



## Analysis Of Drainage Channel Capacity On Prof. M. Yamin Street In Pontianak

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### Abstract

Surface runoff results from precipitation that is not absorbed or infiltrated into the soil due to water-saturated soil conditions. If left uncontrolled, surface runoff can cause puddles or flooding that may disrupt human activities and the environment. In this study, the research site was located on Prof. M. Yamin Street in the city of Pontianak. In the current study, Prof. M. Yamin Street in Pontianak already has a drainage system; however, the performance of this drainage system's capacity needs to be analyzed. The method used to analyze the performance of the drainage system on Prof. M. Yamin Street involves comparing the existing drainage capacity against the surface runoff discharge resulting from the average daily maximum rainfall using the rational method and hydraulic analysis. In the analysis of the drainage system on Prof. M. Yamin Street, the drainage system's capacity is no longer sufficient to accommodate the surface runoff flow rate of 1.1691 m<sup>3</sup>/s, therefore, it is necessary to modify the dimensions of the drainage channels using hydraulic analysis with a width (B) of 1.4 meters, a channel depth (H) of 0.557 meters, and a channel bank height (W) of 0.528 meters on both sides of Prof. M. Yamin Street.

**Keywords:** Rainfall, Drainage, Surface Runoff.

### Abstrak

Limpasan aliran permukaan merupakan akibat presipitasi yang tidak terserap atau terinfiltrasi ke dalam tanah akibat kondisi tanah yang sudah jenuh air. Limpasan aliran permukaan bila tidak dikendalikan dapat menyebabkan genangan atau banjir yang dapat mengganggu aktifitas kehidupan manusia dan lingkungan. Dalam penelitian ini lokasi penelitian yang dilakukan berada di jalan Prof M Yamin kota Pontianak. Dalam penelitian yang dilakukan saat ini Jalan Prof. M. Yamin kota Pontianak sudah memiliki sistem saluran drainase, namun perlu dianalisis kinerja kapasitas saluran drainase tersebut. Metode yang digunakan dalam menganalisis kinerja kapasitas saluran drainase di Jl. Prof. M. Yamin dengan membandingkan kapasitas saluran drainase yang ada terhadap debit limpasan aliran permukaan akibat curah hujan maksimum harian rata-rata dengan menggunakan metode rasional dan analisis hidrolika. Dalam analisis saluran drainase di jalan Prof. M. Yamin kapasitas saluran drainase tidak lagi menampung debit hujan akibat limpasan permukaan sebesar 1,1691 m<sup>3</sup>/detik, sehingga perlu dilakukan perubahan dimensi saluran drainase dengan menggunakan analisis hidrolika dengan lebar (B) sebesar 1,4 meter, kedalaman saluran (H) 0,557 meter dan tinggi jagaan saluran (W) 0,528 meter di kedua sisi jalan Prof. M. Yamin.

**Kata kunci:** Curah Hujan, Drainase, Limpasan Aliran Permukaan

### INTRODUCTION

A drainage system is a structure designed to remove excess surface water. This excess surface water can consist of wastewater from residential areas as well as surface runoff caused by precipitation that is no longer

absorbed by the soil. For this reason, every residential area in this case, urban areas needs to have a proper drainage system. The purpose of a region having a good drainage system is to manage excess surface water in that area so that it does not pool and cause flooding, which can disrupt human activities and the environment.

Prof. M. Yamin Street in Pontianak is the main road connecting the city of Pontianak and Kubu Raya Regency, and serves as the economic hub for the people of Pontianak. During the rainy season, the area along Prof. M. Yamin Street in Pontianak often experiences flooding due to rainwater runoff. This is because the current drainage system along Prof. M. Yamin Street in Pontianak is not yet optimal. The capacity of the existing drainage channels in the area is insufficient to handle surface runoff during heavy rainfall. Consequently, this leads to flooding that can disrupt human activities in the area, affecting both residents and people passing through. Therefore, an analysis and evaluation of the drainage system in this area are necessary to determine the optimal storage capacity of the drainage channels.

## METHOD

In this study, the research method consists of several stages, which are as follows::

- a. Preparation Phase
- b. Survey and Data Collection Phase
- c. Pre-Analysis Data Processing Phase
- d. Analysis and Evaluation Phase
- e. Problem-Solving Phase

Prof. M. Yamin Street is a city road that connects various service centers within the city of Pontianak. To evaluate the drainage channels in this area, primary data collected directly at the study site is required. The data collected directly at the study site includes road width, drainage channel dimensions, and the size of the watershed. (catchment area).



