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ANALYSIS OF PUMP CAPACITY AT THE KARTINI V PUMP HOUSE IN CENTRAL JAKARTA

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ABSTRACT

Kartini Volume Pump House is located at Jalan Kartini Raya Simpang Jalan Kartini V, RT. 01 RW. 04, Kartini Village, Sawah Besar District, Central Jakarta, Special Capital Region Of Jakarta, 10750. The geographical location of the pump is located at 6°09'14.4"S 106°50'08.2" E. In the area around the Kartini Volume Pump House, flooding is rare even though the rain that falls has a high rainfall intensity. Despite these conditions, flooding is rare. In the event of a flood, the flood does not last long and will slowly recede after the rain has stopped. This is because the pump in the Kartini Volume Pump House is still functioning properly and the channel capacity is still sufficient. Flooding in the area is caused by narrowing due to garbage in the channel. Using BMKG Kemayoran rainfall data from 2014 to 2023 and the Pearson III Log method, the maximum rainfall intensity of 567.7745 mm/hour with a maximum planned rain discharge of 1.219 m3/second and an existing channel discharge of 15.793 m^3/second. The pump capacity in the Kartini Volume Pump House is 2,682 m^3/ second with a drain time of 1 hour. The existing pump capacity of the pump gate in the Kartini Volume Pump House is 1 x 2 m^3/second and the pump house is 2 x 0.5 m^3 / second is still able to accommodate rain discharge in the area.

Keywords: *Flood, Drainage System, Pump.*

1. PRELIMINARY

Kartini Volume Pump House is located at Jalan Kartini Raya Simpang Jalan Kartini V, RT. 01 RW. 04, Kartini Village, Sawah Besar District, Central Jakarta, Special Capital Region Of Jakarta, 10750. The geographical location of the pump is located at 6°09'14.4"S 106°50'08.2" E. On the east side of the Kartini Volume Pump House, there is the Ciliwung River.

In the area around the Kartini Volume Pump House, flooding is rare even though the rain that falls has a high rainfall intensity. Despite these conditions, flooding is rare. In the event of a flood, the flood does not last long and will slowly recede after the rain has stopped.

A flood is a river water flow that is relatively larger than normal due to rain that falls upstream or in a certain place continuously, so it cannot be accommodated by the existing river channel, so abundant water comes out and inundates the surrounding area. Flooding can be caused by 2 factors. The first factor is caused by natural factors such as rainfall, erosion and sedimentation, River topography and Geophysics, inadequate river capacity and drainage, soil subsidence, damage to flood control buildings, and so on. The second factor is caused by human factors such as land use change, garbage disposal, slums along the river, improper Flood Control System Planning, and so forth.

In addition to geographical location, natural factors in the form of rainfall and public awareness around the Kartini Volume Pump House are still littering in the trash so that there is a pile of garbage at some point.

One of the efforts to deal with flooding in the area of Rumah Pompa Kartini V is to use a pump. The pump serves to pump water from a reservoir that comes from the Drainage in the Kartini Volume Pump House area. In the Kartini Volume Pump House, there is already a pump house with a capacity of 2 x 0.5 m^3/sec and an existing pump gate of 1 x 2 m^3/sec.

Research Objectives

The objectives of this study are as follows :

a. Knowing the drainage capacity at Jalan Kartini V
b. Know the capacity of the pump in the pump Kartini V
c. Knowing the causes of inundation in the area of The Pump House Kartini V
d. Provide input to overcome the problem of flooding in the area of Rumah Pompa Kartini V
e. Looking for alternatives and providing recommendations on the results of the evaluation of existing drainage Drainage and flood pump capacity.

2. RESEARCH METHODS

Time and Place

This research was conducted from January 2024 to February 2024 in the Kartini Volume Pump House area of Central Jakarta.

Data Retrieval Methods

The method used in this study is :

a. Preparatory Stage

The preparation stage is the initial stage before the research. The activities carried out at this stage are preparing for data collection, data analysis, and making a map of the location to be reviewed.

