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ANALYSIS AND EVALUATION OF THE DRAINAGE NETWORK SYSTEM IN THE RESIDENTIAL AREA OF VILA RIZKI ILHAMI 2 SAWANGAN, DEPOK – WEST JAVA

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ABSTRACT

The impact of the rampant development of residential areas certainly makes the volume of surface water flow or run off to be large. Drainage is a system created to deal with the problem of excess water flow above the earth's surface, some of the things that cause excess water is caused by high water intensity and long rain duration. In this study, the problem occurred in the drainage network in the residential area of Vila Rizki Ilhami 2 Sawangan, which is the transfer of land functions from infiltration land to residential areas. Evaluations that must be done include hydrological analysis and hydraulic analysis to obtain the amount of flood discharge plan that will be used to analyze the capacity of the plan channel so that there is no flooding in the location of residential areas at the time the settlement has been built, recommendations for the design of drainage systems and determining the amount of dimensions / size of the river / times that should be made at the time of accommodating the discharge of water at the time of maximum rain so that the flood management system can be integrated properly. With 3 methods of calculating rainfall, the method of calculation is chosen by using gumbel method which is SNI 2415-2016 (Indonesian National Standard) with a 10-year repeat period. From the evaluation obtained is to increase the height of the guard or free board to accommodate the flood discharge plan.

Keywords: urban drainage; gumbel method; mononobe; rational.

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INTRODUCTION

Along with the increasing rate of human growth, will make the increasing demand for basic human needs, one of which is the needs of boards or human needs for housing. The impact of the rampant development of residential areas certainly makes the volume of surface water flow or run off to be large. Drainage is a system created to deal with the problem of excess water flow on the surface of the earth, some of the things that cause excess water is caused by high water intensity and long rain duration. If the drainage network system is not good then there is water runoff or excess water that causes flooding. Vila Rizki Ilhami 2 Sawangan Residential Area is located in Sawangan Subdistrict, Depok – West Java with an area of ±24 ha. In this study the problem that occurred is in the drainage network in the residential area of Vila Rizki Ilhami 2 Sawangan, which is a transfer of land functions from infiltration land to residential areas, the current condition of settlement development reaches a progress of ±80%, at the time of rain with ordinary intesitas, main river water runoff due to more water discharge resulting in flooding in the area around the residential area vila Rizki Ilhami 2 Sawangan, there are several possibilities that result in water runoff including whether the design of the drainage system is wrong or the study of hydrological studies are not appropriate (Ajeng KD,et.al, 2014; Andri S, et.al, 2016; BMKG, 2018; Dimitri F, 2015; Djati M,et.al, 2016).

Therefore, with this problem, it is necessary to evaluate the drainage network system and hydrological studies on each residential development project, especially the housing of Vila Rizki Ilhami 2 Sawangan, Evaluation that must be done is to include hydrological analysis and hydraulic analysis to obtain the amount of flood discharge plan that will be used to analyze the capacity of the plan channel so that there is no flooding in the location of the settlement area at the time the settlement has been built, recommendations for the design of the drainage system and determine the

amount of dimensions/size of the river/times that should be made at the time of accommodating the discharge of water at the time of maximum rain so that the flood management system can be integrated properly (Fadhila MLT, et.al. 2017; Heri S, 2013; Muhamad ZS, et.al, 2017; Muttaqin AY, 2006; Mohammad I, et.al, 2020; Permen PUPR, 2014; Suripin, 2004).

RESEARCH METHODS

The research location is located in the area of Vila Rizki Ilhami 2 Sawangan, Sawangan District, Depok, West Java Province.

Figure 1. Location Map of Vila Rizki Inspiration 2 Sawangan (Source: Imagery 2018 Digital Globe, Google Data Map 2018)

Flowchart Research follows SNI in the calculation of plan discharge:

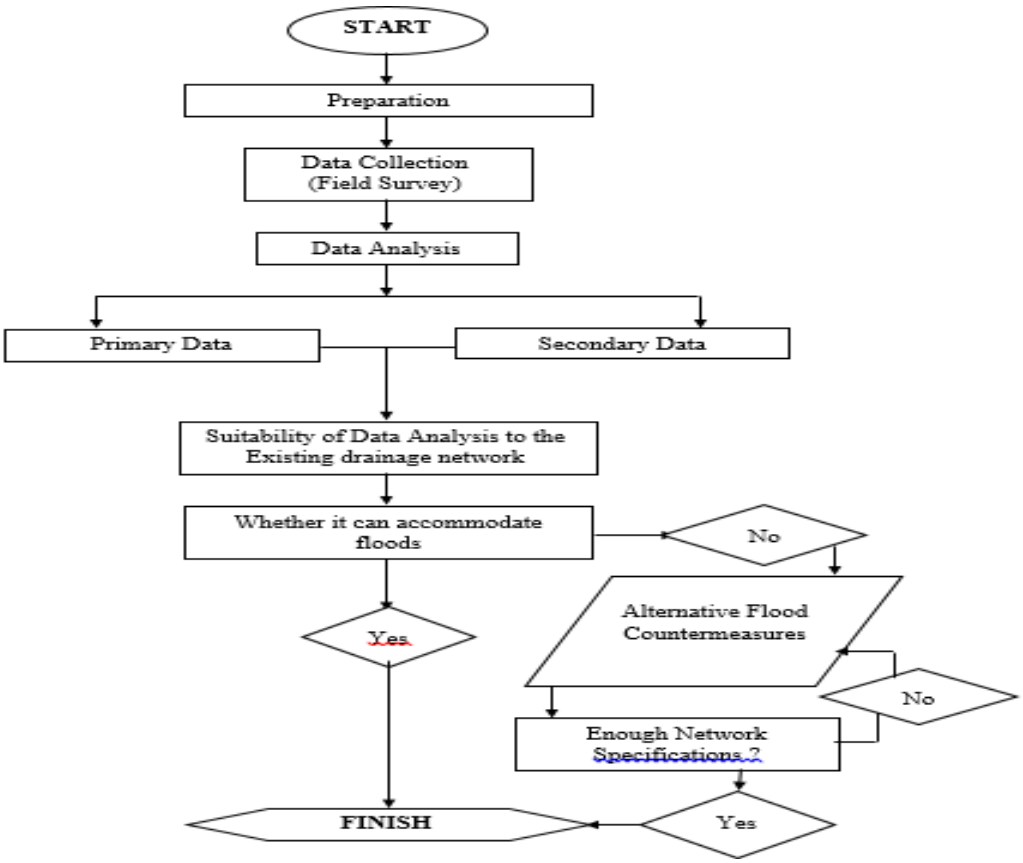

Figure 2. Research Flow Diagrams

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RESULTS AND DISCUSSIONS

Identification of Drainage Network System Administratively residential area of Vila Rizki Ilhami 2 Sawangan is located in Sawangan Lama village, Sawangan District of Depok City, West Java and located in the ciliwung sub watershed of Depok City.

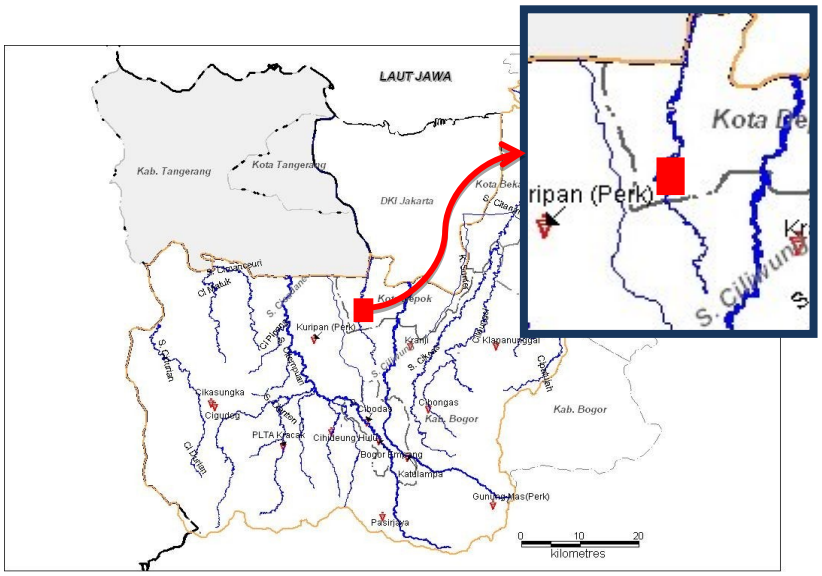

Figure 3. Map of Study Area in Ciliwung Watershed

Vila Rizki Ilhami 2 Sawangan residential area has an area of ±24 ha. The channel flows water from the secondary drainage network in the area of Vila Rizki Ilhami 2 Sawangan Housing. And in existing channels have a dimension of cross-section size as follows:

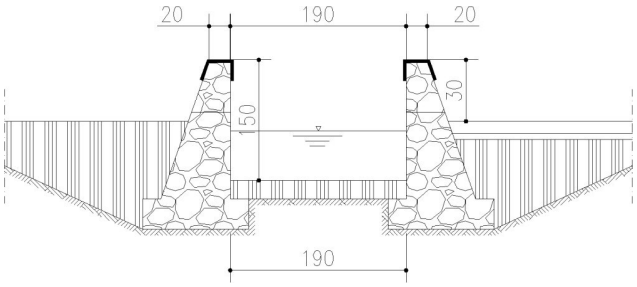

Figure 4. Cross-section of Downstream Existing Channels

Analysis of The Value of Run Off/Flood Discharge

Rain data that will be used in several rain stations and then selected one of the rain stations selected based on the observation station closest to the study area, then a description of the conditions and characteristics of rain in this study area in detail will be explained in the following discussion (Sri HBr, 1983; Triatmojo B, 2008; Wesli, 2008; Iban S, 2017; Mohammad II, Adi TWP, 2021; Mohammad II, Larasati L, 2021).

Rainfall data

Rainfall data obtained from several rain rowing stations close to the study location include Depok Rain Station, Kuripan Rain Station, Cihideung Rain Station, Dramaga Rain Station, Empang Rain Station, Katulampa Rain Station, Botanical Garden Rain Station.

Table 1. Rainfall Data

No	Year	Observation Station						
		Depok[1]	Kuripan[1]	Cihideung[1]	Dramaga[2]	Empang[2]	Katulampa[2]	Kbn Raya[2]
1	1999	82	66	112	150	90	101	123
2	2000	82	80	63	94	75	79	78
3	2001	118	150	84	108	125	102	175
4	2002	117	160	92	127	132	169	158
5	2003	112	80	82	123	99	129	128
6	2004	105	70	95	142	93	109	125
7	2005	89	71	96	127	134	111	157
8	2006	92	76	109	136	95	71	125
9	2007	72	163	131	156	119,5	118,5	120
10	2008	79	147	97	105	144	166	115
11	2009	105	172	125	115	112	112	140
12	2010	95	134	125	145	166	145	149
13	2011	99	98	108	98	101	102	132
14	2012	101	98	108	123	140	136	154
15	2013	76	64	85	137	145	153	151
16	2014	50	148	81	169	127	128	150
17	2015	70	79	81	156	201	126	124
18	2016	112	87	87	109	77	103	102
19	2017	86	118	113	118	137	112	115

Source: West Java Local Government Public Works Office[1], BMKG[2]

Rainfall Frequency and Probability Analysis

Frequency analysis uses Gumbel Distribution to obtain maximum rainfall data. Calculating the frequency factor of Extreme k value:

$k = \frac{Y_t - Y_n}{S_n}$

where,

Y_t = -ln (-ln($\frac{t-1}{t}$))

From n data that can be 19, then can:

Y_n = 0,522

S_n = 1,056

Table 2. Calculation of Extreme Value Frequency Factor

T	yt	sn	yn	k
2	0,36	1,05	0,52	**-0,14**
5	1,49	1,05	0,52	**0,93**
10	2,25	1,05	0,52	**1,64**

Source: Calculation

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Rainfall Plan Calculation

Calculate rainfall plan with a repeat period of 2 years, 5 years and 10 years.

$X_t = \bar{X} + k.S_x$

Average maximum rainfall X at each rain station :

$\bar{X} = \frac{X_t}{n}$

$\bar{X}$ (Rainway Depok) = 91,6 mm
$\bar{X}$ (Rainway Kuripan) = 108,4 mm
$\bar{X}$ (Rainway Cihideung) = 98,6 mm
$\bar{X}$ (Rainway Dramaga) = 128,3 mm
$\bar{X}$ (Rainway Empang) = 121,7 mm
$\bar{X}$ (Rainway Katulampa) = 119,6 mm
$\bar{X}$ (Rainway Kb. Raya) = 132,6 mm

Standard deviation (standard deviation) S_x each rain station:

$S_x = \sqrt{\frac{\sum_{i=1}^{n}(X_i - X)^2}{n-i}}$

S_x (Rainway Depok) = 18,0 mm
S_x (Rainway Kuripan) = 38,0 mm
S_x (Rainway Cihideung) = 18,6 mm
S_x (Rainway Dramaga) = 21,1 mm
S_x (Rainway Empang) = 31,5 mm
S_x (Rainway Katulampa) = 26,2 mm
S_x (Rainway Kebun Raya) = 22,9 mm

So in can daa rainfall plan as follows:

Table 3. Rainfall Plan Data

Rainway	Reset Period		
	2	**5**	**10**
Depok	89	108	121
Kuripan	102	143	171
Cihideung	95	115	128
Dramaga	125	147	161
Empang	116	149	171
Katulampa	115	142	160
Kebun Raya	129	153	168

Source: Calculation

Concentration Time

Concentration time is obtained from the schematic of the flow area and flow coefficient, the concentration time of tc in can be 23.8 minutes or if converted to 0.4 hours.

