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STUDY OF DRAINAGE, PANORAMIC HOUSING, CEMENGKALANG VILLAGE, SIDOARJO DISTRICT

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Abstract
Panorama Residence housing which has an area of 8000 m^2 is located in a plain area with a slope of about 0-1%. The survey results on the Panorama Residence Housing, Cemengkalang Village, Sidoarjo District, have an elevation of -0.20 m, slightly above the flood level – 0.30 m. This area has a high probability of flooding due to overflow from the Pucang River, which runs off (run-off water) from other areas if it rains with high intensity. Moreover, the Panorama Residence area is a dense residential area with roads and parking lots, so rainwater has a smaller chance of infiltrating and running off. After analysis, The flood discharge at the 25-year return period on the Pucang River was 72,561 m^3/sec. At the same time, the cross-sectional capacity of the Pucang River was 64,402 m^3/sec, so the cross-section of the Pucang River at the Panorama Residence Housing location experienced overflow. The run-off volume is 102.6 m^3, while the total capacity is 565.68 m^3, so the extended storage capacity is quite adequate. In rainy conditions, t = 30 minutes, the run-off volume that occurs = 30.96 m^3, and the total channel length = 493.12 m, the total drainage channel capacity = 184.92 m^3 is greater than the run-off volume, 30.96 m^3.

Keywords: Drainage, Housing, Pucang River, Rainfall, Run-Off

1. INTRODUCTION

Drainage is an arch or channel of water on the surface or below soil, both naturally formed and man-made (Prayoga, 2018). Drainage is usually called a ditch at ground level or culvert -underground manhole. Drainage plays an important role in regulating the water supply for flood protection (Zhang et al., 2018). Drainage means to drain, drain, treat or divert water (Skousen et al., 2019). In general, drainage is defined as a series of waterworks whose function is to reduce and/or treat excess water from an area or land so that the land can be utilized optimally (Meilani & Pramitha, 2014).

Drainage is needed in every place, including in residential areas. According to Mulyanto (2013), some of the functions of drainage are: 1) Wasting more water, where as the main function in preventing the emergence of stagnant water on residential land and in the ditches (canals) that are part of the drainage system, 2) Transport waste and wash pollution from urban areas, where drainage will carry away wastewater and other pollution from residential areas naturally, 3) Set the Flow Direction & Speed, where the waste water in the form of rain water and waste water will pass through drainage system and directed to the final shelter or waters load at which the drainage system empties according to a predetermined flow rate, 4) Regulating the groundwater level, which prevents a decrease in the groundwater level due to compaction or subsidence, namely the decrease in the soil surface above the groundwater level due to the space between grains in the soil which was previously filled with water will becomes empty so the soil compacts, 5) Become an alternative water resource, Recycling water from the drainage system can be an alternative fulfillment of water resources with several conditions and 6) one preventative infrastructure erosion and disturbance of slope stability.

Panorama Residence housing, with an 8000 m^2, is located in a plain landscape formed by coastal alluvial deposits and river deltas with a terrain slope of around 0-1%. Land scarcity impacts the flow of rainwater, which often experiences obstacles so that pockets of water or puddles of rainwater will occur. The location of the Panorama Residence Housing, Cemengkalang Village, Sidoarjo District, has an elevation that is slightly above the flood level, and this area has a high probability of flooding due to overflow from the Pucang River, which runs off (run-off water) from other areas in case of high-intensity rain. The drainage channel around the housing also often occurs because residents use this area for rice fields and aquaculture activities.

Based on this, it is necessary to conduct a study regarding the construction of drainage in Panoramic Housing Cemengkalang Village, Sidoarjo District. Hence, the researchers performed current research with the aim of conducting an analysis of the construction of drainage at Panoramic Housing Cemengkalang Village, Sidoarjo District. Besides, with this study researchers can identify the factors that cause flooding which can later be carried out through control measures with several considerations: 1) can be overcome at the most economical cost, 2) can be carried out with simple technology so partners/contractors can do it, and 3) make the most of existing facilities.

2. LITERATURE REVIEW

2.1. Drainage

Drainage is an arch or channel of water on the surface or below soil, both naturally formed and man-made (Prayoga, 2018). Drainage plays an important role in regulating the water supply for flood protection. Drainage is generally defined as a technical measures to reduce excess water, whether it comes from rainwater, seepage, as well as excess irrigation water from an area/seepage so the function of the land/area is not disturbed (Suripin, 2014). Drainage means to drain, drain, treat or divert water. In general, drainage is defined as a series of waterworks whose function is to reduce and/or treat excess water from an area or land so that the land can be utilized optimally.