Figure 1. Primary Data Collection at Prof. M. Yamin Street

The data for the location on Prof. M. Yamin Street is as follows:

- a. The length of Prof. M. Yamin Road is 2,500 meters
- b. The width of the roadway on Prof. M. Yamin Road is 13 meters

- c. The width of the shoulder on Prof. M. Yamin Road toward Kota Baru is 1.4 meters
- d. The width of the shoulder on Prof. M. Yamin Road toward Sutan Syahrir is 2.9 meters
- e. The road surface material on Prof. M. Yamin Road is asphalt
- f. The width of the drainage channel on Prof. M. Yamin Road toward Kota Baru is 0.5 meters
- g. The width of the drainage channel on Prof. M. Yamin Road toward Sutan Syahrir is 1.91 meters
- h. The depth of the drainage channel on Prof. M. Yamin Road toward Sutan Syahrir is 1 meters.
- i. The depth of the drainage channel on Prof. M. Yamin Road toward Kota Baru is 0.5 meters.

In evaluating the drainage channels in the area, secondary data is required to support this study. The secondary data used includes annual daily rainfall data from 2015 to 2024 obtained from the Pontianak Meteorology, Climatology, and Geophysics Agency (BMKG), location sketches obtained from Google Earth, and relevant literature such as SNI 03-3424-1994 regarding Procedures for Planning Road Surface Drainage. The location sketch on Prof. M. Yamin Street is as follows:



Figure 2. Research Map of Prof. M. Yamin Road

## RESULT AND DISCUSSION

### 1. Hydrological Analysis

When evaluating a drainage channel, a hydrological analysis must be conducted. To perform this analysis, data on the maximum annual daily rainfall in the area is required. In this study, rainfall data was obtained from the Indonesian Agency for Meteorology, Climatology, and Geophysics (BMKG) in Pontianak, specifically from the Pontianak City Maritime Rainfall Station. The rainfall data

spans a 10-year period, specifically from 2015 to 2024. The purpose of the hydrological analysis is to estimate the design rainfall depth (XT) based on the return period (T), which is determined using the maximum daily rainfall recorded over the 10-year period. The data was first sorted from the largest to the smallest values. After the rainfall data was sorted from largest to smallest, it was analyzed using frequency distribution analysis. The frequency distribution analysis of the annual maximum rainfall data in Pontianak is shown in the table below:

Table 1. Frequency Distribution Analysis Using the Normal Method

Standard Deviation (Sx)	55,4721151
Skewness Coefficient (Cs)	0,351
Coefficient Sharpness (Ck)	3,681

Source : Calculation Data

Table 2. Frequency Distribution Analysis Using the Logarithmic Method

Standard Deviation (Sx)	0,16598
Skewness Coefficient (Cs)	-0,294
Coefficient Sharpness (Ck)	3,144

Source : Calculation Data

Based on the normal and log-normal distribution tables above, the following conclusions can be drawn :

Table 3. Results of the Frequency Distribution Analysis: Normal and Logarithmic Methods

Methods	Calculation Results	Requirements	Result
Normal	Cs = 0,351	Cs = 0	Fail
	Ck = 3,681	Ck = 3	Fail
Log Normal	Cs = -0,294	Cs = 0	Fail
	Ck = 3,144	Ck = 3	Fail
Gumbel	Cs = 0,351	Cs ≤ 1,139	Ok

	Ck = 3,681	Ck ≤ 5,402	Ok
Log Person III	Cs = -0,294	Cs = 0-9	Fail

Source : Calculation Data

Therefore, based on the table above, the Gumbel method was used to calculate the return period because the values of Cs and Ck satisfy.

