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# Evaluation of Kartini V Street Canal Capacity using HEC-RAS

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## ABSTRACT

The Kartini V Street channel in Central Jakarta plays a vital role in directing the flow of water to the main channel on Kartini Raya Street through the Kartini Pump House, thus effectively addressing water pooling issues in the Kartini neighborhood area. Evaluation of the capacity of the Kartini V Street channel is carried out by comparing the planned rainfall discharge with the existing channel discharge. Hydrological analysis calculations for the planned discharge with a 5-year return period yield planned discharges of 0.0214 m3/second for channel A-B, 0.0068 m3/second for channel B-C, and 0.0226 m3/second for channel B-D. Meanwhile, calculations for the existing channel discharge result in 6.9756 m3/second for channel A-B, 9.3690 m3/second for channel B-C, and 12.0398 m3/second for channel B-D. The analysis indicates that the existing channel capacity is sufficient to accommodate the planned rainfall discharge.

**Keywords:** water; the Kartini Vroad; rainfall; drainage; HEC-RAS.

## INTRODUCTION

Kartini is one of the urban villages in Sawah Besar sub-district, Central Jakarta Administrative City, with postal code 10750. Since 2009, Kartini has been an area prone to flooding. One of the channels that has an important role in the drainage system in the area is the channel on Kartini V Street.

Puddles of water still often occur in the area around the Kartini Pump House if the intensity of rain is quite high, but this condition can be immediately resolved with the existence of the Kartini Pump House which helps channel water to the main channel or river on Jalan Kartini Raya from the channel on Jalan Kartini V.

Drainage functions to control waterlogging to prevent flooding that may arise due to increased surface flow (Rizqiawati, 2018). A good drainage system in a residential area functions to reduce excess water discharge after rain so that it does not cause waterlogging.

Urban drainage management must include various stages. It is also necessary to increase understanding of the drainage system for all parties involved, on an ongoing basis. (Putri & Prawati, 2023).

The aim of this research is to evaluate the channel capacity by comparing the planned rain discharge and the existing channel discharge to find out whether the channel at the research location is able to accommodate the incoming rain discharge.

Drainage channels play a crucial role in managing the flow of water across a landscape, preventing flooding, soil erosion, and waterlogging. The capacity of these channels determines how effectively they can handle runoff, especially during heavy rainfall or storms. This capacity is influenced by a combination of factors, including the size, shape, slope, and surface characteristics of the channel, as well as the volume and speed of water entering the system. (Arif EJ et.al, 2024; Haslinda H et.al, 2024). A fundamental concept that illustrates drainage capacity is that of carrying capacity, which refers to the maximum amount of water a channel can convey without overflowing. This is dictated by the cross-sectional area of the channel and the velocity of the flowing water. Wider and deeper channels typically have higher capacities, but their effectiveness also depends on the gradient of the terrain. Steeper slopes allow water to move faster, increasing the potential for the channel to transport more water, while flatter areas slow the flow, potentially reducing capacity and increasing the risk of overflow during peak discharge periods (Barid B, Ichsan SW, 2024; Adi HP et.al, 2023).

Surface roughness is another important element that affects the capacity of drainage channels. Channels lined with vegetation, rocks, or other obstructions experience greater friction, which slows down the water and reduces overall flow capacity. In contrast, smoother surfaces, such as concrete-lined channels, facilitate faster water movement, enhancing the channel's ability to handle larger volumes. This interplay between surface texture and flow rate is critical in designing drainage systems for urban and rural areas, where land use and topography differ significantly. (Amalia N et.al, 2023; Immamuddin M, Priyo AWD, 2023). The design of drainage channels must also account for the frequency and intensity of rainfall in a given area. In regions prone to heavy storms, channels need to be designed with a higher capacity to accommodate sudden surges in water volume. This often involves the use of reinforced structures or multiple parallel channels that work together to distribute the load. Conversely, in areas with more moderate rainfall, smaller channels may suffice. However, the unpredictability of climate patterns necessitates a degree of flexibility in design, ensuring that channels can handle occasional extreme weather events without failing (Nurul HS, Kendimansyah M, 2023).

