ARTICLE

EVALUATION OF THE DRAINAGE SYSTEM REGARDING WATER INUNDATION ON KARADENAN MAIN ROAD, CIBINONG DISTRICT, BOGOR REGENCY, WEST JAVA PROVINCE

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Abstract

The drainage system along Karadenan Road in Cibinong District, Bogor Regency, plays a crucial role in conveying stormwater runoff to prevent pooling that could disrupt the function of this collector road and impede traffic flow. Field observations revealed that water pooling persists at five locations for durations exceeding two hours; the existing rectangular channels measure 0.50 m × 1.00 m, and sediment deposits were found at the channel bottoms. This study aims to evaluate the capacity of the existing drainage channels against the design flood discharge and to formulate recommendations for adjusting channel dimensions. A descriptive quantitative approach was employed for a catchment area of 22.31 hectares. Hydrological analysis utilized maximum daily rainfall data from 2015 to 2024 recorded at the Cibinong, Ranca Bungur, and Sumur Batu stations. Areal rainfall was calculated using the arithmetic mean method, while rainfall distributions were analyzed using Normal, Log-Normal, Gumbel, and Log-Pearson Type III distributions, followed by Chi-Square and Smirnov-Kolmogorov goodness-of-fit tests. Design flood discharge was calculated using the Rational Method for a five-year return period, whereas channel capacity was calculated using Manning's equation and simulated via HEC-RAS. The study results yielded a design rainfall of 145.88 mm, a rainfall intensity of 46.9 mm/hour, a runoff coefficient of 0.56, and a design flood discharge of 1.63 m^3/s. The existing channel capacity was only 0.26 m^3/s—insufficient to handle the design discharge—and simulations indicated overflow. Adjusting the channel dimensions to 1.20 m × 1.00 m resulted in a capacity of 1.74 m^3/s; HEC-RAS simulations showed the water level remaining below the channel rim, indicating no overflow under the proposed design scenario.
Keywords: Drainage System, Inundation, Hydrological Analysis, Hydraulic Analysis, Rational Method, HEC-RAS.

A. INTRODUCTION

A drainage system is a crucial component of road infrastructure, serving to channel and control surface runoff to prevent water from pooling on the roadway. Effective drainage performance ensures safety, driving comfort, and smooth traffic flow while minimizing the risk of pavement damage. Drainage also functions as part of the urban water management system, safely conveying excess water from the service area to receiving channels (Suripin, 2004).

Karadenan Road in Cibinong District is a collector road spanning approximately 3.28 km, with a roadway width of roughly 8 m and a shoulder width of about 1.5 m. This section experiences high traffic volume and congestion at certain times. Water pooling on the collector road can reduce the road's service capacity, increase accident risks, accelerate pavement surface deterioration, and disrupt community activities.

Preliminary observations indicate that during moderate to heavy rainfall, surface water in several segments of Karadenan Road is not drained optimally. Five locations prone to pooling were identified: points A, B, C, D, and E. At some of these points, the pooled water persists for more than two hours. This situation indicates that the drainage system is not functioning optimally according to urban drainage service criteria and requires a technical evaluation.

The decline in drainage performance is suspected to be linked to sediment accumulation at the channel bed, physical damage or irregularities, inlet limitations, and cross-sectional capacity that is no longer sufficient to handle runoff resulting from area development and changes in land use. The existing drainage system consists of an open concrete channel with a rectangular cross-section, a width of 0.50 m, and a measured effective depth of 0.40 m.

The evaluation involved hydrological analysis to determine the design flood discharge and hydraulic analysis to determine channel capacity. The results of both analyses were compared against the criteria where Qs ≥ Qt indicates compliance and Qs < Qt indicates non-compliance. HEC-RAS modeling was employed to assess water surface profiles, flow velocity, flow area, and potential overflow for both the existing channel and the modified channel design.

This study aims to: (1) analyze runoff discharge and determine the design flood discharge for a five-year return period; (2) calculate the capacity of the existing channel based on its geometry, bed slope, and Manning's roughness coefficient; (3) evaluate the channel's ability to accommodate the design discharge; and (4) formulate technical recommendations to improve drainage performance and minimize inundation. The study's contribution lies in the use of areal rainfall data from three stations surrounding the study site and the integration of manual calculations with HEC-RAS simulations.

