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CANAL CAPACITY IN AREA IKIP AND PULOMAS

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ABSTRACT

IKIP's Pump House is located on Inspeksi Kali Sunter street, North Jakarta, geographically located between 6°9'45.55" South Latitude and 106°52'53.8" East Longitude. While Pulomas's Pump House is located on Perintis Kemerdekaan street North Jakarta, geographically located between 6 °10'0.71'' latitude and 106°52'51.66" east longitude. On the arterial road beside Ria-rio Reservoir to Kayu Putih street, floods often occur during the rainy season. That flood is caused by several factors, one of which is the drainage canal that can't function properly. At several points of water canal that will lead to Pulomas's Pump House there's a lot of plastic waste and people's belongings that cause narrowing of canal. The high sedimentation in the form of mud also causes water capacity that can be accommodated by canal is not optimal. From the above conditions, it is necessary to do an analysis pump capacity to determine whether IKIP's Pump House and Pulomas's Pump House can still accommodate water discharge based on 15 years of rainfall lastly, and it is known that there are three canals in the Pulomas pump house that cannot accommodate the water discharge so that flooding occurs

Keywords: *IKIP's Pump House, Pulomas's Pump House, flood, pump*

1. PRELIMINARY

IKIP's Pump House is located in North Jakarta, more precisely located on Inspeksi Kali Sunter street, RT.7 / RW.4, Kelapa Gading Barat, Kelapa Gading District, east of Inspeksi Kali Sunter street and south of Sunter River. Geographically it's located between 6°9'45.55" south latitude and 106°52'53.8" east longitude. The estuary of the IKIP's Pump House is Sunter River. The canal that flows into the IKIP's Pump House reservoir starts from the University of State Jakarta's canal. There's a horizontal canal (connecting) between the Ria-rio Reservoir and the canal that will lead to the IKIP's Pump House. Water flow of Ria-rio Reservoir will flow to Pulomas's Pump House canal.

Pulomas's Pump House is located in North Jakarta, more precisely located on Perintis Kemerdekaan street, RT.2/RW.4, West Kelapa Gading, Kelapa Gading District. Geographically it's located between 6°10'0.71'' south latitude and 106°52'51.66" east longitude. This pump house accommodates the flow from Ria-rio

Reservoir and will empty in Sunter River. At Ria-rio Reservoir, there is a canal that connects to the IKIP's Pump House flow. It's intended that when the reservoir water discharge increases water flow can also be channeled to the IKIP's Pump House. It's intended that when reservoir water discharge increases, water flow can also be channeled to the IKIP's Pump House.

Storage pool has a very important role, which is to accommodate all the flows around the area, which will then flow to Sunter River with a flow rate that has been determined. To optimize the water flow to flow smoothly, a water pump is needed. At IKIP's Pump House, the reservoir currently has 3 units of water pump with a capacity of 1 x 1000 liters/second while Pulomas's Pump House has a water pump with a capacity of 1 x 2500 liters/second as many as 3 units. The capacity of the pump house must be adequate and accommodate incoming flow to prevent flooding and water from overflowing.

On arterial road beside Ria-rio Reservoir to Kayu Putih street, floods often occur during the rainy season. That flood was caused by several factors. One of the factors that causes frequent flooding apart from high rainfall intensity, drainage canals that are not functioning properly can also cause flooding. At several points of water canal that will lead to the Pulomas' Pump House there is a lot of plastic waste and people's belongings which causes canal narrowing. High sedimentation in the form of mud also causes water capacity that can be accommodated by canal is not optimal. moreover, Ria-rio Reservoir, which functions as flood control, hasn't been dredged for 3 years, resulting in silting which causes reservoir's role not maximal.

Apart from Pulomas Pump House, there are several canal points leading to IKIP's Pump House which are caused narrowing. This is also caused by high level of waste from residents and sedimentation. One of them is at point C, which is located at Pemuda street intersection, canal experiences a large enough narrowing due to residents storing goods beside canal. This can reduce volume of water that can be accommodated by drainage canals. Especially when the sea is high, water from Sunter River can't be channeled into the sea so that water overflows into the roads and houses of residents.

From the above conditions, the writer wants to analyze whether the capacity of pump and drainage canal can accommodate water optimally so that it can overcome the existing flood problems and can be input for government so that drainage can experience renewal.

Research Purposes

The purpose of this research are:

1. To know the rain discharge that enters the canal.
2. To know the situation of capacity canal cross section drainage.
3. To know the required pump capacity.

