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Modeling of a healthy river boundary

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Abstract. The concept used in river management as an effort to prevent flooding is one of them with the concept of hydraulic engineering, namely non-structural river management through efforts to restructure river banks as inundation areas. This concept is carried out by integrating the ecological and hydraulic components of the river. Ecological components on river banks can be used as hydraulic retention components that hold water flow so that flooding occurs on river banks. With the presence of puddles on the banks of the river, the ecological quality of the river can be maintained. Develop a river boundary determination model by optimizing the width of river banks. Maros River boundary with a distance of 50 meters from the edge of the riverbed which is the River Utilization Area. There is a meander or river bend that is quite sharp, that is, at Sta. 20 + 00 to Sta. 23 + 00 so the determination of the alignment follows the outer arch.

1. Introduction

The utilization of water resources that are increasing without taking into account environmental capacity has caused various problems. One of the environmental problems in Indonesia is the degradation of river basin ecosystem functions. In Government Regulation number 121 of 2015 concerning the Concession of Water Resources, it is described that the watershed is a land area which is a unit with the river and its tributaries, which functions to accommodate, store and drain water from rainfall to the lake or to the sea naturally, the land boundary is a topographical separator and boundary in the sea up to the waters that are still affected by land activities. This ecosystem function is very important to the availability of water resources. However, this function decreases due to human activities.

River management and non-structural flood prevention are carried out by structuring river banks which are used as inundation areas. This concept is carried out by integrating the ecological and hydraulic components of the river. Ecological components on river banks can be used as hydraulic retention components that hold water flow so that flooding occurs on river banks. With the presence of puddles on the banks of the river, the ecological quality of the river can be maintained [1].

Riverbanks must be managed according to their characteristics as a flood plain. The flood plain which is actually a river channel that was passed by water only during the flood, when there was no flooding this plain became part of the land system. Floodplains can take the form of vast land and can be used for various activities, but considering the floodplain is actually a river channel, the allocation needs to be regulated only for activities that are in accordance with the characteristics of the plains.

Watershed management aims to maintain the environmental services it provides, namely the balance of the hydrological system in nature. This balance is indicated by the quantity of water, the quality of water, the ratio of maximum and minimum discharge and groundwater level. Indicators of watershed ecosystem balance are strongly influenced by the condition of vegetation, soil quality, and river conditions. A river performance index is determined by watershed area, river length, river slope, watershed geological conditions, breakage density, rainfall, land use, percentage of forest area, controlled percentage of surface flow and density of occupation in the river area.

River when viewed from its shape, the river morphology describes the integration between abiotic characteristics (physical, hydrological, hydraulics, sediments, etc.) and the biotic (biological or ecological) characteristics of the region through which it passes. Factors that influence river morphology are not only abiotic and biotic factors but also a human intervention in their activities to develop in the river area (socio-anthropogenic). The influence of human intervention can lead to changes in river morphology which is much faster than the natural effects of abiotic and biotic only.

The river morphology is essentially an external form was described in previous study [2], which is detailed in figure 1.

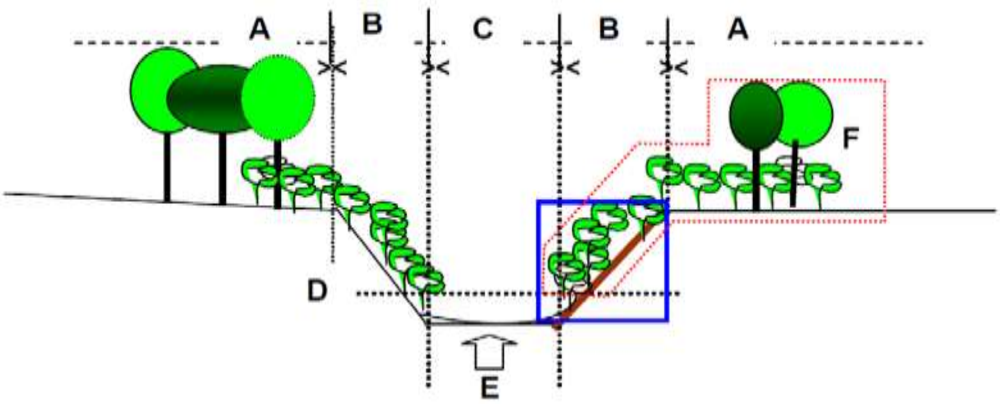

Figure 1. River morphology.

