Drainage System Planning with Eco-Drainage Concept in Bumi Serpong Damai Housing Area (BSD)

Christian Cahyono[1*], and *Prabowo Arif* Setyawan[1]

[1]Civil Engineering Department, Faculty of Engineering, 11480 Bina Nusantara University, Indonesia

Abstract. Drainage is one form of facility that must be designed as a drainage system for the flow of water for the area in order to meet the needs of the community. From a different perspective, this drainage functions to drain water from the surface to water bodies. A good drainage system needs to be provided for good surface water management, especially with changes in land use resulting in increased surface water flow. One form of drainage that can be a solution is eco-drainage. In this study, the eco-drainage concept is applied to a residential location in Bumi Serpong Damai (BSD) to see the effect of eco-drainage applications in overcoming surface water flow problems. after implementing eco-drainage, the runoff flow of water that goes directly to the drainage canal can be reduced, for comparison with using the infiltration well system accommodated about 20% and the runoff discharge leading to the canal reduced to 0.1710 m^3/s and by using biopore holes accommodated approx. With total absorption capacity in channel 1 of about 0.0741 m^3/s to reduce runoff to drainage by 27.85%.

1 Introduction

Urban drainage is a drainage infrastructure system within a city area whose main function is not only to control and safely drain excessive rainwater runoff, but also to control and drain other excess water that has an impact on disturbing and/or polluting the urban environment, namely wastewater or wastewater [1]. Housing is an area or group of houses that function as a residential or residential environment which of course has been equipped with complete and complete facilities for the environment (UU No. 2 of 1992). The development of a residential area in the Bumi Serpong Damai (BSD) area is a form of effort to further improve the economic life of the BSD area and its surroundings because of its strategic area. From a hydrological perspective, the impact of land use changes is an increase in direct surface runoff and a decrease in water that seeps into the ground. The next result is an increasingly unequal distribution of water between the rainy and dry seasons, increased flood discharge and the threat of drought is becoming more real. Both floods and droughts have caused enormous losses, not only property (material) losses, but also loss of life [2].

Drainage is one form of facility that must be designed as a drainage system for the flow of water for the area in order to meet the needs of the community and one of the most important components in housing development planning, because in a residential area a good drainage system will be needed so that the comfort of residents in the area is avoided. from floods or puddles of rain, as well as supporting the lives of the people who inhabit the housing area of the Bumi Serpong Damai (BSD) South Tangerang. When viewed from a different perspective, this drainage functions to drain water from the surface to water bodies (surface and subsurface water sources) or infiltration buildings. In addition, it also functions as a controller for surface water needs to avoid flooding due to high intensity rain. A sustainable drainage system is a drainage system which in addition aims to reduce the problems caused by rainwater runoff on the surface, it also aims to reduce water pollution problems (aquatic), convert water resources and increase the use value of water, especially in the urban environment (urban) [3].

Therefore, there is a need for good planning in planning drainage channels in accordance with applicable regulations. In the application of a good drainage system, surface runoff is sought to be held first to increase the amount of water that seeps into the soil through natural and artificial infiltration areas [4]. For this study, several methods were used, including infiltration wells and biopore infiltration holes. Through infiltration wells and biopore infiltration holes, runoff from housing can be reduced and ground water levels can rise again because rainwater runoff can be channelled into infiltration wells [5].

2 Problem statement and goals

2.1 Problem statement

The identification of the problems studied based on the background of the problems above are as follows:

- How much is the planned flood water discharge in the BSD residential area?
- How to apply the concept of Eco-drainage so that it

* Corresponding author: christian.cahyono@binus.ac.id

can be of more economic value and also environmentally friendly.

2.2 Research goals

The objectives to be achieved in the planning analysis are as follows:

- Analyzing the planned flood discharge in the BSD residential area;
- Planning a drainage system in the BSD residential area with the concept of environmentally friendly drainage (Eco-Drainage);
- Seeing the effect of eco drainage in reducing flood discharge that enters the main channel.

