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Analysis of Flood Control in the Area of Development II City of Pekanbaru (Case Study: In Bukit Raya Sub-District, Pekanbaru)

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Abstract:- Flooding is a major problem that occurs during the rainy season. Planning for the development of retention ponds in Bukit Raya sub-district can be an ecodrain-based flood control effort. The purpose of this study was to analyze the capacity of retention ponds as flood control buildings in the study sites. Determination of 5-year periodic retention analysis in this study is to use Log Person III probability distribution. Then, to analyze the flood flows in this study is to use the EPA SWMM program. The results of the analysis show that the floods occurring at the study sites are caused by the limited drainage capacity and the flow of water flowing into the lowest contour channel. Changes in drainage structures and supporting constructions can overcome flood problems in the study sites. The retention pool capacity is 12,000 m^3 with a maximum depth of 1 m and ponded area of 12,000 m^2.

***Keywords**:- Flood Control, Drainage, Retention Pond.*

I. INTRODUCTION

Simpang Tiga area located at 0º 27' North and 101º 28' East, is one part of Bukit Raya district area. This area has a designation as a central agricultural, green open spaces and tourism, according to documents of Pekanbaru City Spatial Plan. Along with the development plan, the Government needs to implement of integrated water and sanitation management to prevent environmental problems in the future.

The government has developed priority programs on regional development, which has been established in Pekanbaru City RPJMD 2012-2017, including the construction of flood control infrastructure. Based on the stakeholders, Pekanbaru Municipal Government will build a retention pond on the 4.9 Ha City Government land in Simpang Tiga.

The location of the planning is done at locations that have low elevation and is the water terminal during the rainy season. These are used as retention pond planning locations and this is considered appropriate for the empowerment of the area. The purpose of planning the location of the retention pond construction is to solve flood problems, ecotourism development and make retention pond as the main support for irrigation for agriculture and food security in the region.

Planning of retention ponds is necessary, especially in analyzing the capacity of the appropriate storage ponds and places to accommodate the maximum potential water debit in the study area. The use of the SWMM aids program (Storm Water Management Model) is a model capable to analyze the quantity and water quality problems associated with urban runoff.

Storm Water Management has been developed by the EPA (Environmental Protection Agency - US) since 1971 (Huber and Dickinson, 1988). This model is the most widely used and developed for the simulation of hydrological and hydraulic processes in urban areas (Rossman, 2008). Use of this program, it is expected that the conditions occurring in the field can be modeled using the parameters recorded in actual conditions in the field. It is expected that the model generated by the SWMM program, can accurately provide relatively similar simulations to the circumstances in the field.

The formulation of this research problem is to determine the value of capacity or size of retention pond required. This value is determined based on the extent and condition of land use plan and intensity of rain that occurred in the District of Bukit Raya precisely around Labersa street.

Research issues are limited to the rainfall data used is from the Office of Meteorology and Geophysics Agency (BMKG) Riau Province, in the form of rainfall data from 1997 to 2016 with a data length of 20 years, hydrological analysis conducted using EPA-SWMM auxiliary program, and analysis pattern only review from aspects of hydrology and hydraulics. The purpose of this study are analyzing the existing flow conditions in the study area, and determine the plan flow pattern on the drainage as well as calculate the capacity of the retention pool as the flood control building.

II. METODOLOGY

Location of retention pond planning from this research can be seen in Figure 1.

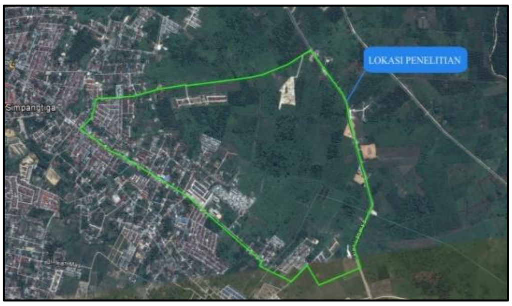

Fig 1:- Location of retention pond based on topography
Source : *Google earth* (2018)

The method of implementation of this research, basically has 5 main stages, namely literature study, data collection, data analysis, data processing using EPA SWMM model and planning the building of retention pond as described in Figure 2.

