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DRAINAGE STUDY OF WAREHOUSE DEVELOPMENT PT. ANEKA INDUSTRI, SIDOARJO DISTRICT

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Abstract

The PT. Aneka Industri warehouse is located on a level with a slope of approximately 0-1%. Survey results from PT. Aneka Industri Warehouse in Tambaksawah Village, Waru District, Sidoarjo Regency, showed a height of -0.20m, slightly above the flood level of -0.10m. The area is likely to flood due to the overflow of Afvoer Bunung, which flows out from other areas (runoff water) during heavy rains. In addition, the storage area is a dense industrial area, and the chance of rainwater infiltration and loss is small. According to the analysis, the flood discharge of Afvoer Buntung during the 25-year return period is 193,305 m^3/s. Meanwhile, the cross-sectional capacity of Afvoer Buntung is 25.707 m^3/s, so the cross-section of Afvoer Buntung at the storage site of PT. Aneka Industri is flooded. It rains for t = 30 minutes, total volume = 297.57 m^3.

Keywords: Afvoer Buntung, Drainage, Warehouse Development

1. INTRODUCTION

Drainage is a water disposal system that stagnates in an area. Drainage comes from the word drain, which means to empty or drain water and is the terminology used to describe methods related to handling excess water problems, both above and below land settlements (Dewi et al., 2014). Drainage must be implemented in urban areas that lack green open space to accommodate and channel water to water bodies (Wihaji et al., 2018). Making drainage will prevent excess water or standing water which can cause other problems. According to Fairizi (2015), a well-organized area must also be followed by structuring a drainage system that functions to reduce or remove excess water from a location or land so that it does not cause stagnant water, which can disrupt community activities and can even cause socio-economic losses, especially concerning aspects of environmental health aspects of settlements.

Drainage in urban areas has several valuable functions, such as 1) draining parts of the city area where the land surface is lower than inundation, 2) channeling excess surface water to the nearest water body as soon as possible so as not to flood or inundate the city which can damage other than community property as well as urban infrastructure areas, 3) Control some surface water due to rain which can be used for water supply and aquatic life, 4) Absorb surface water to preserve groundwater (Dewi et al., 2014). Every urban area is required to be equipped with a sound drainage system (Saidah et al., 2021). Industrial areas are no exception, and every factory must have drainage that supports it so that problems that interfere with the production process do not occur.

PT. Aneka Industri is a company that produces snacks and beverages. The existing drainage system at PT. Aneka Industri Warehouses, Tambaksawah Village, Waru District, Sidoarjo Regency, is a drainage system in a residential area. Drainage of the residential regions is generally a problem because too many sites have been built for warehouses, roads, and parking lots, so rainwater has a smaller chance of infiltrating. In other words, the runoff will be more, coupled with problems of reduced space for making sewers due to pressure from the need for warehousing and other public facilities, especially such as the location of the warehouse for PT. Aneka Industri, Tambaksawah Village, Waru District, Sidoarjo Regency. Drainage at PT. Aneka Industri Warehouse location, Tambaksawah Village, Waru District, Sidoarjo Regency, which serves an area of approximately ± 9046 m^2 (Catchment Area) consisting of Warehousing areas, roads, parks, public facilities, parking lots, vacant land, the most significant percentage of which is Dense warehousing.

Looking at the results of the survey that has been carried out, under these conditions the Waru Warehouse location of PT. Aneka Industri from other areas so that if it rains with high intensity then there is a possibility that this area will experience inundation. PT. Aneka Industri Warehouse, Tambaksawah Village, Waru District, Sidoarjo Regency, is in a plain area with a terrain slope of about 0.0015. Under these conditions, gravity rainwater will flow. Still, if sediment interferes, the flow velocity will decrease so that it is easy for it to inundate occurred in each region.

Based on this, it is necessary to conduct a study regarding drainage construction in PT. Aneka Industries, Sidoarjo Regency. So the researchers will research to analyze the structure of drainage at PT. Aneka Industri, Sidoarjo Regency. In addition, with the implementation of this research, researchers can find out the factors that can cause flooding, which will later be carried out by controlling measures using several considerations such as 1) It can be overcome at the most economical cost, 2) It can be realized with simple technology so that local partners/contractors and 3) Whenever possible, use the existing facilities.

