



Capacity Analysis of Downstream Cijangkelok River Using HEC-RAS Software

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ABSTRACT

This study aims to analyze the capacity of the Cijangkelok River downstream in facing the planned flood discharge, with a hydraulic modeling approach using HEC-RAS software. Maximum daily rainfall data from five rainfall stations during the 2014-2023 period was used as the basis for calculating flood discharge using the Rational method and Nakayasu Synthetic Unit Hydrograph (HSS). The calculation results showed that the peak flood discharge for the 10, 25, and 50-year return periods reached 599.71 m³/det, 648.91 m³/det, and 682.82 m³/det using the Rational method, and 835.01 m³/det, 888.68 m³/det, and 922.90 m³/det using the Nakayasu HSS method, respectively. Flow simulations with HEC-RAS indicated that some river cross sections, especially at STA 27+950, 28+050, and 28+100, were unable to accommodate the maximum discharge, causing runoff outside the channel. This finding indicates that the capacity of the existing channel is not adequate to safely channelize flood flows. The results of this study are expected to serve as a technical reference in river normalization planning and more targeted and sustainable flood mitigation efforts.

INTRODUCTION

Water is one of the sources of life for all living things, but when in very large quantities, water can also be a problem for life. One form of problem that can be caused by a very large volume of water is flooding.

Flooding is a natural disaster that has a major impact on human survival. This disaster always comes during the rainy season. Floods often occur in lowlands or in areas around rivers. Floods occur due to several factors, namely human factors and natural factors. From human factors, floods occur due to massive deforestation, the change of infiltration areas into residential areas, poor maintenance of drainage systems and the frequent dumping of garbage in rivers out of place. Meanwhile, natural factors are caused by high rainfall intensity and sedimentation along the river.

The flood phenomenon that occurs around the Cijangkelok River is caused by several factors. Naturally, the high rainfall in this area, especially in the wet months of September to February, often increases the river water discharge to exceed its capacity. In addition, sedimentation that occurs in the riverbed due to soil erosion worsens the situation by reducing the river's flow capacity. On the other hand, human activities such as conversion of catchment land into settlements, deforestation in upstream areas, dumping of waste into the river, and inadequate drainage systems exacerbate the flood risk in this region.

In response to these problems, a comprehensive analysis is needed to understand the capacity of the Cijangkelok River and design measures to reduce the risk of flooding.

Cijangkelok River and design effective mitigation measures. One technical approach that can be used is through hydraulic analysis using the Hydrologic Engineering Center's River Analysis System (HEC-RAS) software.

HEC-RAS is software designed to simulate water flow in open channels, both in one-dimensional and two-dimensional flow conditions.

The use of HEC-RAS in analyzing the capacity of the Cijangkelok River is very important to provide a scientific basis for decision making. With simulations based on accurate information, the recommendations produced can be more targeted and efficient in efforts to reduce flood risk.

In addition, this analysis is also in line with the need for adaptation to climate change which has an impact on rainfall patterns and river flow intensity. With HEC-RAS-based modeling, future scenarios can be projected, so that planned mitigation measures are more long-term oriented.

LITERATURE REVIEW

River

In SNI 8066: 2015, it is stated that the definition of a river is a natural and / or artificial waterway or container in the form of a water flow network and the water in it, starting from the upstream to the estuary, with the right and left bounded by a border line (PP No. 38 of 2011). A unit of water system area that is formed naturally, where water will flow through rivers and tributaries is called a watershed (DAS). A river is a large, elongated stream of water that flows continuously from upstream to downstream. Rivers must be protected and

preserved, their functions and utilization improved, and their destructive power to the environment controlled (Kurniawan, 2012).

River Bearing Capacity

The wet cross section is the cross section of the water flow, while the wet perimeter is defined as the length of the side of the river cross section that is in contact with water (SNI 2830: 2008).

River storage capacity is one of the important parameters in hydraulic analysis and water resources management, especially in the context of flood control. According to the Department of Public Works (2006), river storage capacity is defined as the maximum discharge that can be carried by a river without causing runoff outside the channel. In other words, this capacity determines the limit of the river's ability to safely channel water from upstream to downstream.

According to Subekti (2015), in his research on evaluating river storage capacity in urban areas, it is known that the imbalance between incoming flood discharge and river capacity is often the main cause of flooding. Therefore, evaluating the capacity is very important in flood control planning.

In practice, capacity analysis is often conducted using hydraulic simulation with software such as **HEC-RAS**. This application is used to calculate the water level profile based on a specific discharge and the physical characteristics of the river, thus enabling the evaluation of potential water runoff (US Army Corps of Engineers, 2016).