Rainfall Intensity Analysis

Rain intensity analysis is calculated using monobe equation (SNI 2415: 2016), with the following formula:

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

Where,

R_{24} can be from the calculation of rainfall plans with a repeat of 2 years, 5 years and 10 years. And then those values are included in the calculation and in can value the intensity of rainfall 1 with T years. Can be seen in the following table:

Table 4. Intensity Rainfall

Rainway	Reset Period		
	2	**5**	**10**
Depok	57	70	78
Kuripan	66	92	110
Cihideung	62	74	83
Dramaga	80	95	104
Empang	75	96	110
Katulampa	74	92	103
Kebun Raya	83	98	109

Source: Calculation

Debit Plan

Calculation of plan debit using rational method, this method is chosen because it becomes Indonesian National Standard (SNI 2451, 2016). Here are the mathematical equations of rational methods:

$$Q_p = 0{,}002778\ C.I.A$$

Where,

C is the Surface Flow Coefficient defined as the equation between the peak of the surface flow to the intensity of rain, from the calculation of the area (A) and the Flow Coefficient (C) as follows:

Area (A) = 595.71 m^2
= 0,59 km^2
Flow Coefficient (C) = **0,39**

So that obtained the results of the calculation of the plan debit on the rain station faithful as follows:

Table 5. Debit Plan

Rainway	Reset Period		
	2	**5**	**10**
Depok	3,70	4,51	5,05
Kuripan	4,27	5,98	7,11
Cihideung	3,99	4,80	5,33
Dramaga	5,20	6,11	6,72
Empang	4,86	6,22	7,13
Katulampa	4,80	5,94	6,69
Kebun Raya	5,37	6,36	7,02

Source: Calculation

From the calculation of the plan debit, the largest plan debit value is obtained in the 10-year anniversary period, namely at Empang Rain Station with the planned discharge reaching 7,130 m^3/s.

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Evaluation of Drainage Network Cross-Section Conditions

To find out if the existing channel capacity is able to accommodate flood discharge or plan discharge, hydraulic analysis is carried out using manning formula equation, as follows:

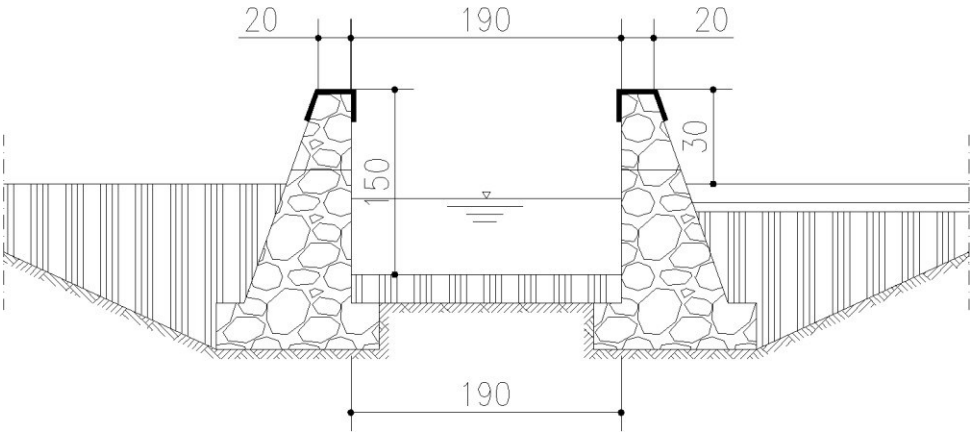

Figure 6. Cross-section of Downstream Existing Channels

Known basic width of channel b = 1.9 m and height of channel h = 1.5 m, the calculation is obtained as follows:

Cross-sectional area (A)

A = b x h
= 1,9 x 1,5
= 2,85 m^2

Wet circumference (P)

P = b + 2.h
= 1,9 + (2 x 1,5)
= 4,90 m

Radius hydraulics (R)

