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VOLUME ANALYSIS OF NORMALIZATION OF THE TELUK DALAM RIVER IN BANJARMASIN CITY USING HEC-RAS SOFTWARE

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ABSTRACT

Teluk Dalam River in Banjarmasin City has a boundary line of less than 5 meters. This causes people to have direct contact with the river, which makes it easy to dispose of waste that will cause sedimentation. Floods can occur at any time with shallowing of the channel, narrowing of the river dimensions, and the increasing population which results in reduced water catchment areas coupled with high rainfall intensity. HEC-RAS 6.5 software will simulate overflows in the river with return periods of 2, 5, 10, and 25 years. Calculation of planned rainfall using the Log Person III distribution method using rainfall data from the Syamsudin Noor Banjarmasin Class II Meteorological Station, rainfall intensity using the mononobe method, and calculation of planned discharge using the rational method. After simulation using HEC-RAS software between the planned discharge of the return period and the existing cross-section, overflows occur at every return period along the river. Normalization is needed so that the planned discharge of the return period can flow without endangering the surrounding environment. A normalization simulation was carried out in the form of changing the cross-section dimensions by increasing the depth of the river so that a dredging volume of 24,708 m3 was obtained.

Keywords: *Normalization, Flood, HEC-RAS*, *Unsteady Flow*, *Teluk Dalam River*

1. INTRODUCTION

The city of Banjarmasin, which is dubbed the "City of a Thousand Rivers" and is fed by many waterways, both natural and artificial, ironically is still often hit by floods and puddles. In 2021, floods hit South Kalimantan Province with heights ranging from 30 cm to 3 m (Bioresita et al., 2022). There are dozens of villages in Banjarmasin City that are affected by this flood, including Teluk Dalam Village. The high intensity of rainfall makes the tide enter the Barito River and the Martapura River to other tributaries which causes river water to overflow and inundate residential areas (Sukarli, 2021).

The Teluk Dalam River which stretches along Jalan Mayjend. Sutoyo S., Teluk Dalam Village, now has a boundary line distance of less than 5 meters from settlements which causes the community to have direct contact with the river so that it is easy to dispose of waste that will result in sedimentation (Muzaidi et al., 2018). The increasing number of people results in a decrease in water catchment areas, increasing waste

discharge, increasingly shallow channel beds due to sedimentation, and high rain intensity causing flooding to occur at any time. River normalization with the main goal of reducing the risk of natural disasters such as floods, restoring the hydrological function of rivers, and improving water quality is an alternative to this problem.

2. THEORETICAL STUDY

Analysis of Frequency

Frequency analysis on hydrological data was carried out to find a relationship between the magnitude of extreme event values and the frequency of occurrence using a probability distribution. The frequency analysis begins with the collection of data series which are divided into partial series and annual maximum data. Followed by the calculation of statistical parameters consisting of the average value parameter ($\bar{X}$), standard deviation (S), coefficient of variation (Cv), coefficient of skewness (Cs), and coefficient of kurtosis (Ck). The calculation continued by matching the values of statistical parameters with the appropriate distribution type, consisting of Normal Distribution, Gumbel Distribution, Log Person III Distribution, and Normal Log Distribution (Triatmodjo, 2008). The probability distribution match test aims to determine whether the selected opportunity distribution equation can be representative of the statistical distribution of the analyzed data sample. The distribution was tested for alignment with the chi-square test and the smirnov-kolmogorov test (Indarto, 2016).

Flood Discharge Plan

The calculation of planned flood discharge has the purpose of determining the amount of discharge that occurs based on rainfall data. To calculate the planned flood discharge in this study using the Rational Method. Some of the hydrological parameters taken into account in this Rational Method are rain intensity, rain duration, rain frequency, watershed area, water loss due to evaporation, interception, infiltration, surface catchment, and flow concentration (Triatmodjo, 2008).

River Normalization

River normalization can be defined as a systematic effort to restore the function of the river as a rainwater catcher and flood control. This series of technical measures is carried out to ensure that the river can accommodate very high water discharge without overflow/runoff (Chendratama et al., 2013).