1) Literature Study

   The literature study is conducted to find reference sources of theories that are relevant to existing cases or problems and get directions to facilitate data collection, data analysis, and report-making.

2) Field Observation

   Field observation aims to determine the location to be reviewed and the state of the channel.

b. Stages of Data Collection

The data collected are primary data and secondary data. The Data are as follows :

1) Primary Data

   Primary Data is data obtained directly in the field consisting of Channel length, Channel width, and Channel depth.

2) Secondary Data

   Secondary Data is supporting data research. The Data is obtained from the relevant agencies as well as existing data such as rainfall data.

c. Stages of Data Analysis

The stages of data analysis are carried out to calculate the data with formulas that follow their use. Stages of data analysis are as follows :

1) Hydrological Analysis

   Hydrological analysis is used to secondermine the magnitude of the flood discharge plan in the planning of water buildings. The Data used in the analysis of this inundation is the nearest rain station data. Rainfall Data is one of the data that can be used to seconder mine flood discharge plans.

1) Hydraulics Analysis

   Hydraulics analysis is used to calculate the magnitude of the channel cross-section that can accommodate the discharge plan. From the analysis of the hydraulics then obtained the capacity of the channel.

2) Pump Capacity Analysis

   Capacity analysis is used to calculate the capacity of the pump used for the line.

Research Procedure

a. Calculate the intensity of 5-year rainfall using the distribution formula.
b. Calculate the flood discharge of a 5-year plan using the rational method.
c. Calculate the cross-sectional capacity of the channel using the necessary hydraulics formulas.
d. Calculate the capacity of the pump that serves to pump water from the reservoir that comes from the channel in the Kartini Volume Pump House area.

3. RESULTS AND DISCUSSION

Calculation of 5-Year Rainfall Intensity

Below is a calculation of the intensity of rainfall 5 years using the formula distributed:

a. Rainfall Data Kemayoran Meteorological Station

Rainfall Data used in this study is rainfall data from Kemayoran Meteorological Station for the last 10 years. The following is the rainfall data for Kemayoran Meteorology Station:

Table 1. Rainfall Data of Kemayoran Meteorological Station For 10 Years

No	Tahun	Bulan Dalam Setahun												Rh Total (mm)	Rh Max (mm)
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
1	2014	147.9	108.2	26.2	53.5	12.1	62	46	36.9	0.1	37.5	41	49	2634.4	147.9
2	2015	134.3	277.5	55.3	33.3	16.6	6.9	0	5.2	0	0	54.1	93.2	2691.4	277.5
3	2016	30.8	115	90.8	124.5	53	59	76	50	59.8	21	51	19.9	2766.8	124.5
4	2017	45	179.7	23.3	49.6	46.5	45.5	81.4	0.8	71	50	60.7	90.7	2761.2	179.7
5	2018	46.4	104.6	51	52.3	7.8	6.7	14.5	32.8	36.6	94.5	47	23.4	2535.6	104.6
6	2019	86.6	49	75.6	22.8	24.5	18.1	0	0	0	1	33	38	2367.6	86.6
7	2020	145.3	277.5	63.6	72	29	6.5	9	68.3	2.5	57.6	26	34.8	2812.1	277.5
8	2021	43.8	94.1	67.2	73.4	92.2	31.4	17.8	66.5	36.7	55.3	34	65.6	2699	94.1
9	2022	34.5	88.3	34.5	54	35.2	32.6	36	15.4	55.8	48.6	42.4	38.5	2537.8	88.3
10	2023	35.3	76.9	79.5	66.6	45.5	31.4	2.5	1.8	0	0	39	36	2437.5	79.5
Jumlah															1460.2

b. Rain Frequency Distribution

After calculating the average rainfall, standard deviation (Sd), coefficient of variation (Cv) coefficient of squalor (Cs), and the coefficient of kurtosis (Ck), then calculate the reset period following the qualified method. The following table of calculation results to secondermine the distribution method.