2. THEORETICAL BASIS

Frequency and Probability Analysis

In statistic, there are several parameters related to data analysis which include the average ($\bar{X}$), standard deviation (S), variant coefficient (Cv), skewness (Cs), and sharpness coefficient (Ck). Here are some formula:

$$\bar{X} = \sum_{i=1}^{n} Xi/n \quad (1)$$

$$S = \sqrt{\frac{\sum_{i=1}^{n}(Xi-\bar{X})^2}{n-1}} \quad (2)$$

$$Cv = \frac{S}{\bar{X}} \quad (3)$$

$$Cs = \frac{n \times \sum_{i=1}^{n}(Xi-\bar{X})^3}{(n-1) \times (n-2) \times S^3} \quad (4)$$

$$Ck = \frac{n^2 \times \sum_{i=1}^{n}(Xi-\bar{X})^4}{(n-1) \times (n-2) \times (n-3) \times S^4} \quad (5)$$

Information:

$\bar{X}$: Average score
Xi : Variant score
n : Amount of data
S : Standard deviation
Cv : Variant coefficient
Cs : Skewness
Ck ; Sharpness coefficient

Normal Distribution

Normal distribution is also called Gauss distribution, here is the formula of normal distribution:

$$X_t = X + K_t . S_x \quad (6)$$

information:

X_t : Rainfall plan return period T years (mm)
X : Rainfall average score (mm)
K_t : Frequency factor (score of the Gauss Variable)
S_x : Standard deviation

Gumbel's Distribution

Here is the formula of Gumbel's distribution:

$$X = \bar{X} + \frac{(Y_t - Y_n)}{S_n} . S_x \quad (7)$$

Information:

X_t : Rainfall plan return period T year (mm)
$\bar{X}$: Rainfall average score (mm)
Y_t : Reduced variate of Gumbel's parameter for period T years
Y_n : Reduced mean is a function of the amount of data
S_n : *Reduced* standard deviation
S_x : Standard deviation

Normal Log Distribution

Normal Log Distribution is the result transformation of normal distribution, by changing variate X into logarithmatic score of variate X. Here is the formula of Normal Log Distribution:

$$Y = \bar{Y} + K . S_d \quad (8)$$

Information:

Y ; Logarithmatic score of X score or InS
$\bar{Y}$: Average score of the data count
K : Characteristic of Log normal probability distribution
S_d : Standard deviation of score Y

Log Pearson III Distribution

Karl Pearson developed several kinds of empirical equations from a distribution, one of them is Log Pearson III Distribution. Here is the formula of Log Pearson III Distribution:

$$\text{Log}\, X_T = Log\, X + G . S_x \quad (9)$$

Information:

Log X_t : Rainfall plan return period T years (mm)
Log X : Rainfall average score (mm)
G : Variable standard for X_t
S_x : Standard deviation

Rainfall Intensity

If there's only daily rainfall, then dr. Mononobe formulates its rainfall intensity as follows:

$$I = \frac{R_{24}}{24}\left[\frac{24}{t}\right]^{2/3} \quad (10)$$

information:

R_{24} : Maximum rainfall in 24 hours (mm)
t : Rainfall duration (hour)
I : Rainfall intensity (mm/hour)

Water Discharge

To calculate the top discharge at a drainage, the Rational Method calculation is used as follows:

$$Q = 0{,}278. C. I. A \quad (11)$$

Information:

Q : Surface runoff peak discharge (m^3/s)
C : Coefficient *run off*
I : Rainfall intensity (mm/hour)
A : Large of drainage area (km^2)

Time of Rain Intensity Concentration (Tc)

To find the concentration time (Tc), it can be calculated using Kirpich formula as follows:

$$T_c = \frac{0{,}0195 \text{ x } L^{0{,}77}}{S^{0{,}385}} \quad (12)$$

Information:

T_c : Concentration time (minute)
L : The length of the water from farthest point to the point under review (m)
S : River slope

Average Flow Speed (V)

To find the average flow velocity (V) can calculated using the following formula:

$$V = \frac{1}{n} . R^{2/3} . S^{1/2} \quad (13)$$

Information:

V : Average flow velocity (m/s)
n : Manning's roughness coefficient
R : Radius of the hydraulic (m)

S : Canal slope

Calculating Existing Canal Discharge

The purpose of examining existing canal is to find out the amount of water flow that can be accommodated by canal with its current state. Analysis capacity of drainage canal is carried out to determine the ability of existing drainage canal to planned discharge from the calculation results.