Software HEC-RAS

HEC-RAS is one of the application programs that functions to model the flow of water in rivers. HAC-RAS has 4 components of the dimensional model, namely the calculation of the permanent flow water level profile, the simulation of non-permanent water flow, the calculation of sediment transport, and the calculation of water quality (Istiarto, 2014).

HEC-RAS software will assist in the analysis of river capacity. The input data that must be entered to perform hydraulic analysis in the HEC-RAS program are river geometric data and manning coefficient. Thus producing water level elevation output data along the channel and the flow profile reviewed (Salman et al., 2021).

3. METHOD

Research Location

The Teluk Dalam River, which has a river length of 3.428 meters, flows along Jalan Mayjend. Sutoyo S., Teluk Dalam Village, Central Banjarmasin District, Banjarmasin City, South Kalimantan. The location of the study can be seen in Figure 1 below.

Figure 1. Data Collection Location

Data Sources and Types

The data used in this study included primary data in the form of existing river geometry data obtained using an echosounder device and river flow velocity data

measured using a current meter. The secondary data in this study includes maximum daily rainfall data for the last 49 years from the Class II Syamsudin Noor Banjarmasin Meteorological Station, data on the area of river watersheds reviewed and measured with Google Earth Pro version 7.1 map, and tidal data obtained from the Nautide application on the Barito River because it is the mouth of the Teluk Dalam River.

Data Analysis

Data analysis was carried out in the form of hydrological analysis and hydraulic analysis. Hydrological analysis is in the form of frequency analysis from determining data series taking, and calculating statistical parameters to obtaining a satisfactory distribution, followed by a probability match test. The next hydrological analysis is the calculation of concentration time, rainfall intensity, and the discharge value of the plan for 2, 5, 10, and 25 years.

Hydraulic analysis was carried out using HEC-RAS 6.5 software, simulating the existing cross-section with the discharge of the re-period plan and tidal data. The output of this analysis is the maximum water level and the water level of the hours that will show the runoff or not in the existing cross-section of the river. Runoff occurs when the maximum water level exceeds the height of the river bank. In the cross-section of the river that experiences runoff, normalization must be carried out by changing the cross-sectional dimensions by increasing the depth of the channel as a simulation to obtain the volume of dredging that will be carried out on the cross-section of the river.

4. RESULTS AND DISCUSSION

Analysis of Frequency

The data series were taken using the annual maximum series method and continued with the calculation of statistical parameters seen in Table 1.

Table 1. Statistical Parameters

No	X	$(x-\bar{x})$	$(x-\bar{x})^2$	$(x-\bar{x})^3$	$(x-\bar{x})^4$
1	62	-40,66	1653,50	-67236,76	2734066,04
2	62,2	-40,46	1637,28	-66249,53	2680672,17
3	62,2	-40,46	1637,28	-66249,53	2680672,17
4	68	-34,66	1201,54	-41649,37	1443703,09
5	70,5	-32,16	1034,48	-33272,11	1070139,84
6	74	-28,66	821,58	-23549,25	674998,26
7	74	-28,66	821,58	-23549,25	674998,26
8	78,9	-23,76	564,69	-13418,94	318877,93
9	79	-23,66	559,95	-13250,25	313544,14
10	79,1	-23,56	555,23	-13082,97	308277,55
11	80	-22,66	513,62	-11640,39	263809,20

