# Study Of Drainage Analysis As Flood Control In Setia Budi Area Medan City

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**Abstract.** The Setia Budi area in Medan city has drainage that is not functioning properly. Where the drainage conditions are no longer able to act as a reservoir for rainfall and runoff in the area. This is caused by the cross section of the channel that has been damaged and irregular, the amount of garbage and the lack of maintenance on the drainage in the area. This condition is the trigger for flooding in the Setia Budi area of Medan City. Given the large number of losses caused by flooding, it is necessary to plan for flood management in the Setia Budi area of Medan, especially Murni street, Perjuangan street and Abadi street. Drainage analysis can be done to determine the capacity and condition of the drainage itself. Primary drainage analyzed along 2.5 Km and 1.2 Km secondary drainage. This analysis aims to determine the ability of the drainage to accommodate and drain and dispose of water from catchment areas along primary and secondary drainage during high rainfall. The analysis was carried out using the Log Person type III distribution method. Based on the results of the hydrological analysis and distribution test, the maximum rainfall intensity (I) is 17.705 mm/hour, the maximum planned flood discharge (Q) is 6.983 $m^3/s$ and the Concentration Time (tc) is 0.79 hours. These results are input into the HEC-RAS 4.1.0 application to obtain a flow simulation.

**Keywords:** Drainage, Flood, Medan City

## 1 Introduction

The phenomenon of flooding is a natural phenomenon that usually occurs in an area that is unable to accommodate maximum rainfall and runoff. In simple terms, flooding is an excess of water in an area that can cause the surface of the area to be inundated by water [1]. Usually floods are caused by a poor drainage system, maximum rainfall and the disobedience of the community around the area in disposing of waste, as well as ignorance of drainage conditions. Drainage generally has a function as a water structure that is used to accommodate, drain and dispose of excess water from an area or land [2]. So the drainage itself is an infrastructure engineering that is made for the purpose of dealing with runoff and flooding.

Medan city, especially the Setia Budi area on Murni street, Perjuangan street and Abadi street often has runoff and even floods that cause paralysis of activities in the area. Floods that occur are not due to extreme natural factors but are other factors such as: diminishing water catchment areas due to an increase in population growth, inappropriate spatial planning, inadequate and unattended drainage facilities, and poor environmental conditions. dirty with garbage. This flood often occurs repeatedly, and there is no special treatment. So for further handling, it is necessary to begin with a drainage analysis in the Medan City Faithful Area.

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## 2 Research Method

The location of the analysis study is the loyal area of Medan City (Murni Street, Perjuangan Street and Abadi Street) Medan Sunggal District. The total area of Medan Sunggal area is 1,316 Ha. With an inundation area of 1.46 km² = 146 Ha. primary data in the form of : (1) Topographic map (length and slope) of the Setia Budi area of Medan City, (2) Picture of the condition of the drainage area (DAS) in the primary drainage and secondary drainage in the Setia Budi area of Medan City. While the secondary data in this study is the maximum monthly and daily rainfall data. This data was obtained from the Meteorology, Climatology and Geophysics Agency (BMKG) Sampali Medan. The data used is data for the last 10 years, namely 2012 - 2021 [3].

Planned rainfall analysis is a rainfall analysis used to obtain the annual rainfall height for the planned year (n year). which will be used to obtain the design flood discharge. This data is obtained from the rain station. To get the price of area rainfall can be calculated using the average/algebraic method.

In this study, the planned flood discharge (Q) is also calculated based on the rain discharge. This is obtained based on an empirical formula by looking at rainfall data from the BMKG according to the area being reviewed and then determining the return period for the plan for the side ditch of the drainage network channel. The method used is the rational method, namely to determine the runoff discharge caused by rainfall which is generally a basis for planning drainage channel discharge [4]. The rational method is as follows:

Q = 0.00278.C.I.A

Where

Q is Debit ($m^3$/debit) ,

A is the area of the drainage area (Ha),

I is Rainfall intensity (mm/hour)

C is the flow coefficient.

