International Journal of Sustainable Building, Infrastructure and Environment (IJOSBIE)
Vol. 7, No.2, October 2026, pp. 27-33
ISSN: 2716-4829 DOI: https://doi.org/10.26877/ijosbie.v7i2.1184

Analysis of Flood Control Measures for the Dombo River in Sayung Based on a 50-Year Return Period Flood Discharge

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Abstract. The Dombo Sayung River in Demak Regency is prone to flooding because of increased discharge during the rainy season and limited cross-section capacity. This study analyzes the river cross-section capacity under the 50-year return period flood discharge (Q50) of 78.96 m³/s using HEC-RAS 6.6. The design discharge was determined with the Nakayasu Synthetic Unit Hydrograph (SUH) method, and steady flow hydraulic analysis was applied at STA 0, STA 29, and STA 60 (Dam 60). At STA 0, the water level rose significantly but remained within the cross-section capacity. At STA 29, the water level approached the riverbank elevation, indicating a critical condition with high overflow potential. At STA 60, the cross-section was still relatively capable of accommodating Q50, although the water level increased. River normalization, sediment dredging, embankment elevation improvement, and routine maintenance are required to enhance flow capacity and reduce flood risk.

Keywords: cross-section capacity, flood control, flood discharge

1. Introduction

Flooding is one of the most common hydrological problems in Indonesia, occurring when river discharge exceeds the capacity of the river channel, particularly during periods of high rainfall intensity [1] [2]. This condition is often exacerbated by sedimentation, land-use changes, river narrowing, and inadequate drainage systems [3]. Demak Regency, especially Sayung District, is classified as a flood-prone area due to its low topography and coastal characteristics [4]. One of the rivers with significant flood potential in this region is the Dombo Sayung River, which frequently experiences rising water levels during the rainy season.

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This study focuses on STA 0, STA 29, and STA 60 (Dam 60) to evaluate the river cross-sectional capacity under the 50-year return period flood discharge (Q50 = 78.96 m^3/s). Preliminary interpretation indicates that STA 0 is still capable of accommodating the flood discharge despite a noticeable increase in water level. At STA 29, the water surface approaches the riverbank elevation, indicating a critical condition with potential overflow if discharge increases further. Meanwhile, STA 60 (Dam 60) remains relatively safe, as the river cross-section is still capable of conveying the flow, although water level increases are observed during high discharge conditions [5].

To evaluate the river capacity in detail, this study applies the Nakayasu Synthetic Unit Hydrograph (SUH) method to determine the design flood discharge and utilizes HEC-RAS 6.6 with a steady flow approach for hydraulic simulation [6]. The results are expected to provide a basis for determining appropriate flood control measures for the Dombo Sayung River.

2. Methods

The research was conducted at the Dombo River, located in Sayung District, Demak Regency, Central Java Province. This river is part of the Pucang Gading Watershed and is recognized as one of the areas that frequently experiences inundation and flooding during periods of high rainfall intensity. The river segment analyzed in this study extends from the Dombo Village area as the upstream section to the Sayung area as the downstream section, with an analyzed river length of approximately 6 km. The selection of this segment was intended to provide a more focused analysis of the river flow hydraulic conditions while minimizing external influences, particularly the effect of tidal seawater fluctuations on the simulation results. The research location is shown in Figure 1.

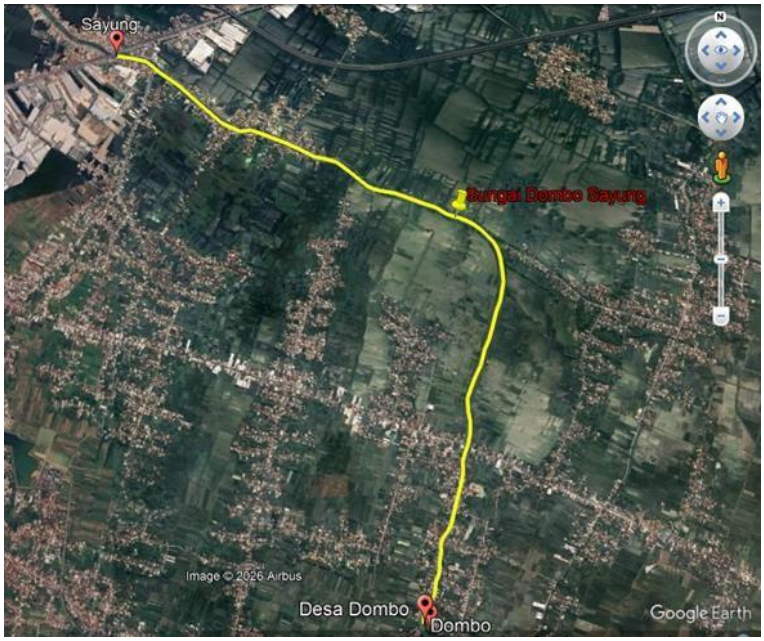


Figure 1. Research location (Source: Google Earth, 2025)