No	X	(x-$\bar{x}$)	(x-$\bar{x}$)^2	(x-$\bar{x}$)^3	(x-$\bar{x}$)^4
12	84	-18,66	348,32	-6500,74	121325,06
13	85	-17,66	311,99	-5510,78	97338,35
14	85,4	-17,26	298,02	-5144,80	88816,12
15	86	-16,66	277,66	-4626,80	77097,52
16	86,1	-16,56	274,34	-4544,00	75263,40
17	87	-15,66	245,34	-3842,79	60190,68
18	90	-12,66	160,36	-2030,66	25714,78
19	92,4	-10,26	105,33	-1081,08	11095,38
20	93,1	-9,56	91,46	-874,62	8364,21
21	94,3	-8,36	69,94	-584,96	4892,19
22	95,4	-7,26	52,76	-383,17	2783,09
23	97	-5,66	32,07	-181,64	1028,65
24	98,9	-3,76	14,16	-53,30	200,57
25	100	-2,66	7,09	-18,89	50,31
26	101	-1,66	2,77	-4,60	7,65
27	102,8	0,14	0,02	0,00	0,00
28	105,2	2,54	6,44	16,32	41,41
29	105,3	2,64	6,95	18,33	48,34
30	109,3	6,64	44,05	292,32	1940,07
31	111	8,34	69,50	579,41	4830,41
32	111,8	9,14	83,48	762,73	6968,90
33	112,1	9,44	89,05	840,36	7930,25
34	113	10,34	106,85	1104,46	11416,51
35	115	12,34	152,20	1877,59	23163,32
36	117,5	14,84	220,13	3265,99	48456,64
37	117,5	14,84	220,13	3265,99	48456,64
38	118,2	15,54	241,39	3750,41	58269,19
39	119,8	17,14	293,67	5032,51	86240,70
40	119,8	17,14	293,67	5032,51	86240,70
41	120,8	18,14	328,94	5965,92	108202,28
42	122,1	19,44	377,79	7342,94	142722,76
43	123,4	20,74	430,01	8917,05	184910,46
44	126,5	23,84	568,19	13543,79	322839,79
45	127,6	24,94	621,84	15506,68	386685,90
46	136,1	33,44	1118,02	37382,78	1249958,05
47	136,2	33,54	1124,71	37719,19	1264978,37
48	145	42,34	1792,40	75884,33	3212694,55
49	249	146,34	21414,44	3133719,21	458578237,1
Total	**5030,5**	**0,000**	**42896,2**	**2953289,7**	**479573159,0**

a. Mean

$$\bar{X} = \frac{5030,5}{49} = 102,66$$

b. Standard Deviation

$$S = \sqrt{\frac{42896,2}{49-1}} = 29,89$$

c. Coefficient Of Variation

$$C_v = \frac{29,89}{102,66} = 0,29$$

d. Coefficient of Skewness

$$C_s = \frac{49\ x\ (2953289,7)}{(49-1)(49-2)\ x\ 29,89^3} = 2,401$$

e. Coefficient Of Kurtosis

$$C_k = \frac{49^2\ x\ (479573159,0)}{(49-1)(49-2)(49-3) x\ 29,89^4} = 13,893$$

Based on the results of the calculation above, an analysis was carried out with distribution conditions to select distribution opportunities that met the Table 2.

Table 2. Selection of Distribution Type

Distribution	Condition	Results	Description
Normal	Cs≈0	2,401	Unqualified
	Ck=3	13,893	Unqualified
Gumbel	Cs≈1,14	2,401	Unqualified
	Ck≈5,4	13,893	Unqualified
Log Pearson III	Cs≠0	2,401	Qualified
Log-Normal	Cs≈3Cv+Cv^2	0,1702	Unqualified
	Ck=5,388	13,893	Unqualified

The type of distribution that meets based on the calculation of the previous statistical parameters is Log Person III, then a match test will be carried out with the chi-square test and the smirnov-kolmogorov test which results in an acceptable probability distribution.

Flood Discharge Plan

This study uses the Rational Method as a method to estimate the planned flood discharge. This method considers the area of the flow area, rainfall intensity, and surface flow coefficient so that the results of the calculation of flood discharge for the 2, 5, 10, and 25-year re-period plan are obtained as follows.

Table 3. Planned Debit Calculation Results

Recurrence Time	I (mm/jam)	C	A (km^2)	Peak Discharge (m^3/detik)
2	26,403	0,653	0,24	1,150
5	33,235	0,653	0,24	1,448
10	38,056	0,653	0,24	1,658
25	57,468	0,653	0,24	2,504

Existing Cross-Section Simulation

The existing cross-section simulation uses HEC-RAS software as a tool with 1D unsteady flow modeling. Simulation of the existing cross-section of the river by entering cross-sectional dimension data on 7 cross-sections along the river as seen in Figure 2. Furthermore, the upstream of the river, Flow Hydrograph data is entered in the form of peak discharge of the re-period, and in the downstream part of the river, Stage Hydrograph data is entered in the form of tidal data to simulate the water level of the estuary.