Figure 1. Distribution of inundation points on Karadenan Main Road
Source: Research documentation and Google Earth, 2026

B. LITERATURE REVIEW

Previous Studies

Oktorio and Nurafni (2025) redesigned the drainage channels in Teluk Pauh Pangean Village to address inundation caused by the existing channels' inability to handle rainfall runoff. Their analysis involved determining the design discharge through hydrological methods and calculating channel dimensions using hydraulic principles. The study is significant as it demonstrates that adjusting channel geometry can serve as a solution to capacity deficits.

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Hendriyani et al. (2021) evaluated drainage channels in Karang Joang Urban Village, Balikpapan, using rainfall data and channel condition assessments. Their findings indicated that the existing capacity was insufficient to optimally handle runoff discharge during specific rainfall events. A key distinction from the Karadenan Highway study was the use of data from three rainfall stations to derive a more representative areal rainfall figure.

Rustan et al. (2020) examined the relationship between existing channel conditions and inundation on the shoulder of D. I. Panjaitan Road, leading to the Lepo-Lepo Aircraft Roundabout. Runoff discharge and channel capacity were calculated based on rainfall data and cross-sectional geometry. The study underscored the importance of comparing design discharge against channel capacity to assess road drainage performance.

Wijayanti et al. (2022) evaluated drainage channels for flood control on Sukowati Road, Sragen, through hydrological and hydraulic analyses. Their research serves as a reference for using design discharge as the basis for evaluating channel capacity. Meanwhile, Yunianta et al. (2022) addressed sustainable drainage in the Hamadi Rawa area of Jayapura by focusing on increasing channel capacity, controlling runoff, and implementing infiltration techniques.

Another study in Malang City also highlighted the necessity of evaluating road drainage capacity relative to runoff discharge (Nurdiansyah et al., 2025). In the Cibinong area, Respati (2025) designed road drainage channels for Nanggewer Mekar Urban Village, further demonstrating that drainage capacity is a relevant issue in the region surrounding the study site. Previous studies have generally focused on capacity evaluation or channel redesign. The Karadenan Road study addresses the need for an analysis that integrates regional rainfall data from three stations, hydrological and hydraulic calculations, and HEC-RAS simulations to formulate site-specific dimensional recommendations.

Drainage and Open Channel Concepts

Drainage is a system designed to channel or discharge excess water from an area. Such systems may comprise receiving channels, collecting channels, and conveyance channels. Drainage is classified into natural and artificial types based on formation; surface and subsurface types based on location; and primary, secondary, and tertiary channels based on hierarchy (Suripin, 2004; Prawati & Fajri, 2021; Cahayadi et al., 2025).

The drainage channel along Karadenan Highway is an artificial, surface-level system functioning as a collecting or secondary channel, featuring a rectangular concrete cross-section. Rectangular cross-sections are widely used in roadway areas due to their relatively small spatial footprint and the ease with which their construction can be adapted to the available road right-of-way.

Hydrological Analysis

Hydrological analysis is employed to determine rainfall characteristics and the design discharge that the drainage system must accommodate (Triatmodjo, 2010). Point rainfall data from gauging stations must be processed into areal rainfall. Commonly used methods include the arithmetic mean, Thiessen Polygon, and isohyetal methods. The arithmetic mean method is suitable when rainfall stations are relatively evenly distributed and exert a comparable influence on the study area.

Frequency analysis estimates design rainfall for a specific return period based on annual maximum series. Normal, Log-Normal, Gumbel, and Log-Pearson Type III distributions can be tested using parameters such as the mean, standard deviation, skewness coefficient, coefficient of variation, and kurtosis coefficient (Soewarno, 2014). The selected distribution must be verified using Chi-Square and Smirnov–Kolmogorov tests.

Design rainfall is subsequently converted into rainfall intensity using the Mononobe equation, taking the time of concentration into account. The runoff coefficient represents the

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proportion of rainfall that becomes runoff and is determined based on land cover type. For relatively small catchment areas, the design flood discharge can be calculated using the Rational Method.

$$\bar{R} = (R_1 + R_2 + \ldots + R_n) / n$$
$$I = (R_{24} / 24) \times (24 / t)^{2/3}$$
$$C = \Sigma(C_i A_i) / \Sigma A_i$$
$$Q_t = 0{,}278 \times C \times I \times A$$

In the equation, $\bar{R}$ is the areal rainfall, R_i is the rainfall at station i, I is the rainfall intensity (mm/h), R_{24} is the design 24-hour rainfall (mm), t is the time of concentration (h), C is the runoff coefficient, A is the catchment area (km²), and Q_t is the design flood discharge (m³/s).

