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Research Article

Analysis Of River Discharge Characteristic In Post-Flood And Normal Season At Perai River Basin, Seberang Perai, Penang

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Abstract

Characterization Of River Discharge Characteristics In The Post-Flood And Normal Seasons Was Carried Out In The Perai River Basin, Penang. The Sampling Study Was Conducted In November 2017 For Post-Flood And In March 2019 For Normal Season. Cross-Sectional Measurements Involving The Measurement Of River Width, River Depth, And Velocity Were Conducted At Both Sampling Times. The Objective Of This Study Was To Identify The Pattern Of River Discharge In The Perai River Basin And To Assess The Relationship Between The Occurrence Of Water Discharge And Other Factors For Both Seasons. The Results Showed That The Average Discharge Rate For Each River After The Rainy Season Was 5.99 M^3s^{-1} For The Kereh River, 19.57 M^3s^{-1} For The Jarak River, 12.17 M^3s^{-1} For The Kulim River, And 52.15 M^3s^{-1} For The Perai River. For The Normal Season, There Were 4.16 M^3s^{-1} For The Kereh River, 6.66 M^3s^{-1} For The Jarak River, 5.81 M^3s^{-1} For The Kulim River And 35.96 M^3s^{-1} For The Perai River. Subsequent Estimates Of Flood Rates During Floods Were Also Estimated By Estimating An Increase In Water Depth By Five Meters. As A Result Of This Estimate, The Average Drainage Rate For The Kereh River Is 25.97 M^3s^{-1}, The Jarak River Is 61.74 M^3s^{-1}, The Kulim River Is 64.77 M^3s^{-1} While The Perai River Is 146.13 M^3s^{-1}. The Results From The Correlation Statistics Analysis Showed A Very Significant Reading Between River Depths And Water Discharge With $R^2 = 0.6131$. The Relationship Between Velocity And Water Discharge Shows A Reading Of $R^2 = 0.0644$ Which Is Not Significant. Whereas The Relationship Between Width And Water Discharge Shows A $R^2 = 0.5709$ Which Is Significant. It Is Hoped That This Study Will Provide As Much Information As Possible Before The Proper Steps Are Taken To Prevent Future Flood Events.

Keywords: *Cross-Section, Flood, River Basin, River Discharge, Correlation.*

Introduction

Water Could Be A Source Of Life, Livelihoods, And Prosperity. Water Is A One Of The Crucial Part And As A Vital Input To The Majority Kinds Of Productions Like Agriculture, Industry, Energy, Transport, And So On (Grey And Sadoff, 2007). It Is A Vital Element In Maintaining Life And Needed For The Survival Of All Organisms (Azlan Et Al., 2012). Added Zakaria Et Al. (2011), Without Water, All Varieties Of Life Could Never Exist And Can Not Survive. The Planet Is Perhaps The Sole Planet Within The Vast Universe That Has Lives, Thereon And Therefore The Only Reason May Be That The Planet Is Endued With Abundant Water.

Malaysia Is One Of The Country's Rich Water Resources, Due To The Annual Rainfall Quantity Received More Than 2500 Mm Each Year, Mainly At The End Of The Year When The Northeast Monsoon (Amran Et Al., 2018). In This Water Source, The River Is One Among Of The Foremost Important Sources Of Water For All Living Things Additionally To Water Catchments Like Lakes, Seas, And Underground Water. The Rivers Are Vital To Humans And Other Organisms As They Are Essential Resources For Living. Variety Of Processes, Like Erosion, Transportation And Deposition, Influence The Sedimentary Content And Quality Of River Water (Zhang & Zang, 2015; Kamarudin Et. Al, 2019)

Rivers That Are Also As A Reservoir And Water Flow Area Should Always Be Prepared To Receive Water Presence From Various Angles Such As Surface Runoff, Rainwater And Tidal Waters. In Most Places, The Hilly Areas That Should Be The Water Catchment Area Have Begun To Be Used To Be A Settlement Of The Residents Due To Dramatically Increasing Population. Such Conditions Will Have An Adverse Impact In The Future Due To The Lack Of Water Catchment. River Morphology Is Changing From Its Natural Channel Because Of Human Activities, Like Sand Excavation From The Bed, Agricultural Activity, Disposal Of Municipal Waste And Construction On The River. The Environment Of The River Should Be Maintained And Would Not Be Extremely Disturbed By Human Activities (Samanta & Pal, 2012).

Safarina & Kamisah (2019) Stated That River Is Very Important A Part Of A Person Which Is Continually Changing From Its Evolutions. The River Slope, Velocity And Nature Of The River Are Responsible Perimeters For Changing The River Shape And Size. The Natural River Will Also Be More Difficult To Accommodate Water Capacity In The Event Of A Sudden Increase In Water Due To The Loss Of The Water Catchment. So There Are Important To Boost The Knowledge And Also The Practice Of Environmental Management Ability Among Communities About Environmental Issues. There Are Important To Realize The Environmental Awareness And Ethics, Values And Attitudes, Skills And Behaviours (Jusoh Et. Al, 2019).

The Water Quality Aspect Is Also Increasingly Ignored While Many Reservoirs And Rivers Become Contaminated Due To Human Settlements And Activities In The Water Catchment Area (Wahab Et Al, 2019). Thus, The River's Emergency Rate Should Be Reviewed To Facilitate The Need To Identify And Examine The Best Steps To Minimise Negative Impacts Such As Flood Events, Landslides And So On If They Occur. Due To Human Activities, River Morphology Is Changing From Its Natural Channel, Like Agricultural Activity, Sand Excavation From The Bed, Disposal Of Municipal Waste And Construction On The River. Human Activities Should Not Extremely Disturb The Environment Of The River Because They Should Be Maintained (Samanta & Pal, 2012).

The Most Common Disaster In Malaysia Is Flood And Flash Floods. Floods Occur Especially During The Wet Season In The East Coast Area Which Is Mainly Influenced By The Northeast Monsoon (Saudi Et Al. 2015; Muhammad Et Al. 2016). In Ongoing Decades, The Quantities Of Utmost Climatic Events Like Storms, Flood, Dry Spells And Warmth Waves Have Expanded Around The World (Sungip Et. Al, 2019; Field Et. Al, 2012; Toriman Et. Al, 2009). The Monitoring Of River Discharge Is Key Frequency For The Body Of Water Resources Direction, Water Residue Rating At The Basin Scale, And Flood Purpose Additionally As For The Calibration And Validation Of Hydrological Models. Spada Et Al. (2017) Stated That Despite The Main Impact Of Discharge Data On Many Environmental Management Takings, Their Evaluation Nearly Always Relies On The Utilization Of The So-Called Rating Curves.

There Are Three Steps That Are Basic To Obtain Data On River Stream I.E. Water Level Measurements; River Discharge Calculation; Define The Relationship Between Water Level And River Expression (Bruce & Clark, 1966). Hydrology Members Focus On The Flow Rate Or River Discharge Feature In The Cubic Meter Unit Per Second (M^3s^{-1}). In The Open Channel Flow Study, A Cross-Section Of The Complicated Channel Is Ready To Determine, Water Velocity In The Meter Per Second (Ms^{-1}) Is Also An Important Key Feature (Toriman Et Al., 2013).

In General, The River Consists Of Three Divisions, The Division Of Upstream, Midstream And Downstream. The River Is A Lotic Ecosystem, Which Has A Variable Depth (Chiras, 2001). In Order To Obtain The Value Of River Depth, The Average Value Must Be Taken By Measuring The Vertical Depth By Cross-Section. The River Has A One-Way Movement Feature And Has A Seasonal Volume Variation. The One-Way Movement Causes The Banks And The River Policies Unstable And Vulnerable To Erosion. This Phenomenon Is Closely Related To The Frequency And Intensity Of The Rain On Certain Expectation In The Area (Ismail, 1994).

Objective

The Main Objective Of This Study Is To Identify The River Static (Trend) In The Perai Basin And To Assess The Relationship Between Water Discharge Which Occur With Other Factors. This Is To See Whether It Exists Or Is Not An Association Of These Factors With The Season Of Expression.

Study Area And Methodology

The Study Area Selected Is The Perai River Basin At The Coordinates Of 5°26'49.2 'N 100°26'40.0' E Consisting Of The Kereh River, Jarak River, Kulim River And Perai River In Penang. The Basin Covers The Northern Part Of Seberang Perai (Spu) With A Total Area Of 352.43 Km^2 And Slightly Enters The Seberang Perai Central Area With An Area Of 96.15 Km^2. The Number Of People In Spu Reached 310,700 In 2015. Land Use Activities In This Area Are For Agriculture And Development Only. Agricultural Activities In This Area Account For Up To 60% Of The Total Area Of The Spu Area Of 26,588 Hectares (Ha) Involving 16 Inhabitants. While Land Use For Development Is Only 10% Of Spu (Penang State Government, 2015).