Morphology of the river does not only include the river body but also the surrounding area. Area A is the riverbank which is a boundary between the river body and the surrounding flat area. Area B is a river bank which is a boundary for the flow area. Area C is the river body and D shows the water level. Vegetation that grows on the banks and riverbanks (F) is also called riparian vegetation.

River border is an area considered in improving the function of aquatic and terrestrial ecology, water quality, hydraulics, and river morphology. Determining river border-width varies depending on the purpose of its use. The river border function for the sake of environmental quality seems to be ignored. At present most of the rivers in agricultural areas have reduced their function to drainage with little self capacity and development of minimal natural conservation values. River conservation is carried out with straightening and dredging to meet water needs for agriculture.

Reduction of river flow length and lack of meandering due to alignment will shorten time retention and reduce hydraulic dissipation energy. This change in physical conditions causes river water to flow faster into the sea, reduced self-cleaning capacity and increased nutrient transport to the sea. Reducing water storage functions will reduce habitat availability for fish and other types of aquatic animals. Furthermore, the absence of flood banks will increase the runoff volume and reduce the water balance function. Biodiversity will also be reduced due to the absence of flora and fauna on the flood banks. Vegetation on flood banks can reduce sediment transport in rivers. As a water source, rivers are very useful in human life, so the river must be managed well in order to maintain the continuity of its function based on its characteristics and complexity [3]

River protection efforts can be carried out structurally (civil technical) and nonstructural (vegetative)[4]. However, in general, river management efforts are carried out structurally. Structural river border management which is still the main choice despite having an impact on biotic and abiotic environmental conditions. This happens because the management only takes into account the hydraulic characteristics without taking into account ecological and social characteristics.

2. Methodology

2.1. Location

Maros River Basin covers an area of 672.24 km2 stretching from east to west located at 4o58'2.96 "- 5o12'53.05" South Latitude and 119o28'31.02 "- 119o47'54,8" East Longitude. Whereas based on the Maros River Administration itself in this study located in the District of Marusu, Turikale, and Maros Baru according to figure 2.

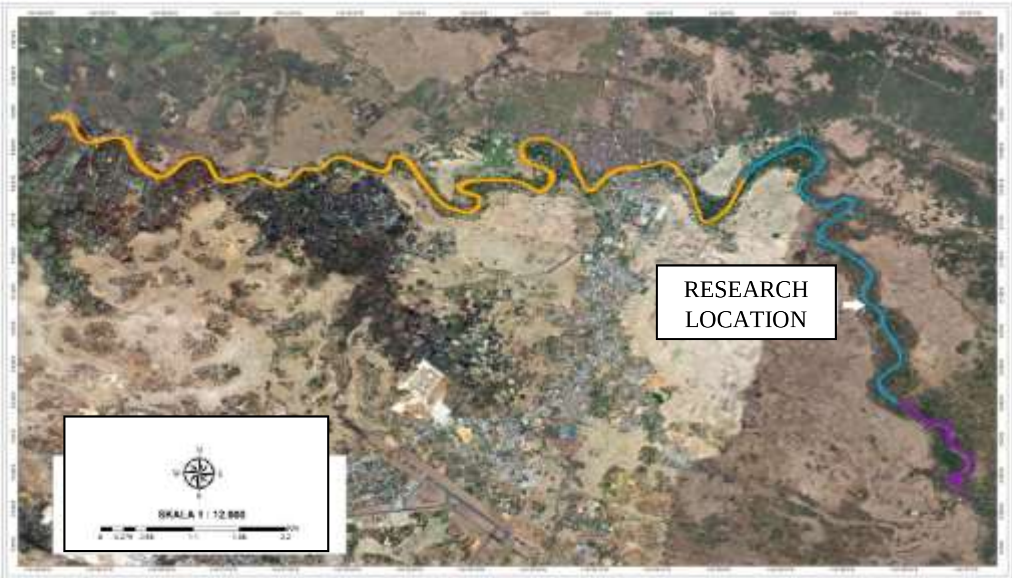

Figure 2. Research location.