2.1. Housing Area

Housing is a group of houses that function as residential environment or residential environment equipped with environmental facilities and infrastructure (Mentari, 2018). Housing is a collection of houses as part of a settlement, both urban and rural, equipped with facilities, infrastructure and utilities as a result of efforts to fulfill livable housing (Law No. 1 of 2011). Housing is one form residential facilities that have a very close relationship with the community

3. RESEARCH METHOD

3.1. Hydrological

The analysis referred to here is the calculation of rainfall and discharge to obtain the design flood discharge.

3.2. Maximum Rainfall

In calculating the maximum rainfall, rainfall data is needed to calculate the planned flood discharge, fill in the missing rainfall data if there is incomplete data, and test data consistency to determine the deviation of the rain data.

3.3. Design Rain Analysis

To calculate the average rainfall data throughout the regional rainfall flow area with the equation:

$$R_{ave} = \frac{An}{A} \text{ x } R_n$$

Information: R_{ave} = average rainfall
R_n = the amount of rainfall at each post
N = the number of rain posts
A = the area of the termination area
An = the area of influence per rain post

The planned rainfall is obtained by analyzing the existing rain data, and then who will know the type of distribution according to the data.

3.4. Calculation of Planned Debits

To calculate the planned debits, the Practical Rational Method is used. The equation used is:

$$Qp = 0.278 *C*I*A$$

Information: Qp = Flood peak debit (m^3/s)
C = run-off coefficient
I = rainfall intensity during concentration time (m^3/s)
A = drainage area (km^2)

Rain intensity is calculated from R_{5th} with the Mononobe formula as follows:

$$I = R_{5th}/24 * (24/Tc)^{2/3}$$

Information: I = rain intensity during concentration time (m^3/s)
R_{5th} = design rain with a 5-year return
Tc = concentration time (hours)

While Tc is calculated using the Kirpich (1940) and Dr. Rziha formula, namely:

Tc = t1 + t2
t1 = 0.0195/60 * $(Lo/S^{0.5})^{0.77}$ (Kirpich's formula) and
t2 = L/V, V = 72 $(H/L)^{0.6}$ (Dr. Rziha's formula)
so formula t2 = L/72 * $I^{0.6}$

Information:
- Lo = slope length (m)
- S = slope (m/m)
- L = length of the river (km)
- V = flood propagation speed (Km/hours)
- H = height difference between the farthest point and the mouth of the drainage area (Km)
- I = river slope

3.5. Channel Planning

For hydraulic planning of a channel, the Maning's formula is set as follows:

Q = V.A　　　A = b.h
V = 1/n*R2/3*S1/2　　　P = b+2h
R = A/P

Information:
- Q = channel discharge (m^3/s)
- V = flow rate (m/s)
- R = hydraulic radius (m)
- A = cross-sectional area of the channel (m^2)
- P = wet circumference (m)
- B = channel bottom wish (m)
- H = height of water (m)
- S = channel slope

Maximum speed for subcritical flow:
- Stone masonry : 2 m/s
- Concrete masonry : 3 m/s
- Ground pair : Maximum allowable velocity

For stable flow Froude number must be less than 0.55 for subcritical flow or more than 1,4 for supercritical flow. Channels with a Froude number between 0.55 and 1.4 can have a flow pattern with standing waves (wavy water level, which will damage the slope of the channel). The minimum price of guard height is presented in Table 1.

Table 1 Minimum price of guard

Qp (m^3/s)	Guard Height (m)	Masonry (m)
< 0.5	0.40	0.20
0.5 – 1.5	0.50	0.20
1.5 – 5.0	0.60	0.25
5.0 – 10.0	0.75	0.30
10.0 – 15.0	0.85	0.40
>15.0	1.00	0.50

Small channels are usually designed with bottom width (B) = design flow depth (h). In this case, the width of the base divided by the depth is B/h = n = 1. The ideal comparison value for the planned discharge can be seen in Table 2.

