

**UNGAUGED FLOOD MODELLING FOR
KUANTAN RIVER BASIN USING HEC-HMS**

MOHD HISYAM BIN ZULKIFLI

B. ENG (HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG



SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

(Supervisor's Signature)

Full Name : EN. NORASMAN BIN OTHMAN
Position : LECTURER
Date : JANUARY 2018

(Co-supervisor's Signature)

Full Name : PN. SHAIRUL ROHAZIAWATI BINTI SAMAT
Position : LECTURER
Date : JANUARY 2018



STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

(Student's Signature)

Full Name : MOHD HISYAM BIN ZULKIFLI

ID Number : AA14260

Date : JANUARY 2018

UNGAUGED FLOOD MODELLING FOR KUANTAN RIVER BASIN
USING HEC-HMS

MOHD HISYAM BIN ZULKIFLI

Thesis submitted in fulfillment of the requirements
for the award of the
Bachelor Degree of Civil Engineering

Faculty of Civil Engineering and Earth Resources
UNIVERSITI MALAYSIA PAHANG

JANUARY 2018

ACKNOWLEDGEMENTS

I have taken efforts for this study. However, it would not have been possible without the kind support and help of many individuals. I would like extend my sincere thanks to all of them. First of all, I would like to thank my supervisor, Mr. Norasman bin Othman with deeply for his motivation, experience, and guidance in this project. His supports via contributing ideas and providing necessary information regarding the project were lead to success of this study. I would like thank my co-supervisor, Mrs. Shairul Rohaziawati Binti Samat for her guidance and support to conduct the study and finish this thesis.

I would like express my gratitude towards my family for their support, kind co-operation and encouragement which help me in completion of this project. I would like to express my gratitude and thanks for my course mates and friends for contributing help and support with understanding some situation throughout the semester. Lastly, I would like thanks to all of members who indirectly help and support me to do this project successfully. I hope this study will be useful for further researchers.

TABLE OF CONTENT

DECLARATION	
TITLE PAGE	
ACKNOWLEDGEMENTS	ii
ABSTRAK	iii
ABSTRACT	iv
TABLE OF CONTENT	v
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF SYMBOLS	xvii
LIST OF ABBREVIATIONS	xviii
CHAPTER 1 INTRODUCTION	1
1.1 Study Background	1
1.2 Problem Statement	2
1.3 Objectives	3
1.4 Scope of Study	3
1.5 Significant of Study	4
CHAPTER 2 LITERATURE REVIEW	6
2.1 Introduction	6
2.2 Hydrology	6
2.3 Hydrologic Cycle	7
2.3.1 Precipitation	8

2.3.2	Evaporation	8
2.3.3	Transpiration	9
2.3.4	Evapotranspiration	9
2.3.5	Condensation	10
2.3.6	Infiltration	10
2.3.7	Percolation	11
2.3.8	Runoff	11
2.3.9	Water Balance	12
2.4	Hydrological Characteristics	13
2.5	Watershed	13
2.6	Rainfall	13
2.6.1	Characteristic of rainfall	16
2.6.1.1	Intensity	16
2.6.1.2	Duration	17
2.6.1.3	Frequency	17
2.6.2	Specific peak discharge	17
2.6.3	Water Balance Equation	17
2.7	Runoff	18
2.7.1	Base Flow	19
2.7.2	Factor Affecting Runoff	20
2.8	Physical Characteristics of the Basin	20
2.8.1	Size, Shape and Slope	20
2.8.2	Land Use	21
2.8.3	Elevation of the Basin	22
2.9	Flood	22

2.9.1	Factors Affecting Flood	22
2.10	Rainfall-runoff Relationship	23
2.11	Hydrograph	24
2.11.1	Unit Hydrograph Method	25
2.11.2	Snyder's UH	25
2.11.3	Clark's UH	26
2.11.4	Clark Parameter Determination	27
2.11.5	Time Lag	27
2.11.6	Baseflow	28
2.12	Software for Analysing Rainfall and Runoff Relationship	28
2.12.1	HEC-HMS	29
2.12.2	Modelling Basin Components	30
2.12.3	Losses	30
2.12.4	Runoff Transform	30
2.12.5	Rainfall-Runoff Simulation	30
2.12.6	Parameter Estimation	31
2.12.7	Computational Result	31
CHAPTER 3 METHODOLOGY		32
3.1	Introduction	32
3.2	Flow Chart of Study	33
3.3	Study Area	34
3.4	Data Collection	35
3.4.1	Rainfall Data	35
3.5	Data Analysis	36