Discharge Canal

Here is the formula of discharge canal:

$$Q = A \, . V \tag{14}$$

Information:

Q : Discharge canal (m^3/s)
A : Large of wet cross-sectional area (m)
V : Average flow velocity (m/s)

Canal Slope

Slope of the canal is obtained from the slope of contour map in Google Earth. Here is the formula of canal slope:

$$S = \frac{\Delta H}{L} \tag{15}$$

Information:

S : Canal slope
ΔH : The different between the height of the farthest point and the area drift
L : Canal length (m)

Wet Cross-Sectional Area

Here is the formula of wet cross-sectional area:

$$A = b . h \tag{16}$$

Information:

A : large of wet cross-sectional area (m^2)
b : Wide canal (m)
h : Water level (m)

Hydraulic Radius

Here is the formula of hydraulic radius of the canal:

$$R = \frac{A}{P} \tag{17}$$

Information:

R : Hydraulic Radius (m)
A : Large of wet cross-sectional area (m^2)
P : Wet circumference (m)

3. RESEARCH METHODOLOGY

Data Collection

Data collection technique in this research is primary data collection where data obtained from direct observation in the field, namely in the form of dimension data on drainage canal around pump house area and secondary data collection is data obtained from other parties related to this research. Secondary data includes rainfall data and maps from Google Earth.

Secondary data were obtained from STA Tanjung Periok and agencies related to research.

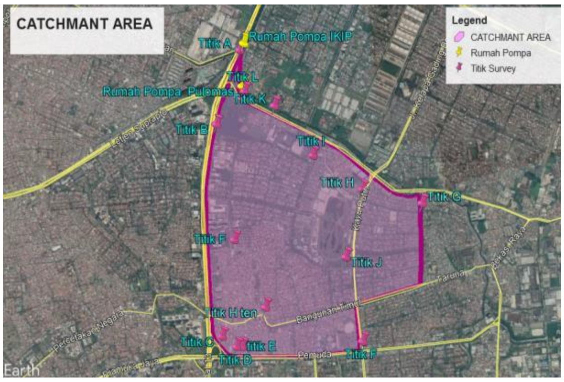

Figure 1. Research Site

Analysis of Rainfall Data Frequency

Calculation analysis of Rainfall Data frequency is carried out in order to obtain the score of planned rainfall using several analysis probability distribution including Gumbel, Normal, Normal Log, and Log Pearson III using a 10 years rainfall cycle.

4. RESULT AND DISCUSSION

Rainfall Data Analysis

Maximum daily rainfall data is obtained from Perum Jasa Tirta II and the Meteorology, Climatology and Geophysics Agency (BMKG). The observation location in Meteorologi Maritim Tanjung Priok Station for 15 years.

Table 1. Maximum Rainfall Data

Year	Maximum Rainfall
2005	109,9
2006	90,3
2007	182,2
2008	87,9
2009	148,9

2010	88,3
2011	78,5
2012	75,1
2013	117,8
2014	284
2015	247
2016	112,7
2017	148,6
2018	129,6
2019	130,3

Table 2. Calculation of Distribution for Rainfall

No	Xi	(Xi-X)	$(Xi-X)^2$	$(Xi-X)^3$	$(Xi-X)^4$
1	109,90	-25,51	650,59	-16594,38	423267,41
2	90,30	-45,11	2034,61	-91774,54	4139643,46
3	182,20	46,79	2189,62	102459,43	4794418,42
4	87,90	-47,51	2256,88	-107217,01	5093522,58
5	148,90	13,49	182,07	2456,73	33149,50
6	88,30	-47,11	2219,04	-104531,49	4924129,84
7	78,50	-56,91	3238,37	-184284,77	10487031,91
8	75,10	-60,31	3636,89	-219328,96	13226998,29
9	117,80	-17,61	309,99	-5457,97	96096,72
10	284,00	148,59	22079,98	3280937,64	487525459,88
11	247,00	111,59	12453,07	1389679,82	155079003,34
12	112,70	-22,71	515,59	-11707,39	265835,84
13	148,60	13,19	174,06	2296,48	30298,29
14	129,60	-5,81	33,72	-195,79	1136,86
15	130,30	-5,11	26,08	-133,17	680,06
Σ	2031,10		52000,57	4036604,65	686120672,42

Based on the table above, it can be seen that the scores include average (X̅), standard deviation (S), variant coefficient (Cv), slope coefficient (Cs), and coefficient of sharpness (Ck):