3 Basic theory

To carry out the analysis in this study, it is necessary to understand the process of the hydrological analysis carried out which includes Frequency Analysis, Rational Methods, Biopore Infiltration Discharge and Infiltration Well Infiltration Discharge.

3.1 Frequency analysis

In planning a water structure, it is necessary to determine the return period discharge value that will enter or need to be accommodated by the water structure. In order to determine the discharge value, it is necessary to carry out a frequency analysis process on the rainfall data held. This rainfall is called the planned rainfall. The planned rainfall for a certain return period can statistically be estimated based on the data series of annual maximum daily rainfall. The basis for calculating the frequency distribution is a parameter related to data analysis which includes the mean, standard deviation, coefficient of variation, and coefficient of skewness

According to SNI 2415;2016 as the standard for calculating planned flood discharge, there are 5 distributions used for the frequency analysis process, namely normal distribution, normal log, Gumbel, Pearson log, and Pearson III. these methods have different parameter values but the five methods have general similarities, namely:

$$XT = \overline{x} + (K \times S) \quad (1)$$

Where:

XT : Return Period Rainfall
$\overline{x}$: Average of Rainfall data
K : Frequency Factor
S : Standard deviation

3.2 Rational method

The rational method is widely used to estimate the peak discharge caused by heavy rain in small catchment areas (DAS). A watershed is called small if the distribution of rain can be considered uniform in space and time, and usually the duration of rain exceeds the time of concentration. Some experts view that a watershed area of less than 2.5 Km^2 can be considered a small watershed [6]. The use of the rational method is very simple, and is often used in urban drainage planning. Several hydrological parameters taken into account are rainfall intensity, rain duration, rainfall frequency, watershed area, abstraction (water loss due to evaporation, interception, infiltration, surface storage) and flow concentration. The rational method is based on the following equation:

$$Q = 0,278\ C.I.A \quad (2)$$

Where:

Q : Rational Method Peak Flow
C : Flow Coefficient depends on Land use
I : Rainfall intensity
A : Area

3.3 Biopore holes

For the analysis of the calculation of the biopore holes needed to absorb the planned water discharge, before looking for the depth of the biopore hole, first an analysis is carried out to determine the value of the geometric factor (F) where the planned infiltration is located on completely porous soil with all permeable well walls and a hemispherical bottom as follows:

$$F=2\pi H/\ln\{(H+2R)/3R+ \sqrt{((H/3R)^2)+1}\} \quad (3)$$

Where:

H : Biopore Holes Depth
R : Biopores Hole Radius
F : Geometry Factors

$$H=Q/(F \times K) \quad (4)$$

Where:

Q : Flow absorbed by Biopores Holes
F : Geometry Factors
K : Soil Permeability
(Source: [7])

3.4 Infiltration wells

For analysis of the calculation of the infiltration wells required to absorb the planned water discharge are as follows:

$$F=2\pi R \quad (5)$$

Where:

F : Geometry Factors
R : Infiltration Wells Radius

$$H=Q/(F \times K) \quad (6)$$

Where:

Q : Flow absorbed by Biopores Holes
F : Geometry Factors
K : Soil Permeability
(Source: [8])

4 Study location

The planning location is in the Kucica Housing Pondok Pucung housing area, Bumi Serpong Damai (BSD), with the planning allocation as shown in the land plan.

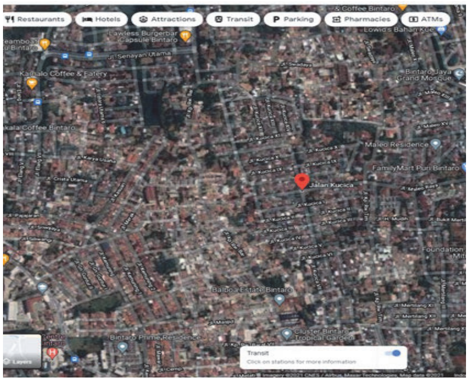

Fig. 1. Kucica housing location map.