Hydraulic Analysis and HEC-RAS

Open-channel capacity is determined by the wetted cross-sectional area, wetted perimeter, hydraulic radius, energy slope, and surface roughness. The Manning equation is used to calculate the velocity and discharge of uniform flow. The Manning coefficient for concrete channels in this study is set at 0.013.

HEC-RAS is hydraulic modeling software used to calculate water surface profiles in open channels. Input data include cross-section geometry, channel length, upstream and downstream elevations, bed slope, roughness coefficients, boundary conditions, and discharge. Model outputs include water surface elevation, energy elevation, velocity, flow area, water surface width, Froude number, and flow regime (Destania, 2020).

$$A = B \times d; \;\; P = B + 2d; \;\; R = A / P$$
$$V = (1 / n) \times R^{2/3} \times S^{1/2}; \;\; Q_s = A \times V$$

C. RESEARCH METHODOLOGY

Research Design and Location

This study employs a descriptive quantitative approach (Damanik et al., 2025; Pasaribu et al., 2022). Numerical data were analyzed to describe existing conditions, determine design discharge, calculate channel capacity, and formulate technical recommendations. The study area is located along a section of Karadenan Road in Cibinong District, Bogor Regency, West Java Province.

The analyzed road section spans a length of 3,280 meters. The starting point is situated at approximately 6°31’47” S and 106°48’36” E with an elevation of 163.02 m, while the endpoint is at approximately 6°30’07” S and 106°48’33” E with an elevation of 141.02 m. An elevation difference of 22 m results in an average bed slope of approximately 0.0067.

Five inundation sites were identified along the road section. Inundation persists for more than two hours during periods of moderate to heavy rainfall. The existing drainage system consists of open, rectangular concrete channels with a width of 0.50 m and an effective depth of 0.40 m. Sediment deposits were found at the channel bottom; consequently, the dimensions used reflect the effective conditions observed during the survey.

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Figure 2. Existing condition of the drainage channel on Jalan Raya Karadenan
Source: Research documentation, 2026

Research Data

The research data consist of primary and secondary data. Primary data were obtained through direct observation and measurement, whereas secondary data were obtained from relevant agencies and spatial sources.

- Primary data: effective channel width and height, cross-sectional shape, channel material, physical condition, sedimentation, flow direction, documentation of inundation points, and upstream and downstream elevations.
- Secondary data: maximum daily rainfall from 2015–2024 recorded at the Cibinong, Ranca Bungur, and Sumur Batu stations; location and topographic maps; and catchment area size.

The three stations were selected due to their proximity to one another and their location flanking Karadenan Road. Cibinong Station is situated in Ciriung Village, Ranca Bungur Station in Mekarsari Village, and Sumur Batu Station in Sumurbatu Village. Rainfall data was obtained from the Ciliwung–Cisadane River Basin Organization. Catchment area boundaries were determined based on surface runoff flow directions and topographic conditions observed via Google Earth. The effective area for collecting runoff directed toward the channel is 22.31 hectares, or 0.2231 km².

Analysis Stages

First, annual maximum rainfall data from three stations were converted into areal rainfall using the arithmetic mean method. This areal data was then analyzed using Normal, Log-Normal, Gumbel, and Log-Pearson Type III distributions. The distribution selection was based on statistical parameters and verified using Chi-Square and Kolmogorov-Smirnov tests at a 5% significance level.

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Second, the design rainfall for a five-year return period was converted into rainfall intensity using the Mononobe equation. The time of concentration was calculated based on flow length and channel bed slope. The area's runoff coefficient was determined as a weighted value based on the extent of residential areas, asphalt and concrete surfaces, and green open spaces.

Third, the design flood discharge was calculated using the Rational Method. Existing channel capacity was determined via Manning's equation, assuming dimensions of 0.50 m × 0.40 m, an effective flow depth of 80% of the channel height, a Manning's coefficient of 0.013, and a slope of 0.0067.

Fourth, a steady-flow HEC-RAS model was developed using a channel length of 3,280 m, an inflow discharge of 1.63 m^3/s, existing cross-sectional geometry, bed slope, and Manning's coefficient. Model results were used to assess whether the water surface elevation exceeded the channel banks.