Drainage channel capacity is not static and can change over time due to sedimentation, vegetation growth, and debris accumulation. As materials build up within the channel, the effective cross-sectional area is reduced, limiting the amount of water that can pass through. Regular maintenance, such as dredging and clearing, is essential to preserve the intended capacity and prevent blockages that could lead to flooding. In urban environments, drainage channels often integrate with broader stormwater management systems that include retention ponds, culverts, and underground pipes. These interconnected systems help distribute water more evenly across different areas, reducing the pressure on individual channels. The efficiency of the entire network hinges on the capacity of each component, making it vital to assess and upgrade drainage infrastructure as cities grow and land use patterns evolve (BaridB et.al, 2022; Immamuddin MI, Larasati L, 2021).

Ultimately, the capacity of drainage channels reflects a balance between natural forces and engineered solutions. By understanding the dynamics of water flow and the factors that influence channel performance, planners and engineers can develop effective systems that safeguard communities, protect the environment, and promote sustainable land management (Erwanto Z et.al, 2021).

## RESEARCH METHODS

### Methods

This research was conducted in January – February 2024 on Kartini V Street, Kartini Urban Village, Central Jakarta. This research began with preparation and data collection activities in the form of channel data and rainfall data.

### Data Analysis

Data analysis is carried out by calculating it using the appropriate formula. The data analysis carried out is:

1. Hydrological analysis used to determine the magnitude of the planned flood discharge using rainfall data obtained from the Meteorology, Climatology and Geophysics Agency (Badan Meteorologi, Klimatologi, dan Geofisika/BMKG).
2. Hydraulic analysis used to calculate how large the channel cross-section is to accommodate the planned flood discharge.

## RESULT AND DISCUSSION

Analyze rainfall data over the last 10 years using the simplest average rainfall calculation, namely the Algebraic method, where the annual maximum rainfall data is divided by the total data.

$$P = \frac{P1 + P2 + \cdots + Pn}{n} = \frac{\sum_{i=1}^{n} Pi}{n}$$

Information:
P = Average value of rainfall (mm)
P1, P2, ..., Pn = Variance value of rainfall (mm)

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n = Number of rainfall data.

**Table 1.** Calculation of average value of rainfall data in year 2014-2023

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | R Max (mm/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2014 | 147,9 | 108,2 | 26,2 | 53,5 | 12,1 | 62 | 46 | 36,9 | 0,1 | 37,5 | 41 | 49 | 147,9 |
| 2015 | 134,3 | 277,5 | 55,3 | 33,3 | 16,6 | 6,9 | 0 | 5,2 | 0 | 0 | 54,1 | 93,2 | 277,5 |
| 2016 | 30,8 | 115 | 90,8 | 124,5 | 53 | 59 | 76 | 50 | 59,8 | 21 | 51 | 19,9 | 124,5 |
| 2017 | 45 | 179,7 | 23,3 | 49,6 | 46,5 | 45,5 | 81,4 | 0,8 | 71 | 50 | 60,7 | 90,7 | 179,7 |
| 2018 | 46,4 | 104,6 | 51 | 52,3 | 7,8 | 6,7 | 14,5 | 32,8 | 36,6 | 94,5 | 47 | 23,4 | 104,6 |
| 2019 | 86,6 | 49 | 75,6 | 22,8 | 24,5 | 18,1 | 0 | 0 | 0 | 1 | 33 | 38 | 86,6 |
| 2020 | 145,3 | 277,5 | 63,6 | 72 | 29 | 6,5 | 9 | 68,3 | 2,5 | 57,6 | 26 | 34,8 | 277,5 |
| 2021 | 43,8 | 94,1 | 67,2 | 73,4 | 92,2 | 31,4 | 17,8 | 66,5 | 36,7 | 55,3 | 34 | 65,6 | 94,1 |
| 2022 | 34,5 | 88,3 | 34,5 | 54 | 35,2 | 32,6 | 36 | 15,4 | 55,8 | 48,6 | 42,4 | 38,5 | 88,3 |
| 2023 | 35,3 | 76,9 | 79,5 | 66,6 | 45,5 | 31,4 | 2,5 | 1,8 | 0 | 0 | 39 | 36 | 79,5 |

Frequency analysis is based on the statistical properties of past event data to obtain the probability of rainfall in the future. The parameters used in frequency analysis calculations include the average value (X), standard deviation (Sd), coefficient of variation (Cv), slope coefficient (Cs), and sharpness coefficient (Ck).