The analysis methods used in this study are as follows:

2.1. Hydrological analysis

The hydrological analysis in this study was conducted to determine the design flood discharge used in the hydraulic simulation of the Dombo Sayung River. The flood discharge calculation was performed using the Nakayasu Synthetic Unit Hydrograph (SUH) method based on annual maximum rainfall data in the Pucang Gading Watershed area.

The analysis stages included rainfall data processing, rainfall frequency analysis, data distribution testing, and design flood discharge calculation. Based on the calculation results, the 50-year return

period flood discharge (Q50) was obtained at 78.96 m³/s. This discharge is the highest compared to other return periods; therefore, it was used as the design discharge in evaluating the capacity of the Dombo Sayung River.

The Q50 discharge indicates that under extreme rainfall conditions, the Dombo River experiences a significant increase in discharge, which has the potential to cause a rise in water level. Therefore, the Q50 discharge was used to determine the most critical condition of the river cross-section, particularly at STA 15 [4].

2.2. Hydraulic analysis

Hydraulic analysis was carried out using HEC-RAS 6.6 with a steady flow approach to evaluate the capacity of the Dombo Sayung River cross-section in accommodating the 50-year return period flood discharge (Q50) [5].

The simulation results at STA 15 or River Station (RS) 15.464 showed that a flood discharge of 78.96 m³/s caused the river water level elevation to reach approximately 2.35 m. The river cross-section at this location has an asymmetric shape with the lowest riverbed elevation of about 0.05 m, while the right bank elevation ranges from approximately 1.15 to 1.27 m.

The flow velocity obtained from the simulation was approximately ±0.24 m/s with an energy slope value of around 0.000309. These results indicate that the flow condition at STA 15 was relatively mild. However, the increase in Q50 discharge caused a significant rise in the river water level compared to normal conditions.

Based on the HEC-RAS cross-sectional profile, the water surface was observed to be close to the riverbank elevation, indicating that the cross-section capacity was in a critical condition. Although major overflow had not yet occurred, the distance between the water surface and the riverbank became increasingly small, creating the potential for flooding due to additional discharge from extreme rainfall or sedimentation that narrows the river cross-section.

The analysis results indicate that STA 15 of the Dombo Sayung River requires measures to improve flow capacity. Several efforts that can be applied include river normalization, sediment dredging, and periodic river maintenance to reduce flood risk during high discharge conditions.

3. **Results and Discussion**

Hydrological analysis was conducted to obtain the design flood discharge used as input in the hydraulic simulation of the Dombo Sayung River. The flood discharge calculation was carried out using the Nakayasu Synthetic Unit Hydrograph (SUH) method based on the annual maximum rainfall data in the Pucang Gading watershed area.

The peak flood discharge for the 50-year return period was calculated using the Nakayasu SUH equation [4] as follows:

$$Q_p = \frac{1}{3.6} \times \frac{A \times R_e}{T_p} \tag{1}$$

$$Q_p = \frac{1}{3.6} \times \frac{174.6 \times 78.97}{2.45} = 1563.2 \text{ m}^3/\text{s} \tag{2}$$

where Q_p is the peak flood discharge (m³/s), A is the watershed area (km²), R_e is the effective rainfall (mm), and T_p is the time to peak of the hydrograph.

Hydrological analysis was carried out using the Nakayasu Synthetic Unit Hydrograph (SUH) method based on the watershed parameters of the Pucang Gading watershed. The calculation was performed using watershed area data, effective rainfall, time to peak of the hydrograph, and hydrograph recession time to determine the design flood discharge.

3.1. Hydraulic analysis at STA 0 using HEC-RAS 6.6

Hydraulic analysis was conducted using HEC-RAS 6.6 with a steady flow approach to evaluate the capacity of the Dombo Sayung River in accommodating the 50-year return period flood discharge (Q50).