The research data processing is done by using EPA SWMM 5.0 program. Data processing is done by experimental modeling divided into 4 types of simulation : (1) Simulation of existing condition, (2) Simulation of calibration of existing condition, (3) Simulation of drainage dimension changes, and (4) Simulation with the addition of retention pool.

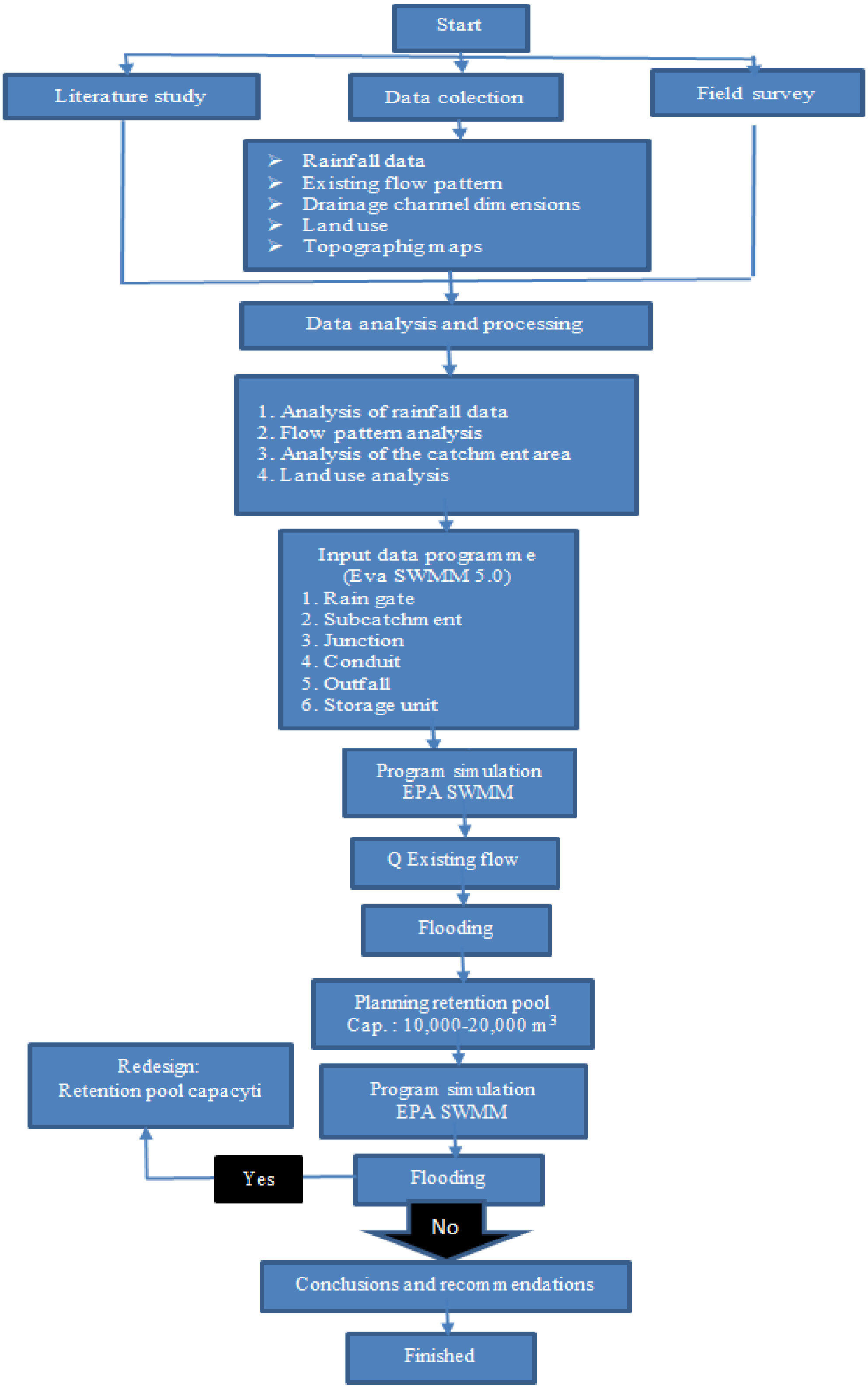

Fig 2:- Flow chart of research

III. RESULTS AND DISCUSSION

Rainfall Intensity Analysis Frequency analysis is performed by choosing the appropriate type of rainfall distribution based on skewness coefficient (Cs), coefficient of variation (Cv) and kurtosis coefficient (Ck).

