Using Remote Sensing and Geographic Information System (GIS) for Peak Discharge Estimating in Catchment of Way Ratai, Pesawaran District, Lampung Province

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Abstract. The catchment of Way Ratai is located in District of Pesawaran, Lampung Province. In the period of the last twenty years, there has occurred three times of flood disasters (1986, 1996, and 2017) in this catchment. Flood in March 2017 gave big impact for the Way Ratai village with the inundation was 1.0 – 1.7 meters. This study aims to estimate runoff coefficient (C) and peak discharge (Qp) using remote sensing and geographic information system (GIS). The research methodology includes cook method to estimate C value, rational method to estimate Qpr, and manning method to measure actual Qpm in field. Landsat 8 OLI imagery, digital elevation model (DEM) of SRTM, and rainfall data of 2014 – 2016 are used for estimate C and Qpr. Qpm is obtained from measure in the field. Qpr is compared with Qpm to analyze potential of flood. The results of this research are the catchment of Way Ratai has C: 0.615, Qpr: 543.45 m3/s, and Qpm: 194.10 m3/s. Qpm show river flow capacity is 543.45 m3/s. Its value is greater than Qpr rational method. It shows that the catchment of Way Ratai has potential of flood.

1. Introduction
Catchment area is a land unit bounded by hills, where the rain that fell above this area received by the stream or river system and streamed through a single outlet channel [1]. Catchment area is a whole ecosystems and hydrological areas that have specific characteristics [2]. One of the characteristics of the catchment area has peak discharge values that can be used as indicator to determine the level of health of a system of river basin, catchment area planning, management, monitoring, evaluation, and to find out the potential of flooding in the catchment area [3].

Various techniques have been used to find out the value of peak discharge, either directly or indirectly [4]. Estimation of peak discharge indirectly can be done using remote sensing data and analysis of geographic information systems (GIS). Remote sensing as one technique to find out the characteristics of the catchment area by image data analysis and interpretation related to hydrological studies, especially in the estimation of peak discharge. Rational methods as one method to determine the value of peak discharge indirectly can be done using remote sensing data.
The rational method in determining peak discharge surface flow considering the time of concentration. Runoff in catchment area has reached disposal point and discharge the peak has been reached if rain fall has been going on during the time of concentration [5]. Concentration time is the time required by the water flowing in the ground from the furthest place in the catchment area to reach the exit point on the area. Rational methods assume the frequency of falling rain and surface flow is the same [6]. The Rational Method is an empirical relation between rainfall intensity and peak discharge flow, the runoff coefficient $C$ is a dimensionless empirical coefficient related to the abstractive and diffusive properties of the basin [7]. Rational methods better use in small catchment area, maximal 800 Ha [8].

Another factor that needs to be taken into account in estimating peak discharge using rational method is the value of surface runoff coefficient ($C$). It is defined as the ratio between the peak surface runoff against rain intensity. The main factors that affect the value of the surface runoff coefficient is the rate of infiltration of land, land cover, and the intensity of the rain. Prior to the determination of surface runoff coefficient ($C$), it is necessary to determine the interval of rainfall, the width of the catchment area, type of land use, topography, and the soil properties [6]. Values of surface runoff coefficient can be estimated either by using the cook.

Estimation of discharge with rational method only as describing the discharge peaks in a catchment area in case of maximum intensity at a given time interval, but that value has not been able to describe the capacity of the major rivers accommodating water [9]. The capacity of the River in the catchment area can being estimated by performing a measurement on the field, one of them by using manning methods. The capacity of the river illustrates the culmination of a peak discharge flow of the main stream, where that value as the threshold to determine a peak discharge can cause flooding or not [10]. The manning method estimates the peak discharge value without having to use flow discharge data, but rather by identifying peak flood marks to find out the main river crossings, hydraulic gradients, and channel roughness factors [11].

Recently, a new technique based on the integration of Remote Sensing (RS) and Geographic Information Systems (GIS) has been developed [12]. Remote sensing can used to identify parameters affecting peak discharge such as rainfall, surface runoff coefficient, and broad basin areas, while GIS serves to assist the process of analysis and processing of peak discharge data [8].

This study aims to compare the results of the estimation of peak discharge using remote sensing and geographic information systems with rational methods and measurement results of peak discharge in the field by the method of manning. The results of the comparison of the value of peak discharge from both methods can be used to find out the potential of flooding in the area of study as well as knowing the level of the health catchment area system with surface runoff coefficient values analysis.