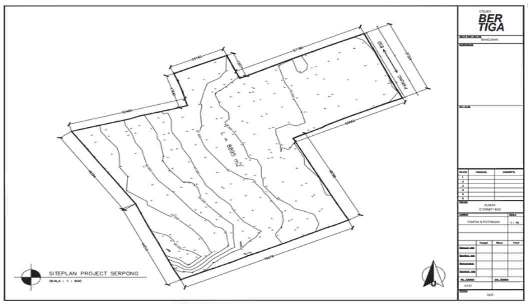

Fig. 2. Land plan used in planning.

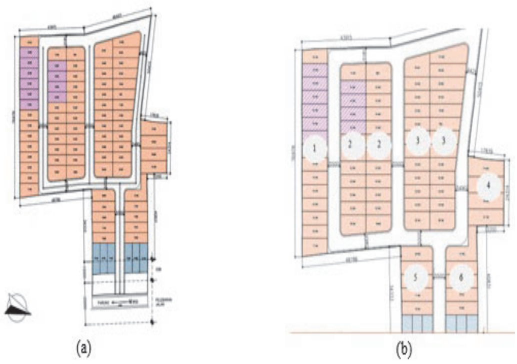

Fig. 3. (a) Building unit plans at residential locations (b) Tributary area for channel planning.

5 Analysis and discussion

As the first step to design channel dimension, it is necessary to do frequency analysis. For this study, rainfall data that are used are annual maximum daily rainfall from 1998-2019 for BSD area taken from Tropical Rainfall Measuring Mission (TRMM) Satellite. Figure 4 shows the maximum daily rainfall from 1998-2019 and Table 1 shows the result of frequency analysis using 5 methods. From Table 1, it shows that Gumbel Method yields the best results with maximum deviation of 11,46 which is lower than delta critical of 28.2. the results come from Kolmogorov-Smirnov Test that are shown in Figure 6. So it can be concluded that design rainfall that are used for Rational Method is 5 year return period using Gumbel method with amount of 129.8 mm.

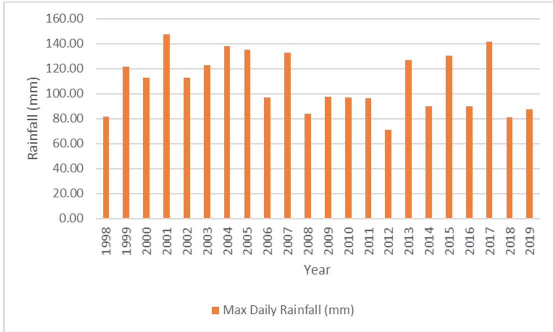

Fig. 4. Annual maximum daily rainfall from 1998-2019 for BSD area.

Table 1. Frequency analysis results.

Period Year (Year)	t	Methods				
		Normal Distribution	*Log normal*	*Gumbel I*	*Pearson III*	*Log Pearson*
2	0.00	108.9	106.6	105.5	108.5	107
5	0.84	128.3	127.1	129.8	128.2	127.9
10	1.28	138.5	139.4	145.9	138.8	140
20	1.64	146.9	150.4	161.3	147.7	150.8
25	1.75	149.3	153.8	166.2	150.3	154.1
Maximum Deviation		16.79	14.24	11.46	16.33	14.43
Delta Critical (Sig. Level 5 %)		28.2	28.2	28.2	28.2	28.2

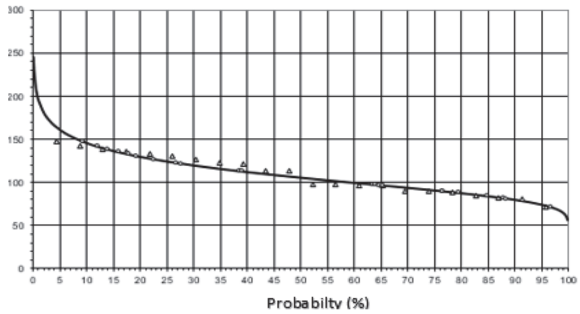

Fig. 5. Kolmogorov Smirnov test result for Gumbel method distribution.

