable geotextile design. The ecological swale is categorized as Type A(Figure 3), Type B (Figure 4) and Type C (Figure 5) depending on the size and capacity. Type A consists of one single module, Type B consists of two single modules and Type C consists of three single modules. Ecological swale is designed for 10 years ARI.

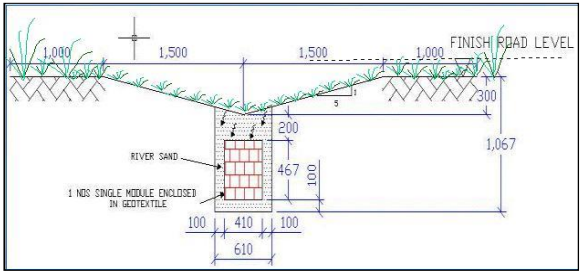


Figure 3 Swale Type A

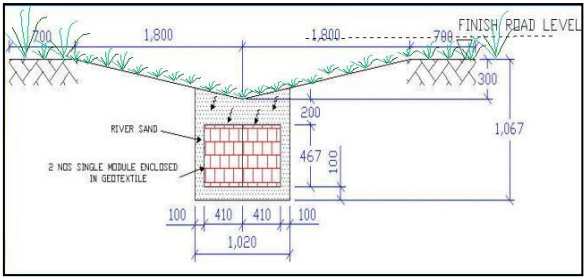


Figure 4 Swale Type B

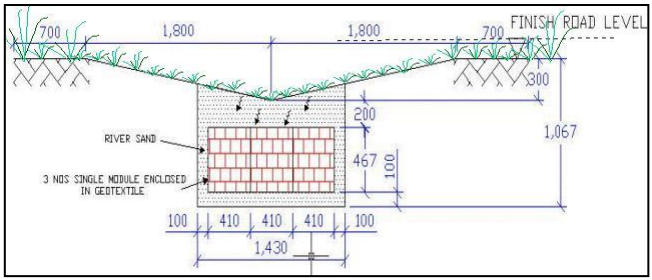


Figure 5 Swale Type C

ii. Detention Storage

c) The excess stormwater is stored as subsurface detention storage. The storage modules have been designed to be placed at the connecting point, junction and critical point of the system. The storage module is categorized into Type A and Type B with different storage capacities and can be arranged accordingly to suit the site conditions.

iii. Dry Pond

d) The excess stormwater is also stored on the dry ponds constructed with a storage function. The dry pond (Figure 6) is a detention pond, which has been integrated with the ecological swale to temporarily store the storm runoff. The modular storage tank is placed beneath the detention basin where the stormwater is drained out by infiltration. The outflow path of the storage module is connected to the ecological swale at the lowest point, in order to drain the dry pond system in less than 24 hours.

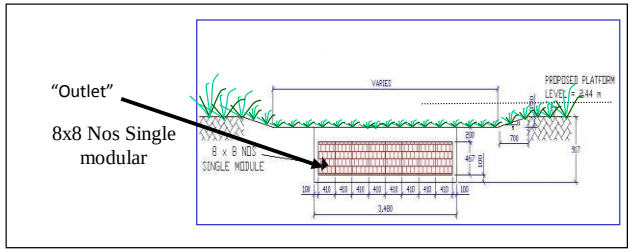


Figure 6 Dry Pond

iv. Wetpond (Figure 7)

e) All of the excess water from built-up areas flows via a wet pond to a detention pond.

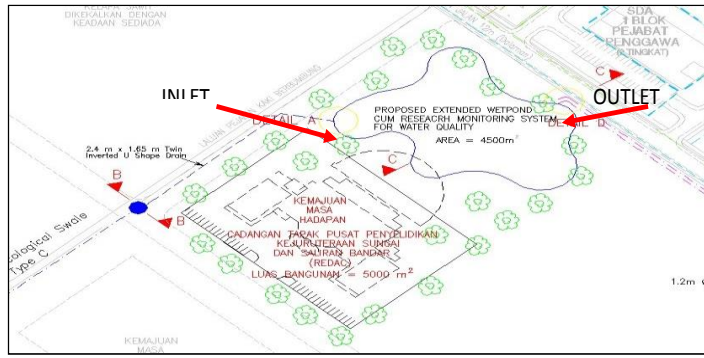


Figure 7 Wetpond

v. Detention Pond(Figure 8)

All of the excess water from wetpond and hostel area flows to a detention pond. Detention pond was designed for 10 years and 50 years ARI. Whereas for event that are less 3 months ARI will convey to a constructed wetland for biological treatment. Detention pond is designed to reduce the peak flow of post development to achieve **Zero Peak Contribution** concept.