## 2. Renewal Period Criteria

The recurrence interval criterion for the evaluation of drainage channels along Prof. M. Yamin Road in Pontianak is 10 years. This is because the area along Prof. M. Yamin Road is an arterial road connecting various districts within the city of Pontianak. This recurrence interval is determined based on land type/land use. The calculation of the recurrence interval begins by determining the frequency factor ( $K_{T10}$ ) using the following formula :

$$K_{T10} = \frac{Y_{Tr} - Y_n}{S_n}$$

With  $Y_{Tr} = 2,2504$  ,  $Y_n = 0,4952$  and  $S_n = 0,9496$

$$K_{T10} = \frac{Y_{Tr} - Y_n}{S_n} = \frac{2,2504 - 0,4952}{0,9496} = 1,8483$$

After obtaining the frequency factor values, the 10-year return period rainfall amounts were calculated. The 10-year return period rainfall amounts are as follows :

$$\begin{aligned} X_{T10} &= \bar{x} + (K_{T10} \cdot S_x) \\ &= 152,6 + (1,8484 \cdot 55,4721) \\ &= 255,1322 \text{ mm} \end{aligned}$$

With a 10-year return period, the maximum rainfall is 255.1322 mm.

## 3. Calculating the Concentration Time (Tc)

The calculation of the concentration time (Tc) involves the following steps:

a. Determining the roughness value of the Nd material in each flow zone.

- Road width (asphalt) (I1) = 13 meters  
Nd = 0,013 (cement and asphalt concrete layers)

S = 3 % (paved)

Width of the Prof. M. Yamin-Sutan

Syahrir Road (I2 ) = 2,9 meters

- Road width on Prof. M. Yamin Street-Kota Baru (I3) = 1,4 meters

Nd = 0,013 (cement and asphalt concrete

layers)

S = 4 % (soil)

b. Determining the value of T1

$$T_1 = \left[ \frac{2}{3} \cdot 3,28 \cdot L_0 \cdot \frac{N_d}{\sqrt{s}} \right]^{0,167}$$

therefore,

$$- T_{\text{Road agency}} = \left[ \frac{2}{3} \cdot 3,28 \cdot 13 \cdot \frac{0,013}{\sqrt{0,03}} \right]^{0,167} = 1,135 \text{ minutes}$$

$$- T_{\text{Road Shoulder 1}} = \left[ \frac{2}{3} \cdot 3,28 \cdot 2,9 \cdot \frac{0,013}{\sqrt{0,04}} \right]^{0,167} = 0,862 \text{ minutes}$$

$$- T_{\text{Road Shoulder 2}} = \left[ \frac{2}{3} \cdot 3,28 \cdot 1,4 \cdot \frac{0,013}{\sqrt{0,04}} \right]^{0,167} = 0,764 \text{ minutes}$$

$$\begin{aligned} \text{So the total } T_1 &= T_{\text{Road Agency}} + T_{\text{Road Shoulder}} \\ &= 1,135 + 0,862 + 0,764 \\ &= 2,761 \text{ minutes} \end{aligned}$$

c. Determining the value of T2

To determine T2, the following equation is used:  $T_2 = \frac{L_s}{60 \cdot V_{\text{permission}}}$

Where,

Ls = Length of Drainage Channel = 2500 meters

Vpermission = Permissible flow rate = 1,5 m/s (concrete or asphalt)

$$T_2 = \frac{2500}{60 \cdot 1,5} = 27,778 \text{ minutes}$$

So, the concentration time,

$$T_2 = T_1 + T_2$$

$$T_c = 2,761 + 27,778 = 30,539 \text{ minutes} = 0,509 \text{ hours}$$

Based on the above calculation, the duration of rainwater runoff across the watershed from the highest point to the lowest point is 30.539 minutes, or 0.509 hours.

4 Calculation of Rainfall Intensity (I)

The calculation of rainfall intensity (I) uses the Mononobe method. The data used for analysis in this calculation are:

R = Maximum daily rainfall over a 24-hour period ( $R_{24}$ ) =  $X_{T10}$  = 255,1322 mm

Tc = Duration of concentration = 0,509 hours

Therefore,

$$\begin{aligned} I &= \frac{R_{24}}{24} \times \left( \frac{24}{T_c} \right)^{2/3} \\ &= \frac{255,1322}{24} \times \left( \frac{24}{0,509} \right)^{2/3} = 138,745 \text{ mm/hours} \end{aligned}$$

5. Calculation of the Flow Coefficient (C)

The calculation of the flow coefficient (C) involves the following steps:

a. Determine the value of the flow coefficient (C) according to the table showing the relationship between soil surface conditions and the flow coefficient, given that:

- Road Agency (Asphalt) =  $l_1$ , Koefisien  $C_1 = 0,70$

- Road Shoulder 1 (Concrete) Prof. M Yamin- Sutan Syahrir =  $l_2$ , Koefisien  $C_2 = 0,70$