Table 2 Ideal Comparative Value According to the Planned Debit

Qp (m^3/s)	n
0.15 – 0.30	1.0
0.30 – 0.50	1.0 – 1.2
0.50 – 0.75	1.2 – 1.3
0.75 – 1.00	1.3 – 1.5
1.00 – 1.50	1.5 – 1.8
1.50 – 3.00	1.8 – 2.3
3.00 – 4.50	2.3 – 2.7
4.50 – 5.00	2.7 – 2.9
5.00 – 6.00	2.9 – 3.1
6.00 – 7.50	3.1 – 3.5
7.50 – 9.00	3.5 – 3.7
9.00 – 10.00	3.7 – 3.9
10.00 – 11.00	3.9 – 4.2
11.00 – 15.00	4.2 – 4.9
15.00 – 25.00	4.9 – 6.5
25.00 – 40.00	6.5 – 9.0

4. RESULTS AND DISCUSSION

4.1. Data on the existing condition of the panoramic residence residential land

Initial conditions Panorama Residence housing is located in the village of Cemengkalang, which faces south in the form of a tertiary landfill of Patusan, the southern boundary with the Dayu Channel, the western and eastern boundaries with the village.

4.2. Data on the existing condition of drainage channels

Tertiary Patusan Drainage is to the north of the location (yellow), and Dayu Channel is to the south of the housing location (blue). The floor plan can be seen in Figure 1.

Figure 1 Map of the Location of Drainage Flow

4.3. Rainfall data

Rainfall data is obtained through 4 stations. While the sewer around the location of the Panorama Residence Housing is the Pucang River which has its upstream in the Sidoarjo District and empties into the Madura Strait. The location of the rainfall station and the Pucang River flow can be seen in Figure 2.

Figure 2 Location of the Pucang Rainfall and Flow Station

The data for the annual maximum rainfall in the Pucang River watershed can be seen in Table 3

Table 3 Annual Maximum Rainfall Data for The Pucang River Watershed

YEAR	DATE	RAINFALL STATION			
		BANJAR KEMANTREN	SIDOARJO	SUMPUT	KLAGEN
2001	23-Jan	**85**	6	15	1
	22-Jan	80	**110**	125	125
	22-Jan	80	110	**125**	125
	22-Jan	80	110	125	**125**
2002	29-Jan	**65**	30	68	58
	28-Jan	0	**90**	0	0
	28-Mar	53	52	**150**	128
	28-Mar	53	52	150	**128**
2003	18-Nop	**70**	89	108	117
	02-Feb	0	**113**	110	110
	02-Feb	0	113	**110**	110
	18-Nop	70	89	108	**117**
Etc.	-	-	-	-	-
2011	02-Mei	**150**	105	88	78
	01-Feb	44	**110**	42	54
	26-Des	40	0	**141**	67
	26-Mar	125	4	136	**103**

The coefficient of Thiesen's influence on the Pucang River watershed can be seen in Table 4.

Table 4 Thiesen's Effect of the Pucang River Watershed

STATION	SHVP	STATION NUMBER	LOCATION	AREA (Km^2)	KOEF
BANJARKEMANTREN	0	182	BANJARKEMANTREN	0,85	0,165
SIDOARJO	5	162	SIDOKLUMPUK	0,90	0,175
SUMPUT	4	153	CEMENGKALANG	1,90	0,369
KLAGEN	5	155	SIDOKEPUNG	1,50	0,291
Source :	Calculation Results			5,15	1,000

The calculation of the annual maximum daily rainfall using the Thiessen method in the Pucang River watershed can be seen in Table 5.

Table 5 The Calculation of The Annual Maximum Daily Rainfall Using the Thiessen Method in The Pucang River Watershed

YEAR	DATE	RAINFALL STATION BANJAR KEMANTREN	SIDOARJO	SUMPUT	KLAGEN	TOTAL (mm)
		0.165	**0.175**	**0.369**	**0.291**	
2001	23-Jan	**85**	6	15	1	20.903
	22-Jan	80	**110**	125	125	**114.951**
	22-Jan	80	110	**125**	125	114.951
	22-Jan	80	110	125	**125**	114.951
2002	29-Jan	**65**	30	68	58	57,951
	28-Jan	0	**90**	0	0	15.728
	28-Mar	53	52	**150**	128	**110,456**
	28-Mar	53	52	150	**128**	110,456
2003	18-Nop	**70**	89	108	117	**101.029**
	02-Feb	0	**113**	110	110	92.369
	02-Feb	0	113	**110**	110	92.369
	18-Nop	70	89	108	**117**	101.029
Etc	-	-	-	-	-	
2011	02-Mei	**150**	105	88	78	**98.291**
	01-Feb	44	**110**	42	54	5.709
	26-Des	40	0	**141**	67	78.136
	26-Mar	125	4	136	**103**	101.505

Average rainfall using the Thiesen Method in the Pucang River Watershed can be seen in Table 6.