2.2 Topographic measurement

Topographic measurements are needed to determine the real condition of the activity location, the condition of the original land contour in the field. This survey is conducted through aerial photography and detailed location identification surveys. This activity produces contoured photo maps that have a scale of 1: 2000 with 1-meter contour intervals and longitudinal and transverse sections of rivers. The results of this topographic measurement survey will be used in hydraulics analysis and delineation of river border lines. Measurements along 7.5 km with intervals of each cross-section of 100 m.

2.3 Hydrological data analysis

Investigation of hydrological data, in general, is carried out in order to determine the flood discharge design that will be used as a basis for hydraulic analysis to determine the water depth and or river water level profile and flood plains that occur in the design flood discharge with a certain return period. Then the results of this investigation are important data that will be used to determine the river borderline (GSS) in accordance with the applicable criteria and references.

The rain stations used in this work are Batu Bassi rain station, Bonti Bonti rain station, and Pakelli rain station. Figure 3 is a map of the location of the rain and polygon stations used in the hydrological analysis that can represent rain conditions (hydrology) in the Maros River watershed. Design flood discharge at the study site was calculated using the Nakayasu HSS method.

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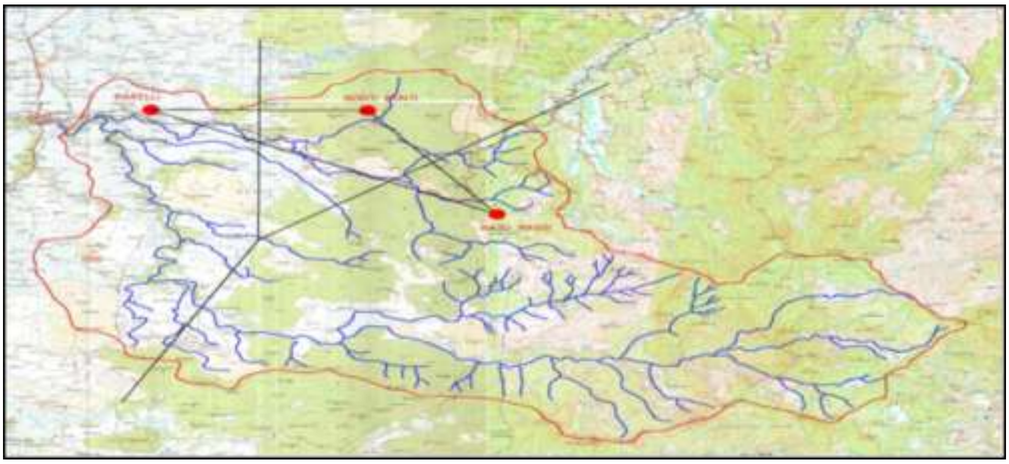

Figure 3. Map of Thiessen watershed and polygon.

2.4 Hydraulics analysis

Hydraulics analysis of water level profile details in various conditions of flood discharge plan to determine the extent of river crossing capacity in flowing flood discharge. Based on the profile of the water level in each cross-section of the river, then it can be known how far the risk of flooding (flood water level and runoff range) might occur. This is one part of the technical analysis which will later be used as one of the considerations in the work of the research on the determination of the river boundary aims to determine in-depth determine the needs of the river width. The method used in estimating the capacity and calculating the river waterfront profile using the Rational formula and Stickler formula translation :

$$Q = A\ x\ V \tag{1}$$

$$V = k\ R_3^2\, I_2^1 \tag{2}$$

which :	Q	=	discharge plan (m^3/det)
	k	=	Stickler's roughness coefficient (m^3/det)
	I	=	slope of the riverbed
	A	=	river crossing area (m^2)
		=	h^2 (n+m)
	n	=	base width ratio with slope
		=	b/h
	m	=	cliff slope
	P	=	wet round
		=	$h(n+2\sqrt{(1+m^2)})$
	R	=	hydraulic radius
		=	A / P