Fifth, if Qs < Qt, the channel dimensions were adjusted. The selected alternative was a rectangular cross-section with a width of 1.20 m and a height of 1.00 m. The capacity of the modified channel was calculated and re-verified using HEC-RAS.

Evaluation Criteria

Channel performance is determined based on the ratio of the channel's maximum capacity to the design flood discharge:

- Qs ≥ Qt: the channel meets capacity requirements and is theoretically capable of conveying the design discharge.
- Qs < Qt: the channel does not meet capacity requirements, necessitating normalization, capacity enhancement, or dimensional adjustments.

The scope of the study is limited to the Karadenan Main Road section. Sedimentation, land-use changes, construction costs, execution methods, and maintenance management were not quantitatively analyzed. The evaluation is based on urban drainage planning principles outlined in the Regulation of the Minister of Public Works and Public Housing (Permen PUPR) Number 12/PRT/M/2014.

D. RESULT AND DISCUSSION

Research Results

Regional Rainfall Analysis

Areal rainfall was calculated using the arithmetic mean method based on annual maximum daily rainfall data from the Cibinong, Ranca Bungur, and Sumur Batu stations for the 2015–2024 period. This method was selected because the three stations are distributed relatively evenly around the study site. For instance, the average areal rainfall for 2015 was calculated as (82.00 + 64.80 + 175.00) / 3 = 107.27 mm. The analysis results indicate that the lowest areal rainfall was 99.20 mm in 2020, while the highest was 189.00 mm in 2019.

Table 1. Annual maximum rainfall and areal rainfall

Years	Cibinong (mm)	Ranca Bungur (mm)	Sumur Batu (mm)	Average (Mm)
2015	82,00	64,80	175,00	107,27
2016	81,00	63,50	181,00	108,50
2017	70,00	290,00	153,00	171,00
2018	135,00	30,50	205,00	123,50
2019	85,00	32,00	450,00	189,00

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2020	100,00	24,00	173,60	99,20
2021	107,50	114,00	130,50	117,33
2022	104,00	129,00	160,80	131,27
2023	105,00	115,50	135,50	118,67
2024	146,00	99,00	98,40	114,47

Source: Research analysis results, 2026.

Rainfall Distribution Analysis

A frequency analysis was conducted on the annual maximum rainfall series using four probability distributions: Normal, Log-Normal, Gumbel, and Log-Pearson Type III. Statistical parameters for the raw data yielded a mean of 128.02 mm, a standard deviation of 29.11 mm, a skewness coefficient (Cs) of 1.47, a coefficient of variation (Cv) of 0.23, and a kurtosis coefficient (Ck) of 5.06. Following logarithmic transformation, the values obtained were a log-mean of 2.098, a log-standard deviation of 0.09, Cs of 1.25, Cv of 0.04, and Ck of 4.60. Based on statistical parameter requirements, the Log-Pearson Type III distribution was selected as it is capable of representing data exhibiting skewness (i.e., $Cs \neq 0$).

Table 2. Summary of analysis results and distribution selection

Distribution	Cs	Cv	Ck	Information
Normal	1,47	0,23	5,06	Does not meet the
Log Normal	1,25	0,04	4,60	Does not meet the
Gumbel	1,47	0,23	5,06	Does not meet Cs requirements
Log Pearson Tipe III	1,25	0,04	4,60	Fulfil

Source: Research analysis results, 2026.

Distribution Goodness-of-Fit Test

The Log-Pearson Type III distribution was subsequently tested using the Chi-Square and Kolmogorov-Smirnov tests. For the Chi-Square test, the 10-year dataset was grouped into five classes with 3 degrees of freedom; the calculated χ^2 value of 7.00 was lower than the tabulated χ^2 value of 7.815 at a 5% significance level. In the Kolmogorov-Smirnov test, the maximum deviation (Dmax) of 0.17 was lower than the critical value (Do) of 0.41. Both results indicate that the Log-Pearson Type III distribution meets the requirements and is suitable for determining design rainfall.

Table 3. Goodness-of-fit test results for the Log-Pearson Type III distribution.

Test	Calculated value	Critical value	Decision
Chi-Kuadrat	7,00	7,815	Accepted
Smirnov–Kolmogorov	0,17	0,41	Accepted

Source: Research analysis results, 2026.

Rainfall Intensity Analysis

The Log-Pearson Type III distribution calculation yielded design rainfall values for various return periods. The study utilized a five-year return period; therefore, the design rainfall value used was 145.88 mm.