However, This Area Is Often Flooded Especially During Heavy Rainfall. There Are 22 Settlements In The Perai River Basin Which Are The Hot Spots For Flood Events Such As Table 1. These Areas Are Often Flooded Due To Their Poor Surface Conditions And Due To Heavy Rainfall Events For Extended Periods, These Areas Are Vulnerable To Flood Water. The Situation Will Worsen In The Event Of High Tide Occurring In The Sea Which Prevents The Flow Of Water From The Mainland. In Addition, The Capacity Of These Four Rivers Is Also Insufficient To Sustain The Flow Rate During Heavy Rains Flowing Upstream Due To The Erosion Of The Banks Of The River Which Causes The River To Become Shallow. Transport Of Sediment From The Upstream Side Of The River Has Also Reduced The Capacity Of Existing Rivers.

Table 1 : Flood Hotspot Area In Perai River Basin

No.	District	River	Flood Hotspot Area	City
1	North Seberang Perai	Perai River	Kampung Merbau Kudung	Butterworth
2	North Seberang Perai	Perai River	Kampung Pengkalan Macang	Butterworth
3	North Seberang Perai	Perai River	Taman Desa Murni	Butterworth
4	North Seberang Perai	Perai River	Kampung Nyior Sebatang	Butterworth
5	North Seberang Perai	Kulim River	Kampung Tok Jawa	Tasek Gelugor
6	North Seberang Perai	Kereh River	Kampung Lahar Yooi	Tasek Gelugor
7	North Seberang Perai	Kereh River	Lubuk Meriam	Tasek Gelugor
8	North Seberang Perai	Kereh River	Padang Tonsun	Tasek Gelugor
9	North Seberang Perai	Kereh River	Kampung Selamat	Tasek Gelugor
10	North Seberang Perai	Kereh River	Kampung Pokok Macang	Tasek Gelugor
11	North Seberang Perai	Jarak River	Paya Tok Akil	Tasek Gelugor
12	North Seberang Perai	Jarak River	Desa Kacang Puri	Tasek Gelugor
13	North Seberang Perai	Jarak River	Padang Cempedak	Tasek Gelugor

14	North Seberang Perai	Jarak River	Kampung Pmtg Berangan	Tasek Gelugor
15	Central Seberang Perai	Perai River	Kampung Manis	Perai
16	Central Seberang Perai	Perai River	Kampung Labuh Banting	Tasek Gelugor
17	Central Seberang Perai	Perai River	Kampung Kota	Permatang Pauh
18	Central Seberang Perai	Perai River	Kampung Kubu	Kubang Semang
19	Central Seberang Perai	Perai River	Kampung Guar Jering	Kubang Semang
20	Central Seberang Perai	Perai River	Kampung Terus	Kubang Semang
21	Central Seberang Perai	Perai River	Kampung Bukit Berangan	Kubang Semang
22	Central Seberang Perai	Perai River	Taman Senangin	Perai

Source : Penang State Government (2019)

Most Of The Land Use In Spu Area Is To Carry Out Paddy Planting Agriculture. Hence, The Geographic Form Of Earth Terrain Is Lower. These Four Rivers Become Water Suppliers To Paddy Planting Areas Around The Area. Water Strings Or More Commonly Known As '*Palong Air'* In Local Residents Such As Figure 1 Are Built To Channel Water To Fields Away From The River.

Figure 1 : Water Ropes Or Water Trunks Were Built To Carry River Water To Paddy Fields

Due To The Low Position Of The Area, Often Flood Events Will Occur When The River Water Level Increases And Overflowing As The River Cannot Afford Excessive Water Capacity Such As The Flood Incident That Occurred In September 2017. The Situation Has Always Been A Problem To The Residents Because Not Only The Paddy Cultivation Is Submerged And Damaged, But There Is A Medication Of Property Damage Each Time The Flood Occurs (Figure 2 (A) And (B)).

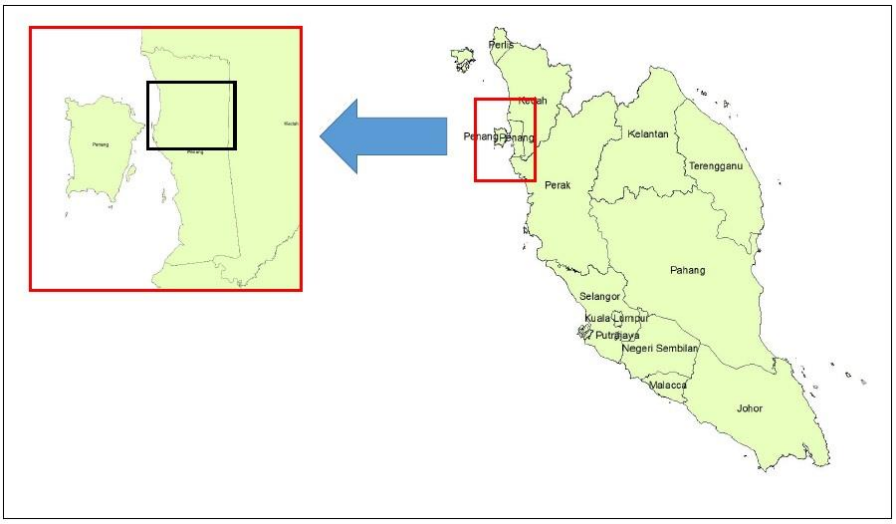
a) Flood Waters Overflow Into Residential Areas

b) The Paddy Fields In Spu Are Flooded

Figure 2: Flood Event At Spu

Source: Malaysiakini January 5, 2018)

Due To The Likelihood Of The Problem Back Without Preparation, Sampling Was Carried Out In The Sungai Perai Basin (Figure 3). The Position Of Sampling Station Was Identified Using The Global Digital Device Positioning System (Dgps) Where Sampling Was Carried Out In The Post-Flood Season In November 2017 And The Usual Season In March 2019. According To The Malaysian Meteorological Department, Weather In Malaysia Is Characterized By The Monsoon Namely The Southwest Monsoon From The End Of May To September And The East-West Monsoon From November To March. The Western Monsoon Brings Heavy Rainfall Especially To The States On The West Coast Of Peninsular Malaysia While Its Relatively Low Sea Monsoon Is Less Heavy In The Area. The Transition Period Between The Two Monsoons Is Known As The Monsoon Season.