To determine the water level of Q50 and Q100 using the formula:

$$Q = A\ x\ V \tag{3}$$

$$A = \frac{Q}{V} \tag{4}$$

$$H = \sqrt{\frac{A}{n+m}} \tag{5}$$

Which : Q = Debit 50 years, Debit 100 years, m3/s
V = Maximum speed, m/s
H = Maximum water level, m
A = Cross sectional area, m^2
n = b/h
m = Slope length

3. Result and discussion

Based on the method described above, it is generally carried out to determine the flood discharge design that will be used as a basis for hydraulic analysis to determine the water depth and / or river water level profile and flood plains that occur at design flood discharge with a certain return period. The results of this analysis are important data that will be used to determine the river borderline in accordance with the applicable criteria and references. The results of the analysis have been done as follows:

The results of cross-sectional measurements of rivers in accordance with figure 4 and figure 5.

Figure 4. Cross Section Layout Map CS77 – CS1.

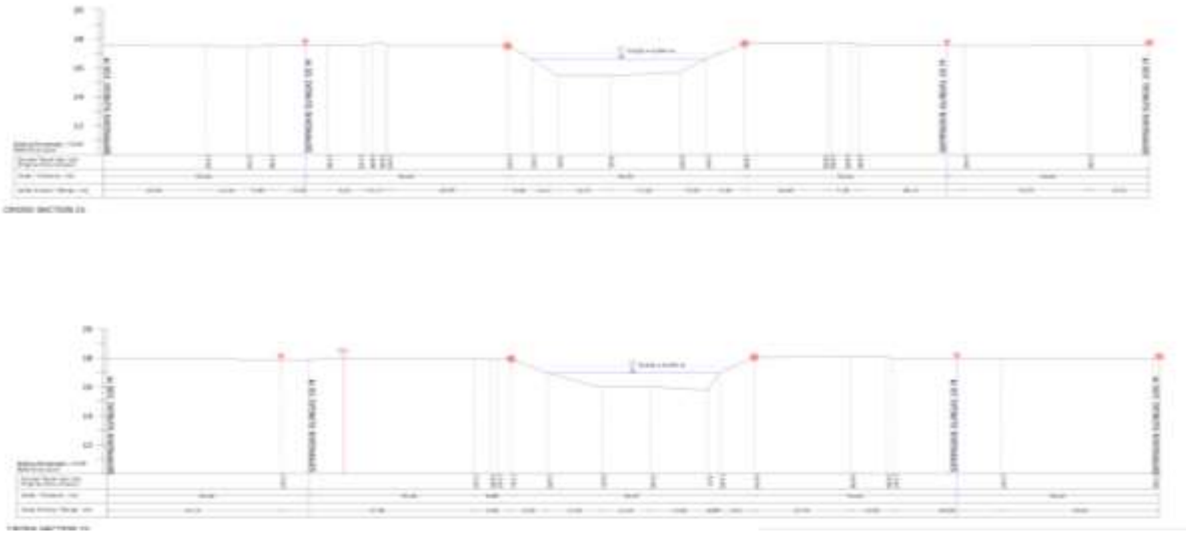

Figure 5. Transverse cut image.

Based on the results of the calculations that have been carried out, the design flood is in accordance with table 1.

Table 1. Flood debit of Nakayasu HSS method design.

No	Flood Plan	Flood Discharge
	(Qn)	(m^3/sec)
1	01.01	260.60
2	2	601.19
3	5	809.83
4	10	945.97
5	20	1059.50
6	25	1116.77
7	50	1243.58
8	100	1370.94

