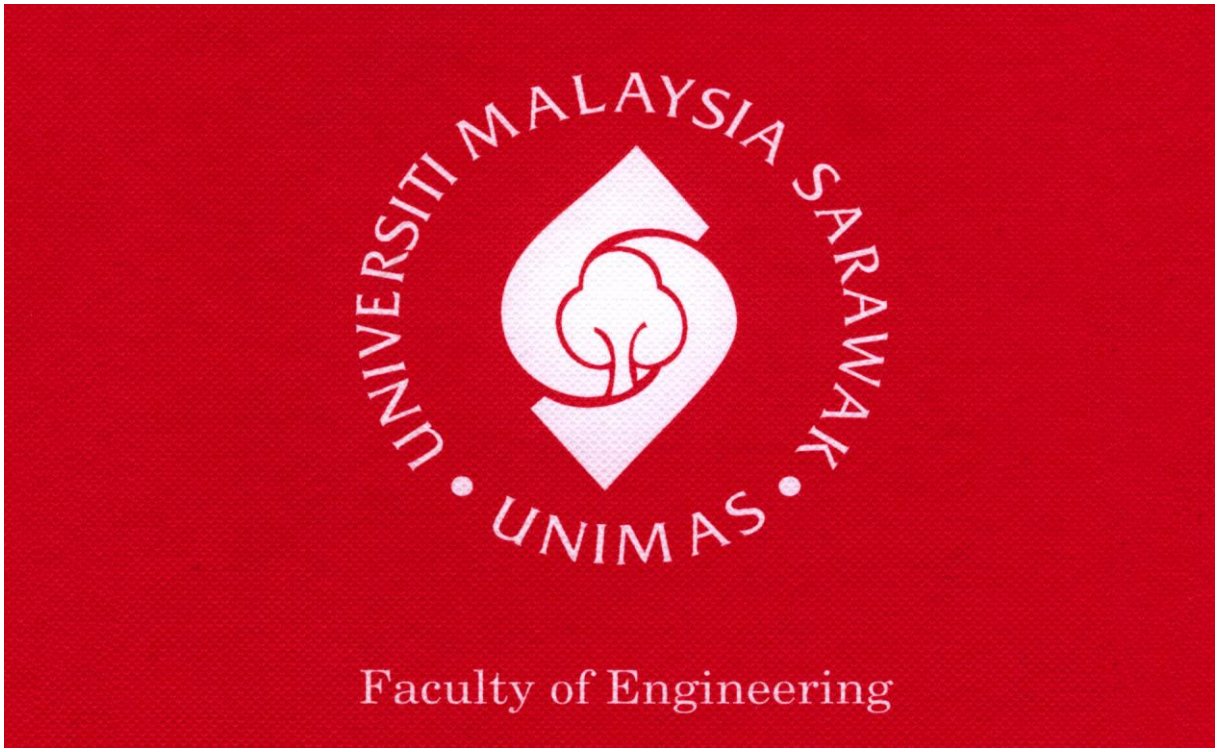

EFFECT OF BUFFER ANGLE FOR STORM FLOW REGULATOR IN CONTROLLING PEAK DISCHARGE

LIOW CHING VERN

Bachelor of Engineering with Honors
(Civil Engineering)
2018

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

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Final Year Project Report ☐

Masters ☐

PhD ☐

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EFFECT OF BUFFER ANGLE FOR STORM FLOW REGULATOR IN CONTROLLING PEAK DISCHARGE

LIOW CHING VERN

A dissertation submitted in partial fulfillment

of the requirement for the degree of

Bachelor of Engineering with Honours

(Civil Engineering)