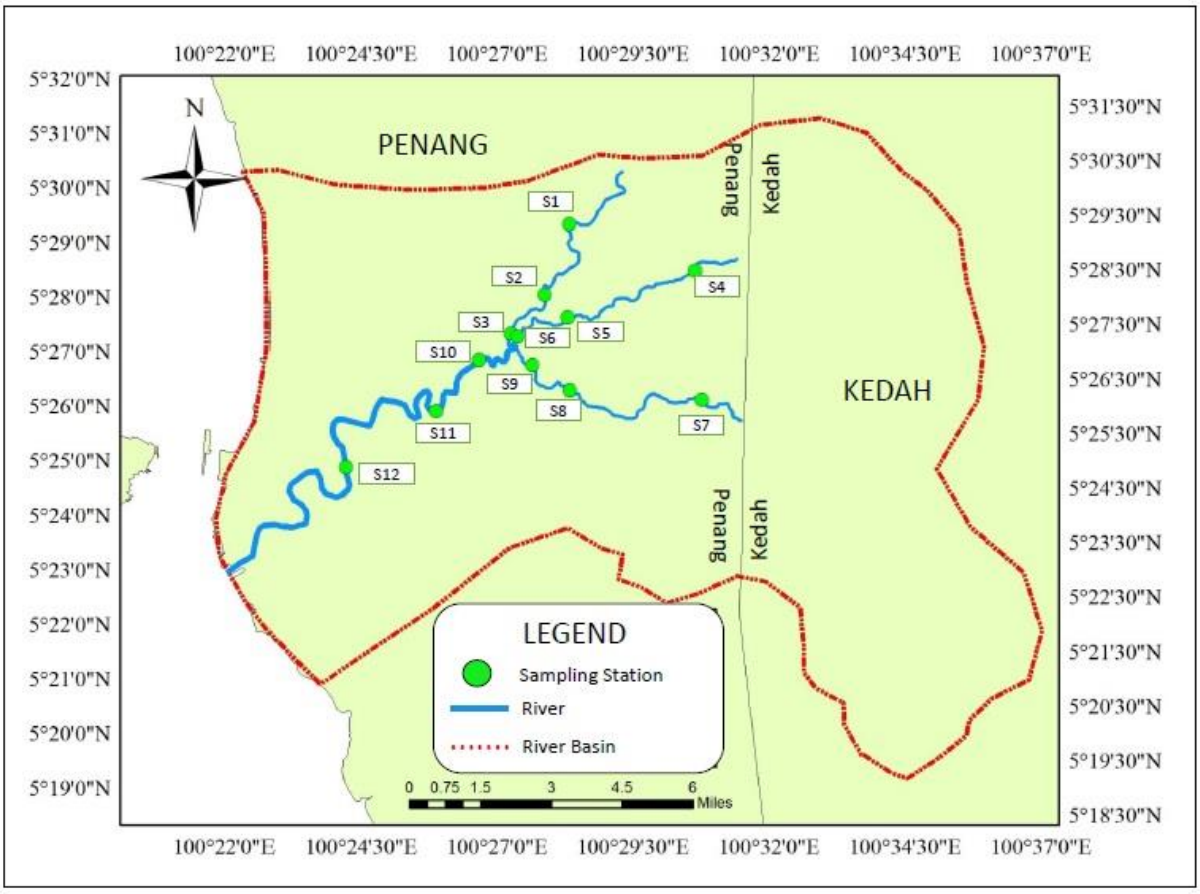


Figure 3: Map Showing Sampling Location

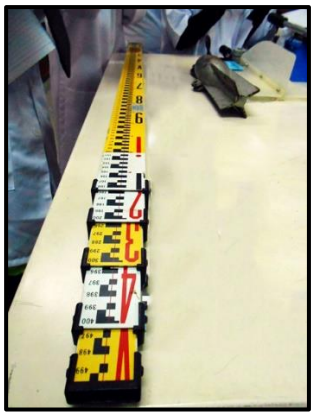
Table 2: Coordinate Of Sampling Stations

No	Station	Latitude	Longitude
S1	Kereh River (Upstream)	5°29'18.7"N	100°28'19.3"E
S2	Kereh River (Midstream)	5°28'00.7"N	100°27'51.9"E
S3	Kereh River (Downstream)	5°27'18.0"N	100°27'15.0"E
S4	Jarak River (Upstream)	5°28'27.4"N	100°30'38.4"E
S5	Jarak River (Midstream)	5°27'36.0"N	100°28'17.3"E
S6	Jarak River (Downstream)	5°27'15.5"N	100°27'21.7"E
S7	Kulim River (Upstream)	5°26'05.4"N	100°30'45.3"E
S8	Kulim River (Midstream)	5°26'15.7"N	100°28'20.0"E
S9	Kulim River (Downstream)	5°26'43.5"N	100°27'38.5"E
S10	Perai River (Upstream)	5°26'49.2"N	100°26'40.0"E
S11	Perai River (Midstream)	5°25'53.0"N	100°25'52.3"E
S12	Perai River (Downstream)	5°24'51.4"N	100°24'12.9"E

A) In-Field Analysis

In Order To Obtain River Discharge Data (Q), Several Methods Have Been Carried Out By Cross-Sectional Measurement Involving River Width (B) Measurement, River Vertical Depth (D) And Water Velocity Measurement (V) And All Of These Readings Were Recorded For Analysis And Computation. The Measuring Instruments Used Are Measuring Tape For Width (Figure 4a), Staff Gauge For Depth (Figure 4b) And Current Meter To Measure Current Velocity (Figure 4c).

a) Tape Meter



b) Staff Gauge

c) Current Meter

Figure 3: Equipment Used For Field Sampling

B) Hydrographic Calculation

Calculation Area (A):

The Area Of Each Section Is Obtained By Taking Into Account The Depth Absorbed By The Vertical Boundary And Multiplied By Between The Vertical Boundaries.

A = B X D ..... [1]
A = Cross Sectional Area (M2)
B = Distance Between Vertical Boundaries (M)
D = Water Depth (M)

C) Calculation Of River Discharge (Q)

If The Cross-Sectional Area (A) And Average Velocity (V) Are Known, The Slope (Q) Can Be Calculated From Q = Va. Because The Water Depth And Flow Velocity Are Not Uniform For The Entire Cross-Section. Accurate Discharge Measurements Are Obtained By Dividing The Cross-Section Into Several Sub-Sections Called Sections. Each Section Is Limited By Surface Water, River Bottom And 2 Vertical Lines, Called Vertical. Each Vertical Is A Common Dimension Of Two Continuous Sections And The Depth Of Water And The Velocity Of The Stream Are Set For Observation. Adequate Velocity Observations Were Made To Obtain The Average Velocity At Each Vertical Boundary (Figure 3). So The Average Velocity Of The Section Is:

V = (V0.2d X V0.8d)/2 Or V0.6d ..... [2]

The Result Of The Average And Wide Velocity Of Each Section Gives The Cut-Off.

Q = (Bd)(V0.2d X V0.8d)/2 ..... [3]

Or Q = (Bd)(V0.6d)

And The Sum Of All The Cutoffs Gives The Sum Of The Sums.

Q = (Q0,1)+(Q1,2) +(Q2,3)...+(Qn,N +1) ..... [4]

Where N Is A Perpendicular Number.

(Jamil Et. Al (2012)

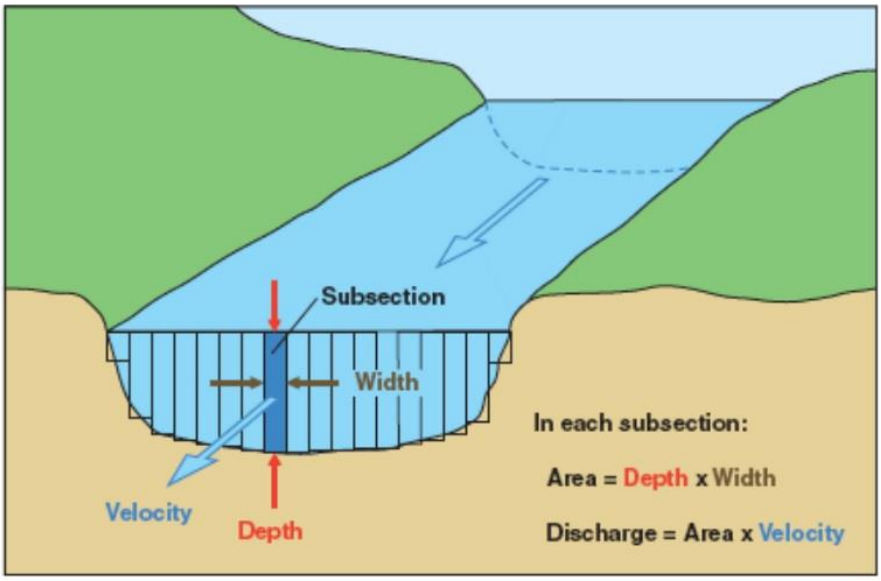


Figure 3: Theory Of Measurement Of Discharge

Source: Usgs Water Science School: How Streamflow Is Measure (2020)

D) Data Analysis

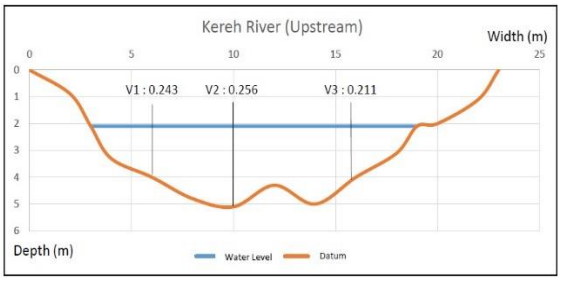
The Data Obtained From Field Analysis Were Analyzed Using Microsoft Excel 2016. The Data Analysis Is To Facilitate The Work Of Interpreting The Data And Looking At The Relevance Of The Parameters Studied.

Results And Discussion

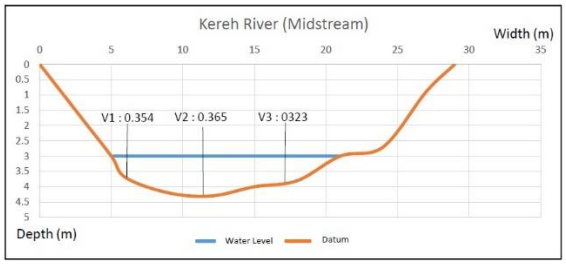
During The Field Sampling, Several Geometric Elements Were Absorbed And Measured In Situ. The Average Value Of River Depth, River Width, And Stream Velocity Is Used To Obtain The Amount Of Discharge. Zackar (1982) Was Stated That The Value Obtained Is Variable At Each Sampling Time. This Is Due To Climate Factors, River Vegetation, Soil And Rock Structure As Well As Basin Morphology And River Hydraulic Geometry As Well As Soil Erosion And Sedimentation.