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Table 4. Design rainfall based on return period

Kala ulang (tahun)	Kt	Hujan rencana X_{24} (mm)
2	-0,195	120,49
5	0,732	145,88
10	1,340	165,37
25	2,085	192,83
50	2,626	215,60
100	3,149	240,16

Source: Research analysis results, 2026

The channel bed slope was determined from an elevation difference of 22 m over a channel length of 3,280 m, resulting in S = 0.0067. Based on the flow length and slope, the time of concentration (tc) was calculated to be 1.12 hours. Rainfall intensity was calculated using the Mononobe equation, yielding a value of 46.9 mm/hour.

$$S = 22 / 3.280 = 0{,}0067; \quad tc = 1{,}12 \text{ hour}$$

$$I = (145{,}88 / 24) \times (24 / 1{,}12)^{2/3} = 46{,}9 \text{ mm/hour}$$

Drainage Runoff Coefficient

The runoff coefficient was determined using a weighted calculation based on land use within a catchment area of 22.31 ha (0.2231 km²). The catchment area comprises residential zones (0.1163 km²), asphalt and concrete surfaces (0.0510 km²), and green open spaces (0.0558 km²). The weighted calculation resulted in a runoff coefficient of 0.56 for the area.

Table 5. Calculation of runoff coefficients based on land use.

Land use	Area (km²)	C
Residential areas	0,1163	0,60
Asphalt and concrete	0,0510	0,85
Green open spaces	0,0558	0,20
Total/weighted	0,2231	0,56

Source: Research analysis results, 2026.

$$C = [(0{,}1163 \times 0{,}60) + (0{,}0510 \times 0{,}85) + (0{,}0558 \times 0{,}20)] / 0{,}2231 = 0{,}56$$

Analysis of Design Flood Discharge

The design flood discharge was calculated using the Rational Method with a runoff coefficient of 0.56, a rainfall intensity of 46.9 mm/hour, and a catchment area of 0.2231 km². The calculated design flood discharge for a five-year return period is 1.63 m³/second.

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

$$Q_t = 0{,}278 \times 0{,}56 \times 46{,}9 \times 0{,}2231 = 1{,}63 \text{ m}^3/\text{detik}$$

Hydraulic Analysis of Existing Channels

Hydraulic analysis of the existing channel utilizes a rectangular cross-section with a width of 0.50 m, a height of 0.40 m, a Manning's coefficient of 0.013, and a bed slope of 0.0067. The effective flow depth is set at 80% of the channel height—specifically 0.32 m—while the freeboard is 0.08 m. Based on this geometry, the calculated values are a wetted area of 0.16

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m², a wetted perimeter of 1.14 m, a hydraulic radius of 0.14 m, and a flow velocity of approximately 1.61 m/s.

Table 6. Parameters and results of the existing channel hydraulic analysis.

Parameter	Value	Unit
Channel width (B)	0,50	m
Channel height (H)	0,40	m
Flow depth (d)	0,32	m
Manning's coefficient (n)	0,013	-
Slope (S)	0,0067	-
Wetted cross-sectional area (A)	0,16	m²
Wetted perimeter (P)	1,14	m
Hydraulic radius (R)	0,14	m
Flow velocity (V)	1,61	m/sec
Channel capacity (Qs)	0,26	m³/sec

Source: Research analysis results, 2026

$$Q_s = A \times V = 0,16 \times 1,606 = 0,26 \text{ m}^3/\text{detik}$$

The existing channel capacity of 0.26 m³/s is lower than the design flood discharge of 1.63 m³/s. Consequently, $Q_s < Q_t$ (0.26 < 1.63); thus, the existing channel fails to meet the required capacity and poses a potential risk of inundation.

HEC-RAS Analysis of Existing Channels

Steady flow modeling in HEC-RAS was conducted using a design discharge of 1.63 m³/s, a channel length of 3,280 m, a bed slope of 0.0067, a Manning's coefficient of 0.013, and an existing channel geometry of 0.50 m × 0.40 m. The model input parameters are presented in Table 7.

Table 7. Existing channel input data for HEC-RAS

Parameter	Symbol	Value	Unit
Design discharge	Q	1,63	m³/sec
Channel length	L	3.280	m
Channel bed slope	S_0	0,0067	-
Manning's roughness coefficient	n	0,013	-
Channel width	b	0,50	m
Channel height	h	0,40	m

Source: Research analysis results, 2026

Simulation results indicate that the water level exceeds the channel bank elevation at both the upstream and downstream cross-sections. This condition demonstrates that the design flood discharge cannot be optimally conveyed by the existing channel, resulting in overflow that has the potential to cause inundation on Karadenan Road.