Table 6 Average Rainfall using the Thiesen Method in the Pucang River Watershed

YEAR	DATE	RAINFALL STATION BANJARKEMANTREN	SIDOARJO	SUMPUT	KLAGEN	TOTAL (mm)
		0,165	**0,175**	**0,369**	**0,291**	
2001	22-Jan	13,20	19,22	46,12	36,41	**114,951**
2002	28-Mar	8,75	9,09	55,34	37,28	**110,456**
2003	18-Nop	11,55	15,55	39,84	34,08	**101,029**
2004	20-Feb	8,25	15,55	35,42	21,26	**80,485**
Etc	-	-	-	-	-	**-**
2011	02-Mei	24,76	18,35	32,47	22,72	**98,291**

The calculation of the consistency test of the Pucang River watershed rain data is shown in Table 7, Table 8, and Table 9.

Table 7 Calculation of the Consistency Test for Pucang River Watershed Rain Data

Num.	YEAR	ANNUAL DAIRY RAIN DATA				STATION CONSISTENCY		
		BANJAR KEMANTEN	SIDOARJO	SUMPUT	KLAGEN	COMMU LATIVE	AVERAGE	COMMU LATIVE
1	2001	80	110	125	125	80	120.00	120.00
2	2002	53	52	150	128	133	110.00	230.00
3	2003	0	113	110	110	133	111.00	341.00
4	2004	50	89	82	76	183	82.33	423.33
Etc	-	-	-	-	-	-	-	-
11	2011	150	105	88	78	669	90.33	1039.33

Table 8 Calculation of the Consistency Test for Pucang River Watershed Rain Data

Num.	YEAR	ANNUAL DAIRY RAIN DATA				STATION CONSISTENCY		
		BANJAR KEMANTEN	SIDOARJO	SUMPUT	KLAGEN	COMMU LATIVE	AVERAGE	COMMU LATIVE
1	2001	80	110	125	125	110	110.00	110.00
2	2002	53	52	150	128	162	110.33	220.33
3	2003	0	113	110	110	275	73.33	293.67
4	2004	50	89	82	76	364	69.33	363.00
Etc	-	-	-	-	-	-	-	-
11	2011	150	105	88	78	1061	105.33	908.67

Table 9 Calculation of the Consistency Test for Pucang River Watershed Rain Data

Num.	YEAR	ANNUAL DAIRY RAIN DATA				STATION CONSISTENCY		
		BANJAR KEMANTEN	SIDOARJO	SUMPUT	KLAGEN	COMMU LATIVE	AVERAGE	COMMU LATIVE
1	2001	80	110	125	125	125	105.00	105.00
2	2002	53	52	150	128	253	85.00	190.00
3	2003	0	113	110	110	363	74.33	264.33
4	2004	50	89	82	76	439	73.67	338.00
Etc	-	-	-	-	-	-	-	-
11	2011	150	105	88	78	931	114.33	952.00

Meanwhile, River Watershed Distribution Determination can be seen in Table 10.

Table 10 River Watershed Distribution Determination

Num	X (mm)	$(X-\bar{X})^2$	$(X-\bar{X})^3$	$(X-\bar{X})^4$
1	74,13	488,87	-10.809,00	238.990,49
2	77,71	343,28	-6.360,21	117.840,79
3	77,82	339,33	-6.250,86	115.147,20
4	80,49	248,10	-3.907,81	61.552,25
5	85,15	123,01	-1.364,27	15.131,03
Etc	-	-	-	-
11	143,78	2.260,07	107.443,93	5.107.901,51
TOTAL	1.058,60	4.384,31	88.297,79	5.820.672,07

Average	:	96,2365
Cs	:	1,0687
Ck	:	4,2057
Std	:	20,9387

Because the values of Cs and Ck do not show typical properties, the distribution chosen is Log Pearson Type III.

Rainfall Designs Various Rework can be seen in Table 11.