A) Hydrographic Measurement Results Post-Flood

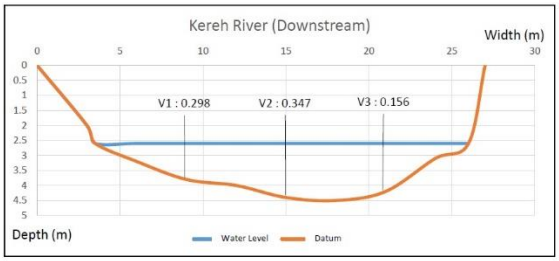
In This Study, There Are Three Sampling Stations Taken In Every River For Four Rivers Namely Kereh River, Jarak River, Kulim River And Perai River. Three Sampling Stations Involve The Area Of Upstream, Midstream And Downstream Of Each River. The Total Sampling Stations Are Twelve Stations As Shown In Table 2. At Each Sampling Station, The Measuring Of The Cross-Section And Water Velocity Is Taken As Shown In Figure 6 (A) (B) (C) (D) (E) (F) (G) (H) (I) (J).



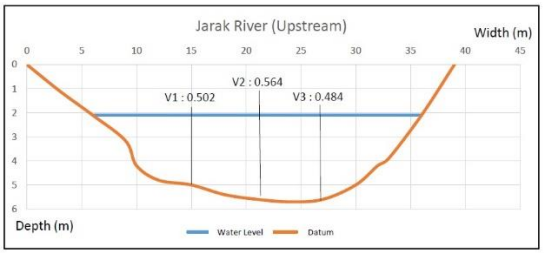
(A) Station 1 : Kereh River (Upstream)



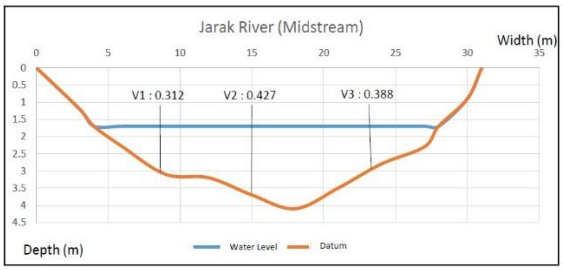
(B) Station 2 Kereh River (Midstream)



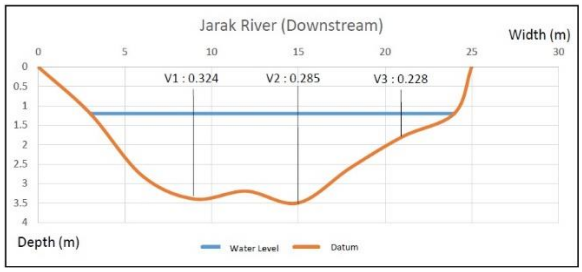
(C) Station 3 Kereh River (Downstream)



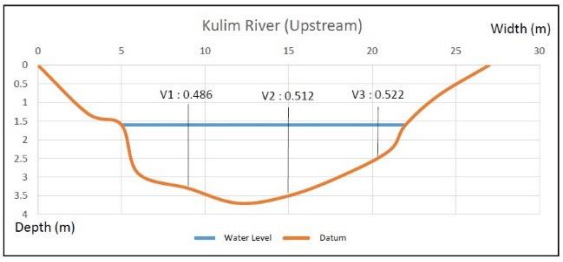
(D) Station 4 : Jarak River (Upstream)



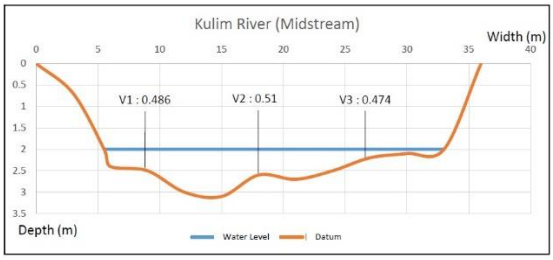
(E) Station 5 : Jarak River (Midstream)



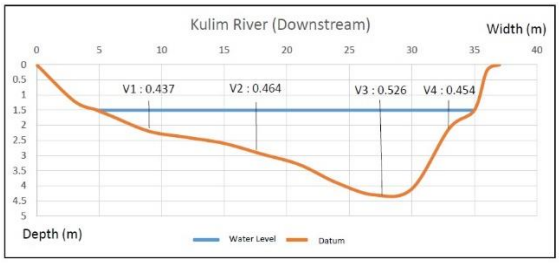
(F) Station 6 : Jarak River (Downstream)



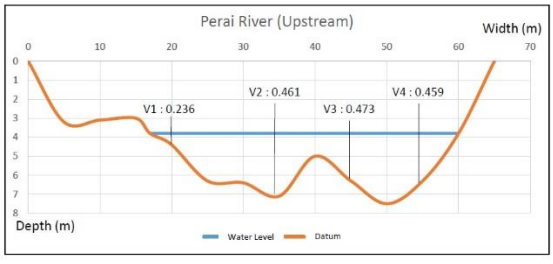
(G) Station 7 : Kulim River (Upstream)



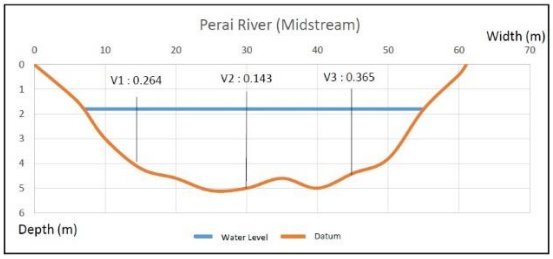
(H) Station 8 : Kulim River (Midstream)



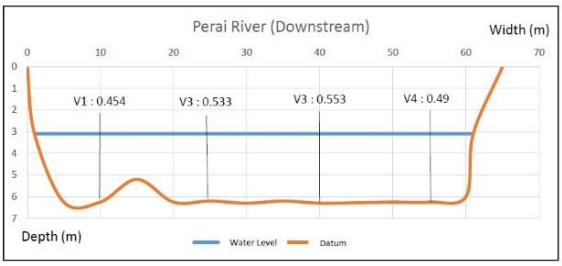
(I) Station 9 : Kulim River (Downstream)



(J) Station 10 : Perai River (Upstream)



(K) Station 11 : Perai River (Midstream)



(L) Station 12 : Perai River (Downstream)

Figure 6: Cross-Section Of River Post-Flood

Perai River Is A River Located Downstream Of The Perai River Basin. So The Width And Depth Of This River Are Higher Than The Other River Which Is The River Of Supply. Figure 6 (A) Shows Station 1, The Kereh River (Upstream) Located In The Upstream Basin. River Width Is 19 Meters And The Average Water Depth Is 3 ± 1 Meter. The Average Current Velocity Recorded Was 0.243 ± 0.211 Ms^{-1}. This River Is One Of The Branches Of The River That Supplies To The Perai River. Although At The Head Of The Basin, The Mean Height At Mean Sea Level (Msl) Is Only 8.5 Meters. This Is Because The Area Is More Heavily Drained Of Alluvial (Clay) And Due To These Factors, Rice Cultivation Can Be Carried Out Easily And Fertile Here.

Figure 6 (B) Shows Station 2, Kereh River (Midstream). The Width Of The River Is 29 Meters And The Average Depth Of The River Is 1.3 ± 0.7 Meters. The Average Current Velocity Recorded Was 0.365 ± 0.323 Ms^{-1}. Whereas Figure 6 (C) Is Station 3 Of The Kereh River (Downstream). The Width Of The River Is 27 Meters And The Average Depth Of The River Is 1.9 ± 0.6 Meters. The Average Current Velocity Recorded Was 0.347 ± 0.156 Ms^{-1}.

Next To The Second River In This Basin Is The Jarak River. Figure 6 (D) Shows Station 4, Which Is The Jarak River (Upstream). The Average Depth Of The River Is Reading 3.6 ± 1.1 Meters. The Average Current Velocity Recorded Was 0.564 ± 0.484 Ms^{-1}. The Height Of Msl In This Area Is 8.9 Meters With A Width Of 39 Meters. Figure 6 (E) Shows Station 5, Which Is Jarak River (Midstream). The Recorded Width Is 31 Meters. On Average, The Water Depth Of The River Recorded 2.4 ± 0.6 Meters. The Average Current Velocity Recorded Was 0.427 ± 0.312 Ms^{-1}.. Station 6, Which Is The Jarak River, Referring To Figure 6 (F), Shows A River Width Of 26 Meters With An Average Depth Of 2.8 ± 0.7 Meters. The Average Current Velocity Was 0.44 ± 0.418 Ms^{-1}.

Next Up Is The Third River For The Perai River Basin, The Kulim River. Figure 6 (H) Shows Station 7, Kulim River (Upstream). The Station Is 27 Meters Wide With An Average River Depth Of 2.1 ± 0.7 Meters. The Average Current Velocity Recorded Was 0.522 ± 0.486 Ms^{-1}. The Height At The Msl Point Of The Station Is 6.7 Meters. Figure 6 (I) Refers To Station 8, Kulim River (Midstream). The Width Of The River Recorded At This Station Is 36 Meters. While The Average Depth Of River Water Is Reading 1 ± 0.1 Meters. The Average Current Velocity Recorded Was 0.51 ± 0.424 Ms-1. Next To Station 9 Is The Kulim River (Downstream) In Figure 6 (J). The Station Recorded Width Of 37 Meters With An Average River Depth Of 2.8 ± 0.2 Meters. The Average Current Velocity Recorded Was 0.526 ± 0.437 Ms^{-1}.

