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Flood Control with Retention Pond in Manjahlega Villages, Rancasari Sub District, Bandung

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Abstract: *Human activities in urban areas have a positive impact on development and economic progress. But on the other side caused environmental problems like floods and groundwater levels to decrease. Several areas in Bandung have become annual flood subscriptions caused by overflow from river or drainage. For example, it is Manjahlega Villages at Rancasari Sub District. In this area, flood always occurs between 20 - 50 cm every year. From the results of the hydrological analysis, it was found that the area of retention ponds was 0.98 ha with a catchment area of 130 ha. A 2year rain period of 85.98 mm produces a discharge of 9.5 m3 / s and a 10year rain return period of 126.16 mm produces a discharge of 13.94 m3 / s. The results of Storm Water Management Model (SWMM) modelling concluded that with the Retention Pond, overflow from drainage channels of the Manjahlega Villages can be solved, these conditions can be optimized by adding drainage capacity and channel maintenance with periodic dredging.*

Keywords*: Flood, Manjahlega, Drainage Channel, Retention Pond, SWMM.*

I. INTRODUCTION

Flooding happens in urban areas is caused by existing drainage capacity cannot accommodate runoff (Kodoatie and Sugiyanto). Also, the characteristics of land cover which is more dominated by impervious layers that cause rainwater to fall almost entirely to be a runoff. This condition is being worse by a massive change in the function of the recharge area to be industrial, commercial and other supporting infrastructure for urban activities. In a watershed, the reduction of green absorption areas has reduced the ability to function as an environmental buffer zone (Dr. Ir. Suripin).

decrease in an absorption area in catchment areas due to increasing population, activities and land requirements, so that happens interventions in urban activities on conservation areas and green open spaces (Hasan et al.).

One of the efforts in managing floods is to create flood controller buildings such as retention pond that function to hold and absorb rainwater into the ground with a large capacity that depends on discharge amount.

Some areas in Bandung are potential for floods caused by overflowing river water level or drainage channels. One of them is Manjahlega Village in Rancasari Sub-District. Rancasari Sub-District Head, Sri Kurniasih said that 1,550 people were affected by the floods that occurred on Thursday, November 16, 2017 (Pikiran Rakyat 2017). The flood was triggered by a

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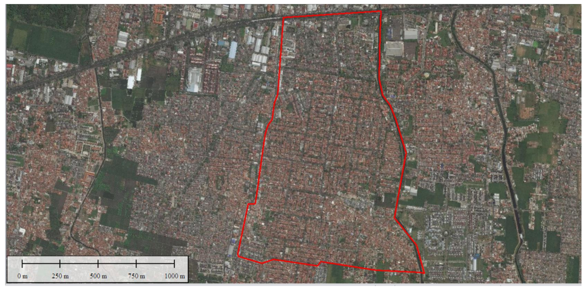


Figure 1: Manjahlega Village Borderline

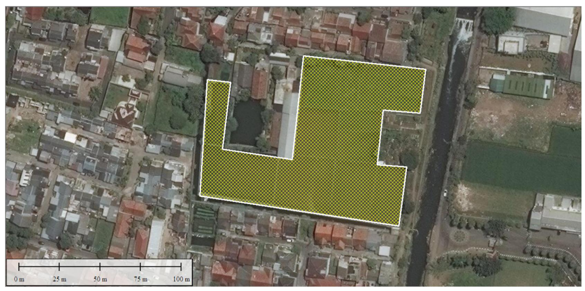


Figure 2 Retention Pond Location (±1 ha)

Based on secondary data observations and field checks it is known that the retention pond water catchment area starting from Margahayu Housing and Sanggarhurip Housing in the north with a catchment area reaching 130 ha.

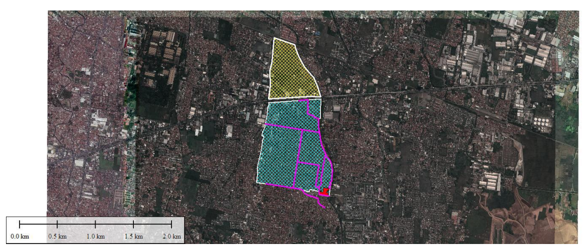


Figure 3 Retention Pond Catchment Area

To find out the existing drainage capability, modeling simulation using SWMM (Storm Water Management Model) software is used. Then modeling for flood Q2 years and Q10 years with and without retention ponds was carried out. So we get a picture of the function and effect of the designed retention pond.