Hydrological Cycle

According to CD Soemarto (1995), Hydrology is the science that explains the presence and movement of water in our nature, which includes various forms of water, which involves changes in its changes between liquid, solid, and gas states in the atmosphere, above and below the ground surface. According to Sri Harto (1990), in general, hydrology is intended as a science concerning water problems.

The hydrological cycle is the process of water circulation on earth that takes place continuously through the stages of evaporation, transpiration, condensation, precipitation, infiltration, and surface flow. This process serves as a natural mechanism in maintaining water balance in the atmosphere, land and oceans (Arsyad, 2010). Water that evaporates from the surface of the sea, lakes, and vegetation (evapotranspiration) rises into the atmosphere and forms clouds through the condensation process. Furthermore, water vapor falls back to the earth's surface in the form of rain or snow (precipitation), then infiltrates into the soil or flows on the surface as runoff (Chow et al., 1988).

This cycle is classified into three forms, namely: (1) short cycles, where water vapor from the ocean falls directly back into the ocean as rain; (2) medium cycles, where water vapor moves over land before undergoing precipitation and returning to the ocean via rivers; and (3) long cycles, which involve the formation of snow or glaciers, then melting and flowing into the ocean (Ward & Robinson, 2000).

Understanding the dynamics of the hydrological cycle is essential in hydrological studies, especially in the context of water resources management, flood prediction, and river basin infrastructure planning (Asdak, 2007).

Discharge

Discharge is defined as the volume of water flowing through a river/open channel cross section per unit time (SNI 8066:2015). According to (Triadmodjo 2008), river flow discharge is the amount of water that passes through the cross section of the river per unit time, which is usually expressed in cubic meters per second (m^3/s).

According to (Chow et al., 1988), discharge is the amount or rate of water flow through a cross section of a river or channel in a certain unit of time. In general, discharge is expressed in units of cubic meters per second (m^3/s) and is calculated as the product of the wet cross-sectional area and water flow velocity.

Factors that influence the size of the discharge include rainfall, watershed characteristics, soil type, land use, and vegetation cover conditions (Asdak, 2007). Changes in land use, such as urbanization and deforestation, can increase peak discharge and accelerate the response of surface flow to rainfall, which impacts the potential for flooding in downstream areas (Ward & Robinson, 2000).

Discharge measurements can be made directly in the field using tools such as current meters or through indirect approaches using empirical methods and hydrological modeling. One of the commonly used indirect approaches is the synthetic unit hydrograph (HSS) method, such as Nakayasu, Snyder, and GAMA I (Triatmodjo, 2008).

Rainfall Analysis

Rainfall is one of the meteorological parameters that greatly affects water availability, hydrological systems, and the potential for natural disasters such as floods and landslides. Understanding the characteristics of rainfall, both spatially and temporally, is important in planning and managing water resources. According to (Setiawan et al. 2020), uneven rainfall distribution can cause an imbalance between water supply and demand in an area, especially in areas with complex topography and land use.

In the context of statistical analysis, rainfall data is often analyzed using descriptive statistical methods, homogeneity tests, and probabilistic methods to determine extreme rainfall patterns. Trend and variability analysis of rainfall is also widely done to assess long-term climate change. Research by (Nugroho and Fitriani 2019) shows that the Mann-Kendall method and Sen's slope estimator are quite effective in identifying rainfall trends in the tropics.

In addition, climate classifications based on rainfall data, such as the Oldeman and Schmidt-Ferguson methods, are commonly used in the agricultural sector to determine appropriate cropping patterns. Research by (Arifin et al. 2021) confirms that rainfall-based climate classification is able to provide an overview of seasonal periodization relevant to agricultural activities in Indonesia.

The study of extreme rainfall is also important in disaster mitigation. According to (Yuliana and Prasetyo 2022), extreme rainfall events often cannot be predicted by annual averages alone, so extreme hydrological approaches such as frequency analysis using Gumbel or Log Pearson Type III distributions are needed.

HEC-RAS

HEC-RAS is a software developed by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers to simulate steady and unsteady flow of one-dimensional rivers. It allows users to analyze the water level profile, flow velocity, and energy distribution along a river cross section based on available topographic and hydrological data (Brunner, 2016).

In various studies, HEC-RAS has been widely used to evaluate river storage capacity, design flood control systems, and assess the impact of land use changes on flow conditions. According to Pratama and Wahyuni (2020), HEC-RAS simulation is able to model flood conditions based on discharge input from hydrological analysis and produce accurate inundation maps when combined with elevation data from GIS.