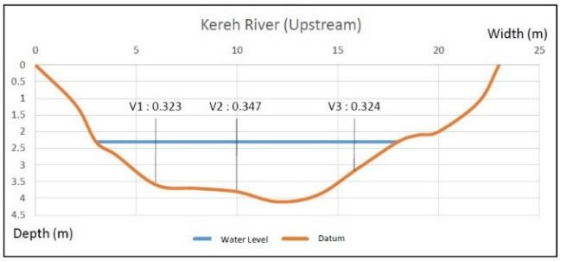
Finally, The Fourth River Found In The Basin Is The Perai River. Perai River Is A River That Is Connected By Three Major Rivers, Kereh River, Jarak River And Kulim River. The Perai River Is Located Downstream Of The Basin That Flows From The Highlands To The Sea. The River Is Much Wider Than The River Of The Supplier. Figure 5 (J) Shows Station 9, The Perai River (Upstream). The Average Depth Of River Water Is 3.7 ± 0.6 Meters. The Average Current Velocity Recorded Was 0.473 ± 0.236 Ms^{-1}. The Height Of Msl In This Area Is 6.7 Meters With A Width Of 65 Meters. Figure 5 (K) Shows Station 11, Perai River (Midstream). The Recorded Width Is 62 Meters. The Average Depth Of River Water Is 3.3 ± 1.2 Meters. The Average Current Velocity Recorded Was 0.365 ± 0.143 Ms^{-1}. The 12^{th} Station Of The Perai River (Downstream) Which Refers To Figure 5 (J) Shows A 65 Meter Width With An Average Depth Of 3.2 ± 2.1 Meters. The Average Current Velocity Was 0.553 ± 0.454 Ms^{-1}.

Table 3 : Average Value Of Flow Velocity, Depth And River Width In The Post-Flood Season

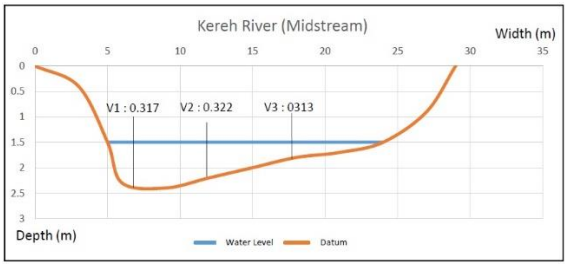
Station	Average Depth (M)	Average Velocity (M/S)	River Width (M)
S1	3 ± 1	0.243 ± 0.211	23
S2	1.3 ± 0.7	0.365 ± 0.323	29
S3	1.9 ± 0.6	0.347 ± 0.156	27
S4	3.6 ± 1.1	0.564 ± 0.484	39
S5	2.4 ± 0.6	0.427 ± 0.312	31
S6	2.8 ± 0.7	0.44 ± 0.418	26
S7	2.1 ± 0.7	0.522 ± 0.486	27
S8	1 ± 0.1	0.51 ± 0.424	36
S9	2.8 ± 0.2	0.526 ± 0.437	37
S10	3.7 ± 0.6	0.473 ± 0.236	65
S11	3.3 ± 1.2	0.365 ± 0.143	62
S12	3.2 ± 2.1	0.553 ± 0.454	65

a) Hydrographic Measurement Results In Normal Season

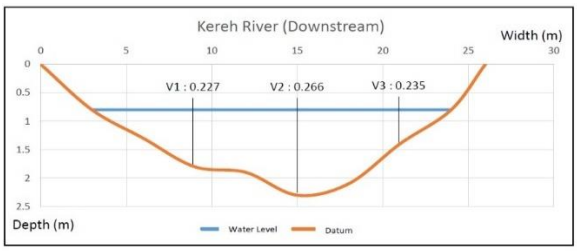
For The Purpose Of Comparison, Sampling During The Normal Season Has Also Been Performed. The Average Stream Of River Velocity In The Regular Season Is Lower Than A Season After The Flood. The Average Water Depth For Both Seasons Is Also Different Because The Factor Of Rainfall Down Is More Time After Flooding Than In The Normal Season. The Cross-Section Of The Kereh River, Jarak River, Kulim River And Perai River In The Normal Season Is As Shown In Figure 7 (A) (B) (C) (D) (E) (F) (G) (H) (I) (J).



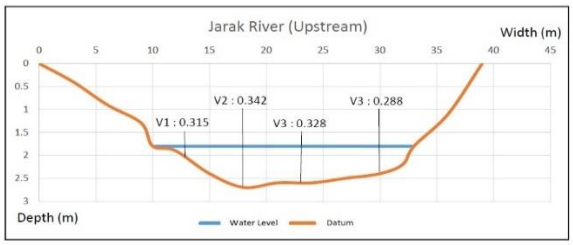
(A) Station 1 : Kereh River (Upstream)



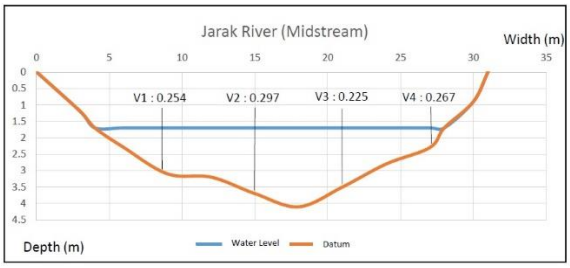
(B) Station 2 : Kereh River (Midstream)



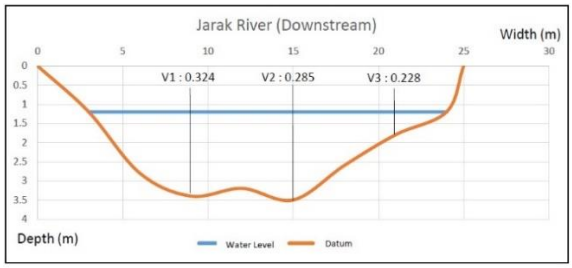
(C) Station 3 : Kereh River (Downstream)



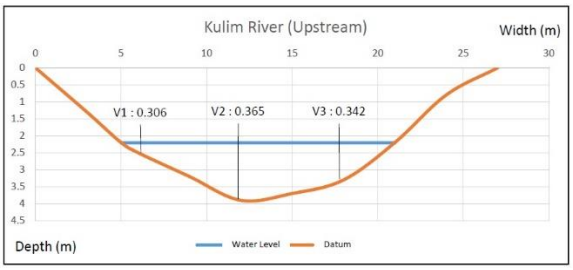
(D) Station 4 : Jarak River (Upstream)



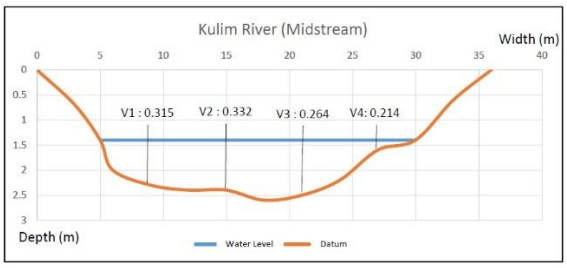
(E) Station 5 : Jarak River (Midstream)



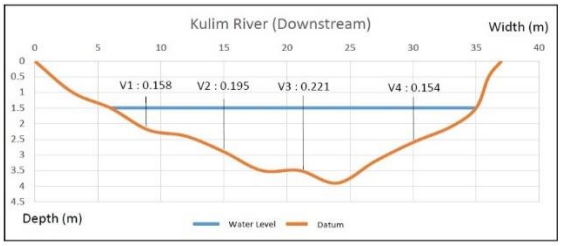
(F) Station 6 : Jarak River (Downstream)



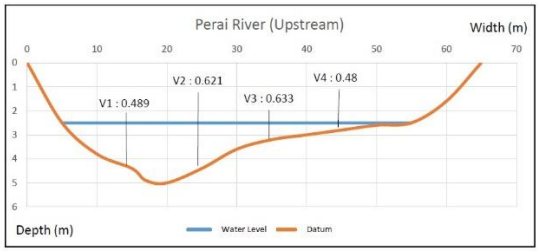
(G) Station 7 : Kulim River (Upstream)



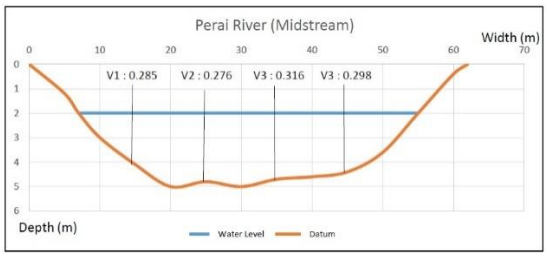
(H) Station 8 : Kulim River (Midstream)