Table 2. Distribution method calculation results and Terms of distribution method

Types of Distribution	Terms	Calculation Results	Description
Gumbel	Cs ≈ 1,14 Ck ≈ 5,4	1.16 3.90	NOT OK
Normal	Cs = 0 Ck = 3	1.16 3.90	NOT OK
Log Normal	Cs = Cv3+3cv = 1,0033 Ck = Cv8+6Cv6+15Cv4 + 16Cv2+3 = 4,8419	1.70 8.85	NOT OK
Log Pearson III	In addition to the above value		OK

Based on the rain frequency test and distribution suitability test that has been done, then for the calculation of drainage channel capacity using rainfall with Pearson Log III method.

c. Pearson III Log Distribution Method

Pearson III Log distribution is widely used in hydrological analysis, especially in the analysis of maximum (flood) and minimum (minimum discharge) data with extreme values. Pearson III Log distribution form is the result of the transformation of Pearson III distribution by substituting the variance into a logarithmic value. Here is the Pearson III Log probability distribution formula as follows:

Log $Xt = Log\ X + Kt \cdot Sx$

Where :

Log Xt = rainfall plan period Re t years (mm)

Log X = average rainfall value (mm)

Kt = standard variable for Xt

Sd = standard deviation

Table 3. KT frequency factor table for Pearson III Log method

Koef. G/Cs	Reset Period T (Tahun)						
	2	5	10	25	50	100	200
	Probability Odds						
	0.5	0.2	0.1	0.04	0.02	0.01	0.005
0.0	0.00	0.84	1.28	1.75	2.05	2.33	2.58
-0.1	0.02	0.84	1.27	1.72	2.00	2.25	2.48
-0.2	0.03	0.85	1.26	1.68	1.95	2.18	2.39
-0.3	0.05	0.85	1.24	1.64	1.89	2.1	2.29
-0.4	0.07	0.85	1.23	1.67	1.83	2.03	2.20
-0.5	0.08	0.86	1.22	1.58	1.78	2.00	2.10
-0.6	0.10	0.86	1.20	1.538	1.72	188	2.01
-0.7	0.12	0.86	1.18	1.49	1.66	1.88	1.97
-0.8	0.13	0.86	1.17	1.49	1.61	1.7	1.84
-0.9	0.15	0.85	1.15	1.41	1.55	1.66	1.74
-1.0	0.16	0.85	1.13	1.37	1.49	1.57	1.66

d. Pearson III Log Method Calculation Results

Here are the results of the calculation of the rainfall re-period plan. In this study, the repeat period used is a 5-year repeat period. The results of the calculation of Pearson III log method 5-year reset period using the nearest Meteorological Station Kemayoran Meteorological Station is 189.20 mm/hours.

Table 4. Pearson III Log method calculation analysis

Years	Log X	K	S	Log Xt	Xt
2	2.164	0.066	0.1316	2.1731	148.9696
5	2.164	0.855	0.1316	2.2769	189.2029
10	2.164	1.23	0.1316	2.3263	211.9711
25	2.164	1.61	0.1316	2.3763	237.8393
50	2.164	1.83	0.1316	2.4052	254.2347
100	2.164	2.03	0.1316	2.4315	270.1185

e. Calculation of The Slope of The Channel

$$S = \frac{\Delta X}{L}$$

Where :

S = Channel Slope

ΔX = Difference in elevation upstream and downstream

L = Channel Length

The channel is divided into 3 areas, which are as follows :