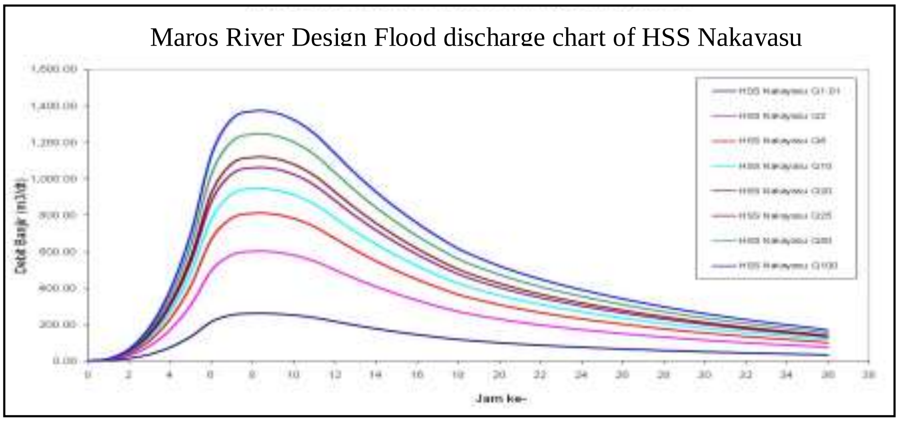

Figure 6. Design flood discharge graph.

Based on the results of the topographic measurements that have been made, the Maros River has 3 (three) types of grooves, in which the upstream is a fairly steep slope. For the middle to the downstream, according to the results of observations and topographic measurements is a sloping area. The transverse profile of the Maros River based on the results of topographic measurements that have been input into the HEC-RAS program can be seen in figure 7.

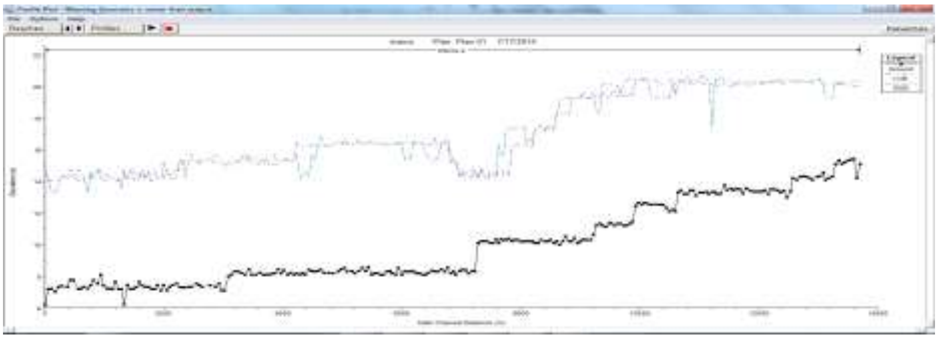

Figure 7. Longitudinal section of Maros River.

Analysis results of the Maros River cross-sectional area are obtained from cross-section data collection from CS77 to CS1, with the layout shown on the Cross Section Map, normal discharge and maximum discharge of the Maros River can be analyzed and presented in table 2, showing normal discharge throughout the study area 7.5 km for Qn = 246,899 m³/second.

Table 2. The results of the analysis of Maros River Basin are Qnormal conditions.

River section	Elevation		L	hydraulic dimension of Qnormal river crossings									Q
				b	h	n	m	A	P	R	I	V	
	up/s	down/s	m		(m)	(m)	(m)	(m²)	(m)	(m)	(m)	(m³/sec)	(m³/sec)
CS77-CS 52	13.21	11.09	2500	27.58	2.70	10.22	7.22	127.102	66.941	1.899	0.000844	1.786	227.013
CS51-CS 26	10.98	8.87	2500	27. 68	2.81	9.85	7.32	135.573	69.20	1.959	0.000844	1.919	246.674
CS25-CS 1	9.21	8.35	2500	3.42	3.42	8.62	9.35	210.179	93.978	2.241	0.000344	1.270	267.009
												Debit rata-rata	246.899

Table 3. Analysis results of Maros River maximum reserves in the research section.

River section	Elevation		L	hydraulic dimension of Qnormal river crossings									Q
				b	h	n	m	A	P	R	I	V	
	up/s	down/s	m		(m)	(m)	(m)	(m²)	(m)	(m)	(m)	(m³/sec)	(m³/sec)
CS77-CS 52	13.21	11.09	2500	27.58	7.62	3.64	14.79	1070	253.49	4.22	0.00	3.04	3255.51
CS51-CS 26	10.98	8.87	2500	27.68	7.47	3.84	11.79	871	204.26	4.26	0.00	3.05	2659.13
CS25-CS 1	9.21	8.35	2500	29.48	7.77	3.80	13.18	1026	234.99	4.37	0.00	1.98	2033.05
												Debit rata-rata	2,649.230

Table 3 shows the maximum recapitulation of the reservoir discharge along the study area 7.5 km at Qmax = 2,649,229 m³ / second. Using the debit equation to calculate Q50 and Q100, the results are obtained according to table 4.