**Average value (X)**

The average value is a value that adequately represents a collection of data in a distribution.

$$X = \frac{\sum_{i=1}^{n} Xi}{n}$$

Information:
X = Average value of rainfall (mm/day)
Xi = Variance value of the i-th rainfall (mm/day)
n = Number of rainfall data

**Table 2.** Calculation of rainfall data

| Year | Average Rh ($X$) | (Xi-X) | $(Xi-X)^2$ | $(Xi-X)^3$ | $(Xi-X)^4$ |
|---|---|---|---|---|---|
| 2014 | 146,02 | 1,88 | 3,5344 | 6,644672 | 12,49198336 |
| 2015 | 146,02 | 131,48 | 17286,99 | 2272893,498 | 298840037,1 |
| 2016 | 146,02 | -21,52 | 463,1104 | -9966,13581 | 214471,2426 |
| 2017 | 146,02 | 33,68 | 1134,342 | 38204,65203 | 1286732,68 |
| 2018 | 146,02 | -41,42 | 1715,616 | -71060,8313 | 2943339,632 |
| 2019 | 146,02 | -59,42 | 3530,736 | -209796,357 | 12466099,53 |
| 2020 | 146,02 | 131,48 | 17286,99 | 2272893,498 | 298840037,1 |
| 2021 | 146,02 | -51,92 | 2695,686 | -139960,038 | 7266725,167 |
| 2022 | 146,02 | -57,72 | 3331,598 | -192299,86 | 11099547,9 |
| 2023 | 146,02 | -66,52 | 4424,91 | -294345,04 | 19579832,05 |

**Standard of deviation (Sd)**

Standard of deviation is a quantity that is influenced by the spread of data towards the average value.

$$Sd = \sqrt{\frac{\sum_{i=1}^{n}(Xi - X)^2}{n-1}}$$

Information:

Sd = Standard of deviation
X = Average value of rainfall
Xi = Variance value of the i-th rainfall

n = Number of rainfall data
then through calculations:

$$Sd = \sqrt{\frac{51873.52}{9}}$$

The standard of deviation (Sd) value obtained was 75.92.

**Coeffiecient of variation (Cv)**

The coefficient of variation is the comparison value between the standard deviation and the average value of a distribution.

$$Cv = \frac{Sd}{X}$$

Information:
Cv = Coefficient of variation
Sd = Standard of distribution
X = Average value of rainfall
, then through calculations:

$$Cv = \frac{75.92}{146.02}$$

The coefficient of variation (Cv) value obtained was 0.52.

**Coefficient of skewness (Cs)**

The coefficient skewness is a value that indicates the degree of asymmetry of a distribution.

$$Cs = \frac{(n)\sum_{i=1}^{n}(Xi - X)^3}{(n-1)(n-2)Sd^3}$$

Information:
Cs = Coefficient of skewness
X = Average value of rainfall
Xi = Variance value of the i-th rainfall
n = Number of rainfall data
Sd = Average value of rainfall
, then through calculations:

$$Cs = \frac{(3)3666570.03}{(9)(8)75.92^3}$$

The slope coefficient (Cs) value obtained is 1.16.

**Coefficient of kurtosis (Ck)**

The coefficient of kurtosis is a value that shows the sharpness of the shape of the distribution curve.

$$Ck = \frac{(n)^2\sum_{i=1}^{n}(Xi - X)^4}{(n-1)(n-2)(n-3)Sd^4}$$

Information:
Ck = Coefficient of kurtosis
X = Average value of rainfall
Xi = Variance value of the i-th rainfall
n = Number of rainfall data
Sd = Standard of deviation
, then through calculations:

$$Ck = \frac{(10)^2 652536834.87}{(9)(8)(7)75.92^4}$$

The kurtosis coefficient (Ck) value obtained is 3.90.