1. Literature Review

1.1 Frequency Analysis

Retention pond serves to temporarily store river discharge so that flood peaks can be reduced. The degree of flood reduction depends on the characteristics of the flood hydrograph, the pond volume and the dynamics of several outlet buildings. The area used for reservoirs is usually in the lowlands or swamps. With good land use planning and implementation, reservoirs can be used for agriculture (Dirjen Cipta Karya).

The dimensions of the reservoir are based on the volume of water due to rain for a predetermined t minutes, meaning that if the rain has reached t minutes, then the pump must have been operated until the water level in the reservoir reaches the maximum limit. To anticipate that the storage pond does not overflow its capacity, the officers who operate the pump must always be ready when it rains. An area with a lower elevation than sea level and flood water level in the river causes the area cannot be served by gravity drainage system. Then the area needs to be equipped with a pumping station. This pump serves to help remove water from the flood reservoir or directly from the drainage channel when water cannot flow gravity.

1.2 Hydroloical Design Criteria for Retenton Pond.

Determination of the return period for retention pond design based on the catchment area and city typology based on PU Permen No.12 / PRT / M / 2014 concerning the Implementation of the Urban Drainage System (Science).

Table 1 Return Period for Retention Pond Design

City Typology	Catchment Area (ha)			
	<10	10-100	100-500	>500
Metropolis	2 yr	2-5 yr	5-10 yr	10-25 yr
Big City	2 yr	2-5 yr	5-10 yr	5-20 yr
Small City	2 yr	2-5 yr	3-5 yr	5-10 yr

Source: (Menteri Pekerjaan Umum)

Based on table, its determined that for the Catchment area with 130 ha in the big city is used 5-10 year return period design.

Frequency analysis in this study uses four types of probability distributions including normal distribution, normal log distribution, gumbel distribution and Pearson III log distribution.

1.3 Normal Distribution

Normal Distribution Equation:

$$X_t = \bar{x} + SK_t$$

where :

Xt = Predicted value with T return period

$\bar{x}$ = average value

S = standard deviation

Kτ = frequency factor

Normal Distribution used if Cs ≈ 0 and Ck ≈ 3.

1.4 Log Normal DIstribution

Log Normal Distribution used if Cs ≈ 0 and Cs ≈ 3 Cv.

Log Normal Distribution Equation:

$$\log X_c = \overline{\log x} + K_t \, S \, log \, x$$

Where:

$\overline{\log x_c}$ = Predicted value with T return period

log x = average value

Kt = frequency factor

S log x = standard deviation

1.5 Distribusi Gumbel

Gumbel Distribution used if Cs ≈ 1.396 and Ck ≈ 5.4002.

$$X_T = \overline{X} + \frac{Y_T - Y_n}{S_a}$$

where:

XT = Variable in T Return Periode

X = Avreage Value

S = Standars Deviation

YT = reduced variate

Yn = reduced variate average

Sn = reduced variate standar deviation

The values of Yn and Sn indicate a certain value at certain n (amount of data). the amount of this price can be seen in the Gumbel table, Ytr is calculated following the following equation:

$$\boldsymbol{Y_{\tau_r} = - Ln \left\{ - \ln \frac{\tau_r - 1}{\tau_r} \right\}}$$

Where:

$\boldsymbol{Y_{\tau_r}}$ = reduced variate

$\boldsymbol{\tau_r}$ = period of re-review

1.6 Log Pearson III Distribution

Log Pearson III Distribution used if Cs ≈ 0 and Ck ≈ 4 – 6.