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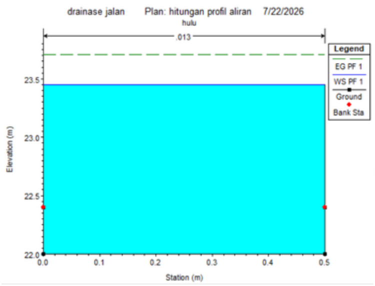

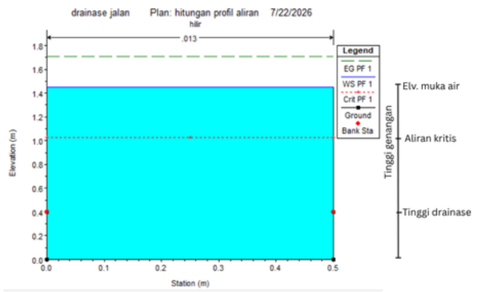

(a) Upstream cross-section *(b) Downstream cross-section*

Figure 3. HEC-RAS simulation results for the existing channel.

Source: HEC-RAS simulation results, 2026

Discussion

Evaluation of Existing Drainage Performance

The performance of the existing drainage system was evaluated by comparing the design flood discharge (derived from hydrological analysis), channel capacity (calculated using Manning's equation), and water surface profiles (obtained from HEC-RAS simulation). The design flood discharge for a five-year return period is 1.63 m³/s, whereas the existing channel capacity is only 0.26 m³/s. This comparison indicates that Qs < Qt, meaning the channel lacks sufficient capacity to convey the design runoff.

This capacity deficit is corroborated by HEC-RAS simulation results, which show the water level exceeding the channel bank elevation at several cross-sections. Channel overflow explains the potential for inundation on the roadway during a five-year return period rainfall event. Therefore, increasing capacity by adjusting channel dimensions is necessary to safely convey the design discharge.

Analysis of Drainage Dimension or Shape Adjustments

Dimensional adjustments were made in response to the condition where Qs < Qt. Based on the discharge formula Q = A × V—using a design discharge of 1.63 m³/s and a reference velocity of 1.606 m/s—the minimum required cross-sectional area is 1.012 m².

$$A_{minimum} = Q / V = 1.63 / 1.606 = 1.012 \text{ m}^2$$

The selected alternative is a rectangular channel with a width of 1.20 m and a height of 1.00 m. With a design flow depth of 0.90 m (representing 90% of the channel height), the available wetted cross-sectional area is 1.08 m². As this value exceeds the minimum area of 1.012 m², the selected dimensions satisfy the geometric requirements.

$$d = 0{,}90 \times 1{,}00 = 0{,}90 \text{ m}$$

$$A = B \times d = 1{,}20 \times 0{,}90 = 1{,}08 \text{ m}^2 > 1{,}012 \text{ m}^2$$

Hydraulic Analysis of Drainage Channel Adjustment

The capacity of the adjusted channel is calculated using a wetted cross-sectional area of 1.08 m² and a flow velocity of 1.606 m/s. The resulting channel discharge is 1.74 m³/s.

$$Q_s = A \times V = 1{,}08 \times 1{,}61 = 1{,}74 \text{ m}^3/\text{sec}$$

This value exceeds the design flood discharge of 1.63 m³/s; thus, Qs > Qt. Hydraulically, a channel with dimensions of 1.20 m × 1.00 m is capable of conveying the design flood discharge under the analyzed scenario.

HEC-RAS Analysis of Channel Modification

The performance of the adjusted channel was subsequently evaluated using HEC-RAS simulation. The discharge, channel length, bed slope, and Manning's coefficient were kept the same as in the existing model, while the geometry was modified to a width of 1.20 m and a height of 1.00 m.