Faculty of Engineering

Universiti Malaysia Sarawak

2018

To my beloved family and friends

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ABSTRACT

Progressive movement from agriculture to an industrialized economy has resulted urbanization everywhere. Yet, this comes along with incidence of flash flood in urban area which is not longer to be surprised by Malaysians. Due to the paucity of data in the literature, this study aimed to determine the effect of angle of buffer for Storm flow regulator in controlling peak discharge. To understand the effect of angle of buffer in reducing the discharge at downstream, the storm flow regulator experiments were carried out in the self-circulating hydraulic flume. Three designed angles (30°, 60°, and 90°) with three different flow conditions (High, medium, and low) were included in this study. Results showed that all the designed angles with different flow conditions do reduce the discharge at downstream. 90° in high flow condition showed the greatest discharge reduction followed by 60° and 30°. Yet, it was reported that, 60° of storm flow regulators shown not much difference of downstream discharge reduction when comparing to the 30°. Besides that, all the designed buffer angles also been noticed that, the upstream flow becoming more subcritical with showing increasing of upstream depth and a detention property to detent a certain amount of water before flowing to downstream. Meanwhile, downstream flow depth decreased greatly and it changed from subcritical (without the flow regulator) to supercritical (with flow regulator). In additional, this study also reported that the head loss of the 90° flow regulators marked the highest in which contributing to the reduction at downstream of the channel. Therefore, with the findings, 90° flow regulator showing the optimum configuration of the buffer in term of the performance of storm flow regulator.

ABSTRAK

Transformasi daripada sektor pertanian ke sektor perindustrian telah mewujudkan pembandaran di merata-rata kawasan. Namun, transformasi ini juga meningalkan impak negatif seperti banjir kilat terutamanya di kawasan bandar seperti di Klang, Selangor. Kajian ini dijalankan untuk mengenalpasti impak sudut penghalang "Storm flow regulator" dalam mengawal pengaliran air. "*Storm flow regulators*" telah diletakkan dalam flum hidraulik di Makmal Hidraulik UNIMAS untuk mengenalpasti impak sudut penghalang dalam mengurangkan pengaliran di bahagian hilir saluran. Kajian ini dijalankan dengan menggunakan tiga jenis sudut (30°, 60° ,and 90°) penghalang dengan kondisi aliran yang berbeza (Tinggi, Sederhana, dan Rendah). Hasil kajian ini menunjukkan semua sudut penghalang yang digunakan dalam kajian ini dapat mengurangkan aliran air di bahagian hilir untuk kondisi aliran yang berlainan. Sudut 90° ketika aliran tinggi menunjukkan pengurangan aliran air yang terbanyak diikuti dengan sudut 60 dan 30°. Sejajar dengan itu, sudut 60° telah menunjukkan sedikit pengurangan aliran air berbanding dengan sudut 30°. Selain itu, kajian ini juga menunjukkan aliran air di bahagian hulu menjadi semakin subkritikal dengan menunjukkan peningkatan dalam kedalaman air di bahagian tersebut. Di samping itu, bahagian hulu juga menunjukkan sifat detensi yang menjadikan bahagian hulu sebagai " takungan sementara" sebelum air mengalir ke bahagian hilir. Pada masa yang sama, kedalaman air di bahagian hilir telah menunjukkan pengurangan yang jelas dan jenis aliran telah bertukar daripada subkritikal ke superkritikal apabila "*Storm flow regulator*" dipasang. Sehubungan itu, sudut 90° juga menunjukkan "*head loss*" yang tertinggi berbanding sudut pengalang lain yang digunakan. Kesimpulannya, sudut 90° sebagai konfigurasi penghalang optimum dalam hasil kajian ini.

TABLE OF CONTENTS

			Page
Acknowledgement			i
Abstract			ii
Abstrak			iii
Table of Contents			iv
List of Tables			vii
List of Figures			viii
List of Symbols			xi
List of Abbreviation			xii
CHAPTER 1	**INTRODUCTION**		
	1.1	Background	1
	1.2	Problem Statement	3
	1.3	Objectives	3
	1.4	Scope of Study	4
	1.5	Thesis Outline	4
CHAPTER 2	**LITERATURE REVIEW**		
	2.1	Introduction	6
	2.2	The Flow In Open Channel	7
		2.2.1 Classification of Flow	7
		2.2.2 Velocity Profile of Developing and Developed Open Channel Flow	10
		2.2.3 Establishment Length In Open Channel	12
		2.2.4 Measurement of Discharge	13
		2.2.5 The Energy Equation	15
	2.3	Urbanisation and Stormwater Management	17
	2.4	Peak Discharge Control	21
		2.4.1 Detention and Retention Facilities	23
		2.4.2 Flow Regulating Devices	27

2.4.2.1 Orifice Plate 27
2.4.2.2 Remote Controlled Gates 29
2.4.2.3 Steinscrew Flow Regulator 30
2.4.2.4 Hydro-Slide 32
2.4.2.5 Vortex Flow Control Devices 33
2.5 Flow Reduction Principles For Open Channels 36
2.5.1 Meandering 36
2.5.2 The Significance of Shape or Curve Angle of The Flow 37
2.5.3 Flow Area 39
2.5.4 Flow Detention 39