Table 11 Rainfall Designs Various Rework

Num.	**Pr %**	**Tr (Year)**	**K**	**Log X**	**X (mm)**
1	99,0099	1,01	-1,759	1,8188	65,89
2	50,0000	2	-0,127	1,9636	91,95
3	20,0000	5	0,784	2,0442	110,72
4	10,0000	10	1,336	2,0932	123,94
5	5,0000	20	1,768	2,1315	135,37
6	4,0000	25	1,985	2,1507	141,47
7	2,0000	50	2,560	2,2017	159,10
8	1,0000	100	2,867	2,2289	169,40

Design Rainfall Calculations Log Pearson I Method in Pucang River Basin can be seen in Table 12

Table 12 Design Rainfall Calculation of Pearson I Log Method in Pucang River Watershed

NO.	**X (mm)**	**Log X**	$(Logx-\overline{Logx})$	$(Logx-\overline{Logx})^2$	$(Logx-\overline{Logx})^3$	$(Logx-\overline{Logx})^4$	**P %**
1	74,13	1,8700	-0,1048	0,0110	-0,0012	0,0001	8,3333
2	77,71	1,8905	-0,0843	0,0071	-0,0006	0,0001	16,6667
3	77,82	1,8911	-0,0837	0,0070	-0,0006	0,0000	25,0000
4	80,49	1,9057	-0,0691	0,0048	-0,0003	0,0000	33,3333
5	85,15	1,9302	-0,0446	0,0020	-0,0001	0,0000	41,6667
Etc	-	-	-	-	-	-	-
11	143,78	2,1577	0,1829	0,0335	0,0061	0,0011	91,6667
TOTAL	1.058,60	21,72	0,0000	0,0785	0,0043	0,0014	

Average	:	1,975
Std	:	0,088626347
Cs	:	0,76286463
Ck	:	3,930750572

4.4. Calculation of planned flood discharge and channel cross-section

Calculation of channel dimensions in Channel 01 – 02:

Length of slope Lo = 15 m; slope = 0.016; Channel length = 62.12 m; Channel Slope = 0.0011

Rain intensity / I = $R_{5th}/24 * (24/Tc)^{2/3}$

Tc = t1 + t2

t1 = $0.0195/60 * (Lo/S^{0.5})^{0.77}$

= $0.0195 / 60 * (15 / 0.0011^{0.5})^{0.77}$ = 0.037 hours

t2 = $L/72 * I^{0.6}$

= $62.12 / 72 * 0.0011^{0.6}$ = 0,051 hours

Tc = 0,088 hours

I = $(110.72 / 24) * (24 / 0,088)^{2/3}$ = 193.957 mm/hours

Flood plan discharge:

Qp = 0.278 * C * I * A

= 0.278 * 0,7 * 193.957 * 0,000415 = 0,016 m^3/s

Planned Channel:

b = 0.5 m (planned); m = 0.00; S = 0.00113; K = 45 (river stones masonry)

Formula:

$V = K.R^{2/3}.I^{1/2}$

R = A/P

Tried : h = 0.5 m,

A = b * h

= 0.25 m^2

P = b + 2h

= 1.50 m

V = $K . R^{2/3} . I^{1/2}$

= 0,457 m/s

Q = V .A

= 0,457*0,25

= 0,1144 m^3/s

Comparison Q Planned / Q Channel = 13.70 %

So that the h plan is appropriate because the calculated debt is equal to or greater than the planned debit.

4.5. Calculation of Pucang River Capacity at the location of the Panorama Residence Housing Plan

Calculation of the Horizontal Distribution Suitability Test using the Smirnov Kolmogorof Method can be seen in Table 13.

Table 13 Calculation of the Horizontal Distribution Suitability Test using the Smirnov Kolmogorof Method

Num.	X (mm)	Log X	Pe(%)	K	Pt'(%)	Pt (%)	Pe-Pt %
1	74,13	1,8700	9,0909	-1,183	7,64	92,36	83,2691
2	77,71	1,8905	18,1818	-0,951	13,35	86,65	68,4682
3	77,82	1,8911	27,2727	-0,945	26,76	73,24	45,9673
4	80,49	1,9057	36,3636	-0,779	32,64	67,36	30,9964
5	85,15	1,9302	45,4545	-0,503	56,55	43,45	2,0045
Etc.	-	-	-	-	-	-	-
11	143,78	2,1577	100,0000	2,064	96,86	3,14	96,8600
Source :	Calculation Result					D max	47,7282

Log X 1,9748
Std 0,08862635
Cs 0,76286463
Ck 3,93075057

The value of D Cr from the table for a = 1% is 0.67 = 67.0%
Maximum < DCr , so the distribution selection is accepted

The calculation of the vertical distribution suitability test using the Chi-Square method can be seen in Table 14.