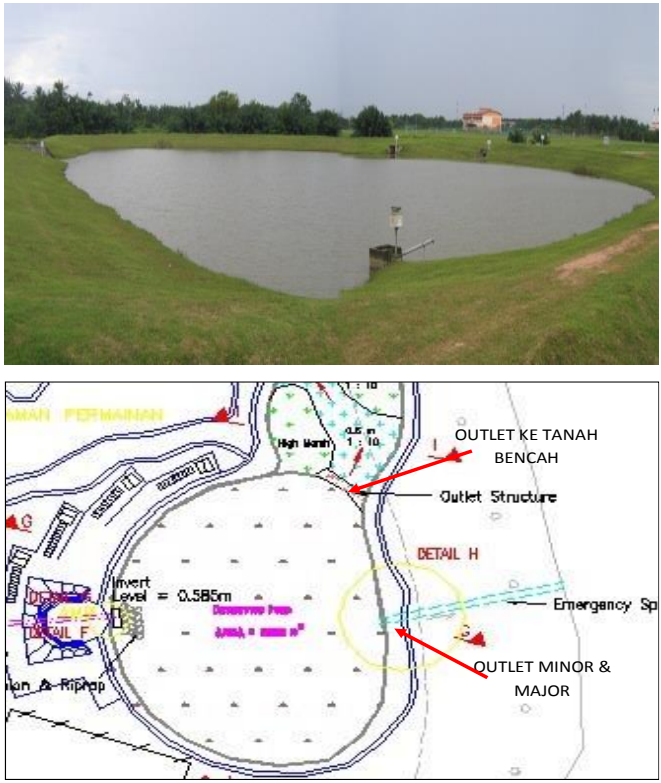


Figure 8 Detention Pond

vi. Constructed Wetland(Figure 9)will receive flows from the event less than 3 months ARI and first flush from event more than 3 months ARI. Wetland is designed depends on width and length ratio accordingly to achieve optimum capability of treatment.

Figure 9 Wetland

vii. Wading River(Figure 10) is a waterway connecting the wetland and recreational pond. It is also an example of river morphology. It consists of mainstream and flood plain on both sides of the river. Its purpose is to increase the dissolved oxygen level through the production of turbulent flow along the channel that basically consists of coarse sand and gravel.

Figure 10 Wading River

viii. Recreational Pond

Recreational pond (Figure 11)is a pond that provides the area for recreational activities. Stormwater runoff flows via Bio-ecological Drainage System is received physically and biologically treatment and collective in this Recreational pond.