Rainfall intensity is the amount of rainfall in a certain time unit, generally mm/hour for short-term rainfall, and the amount of rainfall intensity depends on the duration of rainfall. The method used in this analytical study in determining the intensity of rainfall is the Dr. Method [5]. Mononobe with the equation:

$$I = \frac{R}{24}\ x\ \left[\frac{24}{t_c}\right]^{2/3}$$

Where:

I = rainfall intensity (mm/hour)

tc = duration of rainfall (minutes)

R_24 = rainfall that may occur based on a certain return period (maximum rainfall in 24 hours - mm).

The results of the analytical studies obtained are input into the HEC-RAS (Hydraulic Engineering Center-River Analysis System) application which is used to support the results of the analysis studies, namely for one-dimensional steady and unsteady one-dimensional flow model.

## 3 Results and Discussion

### 3.1 Maximum Daily Rainfall

Table 1 is the maximum daily rainfall data from 2012-2021 obtained from BMKG Sampali.

**Table 1**. Maximum Daily Rainfall

| Year | Maximum Daily Rainfall (mm) |
|---|---|
| 2012 | 36 |
| 2013 | 41.4 |
| 2014 | 38.4 |
| 2015 | 47 |
| 2016 | 57.8 |
| 2017 | 40.3 |
| 2018 | 42.5 |
| 2019 | 45.1 |
| 2020 | 36.2 |
| 2021 | 42.2 |
| n = 10 year | 426.9 |

### 3.2 Frequency Analysis

Frequency analysis is a procedure for estimating the frequency of an event in the past or in the future. This procedure can be used to determine the design rain in various return periods based on the theoretical rainfall distribution with the empirical rainfall distribution. This design rain is used to determine the intensity of rain needed to estimate the peak flow rate (flood discharge). Table 2 and Table 3 are tables that provide information about frequency analysis.

**Table 2.** Analysis of the frequency distribution of Gumbel

| Year | Xi | X | Xi-X | (Xi-X)^2 | (Xi-X)^3 | (Xi-X)^4 |
|---|---|---|---|---|---|---|
| 2012 | 36 | 42,69 | -6,69 | 44,756 | -299,418 | 2003,108 |
| 2032 | 41,4 | 42,69 | -1,29 | 1,664 | -2,146 | 2,769 |
| 2014 | 38,4 | 42,69 | -4,29 | 18,404 | -78,953 | 338,710 |
| 2015 | 47 | 42,69 | 4,31 | 18,576 | 80,062 | 345,071 |
| 2016 | 57,8 | 42,69 | 15,11 | 228,312 | 3449,795 | 52126,415 |
| 2017 | 40,3 | 42,69 | -2,39 | 5,712 | -13,651 | 32,628 |
| 2018 | 42,5 | 42,69 | -0,19 | 0,036 | -0,006 | 0,001 |
| 2019 | 45,1 | 42,69 | 2,41 | 5,808 | 13,997 | 33,734 |
| 2020 | 36,2 | 42,69 | -6,49 | 42,120 | -273,359 | 1774,102 |
| 2021 | 42,2 | 42,69 | -0,49 | 0,240 | -0,117 | 0,057 |
| Σ = 10 | 426,9 | | | 365,629 | 2876,201 | 56656,599 |