Table 14 The Calculation of The Vertical Distribution Suitability Test Using the Chi-Square Method

Num.	Class Limit	Freq. Theoretical Oj's Class	Freq. Observation Ej's Class	(Oj-Ej)2	(Oj-Ej)2/EF
1	0 - 67.92	2,75	1	3,0625	1,114
2	67.92 - 77.32	2,75	2	0,5625	0,205
3	77.32 - 92.68	2,75	4	1,5625	0,568
4	92.68 - »	2,75	4	1,5625	0,568
	total	11	11	6,75	2,4545

Num of classes	=	1 + 3.322 Log n
	=	4,46
n	=	11
Expected Frequency (EF)	=	n/k
EF class limit taken 4	=	2,75

1) Probability 75%
   Log Xt = LogX + K. Std = 1.8225 + 0,114 *0.1157 = 1,8357
   Xt = 68,4999

2) Probability 50% = 1.8225 + 0,225 *0.1157 = 1,8485325
   Xt = 70,55576418

3) Probability 25% = 1.8225 + 0,832 *0.1157 = 1,9187624
Xt = 82,93968851
a = 5% and degree of freedom (V) = K-1, obtained X2 Table = 9,488 So that the distribution selection is accepted

The average rainfall up to the t-t hour can be seen in Table 15.

Table 15 The Average Rainfall Up to the -T Hour

Rainfall Average Until T-hour

$Rt = Ro*(t/T)^{2/3}$

For a daily time of 6 hours, then:

$Rt = Ro*(6/T)^{2/3}$

to :

t = 1	$Rt = (R24/6)*(6/1)^{2/3}$	=	0,55	R24
t = 2	$Rt = (R24/6)*(6/2)^{2/3}$	=	0,35	R24
t = 3	$Rt = (R24/6)*(6/3)^{2/3}$	=	0,26	R24
t = 4	$Rt = (R24/6)*(6/4)^{2/3}$	=	0,22	R24
t = 5	$Rt = (R24/6)*(6/5)^{2/3}$	=	0,19	R24
t = 6	$Rt = (R24/6)*(6/6)^{2/3}$	=	0,17	R24

Average Rain at Hour - T can be seen in Table 16.

Table 16 Average Rain at Hour - T

Rainfall to T-hour

Rt = t * Rt - (t-1) R(t-1)

To :

t = 1	Rt = 1* 0.55 R24 - (1-1) * 0	=	0,55	R24
t = 2	Rt = 2* 0.35 R24 - (2-1) * (0.55 R24)	=	0,14	R24
t = 3	Rt = 3* 0.26 R24 - (3-1) * (0.35 R24)	=	0,10	R24
t = 4	Rt = 4* 0.22 R24 - (4-1) * (0.26 R24)	=	0,08	R24
t = 5	Rt = 5* 0.19 R24 - (5-1) * (0.19 R24)	=	0,07	R24
t = 6	Rt = 6* 0.17 R24 - (6-1) * (0.17 R24)	=	0,06	R24

The recapitulation of the results the T-H Rainfall Calculation can be seen in Table 17.

Table 17 Hour Recapitulation of the Calculation of Rainfall Results - T

Watershed (DAS) Condition	Num of Flow		
Mountains	0,75	-	0,90
Tertiary mountains	0,70	-	0,80
Heavy relief Land and wooded	0,50	-	0,75
Agricultural plain	0,45	-	0,60
Irrigated rice fields	0,70	-	0,80
River in the mountain	0,75	-	0,85
River in lowlands	0,45	-	0,75
Large river with part of its flow in lowland	0,50	-	0,75

Distribution of Rain Every Hour Rainfall the Design of the Pearson Type I Log Method can be seen in Table 18.