The characteristics of the data that have been found through calculations are a requirement in choosing the type of distribution that will be used to calculate the planned rainfall. The following

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are the requirements for selecting the type of distribution/probability frequency distribution that is commonly used:

**Table 3.** Distribution methods type selection

| No. | Distribution Methods | Requirements | | Calculations | Informations |
|---|---|---|---|---|---|
| 1 | Normal | *Cs* | 0 | 1,16 | Does not fulfill |
| | | *Ck* | 3 | 3,90 | |
| 2 | Log Normal | *Cs* | $Cv^2 + 3Cv$ | 1,70 | Does not fulfill |
| | | *Ck* | 5, 838 | 8,55 | |
| 3 | Gumbel | *Cs* | ≤ 1,1396 | 1,16 | Does not fulfill |
| | | *Ck* | ≤ 5,4002 | 3,90 | |
| 4 | Log Pearson III | Other than the values above | | | Fulfill |

Based on the distribution parameters, it can be concluded that rainfall calculations use the Log Pearson III distribution method.

**Table 4.** Calculation of rainfall using Log Pearson III distribution method

| Year | Xi | X | Log Xi | Log X | (Log Xi - Log X) | (Log Xi - Log X)$^2$ | (Log Xi - Log X)$^3$ |
|---|---|---|---|---|---|---|---|
| 2014 | 147,90 | 146,02 | 2,17 | 2,16 | 0,01 | 0,000031 | 0,000000 |
| 2015 | 277,50 | 146,02 | 2,44 | 2,16 | 0,28 | 0,077758 | 0,021683 |
| 2016 | 124,50 | 146,02 | 2,10 | 2,16 | -0,07 | 0,004795 | -0,000332 |
| 2017 | 179,70 | 146,02 | 2,25 | 2,16 | 0,09 | 0,008124 | 0,000732 |
| 2018 | 104,60 | 146,02 | 2,02 | 2,16 | -0,14 | 0,020990 | -0,003041 |
| 2019 | 86,60 | 146,02 | 1,94 | 2,16 | -0,23 | 0,051481 | -0,011681 |
| 2020 | 277,50 | 146,02 | 2,44 | 2,16 | 0,28 | 0,077758 | 0,021683 |
| 2021 | 94,10 | 146,02 | 1,97 | 2,16 | -0,19 | 0,036413 | -0,006948 |
| 2022 | 88,30 | 146,02 | 1,95 | 2,16 | -0,22 | 0,047721 | -0,010425 |
| 2023 | 79,50 | 146,02 | 1,90 | 2,16 | -0,26 | 0,069720 | -0,018409 |

Based on calculations of rainfall, the average rainfall is 146.02 mm/day.

$$Sd = \sqrt{\frac{\sum_{i=1}^{n}(logXi - logX)^2}{n-1}}$$

, then through calculations:

$$Sd = \sqrt{\frac{0.394791}{13}}$$

The standard deviation (Sd) value from frequency analysis using the Log Pearson III method is 0.132.

$$Cs = \sqrt{\frac{\sum_{i=1}^{n}(logXi - logX)^3}{(n-1)(n-2)Sd^3}}$$

, then through calculations:

$$Cs = \sqrt{\frac{-0.00674}{(13)(12)0.132^3}}$$

The slope coefficient (Cs) value from frequency analysis using the Log Pearson III method is -0.411.

**Rainfall Intensity**

The method used to calculate rainfall intensity using average rainfall data is the Monobebe equation.

$$I = \frac{R24}{24}\left(\frac{24}{T}\right)^{\frac{2}{3}}$$

Information:
I = Rainfall intensity (mm/hour)
R24 = Max rainfall. in 24 hours (mm)
T = Rainfall time (mm)
With,

$$Tc = \frac{0{,}0195 \times L^{0{,}77}}{S^{0{,}385}}$$

Tc = Concentration time (minutes)
L = Length of the water path from the furthest point to the point under consideration (m)
S = Drainage surface slope