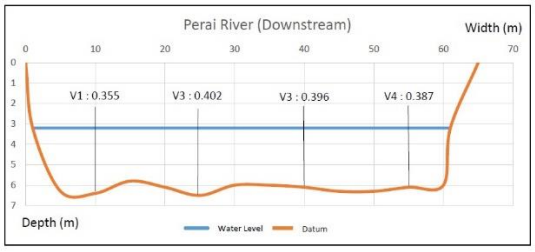
(I) Station 9 : Kulim River (Downstream)



(J) Station 10 : Perai River (Upstream)



(K) Station 11 : Perai River (Midstream)



(L) Station 12 : Perai River (Downstream)

Figure 7 : Cross-Section Of River On Normal Season

Figure 7 (A) Shows Station 1, The Kereh River (Upstream) Located In The Upstream Basin. River Width Is 19 Meters And The Average Water Depth Is 1.8 ± 0.4 Meters. The Average Current Velocity Recorded Was 0.347 ± 0.323 Ms^{-1}. Figure 7 (B) Shows Station 2, The Kereh River (Midstream). The Width Of The River Is 29 Meters And The Average Depth Of The River Is 0.9 ± 0.2 Meters. The Average Current Velocity Recorded Was 0.322 ± 0.313 Ms^{-1}. Whereas Figure 7 (C) Is Station 3 Of The Kereh River (Downstream). The Width Of The River Is 27 Meters And The Average Depth Of The River Is 1.5 ± 0.5 Meters. The Average Current Velocity Recorded Was 0.327 ± 0.235 Ms^{-1}.

Next To The Second River In This Basin Is The Jarak River. Figure 7 (D) Shows Station 4, Which Is The Jarak River (Upstream) With An Average Reading Of River Water Depth Of 0.9 ± 0.1 Meters. The Average Current Velocity Recorded Was 0.342 ± 0.288 Ms^{-1}. Figure 7 (E) Shows Station 5, Which Is The Jarak River (Midstream). The Recorded Width Is 31 Meters. While The Average Depth Of River Water Is Reading 1.6 ± 0.6 Meters. The Average Current Velocity Recorded Was 0.297 ± 0.225 Ms^{-1}. Station 6, Which Is The Jarak River (Referring To

Figure 7 (F), Shows A River Width Of 26 Meters With An Average Depth Of 2.3 ± 0.6 Meters. The Average Current Velocity Was 0.324 ± 0.228 Ms^{-1}.

Next Up Is The Third River For The Perai River Basin, The Kulim River. Figure 7 (H) Shows Station 7, Kulim River (Upstream). The Station Is 27 Meters Wide With An Average River Depth Of 1.7 ± 0.3 Meters. The Average Current Velocity Recorded Was 0.365 ± 0.306 Ms^{-1}. Figure 7 (I) Refers To Station 8, Kulim River (Midstream). The Width Of The River Recorded At This Station Is 36 Meters. While The Average Depth Of The River Is Reading 1.2 ± 0.2 Meters. The Average Current Velocity Recorded Was 0.332 ± 0.214 Ms-1. Next To Station 9 Is The Kulim River (Downstream) In Figure 7 (J). The Station Recorded Width Of 37 Meters With An Average River Depth Of 2.4 ± 0.6 Meters. The Average Current Velocity Recorded Was 0.221 ± 0.154 Ms^{-1}.

Finally, The Fourth River Found In The Basin Is The Perai River. Figure 6 (J) Shows Station 9, The Perai River (Upstream). The Average River Water Depth Is 2.5 ± 0.1 Meters. The Average Current Velocity Recorded Was 0.633 ± 0.48 Ms^{-1}. Figure 6 (K) Also Shows Station 11, Perai River (Midstream). The Recorded Width Is 62 Meters. On Average, The Water Depth Of The River Recorded 2.8 ± 1 Meter. The Average Current Velocity Recorded Was 0.316 ± 0.276 Ms^{-1}. The 12th Station Of The Perai River (Downstream) Which Refers To Figure 7 (J) Shows A 65 Meter Width With An Average Depth Of 3.3 ± 2.6 Meters. The Average Current Velocity Was 0.402 ± 0.355 Ms^{-1}.

Table 4: Average Values Of Current, Depth And Width Of River During Normal Season

Station	Average Depth (M)	Average Velocity (M/S)	River Width (M)
S1	1.8 ± 0.4	0.347 ± 0.323	23
S2	0.9 ± 0.2	0.322 ± 0.313	29
S3	1.5 ± 0.5	0.327 ± 0.235	27
S4	0.9 ± 0.1	0.342 ± 0.288	39
S5	1.6 ± 0.6	0.297 ± 0.225	31
S6	2.3 ± 0.6	0.324 ± 0.228	26
S7	1.7 ± 0.3	0.365 ± 0.306	27
S8	1.2 ± 0.2	0.332 ± 0.214	36
S9	2.4 ± 0.6	0.221 ± 0.154	37
S10	2.5 ± 0.1	0.633 ± 0.48	65
S11	2.8 ± 1	0.316 ± 0.276	62
S12	3.3 ± 2.6	0.402 ± 0.355	65

Looking At A Rough Difference Involves The Form Of River And Cross-Section, It Can Be Noted That The River Becomes More In And Has A Higher Current Velocity In The After-Flood Season Than In The Normal Season.

C) Hydrological Data Results

I) River Discharge

The Calculation Was Done Using The Data Of The Current, Width And River Depth Value In Obtaining The Value Of The Carrying Rate And The Water Capacity Taken By The Two Rivers. The Discharge Rate Is The Amount Of Water That Passes A Cross Point Of The Article At Every Second (Gordon Et Al 2004). The Average Occupancy Rate At Kereh River Was 5.99 M^3s^{-1}, The Jarak River(19.57 $M^3s^{-1)}$ Kulim River (12.17 M^3s^{-1}) And Perai River (52.15 M^3s^{-1}) While The Normal Season Was 4.16 M3s -1 For Kereh River, 6.66 M3s -1 For The River Range, 5.81 $M^3s^{-1}$for Kulim River And 35.96 $M^3s^{-1}$for Perai River. The Value Difference For The Discharge And Average Of All Rivers According To The Season Is Shown In Table 5 And Figure 6.

Table 5 : Water Discharges Occurring By Place And Season

Station	Location	Discharge (M^3/S)	
		Post-Flood	Normal
S1	Kereh River (Upstream)	6.90	5.07
S2	Kereh River (Midstream)	4.74	2.75
S3	Kereh River (Downstream)	6.32	4.67
S4	Jarak River (Upstream)	34.04	4.21
S5	Jarak River (Midstream)	11.71	6.54
S6	Jarak River (Downstream)	12.97	9.24
S7	Kulim River (Upstream)	11.44	6.19
S8	Kulim River (Midstream)	4.99	5.02
S9	Kulim River (Downstream)	20.09	6.22
S10	Perai River (Upstream)	41.76	15.54
S11	Perai River (Midstream)	29.16	29.02
S12	Perai River (Downstream)	85.52	63.32

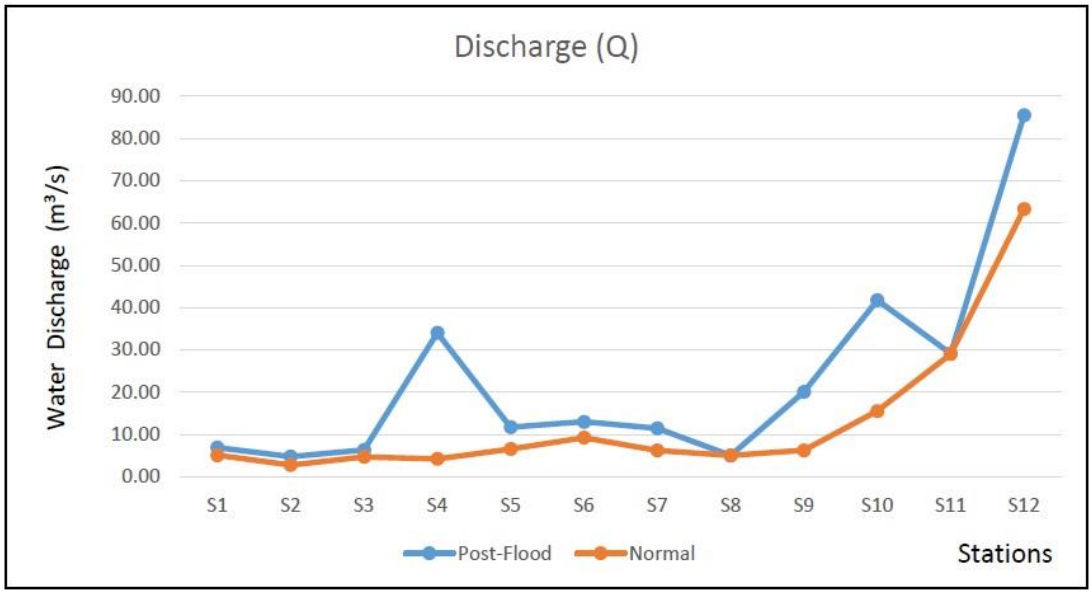


Figure 8: Water Discharge Values By Station And Season.

