Retention Storage Analysis On The Karangasam Besar River In Samarinda City

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***Abstract*—Flooding is an event that often occurs in Samarinda when the rainy season arrives. One of them is Kecamatan Sungai Kunjang, precisely in Kelurahan Lok Bahu. Alternative flood control in the study area is by making a retention storage. The maximum daily rainfall is processed to obtain the value of the planned rainfall and then calculates the planned flood discharge using the Nakayasu HSS Method. The flood discharge is used to calculate the flood routing and then it can be seen the volume of the pond storage capacity and the dimensions and location of the retention storage. Retention storage modeling simulation was carried out with the help of EPA SWMM 5.1. This retention storage will then be compared against the effectiveness of the flood which will be taken into account. The results of this study show that the peak discharge value of the planned flood is 247.390 m^3/second at the 3rd hour, the pool storage capacity is 252.317 m^3/second = 908.342.324 m^3, the dimensions of the planned retention pond are 600 × 505 × 3 m with a location at upstream part of the Karangasam Besar watershed. In the simulation results using EPA SWMM 5.1, the river area in the upstream watershed was initially red as a marker for runoff, with the addition of a retention storage making the river in the upstream watershed no longer runoff. The effectiveness of flood prevention with the retention storage is able to reduce flooding that overflows from the river body by 87.758%. The remaining percentage of 12.242% indicates that there is still a discharge that cannot be accommodated in the retention storage and then flows into the river body. However, the simulation results show that the water level flowing in the river does not cause runoff in the Karangasam Besar watershed.**

Keywords—River, runoff, retention storage

I. INTRODUCTION

Floods are an event that often occurs in Samarinda City when the rainy season arrives. The increasing problem of flooding that occurs today is a form of accumulation of factors causing flooding that have not been resolved previously.

Flood areas or runoff that occurred in the Samarinda City, including the Karangasambesar River on one of the river sections in Sungai Kunjang District, precisely in Kelurahan Lok Bahu (Pro Kaltim, 2021). The factors that cause flooding in the area are:

1. Encroachment of riverbank into settlements and other functions
2. The loss of public awareness to keep the river clean
3. The occurrence of land stripping and changes in land use used as business land, settlements, and coal mines

II. RESEARCH METHODS

A. Study Area Condition

This research was conducted on the Karangasam Besar River, Samarinda City, East Kalimantan Province, which is a sub-watershed of the Mahakam River. It is known that the area of the Karangasam Besar watershed is 2,527,922 ha or 25,279 km^2, the length of the river is 10,831,880 m or 10,832 km, and the land use is used for residential, industrial, mining, and green open spaces that have poor water absorption areas.

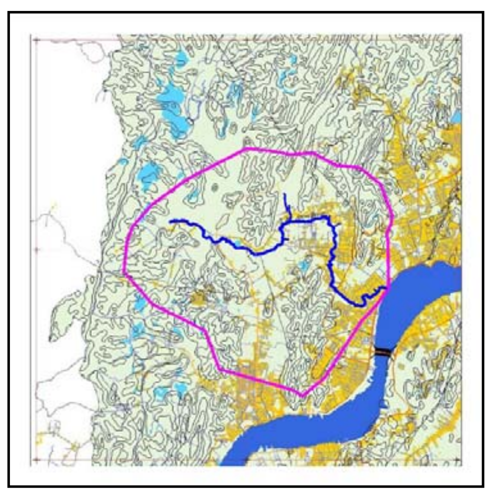


Fig 1. Karangasam Besar Watershed Boundary

B. Research Stages

The stages of the research are as follows:

1) Determine the boundaries of the watershed or catchment area, the area of watertight and non-waterproof areas, and the slope of the land based on topographic maps and land use maps that are plotted into the Auto CAD application.
2) From the results of the field survey at the study site and the acquisition of a map of the river network, as well as the design of the longitudinal and cross-sectional dimensions of the river, the direction of the water flow and the dimensions of the channel can be determined.
3) Processing daily rainfall data for the BMKG Temindung Station, Samarinda City in 2001 – 2020 obtained into hydrological analysis calculations consisting of dispersion measurements, rainfall distribution frequency analysis, distribution suitability test, then calculating the planned rainfall intensity using the Mononobe Method, continued calculation of the hydrograph of the planned flood discharge and flood routing.
4) Planning the placement location, number, and dimensions of retention storage in flood control efforts.
5) Make a model of the existing rain runoff with the EPA SWMM 5.1 application.
6) If it is known that the simulation results of existing conditions indicate that runoff has occurred, then re-simulate the river channel by adding the planned retention storage using the EPA SWMM 5.1 application.
7) Provide conclusions on the results of calculations and simulations using the EPA SWMM 5.1 application.