2. Material and Method

2.1. Study Site

This research was conducted in catchment area of Way Ratai, Pesawaran District, Lampung Province. Geographically catchment area of Way Ratai is located at position 05°25'12,294" – 05°39'45,064" south and 104°59'53,322" – 105°15'59,444" east. It has an area of 197.074251 km$^2$. It is a tropical region with an average rainfall of 158.4 mm/month with a wind speed of 2 knots in 2014 and it has a minimum average air temperature of 23.08°C, the average temperature air maximum 32.84°C, average air temperature of 26.83°C, with an average relative air humidity of 81.19%. The average number of rainy days in the Way Ratai catchment is 12.1 days/month. The Way Ratai catchment has a varied topography, ranging from lowland to highland areas, some of which are hilly to mountainous areas with varying heights of sea level. The elevation class found is about 500 to 600 meters above sea level. Based on the slope, it is about >40%. It appears that the Way Ratai catchment has a characteristic rounded basin shape resembling a bowl shape. This indicates that the potential for surface runoff accumulation in the main river with short distances. The analysis results show that the total length of the main river is calculated using tools in ArcGIS and get the value of 27.84 km, while the average length of the main river in each channel of 0.73 km.
Figure 1. Study site in Way Ratai catchment area

2.2. Data Collecting

2.2.1. SRTM Imagery. SRTM imagery is obtained from the website usgs.glovis.gov is used to determine the topographical condition of the study area. This imagery is selected as the basic data making slope because the ability of radar that can penetrate the vegetation, so that the height data obtained from this image is the actual surface height of the soil [13]. SRTM image is derived into slope and shape information. A land distribution map was used to estimate texture conditions and soil infiltration in the study area. The SRTM image has a spatial resolution of 30 m.

2.2.2. Landsat-8 OLI/TIRS Imagery. The Landsat 8 OLI image is obtained from the usgs.glovis.gov website with 123 rows 64 path recording date June 16, 2015. Landsat 8 OLI imagery is used to obtain land cover information by visual interpretation. Land cover information is used to estimate the percentage of vegetation of each type of land cover [11].

2.2.3. Rainfall Data. Rainfall data from 2014 to 2016 is obtained from the Meteorology, Climatology and Geophysics Agency of Lampung Province. This data is used to analysis the meteorological condition of the study area and determine the intensity value of the design rain in estimating the peak discharge value in the rational method [14].

2.2.4. Field Survey. Field measurement data is measurement of peak discharge by manning method [9]. This data is used to determine the value of the main river capacity in the study area and compare with the estimation data of peak discharge indirectly using the rational method so that it can be known the potential of flood in the study area [15]. The variables measured in the field include the cross-sectional area of the river, the value of the hydraulic radius, the river hydraulic gradient, and the estimated roughness of the river surface.

2.3. SRTM Imagery Slope
The SRTM image is transformed into slope. SRTM image transformation to slope is using ArcGIS 10.3 software. Slope classification is divided into 4 classes i.e. 0-5%, 5-10%, 10% -30% and >30%. The size of the slope pixel follows the SRTM image size of 30 m. slope inclination information is used to determine the effect of surface flow factors.

2.4. Landsat-8 OLI/TIRS Pre-processing
The aim of pre-processing data to make pixel value in ideal condition so that it can be used for both visual and mathematical analysis [16]. Landsat-8 OLI/TIRS images should be performed radiometric calibration and atmospheric correction. The raw image value calibrated pixel value or digital number (DN) of the multispectral sensor must be converted into Top of Atmosphere (TOA) reflectance.

\[ L\lambda (\text{Landsat} - 8) = (ML \ast Qcal) + AL \]  

Where \( L\lambda \) is the TOA spectral radiance (Watts/(m²*srad*µm)), \( ML \) is the band-specific multiplication factor rescaling from metadata, \( AL \) is the band-specific additive rescaling factor from metadata, and \( Qcal \) is the the value of standard pixel products quantized and calibrated (DN) [17]. From TOA spectral radiance, then converted to TOA reflected value

The image processed into required atmospheric correction to the level of at-sensor reflectance. Atmospheric correction of Landsat-8 OLI/TIRS image using histogram adjustment. The histogram evaluated is a histogram of reflected values on the sensor in the form of fractional numbers [18]. The method used in histogram adjustment is dark subtraction [19].