**Table 5.** Calculation of concetration time (Tc)

| No. | Channel | L (m) | Upstream E. (m) | Downstream E. (m) | ∆H (m) | S (%) | Tc (h) |
|---|---|---|---|---|---|---|---|
| 1 | A-B | 374 | 3 | 2 | | 0,003 | 0,3045 |
| 2 | B-C | 126 | 6 | 3 | 1 | 0,024 | 0,0568 |
| 3 | B-D | 80 | 5 | 3 | 3 | 0,025 | 0,0393 |

then the calculation of rainfall intensity(I) are obtained:

**Table 6.** Calculation od rainfall intensity (I)

| No. | Area | Rainfall intensity (I) (mm/hour) |
|---|---|---|
| 1 | A-B | 144,9297 |
| 2 | B-C | 444,0627 |
| 3 | B-D | 567,7453 |

**5-Year Rain Discharge Plan**

In calculating the planned debit, the following formula is used:

$$Q = 0{,}278 \times C \times I \times A$$

With,

$$C_{average} = \frac{\sum_{i=1}^{n} Ci \times Ai}{\sum_{i=1}^{n} Ai}$$

Q = Survace run off peak discharge ($m^3$/second)
C = Coefficient run off
I = Rainfall intensity (mm/hour)
A = Range area($km^2$)

**Table 7.** Calculation of coefficient run off

| No. | Type | A ($km^2$) | Coefficients | C |
|---|---|---|---|---|
| 1 | Street | 0,0096 | 0,7 | 0,0067 |
| 2 | House | 0,0287 | 0,75 | 0,0215 |
| 3 | Park | 0,0096 | 0,3 | 0,0029 |
| | Total | 0,0478 | | 0,0311 |

$$C_{average} = \frac{(0.0067 \times 0{,}0096)(0.0215 \times 0{,}0287)(0.0096 \times 0{,}0029)}{0.0478}$$

Then based on calculations, the run off coefficient value obtained is 0.0148.

Then, the planned debit can be calculated using the following calculations:

**Table 8.** Calculations of Rain Discharge Plan (Qr)

| No. | Channel | C | I (mm/hour) | A ($km^2$) | Rain Discharge Plan (Qr) ($m^3$/second) |
|---|---|---|---|---|---|
| 1 | A-B | 0,0148 | 144,9297 | 0,0358 | 0,0214 |
| 2 | B-C | 0,0148 | 444,0627 | 0,0037 | 0,0068 |

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| | | | | | |
|---|---|---|---|---|---|
| 3 | B-D | 0,0148 | 567,7453 | 0,0097 | 0,0226 |

Based on the calculation above, the planned discharge value (Qr) with a return period of 5 years are:
a. Channel A to channel B is 0.0214 $m^3$/second.
b. Channel B to channel C is 0.0068 $m^3$/second.
c. Channel B to channel D is 0.0226 $m^3$/second.

**Channel Drainage Capacity**

1. Analysis of the channel drainage capacity.

The calculation of drainage capacity is regulated in SNI 02-2406-1991 and aims to determine the capacity of the drainage channel to accommodate the planned flood discharge. The equation for calculating drainage capacity uses:

$$V = \frac{1}{n} \times R^{2/3} \times S^{2/3}$$

$$Qs = V \times A$$

$$Qs = A\,\frac{1}{n} \times R^{2/3} \times S^{2/3}$$

Information:

Qs = Existing channel discharge (m3/s)
V = Average flow speed (m/s)
A = Cross-sectional area (m)
n = Manning hardness coefficient
R = Hydraulic radius (m)
S = Drainage surface slope
L = Length (m)

**Table 9.** Calculation of channel drainage capacity

| **Channel** | **L (m)** | **S (%)** | **b (m)** | **h (m)** | **A ($m^2$)** | **P (m)** | **R (A/P) (m)** | **N** | **V (m/det)** | **Qs ($m^3$/det)** |
|---|---|---|---|---|---|---|---|---|---|---|
| A-B | 374 | 0,003 | 3 | 1,6 | 4,8 | 6,2 | 0,774 | 0,03 | 1,4533 | 6,9756 |
| B-C | 126 | 0,024 | 2,65 | 1 | 2,65 | 4,65 | 0,570 | 0,03 | 3,5355 | 9,3690 |
| B-D | 80 | 0,025 | 2,5 | 1,25 | 3,13 | 5 | 0,625 | 0,03 | 3,8527 | 12,0398 |

Based on calculations, the average flow velocity (V) value is obtained at:
a. 1,4533 m /second in Channel A to channel B.
b. 3,5355 m/second in Channel B to channel C.
c. 3,8527 m/second in Channel B to channel D.
The existing channel discharge value (Qs) is obtained at:
a. 6,9756 $m^3$/second in Channel A to channel B.
b. 9,3690 $m^3$/second in Channel B to channel C
c. 12,0398 $m^3$/second in Channel C to channel D.