The implementation of HEC-RAS also allows users to examine the effect of artificial structures such as bridges, embankments, and weirs on river flow. In a study by Sari et al. (2021), the use of HEC-RAS showed that the presence of inadequate bridges can cause narrowing of the effective cross-section of the flow and increase the potential for overflow during peak discharge.

On the other hand, validation of the HEC-RAS model is a crucial part in ensuring the accuracy of the simulation results. The process of calibration and verification against actual water level data is standard in this modeling. As stated by Nurhasanah and Damanik (2019), accuracy in inputting geometry and hydrology parameters greatly affects the output results, so detailed and accurate field data is required.

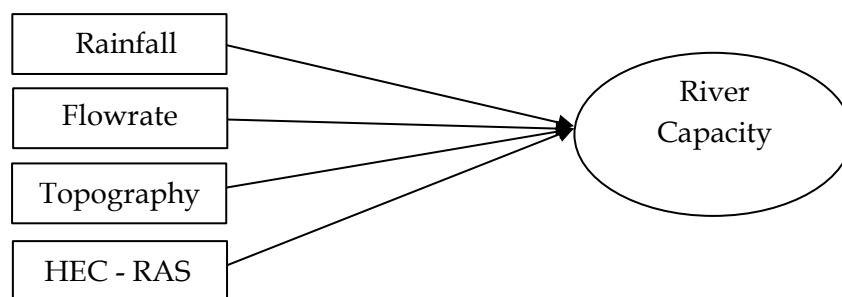


Figure 1. Thinking Framework

METHODOLOGY

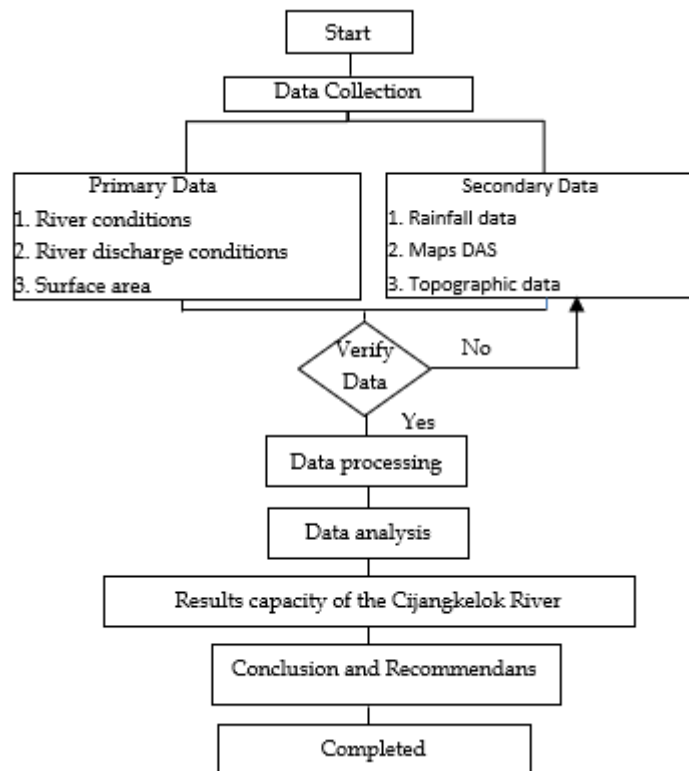


Figure 2. Framework of Thought

The basic theory underlying this research is functionalist theory, which suggests that each element in a system or structure has a specific function that contributes to the sustainability of the system. In this research, a quantitative method is used. This approach aims to measure and analyze phenomena using data in the form of numbers and statistics. Some methods commonly applied in the quantitative approach include surveys, experiments, and statistical analysis.

RESEARCH RESULTS

Determination of Watershed

Watershed processing results can be seen in the following figure:



Figure 3. Cijangkelok Watershed Map

Maximum Rainfall

The following will present a table recapitulating the maximum rainfall data of the Cijangkelok River rain station.

Table 1. Recapitulation of maximum rainfall data

Year	Rainfall Data				
	Cibingbin	Malahayu	Cibendung	Cikeusik	Jatiseeng
2014	161	114	106	119	28
2015	72	199	97	182	52
2016	70	81	87	120	86
2017	169	79	130	65	60
2018	237	136	119	110	74
2019	169	187	124	126	68
2020	103	74	166	103	70
2021	79	147	121	131	42
2022	82	126	100	85	80
2023	93	158	132	87	51

Area Rain

To be processed, point rain must be converted into area rain. There are several methods that can be used to analyze rainfall areas, but in this study the method used is the Polygon Thiessen method.