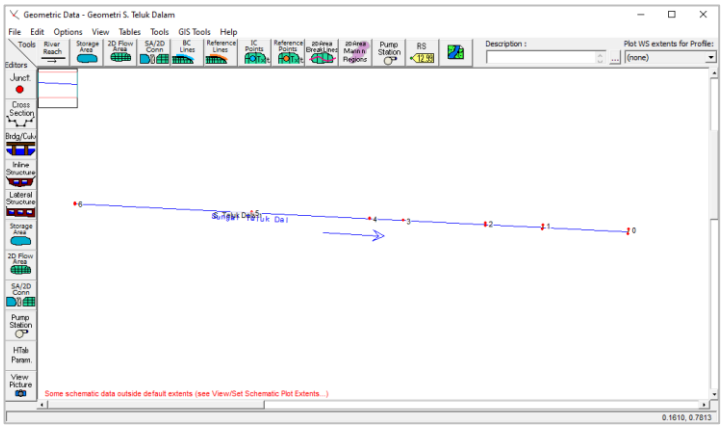


Figure 2. Geometry of Teluk Dalam River

The following is a recapitulation of the HEC-RAS output at each re-interval and each existing cross-section to determine whether runoff occurs at that cross-section.

Table 4. Existing Cross-section HEC-RAS Output Recapitulation

Recurrence time	River Sta	Q Total (m^3/s)	V (m/s)	River Bank (m)	W.S Elevation (m)	Description
2	C1	1.15	0,08	0,96	1.66	Overflow
	C2	1.14	0,12	0,87	1.65	Overflow
	C3	1.14	0,14	0,95	1.63	Overflow
	C4	1.14	0,24	1,18	1.62	Overflow
	C5	0.71	0,03	1,5	1.60	Overflow
	C6	0.58	0,02	1,5	1.60	Overflow
	C7	0.01	0	1,5	1.60	Overflow
5	C1	1,45	0,1	0,96	1,69	Overflow
	C2	1,44	0,14	0,87	1,67	Overflow
	C3	1,44	0,17	0,95	1,65	Overflow
	C4	1,43	0,3	1,18	1,63	Overflow
	C5	1,03	0,04	1,5	1,61	Overflow
	C6	1,01	0,03	1,5	1,60	Overflow
	C7	0,33	0,01	1,5	1,60	Overflow
10	C1	1,66	0,12	0,96	1,72	Overflow
	C2	1,64	0,16	0,87	1,69	Overflow
	C3	1,64	0,19	0,95	1,66	Overflow
	C4	1,64	0,34	1,18	1,64	Overflow
	C5	1,25	0,05	1,5	1,61	Overflow
	C6	1,23	0,03	1,5	1,60	Overflow
	C7	0,55	0,01	1,5	1,60	Overflow
25	C1	1,66	0,16	0,96	1,89	Overflow
	C2	1,64	0,22	0,87	1,84	Overflow
	C3	1,64	0,26	0,95	1,79	Overflow
	C4	1,64	0,44	1,18	1,74	Overflow
	C5	1,25	0,09	1,5	1,68	Overflow
	C6	1,23	0,05	1,5	1,68	Overflow
	C7	0,55	0,03	1,5	1,60	Overflow

From the results of the HEC-RAS software simulation on the Teluk Dalam River with a range of 2, 5, 10, and 25 years in each cross-section, it overflowed. This runoff

occurs because the existing cross-section of the river is unable to accommodate the discharge of the re-period in each period, therefore it is necessary to carry out normalization in the form of increasing the depth of the river so that the planned discharge can be accommodated.