After frequency analysis process done, the next step is to determine the flow using Rational Method. For this residential area there are 4 main channels. Table 2 shows the tributary area for each main channel.

Table 2. Channel tributary area.

Channel	Tributary Area	Area (m^2)
Channel A	A1	955.6
	B1	790
Channel B	B2	781
	C1	806
Channel C	C2	995
	D1	434.4
Channel D	A1	955.6
	B1	790
	B2	781
	C1	806
	C2	995
	D1	434.4
	D2	537.2
	D3	647.5

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For rainfall intensity using Mononobe Method where Rainfall used is from 5 year return period from Frequency Analysis,

$$I_{10} = \frac{129.8}{24} \times \left(\frac{24}{T_c}\right)^{\frac{2}{3}} \quad (7)$$

and for flow coefficient, the value depends on land use on the actual site. For this study there are 2 flow coefficient value used first one is for multi-unit housing with value of 0.75 and for Road with amount 0.9. so for each channel the composite flow coefficient must be found with this equation:

$$C\text{comp} = \frac{\text{C1A1+C2A2+}\cdots\text{+CnAn}}{\text{A1+A2+}\cdots\text{+An}} \quad (8)$$

Using equation 2, 7, and 8 Design flow for each channel can be calculated. The results shown in Table 3.

Table 3. Rational method flow for each channel.

Channel	Q_{Inflow} (m^3/s)
Channel A	0,2269
Channel B	0,2146
Channel C	0,1852
Channel D	0,602

After the discharge of the entire channel has been determined, the use of eco-drainage is carried out to see how much the reduction in discharge will enter the main channel. First method used is Infiltration Well. For this study, the amount of infiltration well implemented is 1 for each housing unit and Soil permeability in the location is around 6.1 cm/hour. Using the equation 5 and 6 flow infiltrated by infiltration well can be calculated, and also the amount of flow goes directly to main channel can be found also. Table 4 and Figure 6 show the result of using infiltration well.

Table 4. Summary of infiltration well implementation.

Channel	Q_{Inflow} (m^3/s)	$Q_{Infiltrated}$ (m^3/s)	$Q_{Channel}$ (m^3/s)	Reduction
Channel A	0.2269	0.0558	0.171	24.64%
Channel B	0.2146	0.0446	0.1699	20.83%
Channel C	0.1852	0.0271	0.158	14.69%
Channel D	0.602	0.1434	0.4586	23.82%

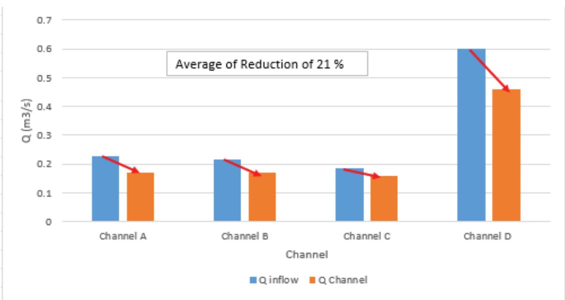

Fig. 6. Reduction using infiltration wells.

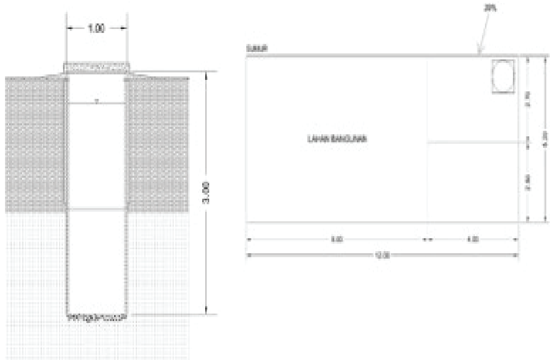

Fig. 7. Infiltration wells dimension and location.