1. Average score ($\bar{X}$) = 135,40
2. Standard deviation (S_d) = 60,94
3. Variant coefficient (C_v) = 0,45
4. Slope coefficient (C_s) = 1,46
5. coefficient of sharpness (C_k) = 5,12

Table 3. Result Calculation of Distribution Method and Requirements of Distribution Method

No	Distribution	Requirements	Calculation	Information
1	Gumbel	Cs < 1,14	Cs = 1,4696	Not qualify
		Ck < 5,4	Ck = 5,1235	Qualify
2	Normal	Cs = 0	Cs = 1,4696	Not qualify
		Ck = 3	Ck = 5,1235	
3	Log Normal	Cs = 1,441	Cs = 1,4696	Not qualify
		Ck = 6,908	Ck = 5,1235	
4	Log Pearson III	No requirement	-	Qualify

Rainfall Plan Log Pearson III Method

After calculating rainfall, standard deviation, slope coefficient, and sharpness coefficient, then calculate return period according to the method that meets the requirements of Log-Pearson III method.

Table 4. Rainfall Plan Log Pearson III Method

No	Year	Xi	Log Xi	$(\text{Log Xi} - \log X)^2$	$(\text{Log Xi} - \log X)^3$
1	2005	109,9	2,0410	0,0032	-0,0002
2	2006	90,3	1,9557	0,0200	-0,0028
3	2007	182,2	2,2605	0,0267	0,0044
4	2008	87,9	1,9440	0,0235	-0,0036
5	2009	148,9	2,1729	0,0057	0,0004
6	2010	88,3	1,9460	0,0229	-0,0035
7	2011	78,5	1,8949	0,0410	-0,0083
8	2012	75,1	1,8756	0,0491	-0,0109
9	2013	117,8	2,0711	0,0007	0,0000
10	2014	284,0	2,4533	0,1268	0,0451
11	2015	247,0	2,3927	0,0873	0,0258
12	2016	112,7	2,0519	0,0021	-0,0001
13	2017	148,6	2,1720	0,0056	0,0004
14	2018	129,6	2,1126	0,0002	0,0000
15	2019	130,3	2,1149	0,0003	0,0000
	∑	2031,1	31,4592	0,4150	0,0467
	Log X	135,40	2,09728		

Based on the table above, it can be seen that the scores include average Log score ($\overline{X}$), standard deviation Log x (Sd) and slope coefficient Log x (Cs):

1. Average score ($\bar{x}$) Log x = 2,0972
2. Standard deviation (S_d) log x= 0,1721
3. Slope coefficient (Cs) log x = 0,7549

Table 5. Return Period Maximum Rainfall

Period (T)	(Average Log X)	Coefficient (G)	Sd log X	Log X Year	Rainfall Plan
2	2,0973	-0,125	0,17217	2,08	119,93
5	2,0973	0,785	0,17217	2,23	171,18
10	2,0973	1,335	0,17217	2,33	212,30
25	2,0973	1,981	0,17217	2,44	273,28
50	2,0973	2,432	0,17217	2,51	325,91
100	2,0973	2,861	0,17217	2,59	385,35
200	2,0973	3,272	0,17217	2,66	452,44

Calculate the Run off Coefficient

Based on the existing condition of canal which has different dimensions and location of canal between residents' house and main road, catchment area is divided into 17 parts.

Table 6. Run Off Coefficient Calculation Results

No	Type	Large (km)
1	Industrial area	0,32
2	Pavement or concrete path	0,497
3	Housing	2,557
	Total	3,374

Calculating Rainfall Intensity

Before looking for canal rainfall intensity, first calculate time of rain intensity concentration that occurs using Kirpich formula.

Table 7. Canal Concentration Time (Tc) Calculation

No	Area	Length (L)	Upstream elevation	Downstream Elevation	Different Elevation	Slope (s)	Time Concentration (Tc)	
		m	m	m	m		Minute	Hour
1	Canal 1	2168,3	6	3	3	0,0014	91,1089	1,518481657
2	Canal 2	1050,4	8	6	2	0,0019	46,1108	0,76851351
3	Canal 3	276,7	8	7	1	0,0036	12,899	0,214982911
4	Canal 4	1161,1	5	2	3	0,0026	44,2861	0,738101512
5	Can	676,9	3	2	1	0,000	36,2485	0,604142203

	al 5					15		
6	Canal 6	966,5	4	3	1	0,001	54,6944	0,911573114
7	Canal 7	534	3	2	1	0,0019	27,5642	0,459402668
8	Canal 8	1583,5	4	3	1	0,0006	96,7372	1,612286543
9	Canal 9	975,5	5	4	1	0,001	55,2831	0,921384415