1) Area A – B

Channel length = 374 m

Upstream elevation = 3 m

Downstream elevation = 2 m

$$S = \frac{(3-2)}{374} = 0.002673797\ \%$$

2) Area B – C

Channel length = 80 m
Upstream elevation = 5 m
Downstream elevation = 3 m

$$S = \frac{(6-3)}{126} = 0.023809524\ \%$$

3) Area C – D
Channel length = 126 m
Upstream elevation = 6 m
Downstream elevation = 3 m

f. Calculation Of Concentration Time (Tc)

$$Tc = \frac{0.0195\ x\ L^{0.77}}{S^{0.385}}$$

1) Area A – B
L = 374 m
S = 0.002673797 %

$$Tc = \frac{0.0195\ x\ 374^{0.77}}{0.003^{0.385}} = 18.27 \text{ minutes}$$

Tc = 0.3 hours

2) Area B – C
L = 126 m
S = 0.023809524 %

$$Tc = \frac{0.0195\ x\ 126^{0.77}}{0.024^{0.385}} = 3.41 \text{ minutes}$$

Tc = 0.06 hours

3) Area C – D
L = 80 m
S = 0.025 %

$$Tc = \frac{0.0195\ x\ 80^{0.77}}{0.025^{0.385}} = 2.36 \text{ minutes}$$

Tc = 0.04 hours

g) Calculation Of Rainfall Intensity

Rainfall intensity is the height of rainfall that occurs during a certain period when rainwater concentrates. This rainfall intensity can be processed based on rainfall data that has occurred in previous years. The calculation of the amount of rainfall intensity can use several empirical formulas in hydrology. One of them is to use the mononobe formula, which is as follows :

$$I = \frac{R_{24}}{24}\left[\frac{24}{Tc}\right]^{2/3}$$

Where :
I = rainfall intensity (mm / h)
t = duration of rainfall (hours)
R24 = maximum rainfall in 24 hours (mm)

By using the maximum rainfall data repeated period using the Pearson III Log method, it can be calculated rainfall intensity data. The 5-year rainfall reset period that has been calculated by the Pearson III Log method is as follows :

1) Area A – B
R_{24} = 189.203 mm
Tc = 0.3 hours

$$I = \frac{189.203}{24}\left[\frac{24}{0.3}\right]^{2/3} = 144.93\ mm/\text{hours}$$

2) Area B – C
R_{24} = 189.203 mm
Tc = 0.06 hours

$$I = \frac{189.203}{24}\left[\frac{24}{0.06}\right]^{2/3} = 444.06\ mm/\text{hours}$$

3) Area C – D
R_{24} = 189.203 mm
Tc = 0.04 hours

$$I = \frac{189.203}{24}\left[\frac{24}{0.04}\right]^{2/3} = 567.75\ mm/\text{hours}$$

h) Calculation of The Runoff Coefficient

After seconder mining the catchment area by location, then seconder mining the runoff coefficient for each channel.

Table 5. The value of the Runoff coefficient used in areas A-B

No.	Tipe	Ca (km2)	Koef.	C
1	Road	0.00716	0.9	0.00645
2	House	0.02148	0.9	0.01934
3	Park	0.00716	0.4	0.00286
	Total	0.03581		0.02865

Table 6. The value of the Runoff coefficient used in Area B-C

No.	Tipe	Ca (km2)	Koef.	C
1	Road	0.00074	0.9	0.00066
2	House	0.00222	0.9	0.00199
3	Park	0.00074	0.4	0.0003
	Total	0.00369		0.00296

Table 7. The value of the Runoff coefficient used in Area C-D

No.	Tipe	Ca (km2)	Koef.	C
1	Road	0.00193	0.9	0.00174
2	House	0.00579	0.9	0.00521
3	Park	0.00193	0.4	0.00077
	Total	0.00965		0.00772

Based on the above calculation, the runoff coefficient is obtained according to the respective catchment area which can be obtained from the formula :

$$Caverages = \frac{\sum_{i=1}^{n} Ci\ Ai}{\sum_{i=1}^{n} Ai}$$

Where :

Ci = coefficient x total catchment area of each channel

Ai = total catchment area of each channel

Table 8. Calculation Result Of Runoff Coefficient Of Each Channel

Area	***Catchment Area***	**C**	**$C_{average}$ Saluran**
A – B	0.03581	0.02865	0.8
B – C	0.00369	0.00296	0.8
C – D	0.00369	0.00772	0.8