- Road Shoulder 2 (Concrete ) Prof. M Yamin- Kota Baru =  $l_3$ , Koefisien  $C_2 = 0,70$

b. Determining the drainage area (A)

Based on the data on the width and length of the roadway and shoulders, the drainage area is calculated as follows:

$$\text{Road Agency } (A_1) = 32500 \text{ m}^2$$

$$\text{Road Shoulder } (A_2) = 7250 \text{ m}^2$$

$$\text{Road Shoulder } (A_3) = 3500 \text{ m}^2$$

c. Determining the average flow coefficient (average C)

$$\begin{aligned} C &= \frac{C_1 \cdot A_1 + C_2 \cdot A_2 + C_3 \cdot A_3}{A_1 + A_2 + A_3} \\ &= \frac{(0,70 \cdot 32500) + (0,7 \cdot 7250) + (0,70 \cdot 3500)}{32500 + 7250 + 3500} \\ &= \frac{30275}{43250} \\ C &= 0,7 \end{aligned}$$

Based on the existing conditions described above, the average runoff coefficient (C) was determined to be 0.7, which means that the average runoff rate is 70%.

The rational method was used to calculate the runoff discharge in the drainage channel on Prof. M. Yamin Street. The data to be used are as follows:

Average runoff coefficient (C) = 0,7

Rainfall intensity (I) = 138,745 mm/jam

Drainage area (A1) = 23500  $m^2$  = 0,0235  $km^2$

Drainage area (A2) = 19750  $m^2$  = 0,0198  $km^2$

Total Drainage Area (A) = 43250  $m^2$  = 0,0433  $km^2$

Therefore, the runoff discharge value is

$$Q_r \text{ Prof. M. Yamin} = 0,278 \cdot C \cdot I \cdot A$$

$$= 0,278 \cdot 0,7 \cdot 138,745 \cdot 0,0433$$

$$= 1,1691 \text{ m}^3/\text{s}$$

Based on the results of the hydrological analysis, the design runoff discharge for the existing channel was determined to be 1,1691  $m^3/s$  for the Prof. M. Yamin road drainage channel, with a 10-year return period.

6. Duct Dimension Calculation

The drainage channels on Prof. M. Yamin Street in Pontianak consist of two channels used to collect rainwater. The current dimensions of the channel are 1.91 meters wide and 1 meter deep for the drainage channel running from Prof. M. Yamin Street toward Sutan Syahrir Street. The drainage channel on the section of Prof. M. Yamin Street heading toward Kota Baru has dimensions of 0.5 meters in width and 0.5 meters in depth. The purpose of calculating these drainage channel dimensions is to determine whether the existing drainage channel's storage capacity remains optimal or not. The data required for calculating the drainage channel dimensions on Purnama 1 Street are as follows:

- Design runoff discharge ( $Q_r$ ) = 1.1691 m<sup>3</sup>/s
- Width of the existing Prof. M. Yamin – Sutan Syahrir channel ( $b_1$ ) = 1.9 meters
- Depth of the existing Prof. M. Yamin – Sutan Syahrir channel ( $y_1$ ) = 1 meter
- Width of the existing Prof. M. Yamin – Kota Baru channel ( $b_2$ ) = 0.5 meters
- Depth of the existing Prof. M. Yamin – Kota Baru channel ( $y_2$ ) = 0.5 meters
- Flow velocity in Vijin concrete = 1.5 m/s
- Manning roughness coefficient ( $n$ ) = 0.013

The dimensions of a drainage channel can be calculated using the following steps:

- Determining the cross-sectional area, hydraulic radius, and flow rate of the existing drainage channel for Prof. M. Yamin–Sutan Syahrir Road..

$$\begin{aligned} A &= b \times y \\ A &= 1,9 \times 1 \\ A &= 1,9 \text{ m}^2 \\ P &= 2b + 2y \\ &= 2 \cdot 1,9 + 2 \cdot 1 \\ &= 5,8 \text{ m} \\ R &= \frac{A}{P} \\ &= \frac{1,9}{5,8} = 0,328 \text{ m} \end{aligned}$$

Once the channel cross-sectional area (A), wet perimeter (P), and hydraulic radius (R) have been determined, the flow rate of the existing channel cross-section in the Prof. M. Yamin–Sutan Syahrir Road drainage channel, using a design flow velocity of 1.5 m/s, is calculated as follows:

$$\begin{aligned} Q (\text{eksisting}) &= A \times V \\ &= 1,9 \times 1,5 \\ &= 2,85 \text{ m}^3/\text{s} \end{aligned}$$

Based on the above calculations, the existing flow rate of the drainage channel along Prof.