3.5.1	ArcGIS	37
3.5.1.1	Sub-Basin Area, Stream Length and Slope	37
3.5.2	Intensity-Duration-Frequency Curve	39
3.5.3	Area Reduction Factor	40
3.5.4	Thiessen Polygon	41
3.5.4.1	Construction of Thiessen Polygon	41
3.5.5	Temporal Pattern	42
3.6	Method of Simulation Rainfall-Runoff Data in HEC-HMS	45
3.6.1	Parameter Used in HEC-HMS	45
3.6.2	Equation Development	45
3.6.3	Design Base Flow	46
3.6.4	SCS Method	46
CHAPTER 4 RESULTS AND DISCUSSION		48
4.1	Introduction	48
4.2	Basin Model	48
4.3	Rainfall-Runoff Analysis	49
4.4	Analysis and Simulation	51
4.4.1	Transform Method	51
4.4.2	Losses Method	53
4.5	Clark Method	55
4.5.1	Result for 1 Hour Rainfall Duration for 2-years ARI	55
4.5.2	Result for 6 Hour Rainfall Duration for 2-years ARI	61
4.5.3	Result for 24 Hour Rainfall Duration for 2-years ARI	67
4.5.4	Result for 72 Hour Rainfall Duration for 2-years ARI	73

4.5.5	Result for 1 Hour Rainfall Duration for 10-years ARI	79
4.5.6	Result for 6 Hour Rainfall Duration for 10-years ARI	84
4.5.7	Result for 24 Hour Rainfall Duration for 10-years ARI	91
4.5.8	Result for 72 Hour Rainfall Duration for 10-years ARI	97
4.5.9	Result for 1 Hour Rainfall Duration for 100-years ARI	103
4.5.10	Result for 6 Hour Rainfall Duration for 100-years ARI	109
4.5.11	Result for 24 Hour Rainfall Duration for 100-years ARI	115
4.5.12	Result for 72 Hour Rainfall Duration for 100-years ARI	121
CHAPTER 5 CONCLUSION		130
5.1	Introduction	130
5.2	Recommendation	130
REFERENCES		131
APPENDIX A SAMPLE APPENDIX 1		135

LIST OF TABLES

Table 3.1	Rainfall gauging stations within KRB boundry	36
Table 3.2	Rainfall gauging stations located near to the boundry of KRB	36
Table 3.3	Area, stream length and slope for all sub-basins in KRB	39
Table 3.4	Areal reduction factor	41
Table 3.5	Temporal pattern used for KRB, in MSMA 2	44
Table 4.1	Result of rainfall depth for various rainfall duration and ARIs	50
Table 4.2	The T_c and R for all sub-basin in KRB	52
Table 4.3	The CN and percentage of impervious (%) for all sub-basin in KRB	54
Table 4.4	Result of maximum discharge Q_{peak} for every sub-basin	143