No	Distribution	Terms	Calculation	Information
1.	Log Normal	Cs ≈ 0,0 Ck ≈ 3,0	Cs = -0,089 Ck = 2,701	Inadequate
2.	Normal	$Cs = Cv^3 + 3\ Cv$ $Ck = Cv^8 + 6Cv^6 + 15\ Cv^4 + 16\ Cv^2 + 3$	Cs = 0,801 Ck = 4,187	Inadequate
3.	Gumbel	Cs ≈ 1,396 Ck ≈ 5,4002	Cs = -0,089 Ck = 2,701	Inadequate
4.	Log Person III	Does not comply with the nature of the above three distributions		

Table 1:- Statistical parameters for determining distribution types

Based on Table 1, it is suggested that the distribution used is the Log Person III distribution. Calculation of rain intensity conducted using Mononobe formula, and the result of calculation of rain intensity with a certain duration is shown in Table 2.

Duration (t)		Rainfall Intencity (mm/jam)				
		2 years	**5 years**	**10 years**	**25 years**	**50 years**
Minits	**Hour**	**124,65**	**141,09**	**148,98**	**156,69**	**161,29**
5	0,08	226,50	256,37	270,72	284,72	293,08
10	0,17	142,69	161,50	170,54	179,36	184,63
15	0,25	108,89	123,25	130,15	136,88	140,90
30	0,50	68,60	77,64	81,99	86,23	88,76
45	0,75	52,35	59,25	62,57	65,81	67,74
60	1,00	43,21	48,91	51,65	54,32	55,91
120	2,00	27,22	30,81	32,54	34,22	35,22
180	3,00	20,77	23,51	24,83	26,11	26,88
360	6,00	13,09	14,81	15,64	16,45	16,93
720	12,00	8,24	9,33	9,85	10,36	10,67

Table 2:- Rainfall intensity calculation

Rain intensity value is recorded periodically 5 years, based on criteria of re-determination based on city typology and drainage area (Directorate General of Human Settlements, 2010). Typology of this research area is classified as small or medium town typology, because it is located in the suburbs, and has a drainage area of only 77.23857 Ha and is in the range of 10-100 Ha. Preparation of EPA SWMM program parameters.

A. Simulation of Existing Condition

The results showed that the catchment area was 32 subcatchment, 34 junction, 2 outfall and 34 conduit. The results of the SWMM model in the study sites are shown in Figure 3.

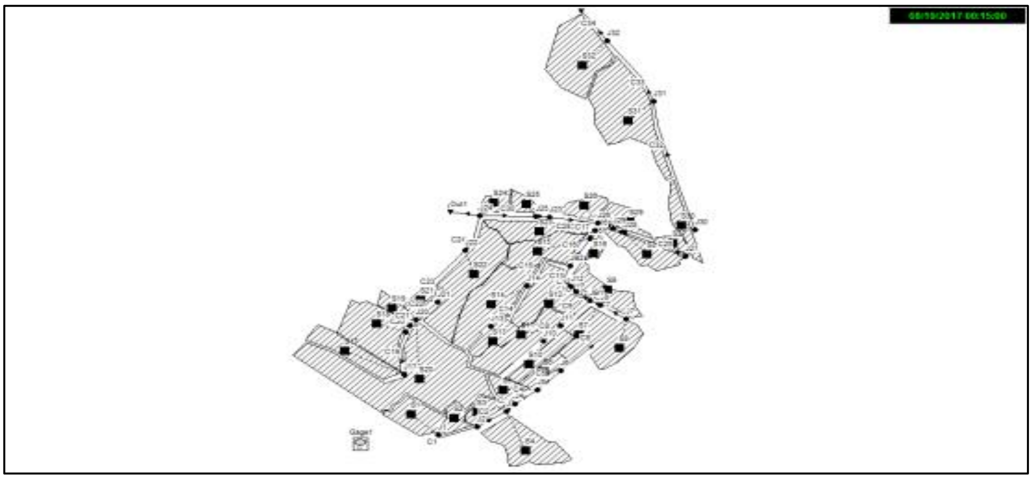

Fig 3:- SWMM model in site area

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The values of EPA SWPA input parameters are as follows.