M. Yamin Street to Sutan Syahrir Street is 2.85 m<sup>3</sup>/s. Determining the cross-sectional area, perimeter, hydraulic radius, and flow rate of the existing drainage channel for Prof. M. Yamin–Kota Baru Road..

$$\begin{aligned} A &= b \times y \\ A &= 0,5 \times 0,5 \\ A &= 0,25 \text{ m}^2 \\ P &= 2b + 2y \\ &= 2 \cdot 0,5 + 2 \cdot 0,5 \\ &= 2 \text{ m} \\ R &= \frac{A}{P} \\ &= \frac{0,25}{2} = 0,125 \text{ m} \end{aligned}$$

Once the channel cross-sectional area (A), wet perimeter (P), and hydraulic radius (R) have been determined, the flow rate of the existing channel cross-section in the Prof. M. Yamin–Kota Baru drainage channel, using a design flow velocity of 1.5 m/s, is calculated as follows:

$$\begin{aligned} Q (\text{eksisting}) &= A \times V \\ &= 0,25 \times 1,5 \\ &= 0,375 \text{ m}^3/\text{s} \end{aligned}$$

Based on the above calculation, the existing flow rate of the drainage channel on Prof. M. Yamin Street to Kota Baru is 0.375 m<sup>3</sup>/s.

Calculating the dimensions of drainage channels based on the design rainfall runoff rate. The calculation of drainage channel dimensions based on the design rainfall runoff rate is as follows:

- Determining the capacity of the drainage channel from Jl. Prof. M. Yamin to Sutan Syahrir

$$\begin{aligned} Q_r &= V_1 A_1 \\ 1,1691 &= 1,5 \cdot A_1 \\ A_1 &= \frac{1,1691}{1,5} = 0,7794 \text{ m}^2 \end{aligned}$$

The best hydraulic cross-section, in the form of a square, is used, with the following calculations:  $A_1 = h \times B$ , where B refers to the existing width of the drainage channel along Jl. Pro. M. Yamin to Sutan Syahrir, which is 1.9 meters

$$\begin{aligned} A_1 &= h \times 1,9 \\ 0,7794 &= h \times 1,9 \\ h &= \frac{0,7794}{1,9} \\ h &= 0,41 \text{ m} \\ h &= 0,41 \text{ m dan } B = 1,9 \text{ m} \end{aligned}$$

Based on the calculations, the dimensions of the drainage channel for the road from Prof. M. Yamin to Sutan Syahrir are as follows: width (B) = 1.9 m and depth (h) = 4.1 m, with: a

design flow velocity of 1.5 m/s and a channel slope of 3%.

b. Determining the Capacity of the Drainage Channel on Jl. Prof. M. Yamin to Kota Baru

$$Q_r = V \cdot A_2$$

$$11,691 = 1,5 \cdot A_2$$

$$A_2 = \frac{1,1691}{1,5} = 0,7794 \text{ m}^2$$

The best hydraulic cross-section, in a square shape, is used, with the following calculations:  $A = h \times B$ , where B refers to the existing width of the drainage channel along Jl. Pro. M. Yamin to Kota Baru, which is 0.5 meters

$$A_2 = h \times 0,5$$

$$0,7794 = h \times 0,5$$

$$h = \frac{0,7794}{0,5}$$

$$h = 1,558 \text{ m}$$

$$h_2 = 1,558 \text{ m dan } B_2 = 0,5 \text{ m}$$

Based on the calculations, the dimensions of the drainage channel for the road from Prof. M. Yamin to Sutan Syahrir are as follows: width (B) = 0.5 m and depth (h) = 1.558 m, with a design flow velocity of 1.5 m/s and a channel slope of 3%.