2. LITERATURE REVIEW

2.1. Drainage

Drainage comes from the word to drain, which means to dry or drain water, and is the terminology used to describe systems related to handling excess water problems, both above and below land settlements (Dewi et al., 2014). Drainage is a means of collecting water, especially rainwater, so that rainwater does not collect or concentrate on the road (Kartika et al., 2018). Excess water can be caused by high rainfall intensity or due to long duration of rain.

2.2. Rainfall

Rainfall is one of the weather elements whose data is obtained by measuring it using a rain gauge so that the amount can be known in millimeters (mm) (Chandra & Heri, 2016). Rainfall is limited as the height of rainwater received on the surface before experiencing surface runoff, evaporation, and infiltration into the soil (Li et al., 2022). Certain areas with topographic slopes, underwater areas, or lowlands with very high rainfall intensity have the potential to cause disasters in these areas, both floods, and landslides.

2.3. Afvoer

Afvoer or drain water channel is a channel for draining water from land to the sea (Cahya et al., 2019). Afvoer has a significant role in keeping water from gathering and becoming puddles that can interfere with human activities. Afvoer that is well maintained and following the water discharge that can be accommodated can prevent flooding in urban areas (Roosjen, 2017).

3. RESEARCH METHOD

The first step taken in this study was to carry out a hydrological analysis by calculating rainfall and discharge to obtain the design flood discharge. To get an overview of rainfall characteristics in an area, calculations were made from the results of recording rainfall measuring posts, including hourly rainfall patterns and regional rainfall patterns (area rainfall), where the effects will be beneficial for making calculations. Other hydraulics. This study will used rainfall data in the study area. Analyses and tests were the calculation of Filling in Missing Rainfall Data, Data Consistency Test, Calculation of regional rainfall, estimation of design rainfall, Smirnov – Kolmogorov Compatibility Test, Chi-Square Test, Calculation of Design Discharge and Planning of Pair Channels.

4. RESULT AND DISCUSSION

4.1. Data on the Existing Conditions of Warehouse Land

Initial conditions PT. Aneka Industri Warehouse is located in the village of Tambaksawah, which faces south in the Afvoer Buntung, the southern and western boundary with the Industrial, the eastern boundaries with the factory.

4.2. Data on the existing condition of drainage channels

Afvoer Buntung is to the north of the location (red), and Tertiary Patusan Drainage is to the east of the warehouse 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 PT. Aneka Industri Warehouse is the Afvoer Buntung which has its upstream in the Waru District and empties into the Madura Strait. The location of the rainfall station and the Afvoer Buntung flow can be seen in Figure 2

Figure 2 Location of the Flow Station

The data for the annual maximum rainfall in the Afvoer Buntung watershed can be seen in Table 1.

Table 1 Annual Maximum Rainfall Data for the Afvoer Buntung Watershed

YEAR	DATE	RAINFALL STATION			
		BONO	SRUNI	SEDATI	BANJAR KEMANTREN
2003	23-Jan	**95**	30	75	50
	8-Nov	75	**100**	80	70
	10-Jan	72	80	**80**	58
	18-Nov	75	100	80	**70**
2004	14-Mar	**75**	21	72	50
	20-Feb	60	**102**	40	50
	10-Mar	75	98	**73**	50
	13-Mar	50	23	54	**65**
2005	11-Jul	**130**	105	80	50
	11-Jul	130	**105**	80	50
	11-Jul	130	105	**80**	50
	19-Jan	45	55	15	**76**
Etc.	-	-	-	-	-
2013	26-Nov	**115**	91	142	125
	12-Mar	35	**93**	27	44
	26-Nov	115	91	**142**	125
	26-Nov	115	91	142	**125**

The coefficient of Thiesen's influence on the Afvoer Buntung watershed can be seen in Table 2.