The frequency factor depends on the period T and the skewness coefficient (Cs). If Cs = 0, the frequency follows the normal standard x variable. If Cs ≠ 0. Pearson Log Log Equation III:

$$\log X_c = \overline{\log x} + K_t \, S \, log \, x$$

$\overline{\log x_c}$ = Predicted value with T return period

log x = average value

Kt = frequency factor

S log x = standard deviation

1.7 Smirnov Kolmogorov Test

A match test is needed to test the suitability of the frequency of the sample data against the opportunity distribution function that represents the frequency distribution. The testing parameters used are Smirnov-Kolmogorov. Smirnov-Kolmogorov, often also called a non-parametric test because the test does not use a particular distribution function. Testing the distribution of fit with this method is done by comparing the probability for each variable of the empirical distribution and the theoretical obtained a certain difference (Δ). The maximum difference calculated (Δmax) compared to the critical difference (Δcr) for a certain degree and the number of certain variates, the distribution is appropriate if (Δmax) <(Δcr).

1.8 Rainfall Intensity

From the return rainfall period that has been calculated then determined the intensity of rainfall per hour with the assumption that the duration of rain for 6 hours. To get the rainfall intensity Monobe formula is used :

$$I = \frac{R_{24}}{24}\left(\frac{24}{T}\right)^{\frac{2}{3}}$$

Where:

I = Rainfall Intensity (mm/hr)

T = Rainfall Duration Time (hr)

R24 = Maximum Rainfall in 24 hour (mm)

1.9 SWMM

Storm Water Management Model (SWMM) is a dynamic simulation model of the relationship between rainfall and runoff. This model is used to simulate single or continuous events over a long period, both in the form of runoff volume and water quality, especially in an urban area.

In modeling using SWMM there are parameters used in data processing, these parameters are:

Table 2 Parameter – Parameter Pengolahan Data SWMM

No	Fixed Parameter	Free Parameter
1	Rainfall	%Imperv
2	Area	Channel Width
3	Elevation	Channel Height
4	Width	Channel Shape
5	Infiltration	
6	%Slope	
7	N-Imperv	
8	N-Perv	
9	Dstore Imperv	
10	Dstore Perv	
11	%Zero Imperv	

Source: (Rossman)

The fixed parameters are parameters that are not changed and the free parameters are parameters that are changed with the aim to get the relationship between the retention pond capacity and the discharge. The compiled data is then processed with EPA SWMM 5.1 with known parameters and variables.

II. METHOD

This research is focused on assessing the technical feasibility of the retention pond development plan so that it is expected to be an ideal solution in order to resolve the flooding problem at the study site.

The first stage of this research is collecting primary and secondary data. Secondary data in the form of monthly rainfall and climatology data for the past 10 years were obtained from BMKG in Bandung. Whereas other secondary data, namely the condition of land use and existing drainage networks, were obtained from the Public Works Department (PU) of the City of Bandung. Contour Maps are processed results from DEMNAS Geospatial Information Agency (BIG) data and other thematic maps.

From the analysis of the existing contour and drainage network data, it can be seen the characteristics of the water flow and the extent of the retention pond catchment area.Then an analysis of rainfall data is carried out to obtain extreme rainfall, a

2-year and 10-year rain return period. From the results of the return period the hourly rain intensity was calculated using the Mononobe formula for a duration of 6 hours. The results from the calculation of rainfall intensity are then used as input for modeling existing drainage and plans for retention ponds. In this model, calibration and validation of flood events occurring at the location. in this case flood events in 2017 which according to residents are the most extreme flood events. The final stage of this research is to compare the conditions of existing modeling and modeling with the presence of a retention pool.

III. RESULT AND ANALYSIS

Storm Water Management Model (SWMM) is a rainfall-runoff simulation model that is used to simulate the quantity and quality of surface runoff from urban areas. Surface runoff is produced from catchment areas that receive rain. The surface runoff load is then channeled through a system of pipelines, open channels, reservoirs, pumps, and so on. SWMM calculates the quantity and quality of surface runoff from each catchment area, and the flow rate, depth of flow, and water quality in each pipe and channel during the simulation period.

For the input water catchment model (DTA) the model is divided into 9 parts, namely:

1) Margahayu Housing: 8 Catchment Area,
2) North housing: 1 Catchment Area, and,
3) Cidurian River Catchment Area.