Table 18 Distribution of Rain Every Hour Rainfall the Design of the Pearson Type I Log Method

Time	Ratio	Rainfall Every Hours							
Hour	(%)	1.01 Th	2Th	5Th	10Th	20TH	25Th	50Th	100Th
		65,894	91,951	110,724	123,937	135,368	141,472	159,102	169,398
1	55,03	27,197	37,952	45,700	51,154	55,872	58,391	65,668	69,918
2	34,67	17,133	23,908	28,789	32,225	35,197	36,784	41,368	44,045
3	26,46	13,075	18,245	21,970	24,592	26,860	28,072	31,570	33,613
4	21,84	10,793	15,061	18,136	20,300	22,173	23,173	26,060	27,747
5	18,82	9,301	12,979	15,629	17,494	19,108	19,970	22,458	23,911
6	16,67	8,237	11,494	13,840	15,492	16,921	17,684	19,888	21,175

Synthetic Unit Hydrograph Analysis of the Nakayasu Method in the Pucang River Watershed can be seen in Table 19.

Data:

Pucang River Watershed (DAS) Area's = 18,7 Km^2
Main River's Length = 8,5 Km
Riverbed Slope Average = 0,001212
Alfa Parameter = 2
Flow Coefficient = 0,7
Ro (Unit Rain) = 1 mm

Table 19 Synthetic Unit Hydrograph Analysis of the Nakayasu Method in the Pucang River Watershed

t (hour)	Q (m^3/dt)	desc
1	0,00841	
2	0,04437	
3	0,11740	Qa
4	0,23416	
5,36	0,47269	
6	0,43609	
7	0,38349	
8	0,33723	
10	0,26078	Qd1
12	0,20166	
14	0,15594	
14,72	0,14215	
15	0,13873	
16	0,12734	
18	0,10728	
19	0,09847	
20	0,09038	
23	0,06989	Qd2
25	0,05888	
27	0,04961	
28	0,04553	
28,77	0,04263	
29	0,04199	
35	0,02856	
40	0,02071	Qd3
45	0,01502	
50	0,01089	

Tg = 4,683 hour, $Tg = 0.21+L^{0.7}$, for L<15 Km
Tp = 5,363 hour, Tp = Tg + 0.8 Tr
T0.3= 9,366 hour, T0.3 = □ Tg
Qp = 0,473 m^3/dt
Tr = (0.5 to 1)*Tg
Qa = $Qp (t/Tp)^{2.4}$
Qd1 = Qp*0.3^(t-Tp/T0.3)
Qd2 = Qp*0.3^(t-Tp+0.5*T0.3)/1.5*T0.3
Qd3 = Qp*0.3^(t-Tp+1.5*T0.3)/2*T0.3

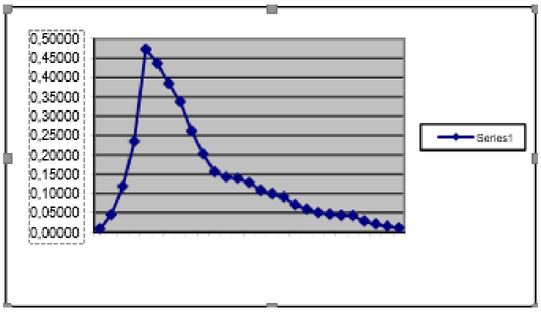

Figure 3 Hydrograph Analysis

The unit hydrograph equation is as follows:

1) Rising line
   $0 \leq t \leq Tp$
   $0 \leq t \leq 5.363$

2) Recession line
   a) $Tp \leq t \leq (Tp+T0.3)$
      $5,363 \leq t \leq 14,729$
   b) $Tp + T0.3 \leq t \leq (Tp+T0.3+ 1.5*T0.3)$
      $14,729 \leq t \leq 28,778$
   c) t^{3} (Tp+T0.3+ 1.5*T0.3)
      t^{3} 28,778

Design Flood Discharge with a 25-year return period can be seen in Table 20.