III. RESULTS AND DISCUSSION

A. Hydrological Analysis

The planned rainfall values obtained using the Pearson III Log Distribution are listed in Table 1.

Table 1. Rainfall Probability Distribution Plan Log Pearson III

No.	Rainfall Plan (mm)	Return Period (years)
1	97.107	2
2	111.909	5
3	118.974	10
4	121.222	15
5	125.847	25
6	129.899	50
7	133.268	100

The planned rainfall value in Table 1 is then processed to obtain the Mononobe rainfall intensity value, the results of which are listed in Table 2 and Graph 1 as follows.

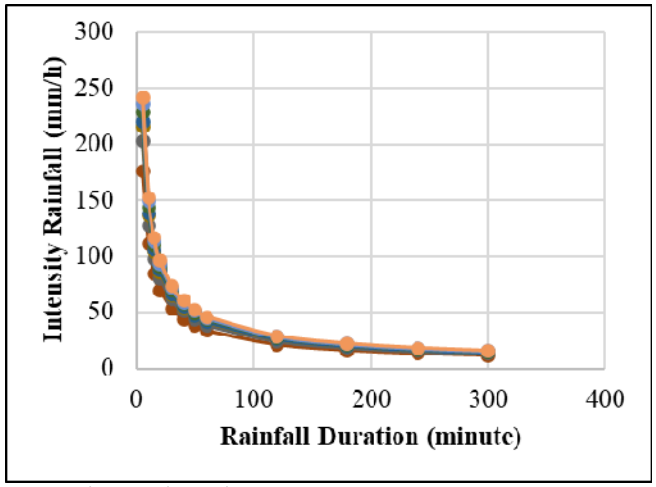


Fig. 2. Graph of Rainfall Intensity Plan Mononobe Method

The planned rainfall is then distributed in the form of hourly rain (hyetograph) with the Alternating Block Method (ABM) model and processed into a planned flood discharge using the Nakayasu Synthetic Hydrograph Method.

The hourly rainfall distribution is then processed into a planned flood discharge using the Nakayasu Synthetic Unit Hydrograph Method. The planned discharge is used to calculate the flood routing and then calculate the storage capacity of the retention pond using the Muskingum Method with the 25-year return period (Directorate General of Human Settlements, 2010). The graph of flood routing and pond storage capacity is attached as follows.