CHAPTER 3 METHODOLOGY

3.1 Background 41
3.2 Design of Storm Flow Regulators 43
3.2.1 The Concepts of The Storm Water Regulators 46
3.2.1.1 The Concept Meandering Path 46
3.2.1.2 The Concept of Detention 47
3.3 Temperature Measurement 47
3.4 Clear Water Experiment 48
3.4.1 Determining The Location of Fully Developed Zone 49
3.4.2 Producing The Rating Curve of The Flume 51
3.5 Storm Flow Regulator Experiment 52

CHAPTER 4 RESULT AND DISCUSSION

4.1 Introduction 54
4.2 Discharge 55
4.3 Reynold Number And Froude Number 64
4.4 Head Loss 69
4.5 Detention (Upstream) 73
4.6 Summary 76

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion 78

5.1.1 The Effect of Angle of Buffer in Discharge Reduction 78

5.1.2 The Optimum Configuration Of The Buffer In Term Of The Performance Of Flow Regulator 79

5.2 Recommendation For Future Study 79

REFERENCES **80**

APPENDIX A Data For Clear Water Experiment **87**

APPENDIX B Data For Storm flow Regulator Experiment **89**

LIST OF TABLES

Tables		Page
2.1	Summary of selected studies for prediction of the establishment length value (Bonakdari, Lipeme-kouyi, & Asawa, 2014)	12
2.2	Comparison of various characteristics of conveyance oriented and storage-oriented storm water system (DID, 2000)	19
2.3	The advantages of above and below-ground storages (DID, 2000)	23
2.4	Advantages and disadvantages of Orifice plate (O'Brien, 2008)	28
2.5	Advantages and disadvantages of Remote Controlled Gates (Urbonas & Stahre, 1993)	30
2.6	Advantages and disadvantages of Steinscrew flow regulator (O'Brien, 2008)	31
2.7	Advantages and disadvantages of Hydro-Slide flow regulator (O'Brien, 2008)	33
2.8	Advantages and disadvantages of Vortex Flow Control (VFC) (O'Brien, 2008)	35
3.1	Dimension of the baffle of the stormflow regulator	45
3.2	Velocity along the centre line of the flume for flow depth of 0.044m	50
3.3	Range of clear water experiment	51
4.1	Upstream flow depth with and without flow regulator	61
4.2	Reynold number with and without flow regulator	66
4.3	Froude number and flow types for before and after the flow regulator	67
4.4	Head loss of the flow regulator for low flow	70
4.5	Head loss of the flow regulator for medium flow	70
4.6	Head loss of the flow regulator for high flow	71
4.7	The percentage changes of different flow regulator for low flow	74
4.8	The percentage changes of different flow regulator for medium flow	74
4.9	The percentage changes of different flow regulator for high flow	75

LIST OF FIGURES

Figures		Page
1.1	Hydrograph changes due to urbanisation (Hashim & Rainis, 2003)	2
2.1	Flow in an open channel (a) Uniform flow and (b) non-uniform flow (Hamill, 2001)	7
2.2	Uniform flow (UF), gradually varied flow (GVF), and rapidly varied flow (RVF) in an open channel (Cengel & Cimbala, 2006)	8
2.3	Velocity profile in developing and fully developed open channel flow (Kirkgöz & Ardiçlioğlu, 1997)	10
2.4	(a) Velocity distribution in rectangular channel and (b) typical velocity profile (Subramanya, 2009)	11
2.5	Type of area velocity method	13
2.6	Subsection in the midsection method (Gupta, 2008)	14
2.7	The total energy of a liquid flowing in an open channel (Cengel & Cimbala, 2006)	15
2.8	Total energy of a liquid at two sections of an open channel (Cengel & Cimbala, 2006)	16
2.9	Effect of pervious surfaces and impervious surfaces in rainfall (Chithra et al., 2015)	17
2.10	Detention/ Retention storage classifications (DID, 2000)	22
2.11	Typical OSD Storage Facilities (DID, 2000)	23
2.12	Community and regional basin types (DID, 2000)	24
2.13	Infiltration trench (XP drainage, n.d.)	25
2.14	Soakaway pit (United Nations Environment Programme, n.d.)	25
2.15	Porous pavement (XP drainage, n.d.)	26
2.16	Infiltration basin (Minnesota Stormwater Manual, 2016)	26
2.17	Various types of outflow control devices	27
2.18	Orifice plate (O'Brien, 2008)	27
2.19	Orifice plate (vertical section) (a) free outfall; (b) drowned (Butler & Davis, 2011)	28