$R = \frac{A}{P}$
$= \frac{2,85}{4,90}$
= 0,58 m

Flow Speed (V)

$V = \frac{1}{n} . R^{2/3} . S^{1/2}$
$= \frac{1}{0,02} . 0,58^{2/3} . 0,00157^{1/2}$
$= 1,38\ m^{3/dtk}$

Channel Discharge (Q)

Q = A x V
= 2,85 x 1,38
= 3,934 $m^{3/dtk}$

From the calculation above the existing channel discharge has a capacity of 3,934 m^3/s, it can be known whether the existing channel capacity can accommodate water discharge or can not be seen in the following table:

Table 6. Conformity of Plan Debit (Qp) To Existing Channel (Qs)

Rainway	Reset Period			(Qs)	Qs > Qp
	2	5	10		
Depok	3,70	4,51	5,05	3,93	Exceeded
Kuripan	4,27	5,98	7,11	3,93	Exceeded
Cihideung	3,99	4,80	5,33	3,93	Exceeded
Dramaga	5,20	6,11	6,72	3,93	Exceeded
Empang	4,86	6,22	7,13	3,93	Exceeded
Katulampa	4,80	5,94	6,69	3,93	Exceeded
Kebun Raya	5,37	6,36	7,02	3,93	Exceeded

Source : Calculation

With existing channel discharge of 3.93 m3/s, the existing channel capacity is still not able to accommodate the plan discharge. To meet the discharge capacity of the plan, countermeasures are carried out tehadap existing channels. From several rain stations selected one of the closest rain exchange stations and has a large plan discharge as in the following table:

Table 7. Distance and Discharge of Rain Station Plan to Study Location

No	Observation Station	LS	BT	Dist.	Discharge Plan		
	Research location	**6,4**	**106,74**		**2**	**5**	**10**
1	Depok	6,4	106,75	0,010	3,7	4,5	5,0
2	Perk. Kuripan	6,44	106,69	0,064	4,2	5,9	7,1
3	Cihideung Udik	6,59	106,71	0,192	3,9	4,8	5,3
4	Dramaga	6,56	106,74	0,160	5,2	6,1	6,7
5	Empang	6,61	106,79	0,216	4,8	6,2	7,1
6	Katulampa	6,6	106,8	0,209	4,8	5,9	6,6
7	Kebun Raya Bogor	6,59	106,79	0,196	5,3	6,3	7,0

Source : Calculation

From the results of the calculation above, it was chosen Perk Rain Station. Kuripan to calculate the capacity of channels that can accommodate the discharge load of the plan in the study area.

Runoff Countermeasures

From the results of the calculation of conformity between hydrological analysis to existing channels, it must be done countermeasures in one way that is to increase the height of care in existing channels as follows:

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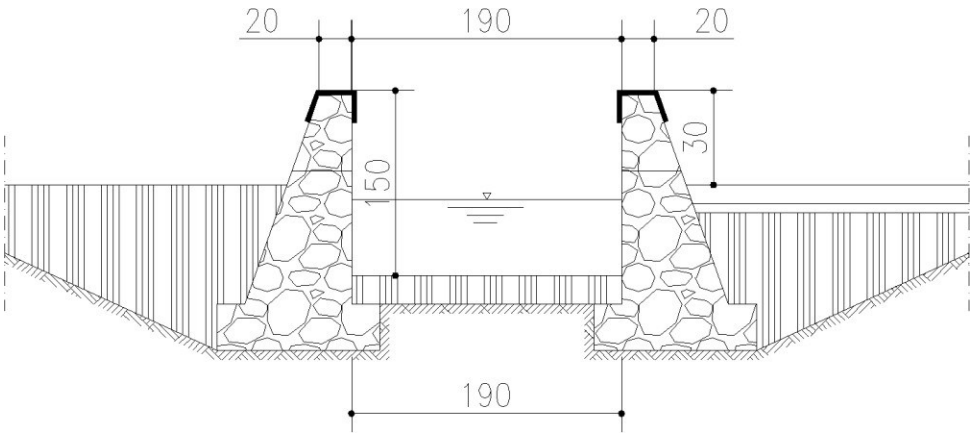

Figure 7. Existing Channel Transverse Pieces

Known:

Plan debit with 10 Year repeat period

Q_T = 7,12 m^3/dtk

Existing channel base slope
S = 0,00157

Coefficient of roughness manning (n), for stone pairs times
n = 0,015

Economical square cross-section

Q = A x V

Q = b x h x $\frac{1}{n}$ x $(R)^{2/3}$ x $S^{1/2}$

Q = b x h x $\frac{1}{n}$ x $(\frac{bh}{b+2h})^{2/3}$ x $S^{1/2}$

Q = 1,9 x h x $\frac{1}{0,015}$ x $(\frac{bh}{b+2h})^{2/3}$ x $0,00157^{1/2}$

Q = 1,9 x h x 66,667x $(\frac{bh}{b+2h})^{2/3}$ x 0,0396

Q = 1,9 x h x $(\frac{1,9h}{1,9+2h})^{2/3}$ x 2,641

Q = 1,9 x h x $(\frac{1,9h}{1,9+2h})^{2/3}$ x 2,641

7,130 = 5,0189 x h x $(\frac{1,9h}{1,9+2h})^{2/3}$

$\frac{7,130}{5,0189}$ = h x $(\frac{1,9h}{1,9+2h})^{2/3}$

1,421 = h x $(\frac{1,9h}{1,9+2h})^{2/3}$

h = $\frac{1,421}{(\frac{1,9 .0,2}{1,9+2.0,2})^{2/3}}$

h = $\frac{1,421}{0,301}$

h = 4,718

The calculation is continued with the iteration method to get the required height of care, can be seen in the following table:

Table 8. Iteration Method Table

No	h	h (New)	Average
1	0,20	4,71	2,45
2	2,45	1,82	2,14
3	2,14	1,87	2,01
4	2,01	1,90	1,95
5	1,95	1,91	1,93
6	1,93	1,91	1,92
7	1,92	1,92	1,92
8	1,92	1,92	1,92
9	1,92	1,92	1,92
10	1,92	1,92	1,92
11	1,92	1,92	1,92
12	1,92	1,92	1,92
13	1,92	1,92	1,92
14	1,92	1,92	1,92

Source: Calculation

from the calculation results by using the iteration method then the height h = 1.9215 m, then to meet the discharge capacity of the plan then the height of care must be added as in the following figure:

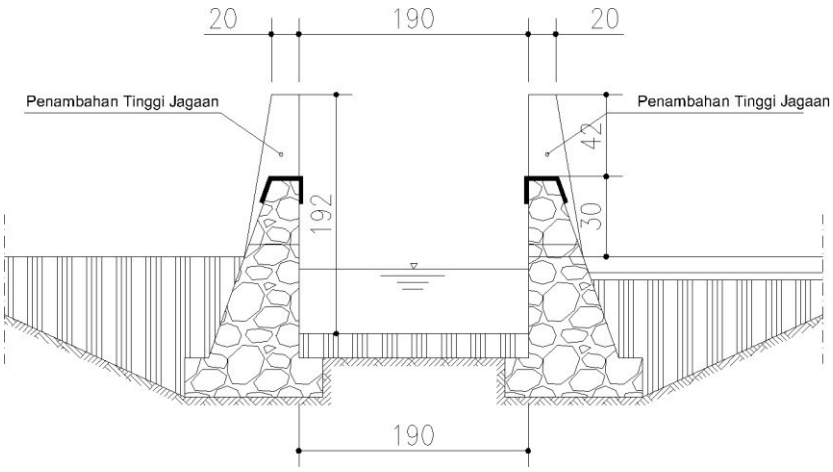

Figure 8. Addition of High Guard or Free Board

CONCLUSION

Based on the research and calculations made, from 3 methods of calculating rainfall, the method of calculation is chosen using gumbel method which is SNI 02-2406-1991 (Indonesian National Standard) with a 10-year repeat period. Data collection from 7 rain penkar stations including Depok Rain Station, Pek Rain Station. Kuripan, Cihideung Udik Rain Station, Dramaga Rain Station, Empang Rain Station, Katulampa Rain Station and Kenun Raya Rain Station. Then selected one rain exchange station that has close proximity to the study site and has the largest plan discharge for the calculation of hydrological and hydraulic analysis in conducting the suitability of the study with existing channel conditions. From the results of the calculation analysis in can the value of the discharge capacity of the excitation channel is Q_s = 3.9 m^3/s, and the value of the plan debit with a repeat of $Q_{(T, 10years)}$ = 7.1 m^3/s, then $Q_s < Q_T$. Then it can be concluded that on existing channels have not been able to accommodate flood discharge plan. The runoff in the drainage channel in Vila

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Rizki Ilhami2 Sawangan Residential area is caused by a smaller drainage capacity than the planned discharge. There needs to be action or rehabilitation to increase the capacity of the network.

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