Table 2 Thiesen's Effect of the Afvoer Buntung Watershed

Station	SHVP	STATION NUMBER	LOCATION	AREA (Km²)	KOEF
BONO	3	139	PRANTI	4.25	0.284
SRUNI	6	147	KEBOAN ANOM	4.35	0.291
SEDATI	5	26	PULUNGAN	3.25	0.217
BANJAR KEMANTREN	0	182	BANJAR KEMANTREN	3.10	0.207
			TOTAL	14.95	1,000

The calculation of the annual maximum daily rainfall using the Thiessen method in the Afvoer Buntung watershed can be seen in Table 3.

Table 3 The Calculation of the Annual Maximum Daily Rainfall Using the Thiessen Method in The Afvoer Buntung Watershed

YEAR	DATE	RAINFALL STATION				TOTAL (mm)
		BONO	SRUNI	SEDATI	BANJAR KEMANTREN	
		0.284	**0.291**	**0.217**	**0.207**	
2003	23-Jan	**95**	30	75	50	62.408
	8-Nov	75	**100**	80	70	82.324
	10-Jan	72	80	**80**	58	73.164
	18-Nov	75	100	80	**70**	**82.324**
2004	14-Mar	**75**	21	72	50	53.452
	20-Feb	60	**102**	40	50	65.799
	10-Mar	75	98	**73**	50	**76.074**
	13-Mar	50	23	54	**65**	46.124
2005	11-Jul	**130**	105	80	50	**95.268**
	11-Jul	130	**105**	80	50	95.268
	11-Jul	130	105	**80**	50	95.268
	19-Jan	45	55	15	**76**	47.816
Etc	-	-	-	-	-	-
2013	26-Nov	**115**	91	142	125	**127,331**
	12-Mar	35	**93**	27	44	52.003
	26-Nov	115	91	**142**	125	127,331
	26-Nov	115	91	142	**125**	127.331

Average rainfall using the Thiesen Method in the Afvoer Buntung Watershed can be seen in Table 4.

Table 4 Average Rainfall using the Thiesen Method in the Afvoer Buntun

YEAR	DATE	RAINFALL STATION				TOTAL (mm)
		BONO	SRUNI	SEDATI	BANJAR KEMANTREN	
		0.284	**0.291**	**0.217**	**0.207**	
2003	18-Nov	21.32	29.10	17.39	14.52	82.324
2004	10-Mar	21.32	28.52	15.87	10.37	76.074
2005	11-Jul	36.96	30.55	17.39	10.37	95.268

YEAR	DATE	RAINFALL STATION				TOTAL (mm)
		BONO	SRUNI	SEDATI	BANJAR KEMANTREN	
		0.284	0.291	0.217	0.207	
2006	27-Feb	19.90	26.48	13.04	20.74	80.157
Etc	-	-	-	-	-	-
2013	26-Nov	44.06	26.48	30.87	25.92	127.331

The calculation of the consistency test of the Afvoer Buntung watershed rain data is shown in Table 5, Table 6, Table 7 and Table 8.

Table 5 Calculation of the Consistency Test for Afvoer Buntung Watershed Rain Data

Num.	YEAR	ANNUAL DAIRY RAIN DATA				STATION CONSISTENCY		
		BONO	SRUNI	SEDATI	BANJAR KEMANTREN	COMMU LATIVE	AVERAGE	COMMU LATIVE
1	2003	75	100	80	70	75	83.33	83.33
2	2004	75	98	73	50	150	73.67	157.00
3	2005	130	105	80	50	280	78.33	235.33
4	2006	70	91	60	100	350	83.67	319.00
Etc	-	-	-	-	-	-	-	-
11	2013	115	91	142	125	1025	119.33	904.33

Table 6 Calculation of the Consistency Test for Afvoer Buntung Watershed Rain Data

Num.	YEAR	ANNUAL DAIRY RAIN DATA				STATION CONSISTENCY		
		BONO	SRUNI	SEDATI	BANJAR KEMANTREN	COMMU LATIVE	AVERAGE	COMMU LATIVE
1	2003	75	100	80	70	100	75.00	75.00
2	2004	75	98	73	50	198	66.00	141.00
3	2005	130	105	80	50	303	86.67	227.67
4	2006	70	91	60	100	394	76.67	304.33
Etc	-	-	-	-	-	-	-	-
11	2013	155	91	142	125	1057	140.67	909.00