Radiometric corrected satellite imagery is done geometric correction process to improve geometric position accuracy and reduce distortion of earth curvature effect [18]. The first thing to do is to determine the GCP (Ground Control Points) and then done the process of geometric correction. This control point is an object visible to the image as well as visible on the reference map used in geometric correction. This control point can be an object visible to the image as well as seen on the reference map used in geometric correction, such as crossing between rivers and road or crossroads and some other objects clearly visible in the image and reference map [20]. The reference map in this study is a map of the Geospatial Information Agency with a projection of the WGS 1984 Transverse Mercator 49M with a UTM grid. The points taken as much as five points for each image with RMS less than 0.5.

2.5. Maximum Likelihood Classification
The Landsat-8 OLI image is classified as land cover using maximum likelihood algorithm. Maximum likelihood algorithm using base probability calculation or homogeneous object will always display normal distributed histogram [18]. Pixels are described as objects through the shape, size and orientation of samples in feature space [21]. Detailed maximum likelihood algorithm procedure can be found in [11]. The number of land cover classes is divided into 8 classes, namely forest, built-up land, bare land, mangrove forest, plantation, irrigated paddy field, shrubs and sea. This land cover classification uses 200 samples per class of land cover.

2.6. Data Analysis
2.6.1. Flow Surface Coefficient (C). The flow surface coefficient (C) is a number that shows the ratio of the surface flow to the amount of rainfall. Mathematically, the value of C is formulated in equation (2) which refers to the Cook method [22]. C is an indicator showing the physical condition of a catchment area. It has number ranges from 0 to 1. The larger the value of C or near 1 then the more rainfall that becomes the flow of the surface or the amount of water infiltrated less. A large C value indicates a significant probability of erosion. Associated with the level of watershed health, the greater the value of C or more than 0.5 indicates an unhealthy catchment area.

\[ \text{Flow coefficient (C)} = \frac{\text{surface flow (mm)}}{\text{rainfall (mm)}} \]  

Surface flow coefficient values were obtained using slope parameters, infiltration, vegetation percentage, and flow score. The technique used in calculating the C value is quantitative modelling (overlay) with GIS. The result of modelling is the value of flow coefficient in each unit of land.
Scoring results of each parameter then summed to get the total score. To determine the value of C per unit of land, the total score of each unit of land is multiplied by the weighting factor of each unit of land. The weighting factor is obtained by equation (3). The value of C DAS is the total of the total C of each unit of land. Table 1. – 4. shows some parameters and its score [23].

Weight factor per unit of land = Area of Land / Width of catchment

\[ \text{Area of Land} / \text{Width of catchment} \]

Table 1. Slope parameter

| Slope class | Relief configuration | Score |
|-------------|----------------------|-------|
| 0 – 5 %     | Flat                 | 10    |
| 5 – 10%     | Wavy                 | 20    |
| 10 – 30%    | Hills                | 30    |
| >30%        | Rugged and Crude     | 40    |

Table 2. Infiltration parameter

| Infiltration | Terrain characteristic | Score |
|--------------|------------------------|-------|
| Fast         | Sand in or other land that can absorb faster | 5     |
| Medium       | Deep clay with infiltration approximately setipe with prairie ground | 10    |
| Slow         | Clay / other soils with low infiltration capacity | 15    |
| Very slow (ignored) | No effective ground cover, thin, ground layer | 20    |

Table 3. Land Cover parameter

| Land cover | Score |
|------------|-------|
| Approximately 90% covered either by wood | 5     |
| Approximately 50% covered both by trees and grasses | 10    |
| Crop cover little, no crops and natural cover little | 15    |
| No effective cover or similar | 20    |

Table 4. Flow Density parameter

| Class | Flow density (mil/mil2) | Score |
|-------|-------------------------|-------|
| High  | >5                      | 5     |
| Normal| 2 – 5                   | 10    |
| Low   | 1 – 2                   | 15    |
| Ignored | <1                    | 20    |

2.6.2. Rational Method Peak Discharge. Estimate the peak discharge by rational method using the following equation.

\[ Q_p = 0.278 \times C \times I \times A \]

where \( Q_p \): peak discharge (m³/s), \( A \): area of river basin (km²), \( I \): maximum rain intensity for the same time concentration (mm/h), \( C \): surface flow coefficient, and 0.278: coefficient.