LIST OF FIGURES

Figure 1.1	Flood disaster at Sungai Isap area in 2013	3
Figure 1.2	Flood prone areas in Peninsular Malaysia	5
Figure 2.1	Hydrologic cycle	7
Figure 2.2	Process of evaporation and evapotranspiration	9
Figure 2.3	Process of infiltration	10
Figure 2.4	Process of percolation	11
Figure 2.5	Process of surface runoff	12
Figure 2.6	Conventional precipitation	14
Figure 2.7	Orographic precipitation	15
Figure 2.8	Cyclonic precipitation	16
Figure 2.9	Type of surface runoff	19
Figure 2.10	Land use decisions affect runoff, recharge and water quality	22
Figure 2.11	Relationship between rainfall, infiltration and runoff	24
Figure 2.12	Hydrograph	25
Figure 2.13	Snyder's unit hydrograph	26
Figure 2.14	Icon of HEC-HMS software	29
Figure 3.1	Flow chart of the study	33
Figure 3.2	Location of the site in Pahang map	34
Figure 3.3	Condition of study area	35
Figure 3.4	Icon software ArcGIS version 10.2	37
Figure 3.5	Sub-basin area for delineation KRB using ArcGIS software	38
Figure 3.6	Development of thiessen polygon for river sub-basin in KRB	42
Figure 4.1	Development of basin model in HEC-HMS	49
Figure 4.2	Hydrograph simulation of Ulu Sungai Kuantan (1 hour, 2-years ARI)	55
Figure 4.3	Summary of simulation result of Ulu Sungai Kuantan (1 hour, 2-years ARI)	55
Figure 4.4	Hydrograph simulation of Junction 2 (1 hour, 2-years ARI)	56
Figure 4.5	Summary of simulation result of Junction 2 (1 hour, 2-years ARI)	56
Figure 4.6	Hydrograph simulation of Junction 9 (1 hour, 2-years ARI)	57
Figure 4.7	Summary of simulation result of Junction 9 (1 hour, 2-years ARI)	57
Figure 4.8	Hydrograph simulation of Sg. Belat (1 hour, 2-years ARI)	58
Figure 4.9	Summary of simulation result of Sg. Belat (1 hour, 2-years ARI)	58

Figure 4.10	Hydrograph simulation of Sg. Galing (1 hour, 2-years ARI)	59
Figure 4.11	Summary of simulation result of Sg. Galing (1 hour, 2-years ARI)	59
Figure 4.12	Hydrograph simulation of Junction 11 (1 hour, 2-years ARI)	60
Figure 4.13	Summary of simulation result of Junction 11 (1 hour, 2-years ARI)	60
Figure 4.14	Hydrograph simulation of Ulu Sungai Kuantan (6 hour, 2-years ARI)	61
Figure 4.15	Summary of simulation result of Ulu Sungai Kuantan (6 hour, 2-years ARI)	61
Figure 4.16	Hydrograph simulation of Junction 2 (6 hour, 2-years ARI)	62
Figure 4.17	Summary of simulation result of Junction 2 (6 hour, 2-years ARI)	62
Figure 4.18	Hydrograph simulation of Junction 9 (6 hour, 2-years ARI)	63
Figure 4.19	Summary of simulation result of Junction 9 (6 hour, 2-years ARI)	63
Figure 4.20	Hydrograph simulation of Sg. Belat (6 hour, 2-years ARI)	64
Figure 4.21	Summary of simulation result of Sg. Belat (6 hour, 2-years ARI)	64
Figure 4.22	Hydrograph simulation of Sg. Galing (6 hour, 2-years ARI)	65
Figure 4.23	Summary of simulation result of Sg. Galing (6 hour, 2-years ARI)	65
Figure 4.24	Hydrograph simulation of Junction 11 (6 hour, 2-years ARI)	66
Figure 4.25	Summary of simulation result of Junction 11 (6 hour, 2-years ARI)	66
Figure 4.26	Hydrograph simulation of Ulu Sungai Kuantan (24 hour, 2-years ARI)	67
Figure 4.27	Summary of simulation result of Ulu Sungai Kuantan (24 hour, 2-years ARI)	67
Figure 4.28	Hydrograph simulation of Junction 2 (24 hour, 2-years ARI)	68
Figure 4.29	Summary of simulation result of Junction 2 (24 hour, 2-years ARI)	68
Figure 4.30	Hydrograph simulation of Junction 9 (24 hour, 2-years ARI)	69
Figure 4.31	Summary of simulation result of Junction 9 (24 hour, 2-years ARI)	69
Figure 4.32	Hydrograph simulation of Sg. Belat (24 hour, 2-years ARI)	70
Figure 4.33	Summary of simulation result of Sg. Belat (24 hour, 2-years ARI)	70
Figure 4.34	Hydrograph simulation of Sg. Galing (24 hour, 2-years ARI)	71
Figure 4.35	Summary of simulation result of Sg. Galing (24 hour, 2-years ARI)	71
Figure 4.36	Hydrograph simulation of Junction 11 (24 hour, 2-years ARI)	72
Figure 4.37	Summary of simulation result of Junction 11 (24 hour, 2-years ARI)	72
Figure 4.38	Hydrograph simulation of Ulu Sungai Kuantan (72 hour, 2-years ARI)	73
Figure 4.39	Summary of simulation result of Ulu Sungai Kuantan (72 hour, 2-years ARI)	73
Figure 4.40	Hydrograph simulation of Junction 2 (72 hour, 2-years ARI)	74