Dredging Volume

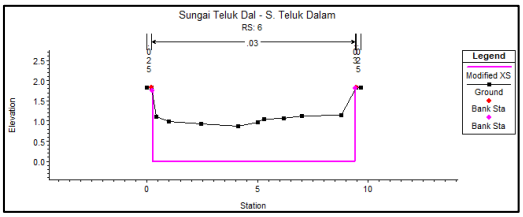
The dredging volume is obtained directly after the modification of the Teluk Dalam River cross-section so that the discharge of the re-period plan can flow without runoff. This volume is calculated based on the length, width, and depth of the dredging area on the river. The following is a table of dredging output at each cross-section and dredging along the Teluk Dalam River.

Table 5. HEC-RAS Output Dredging Volume of Teluk Dalam River

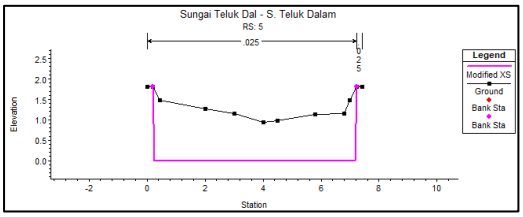
No	River	River Sta	Length (m)	Cut Volume (m^3)
1	Sungai Teluk Dalam	C1 to C2	1095	9813
2		C2 to C3	730	5586
3		C3 to C4	209	915
4		C4 to C5	510	2161
5		C5 to C6	354	2380
6		C6 to C7	530	3853
Total			**3428**	**24708**

Based on Table 5, Teluk Dalam River with a river length of 3.428 meters requires a total dredging volume of 24.708 m^3. The following is a comparison of the dimensions of the existing cross-section of the river with the cross-section after normalization.

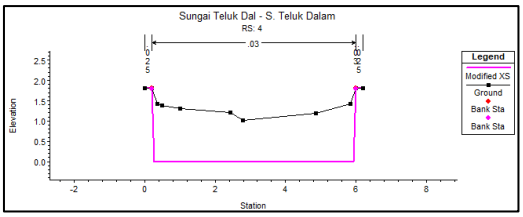
Cross 1



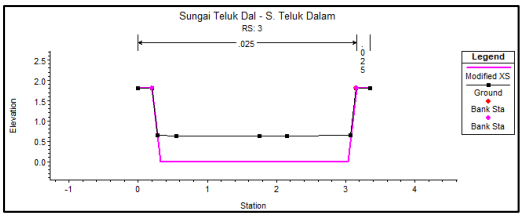
Cross 2



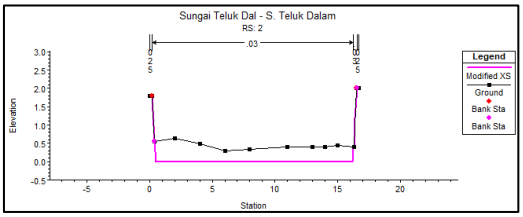
Cross 3



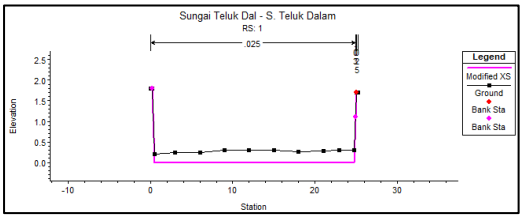
Cross 4



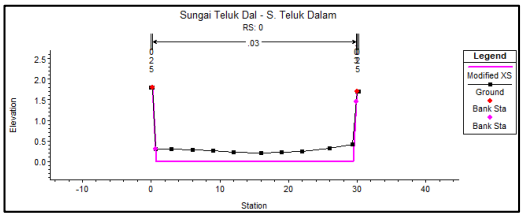
Cross 5



Cross 6



Cross 7



5. CONCLUSION

The hydrological analysis of the Teluk Dalam River uses the maximum rainfall data of the last 49 years with a distribution that satisfies the Pearson III Log. The re-cycles used are 2, 5, 10, and 25 years with planned flood discharge results of 1,150 m^3/second, 1,448 m^3/second, 1,658 m^3/second, and 2,504 m^3/second. From the results of the simulation of the existing cross-section using HEC-RAS software, the existing cross-section along the river is not able to accommodate the flood discharge of the re-period plan. Normalization was carried out by changing the cross-sectional dimensions by increasing the depth of the channel so that a dredging volume of 24.708 m^3 was obtained.

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