Nodes	***Invert Elevation (m)***	***Max Depth (m)***	***Nodes***	***Invert Elevation (m)***	***Max Depth (m)***
J1	20,00	1,50	J19	14,38	1,00
J2	18,59	1,50	J20	13,71	1,00
J3	17,00	1,50	J21	12,22	1,40
J4	17,00	1,50	J22	12,10	2,00
J5	14,60	1,50	J23	11,40	1,00
J6	12,56	1,50	J24	12,05	0,80
J7	12,40	1,10	J25	11,65	1,00
J8	12,30	0,75	J26	10,53	0,95
J9	12,20	1,00	J27	11,32	0,60
J10	12,47	1,00	J28	11,20	0,60
J11	12,35	1,00	J29	11,00	0,80
J12	12,10	1,00	J30	11,00	0,70
J13	13,00	0,50	J31	10,42	0,70
J14	12,15	1,00	J32	10,19	0,70
J15	12,00	1,00	JB1	12,25	1,20
J16	11,58	1,00	JB2	12,10	1,00
J17	17,65	1,00	Out 1	12,00	-
J18	16,71	1,00	Out 2	10,00	-

Table 3:- Data of *Junction* and *Outfall*

Data	**Subcatchment**							
	1	2	3	4	5	6	**7**	**8**
Outlet	J1	J2	J4	J3	J5	J6	J8	J7
Area (ha)	1,859025	0,947549	1,201252	3,48471	1,087743	1,15684	2,893763	1,754125
Width (m)	110,2189	106,4662	153,3513	124,9	93,50226	186,5871	246,6275	190,6658
% Slope	1,78	2,25	1,28	0,72	0,86	1,61	0,85	1,09
% Impervious	70,97	14,26	69,12	54,32	8,05	45,86	17,09	43,05
N-Impervious	0,040	0,040	0,040	0,040	0,014	0,040	0,040	0,040
N-Pervious	0,12	0,09	0,075	0,12	0,12	0,12	0,12	0,09
D-Store Imp (mm)	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05
D- Store Perv (mm)	0,2	0,3	0,2	0,2	0,2	0,2	0,2	0,3
% Zero Impervious	25	25	25	25	25	25	25	25
Method Infiltration	HORTON	HORTON	HORTON	HORTON	HORTON	HORTON	HORTON	HORTON

Table 4:- Subcatchment of data input

Data	**Subcatchment**							
	9	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Outlet	J9	J10	J11	J12	J13	J14	J15	J16
Area (ha)	2,403977	1,735975	3,087673	4,217298	1,337117	4,275972	2,678054	0,520957
Width (m)	258,4922	268,4497	312,9398	242,8387	86,82578	334,0603	186,4075	90,86459
% Slope	4,30	1,55	2,03	0,86	2,60	2,34	2,09	0,87
% Impervious	2,00	67,10	17,46	2,13	70,02	5,73	2,00	2,00
N-Impervious	0,000	0,040	0,040	0,014	0,040	0,040	0,000	0,000
N-Pervious	0,09	0,12	0,12	0,09	0,12	0,12	0,09	0,09
D-Store Imp (mm)	0	0,05	0,05	0,05	0,05	0,05	0	0
D- Store Perv (mm)	0,3	0,2	0,2	0,3	0,2	0,2	0,3	0,3
% Zero Impervious	25	25	25	25	25	25	25	25
Method Infiltration	HORTON	HORTON	HORTON	HORTON	HORTON	HORTON	HORTON	HORTON