Table 8. Rainfall Intensity

No	Area	Return Period	Rainfall Plan		Rainfall Intensity (I)
			Log Pearson III	Tc (Hour)	Log Pearson III (mm/hour)
1	Canal 1	10	212,3	1,518	55,711
2	Canal 2	10	212,3	0,769	87,723
3	Canal 3	10	212,3	0,215	205,09
4	Canal 4	10	212,3	0,738	90,116
5	Canal 5	10	212,3	0,604	102,988
6	Canal 6	10	212,3	0,912	78,286
7	Canal 7	10	212,3	0,459	123,619
8	Canal 8	10	212,3	1,612	53,528
9	Canal 9	10	212,3	0,921	77,729

Rain Discharge Plan (Qt)

Calculation of rain discharge plan uses a rational method.

Table 9. Rain Discharge Plan (Q_t)

Location	Return Period		Coeff. Run Off (c)	Rainfall Intensity (I)	Catchment Area (A)	Rain Discharge Plan (Q)
	(T)			mm/hour	(km^2)	(m^3/s)
Canal 1	10	0,278	0,794	55,711	0,329	4,048
Canal 2	10	0,278	0,794	87,723	0,46	8,903
Canal 3	10	0,278	0,794	205,09	0,401	27,036
Canal 4	10	0,278	0,794	90,116	0,48	36,58
Canal 5	10	0,278	0,794	102,988	0,12	39,306
Canal 6	10	0,278	0,794	78,286	0,178	3,069
Canal 7	10	0,278	0,794	123,619	0,489	13,349
Canal 8	10	0,278	0,794	53,528	0,62	13,997
Canal 9	10	0,278	0,794	77,729	0,282	4,829

Table 10. Existing Drain Discharge

EXISTING CANAL CAPACITY										
Location	L (m)	S	b (m)	h (m)	A-SAL (b*h) (m)	P (2h+b) (m)	R (A/P) (m)	n	V (1/n*R^2/3*S^0,5) (m/s)	Qs (m³/s)
Canal 1	2168,3	0,0014	8,60	3,20	27,52	15,00	1,835	0,013	4,288	118,008
Canal 2	1050,4	0,0019	5,50	2,42	13,31	10,34	1,287	0,013	3,972	52,866
canal 3	276,7	0,0047	8,20	2,02	16,56	12,24	1,353	0,013	6,450	106,837
Canal 4	1161,1	0,0026	9,00	2,33	20,97	13,66	1,535	0,013	5,203	109,114
Canal 5	676,9	0,0015	4,00	1,65	6,60	7,30	0,904	0,013	2,764	18,245
Canal 6	966,5	0,0010	6,70	2,20	14,74	11,10	1,328	0,013	2,989	44,063
Canal 7	534	0,0019	5,20	2,83	14,72	10,86	1,355	0,013	4,076	59,986
Canal 8	1583,5	0,0006	7,00	1,80	12,60	10,60	1,189	0,013	2,169	27,331
Canal 9	975,5	0,0010	1,30	1,12	1,46	3,54	0,411	0,013	1,362	1,983

Based on rain discharge data and existing canal capacity, it can be compared to know whether canal capacity is able or not to accommodate the rain discharge.

Table 11. Comparison of Canal Discharge Capacity with Rainfall Discharge

Area	Discharge Rainfall Plan (Q)	Discharge Existing Canal (Qs)	Information
Canal 1	4,048	118,008	ABLE
Canal 2	8,903	52,866	ABLE
Canal 3	27,036	106,837	ABLE
Canal 4	36,58	109,114	ABLE
Canal 5	39,306	18,245	NOT ABLE
Canal 6	3,069	44,063	ABLE
Canal 7	13,349	59,986	ABLE
Canal 8	13,997	27,331	ABLE
Canal 9	4,829	1,983	NOT ABLE

5. CONCLUSION

Analysis of planned floods in area of Pulomas's Pump Houses and IKIP's Pump Houses using daily rainfall data for STA Tanjung Periok, it was found that canal 5 and canal 9 are canals to Pulomas's Pump houses. That canals can't accommodate planned rain discharge this is what causes flooding. Therefore, it is necessary to widen drainage canals and add a pump.

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