Figure 4. Polygon Thiessen results

$$\begin{aligned}
 \text{koef. thiesen} &= \frac{A_i}{A} \\
 &= \frac{0,56}{88,06} \\
 &= 0,006
 \end{aligned}$$

Table 2. Watershed area affecting 5 STAs

No	Station Name Rain	Area Represented (Ai) km ²	Thiessen coefficient Ai/A (Fk)	Percentage/Weight (%)
1	Malahayu	0,56	0,006	0,64
2	Cibendung	50,00	0,568	56,78
3	Cibingbin	22,20	0,252	25,21
4	Cikeusik	6,90	0,078	7,84
5	Jatiseeng	8,40	0,095	9,54
Total (A)		88,06	1,000	100,00

Table 3. Rainfall Calculation Results of Thissen Polgon Method

No	Year	Date	Max Rainfall with the Same Occurrence					Watershed Rainfall	Rainfall Area
			Cibingbin Station	Malahayu Station	Cibendung Station	Cikeusik Station	Jatiseeng Station		
		Coefficient	0,25	0,01	0,57	0,08	0,10		
1	2014	19-Feb-14	161	10	17	0	0	50,30	62,17
		07-Dec-14	0	114	0	14	0	1,82	
		20-Dec-14	0	0	106	7	15	62,17	
		08-Mar-14	15	20	7	119	42	21,21	
		09-Mar-14	23	23	10	27	63	19,75	
2	2015	20-Jan-15	72	1	97	63	28	80,84	80,84
		24-Jan-15	23	199	0	3	9	8,16	
		20-Jan-15	72	1	97	63	28	80,84	
		15-Nov-15	20	5	0	182	7	20,00	
		09-Mar-15	23	23	11	25	63	20,16	
3	2016	26-Nov-16	70	9	0	72	5	23,82	57,55
		28-Nov-16	13	81	12	0	0	10,61	
		21-Nov-16	32	14	87	0	0	57,55	
		31-May-16	0	8	4	120	84	19,74	
		16-Nov-16	14	4	0	0	103	13,38	
4	2017	28-Dec-17	169	0	0	0	0	42,61	73,91
		11-Feb-17	21	79	0	0	0	5,80	
		09-Jan-17	0	15	130	0	0	73,91	
		22-Mar-17	0	4	0	65	0	5,12	
		20-Jan-17	0	16	18	34	60	18,71	
5	2018	23-Feb-18	237	10	0	2	0	59,97	70,35
		12-Dec-18	0	136	0	0	0	0,86	
		06-Feb-18	6	20	119	0	12	70,35	
		26-Jan-18	0	6	12	110	0	15,47	
		16-Feb-18	60	3	22	0	77	34,98	
6	2019	28-Dec-19	169	16	0	42	22	48,10	83,17
		23-Feb-19	81	187	9	0	21	28,72	
		11-Feb-19	40	16	124	22	9	83,17	
		01-May-19	0	3	8	126	1	14,53	
		03-Mar-19	30	3	12	69	87	28,10	
7	2020	15-Apr-20	103	8	14	103	51	46,90	94,39
		27-Dec-20	56	74	14	56	17	28,55	
		29-Jan-20	0	7	166	0	1	94,39	
		15-Apr-20	103	8	14	103	51	46,90	
		24-Nov-20	12	8	13	12	86	19,60	
8	2021	06-Mar-21	79	31	0	6	0	20,58	78,76
		20-Mar-21	0	147	27	0	0	16,27	
		27-Mar-21	31	0	121	25	3	78,76	
		19-Feb-21	6	12	0	131	97	21,11	
		12-Apr-21	3	10	5	29	107	16,14	
9	2022	13-Dec-22	82	0	17	25	2	32,47	61,35
		27-Dec-22	1	126	105	5	3	61,35	
		17-Feb-22	0	10	100	9	0	57,55	
		21-Apr-22	0	10	4	85	95	18,06	
		21-Apr-22	0	10	4	85	95	18,06	
10	2023	09-Mar-23	93	28	6	1	0	27,11	90,09
		12-Jan-23	18	158	0	0	0	5,54	
		18-Jan-23	58	27	132	2	2	90,09	
		02-May-23	50	4	10	87	55	30,37	
		26-Nov-23	0	6	0	0	71	6,81	
Average			123,500	130,100	118,200	112,800	81,200	75,259	

Std. Dev	68,007	44,132	22,508	31,992	17,067	12,456
Co. Variance	0,551	0,339	0,190	0,284	0,210	0,166
Co. Kurtosis	3,913	2,945	5,070	5,558	2,664	2,910
Co. Skewness	-0,243	0,170	0,803	0,812	0,216	0,027

Frequency Analysis

Hydrological factors are not only determined by their mean values, but also by the distribution of their values, which can be greater or less than the mean. The extent of this spread-or dispersion-can be measured by parameters such as mean value, standard deviation (Sx), coefficient of variation (Cv), slope coefficient (Cs), and kurtosis coefficient (Ck).