Continued: Table 4:- Subcatchment of data input

Data	Subcatchment							
	17	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Outlet	J17	J18	J19	J20	J21	J22	J23	J24
Area (ha)	2,032751	4,005036	0,732431	6,192518	1,017336	5,500332	2,901031	0,793478
Width (m)	66,35749	167,8088	45,77694	586,0427	141,9539	417,7467	361,1242	93,3504
% Slope	0,98	0,42	1,25	1,89	1,40	1,52	3,73	3,53
% Impervious	77,99	49,65	11,80	25,05	2,00	7,29	2,00	2,00
N-Impervious	0,040	0,040	0,014	0,040	0,014	0,040	0,000	0,000
N-Pervious	0	0,09	0,12	0,09	0,12	0,09	0,09	0,09
D-Store Imp (mm)	0,05	0,05	0,05	0,05	0,05	0,05	0	0
D- Store Perv (mm)	0	0,3	0,2	0,3	0,2	0,3	0,3	0,3
% Zero Impervious	25	25	25	25	25	25	25	25
Method Infiltration	HORTON	HORTON	HORTON	HORTON	HORTON	HORTON	HORTON	HORTON

Continued: Table 4. Subcatchment of data input

Data	Subcatchment							
	25	**26**	**27**	**28**	**29**	**30**	**31**	**32**
Outlet	J25	J26	J27	J28	J29	J30	J31	J32
Area (ha)	0,791813	1,383407	0,538893	1,980736	1,320381	1,575402	6,144421	5,686574
Width (m)	101,9502	183,6381	124,3599	244,5353	179,2372	328,2088	422,7813	290,1313
% Slope	2,58	1,33	1,15	0,62	2,71	2,08	1,38	0,51
% Impervious	2,00	2,00	2,00	2,00	2,00	5,20	9,24	5,06
N-Impervious	0,000	0,000	0,010	0,000	0,000	0,014	0,040	0,040
N-Pervious	0,09	0,09	0,1	0,09	0,09	0,09	0,09	0,09
D-Store Imp (mm)	0	0	0,05	0	0	0,05	0,05	0,05
D- Store Perv (mm)	0,3	0,3	0,05	0,3	0,3	0,3	0,3	0,3
% Zero Impervious	25	25	25	25	25	25	25	25
Method Infiltration	HORTON	HORTON	HORTON	HORTON	HORTON	HORTON	HORTON	HORTON

Continued: Table 4. Subcatchment of data input

➢ *Simulation of Drainage Dimension Changes*

Changes are made using trial and error against 2 channel C7 and C10 channels. If there is a dimension change during the experiment, the channel will be stopped, and if it has found the right dimension, it is used to accommodate runoff discharge at the research site. Changes in the value of manning on each drainage channel are also done with the assumption that the drainage at the study site has been completely repaired and replaced with drainage with concrete material. So the value of all channel manning (roughness of the channel) based on the value is in the range of 0.011-0.014.

➢ *Simulation of Addition of Retention Pool*

The input parameters in the condition between the addition of the retention pool have the same value as the drainage channel dimension. The difference is only in the addition of channels, sub-catch and storage units. In the channel is done addition of 4 subkatch, 6 channel and 4 intersection. More information, Unit Data Storage Unit can be seen in Table 5.