Figure 4.41	Summary of simulation result of Junction 2 (72 hour, 2-years ARI)	74
Figure 4.42	Hydrograph simulation of Junction 9 (72 hour, 2-years ARI)	75
Figure 4.43	Summary of simulation result of Junction 9 (72 hour, 2-years ARI)	75
Figure 4.44	Hydrograph simulation of Sg. Belat (72 hour, 2-years ARI)	76
Figure 4.45	Summary of simulation result of Sg. Belat (72 hour, 2-years ARI)	76
Figure 4.46	Hydrograph simulation of Sg. Galing (72 hour, 2-years ARI)	77
Figure 4.47	Summary of simulation result of Sg. Galing (72 hour, 2-years ARI)	77
Figure 4.48	Hydrograph simulation of Junction 11 (72 hour, 2-years ARI)	78
Figure 4.49	Summary of simulation result of Junction 11 (72 hour, 2-years ARI)	78
Figure 4.50	Hydrograph simulation of Ulu Sungai Kuantan (1 hour, 10-years ARI)	79
Figure 4.51	Summary of simulation result of Ulu Sungai Kuantan (1 hour, 10-years ARI)	79
Figure 4.52	Hydrograph simulation of Junction 2 (1 hour, 10-years ARI)	80
Figure 4.53	Summary of simulation result of Junction 2 (1 hour, 10-years ARI)	80
Figure 4.54	Hydrograph simulation of Junction 9 (1 hour, 10-years ARI)	81
Figure 4.55	Summary of simulation result of Junction 9 (1 hour, 10-years ARI)	81
Figure 4.56	Hydrograph simulation of Sg. Belat (1 hour, 10-years ARI)	82
Figure 4.57	Summary of simulation result of Sg. Belat (1 hour, 10-years ARI)	82
Figure 4.58	Hydrograph simulation of Sg. Galing (1 hour, 10-years ARI)	83
Figure 4.59	Summary of simulation result of Sg. Galing (1 hour, 10-years ARI)	83
Figure 4.60	Hydrograph simulation of Junction 11 (1 hour, 10-years ARI)	84
Figure 4.61	Summary of simulation result of Junction 11 (1 hour, 10-years ARI)	84
Figure 4.62	Hydrograph simulation of Ulu Sungai Kuantan (6 hour, 10-years ARI)	85
Figure 4.63	Summary of simulation result of Ulu Sungai Kuantan (6 hour, 10-years ARI)	85
Figure 4.64	Hydrograph simulation of Junction 2 (6 hour, 10-years ARI)	86
Figure 4.65	Summary of simulation result of Junction 2 (6 hour, 10-years ARI)	86
Figure 4.66	Hydrograph simulation of Junction 9 (6 hour, 10-years ARI)	87
Figure 4.67	Summary of simulation result of Junction 9 (6 hour, 10-years ARI)	87
Figure 4.68	Hydrograph simulation of Sg. Belat (6 hour, 10-years ARI)	88
Figure 4.69	Summary of simulation result of Sg. Belat (6 hour, 10-years ARI)	88
Figure 4.70	Hydrograph simulation of Sg. Galing (6 hour, 10-years ARI)	89
Figure 4.71	Summary of simulation result of Sg. Galing (6 hour, 10-years ARI)	89
Figure 4.72	Hydrograph simulation of Junction 11 (6 hour, 10-years ARI)	90