Rain intensity values are obtained through the following equation.

\[ I = \frac{R}{24} \times \left( \frac{24}{T_c} \right)^{0.67} \]

where \( I \): intensity of rain plan during concentration time (mm/h), \( R \): daily rain plan (mm), \( T_c \): concentration time (hours).

The rain calculation plan uses the Log Pearson Type III technique with the following equation.

\[ \log P_{r} = R + KS \]

where \( P_r \): rain plan with return period \( T_r \), \( R \): average rainfall based on population sample, \( K \): frequency factor, \( S \): standard deviation.

Calculation time of concentration using equation as follows.
\[ Tc = \frac{L}{V} \]  (7)

Where \( L \): long river main river basin (m), \( V \): \( 72 \times (H \times L) \) 0.6 with \( H \) being the height difference of the watershed (m).

### 2.6.3. Manning Method Peak Discharge

\[ Q_p = \frac{1}{n} \times A \times R^{2/3} \times S^{1/2} \]  (8)

where \( Q_p \): peak discharge (m\(^3\)/s), \( n \): roughness coefficient of river channel surface, \( A \): sectional area of the river on the former flood (m), \( R \): hydraulic radius (m), \( S \): hydraulic gradient.

The value of the hydraulic radius is obtained by the following equation.

\[ R = \frac{A}{P} \]  (9)

where \( A \): sectional area of the river on the former flood (m\(^2\)), \( P \): wet perimeter (m)

The value of the hydraulic gradient is obtained by the following equation.

\[ S = \frac{H}{L} \]  (10)

where \( H \): height difference of river surface (m), \( L \): length of measurement (m)

The coarse coefficient value is obtained by equation (9). The amount of coefficient value based on field observation with value determination is shown in Table 5. [10].

\[ n = (n_0 + n_1 + n_2 + n_3 + n_4) m^5 \]  (11)

where \( n \): value of the roughness of the channel, \( n_0 \): basic material, \( n_1 \): level of channel uniformity, \( n_2 \): cross section variation of channels, \( n_3 \): effect of narrowing on transverse sections, \( n_4 \): plants, and \( n_5 \): level of meander.

#### Table 5. Manning Roughness Coefficient

| Channel condition | Characteristic       | \( n \)   | Coefficient |
|-------------------|----------------------|----------|-------------|
| Basic material    | Soil                 | \( n_0 \) | 0.02        |
|                   | Rock                 |          | 0.024       |
|                   | Smooth gravel        |          | 0.025       |
|                   | Rough gravel         |          | 0.028       |
| Channel uniformity| Smooth               | \( n_1 \) | 0           |
|                   | Low smooth           |          | 0.005       |
|                   | Medium               |          | 0.01        |
|                   | Coarse               |          | 0.02        |
| Cross sectional variation | Very slow | \( n_2 \) | 0           |
|                   | Slow                 |          | 0.005       |
|                   | Medium               |          |             |
|                   | Fast                 |          | 0.01 – 0.015|
| Effect of narrowing | Ignored        | \( n_3 \) | 0           |
|                   | Low influence        |          | 0.01 – 0.015|
|                   | Medium influence     |          | 0.02 – 0.03 |
|                   | High influence       |          | 0.04 – 0.06 |
| Plants            | Low                  | \( n_4 \) | 0.0005 – 0.01|
|                   | Medium               |          | 0.01 – 0.025|
|                   | High                 |          | 0.025 – 0.05|
|                   | Very high            |          | 0.05 – 0.1  |
| Meander           | Low                  | \( n_5 \) | 1           |
|                   | Medium               |          | 1.15        |
|                   | High                 |          | 1.3         |

#### 3. Result and Discussion

##### 3.1. Flow Surface Parameters
There are four parameters considered in determining the runoff coefficient using Cook method of slope, soil texture, land cover, and drainage density. Figure 2d. Represents slope information in Way Ratai catchment area. It appears that the study area has a gradient of slope that varies with the dominance of slope >10%. There is a difference in the value of the slope between the flat area and the surrounding area. The flat area or lowest slope (0 - 5%) is located in the main stream to the downstream. A firm slope divergence indicates that surface runoff will accumulate rapidly in the region with the lowest slope.