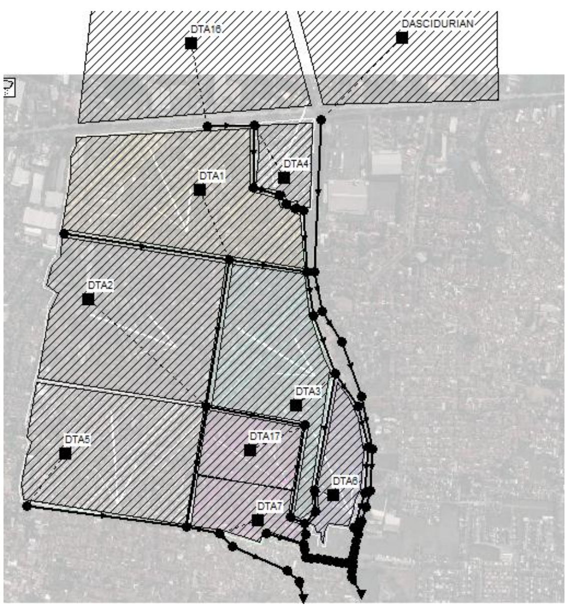


Figure 4 SWMM Model Layout Setting

Table 3 Subcatchment Set up

No DTA	Area (ha)	Width (m)	%Slope	%Imperv	CN
DTA 1	21.12	710	0.296	90	95
DTA	21.16	491	0.25	90	95

No DTA	Area (ha)	Width (m)	%Slope	%Imperv	CN
2					
DTA 3	14.5	250	0.25	90	95
DTA 4	3.8	182	0.25	90	95
DTA 5	17.6	475	0.25	90	95
DTA 6	4.93	123	0.25	90	95
DTA 7	4.48	268	0.25	90	95
DTA 17	5.62	200	0.25	90	95
DTA 16	35.26	400	0.25	90	95
DAS Cidurian	2787	500	0.25	80	80

1.10 First Modeling Scenario

In this first scenario, there is an existing modeling that aims to equate the modeling conditions with conditions in the field. In this scenario several parameters are also regulated so that results are obtained that are close to field conditions.

The parameters set in this scenario are;

1) % Impervious = 90 (dense urban settlement)

2) Roughness = 0.01 (concrete lining channel)

3) 2 year rainfall period

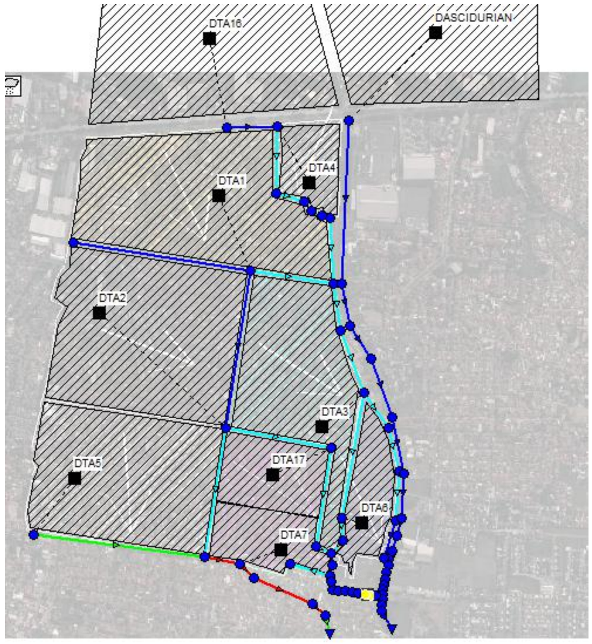


Figure 5 Channel Condition (link) Result on the First Scenarios

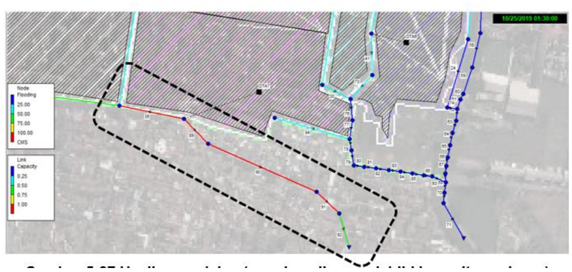
From the modeling results it can be seen that the channel in the lower area is red which indicates that the capacity of the channel can no longer accommodate the water discharge, while the other channels are still within safe limits namely blue and green.