Table 4. Maros River crossing in Q50 and Q100.

Qplan	Q	maximum river crossing dimension					Hmax	statement	
		V	A=Q/V	m	n	H=/(A/(n+m))			
	(m³/sec)	(m/sec)	(m²)	(m)	(m)	(m)			
Q50	1243.58	2.693	461.797	13.254	3.760	6.213	7.618	Hmax>H	OK
Q100	1370.94	2.693	509.092	13.254	3.760	6.213	7.618	Hmax>H	OK

An average water level profile is obtained as illustrated by the crossing of the Maros River in figure 8.

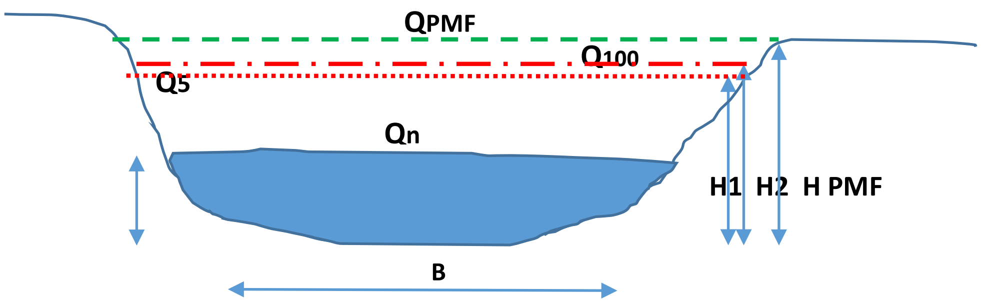

Figure 8. Maros River water profile in Q50 and Q100.

Maros watershed with an area of 672.24 km2 and physical and social characteristics are in the category of areas outside the urban area, according to the applicable regulations:

a. PUPR Ministerial Regulation No.28 / PRT / M / 2015 Regarding the Determination of the River and Lake Border Line, watershed area > 500 km2, outside the urban area is determined at least 100 (one hundred) meters from the left and right edges of the river trough along the river channel.
b. PERDA No. 4 of 2012 concerning the Maros Regency Spatial Plan (RTRW) in 2012-2032, explained that the Maros River area was designated as a strategic area to improve the function of protected areas and river boundaries categorized as Local Protection Areas to protect rivers from cultivation activities that can disrupt the sustainability of its function, which is determined by the following conditions:

- Land along a wide bank with a width of at least 5 (five) meters from the foot of the outer embankment.
- Land along the banks of large rivers is not undated outside residential areas with a width of at least 100 (one hundred) meters from the river bank.
- Land along the banks of a tributary does not bear in a residential area with a width of at least 50 (fifty) meters from the river bank.

Maros River boundary can be described according to figure 9.

Figure 9. Sketch of river boundary of the Maros River.

Recent research indicates that for a riparian buffer zone to effectively act as a habitat corridor, a minimum width of 30 meters, and up to 100 meters in some cases, is desirable, in order to achieve the full range of plant communities needed for a range of species and to link effectively with adjacent terrestrial ecosystems. A healthy riparian zone not only has ecological value but also provides pleasant surroundings that are popular recreational areas near which people often choose to live. Rivers and the riparian zone are an important recreational resource, with fishing, swimming, boating, walking, picnicking and bird watching all being common riparian zone activities. The river and riparian zone tend to dominate the local landscape and may also contribute significantly to the regional landscape and so are important to the aesthetic value of an area [5].

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4. Conclusions

Maros River boundary with a distance of 50 meters from the edge of the riverbed which is the River Utilization Area. There is a meander or river bend that is quite sharp, that is, at Sta. 20 + 00 to Sta. 23 + 00 so the determination of the alignment follows the outer arch.

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