Figure 11 Recreational Pond

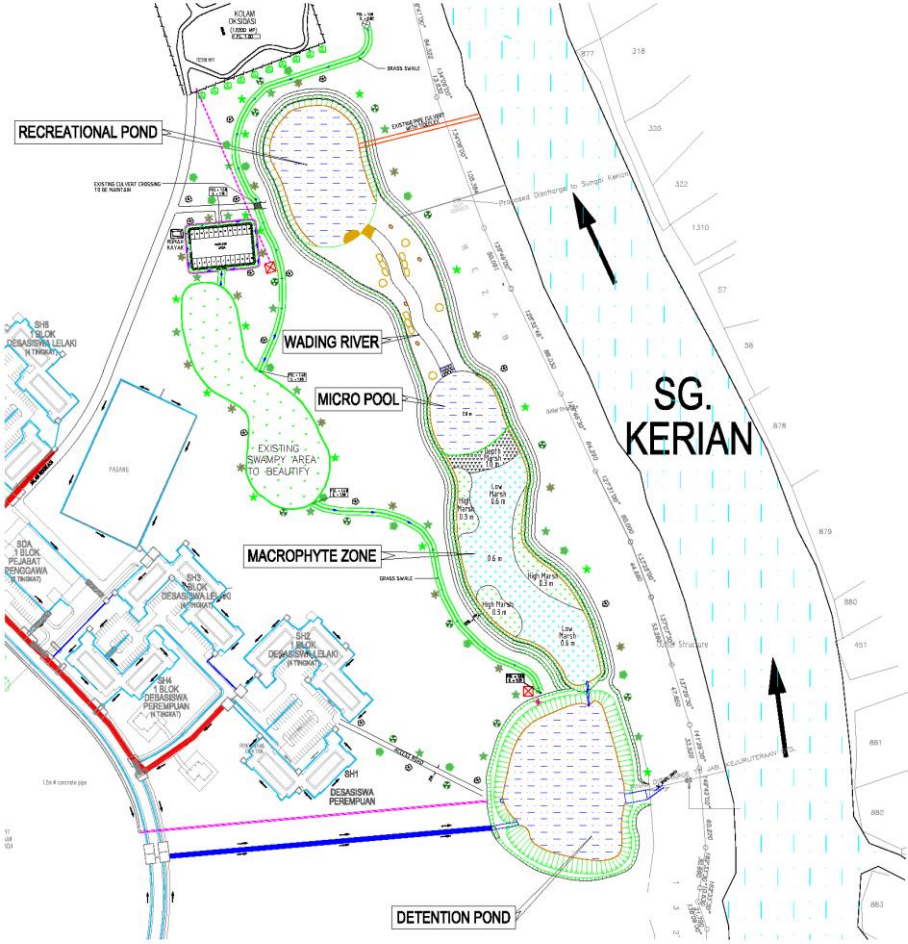


Figure 12 Wetland, Wading River and Recreational Pond

3.0 Award And Recognition

BIOECODS project has won a number of awards throughout the year 2001 and 2002 as listed below:-

- USM Engineering Research Excellence Award 2001 by Yayasan Perak
- Merit Award for "Construction Innovation & Invention 2001" by Construction Industry Development Board Malaysia (CIDB)
- World Class Research Award 2001 by the Vice-Chancellor of USM
- USM Gold Medal Sanggar Sanjung Award 2002 by USM Chancellor
- Silver Medal, I-Tex 2002
- Gold Medal (BIOECODS –Sustainable Development Goals) International Conference and Exhibitions on Inventions by Institutions of Higher Learning (PECIPTA), 2017
- Pingat Perak (BIOECODS- Securing Water for Future Generations) International Conference and Exhibitions on Inventions by Institutions of Higher Learning (PECIPTA), 2017

BIOECODS innovators who have brought the university to the national and international levels are as follows:-

- Prof.Dr. Nor Azazi Zakaria
- Prof.Dr. Haji Aminuddin Ab. Ghani
- Associate Prof.Dr. Rozi Abdullah
- Associate Prof.Dr. Ir. Lariyah Mohd. Sidek

A total of 30 papers were presented and published in national and international level since BIOECODS was introduced in 1999. BIOECODS project has also been visited by many from within and outside the country since the Engineering Campus was opened in May 2001. The latest information on BIOECODS and other research conducted by REDAC can be accessed at **http://redac.eng.usm.my**

4.0 Conclusion

It is believed that the concept of Bio-Ecological Drainage System (BIOECODS) could be implemented throughout the country with great success although it is viewed as a new approach in Malaysia. In the year 2020, Malaysia would become a fully industrial country and there would be many areas to be developed. The phenomenon of flooding and pollution of the river will be one of the inevitable consequences of a rapid development country. These are the challenges that the new drainage system which is more environmentally friendly has to face in order to compete with the more challenging environment.

It is hoped that the effort put in by the team of researchers in REDAC USM in order to address the problems arising from the current issues revolving river engineering and urban drainage and river pollution in Malaysia will continue to receive support from the Government, especially from the Irrigation and Drainage Department and the Local Authorities in realizing the change in the quality of life in the city one day.

The River Engineering and Urban Drainage Research Centre (REDAC) is hoped to be a Regional Centre of Expertise in the management of rainfall and river runoff which in turn will regard USM as a leader of this field in the world.

Acknowledgement

REDAC would like to thank you for the support given by the management of the UniversitiSains Malaysia, especially the Former Vice-Chancellor Y.Bhg. Prof. Dato' Dzulkifli Abdul Razak and Y. Bhg. Dato' Ishak TambiKechik, in realizing the BIOECODS development in the Engineering Campus, Seri Ampangan, NibongTebal, Penang.

REDAC would also like to thank the Department of Irrigation and Drainage Director General Y. Bhg. Dato' Keizrul Abdullah, who has contributed a research grant of RM 2.9 million in making BIOECODS a national pilot project for Stormwater Management System in line with the launch of the Urban Stormwater Management Manual (MSMA) effective 1st January 2001.