Table 7 Calculation of the Consistency Test for Afvoer Buntung Watershed Rain Data

Num.	YEAR	ANNUAL DAIRY RAIN DATA				STATION CONSISTENCY		
		BANJAR KEMANTEN	SIDOARJO	SUMPUT	KLAGEN	COMMU LATIVE	AVERAG E	COMMU LATIVE
1	2003	75	100	80	70	80	81.67	81.67
2	2004	75	98	73	50	153	74.33	156.00
3	2005	130	105	80	50	233	95.00	251.00
4	2006	70	91	60	100	293	87.00	338.00
Etc	-	-	-	-	-	-	-	-
11	2013	115	91	142	125	859	123.67	975.00

Table 8 Calculation of the Consistency Test for Afvoer Buntung Watershed Rain Data

Num.	YEAR	ANNUAL DAIRY RAIN DATA				STATION CONSISTENCY		
		BANJAR KEMAN TEN	SIDOARJO	SUMPUT	KLAGEN	COMMU LATIVE	AVERAGE	COMMU LATIVE
1	2003	75	100	80	70	70	85.00	85.00
2	2004	75	98	73	50	120	82.00	167.00
3	2005	130	105	80	50	170	105.00	272.00
4	2006	70	91	60	100	270	73.67	345.67
Etc	-	-	-	-	-	-	-	-
11	2013	115	91	142	125	797	129.33	995.67

Meanwhile, River Watershed Distribution Determination can be seen in Table 9.

Table 9 River Watershed Distribution Determination

Num	X (mm)	$(X-\bar{X})^2$	$(X-\bar{X})^3$	$(X-\bar{X})^4$
1	27.88	3.770,05	-231.483,80	14.213.274,05
2	61.77	756,68	-20.814,47	572.559,30
3	76.07	174,42	-2.303,50	30.421,72
4	79.83	89,26	-843,25	7.966,68
5	80.16	83,23	-759,33	6.927,51
Etc	-	-	-	-
11	145,61	3.172,88	178.723,43	10.067.198,98
TOTAL	982,08	10.087,01	-11.855,97	27.229.010,87

Average	:	89,2803
Cs	:	-0,0411
Ck	:	3,7168
Std	:	31,7601

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 10.

Table 10 Rainfall Designs Various Rework

Num.	Pr %	Tr (Year)	K	Log X	X (mm)
1	99,0099	1,01	-3,449	1,2645	18,39
2	50,0000	2	0,261	1,9685	93,01
3	20,0000	5	1,012	2,1109	129,10
4	10,0000	10	1,222	2,1508	141,51
5	5,0000	20	1,304	2,1664	146,68
6	4,0000	25	1,345	2,1742	149,34
7	2,0000	50	1,327	2,1707	148,16
8	1,0000	100	1,292	2,1641	145,90

Design Rainfall Calculations Log Pearson I Method in Afvoer Buntung Basin can be seen in Table 11.

Table 11 Design Rainfall Calculation of Pearson I Log Method in Afvoer Buntung Watershed

NO.	**X (mm)**	**Log X**	**$(Logx-\overline{Logx})$**	**$(Logx-\overline{Logx})^2$**	**$(Logx-\overline{Logx})^3$**	**$(Logx-\overline{Logx})^4$**	**P %**
1	27,88	1,4453	-0,4736	0,2243	-0,1063	0,0503	8,3333
2	61,77	1,7908	-0,1281	0,0164	-0,0021	0,0003	16,6667
3	76,07	1,8812	-0,0377	0,0014	-0,0001	0,0000	25,0000
4	79,83	1,9022	-0,0167	0,0003	0,0000	0,0000	33,3333
5	80,16	1,9039	-0,0150	0,0002	0,0000	0,0000	41,6667
Etc	-	-	-	-	-	-	-
11	145,61	2,1632	0,2443	0,0597	0,0146	0,0036	91,6667
TOTAL	982,08	21,11	0,0000	0,3600	-0,0850	0,0556	