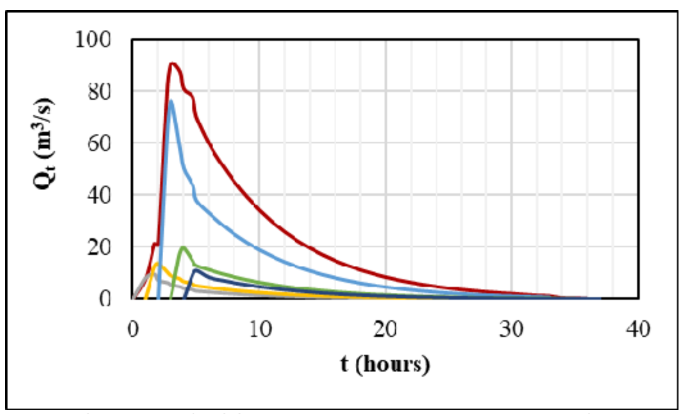


Fig. 3. Graphics of HSS Nakayasu with a Return Period of 25 Years

Table 2. Intensity of Rainfall Planned Mononobe Method

Duration	Return Period (years)						
(minute	2	5	10	15	25	50	100
5	176.454	203.351	216.191	220.276	228.679	236.042	242.163
10	111.159	128.103	136.192	138.765	144.059	148.697	152.553
15	84.830	97.761	103.934	105.898	109.937	113.477	116.420
20	70.026	80.700	85.795	87.417	90.751	93.673	96.103
30	53.440	61.586	65.474	66.711	69.256	71.486	73.340
40	44.114	50.838	54.048	55.069	57.170	59.011	60.541
50	38.016	43.811	46.577	47.457	49.267	50.854	52.172
60	33.665	38.797	41.246	42.025	43.629	45.033	46.201
120	21.208	24.440	25.983	26.474	27.484	28.369	29.105
180	16.184	18.651	19.829	20.204	20.975	21.650	22.211
240	13.360	15.396	16.369	16.678	17.314	17.872	18.335
300	11.513	13.268	14.106	14.373	14.921	15.401	15.801
360	10.196	11.750	12.492	12.728	13.213	13.639	13.992
420	9.200	10.602	11.272	11.485	11.923	12.307	12.626

Table 3. Pond Storage Capacity

t (h)	I (m^3/s)	O (m^3/s)	$K_{storage}$ (m^3/s)	$V_{storage}$ (m^3)
0.000	0.000	0.000	0.000	0.000
1.000	8.111	1.347	6.763	24,347.609
2.000	119.670	24.947	101.486	365,349.553
3.000	247.390	117.129	231.747	834,288.827
4.000	232.879	212.308	252.317	908,342.324
5.000	168.982	217.104	204.194	735,100.006
6.000	105.962	170.582	139.574	502,465.515
7.000	70.148	116.220	93.502	336,607.524
8.000	47.812	77.993	63.321	227,956.600
9.000	33.743	53.045	44.019	158,468.384
10.000	23.907	36.950	30.976	111,513.431
11.000	18.476	26.276	23.176	83,433.828
12.000	14.131	19.711	17.597	63,347.846
13.000	10.898	14.993	13.501	48,602.615
14.000	8.315	11.496	10.320	37,152.902
15.000	6.345	8.786	7.880	28,366.399
16.000	4.842	6.708	6.014	21,649.330
17.000	3.695	5.119	4.589	16,520.702
18.000	2.819	3.906	3.502	12,606.486
19.000	2.151	2.981	2.672	9,619.522
20.000	1.641	2.275	2.039	7,340.252
21.000	1.253	1.736	1.556	5,601.029
22.000	0.956	1.324	1.187	4,273.900
23.000	0.729	1.011	0.906	3,261.226
24.000	0.556	0.771	0.691	2,488.499

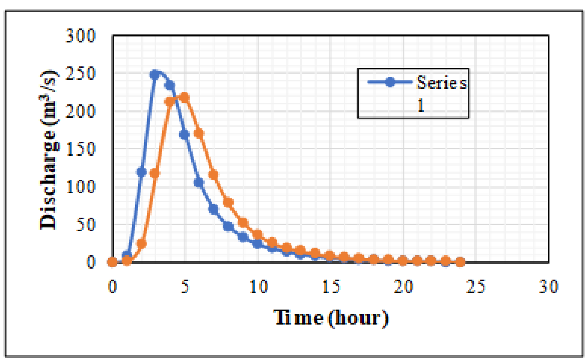


Fig. 4. Inflow and Outflow Relationship with Muskingum Method

The maximum pool storage volume value of 908,342.324 m^3 in an interval of 4 hours with a retention pond depth (h) of 3 m can then be used to calculate the required retention pond area and the dimensions of the length and width of the retention pond as follows.

$$A = \frac{V}{h} \quad (1)$$

$$= \frac{908.342,324}{3}$$

$= 302,780.775\ m^2$ or 30.278 ha

Length (p) = 600.000 m
Width (l) = 504.635 m ≈ 505.000 m

The following is a plan for the location of the placement and the design of the top view of the retention storage.