Conduit	Length (m)	Shape	Conduit Roughness	Dimension			
				Max Depth	Bottom Width	Left Slope	Right slope
C1	158	*rect_open*	0,013	1,50	1,00	-	-
C2	119	*rect_open*	0,013	1,50	1,00	-	-
C3	45	*rect_open*	0,013	1,50	1,00	-	-
C4	93	*rect_open*	0,013	1,50	2,00	-	-
C5	116	*rect_open*	0,013	1,50	2,00	-	-
C6	304	*rect_open*	0,050	1,10	1,20	-	-
C7	103	*travezoidal*	0,030	0,75	0,90	0,20	0,20
C8	86	*rect_open*	0,013	1,00	0,80	-	-
C9	153	*travezoidal*	0,050	1,20	0,90	0,20	0,20
C10	45	*travezoidal*	0,050	0,90	1,00	0,20	0,20
C11	53	*travezoidal*	0,050	1,00	1,50	0,20	0,20
C12	28	*travezoidal*	0,050	1,00	1,50	0,20	0,20
C13	108	*travezoidal*	0,050	1,00	1,50	0,20	0,20
C14	260	*rect_open*	0,013	0,50	0,50	-	-
C15	230	*travezoidal*	0,070	1,00	1,00	0,10	0,10
C16	154	*travezoidal*	0,070	1,00	1,50	0,20	0,20
C17	19	*travezoidal*	0,070	1,00	1,50	0,20	0,20
C18	25	*travezoidal*	0,070	1,00	1,50	0,20	0,20
C19	172	*rect_open*	0,013	1,00	0,80	-	-
C20	44	*travezoidal*	0,030	1,00	0,90	0,10	0,10
C21	14	*travezoidal*	0,030	1,00	0,90	0,10	0,10
C22	93	*travezoidal*	0,013	1,40	2,00	0,10	0,10
C23	285	*travezoidal*	0,030	2,00	1,20	0,20	0,20
C24	153	*travezoidal*	0,050	0,80	1,70	0,20	0,20
C25	235	*travezoidal*	0,070	0,60	2,00	0,10	0,10
C26	43	*travezoidal*	0,050	0,80	1,50	0,10	0,10
C27	59	*travezoidal*	0,050	1,00	1,50	0,20	0,20
C28	190	*travezoidal*	0,050	1,00	1,60	0,20	0,20
C29	24	*travezoidal*	0,050	1,00	1,60	0,20	0,20
C30	191	*travezoidal*	0,050	1,00	1,60	0,20	0,20
C31	107	*travezoidal*	0,050	1,00	1,60	0,20	0,20
C32	539	*travezoidal*	0,050	0,70	1,50	0,20	0,20
C33	286	*travezoidal*	0,050	0,70	1,50	0,20	0,20
C34	179	*travezoidal*	0,050	0,70	1,50	0,20	0,20

Table 5. Data of Conduit

Nodes	*Invert Elevation (m)*	*Max Depth (m)*	*Ponded Area (m^2)*
SU1	9,50	1,00	Variasi

Table 6:- Storage Unit Input Value (Retention Pool)

B. Simulation Results

➢ *Simulation of Existing Condition*

Based on the results of EPA SWMM simulation on existing condition indicate that flood occurred in some drainage channel at research location.

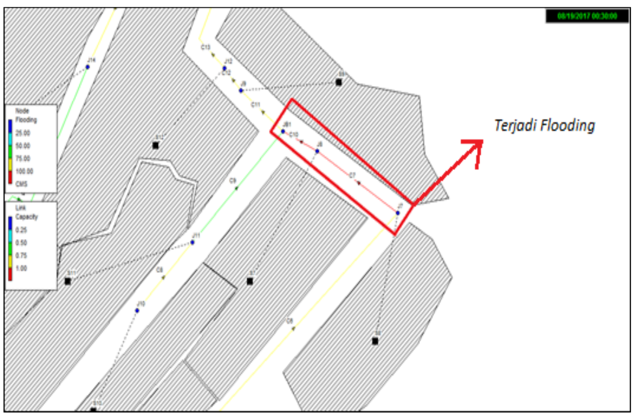

Fig 4:- Simulation result of existing condition at food point

Drainage channels that experienced flooding in this simulation is on channel C7 and C10. Drainage channels abound after 30 minutes of rain.

The height of the flooding can be seen at the intersection that connects between channels. Conduit C7 and C10 are channels connected by J8 junction. After rain for 30 minutes J8 intersections start flooding as high as 0.15 m and occur for 45 minutes. In addition to J8, there is another junction that floods, namely J26. Junction J26 has a low elevation contour, allowing water to flow into the Out1 switch to J26's lowest altitude. Junction J26 starts to flood after 30 minutes rainfall with flood heights of 0.05 m.