Optimal Design of the Drainage Channel for Prof. M. Yamin Road, Based on the calculation of drainage channel dimensions using the design runoff rate (Q) of 1.1691 m<sup>3</sup>/s, the optimal dimensions for the drainage channel on Prof. M. Yamin-Sutan Syahrir Road—which has a rectangular cross-section—are a width (B) of 1.9 m and a depth (h1) of 0.41 m. Meanwhile, for the Prof. M. Yamin-Kota Baru Road drainage channel, which is square in shape, the width (B) is 0.5 meters and the depth (h2) is 1.558 meters. These dimensions align with the existing width of the drainage channel. Therefore, a re-calculation of the drainage channel dimensions on-site is necessary. Based on data collected on-site, the road shoulder width on both sides of the road is 4.3 meters, with the Prof. M. Yamin–Sutan Syahrir road shoulder being 2.9 meters and the Prof. M. Yamin–Kota Baru road shoulder being 1.4 meters. If the existing road shoulders are utilized, we can calculate the optimal drainage channel by constructing a road drainage channel that follows the width of the narrowest road shoulder. The narrowest road shoulder is located on the Prof. M. Yamin-Kota Baru road, with a width of 1.4 meters. Therefore, if we use a road shoulder width of 1.4 meters as the width of the drainage channel to be calculated, the optimal drainage channel with a specified

flow velocity of 1.5 m/s is as follows:

7. Determining the dimensions of the drainage channel for Prof. M. Yamin Road

$$Q_r = A \cdot V$$

$$1,1691 = A \cdot 1,5$$

$$A = 1,1691/1,5$$

$$= 0,7794 \text{ m}^2$$

By using a square-shaped drainage channel cross-section made of reinforced concrete, the following dimensions for the channel's width and depth are obtained:

$$A \text{ persegi} = b \cdot h$$

$$0,7794 = b \times h$$

$$0,7794 = 1,4 \times h$$

$$h = 0,557 \text{ meters}$$

Based on the measured depth of the drainage channel, the freeboard (w) for the drainage channel on Prof. M. Yamin Road must be calculated as follows:

$$W = \sqrt{0,5 \cdot h}$$

$$W = \sqrt{0,5 \cdot 0,557}$$

$$W = 0,528 \text{ meters}$$

Based on the above calculations, the optimal drainage channels on both sides of Prof. M. Yamin Road to handle stormwater runoff are as follows:

Table 4. Summary of calculation results and optimal drainage channel dimensions on Prof. M. Yamin Street

Q <sub>r</sub> (Runoff Discharge)	1,1691 m <sup>3</sup> /s
A square (Cross-sectional area of a square channel)	0,7794 m <sup>2</sup>
B (channel width)	1,4 meters
H (channel depth)	0,557 meters
W (Channel head height)	0,528 meters

The cross-sectional diagram of the drainage channel on Prof. M. Yamin Street is as follows:

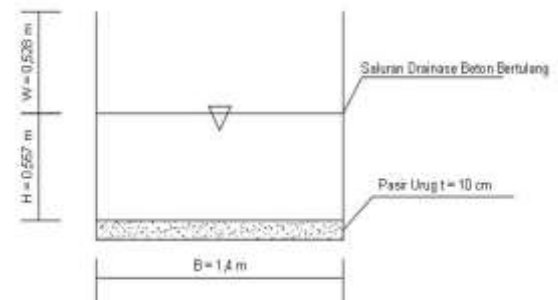


Figure 3. Optimal Cross-Section of the Drainage Channel on Prof. M. Yamin Street

## CONCLUSION

Based on the research conducted, it can be concluded that the existing drainage channels are no longer capable of effectively accommodating surface runoff resulting from maximum daily rainfall. This is particularly true for the road drainage channels from the direction of Prof. M. Yamin – Kota Baru. In a hydrological analysis based on a 10-year return period for maximum daily rainfall, a runoff discharge of 1.1691 m<sup>3</sup>/s was determined, whereas the runoff discharge from daily rainfall that can be accommodated by the existing drainage channels on the Prof. M. Yamin - Sutan Syahrir and Prof. M. Yamin–Kota Baru are 2.85 m<sup>3</sup>/s and 0.375 m<sup>3</sup>/s, respectively. Therefore, the dimensions of the existing drainage channels must be modified so that they can accommodate the maximum daily rainfall runoff. The optimal channel dimensions are square-shaped, with the drainage channel dimensions for Prof. M. Yamin - Sutan Syahrir - Kota Baru streets are a width (B) of 1.4 meters, a depth (h) of 0.557 meters, a freeboard (W) of 0.528 meters, and a channel slope of 3%. The design velocity is 1.5 m/s.

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