Average : 1,919
Std : 0,18973182
Cs : -1,520275795
Ck : 7,215692889

4.4. Calculation of Planned Flood Discharge and Channel Cross-Section

Calculation of channel dimensions in Channel 01 – 02:

Length of slope Lo = 40 m; slope = 0.001; Channel length = 15.50 m; Channel Slope = 0.0010

Rain intensity / I = R5th/24 * $(24/Tc)^{2/3}$

Tc = t1 + t2

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

= 0.0195 / 60 * $(40/0.0010^{0.5})^{0.77}$ = 0.080 hours

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

= 15.50/72 * $0.0010^{0.6}$ = 0,012 hours

Tc = 0,091 hours

I = (93.011/24) * $(24/0{,}091)^{2/3}$ = 159.176 mm/hours

Flood plan discharge:

Qp = 0.278 * C * I * A

= 0.278 * 0,7 * 159.176 * 0,000794 = 0,025 m3/s

Planned Channel:

b = 0.82 m (planned); m = 0.00; S = 0.00129; K = 45 (river stones masonry)

Formula:

V = K.R2/3.I1/2

R = A/P

Tried: h = 0.82 m,

A = b * h

= 0.574 m^2
P = b + 2h
= 2.34 m
V = K.R2/3.I1/2
= 0,633 m/s
Q = V.A
= 0,633*0,574
= 0,3636 m^3/s

Comparison Q Planned / Q Channel = 6.76 %

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

4.5. Calculation of Afvoer Buntung Capacity at the location of the PT. Aneka Industri Warehouse Plan

Calculation of the Horizontal Distribution Suitability Test using the Smirnov Kolmogorof Method can be seen in Table 12.

Table 12 Calculation of the Horizontal Distribution Suitability Test using the Smirnov Kolmogorof Method

Num.	X (mm)	Log X	Pe (%)	K	Pt' (%)	Pt (%)	Pe-Pt %
1	27,88	1,4453	9,0909	-2,496	7,64	92,36	83,2691
2	61,77	1,7908	18,1818	-0,675	13,35	86,65	68,4682
3	76,07	1,8812	27,2727	-0,199	26,76	73,24	45,9673
4	79,83	1,9022	36,3636	-0,088	32,64	67,36	30,9964
5	80,16	1,9039	45,4545	-0,079	56,55	43,45	2,0045
Etc.	-	-	-	-	-	-	-
11	145,61	2,1632	100,0000	1,287	96,86	3,14	96,8600
Source :	Estimation Result					D maks	0.9686

Log X	1,9189	The value of D Cr from the table for a = 1% is 0.67 = 67.0%
Std	0,18973182	Maximum < DCr , so the distribution selection is accepted
Cs	-1,5202758	
Ck	7,21569289	

The calculation of the vertical distribution suitability test using the Chi-Square method can be seen in Table 13.

Table 13 The Calculation of The Vertical Distribution Suitability Test Using The Chi-Square Method

Num.	Class Limit	Freq. Theoritical 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% dan degree of freedom (V) = K-1, obtained X2 Tabel = 9,488 So that the distribution selection is accepted

The average rainfall up to the t-t hour can be seen in Table 14.

Table 14 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 15.

Table 15 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 16.

Table 16 Hour Recapitulation of the Calculation of Rainfall Results – T

Hour	Rainfall average to T hours (Rt)		Rainfall at T hours (RT)	
1	0.55	R24	0.55	R24
2	0.35	R24	0.14	R24
3	0.26	R24	0.10	R24
4	0.22	R24	0.08	R24
5	0.19	R24	0.07	R24
6	0.17	R24	0.06	R24

Distribution of Rain Every Hour Rainfall The Design of the Pearson Type I Log Method can be seen in Table 17.