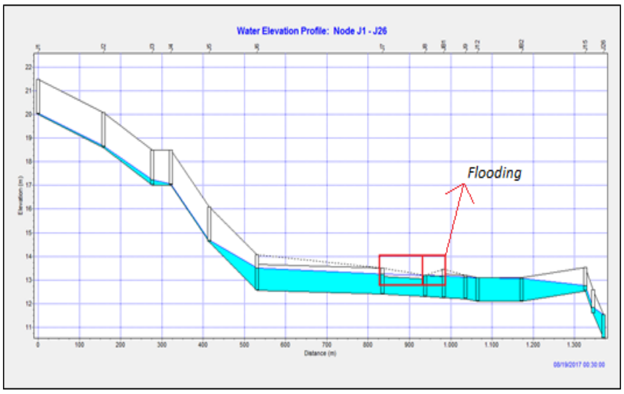

Fig 5:- Water elevation profile Node J1-J26

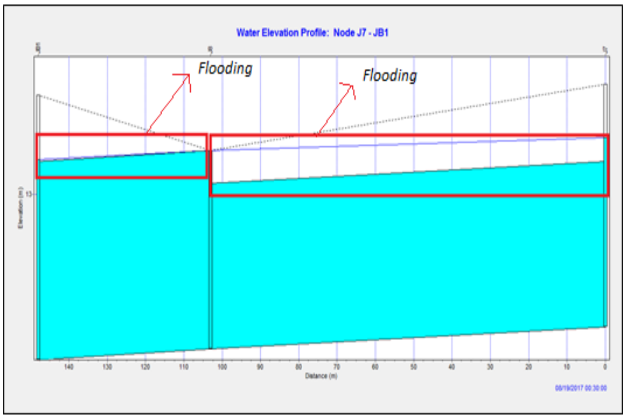

Fig 6:- Water elevation profile Node J7-JB1

Based on the simulation result of existing condition using EPA SWMM, it was found that at the location of research potential of J26 downstream puddle flows happened because elevation condition and point J8 could be caused by drainage capacity which cannot accommodate channel.

➢ *Simulation of Drainage Dimension Changes*

Simulation with drainage dimension changes is done by changing the channel swing value to 0,013 and changing the drainage channel dimension as in the following table.

Number Conduit	***Conduit Roughness***	***Dimension***			
		Max Depth	***Bottom Width***	***Left Slope***	***Right slope***
C7	0,013	1,00	1,00	0,30	0,30
C10	0,013	1,00	1,00	0,30	0,30

Table 7:- Value of change of dimensions C7 and C10

Based on the simulation results, after changing the drainage dimension and the value of channel changes, no more floods occur on channel C7, C9 and all channels in the research location.

Junction	**Eksisting**	**Change of conduit condensity dimension and value**	**% Flood Control**
	(m)	**(m)**	**(%)**
J8	0,15	0,00	100%
J26	0,05	0,05	0%

Table 8:- High flood at the crossroads by changing channel dimensions

Based on the above table there is still flooding at J26 intersection. This is due to the central water flow at the lowest altitude. As a solution of the flood problem at point J26 needs to be built drainage from J26 to the pond at the study site.

➢ *Simulation of Addition of Retention Pool*

Based on simulation results 11 times, it shows that every drainage channel is not submerged. This is because the runoff water in the drainage is channeled into the retention pool.

Each difference is run by varying the value of the moor area resulting in various flood values in the storage unit. This is due to the storage capacity of the unit that is unable to accommodate the flood discharge at the study site.

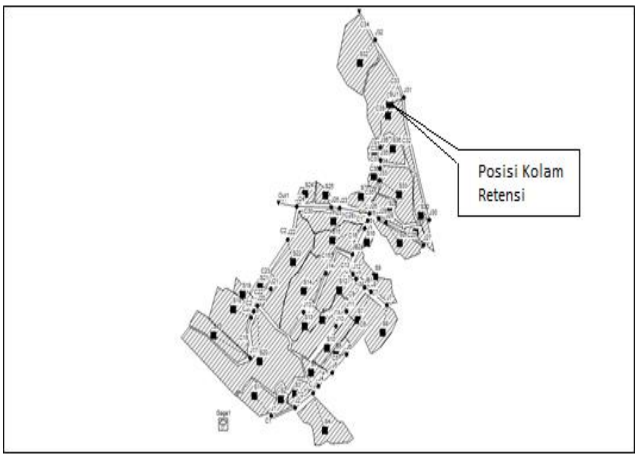

Fig 7:- Simulation of Addition of Retention Pool

Running 3 with a 12,000 m^2 foundation area can accommodate flood discharge due to rainwater runoff at the study site. Not experiencing flooding in the storage unit until the end of the current period. The result of recapitulation that runs by varying the storage unit can be seen in Table 8.