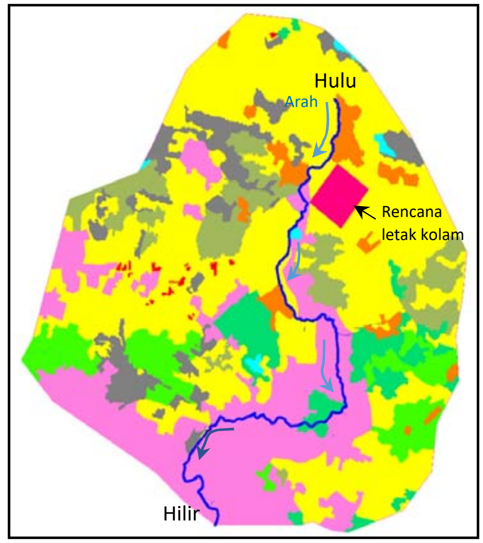


Fig. 5. Retention Pond Location Plan

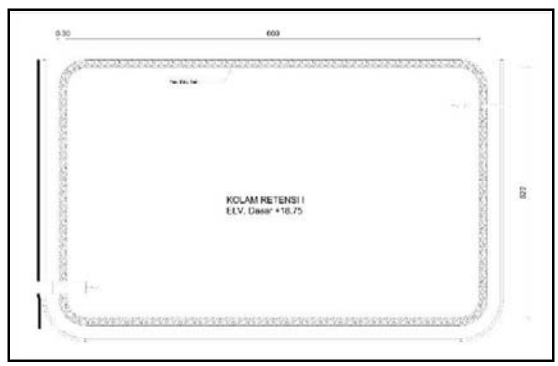


Fig. 6. Design of the Top View of the Retention Storage

B. Simulation Using EPA SWMM 5.1 Application

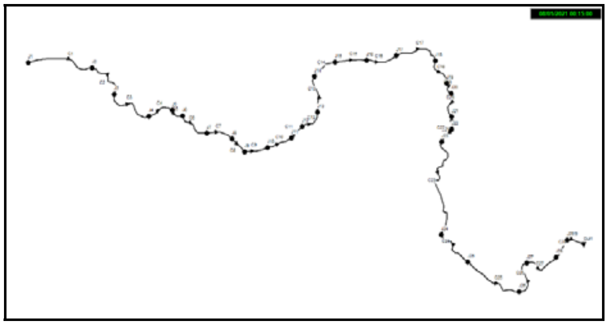
Stages of work on the EPA SWMM 5.1 application:

1) Layout settings and system components
2) Data input process
3) Setting the boundary conditions
4) System depiction in map
5) Editing components
6) Storage of work
7) Simulation settings
8) Run the simulation and access the results

a) Simulation of River Networks for Existing Conditions Before Flood Handling

The scheme of the existing river network is shown in Figure 8 below. Meanwhile, the inundation map of the Karangasam Besar watershed of Samarinda City is shown in Figure 9.

Fig. 7. Schematic of River Network with Existing Condition



The results of running the EPA SWMM model for the river network model with existing conditions prior to the retention pond as a flood control building are shown in Figures 10 and 11 below.

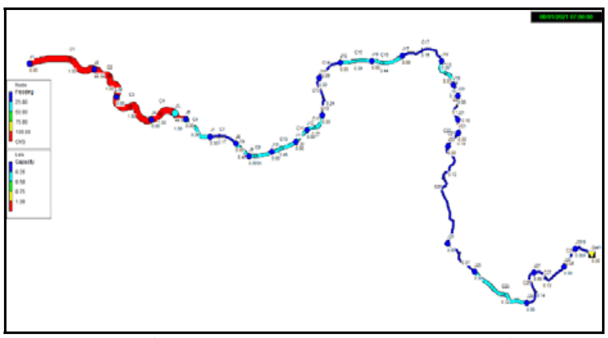


Fig. 8. EPA SWMM Running Model Results for River Network Schematization in Existing Conditions

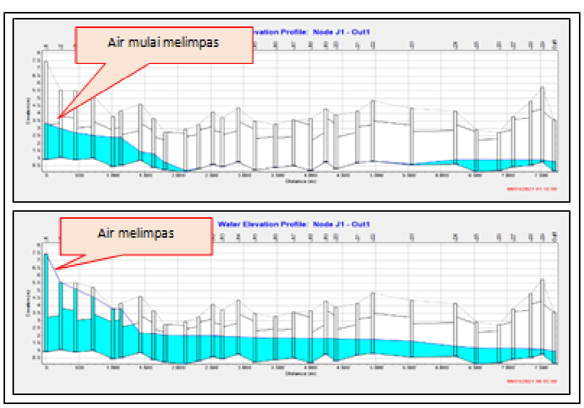


Fig. 9. Flow Profiles Longitudinal Cross-section of the River Runoff Occurrence

b) Simulation of River Network with Application of Retention Storage

After planning the retention pool unit at the study site, then perform a simulation of the flood mitigation model using the retention pool. The results of running the EPA SWMM model for flood control conditions at the study site are shown in Figure 10 below.