**Table 3**. Frequency analysis for log normal distribution and log Pearson III

| year | Xi | Yi =Log Xi | LogYi-LogY | (LogYi-LogY)^2 | (LogYi-LogY)^3 | (LogYi-Log Y)^4 |
|---|---|---|---|---|---|---|
| 2012 | 36 | 1,556302501 | -0,01912137 | 0,00036563 | -0,00000699 | 0,0000001337 |
| 2032 | 41,4 | 1,617000341 | -0,00250527 | 0,00000628 | -0,00000002 | 0,0000000000 |
| 2014 | 38,4 | 1,584331224 | -0,01136940 | 0,00012926 | -0,00000147 | 0,0000000167 |
| 2015 | 47 | 1,672097858 | 0,01204631 | 0,00014511 | 0,00000175 | 0,0000000211 |
| 2016 | 57,8 | 1,761927838 | 0,03477273 | 0,00120914 | 0,00004205 | 0,0000014620 |
| 2017 | 40,3 | 1,605305046 | -0,00565781 | 0,00003201 | -0,00000018 | 0,0000000010 |
| 2018 | 42,5 | 1,62838893 | 0,00054276 | 0,00000029 | 0,00000000 | 0,0000000000 |
| 2019 | 45,1 | 1,654176542 | 0,00736647 | 0,00005426 | 0,00000040 | 0,0000000029 |
| 2020 | 36,2 | 1,558708571 | -0,01845046 | 0,00034042 | -0,00000628 | 0,0000001159 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2021 | 42,2 | 1,625312451 | -0,00027852 | 0,00000008 | 0,00000000 | 0,0000000000 |
| Σ=10 year | 426,9 | 16,2635513 | | 0,00228249 | 0,00002925 | 0,0000017534 |

### 3.3 Rainfall Distribution

There are several methods to obtain the rainfall distribution which are shown in table 4. And the Log person III method is the choice for this analytical study.

**Table 4**. Selection of Rainfall Distribution

| Type | Criteria | Result | Note |
|---|---|---|---|
| Normal | Cs = 0<br>Ck = 3 | Cs =1,542<br>Ck = 3,432 | |
| Log Normal | Cs= 3 Cv+Cv$^3$ = 0.2773<br>Ck = $C_v 8 + 6C_{v^6} + 15C_{v^4} + 16C_{v^2} + 3$ = 3.7676<br>Ck=Cv$^8$+6Cv$^6$+15Cv$^4$+16Cv$^2$+3= 3.8745 | CS= 1,006<br>CK= 2,726 | |
| Gumbel | Cs= 1,14<br>Ck= 5,4 | CS= 1,542<br>CK= 3,432 | |
| Log pearson Type III | Cs≠ 0 | CS= 1,006 | chosen |

Based on the normal scale rain data parameters, the estimated value of the distribution according to a certain rainfall is obtained. The distribution chosen in this study is the Log Pearson Type III method.

### 3.4 Rainfall Intensity and Planned Flow

With Dr. Method. Mononobe obtained the value of rainfall intensity. The intensity of rainfall for the return period of 2, 5 and 10 years is shown in table 5.

**Table 5**. Intensity of Rainfall During the Repeat Period

| Priode | R24 (mm) | C | tc (h) | I (mm/h) |
|---|---|---|---|---|
| 2 | 42,057 | 0,95 | 1,087 | 13,802 |
| 5 | 43,626 | 0,95 | 1,087 | 14,317 |
| 10 | 44,622 | 0,95 | 1,087 | 14,644 |

Debit plans in this study using the rational method, the results of the calculation of return periods of 2, 5 and 10 years are in table 6:

**Table 6.** Debit of Planned Repeat Period

| No | Periode | L (Km) | C | tc (h) | I (mm/h) | A (Ha) | Q ($m^3$/s) |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 3,78 | 0,95 | 1,087 | 13,802 | 146 | 5,322 |
| 2 | 5 | 3,78 | 0,95 | 1,087 | 14,317 | 146 | 5,520 |
| 3 | 10 | 3,78 | 0,95 | 1,087 | 14,644 | 146 | 5,646 |

### 3.5 Channel Capacity

The following table 7 is a sketch of the dimensions of the primary and secondary channels.