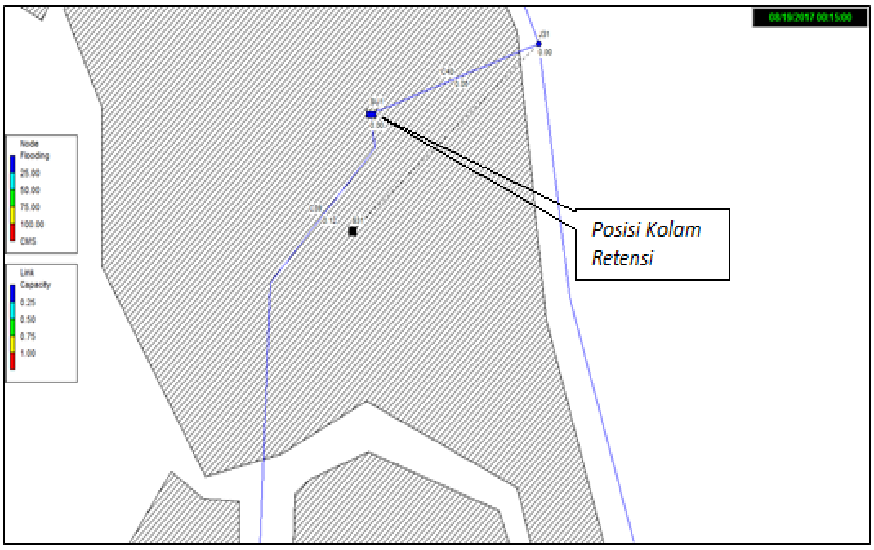

Fig 8:- Flood control simulation with added pool retention

Simulation results of the addition of a storage unit with a maximum depth of 1 m and a foundation area of 12,000 m2 indicate that inundation on some channels is overcome and the retention pond can accommodate the flood discharge at the study site. Based on the above results it can be concluded that with the development of retention ponds can contribute to the prevention of flood problems in the study sites.

Running ke-	***Max Depth* (m)**	***Ponded Area* (m^2)**	***Volume* (m^3)**	***Flooding* (10^6 ltr)**
1	1	10.000	10.000	1,238
2	1	11.000	11.000	0,293
3	1	12.000	12.000	0
4	1	13.000	13.000	0
5	1	14.000	14.000	0
6	1	15.000	15.000	0
7	1	16.000	16.000	0
8	1	17.000	17.000	0
9	1	18.000	18.000	0
10	1	19.000	19.000	0
11	1	20.000	20.000	0

Table 8. Recapitulation Result of Storage Unit

IV. CONCLUSION

Based on the results of analysis and discussion of retention pond planning obtained some conclusions as follows:

1. EPA's SWMM Simulation results show that in the research site of Simpang Tiga village, Bukit Raya sub-district, flood occurred at point J8 caused by drainage channel capacity and J26 point due to water contour caused by low contour and caused water collected at that point
2. Solve the problem at the research location is as follows:

- The solution at point J8 is to change the drainage channel dimension in 2 channels (C7 and C10) into trapezoidal form with a maximum depth of 1.00 m, width below 1.00 m and a slope of 0.30 m.
- The solution at point J26 is the stagnant runoff water drain at that point to the retention basin. Based on the EPA SWMM simulation with the addition of a retention pool having a maximum depth dimension of 1 m and a foundation area of 12,000 m2, indicating that flooding did not occur in the study area. This indicates that the capacity is able to accommodate maximum potential runoff water.
- The dimensions of retention pond type planning beside this river body are high freeboard = 0.75 m, total depth = 1.75 m, and the length of the base side and the top of the retention pool is 109 m and 112.5 m

Suggestion in this research is need more research about resilience (%) of material to catching rain water in catchment area and this need to anticipate development of area into metropolitan city category and determine its capacity. from the retention pool

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