Based On Figure 8, The Value Of After Flood Is Higher For Almost All Stations Except Station 11 Only That Recorded The Same Readings As The Usual Season. This Is Likely Due To The Obstruction Of Abandoned Materials Or Rubbish Discarded Into The River. Station 11 Is Near The Resident's Settlement Area. This Is A Slight Extent Affecting The Current Velocity And Also Affects The Value Of Water Discharge.

Ii) Estimation Of Flood

A Sampling At Kereh River, The Jarak River, Kulim River And Perai River Could Not Be Made When The Bad Floods Hit Penang In September 2017 On Security. As Such, The Estimated Expression Was Made For All Four Rivers For The Season With An Estimated Water Level Of 5 Metres Per River Compared To A Normal Season. The Average Occupancy Rate For The Four Rivers Is Shown In Table 6 And Figure 8. From The Estimates Made, It Was Found That The River's Rate Of Expression Has Reached A Higher Level Compared To The Normal Season. The Average Occupancy Rate Of Kereh River Is 25.97 M^3s^{-1}, The Average Length Of Jarak River Is 61.74 M3s -1, Kulim River At 64.77 M^3s^{-1} And Perai River Of 146.13 M^3s^{-1}.

Table 6 : Estimated Water Discharge During Floods

Station	Location	Discharge (M^3/S)		
		Post-Flood	Normal	Flood
S1	Kereh River (Upstream)	6.90	5.07	21.76
S2	Kereh River (Midstream)	4.74	2.75	28.68
S3	Kereh River (Downstream)	6.32	4.67	27.46
S4	Jarak River (Upstream)	34.04	4.21	90.13
S5	Jarak River (Midstream)	11.71	6.54	49.76
S6	Jarak River (Downstream)	12.97	9.24	45.32
S7	Kulim River (Upstream)	11.44	6.19	48.62
S8	Kulim River (Midstream)	4.99	5.02	60.58
S9	Kulim River (Downstream)	20.09	6.22	85.12
S10	Perai River (Upstream)	41.76	15.54	130.44
S11	Perai River (Midstream)	29.16	29.02	86.67
S12	Perai River (Downstream)	85.52	63.32	221.28

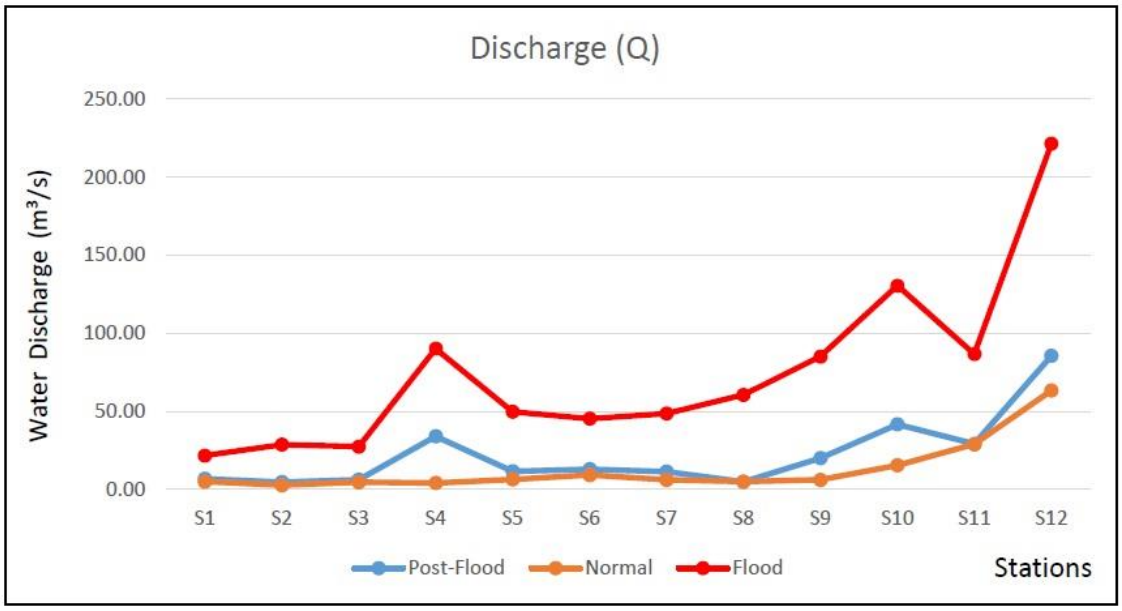


Figure 9 : Estimating Discharge Value In Flood

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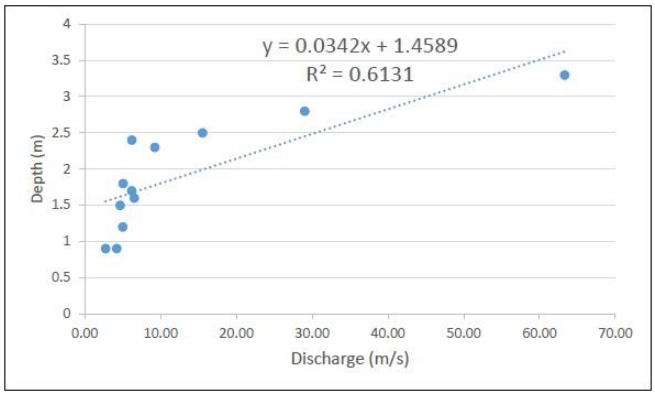
Based On Figure 9, All The Stations Have Been Added With The Probability Of Flooding, Which Increases The River Depth Of 5 Metres Per Station. Of This Diagram Is Found To Be The Value Of The Expression When Floods Occur Is High For All Stations During The Flood. This Situation Indicates That The Increase In Water Capacity Due To Heavy Rain Or Water Emissions In Upstream Will Cause The Flood. Authorities Should Immediately Take Appropriate Action So That The Impact Of The Flood Occurs, Especially The Property And Life Of The Population Is Only At A Minimal Level.

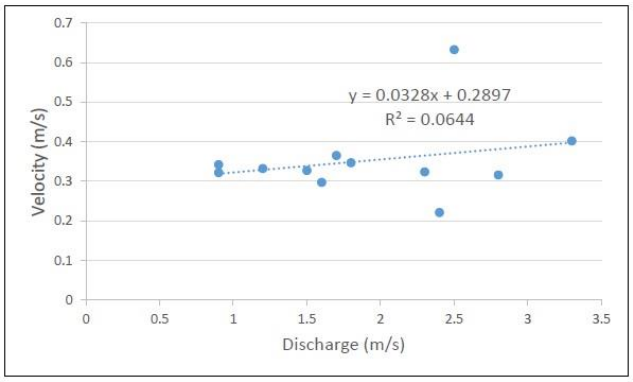
Iii) Statistical Analysis (Correlation)

Correlation Tests Were Performed To Determine Whether Changes In River Discharge Rates Were Influenced By The River Depth Values For Each Station. The Results Are As Shown In Figure 10. Based On Figure 10 (A), There Is A Significant Correlation (R2 = 0.6131) And This Shows That The Change In The Value Of The Water

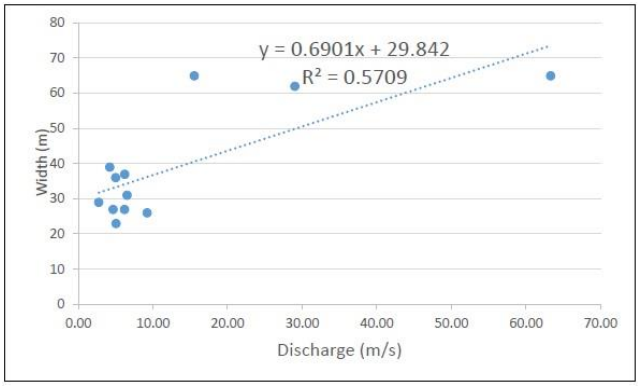
Discharge Rate Is Influenced By The Depth Value Of Each Station. The High Depth Of The River Led To The Increase In River Discharge Rate.