From Figure 6 and Table 4, it is shown that by implementing infiltration well there are decrease in each of channel on area. From calculation also there is reduction of channel discharge by 21% on average. This decrease can help lessen the burden on drainage channel outside study area and also can decrease the channel size. From Figure 7, it is shown Infiltration well that will be installed has the dimension of 1x1 m with 3-meter depth and placed on the outermost of each unit.

The second eco-drainage method used is Biopore Holes. For this method, using the same Soil permeability and for amount of land used for biopore holes is 20% of each housing unit. Using equation 3 and 4 flow infiltrated by biopore holes can be calculated, and also the amount of flow goes directly to main channel can also be determined. Table 5, 6 and Figure 8 shows result of using biopore holes.

Table 5. Summary of biopore holes implementation.

Channel	Q Inflow (m^3/s)	Q Infiltrated (m^3/s)	Q Channel (m^3/s)	Reduction
Channel A	0.2269	0.0402 0.0339	0.1528	32.66%
Channel B	0.2146	0.0339 0.0254	0.1553	27.63%
Channel C	0.1852	0.0275 0.0085	0.1492	19.44%
Channel D	0.602	0.1906	0.4114	31.66%

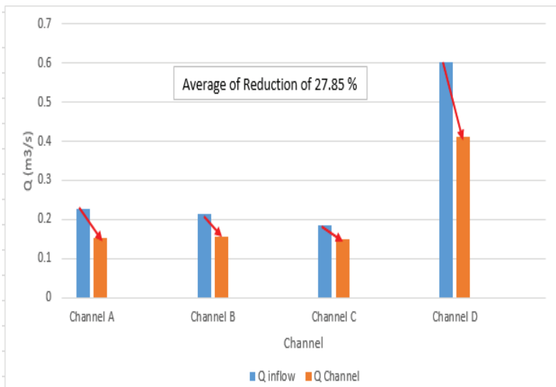

Fig. 8. Reduction using biopore holes.

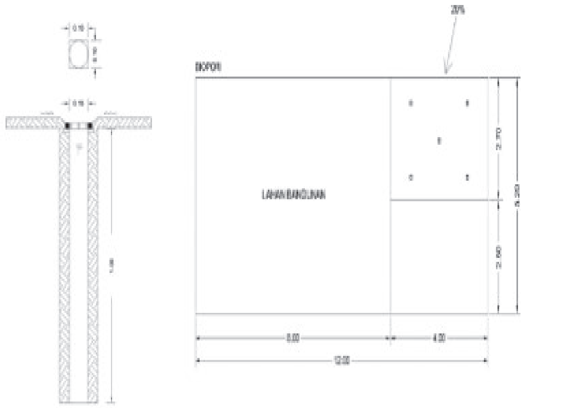

Fig. 9. Biopore holes configuration and location.

From Figure 8 and Table 5, it is shown that by implementing biopore holes there are decrease in each of channel on area. From calculation also there is reduction of channel discharge by 27.85% on average. This decrease can help lessen the burden on drainage channel outside study area and also can decrease the channel size. From Figure 9, it is shown 1 biopore holes that will be installed has the dimension of 10 cm in diameter with 1 meter depth. Each unit installed with 5 unit biopore holes with configuration as shown in Figure 9.

6 Conclusion

From the results obtained there are several things that can be concluded, for the return period discharge value of each channel can be seen in table 3, besides that it can be seen that with the application of eco-drainage it can be seen that there is a significant decrease in the discharge value for both types of eco-drainage used. for infiltration well there is a reduction of 20% on average while for biopore holes there is a reduction of 27.85% on average. With the implementation of eco-drainage, it is hoped that the value of the discharge to the main channel outside the residential area will decrease and can ease the burden of the main drainage channel.

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