2.20	Remote Controlled Gate (Umvelt und Fluidtehnik GmbH, 2017)	29
2.21	Steinscrew flow regulator (O'Brien, 2008)	30
2.22	Discharge characteristics of the Steinscrew (Urbonas & Stahre, 1993)	31
2.23	Hydro-Slide (Copa, n.d.)	32
2.24	Performance Curve of flow control devices (O'Brien, 2008)	32
2.25	Sump and conical style vortex flow controls (Faram, Stephenson, & Robert, 2010)	33
2.26	Vortex flow control hydraulic characteristics (Faram et al., 2010)	34
2.27	Vortex flow control and orifice plate hydraulic characteristic comparisons (Faram et al., 2010)	35
2.28	Aerial photograph of a meandering river (Dey, 2014)	36
2.29	Velocity contours in the curved section (a) 90° and (b) 30° bend case (Seyedashraf & Akhtari, 2017)	37
2.30	Schematic of a sine-generated river bend (Xu, Ji, Bai, & Song, 2017)	38
2.31	Simplified schematic for a detention time of 10min (American Water Works Association, 2003)	39
3.1	Flow of methodology of this study	42
3.2	Designation of the storm flow regulator with baffle angle of (a) 30°, (b) 45°, (c) 60° and (d) 90°	43
3.3	Different views of the stormflow regulator with 90° of its baffles	44
3.4	The direction of flow though the prototype	44
3.5	Dimension arrangement of the stormflow regulator with 90° of its baffles	45
3.6	Constructed designed storm water regulators	45
3.7	(a) Flow path of with prototype, (b) Flow path without prototype	46
3.8	Used to measuring the temperature of water	47
3.9	Self-Circulating Hydraulic Flume	48
3.10	Nixon Streamflo 420 Flow meter	48
3.11	Probe parts of the Flow meter (Probe 403)	49
3.12	Positions of verticals for velocity measurement for determination of fully developed zone	50
3.13	Measured velocity profile along the flume for flow depth of 0.067m	51
3.14	The rating curve of the flume	52

3.15	Position of verticals for velocity measurements for determination of the effect of angle of the prototype	53
3.16	Schematic diagram of the flume with prototype	53
4.1	Graph of discharge against angle of flow regulator in low condition	55
4.2	Graph of discharge against angle of flow regulator in medium condition	56
4.3	Graph of discharge against angle of flow regulator in high condition	56
4.4	Graph of discharge reduction against the buffer plate angles	57
4.5	Water flow path for (a) without and (b) without flow regulator	58
4.6	Traveling path of high flow for (a) 90° (b) 60° (c) 30°	58
4.7	Changes of upstream depth of flow after flow regulator had installed.	60
4.8	Graph showing the flow depth before installing the flow regulator and after installing the flow regulator	61
4.9	Flow depth at upstream (a) with 90° buffer angle of flow regulator (b) with 60° buffer angle of flow regulator (c) with 30° buffer angle of flow regulator for high flow	62
4.10	Flow depth at upstream (a) with 90° buffer angle of flow regulator (b) with 60° buffer angle of flow regulator (c) with 30° buffer angle of flow regulator for medium flow	62
4.11	Flow depth at upstream (a) with 90° buffer angle of flow regulator (b) with 60° buffer angle of flow regulator (c) with 30° buffer angle of flow regulator for low flow	63
4.12	Flow observed at (a) X= 5m and (b) X= 6.5m	64
4.13	Flow observed at X= 2m	65
4.14	Summary of the effect of the flow regulators	68
4.15	Induced meandering flow patter after flow regulator	69
4.16	Graph of head loss across X=2m to 5m for different flow regulators	71
4.17	Graph of head loss across X=5m to 6.5m for different flow regulators	71
4.18	Head loss across the flow regulator	72
4.19	Upstream flow area	73
4.20	Graph of detention time against different angle of flow regulators	75
4.21	Graph of detention time reduction against different flow regulators	75