The results obtained are as follows:

1) At link 36 (Saturn road), 89, 90 and 91 at the 1.5 hour there was an overflow due to the channel not being able to accommodate the discharge. This channel is located on the street Rw 12 Manjahlega VIllages.

2) At the link or channel there is an overflow as high as 10 cm.

3) This is in accordance with theinformation given by public regarding flood conditions. So it can be said that the modeling conditions are appropriate.



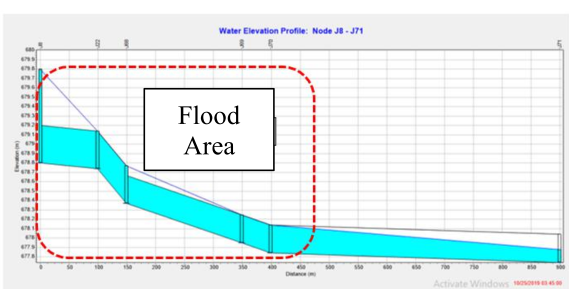


Figure 6 The results of SWMM modeling first scenarios at the channel location that occurred overflow

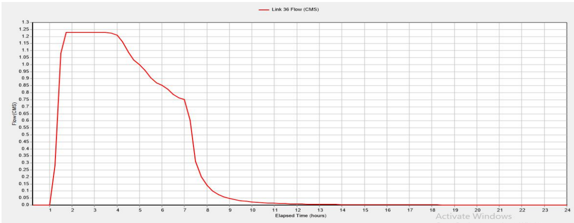


Figure 7 Discharge Water on the channel that occurs overflow

Whereas in the area of the retention pond plan from modeling results we get:

1) For 2 yearly rainfall there is no overflow in the channel around the retention pond due to the large channel capacity.

2) There is backwater from the cidurian river, but with the floodgates and pumps the impact can be minimized.

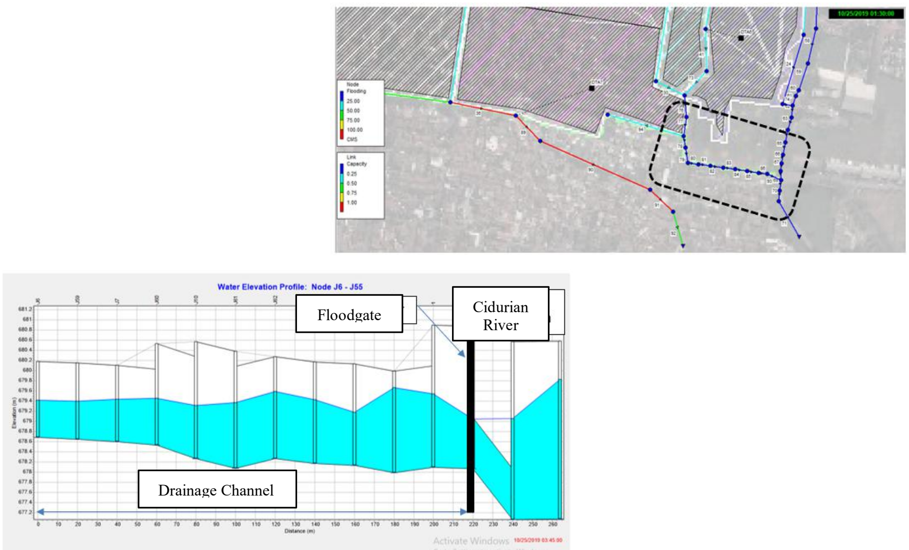


Figure 8 Channel Long Section on Retention Pond Location.

1.11 Second Modeling Scenario

In this scenario the model is run by inputting a 10 year rain with a rain duration of 6 hours.