- a. Standard Deviation (S)

$$Sx = \sqrt{\frac{\sum(xi - x)^2}{n - 1}}$$

- b. Coefficient of Variation (Cv)

$$Cv = \frac{sx}{average}$$

- c. Coefficient of Skewness (Cs)

$$cs = \frac{n \times (xi - x)^3}{(n - 1) \times (n - 2) \times sx^3}$$

- d. Kurtosis Coefficient (Ck)

$$ck = \frac{n^2 \times (xi - x)^4}{(n - 1) \times (n - 2)(n - 3) \times Sx^4}$$

Table 4. Frequency analysis recapitulation

N	Distribution	Requirement	Calculation	Conclusio
o.	Type		Result	n
1	Gumbel	Cs ≤ 1.1306 Ck ≤ 5.40	0.0269 2.9104	Meets Meets
2	Log Normal	Cs Cv ³ +3Cv = Ck = Cv ⁸ + 6Cv ⁶ + 15Cv ⁴ +16Cv ² + 3	0.5011 3.4497	Does not meet Does not meet
3	Normal	Cs = 0 Ck = 3	0.0269 2.9104	Does not meet Not Meets
4	Log Person Type III	Other than the above value/flexible		Meets

Rain Distribution with Gumbel

The method used to determine the amount of rainfall in this method is usually used to analyze surface runoff and flood frequency in a watershed. The

data generated using this method is in the form of annual maximum period rainfall data.

$$K = \frac{y_t - y_n}{s_x}$$

$$R_{max} = \text{average} + (K \times S_x)$$

Table 5. Gumbel Recapitulation

P. Recurrence (Year)	Yt	K	Rmax (mm)
10	2,2502	1,8481	98
25	3,1985	2,8468	111
50	3,9019	3,5875	120

Chi-Square

The methods used to test the alignment of the distribution analytically are using the Chi-Square and Sminov Kolmogorov methods graphically.

Table 6. Chi-Square Test Results

Clas s	Interval		P	Oi	Ei	(Ei - Oi)	(Ei - Oi) ⁽²⁾	(Ei - Oi) ² /Ei
1		<	64,5	1	2	1	1	0,5
2	64,53	<	71,3	1	2	1	1	0,5
3	71,3	<	77,5	4	2	-2	4	2
4	77,5	<	85,6	3	2	-1	1	0,5
5		>	85,6	1	2	1	1	0,5
Total				10	10	0	8	4

Table 7. Recapitulation of Chi-Square Test Results

Probability Distribution	calculated c2	c2 _{cr}	c2 > c2 _{cr}	Description
Gumbel	2	5,9910	c2 < c2 _{cr}	Accepted
Normal	1	5,9910	c2 < c2 _{cr}	Accepted
Log Normal	4	5,9910	c2 < c2 _{cr}	Accepted
Log Pearson Type 3	4	5,9910	c2 < c2 _{cr}	Accepted

Smirnov Kolmogorov

The rain distribution suitability test was conducted to determine the suitability between the calculation method and the rain data.

Table 8. Kolmogorov Smirnov Test Results

No	xi	P(Xi)	f(t)	P'(xi)	DP
1	94,39	0,09	1,54	0,17	0,08
2	90,09	0,18	1,19	0,21	0,03
3	83,17	0,27	0,64	0,24	0,03
4	80,84	0,36	0,45	0,26	0,11
5	78,76	0,45	0,28	0,46	0,01
6	73,91	0,55	-0,11	0,49	0,05
7	70,35	0,64	-0,39	0,62	0,02

8	62,17	0,73	-1,05	0,64	0,09
9	61,35	0,82	-1,12	0,70	0,12
10	57,55	0,91	-1,42	0,98	0,07
				max	0,12

Table 9. Recapitulation of Smirnov Kolmogorov Test Results

Probability Distribution	D Pmax	D Pcritical	DPmax < DPcr	Description
Gumbel	0,120	0,4090	DPmax > DPcr	Accepted
Normal	0,153	0,4090	DPmax > DPcr	Accepted
Log Normal	0,185	0,4090	DPmax > DPcr	Accepted
Log Pearson Type 3	0,840	0,4090	DPmax < DPcr	Not Accepted

Flood Discharge Analysis

The calculation of runoff water discharge is carried out with the following rational formula: "Q Max = 0.278 x C x I x A"