Figure 2. Way Ratai catchment (a) stream order, (b) drainage density, (c) land cover, (d) slope, (e) soil texture and (f) polygon thiessen map. These six parameters for flow surface coefficient variable using Cook method.
The slope conditions of the Way Ratai catchment are influenced by the landform formed by volcanic and fluvial processes. The northern and western regions of the Way Ratai catchment have a slope of >30%. This is due to the inactive volcanoes of Mount Ratai in the northern part of Way Ratai catchment and the volcanic hills degraded in the western part of Way Ratai catchment. The central region of Way Ratai catchment has a slope of 0-5%. This is due to the presence of alluvial plains that are the main stream of Way Ratai. Based on Figure 2d, the direction of the Way Ratai stream flows leads to the eastern part of the catchment due to the lower slopes in the eastern part of the catchment.

Based on Figure 2d, the drainage density of Way Ratai catchment is influenced by the slope characteristic. It is shown that the steeper the slope will be the higher the drainage density. The northern and western part of the Way Ratai catchment has a high drainage density level proportional to the slope level, while the middle of the Way Ratai catchment has low drainage density with sloping slopes.

Based on Figure 2e, the soil texture in the north, west and south of Way Ratai catchment is dominated by very rough soil texture. This is due to the formation of depressed volcanic hills and volcanic mountains and steep slopes. The soil texture in the middle of the Way Ratai River catchment is dominated by a fine and very fine soil texture. The texture of the soil is very fine and fine it is in the landform of alluvial plains and flat slope. Figure 2e. shows the closer to the main river Way Ratai then the texture of the soil will be finer. This geomorphological process has influenced the soil texture characteristics of Way Ratai stream by contrast.

Distribution information of relatively soil texture obtained by considering the parameters of landform and slope. There are four relatively soil texture classes that are soft, coarse, and very coarse. Based on Figure 3. Way Ratai catchment area is dominated by relatively coarse texture - very coarse. There is an area with a fine texture is a region with a relatively flat. The relative texture value of the soil is reduced to the information of the soil infiltration rate. The assumption is built that the more coarse soil texture the higher the infiltration rate, the more fine the texture of the soil the lower the infiltration rate. Referring to the relatively soil texture distribution in Figure 2e. Then most Way Ratai catchment area have high infiltration rates - very high, while low infiltration rates are present in areas of low slope and fine texture.

Land cover that has a high density vegetation presentation in the form of timber will have an impact on low surface runoff. Land cover classes that have low surface runoff impacts are plantations and forests except for mangrove forests due to flooded areas, while land cover that has a high impact of surface runoff i.e. bare land, irrigated paddy fields and built-up land. The absorption capacity of the surface flow to the cover is influenced by the presence of vegetation which can absorb the surface flow so that no surface runoff will occur.

Figure 4. Represents conditions of Way Ratai catchment area dominated by land cover of plantation. The northern region of the Way Ratai Catchment area has bush cover and forest cover. This shrub cover is located on the lower slopes and the slopes of Mount Pesawaran. The southern region of Way Ratai catchment area has a land cover that is plantation and built up area. The central region of the Way Ratai Catchment area consists of built-up land, irrigated paddy fields and bare land. The built up area in the middle of the Way Ratai Catchment area follows the main stream of Way Ratai. There is a mangrove forest in the eastern part of the vast Way Ratai catchment area. This mangrove forest is located in the upstream of Way Ratai Catchment area or in the form of alluvial coastal plains.

Based on Figure 2c. the area with the land cover has a high impact of surface runoff i.e. the middle of Way Ratai catchment. In the middle of Way Ratai catchment there is built-up land, bare land and irrigated paddy fields which are potential for surface runoff, while the northern and western part of Way Ratai catchment is plantation and forest so there is no potential for surface runoff.

Drainage density is used as one of the determinants of the runoff coefficient Cook method. Drainage density is obtained by comparing the length of the stream in each unit of land with the area of the land. Assumption of this measurements is more dense that drainage, the area is considered to have a high runoff. Units of high density are considered high if their drainage density is above 5 mil/mil² so that it is given a score of 20, whereas for units of land whose drainage density below 1
mile/mil² is considered to have very low value and given a score of 5. In units of land with normal drainage density values of 2-5 mil/mil² are given a score of 15 and that have a low value of 1-2 miles/mil² given a score of 10.