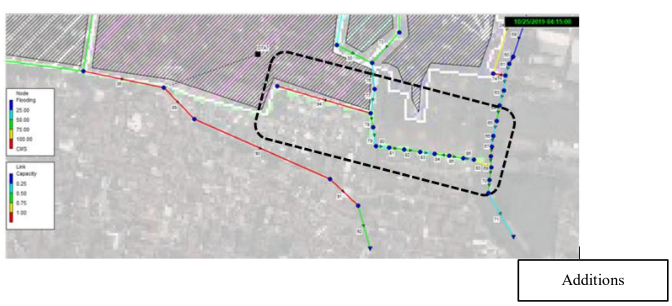


Figure 9 Channel Condition based on Capacity

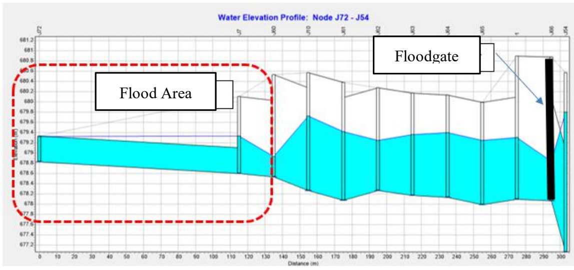


Figure 10 Channel Long Section on Retention Pond Location.

From the picture above it can be seen that the conditions that occur are still almost the same as the conditions in first scenario. However, there are additions for channels whose capacities cannot accommodate 10-year flow discharges at 4.15 hours on channel / link 94 which are directly related to the main drain and is located east of the retention pond. This is in accordance with the results of observations in the field which states that this area is an area affected by inundation / flooding which is quite often in addition to the RW12 area. The condition occurs due to backwater in the main drainage channel from Cidurian River.

1.12 Third Modeling Scenario

In this scenario alternative flood management is made as follows:

1. Adding channels (links 95 and link 96) to the retention pond from the direction of the Saturn road (reopening the channel that was closed) with a slope of 0.004. The purpose of this step is devided the water that will flow into the RW12 into retention ponds thereby reducing runoff discharge that will occur downstream of the channel due to the slope of the channel plan made steeper than the slope of the existing channel so that it is expected that water will quickly enter the channel the.

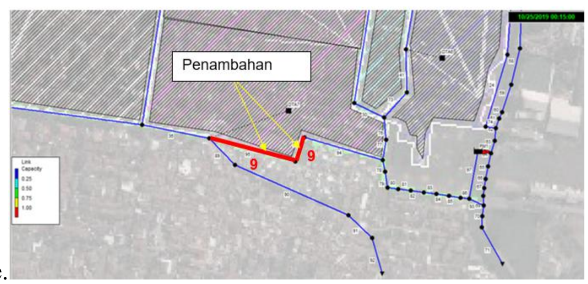


Figure 11 Channel Additions

2. Normalization of the existing channel from the drainage channel to the east of the retention pond to the end of the main drainage channel / floodgates. (link 94, links 78-86).