Table 10: Rainfall Distribution

Return Period	Method				USED
	Gumbel	Normal	Log Normal	Log Pearson	
2	75,2593	75,2593	74,3187	74,3187	75,2593
5	85,7227	85,7227	85,5913	85,6201	85,7227
10	91,2035	91,2035	92,1629	92,1939	92,1939
20	95,6878	95,6878	97,9132	98,4546	98,4546
25	97,0580	97,0580	99,7408	99,7575	99,7575
50	100,7949	100,7949	104,9003	104,9709	104,9709
100	104,2827	104,2827	109,9565	109,8826	109,9565

The calculation of runoff water discharge is carried out with the following rational formula: "Q Max = 0.278 x C x I x A"

$$\text{Intensity formula (I)} = \frac{R_{10}}{24} \times \left(\frac{24}{t}\right)^{\frac{2}{3}}$$

Table 11. Rain Intensity Recapitulation

Return Period	I 10	I 25	I 50
Discharge (m3/det)	31	33	35

Table 12. Recapitulation of Discharge Return Periods

Return Period	Q 10	Q 25	Q 50
Discharge (m3/det)	599,709	648,910	682,822

HSS Nakayasu

The method for analyzing the calculation of Cijangkelok river flow discharge is HSS-Nakayasu

$$Q_{(\max)} = \frac{A \times R}{3,6 \times (0,3 \times Tp) + T_{0,3}}$$

Table 13. HSS - Nakayasu results

Time (Hour)	Qt		
	Q10	Q25	Q50
0,00	0	0	0
0,42	441,3551	469,8296	498,3041
1,00	283,8422	302,1546	320,4671
2,00	133,3267	141,9284	150,5301
2,01	132,4065	140,9489	149,4912
3,00	80,37873	85,56445	90,75018
4,00	48,56997	51,70351	54,83706
4,40	39,72196	42,28466	44,84737
5,00	31,65582	33,69813	35,74044
6,00	21,69569	23,09541	24,49514
7,00	14,8694	15,82872	16,78803
8,00	10,19092	10,8484	11,50588
9,00	6,984471	7,435082	7,885693
10,00	4,786891	5,095722	5,404554
11,00	3,280753	3,492414	3,704076
12,00	2,248503	2,393568	2,538633
13,00	1,541039	1,64046	1,739882
14,00	1,056169	1,124309	1,192449
15,00	0,723858	0,770559	0,817259
16,00	0,496105	0,528112	0,560118
17,00	0,340011	0,361948	0,383884
18,00	0,233031	0,248065	0,263099
19,00	0,159711	0,170014	0,180318
20,00	0,10946	0,116521	0,123583
21,00	0,075019	0,079859	0,084699
22,00	0,051415	0,054733	0,05805
23,00	0,035238	0,037512	0,039785
24,00	0,024151	0,025709	0,027267

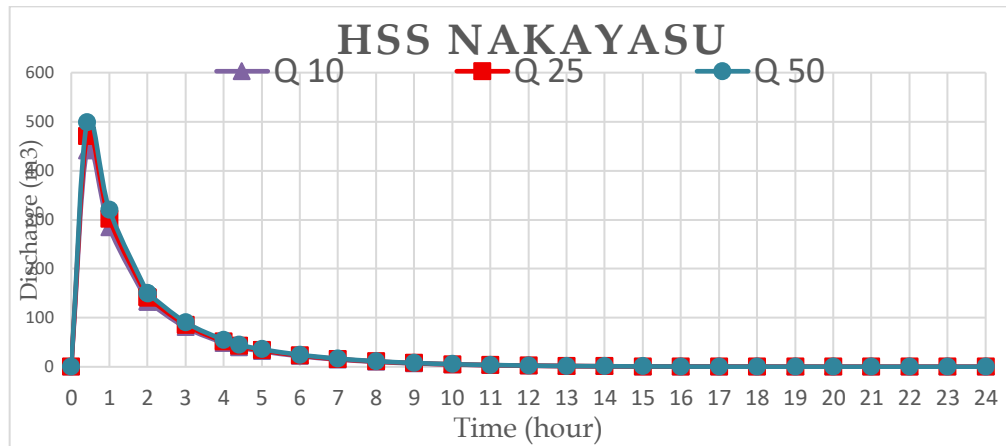


Figure 5. Nakayasu HSS Return Period Q10, Q25, Q50

HEC-RAS

River flow modeling in HEC-RAS is based on topographic measurement data in the field where river flow data from upstream to downstream are digitized in HEC-RAS then enter the cross section data in the cross section window as shown in Figure 5.