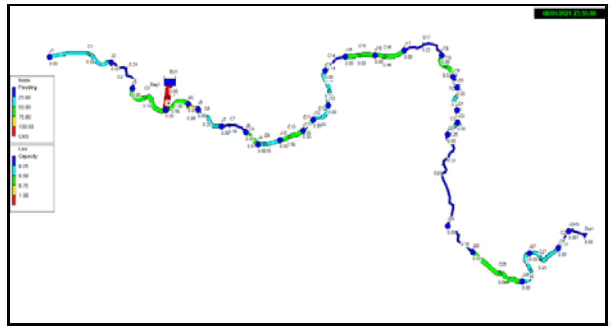


Fig. 10. River Network Schematization with The Addition of a Retention Storage Using EPA SWMM Application

Referring to the results of running the EPA SWMM model in flood management conditions, it shows that the channel/conduit (link capacity) is no longer red, which indicates that the capacity of the channel/conduit has no longer runoff. The results of the EPA SWMM running in Figure 11 show the simulation results that show the water level profile along the river.

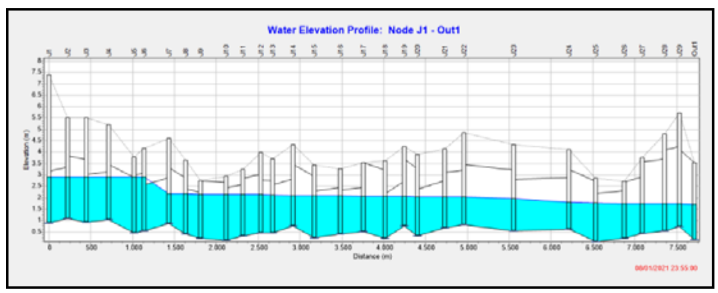


Fig. 11. Flow Profile of River Cross Section After Addition of Retention Storage

C. Calculation of the Effectiveness of Flood Management

The calculation of the effectiveness of flood prevention with the retention pond is as follows.

Inflow peak discharge = 247,390 m^3/s, at 3-hour
Outflow peak discharge = 217,104 m^3/s, at 5-hour
Difference = 247,390 – 217,104
= 30,286 $m^3/s \sim Q_{runoff}$

Percentage of flood effectiveness =

$$\frac{\text{Outflow peak discharge}}{\text{Inflow peak discharge}} \times 100\% \quad (1)$$

$$= \frac{217{,}104}{247{,}390} \times 100\% = 87{,}758\%$$

Percentage of runoff =

$$\frac{\text{Difference}}{\text{Inflow peak discharge}} \times 100\% \quad (2)$$

$$= \frac{30{,}286}{247{,}390} \times 100\% = 12{,}242\%$$

IV. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusion

Based on the discussion and analysis that has been delivered, it can be concluded several things, namely:

1. Calculation of the Q_{plan} in the Karangasam Besar watershed using the Nakayasu HSS Method with a return period of 25 years and a calculation duration of 28 hours, the result of the calculation of the flood peak is 247.390 m^3/s at the 3rd hour.
2. Dimensions of the planned retention pond: length (p) = 600,000 m; width (l) = 505,000 m; and the depth of the pond (h) = 3,000 m with the location of the retention pond in the upstream part of the Karangasam Besar watershed.
3. The effectiveness of flood prevention with the retention pond is 87.758% which indicates that the retention pond planning is able to reduce runoff flooding. The remaining percentage of 12.242% shows that there is still a discharge that cannot be accommodated in the retention pond and then flows into the river body but does not cause runoff in the Karangasam Besar River.

B. Suggestion

Efforts that can be made to realize comprehensive flood control are:

1. There needs to be a role for the local government in terms of educating the community not to throw garbage in rivers and not to close channels or not build buildings in river areas. On the other hand, public awareness is needed to be able to maintain and repair channels so that the river flows smoothly.
2. It is necessary to conduct further studies on flood control in other forms other than retention storage as a comparison in determining flood control planning.

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