Based on the hydraulic simulation results using HEC-RAS 6.6 on the Dombo Sayung River cross-section at STA 0 with the 50-year return period flood discharge (Q50 = 78.96 m³/s), the water surface elevation reached 1.77 m, while the minimum channel bed elevation was -0.99 m. The energy grade elevation was recorded at 1.97 m, with an energy slope of 0.001 m/m. The flow velocity in the channel reached 1.98 m/s, with a flow area of 39.8 m² and a top width of 15.3 m. Based on the cross-sectional profile shown in Figure 2, the water surface remained below the riverbank elevation, indicating that the river cross-section was still capable of accommodating the 50-year return period flood discharge. Therefore, the condition at STA 0 can be categorized as non-flooded. However, routine maintenance is still required to preserve river capacity and prevent sedimentation or channel narrowing.

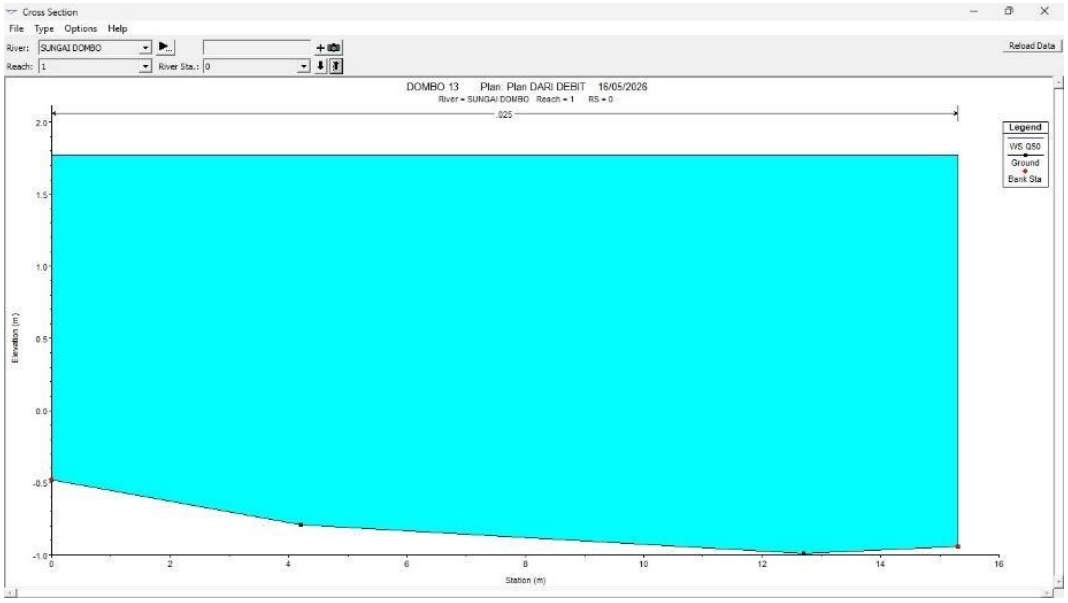


Figure 2. Cross section of STA 0 under Q50 discharge (Source: HEC-RAS, 2026)

3.2. Hydraulic analysis at STA 29 using HEC-RAS 6.6

The hydraulic simulation results at STA 29 indicate that the 50-year return period flood discharge (Q50 = 78.96 m³/s) produced a water surface elevation of 3.00 m, with a minimum channel elevation of 0.86 m. The energy grade elevation was 3.06 m, while the energy slope was 0.000587 m/m, indicating relatively mild flow conditions. The flow velocity at this location reached 1.12 m/s, with a flow area of 70.25 m² and a top width of 54.28 m. Based on the interpretation of Figure 3, the water surface was observed to approach the riverbank elevation, indicating that the cross-sectional condition was critical. Although overflow did not occur during the simulation, the freeboard between the water surface and riverbank was relatively small, creating the potential for flooding if additional discharge occurs due to extreme rainfall or river sedimentation. Therefore, flood control measures such as river normalization and periodic sediment dredging are required to maintain flow capacity.