Figure 4.73	Summary of simulation result of Junction 11 (6 hour, 10-years ARI)	90
Figure 4.74	Hydrograph simulation of Ulu Sungai Kuantan (24 hour, 10-years ARI)	91
Figure 4.75	Summary of simulation result of Ulu Sungai Kuantan (24 hour, 10-years ARI)	91
Figure 4.76	Hydrograph simulation of Junction 2 (24 hour, 10-years ARI)	92
Figure 4.77	Summary of simulation result of Junction 2 (24 hour, 10-years ARI)	92
Figure 4.78	Hydrograph simulation of Junction 9 (24 hour, 10-years ARI)	93
Figure 4.79	Summary of simulation result of Junction 9 (24 hour, 10-years ARI)	93
Figure 4.80	Hydrograph simulation of Sg. Belat (24 hour, 10-years ARI)	94
Figure 4.81	Summary of simulation result of Sg. Belat (24 hour, 10-years ARI)	94
Figure 4.82	Hydrograph simulation of Sg. Galing (24 hour, 10-years ARI)	95
Figure 4.83	Summary of simulation result of Sg. Galing (24 hour, 10-years ARI)	95
Figure 4.84	Hydrograph simulation of Junction 11 (24 hour, 10-years ARI)	96
Figure 4.85	Summary of simulation result of Junction 11 (24 hour, 10-years ARI)	96
Figure 4.86	Hydrograph simulation of Ulu Sungai Kuantan (72 hour, 10-years ARI)	97
Figure 4.87	Summary of simulation result of Ulu Sungai Kuantan (72 hour, 10-years ARI)	97
Figure 4.88	Hydrograph simulation of Junction 2 (72 hour, 10-years ARI)	98
Figure 4.89	Summary of simulation result of Junction 2 (72 hour, 10-years ARI)	98
Figure 4.90	Hydrograph simulation of Junction 9 (72 hour, 10-years ARI)	99
Figure 4.91	Summary of simulation result of Junction 9 (72 hour, 10-years ARI)	99
Figure 4.92	Hydrograph simulation of Sg. Belat (72 hour, 10-years ARI)	100
Figure 4.93	Summary of simulation result of Sg. Belat (72 hour, 10-years ARI)	100
Figure 4.94	Hydrograph simulation of Sg. Galing (72 hour, 10-years ARI)	101
Figure 4.95	Summary of simulation result of Sg. Galing (72 hour, 10-years ARI)	101
Figure 4.96	Hydrograph simulation of Junction 11 (72 hour, 10-years ARI)	102
Figure 4.97	Summary of simulation result of Junction 11 (72 hour, 10-years ARI)	102
Figure 4.98	Hydrograph simulation of Ulu Sungai Kuantan (1 hour, 100-years ARI)	103
Figure 4.99	Summary of simulation result of Ulu Sungai Kuantan (1 hour, 100-years ARI)	103
Figure 4.100	Hydrograph simulation of Junction 2 (1 hour, 100-years ARI)	104

Figure 4.101	Summary of simulation result of Junction 2 (1 hour, 100-years ARI)	104
Figure 4.102	Hydrograph simulation of Junction 9 (1 hour, 100-years ARI)	105
Figure 4.103	Summary of simulation result of Junction 9 (1 hour, 100-years ARI)	105
Figure 4.104	Hydrograph simulation of Sg. Belat (1 hour, 100-years ARI)	106
Figure 4.105	Summary of simulation result of Sg. Belat (1 hour, 100-years ARI)	106
Figure 4.106	Hydrograph simulation of Sg. Galing (1 hour, 100-years ARI)	107
Figure 4.107	Summary of simulation result of Sg. Galing (1 hour, 100-years ARI)	107
Figure 4.108	Hydrograph simulation of Junction 11 (1 hour, 100-years ARI)	108
Figure 4.109	Summary of simulation result of Junction 11 (1 hour, 100-years ARI)	108
Figure 4.110	Hydrograph simulation of Ulu Sungai Kuantan (6 hour, 100-years ARI)	109
Figure 4.111	Summary of simulation result of Ulu Sungai Kuantan (6 hour, 100- years ARI)	109
Figure 4.112	Hydrograph simulation of Junction 2 (6 hour, 100-years ARI)	110
Figure 4.113	Summary of simulation result of Junction 2 (6 hour, 100-years ARI)	110
Figure 4.114	Hydrograph simulation of Junction 9 (6 hour, 100-years ARI)	111
Figure 4.115	Summary of simulation result of Junction 9 (6 hour, 100-years ARI)	111
Figure 4.116	Hydrograph simulation of Sg. Belat (6 hour, 100-years ARI)	112
Figure 4.117	Summary of simulation result of Sg. Belat (6 hour, 100-years ARI)	112
Figure 4.118	Hydrograph simulation of Sg. Galing (6 hour, 100-years ARI)	113
Figure 4.119	Summary of simulation result of Sg. Galing (6 hour, 100-years ARI)	113
Figure 4.120	Hydrograph simulation of Junction 11 (6 hour, 100-years ARI)	114
Figure 4.121	Summary of simulation result of Junction 11 (6 hour, 100-years ARI)	114
Figure 4.122	Hydrograph simulation of Ulu Sungai Kuantan (24 hour, 100-years ARI)	115
Figure 4.123	Summary of simulation result of Ulu Sungai Kuantan (24 hour, 100- years ARI)	115
Figure 4.124	Hydrograph simulation of Junction 2 (24 hour, 100-years ARI)	116