**Table 7**. Dimensions of primary and secondary channels

| Drainage | Channel Size | | | | channel length (m) | Channel Existing Condition |
|---|---|---|---|---|---|---|
| | T (m) | B (m) | H (m) | m (m) | | |
| primary | 5 | 3 | 1,2 | 1 | 3780 | Cemented Crushed Stone |
| secondary | 1 | 0,5 | 1 | 0,25 | 1700 | Cemented Crushed Stone |

**Table 8**. Comparison of Design Q and Q Primary Drainage Channels

| Drainage | Q existing channel | Q design | | | Note |
|---|---|---|---|---|---|
| | | 2 year | 5 year | 10 year | |
| primary | 17,188 $m^3/s$ | 5,322 $m^3/s$ | 5,520 $m^3/s$ | 5,646 $m^3/s$ | Safe for 2 and 5 years, and for 10 year |
| secondary | 1,317 $m^3/s$ | 8,022 $m^3/s$ | 8,322 $m^3/s$ | 8,512 $m^3/s$ | Not Safe for 2 and 5 years, and for 10 |

**3.6 HEC - RAS**

The calculation results obtained from the analysis are input to the Hec-RAS application and the cross section of the primary and secondary channels is obtained (Figure 2 and Figure 3). The results obtained from HEC – RAS in the form of a water level profile are shown in the following pictures:

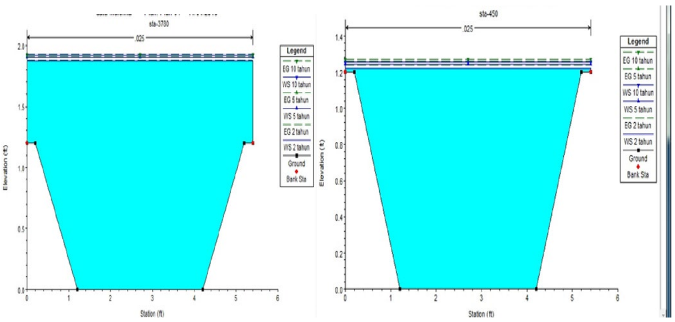

**Figure 1**. Cross Section Of Primary Drainage Channel

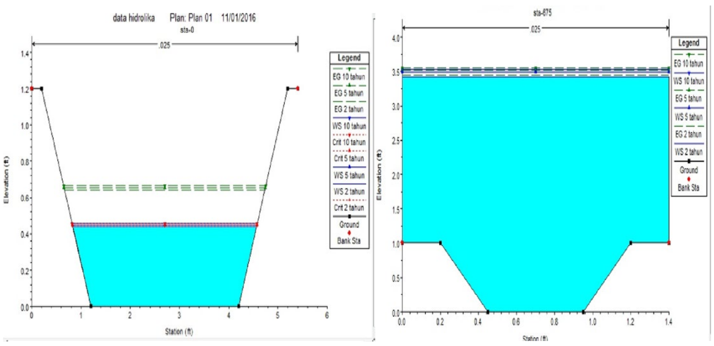

Figure 3. Cross Section Of Secondary Drainage

## 4 Conclussions

The results of the analysis concluded that:

1) Lack of primary drainage treatment causes high sedimentation, irregular drainage forms, and blockage of garbage so that the primary drainage can no longer accommodate the design flood discharge for 2, 5, to 10 year return periods.
2) Lack of capacity for secondary drainage channels causes drainage to be unable to accommodate the design flood discharge for 2, 5 and 10 year return periods, so it is necessary to widen the drainage capacity.
3) The problems that arise in the primary drainage and secondary drainage are the causes that lead to the overflow of water on Murni Street, Perjuangan Street and Abadi Street - Medan City and caused flooding.

## References


[1] Hadihardjaja. (1997). *Urban Drainage*. Yogyakarta: UII Press

[2] Standar Nasional Indonesia. (1990). *General Planning Procedures for Urban Drainage*. Jakarta.

[3] Soemarto, C.D. (1999). *Hidrologi Teknik* . Jakarta : Erlangga

[4] Rumilla, H. Kemala, J., Bambang, H. (2018). Flood Discharge Analysis with Nakayasu Method Using Combination of HEC-RAS Method on Deli River in Medan City. *Journal of Physics: Conference Series*, Volume 970, doi:10.1088/1742-6596/970/1/012011

[5] Rumilla, H. Kemala, J., Sarra, R. (2020). Flood mitigation in drainage system. *UISU National Engineering Seminar (SEMNASTEK).*