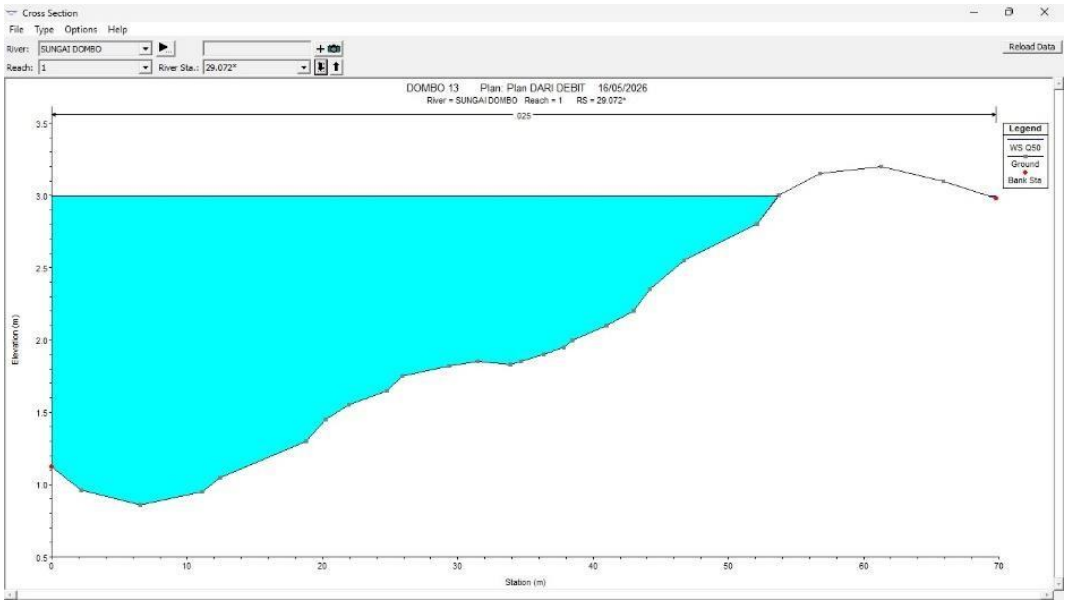


Figure 3. Cross section of STA 29 under Q50 discharge (Source: HEC-RAS, 2026)

3.3. Hydraulic analysis at STA 60 using HEC-RAS 6.6

Based on the simulation results at STA 60 (Dam 60), the 50-year return period flood discharge produced a water surface elevation of 5.38 m, while the minimum channel bed elevation was 2.82 m. The energy grade elevation reached 5.45 m, with an energy slope of 0.001054 m/m. The flow velocity at STA 60 was 1.22 m/s, with a flow area of 64.74 m² and a top width of 68.49 m. Based on the cross-sectional profile shown in Figure 4, the water level increased significantly, indicating the potential occurrence of flooding or overflow, particularly because the river cross-section began to experience substantial hydraulic loading under high discharge conditions. This condition suggests that STA 60 requires special attention, including river capacity improvement measures such as embankment elevation enhancement, river normalization, and sediment management to minimize flood risk.

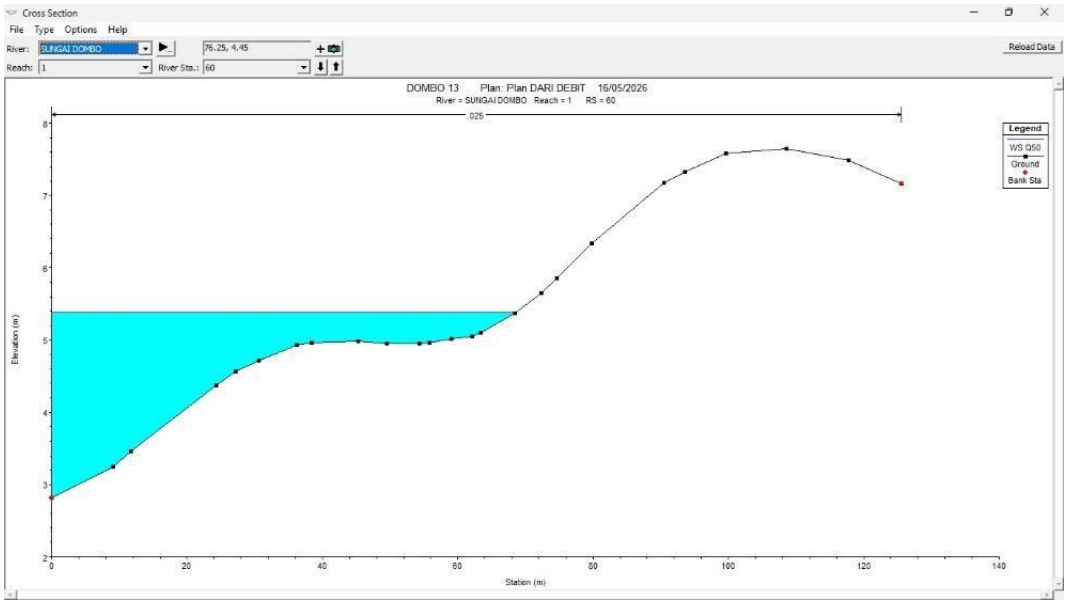


Figure 4. Cross section of STA 60 under Q50 discharge (Source: HEC-RAS, 2026)