2. Comparative analysis of Qr and Qs

Based on data on planned rain discharge (Qr) and existing channel discharge (Qs), it can be compared to determine whether the channel capacity is able to accommodate the rain discharge.

**Table 10.** Comparison of Qr and Qs

| **Channel** | **Qr ($m^3$/sec)** | **Qs ($m^3$/sec)** | **Description** |
|---|---|---|---|
| A-B | 0,0214 | 6,9756 | Capable |
| B-C | 0,0068 | 9,3690 | Capable |
| B-D | 0,0226 | 12,0398 | Capable |

Qr <Qs, then the channel is able to accommodate the planned rain discharge.

3. Analysis of channel drainage capacity using HEC-RAS.

a. Channel A to channel B's cross-section.

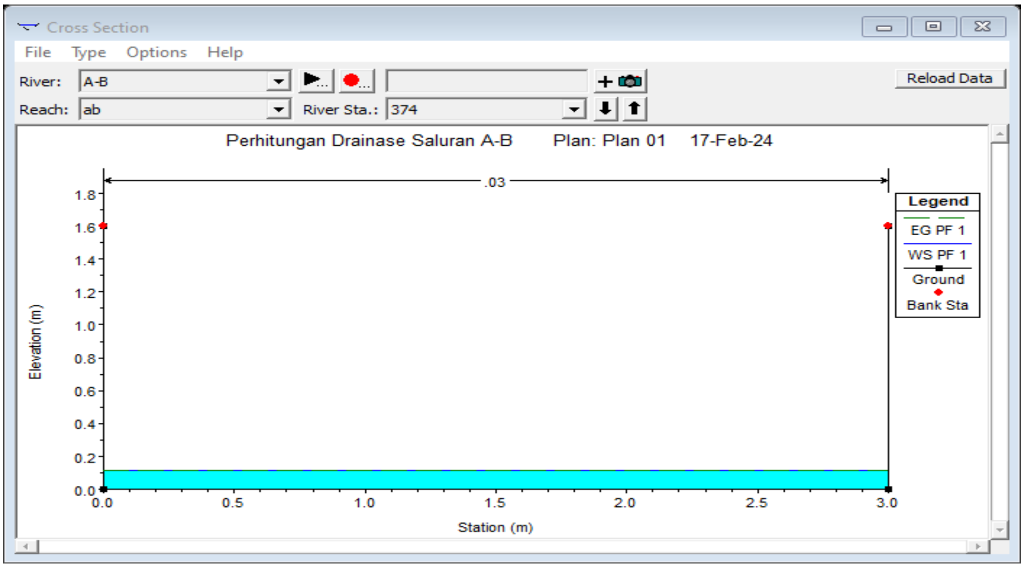


**Figure 1.** Channel A to Channel B's cross-section

b. Channel B to channel C's cross-section.