Table 17 Distribution of Rain Every Hour Rainfall The Design of the Pearson Type I Log Method

Time Hour	Ratio (%)	Rainfall Every Hours							
		1.01 Th	2Th	5Th	10Th	20TH	25Th	50Th	100Th
		18,388	93,011	129,105	141,507	146,683	149,341	148,163	145,903
1	55,03	7,590	38,389	53,287	58,406	60,542	61,639	61,153	60,220
2	34,67	4,781	24,184	33,569	36,793	38,139	38,830	38,524	37,936
3	26,46	3,649	18,456	25,618	28,079	29,106	29,633	29,399	28,951
4	21,84	3,012	15,235	21,147	23,178	24,026	24,462	24,269	23,898
5	18,82	2,596	13,129	18,224	19,974	20,705	21,080	20,914	20,595
6	16,67	2,299	11,626	16,138	17,688	18,335	18,668	18,520	18,238

Synthetic Unit Hydrograph Analysis of the Nakayasu Method in the Afvoer Buntung Watershed can be seen in Table 18.

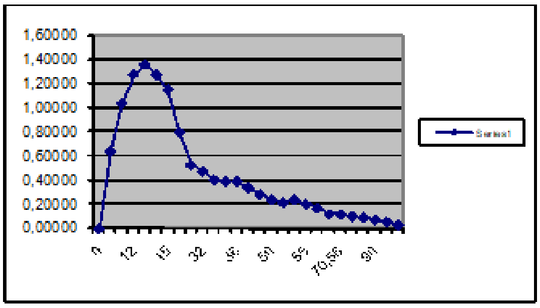
Data:

Afvoer Buntung DAS Area's = 128 Km^2
Main River's Length = 32 Km
Riverbed Slope Average = 0,03333
Alfa Parameter = 2
Flow Coefficient = 0,7
Ro (Unit Rain) = 1 mm

Table 18 Synthetic Unit Hydrograph Analysis of the Nakayasu Method in the Afvoer Buntung Watershed

t (hour)	Q (m^3/s)	desc
0	0,00000	
9	0,64100	
11	1,03758	Qa
12	1,27853	
12,32	1,36189	
13	1,27700	
15	1,15032	
22	0,79801	
30	0,52543	Qd1
32	0,47330	
35	0,40465	
35,62	0,39175	
36	0,38909	
40	0,33850	
45	0,28440	
50	0,23895	
		Qd2
53	0,21524	
50	0,23895	
55	0,20076	
60	0,16868	
76	0,10196	
80	0,09184	
90	0,07073	Qd3
100	0,05447	
120	0,03231	

Tg = 11.524 hour, $Tg = 0.21+L^{0.7}$, for L<15 Km
Tp = 12.204 hour, Tp = Tg + 0.8 Tr
T0.3 = 23.047 hour, T0.3 = □ Tg
Qp = 0,473 m^3/s
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



The unit hydrograph equation is as follows:

1) Rising line

   $0 \leq t \leq Tp$

   $0 \leq t \leq 12.204$

2) Recession line

   a) $Tp \leq t \leq (Tp+T0.3)$

      $12.204 \leq t \leq 35.251$

   b) $Tp + T0.3 \leq t \leq (Tp+T0.3+ 1.5*T0.3)$

      $35.251 \leq t \leq 69.822$

   c) $t \geq (Tp+T0.3+ 1.5*T0.3)$

      $t \geq 69.822$

Design Flood Discharge with a 25-year return period can be seen in Table 19.