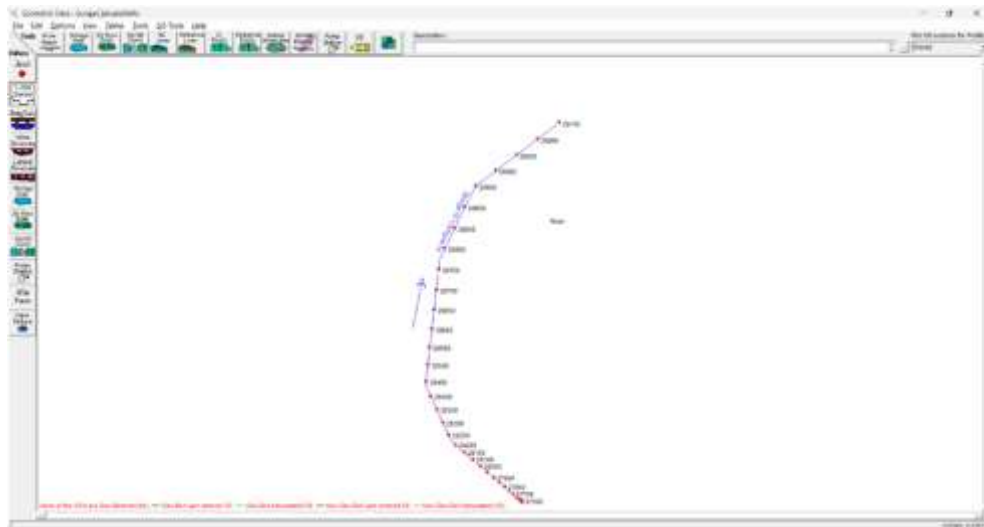


Figure 6. Cijangkelok River Flow Modeling

Extreme depth occurs at STA 28 + 100. Where the river water overflows due to the condition of the cross section that is not good enough.

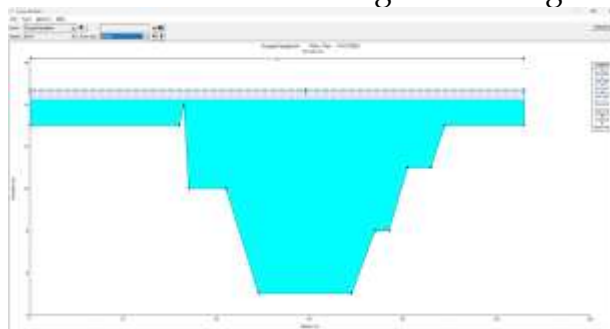


Figure 7. section at STA 28 + 100

The following is a cross-sectional image of the HEC-RAS results that exceed the embankment on the cijang kelok river:

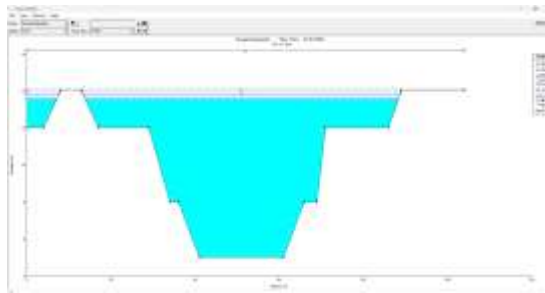


Figure 8. STA 27+950

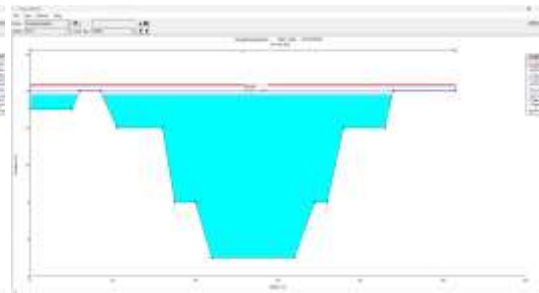


Figure 9. STA 28+000

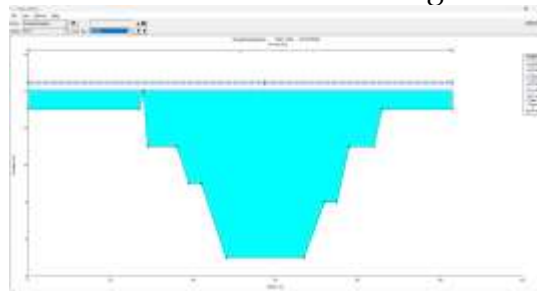


Figure 10. STA 28+050

The following are cross-sectional images of HEC-RAS results that do not exceed the embankment on the cijangkelok river:

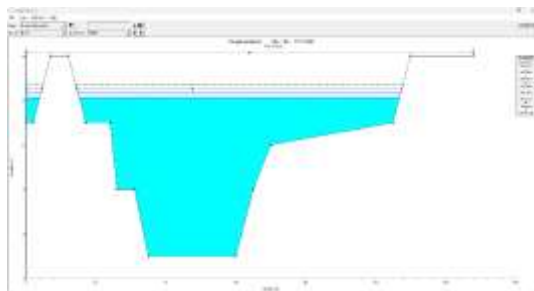


Figure 11. STA 27+600

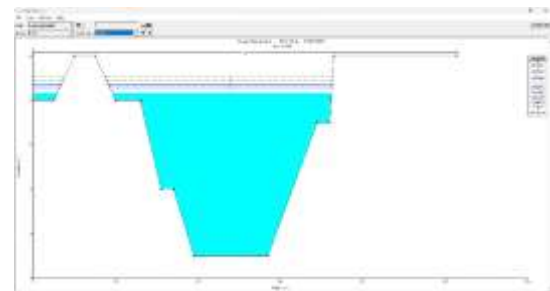


Figure 12. STA 27+700

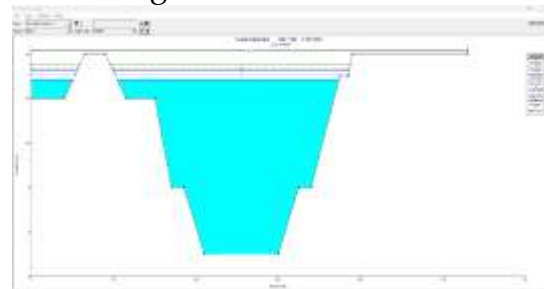


Figure 13. STA 27+800

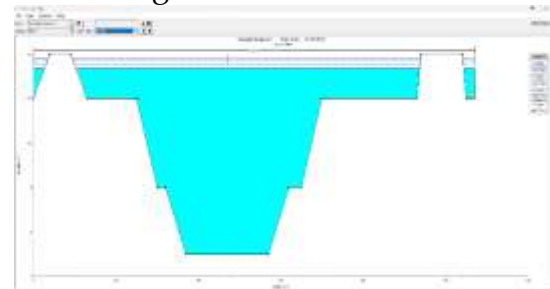


Figure 14. STA 27+900

DISCUSSION

Based on the results of the Cijangkelok River capacity research analysis, it shows that several river cross sections are unable to accommodate the 50-year return period flood discharge. The cross sections at STA 27+950, STA 28+050, and STA 28+100 experience overflow because the water level exceeds the existing embankment or riverbank. This condition indicates that the capacity of the existing

cross section is not sufficient to channel the peak discharge. In contrast, the cross sections at STA 27+600, 27+700, 27+800 and 27+900 are still able to accommodate flows up to Q50 discharge, indicating variations in geometric conditions and local capacity along the river.

CONCLUSIONS AND RECOMMENDATIONS

From the results of the research mentioned for hydrological calculations using 5 rain stations namely STA Cibendung, STA Cibingbin, STA Cikeusik, STA Malahayu, and STA Jatiseeng. The calculation resulted in the following return period discharge: Q10 = 599.7091 m³/det, Q25 = 648.9097 m³/det, and Q50 = 682.8221 m³/det.

The calculation of the Hydrological analysis used is the rational method and runoff calculation using the Nakayasu HSS, the rational method is used because the watershed area is less than 100km² and the Nakayasu HSS method is chosen because the Nakayasu HSS is the main choice in Indonesia because its empirical coefficients, such as peak discharge coefficients and time coefficients, have been calibrated and validated widely with data from watersheds in Indonesia and the Asian region in general. This makes it more suitable and provides more accurate results for local hydrological conditions than other HSSs that may be developed in very different climates or geographies (eg HSS SCS developed in the United States).

From the results of research and modeling using HEC-RAS, it can be concluded that the downstream Cijangkelok River has an inadequate capacity to cope with the planned flood discharge for the 50-year return periods. This is concerning, considering river planning uses a lower return period discharge, namely Q10, as the benchmark for normal river capacity.

This is evidenced by the inundation or overflow of water in several river cross sections, especially when the maximum discharge occurs. In the analysis of the Cijangkelok River cross section in the HEC-RAS program, there is some runoff through the embankment, such as at STA 27+950, STA 28+850, and 28+100.

ADVANCED RESEARCH

Further research is recommended to use a two-dimensional (2D) model or a combination of 1D-2D in HEC-RAS to obtain more detailed inundation simulation results, especially in residential areas. Integration with GIS data and satellite images is also required for spatial mapping of affected areas. In addition, it is necessary to calibrate the hydraulic model using actual water level data to improve simulation accuracy. Further research could also include evaluating flood control scenarios, such as river widening, levee construction and retention ponds. Social and economic aspects analysis is also added to strengthen technical recommendations oriented towards community-based mitigation.

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