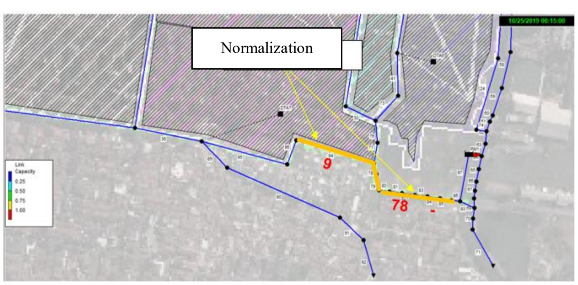


Figure 12 Channel with Normalization

3. Making a retention pond with an area of 0.98 ha depth of 6 m with a capacity of 59384.1 m3

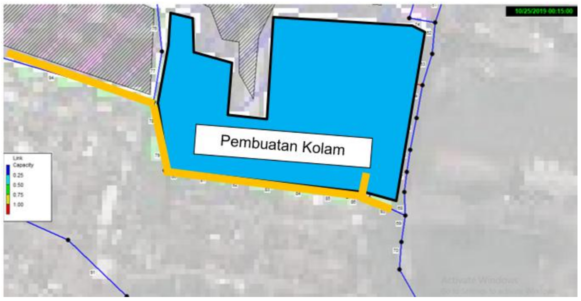


Figure 13 Retention Pond Area

4. Installation of 3 pumps with a capacity of 1 m3 / s.

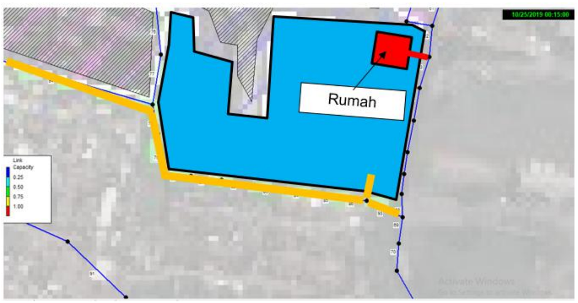


Figure 14 Location od Pump House

5. After adding these 4 variables to the modeling in scenario 3, the results are that all channels are at the critical safe level or there is no overflow in the downstream channel during peak hours during the 10-year rain event (R10)

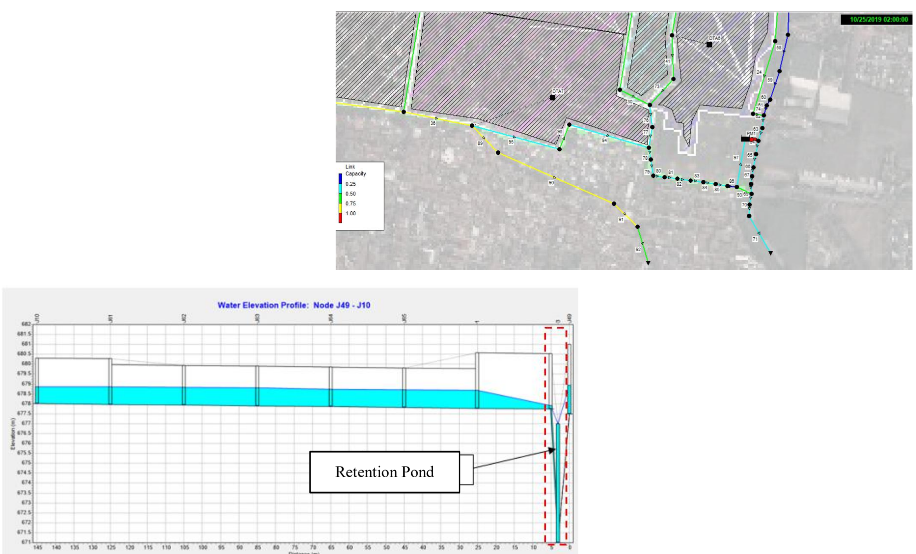


Figure 15 The condition of the water level during peak hours Q10 discharge flow in the long section of the main channels and retention pond

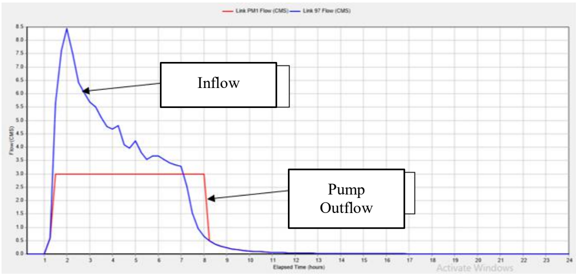


Figure 16 Comparison of Inflow to Retention Pond and Outflow from Pumps

1.13 Fourth Modeling Scenario

In this scenario alternative flood management is made similar to the third scenario, only in this scenario the main drain channel is eliminated so that the flow from the drainage outlet channels goes directly into the retention pond.