3.4. Comparison of cross-section conditions

Based on the hydraulic simulation results presented in Table 1 for the Dombo Sayung River cross-section under the 50-year return period flood discharge (Q50 = 78.96 m^3/s), different hydraulic characteristics were observed at each monitoring location. STA 0 showed relatively safe conditions because the water surface remained within the river cross-sectional capacity. STA 29 was categorized as a critical condition since the water surface approached the riverbank elevation, although overflow had not yet occurred. Meanwhile, STA 60 showed the highest flood potential because the flow discharge significantly increased the water level, potentially causing overflow. The variation in conditions among the cross-sections was influenced by river geometry, channel bed elevation, storage capacity, and river width. The smaller the cross-sectional capacity relative to the incoming discharge, the greater the risk of overflow. Therefore, flood control in the Dombo Sayung River should be implemented comprehensively through river normalization, sediment dredging, embankment improvement, and routine maintenance to enhance river flow capacity under extreme discharge conditions.

Table 1. Cross-section analysis results at STA 0, 29, and 60 for the 50-year return period (Source: HEC-RAS calculation results)

Reach	River Sta	Profile	Q Total (m^3/s)	Min Ch El (m)	W.S. Elev (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m^2)	Top Width (m)	Remark
1	0	Q50	78.96	-0.99	1.77	1.97	0.001	1.98	39.8	15.3	Not flooded
1	29	Q50	78.96	0.86	3.00	3.06	0.000587	1.12	70.25	54.28	Not flooded
1	60	Q50	78.96	2.82	5.38	5.45	0.001054	1.22	64.74	68.49	Flooded

4. Conclusion

Based on the results of the hydrological and hydraulic analyses of the Dombo Sayung River using the Nakayasu Synthetic Unit Hydrograph (SUH) method and HEC-RAS 6.6 simulation, the 50-year return period flood discharge (Q50) was determined to be 78.96 m^3/s. This discharge was used as the basis for evaluating the river cross-sectional capacity in accommodating flood flow.

The simulation results indicate that the river cross-section conditions at each observation point have different hydraulic characteristics. At STA 0, the river cross-section was still capable of accommodating the 50-year return period flood discharge and was therefore categorized as being in a safe condition with no flooding. At STA 29, the water surface elevation approached the riverbank level, indicating a critical condition with potential overflow if additional discharge occurs due to extreme rainfall or sedimentation. Meanwhile, at STA 60 (Dam 60), a significant increase in water level was observed, indicating the potential occurrence of flooding or overflow due to the river cross-section capacity being increasingly burdened by high discharge.

Based on these conditions, the Dombo Sayung River requires flood control measures to improve flow capacity and minimize future inundation risks. Several mitigation efforts can be implemented, including river normalization, sediment dredging, embankment elevation improvement, and periodic river maintenance to maintain the river's optimal carrying capacity in handling extreme flood discharges.

Declaration of AI and AI assisted technologies in the writing process

During the preparation of this work the author(s) used Google translate in order to Translate from Indonesian to English. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Acknowledgements

The author would like to express sincere gratitude to Universitas PGRI Semarang, particularly the Faculty of Engineering and Informatics, for providing academic support and facilities throughout the

implementation of this research. The author also extends appreciation to the academic supervisor for the guidance, valuable suggestions, and continuous support during the preparation of this study.

The author would also like to thank all parties who contributed to data collection, analysis processes, and the completion of this research on flood control analysis of the Dombo Sayung River. The support, advice, and motivation provided were highly valuable and played an important role in the successful completion of this study.

References

[1] Suripin, *Sistem Drainase Perkotaan yang Berkelanjutan*. Yogyakarta: Andi Offset, 2004.

[2] Yudaningrum, F., & Ikhwanudin, I. (2020). Banger Retention Pool as Alternative Control Flood. International Journal of Sustainable Building, Infrastructure and Environment (IJOSBIE), 1(1).

[3] Ikhwanudin, H. Imadudin, and Y. Farida, "Design of Water Pump Station Control in Polder System using IoT and Hybrid Fuzzy Neural Network," 2025, doi: 10.1088/1755-1315/1321/1/012014.

[4] S. Harto, *Analisis Hidrologi*. Jakarta: Gramedia Pustaka Utama, 2000.

[5] B. Triatmodjo, *Hidrologi Terapan*. Yogyakarta: Beta Offset, 2008.

[6] U.S. Army Corps of Engineers, "HEC-RAS Hydraulic Reference Manual, Version 6.6," Hydrologic Engineering Center, 2021. [Online]. Available: https://www.hec.usace.army.mil/software/hec-ras/documentation.aspx