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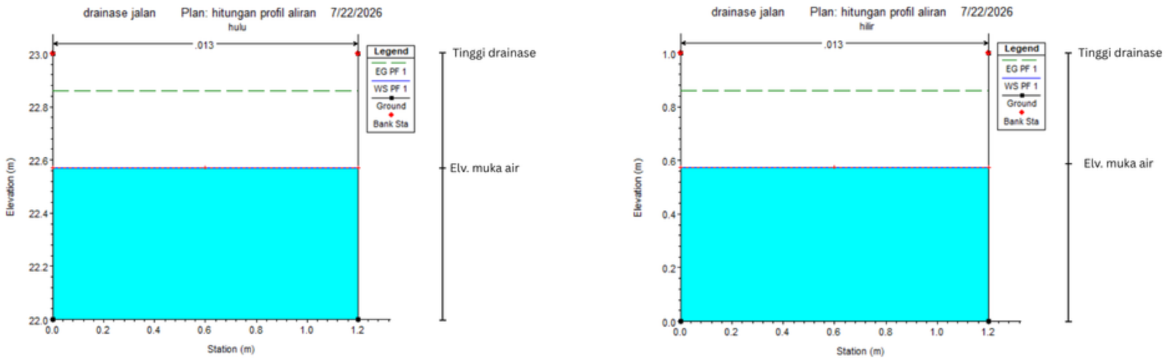
Table 8. Channel adjustment input data for HEC-RAS

Parameter	Symbol	Value	Unit
Design discharge	Q	1,63	m³/sec
Channel length	L	3.280	m
Channel bed slope	S_0	0,0067	-
Manning's roughness coefficient	n	0,013	-
Channel width	b	1,20	m
Channel height	h	1,00	m

Source: Research analysis results, 2026.

Simulation results for the upstream and downstream cross-sections indicate that the water surface elevation remains below the channel edge. Consequently, the adjusted channel is capable of accommodating the design flood discharge without overflowing under the five-year return period scenario.



(a) Upstream cross-section *(b) Downstream cross-section*

Figure 4. HEC-RAS simulation results after channel dimension adjustment.

Source: HEC-RAS simulation results, 2026

Performance Evaluation of Drainage Channel Adjustments

The final evaluation was conducted by comparing the existing conditions with the conditions following the adjustments. The channel width increased from 0.50 m to 1.20 m, and the channel height increased from 0.40 m to 1.00 m. This increase in dimensions raised the channel capacity from 0.256 m³/s to 1.74 m³/s.

Table 9. Comparison of existing conditions and conditions after adjustment

Parameter	Existing conditions	Adjustment conditions
Width (B)	0.50 m	1.20 m
Height (H)	0.40 m	1.00 m
Channel capacity (Qs)	0.256 m³/s	1.74 m³/s
Design flood discharge (Qt)	1.63 m³/s	1.63 m³/s
Capacity evaluation	Qs < Qt (does not meet requirements)	Qs > Qt (compliant)
HEC-RAS simulation	Overflow occurs	No overflow occurs

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Source: Research analysis results, 2026

Under existing conditions, the channel capacity is lower than the design discharge, and HEC-RAS simulations indicate that overflow occurs. Following adjustments, the channel capacity exceeds the design discharge, and simulations show no overflow. These results demonstrate that adjusting the dimensions to 1.20 m × 1.00 m effectively improves the drainage system's performance and can serve as a technical recommendation to mitigate inundation on Karadenan Highway.

E. CONCLUSION

Based on hydrological and hydraulic analyses and HEC-RAS software simulations, it is concluded that the design flood discharge for Jalan Raya Karadenan, based on a five-year return period, is 1.63 m^3/s. This value was derived from a design rainfall of 145.88 mm, a rainfall intensity of 46.9 mm/hour, a runoff coefficient of 0.56, and a catchment area of 0.2231 km^2. Evaluation results indicate that the existing drainage channel—measuring 0.50 m × 0.40 m—has a capacity of only 0.26 m^3/s, rendering it incapable of conveying the design flood discharge. This finding is corroborated by HEC-RAS simulation results showing that water levels at several cross-sections exceed the channel's edge elevation, creating a potential for overflow and inundation in the Jalan Raya Karadenan area.

To address this issue, the channel dimensions were redesigned to 1.20 m × 1.00 m, resulting in a flow capacity of 1.74 m^3/s—exceeding the design flood discharge. HEC-RAS simulations for the redesigned channel indicate no water overflow during a five-year return period; thus, the proposed design is deemed capable of resolving the inundation problem at the study site. To ensure optimal long-term drainage system performance, the channel capacity upgrade must be supported by routine maintenance—including the removal of sediment and debris and the inspection of inlets and outlets—as well as further studies regarding land-use changes and drainage network development in the vicinity of the study site.

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