Figure 4.125	Summary of simulation result of Junction 2 (24 hour, 100-years ARI)	116
Figure 4.126	Hydrograph simulation of Junction 9 (24 hour, 100-years ARI)	117
Figure 4.127	Summary of simulation result of Junction 9 (24 hour, 100-years ARI)	117
Figure 4.128	Hydrograph simulation of Sg. Belat (24 hour, 100-years ARI)	118
Figure 4.129	Summary of simulation result of Sg. Belat (24 hour, 100-years ARI)	118
Figure 4.130	Hydrograph simulation of Sg. Galing (24 hour, 100-years ARI)	119
Figure 4.131	Summary of simulation result of Sg. Galing (24 hour, 100-years ARI)	119
Figure 4.132	Hydrograph simulation of Junction 11 (24 hour, 100-years ARI)	120
Figure 4.133	Summary of simulation result of Junction 11 (24 hour, 100-years ARI)	120
Figure 4.134	Hydrograph simulation of Ulu Sungai Kuantan (72 hour, 100-years ARI)	121
Figure 4.135	Summary of simulation result of Ulu Sungai Kuantan (72 hour, 100-years ARI)	121
Figure 4.136	Hydrograph simulation of Junction 2 (72 hour, 100-years ARI)	122
Figure 4.137	Summary of simulation result of Junction 2 (72 hour, 100-years ARI)	122
Figure 4.138	Hydrograph simulation of Junction 9 (72 hour, 100-years ARI)	123
Figure 4.139	Summary of simulation result of Junction 9 (72 hour, 100-years ARI)	123
Figure 4.140	Hydrograph simulation of Sg. Belat (72 hour, 100-years ARI)	124
Figure 4.141	Summary of simulation result of Sg. Belat (72 hour, 100-years ARI)	124
Figure 4.142	Hydrograph simulation of Sg. Galing (72 hour, 100-years ARI)	125
Figure 4.143	Summary of simulation result of Sg. Galing (72 hour, 100-years ARI)	125
Figure 4.144	Hydrograph simulation of Junction 11 (72 hour, 100-years ARI)	126
Figure 4.145	Summary of simulation result of Junction 11 (72 hour, 100-years ARI)	126

LIST OF SYMBOLS

A	Watershed Area
A_m	Drainage Area
C	Runoff Coefficient
C_p	Peak Coefficient
cfs	Cubic Square Foot
i	Rainfall Intensity
km	Kilometer
mm	Millimeter
m^3	Meter Cube
m^3/s	Meter Cube Per Second
Q	Flow Rate of Runoff
Q_p	Peak Runoff
R	Storage Coefficient
S	Slope
t_c	Time Concentration
T_{lag}	Snyder's Standard Lag (hours)
Σ	Summation

LIST OF ABBREVIATIONS

ARI	Average Recurrence Interval
CN	Curve Number
DID	Department of Irrigation and Drainage
HEC-HMS	Hydrologic Engineering Center Hydrologic Modelling System
SCS	Soil Conservation Service