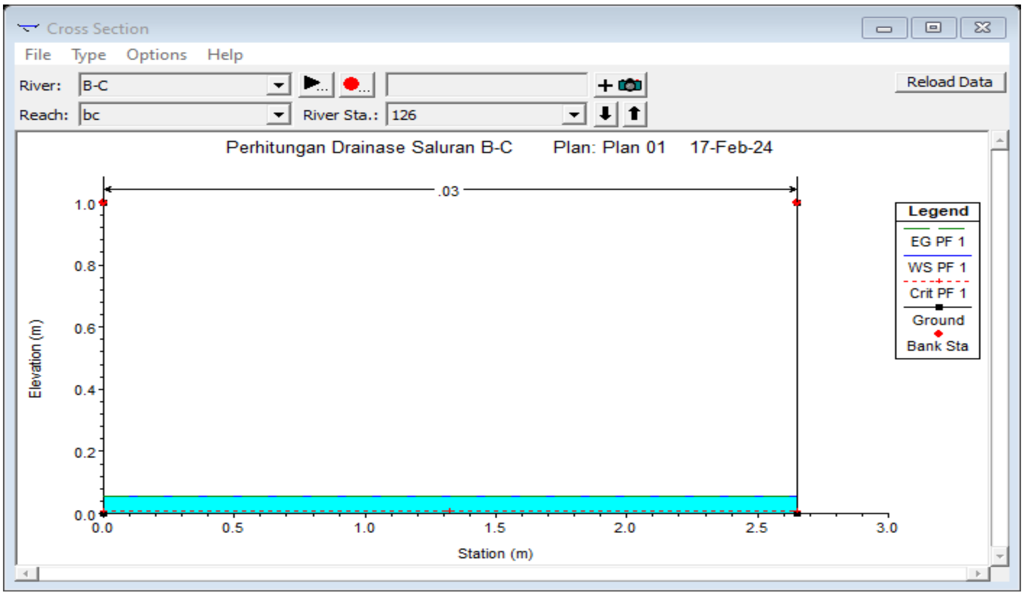


**Figure 2.** Channel B to Channel C's cross-section

c. Channel C to channel D's cross-section.

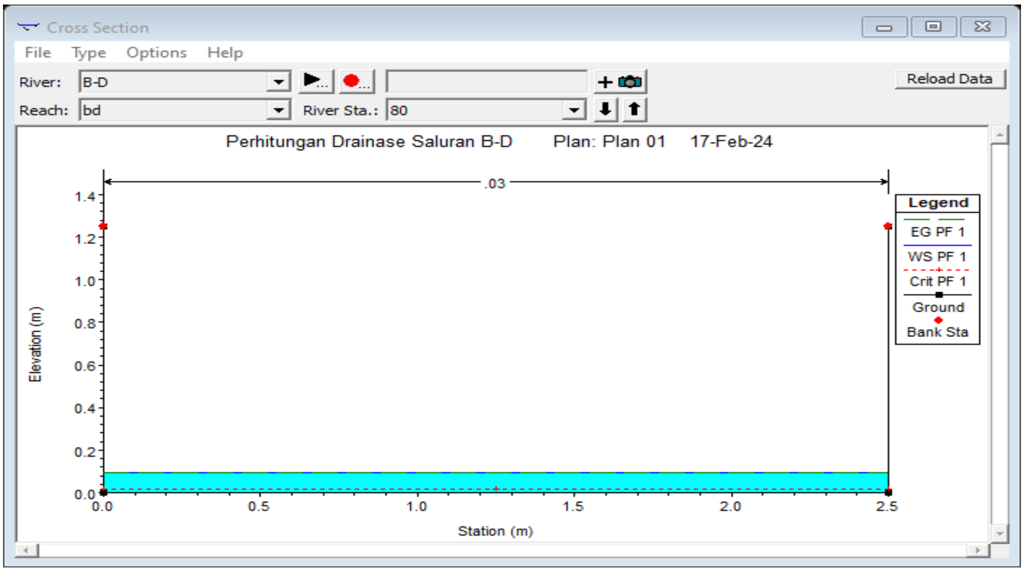


**Figure 3.** Channel C to Channel D's cross-section

From the results of this analysis, it can be seen that each channel is able to accommodate the planned rain discharge.

## CONCLUSION

Based on the results of the previous discussion, several things can be concluded, namely: 1) average rainfall in Kartini sub-district is 146.02 mm/day 2) channel A-B with a size of 300 x 160 cm with a capacity of 6.9756 $m^3$/second can accommodate the planned rainfall discharge of 0.0214 $m^3$/second, 3) the B-C channel with a size of 265 x 100 cm with a capacity of 9.3690 $m^3$/second is able to accommodate the planned rainfall discharge of 0.0068 $m^3$/second, 4) the B-D channel with a size of 250 c 125 cm with a capacity of 12.0398 $m^3$/second is able to accommodate the planned rainfall discharge of 0.0226 $m^3$/second.

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