LIST OF SYMBOLS

A_d	-	Area of detention [m^2]
b_r	-	Width of the buffer plates of storm water regulator [m]
Fr	-	Froude number
g	-	Acceleration due to gravity [m/s^2]
h_L	-	Head loss [m]
h_r	-	Height of the buffer plates of storm water regulator [m]
Q	-	Discharge [m^3/s]
R_{hz}	-	Hertz [Hz]
Re	-	Reynold number
t	-	Detention time [s]
t_r	-	Thickness of the buffer plates of storm water regulator [m]
T	-	Flow temperature [°C]
V	-	Velocity of flow [m/s]
V_d	-	Volume detention at upstream [m^3]
y	-	Depth of flow [m]
γ	-	Kinematic viscosity of flow [m^2/s]

LIST OF ABBREVIATIONS

DID	-	Department of Irrigation and Drainage
GVF	-	Gradually varied flow
MSMA	-	Manual Saliran Mesra Alam
NUF	-	Non-uniform flow
OSD	-	On-site detention
RVF	-	Rapidly varied flow
UF	-	Uniform flow
UNIMAS	-	Universiti Malaysia Sarawak
VFC	-	Vortex flow control devices

CHAPTER 1

INTRODUCTION

1.1 Background

Development in Malaysia has progressed rapidly since independence in 1957. Progressive movement from agriculture to an industrialized economy has shifted the population into urban centers which it has resulted in population growth in the urban area. Today, Malaysians are no longer surprised with news about flash floods. A flash flood can be defined as "a flood that threatens damage at a critical location in the catchment where the time for the development of flooding from upstream is less than the time to activate warning, flood defense, or mitigation measures downstream of the critical location" (Sene, 2008). There is little warning before the onset of flash flood. According Hashim and Rainis (2003), most urban communities in Malaysia have experienced flash flood after high intensity of storm events. The latest hit was on the east coast during end of 2014 with up to 200,000 peoples affected and 21 killed (Dzulkifli, 2016). This sudden increase fluctuating amount of surface runoff can be explained in term of urbanisation of a catchment (Abas & Hashim, 2014). As a land surface is developed for urban use, the area is converted from natural state to a totally people modified with increasing the impermeable surface. The term impermeable surface may refer to roads, parking lots, roof tops in the urban area which prevent rainfall to infiltrates into ground. Due to this, the peak flow and the volume of the runoff have increased as shown in **Figure 1.1.**

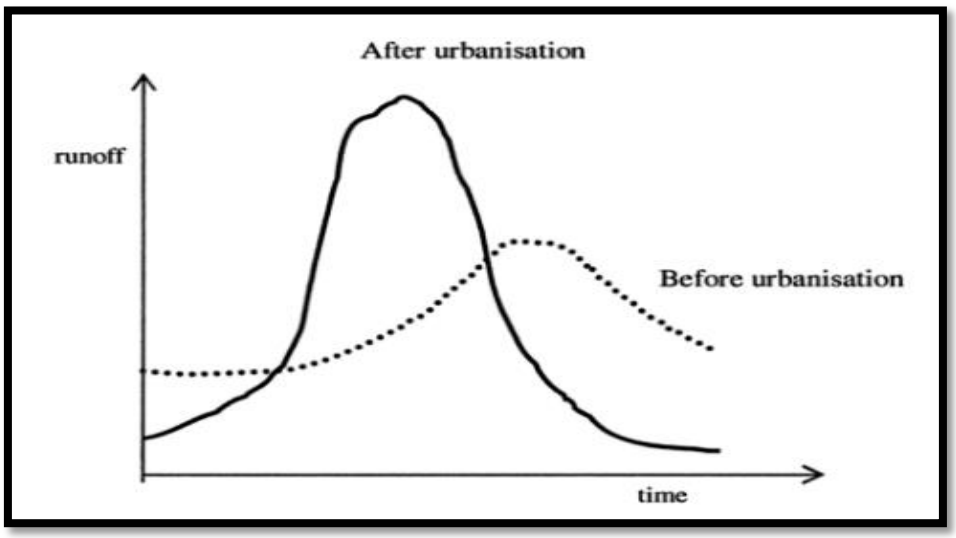

***Figure 1.1*:** Hydrograph changes due to urbanisation (Hashim & Rainis, 2003)

Rao et al. (1972) found that an increase in the area of imperviousness from 0 to 40 percent would increase its magnitude of runoff by 90 percent and approximately halve the time to peak discharge. The significant increment of peak discharge and total volume was exceeding the drainage system's design capacity. Consequently, this causes the drainage failure and results in flash flood in urban basin.