Table 19 Design Flood Discharge with A 25-Year Return Period

t (hour)	U (t,1) (m^3/s)	Q Cause Rain Netto (m^3/s) 58,3915	36,7843	28,0717	23,1727	19,9696	17,6841	Q flood (m^3/s)
0	0	0,000						0,000
1	0,641002	34,157	0,000					34,157
2	1,037575	55,289	34,830	0,000				90,119
3	1,278533	68,129	42,919	32,753	0,000			143,801
4	1,361892	72,571	45,717	34,888	28,800	0,000		181,976
5	1,277003	68,047	42,867	32,714	27,005	23,272	0,000	193,905
6	1,150318	61,297	38,615	29,468	24,326	20,963	18,564	193,232
7	0,79801	42,523	26,788	20,443	16,875	14,543	12,878	134,051
8	0,525426	27,998	17,638	13,460	11,111	9,575	8,479	88,262
9	0,473301	25,221	15,888	12,125	10,009	8,625	7,638	79,506
10	0,404647	21,562	13,583	10,366	8,557	7,374	6,530	67,973
11	0,391751	20,875	13,151	10,036	8,284	7,139	6,322	65,807
12	0,389092	20,733	13,061	9,968	8,228	7,091	6,279	65,360
13	0,338496	18,037	11,363	8,671	7,158	6,169	5,463	56,861
14	0,2844	15,155	9,547	7,286	6,014	5,183	4,590	47,774
15	0,238949	12,733	8,021	6,121	5,053	4,355	3,856	40,139
16	0,215244	11,470	7,225	5,514	4,552	3,923	3,474	36,157
17	0,238949	12,733	8,021	6,121	5,053	4,355	3,856	40,139
18	0,200762	10,698	6,739	5,143	4,246	3,659	3,240	33,724
19	0,168678	8,988	5,662	4,321	3,567	3,074	2,722	28,335
20	0,119073	6,345	3,997	3,050	2,518	2,170	1,922	20,002
21	0,116773	6,222	3,920	2,991	2,469	2,128	1,884	19,616
22	0,101958	5,433	3,423	2,612	2,156	1,858	1,645	17,127
23	0,091843	4,894	3,083	2,353	1,942	1,674	1,482	15,428
24	0,070731	3,769	2,374	1,812	1,496	1,289	1,141	11,882
25	0,054473	2,903	1,829	1,395	1,152	0,993	0,879	9,150

The flood discharge at the 25-year return period on the Afvoer Buntung was 193.905 m^3/sec. At the same time, the river capacity at the PT. Aneka Industri Warehouse location with river dimensions of 11 x 2.0 m^2 was = 25.707 m^3/sec, so the cross-section of the Afvoer Buntung at the PT. Aneka Industri Warehouse location experienced overflow.

Channel Name	: Afvoer Buntung	K	: 70
Channel Length	: 32000 meter	m	: 1.5
Channel Width	: 11.00 meter	Crosssectional Area	: 28.00 m^2
Channel Height	: 2.00 meter	Wet Section (P)	: 18.21 meter
Upstream Elv.	: 10.00 meter	Flow Rate	: 0.9181 m/s
Downstream Elv.	: 6.90 meter	Channel Discharge	: 25.707 m^3/s
Slope (S)	: 0.000969		

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 PT. Aneka Industri area is as follows:

Area 9046 m^2 = 0.0090 km^2,

Qp = 0.278 * C * I * A

= 0.278 * 0.7 * 93.011* 0,0090 = 0.16 m^3/s.

In rainy conditions, t = 30 minutes, the run-off volume that occurs = 288 m^3, and the total channel length = 493.12 m, the total drainage channel capacity = 297.57 m^3, so the total capacity is 297.57 m^3 > the run-off volume, 288 m^3.

4.7. Installation of Biopori

In order to enlarge the infiltration that occurs so that the run-off flow that occurs can be reduced, it is necessary to install Infiltration wells with dimensions of 2.1 meters and a depth of 2.8 meters from the original ground level installed in warehousing and industrial locations, which are expected to reduce inundation due to rainwater. What happened, besides that, was also to keep the groundwater level maintained and as water conservation in the environment of PT. Aneka Industri.

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 Afvoer Buntung. Highest Flood Peil on Elev. –0.10 m from the fixed point, while Elv. company plan road at -0.20 m elevation. The flood discharge at the 25th return period that occurred on the Afvoer Buntung was 193.905 m3/sec. At the same time, the cross-sectional capacity of the Afvoer Buntung was 25.707 m3/sec, so the cross-section of the Afvoer Buntung at the PT. Aneka Industri Warehouse location experienced overflow. The run-off volume is 288 m3 while the total capacity is 297.57 m3, 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. Then it is necessary to install hydro pole wells at the warehouse Locations to increase run-off absorption.

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