Drainage density in the study area has a very diverse value. In the area around Way Ratai tends to have high drainage density value, it is caused by the number of tributaries that go to Way Ratai. Visually the study area is dominated by normal drainage density classes in the range 2-5 mil/mil². The total area of this class is 99.490419 km² while the total area of study is 197.074246 km² or almost half of it is an area with normal drainage density. Based on this it can be assessed if the Way Ratai catchment area has a normally tended surface flow, only a few areas of high or low drainage density.

3.2. Flow Surface Coefficient (C)

The runoff coefficient of the cook method obtained based on the above input parameters shows a considerable result that is 61.5% or 0.615. The value indicates that 61.5% of the water falling in the study area is likely to become a runoff. The above runoff coefficient indirectly expresses the characteristic of the Way Ratai Catchment area which tends to show that falling rainwater will form a surface stream compared to infiltrate into ground water. If analysis based on four input parameters, slope parameter is analysis as the most influential parameter to high runoff coefficient value. This is in accordance with the prediction because the study area is surrounded by hills and has a high slope of the slope it will produce a high surface flow.

![Figure 3. Way Ratai catchment flow surface coefficient map](image)

The coefficient of runoff in each unit of land is in the range 0 to 5.174%. Based on its distribution, units of land with high flow coefficient values or in the range of values of 2.11 - 5.174% are located on the part of Pesawaran Mount and structural hills on the west and south sides of the study area. Compared to slope gradient maps in areas where high flow coefficient values lie in high slope classes, this further strengthens the assumption that high slope gradients are the reason for the large surface runoff coefficients.
Figure 3. shows that the middle section is dominated by a moderate to low-grade runoff coefficient class, due either to a low slope or in grades 0 to 10%. When compared to other parameters, in the middle of the catchment area basically has a high score or influence on large surface flows. For example, in infiltration parameters dominated by moderate to very low infiltration rates, as well as land cover parameters dominated by open-field and built up area that are considered to have no effective vegetation cover or the like, increasing the likelihood of surface runoff. However, with a small slope inclination, the movement of the water tends to be slow and ultimately remains infiltrated, although other parameters show a large impact on the formation of surface flow.

3.3. Rational and Manning Method Peak Discharge

The result of runoff coefficient value with the Cook method is 0.615 (Table 6). C values greater than 0.5 indicate that catchment area conditions in the study area already have high surface flow potential. A value of 0.615 indicates that 61.5% of water derived from rainfall flows in the form of a runoff. This means that the amount of water absorbed into the soil is less than the amount of water that becomes runoff. Judging from the level of catchment area, the value of coefficient 0.615 indicates the existence of damage catchment area management. The result of the analysis shows that the slope parameter has a considerable influence on the value of C obtained. This is characterized by a rounded catchment area shape such as a bowl with a fairly firm slope between the downstream with the center and the upstream. The High slope enough to cause rain water quickly to be runoff than infiltrated. The watershed-like watershed condition results in accumulated rapid water downstream or the lowest slope.

| C   | I (mm/hour) | A (km²) | Qp (m³/s) |
|-----|-------------|---------|-----------|
| 0.615 | 58.06      | 197.07  | 543.45    |

(Source: Data Processing, 2017)

The peak discharge measurements with rational method resulted in values of 543.45 m³/s and Manning method of 194.10 m³/s. The peak discharge value of the Manning method signifies the value of the stream capacity in holding water. The result of measuring the value of stream capacity is smaller than the peak discharge of the rational method. Higher peak discharge of the stream capacity indicates that the study area has potential flooding. Based on the results of field observations, there have been floods in other areas of study in March 2017. This indicates that there is alignment between the results of flood potential analysis using remote sensing with actual flood events. Based on interviews, the flood that occurred in 2017 was influenced by the increasingly shallow stream conditions. The silting of the river causes the river capacity to decrease, so as to reduce the potential for flooding, one of the efforts that can be done is to rehabilitate the river by dredging the river sediment material to increase the river capacity.

4. Conclusion

The Way Ratai catchment area has a surface coefficient of 0.615 which indicates the condition of the Way Ratai Catchment area is unhealthy. Based on four parameters used, slope parameter is the most influential parameter to high surface coefficient value. The coefficient of surface flow in each unit of land is in the range 0 - 5,174%. The peak discharge measurements with rational method resulted in values of 543.45 m³/s and Manning method of 194.10 m³/s. The result of the measurement of stream
capacity value is smaller than the peak discharge of rational method result. Higher peak discharge of the stream capacity indicates that the study area has potential flooding.

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