In order to increase a catchment's flood resistance level, urbanised catchment can be adapted to tackle these hydraulic issues by transporting, attenuating, evaporating and infiltrating the surface water runoff with the goal of decreasing flood volumes and managing the conveyance of flows to within acceptable flow rates (Newton, Jarman, Memon, Andoh, & Butler, 2014). These includes detention facilities, retention facilities and lengthen or increasing the size of the storm sewers. Yet, not all of these methods are applicable to all catchments. For example, underground storage facilities are expensive to construct and are not easily maintained (United State Environmental Protection Agency, 1999). Apart from that, another current practice such as the installation of on-site detention facilities required a large area which has contributed one of the limitations to small sites or highly developed areas. Moreover, the installation of retention facilities such as infiltration trench, porous pavement, soakaway pit and infiltration basin cannot be managed alone when the soil's infiltration rate is inadequate. This limitation is obvious when Shaari et al. (2016), found that 70% of the soil samples collected from

Kota Bharu, Kelantan, Malaysia exhibits low permeability and only 5% of the soil is constituted of high permeability.

Due to the limitations of the current practices in the existing urban catchment, flow controls devices such as Vortex Flow Controls (VFC), orifice plates, penstocks, and weirs have been implemented in existing sewer infrastructures to reduce the peak discharge. Therefore, presented here are findings from a flume study regarding a new flow control device that has the potential to reduce flood risk by increasing the flood resistance.

1.2 Problem Statement

The flooding events that have been at the forefront of the news over this decade have highlighted the requirement for more effective urban storm water management controls. Despite the Department of Irrigation and Drainage (DID) Malaysia has introduced Manual Saliran Mesra Alam (MSMA) for urban stormwater management, certain limitations such as high cost installation, large land area required, etc has limited people to implement solutions that have been introduced. A simple yet effective urban stormwater regulator is needed to attenuate flood flows or reduce the peak discharge. Khairunnisa (2016) found that her design prototype with buffers were able to retard the flow and reduce the peak discharge. The buffers in her prototype were designed perpendicular to the direction of flow. However, no work has been reported for other angles of the buffers, e.g. 30°, and 60°. The degree of curve angle is related to the flow resistance (Leopold, 1994). This will eventually affect the downstream discharge. Thus, this thesis is to further research the prototype with the aim of finding the effect of angle of buffer for the prototype (storm water regulator) in controlling peak discharge.

1.3 Objectives

The objectives of this thesis are as follows:

- To determine the effect of angle of buffer in discharge reduction.
- To determine the optimum configuration of the buffer in term of the performance of storm flow regulator.

1.4 Scope of Study

In this thesis, the effect of angle of the buffer in the designed storm water regulator to attenuate the storm water discharge in an open channel is studied. An open channel is simulated into tilting flume and the material used in the prototype of proposed storm water regulator is timber as it is easy to construct and low cost. The prototype is designed such a way that by applying the concept of meandering flow, and flow retention for temporary storage. The input for this experimental work is the storm water regulator prototype design angle of buffers while the output is the velocity which is used to determine the flow rate, types of flow, head loss as well as the detention property after installing the storm water regulator. These will indicate the potential of the prototype to attenuate the storm water in open channel.

1.5 Thesis Outline

This thesis is organized as follow.

Chapter 1: The introduction and general discussion of the research of the study; factors of flash flood occurrence or peak discharge; methods to reduce the peak discharge and the limitations. This chapter also presents the problems statement, objectives as well as scope of study.

Chapter 2: This chapter will include the literature relating to the study. A review of literature of open channel flow, urbanisation, as well as the storm water managements particularly by DID. Besides that, the principle of flow reduction will be also discussed in this chapter. This will give a better understanding to reader of what the study about.

Chapter 3: This chapter will include the methodology used in the current study. The prototype model is further described in this chapter along with the methodology. Relevant formulas and equations as well as important calculations from the data obtained will also be presented in this chapter.