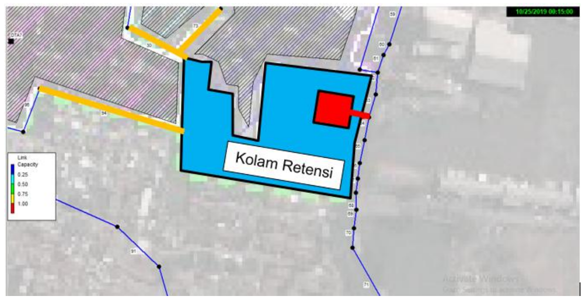


Figure 17 Retention Pond Area Without Main Drain

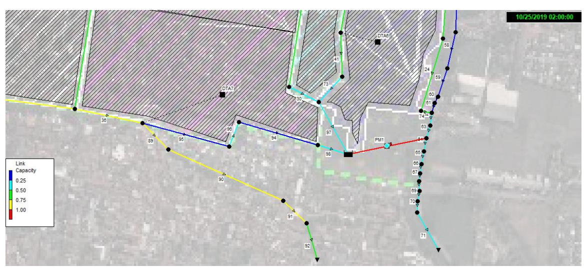


Figure 18 Condition of Drain Capacity in Fourth Modeling Scenario

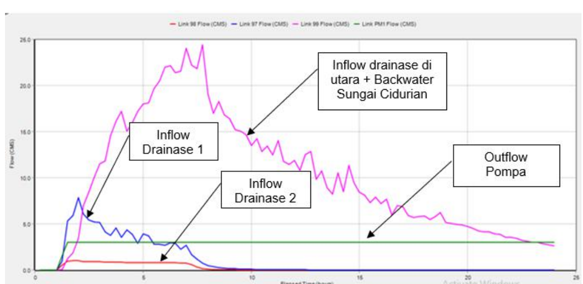


Figure 19 Comparison of Inflow to Retention Pond and Outflow from Pumps

IV. CONCLUSION

From the modeling results can be concluded as follows:

1) Based on map observations and analysis, the area of the Manjahlega Retention Pond (DTA) is 130 ha / 1.3 km^2.

2) The plan rainfall return period used as modeling input is R 2 years (2 year return period) and R 10 years (10 year return period). 2 years R of 85.98 mm which produced a Q2 year discharge plan of 9.5 m^3 / s and 10 years R of 126.16 mm which resulted in a discharge of 13.94 m^3 / s

3) Based on Modeling:

a. Scenario 1: Existing modeling with 2 year period (R2) with a rain duration of 6 hours, resulting in overflow in several channel sections, namely:

- Link 36, the location of Saturn Street with overflow height of 10-20 cm.
- Link 89, location of Manjahlega Street with overflow height of 10-20 cm.
- Link 90, location of Manjahlega Street with overflow height of 10-20 cm
- Link 91, location of Manjahlega Street with overflow height of 10-20 cm
- Link 94, the location of Dead-end Street with overflow height of 10-15 cm

b. Scenario 2: Existing modeling with a 10year rain periode (R10) with a rain duration of 6 hours produces an overflow in several channel sections, namely:

- Link 36, the location of Saturn Street with overflow height of 10-20 cm
- Link 89, location of Manjahlega Street with overflow height of 10-20 cm
- Link 90, location of Manjahlega Street with overflow height of 10-20 cm
- Link 91, location of Manjahlega Street with overflow height of 10-20 cm
- Link 94, dead-end street with 10-30 cm high overflow

c. Scenario 3: Modeling with a 9897 m2 / 0.98 ha retention pond downstream of the main drain channel and adding 95 and 96 link channels located on Saturn Road towards the retention pond with R10 . The results is a decrease in water level so that at the channels in scenario 2 do not overflow but the conditions are critical.

d. Scenario 4: Modeling with a retention pond of 10000 m2 / 1 ha downstream of the main drain and adding 95 and 96 link channels located on Saturn Road towards the retention pond with R10. The results is a decrease in water level so that the channels in scenario 4 does not overflow but the conditions are critical.

4) The retention pond is also indirectly beneficial as the addition of the Green Open Space (RTH) of Bandung by 0.01%. and Bandung City happiness index (0.02 - 0.08%).

V. SUGGESTION

1) To maximize flood control, it is necessary to normalize and increase the dimensions of drainage channels in several roads, especially Saturn Street - Manjahlega Street.

2) Need to build a dike on the cidurian river so that runoff does not occur when the Cidurian River discharge increases extreme.

3)

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