(a) Graph Of Depth And Water Discharge



(a) Graph Of Velocity And Water Discharge



(C) Graph Of Width And Water Discharge

Figure 10 : Graph Of Correlation

Correlation Tests Were Also Performed To Determine Whether The Outflow Rate Changes Were Influenced By The Velocity Values. Referring To Figure 10 (B), The Current Velocity Value Does Not Show A Significant Correlation (R2 = 0.0644) With The Flow Rate. This Indicates That The Flow Velocity Did Not Significantly Affect The Outflow Rate Compared To River Depth. Correlation Tests Between River Width And Water Runoff Rate (R2 = 0.5709) Showed That The Change In Runoff Value Was Also Slightly Influenced By River Width. Referring To Figure 10 (C), A Significant Correlation Exists Between The Discharge Rate And River Width. Therefore, A Wider River May Cause An Increase In The Value Of The Water Discharge Rate.

Conclusion

This Study Shows That The Rate Of Discharge Is Directly Proportional To The Depth Of The River. Depth Of The River Can Also Be Caused By Uncontrollable Variables Such As Rainfall. In Addition, The Occurrence Of Cliff Erosion, Sedimentation And Transport Of Sediment In The Water Can Also Cause The River To Become Shallow And Further Influence The Rate Of Erosion Which May Occur In The Event Of A Sudden Increase In Water. The Process Of Sedimentation Also Causes Rivers To Become Shallow Resulting In The Flood In The Estuary Of Drainage. Loads Of Sediment Load Policy Are Between 0.2 Mm To 2 Mm In Diameter, Depending On The Basic Structure Of The Rocks And Soil Around The Area (Razak Et Al., 2019; Hashim Et Al., 2001). The Sudden Increase In River Water Level Beyond The Maximum Capacity Of The River Can Result In Floods, Thereby Increasing The Risk And Impact Of Floods In Areas Near The River (Rohaizah Et.Al, 2012). The Area Most Affected By This Situation Is The Tasug Gelugor Area Because Of The Perai And Kereh River Located There. Perai River Is A River Located At The Head Of The Basin. In The Event Of High Tide And Heavy Rainfall, The Area In The Perai River Basin Will Experience Unforeseen Flood Events Again.

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References

1. Amran, N. H. M., Kamarudin, M. K. A., Wahab, N. A., Saad, M. H. M., & Jusoh, S. (2018). Environmental Management On Natural River Based On Water Quality Deterioration In Terengganu River Basin, Terengganu, Malaysia. *International Journal Of Engineering & Technology*, *7*(4.34), 132-136.
2. Azlan, A., Khoo, H. E., Idris, M. A., Amin, I., & Razman, M. R. (2012). Consumption Patterns And Perception On Intake Of Drinking Water In Klang Valley, Malaysia. *Pakistan Journal Of Nutrition*, *11*(6), 584.
3. Bruce, J. P., & Clark, R. H. (2013). *Introduction To Hydrometeorology: Pergamon International Library Of Science, Technology, Engineering And Social Studies*. Elsevier.
4. Chiras, D. D. (2004). *Environmental Science: Creating A Sustainable Future*. Jones & Bartlett Learning.
5. Field, C. B., Barros, V., Stocker, T. F., & Dahe, Q. (Eds.). (2012). *Managing The Risks Of Extreme Events And Disasters To Advance Climate Change Adaptation: Special Report Of The Intergovernmental Panel On Climate Change*. Cambridge University Press.
6. Grey, D., & Sadoff, C. W. (2007). Sink Or Swim? Water Security For Growth And Development. *Water Policy*, *9*(6), 545-571.
7. Hashim, N. M., Saad, J. M., Othman, N. F., Mei, W. K., & Rani, H.A. (2001). Kajian Angkutan Sedimen Dan Beban Dasar Sungai Di Lembangan Sungai Hijau Bukit Fraser. Pusat Pengurusan Penyelidikan Ukm, Malaysia.
8. Ismail, R. (1994). *Pengantar Hidrologi*. Dewan Bahasa Dan Pustaka.
9. Jamil, N. R., Toriman, M. E., Idris, M., & How, N. L. (2012). Analisis Ciri-Ciri Luahan Sungai Chini Dan Sungai Paya Merapuh Tasik Chini, Pahang Bagi Waktu Normal, Waktu Basah Dan Selepas Banjir. *E-Bangi*, *9*(1).
10. Jusoh, S., Kamarudin, M. K. A., Abd, N., Wahab, Saad, M. H. M., Rohizat, N. H., Nik Mat, N. H. (2018). Environmental Awareness Level Among University Students In Malaysia: A Review. *International Journal Of Engineering & Technology*, *7*(4.34), 28-32

11. Kamarudin, M. K. A., Muhammad, N.S., Saad, M. H. M., Abd, N., Wahab, (2019). Environmental Awareness Level Among University Students In Malaysia: A Review. *International Journal Of Engineering & Technology*, *7*(5s4), 509-511
12. Mohamed A., Rahim S.A., Aitman D.A., Kamarudin M.K.A. (2016). Analysis Of Seasonal Soil Organic Carbon Content At Bukit Jeriau Forest, Fraser Hill, Pahang. *Malaysian Journal Of Analytical Sciences*, *20*(2), 452-460.\
13. Mohd, E. T., Ata, F. M., Mohd, K., & Mushrifah, I. (2013). Bed-Load Sediment Profile And Effect Of River Bank Erosion On River Cross-Section. *American Journal Of Environmental Sciences*, *9*(4), 292-300.
14. Penang State Government (2019, July 1). *Penang Flood Hotspot Area.* Retrieved From Http://Www.Data.Gov.My/Data/Ms_My/Dataset?Organization=Penang-State-Government & Organization_Limit=0&Groups=Alam-Sekitar
15. Razak, N. A. E. M., Kamarudin, M. K. A., Wahab, N. A., Shakir, A., Saudi, M., Saad, M. H. M., ... & Amran, N. H. M. (2018). Water Resources Management Of Sedimentation Problems In Terengganu River Basin, Terengganu, Malaysia. *International Journal Of Engineering & Technology*, *7*(4.34), 14-20
16. Safarina, A. B., Karnisah, I., & Permana, A. S. (2019, June). Study Of The Effect Of River Basin Morphology Change On Threshold Parameters In Cimahi Flood Early Warning System. In *Iop Conference Series: Earth And Environmental Science* (Vol. 273, No. 1, P. 012013). Iop Publishing
17. Samanta, S. And Pal, B. (2012) Change Detection Of Channel Morphology Using Gis Technique. *International Journal Of Advances In Science And Technology 4*(2): 53-59
18. Saudi, A. S. M., Azid, A., Juahir, H., Toriman, M. E., Amran, M. A., Mustafa, A. D., ... & Saudi, M. M. (2015). Flood Risk Pattern Recognition Using Integrated Chemometric Method And Artificial Neural Network: A Case Study In The Johor River Basin. *Jurnal Teknologi*, *74*(1).
19. Spada, E., Sinagra, M., Tucciarelli, T., & Biondi, D. (2017). Unsteady State Water Level Analysis For Discharge Hydrograph Estimation In Rivers With Torrential Regime: The Case Study Of The February 2016 Flood Event In The Crati River, South Italy. *Water*, *9*(4), 288.
20. Sungip, F. N., Kamarudin, M. K. A., Saad, M. H. M., Abd, N., Wahab, A. P. M. S., Umar, R., & Harith, H. (2018). The Impact Of Monsoon Flood Phenomenon On Tourism Sector In Kelantan, Malaysia: A Review. *International Journal Of Engineering & Technology*, *7*(4.34), 37-40.
21. Toriman, M. E., Kamarudin, M. K. A., Sa, S. M., Idris, M. H., Jamil, N. R., & Gasim, M. B. (2009). Temporal Variability On Lowland River Sediment Properties And Yield. *American Journal Of Environmental Sciences*, *5*(5), 657-663.
22. Usgs Water Science School (N.D). *How Streamflow Is Measure.* Retrieve From Https://Www.Usgs.Gov/Special-Topic/Water-Science-School/Science/How-Streamflow-Measured?Qt-Science_Center_Objects=0#Qt-Science_Center_Objects.
23. Wahab, N. A., Kamarudin, M. K. A., Toriman, M. E., Juahir, H., Saad, M. H. M., Ata, F. M., ... & Hanafiah, M. M. (2019). Sedimentation And Water Quality Deterioration Problems At Terengganu River Basin, Terengganu, Malaysia. *Desalination And Water Treatment*, *149*, 228-241.
24. Zachar, D. (2011). *Soil Erosion*. New York: Elsevier Science Publishing Company
25. Zakaria, S., L. Jin And L. Iyer (2011). *Water Resources And Climate Change. Proceedings Of The National Conference On The Impact Of Climate Change On Water Resources And Their Consequences To Major Economic Sectors*, 25 July 2011, Ministry Of Natural Resources And Environment (Nre), Putrajaya, Malaysia. Isbn: 978-983-9445-86-2. Pp: 15-39.