Table 20 Design Flood Discharge with A 25-Year Return Period

t	**U (t,1)**	**Q Cause Rain Netto (m^3/s)**						**Q flood**
(hour)	**(m^3/s)**	**58,3915**	**36,7843**	**28,0717**	**23,1727**	**19,9696**	**17,6841**	**(m^3/s)**
0	0,008406	0,000						0,000
1	0,044366	2,591	0,000					2,591
2	0,1174	6,855	4,318	0,000				11,174
3	0,234164	13,673	8,614	6,573	0,000			28,860
4	0,472685	27,601	17,387	13,269	10,953	0,000		69,211
5	0,436092	25,464	16,041	12,242	10,105	8,709	0,000	72,561
6	0,383487	22,392	14,106	10,765	8,886	7,658	6,782	70,590
7	0,337227	19,691	12,405	9,467	7,814	6,734	5,964	62,075
8	0,260775	15,227	9,592	7,320	6,043	5,208	4,612	48,002
9	0,201655	11,775	7,418	5,661	4,673	4,027	3,566	37,119
10	0,155939	9,105	5,736	4,377	3,614	3,114	2,758	28,704
11	0,142154	8,301	5,229	3,990	3,294	2,839	2,514	26,167
12	0,138731	8,101	5,103	3,894	3,215	2,770	2,453	25,537
13	0,127337	7,435	4,684	3,575	2,951	2,543	2,252	23,439
14	0,107279	6,264	3,946	3,012	2,486	2,142	1,897	19,747
15	0,098469	5,750	3,622	2,764	2,282	1,966	1,741	18,125
16	0,090381	5,278	3,325	2,537	2,094	1,805	1,598	16,637
17	0,069891	4,081	2,571	1,962	1,620	1,396	1,236	12,865
18	0,058882	3,438	2,166	1,653	1,364	1,176	1,041	10,839
19	0,049608	2,897	1,825	1,393	1,150	0,991	0,877	9,131
20	0,045533	2,659	1,675	1,278	1,055	0,909	0,805	8,381
21	0,042626	2,489	1,568	1,197	0,988	0,851	0,754	7,846
22	0,041993	2,452	1,545	1,179	0,973	0,839	0,743	7,730
23	0,028556	1,667	1,050	0,802	0,662	0,570	0,505	5,256
24	0,020707	1,209	0,762	0,581	0,480	0,414	0,366	3,812
25	0,015016	0,877	0,552	0,422	0,348	0,300	0,266	2,764

The flood discharge at the 25-year return period on the Pucang River was 72,561 m^3/sec. At the same time, the river capacity at the Panorama Residence Housing location with river dimensions of 2.5 x 8.5 m^2 was = 64,402 m^3/sec, so the cross-section of the Pucang River at the Panorama Residence Housing location experienced overflow.

Channel Name	: Pucang River	K	: 70
Channel Length	: 8500 meter	m	: 1.5
Channel Width	: 8.00 meter	Crosssectional Area	: 29.38 m^2
Channel Height	: 2.5 meter	Wet Section (P)	: 17.01 meter
Upstream Elv.	: 7.00 meter	Flow Rate	: 2.1245 m/s
Downstream Elv.	: 3.22 meter	Channel Discharge	: 62.406 m^3/s
Slope (S)	: 0.000445		

4.6. Calculation of Channel Capacity

The construction of a reservoir in the residential drainage system aims to avoid increasing the discharge at peak discharge by calculating the drainage channel capacity that will accommodate surface run-off. The planned flood discharge for the Panorama Residence area is as follows:

Area 8.000 m^2 = 0,0008 km^2,
Qp = 0.278 * C * I * A
= 0.278 * 0.7 * 110.72* 0,0008 = 0.0172 m^3/s.

In rainy conditions, t = 30 minutes, the run-off volume that occurs = 30.96 m^3, and the total channel length = 493.12 m, the total drainage channel capacity = 184.92 m^3, so the total capacity is 184.92 m^3 > the run-off volume, 30.96 m^3.

4.7. Installation of Biopori

To enlarge the infiltration to reduce the run-off flow, it is necessary to install Biopori with dimensions of ϕ 30 cm and a depth of 2 meters from the original soil surface. One unit of installed Biopori represents the infiltration absorption area of 10 m^2.

5. CONCLUSION

The results of the data analysis show that the drainage channel's direction from the drainage channel is directed to the Tertiary Patusan and forwarded to the Pucang River. Highest Flood Peil On Elev. –0.30 m from the fixed point, while Elv. Housing plan road at -0.20 m elevation. The regional rainfall intensity for the 5-year return period is 110.72 mm. The flood discharge at the 25^{th} return period that occurred on the Pucang River was 72,561 m^3/sec. At the same time, the cross-sectional capacity of the Pucang River was 64,402 m^3/sec, so the cross-section of the Pucang River at the Panorama Residence Housing location experienced overflow. The run-off volume is 102.6 m^3 while the total capacity is 565.68 m^3, so the extended storage capacity is quite adequate, and it is necessary to install a floodgate at the outlet. As a recommendation for the Patusan channel, which is planned to be used by the developer, it is necessary to revitalize it. The need for land for public facilities by 40% is recommended as a green and open area accompanied by tree planting. As such, it is necessary to install hydro pole wells at the Housing Locations to increase run-off absorption.

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