5-Year Discharge Plan

The discharge plan can be calculated using the following formula:

$$Q_r = 0.278 \text{ x } C \text{ x } I \text{ x } A$$

Where :

Qr = discharge plan (m^3/sec)

C = Runoff Coefficient

A = area of drainage area (km^2)

I = rainfall intensity (mm/h)

Each channel's 5-year plan Debit is as follows :

1) Area A – B
   C = 0.8
   I = 144.93 mm/hours
   A = 0.03581 km^2
   Q_r = 0.278 x C x I x A
   Q_r = 0.278 x 0.8 x 144.93 x 0.03581
   Q_r = 1.154 m^3/second

2) Area B – C
   C = 0.8
   I = 444.06 mm/hours
   A = 0.00369 km^2
   Q_r = 0.278 x C x I x A
   Q_r = 0.278 x 0.8 x 444.06 x 0.00369
   Q_r = 0.365 m^3/second

3) Area C – D
   C = 0.8

I = 567.75 mm/hours

A = 0.0095 km^2

Q_r = 0.278 x C x I x A

Q_r = 0.278 x 0.8 x 567.75 x 0.0095

Q_r = 0.365 m^3/second

Calculating the Section of The Existing Channel

To get the channel capacity (Qs), the first step is to find the flow velocity (V), after getting the value of V the next step is to find the discharge from each channel.

The calculation of the channel speed can be calculated using the following formula:

$$V = \frac{1}{n} R^{\frac{2}{3}} s^{\frac{1}{2}}$$

Where :

V = flow velocity (m / sec)

n = manning coefficient

R = hydraulic radius (m)

S = Channel slope (m)

As for the calculation of the existing channel discharge can be calculated using the following formula :

Q = A x V

Where :

Q = Flow Rate (m^3/sec)

V = average velocity of flow at Channel cross section (m / sec)

A = cross-sectional area of the channel (m2)

Calculation of existing Drainage in this study is as follows :

1) Drainage A – B

Cross-sectional area (A) = 4.8 m^2

Wet perimeter (P) = 5.4 m

Hydraulic radius (R) = A/P = 4.8 m^2 / 5.4 m = 0.889 m

Slope (S) = 0.0027

Based on the data at the location of research, Channel masonry, the value of n is 0.025.

Flow velocity :

$$V = \frac{1}{n} R^{\frac{2}{3}} s^{\frac{1}{2}}$$

$$V = \frac{1}{0.025} 0.889^{\frac{2}{3}} 0.0027^{\frac{1}{2}}$$

$$= 1.912\ m/second$$

Debit saluran (Qs)
Qs = A x V
Qs = 4.8 x 1.912
Qs = 9.178 m / second

2) Drainage B – C

Cross-sectional area (A) = 2.65 m^2

Wet perimeter (P) = 4.15 m

Hydraulic radius (R) = A/P = 2.65 m^2 / 4.15 m = 0.639 m

Slope (S) = 0.0238

Based on the data at the location of research, Channel masonry, so the value of n is 0.025.

Flow velocity :

$$V = \frac{1}{n} R^{\frac{2}{3}} s^{\frac{1}{2}}$$

$$V = \frac{1}{0.025} 0.639^{\frac{2}{3}} 0.0238^{\frac{1}{2}}$$

$$= 4.577\ m/second$$

Debit saluran (Qs)
Qs = A x V
Qs =2.65 X 4.557
Qs = 12.129 m / second

3) Drainage C – D

Cross-sectional area (A) = 3.125 m^2

Wet perimeter (P) = 4.375 m

Hydraulic radius (R) = A/P = 3.125 m^2 / 4.375 m = 0.714 m

Slope (S) = 0.025

Based on the data at the location of research, Channel masonry, the value of n is 0.025.

Flow velocity :

$$V = \frac{1}{n} R^{\frac{2}{3}} s^{\frac{1}{2}}$$

$$V = \frac{1}{0.025} 0.714^{\frac{2}{3}} 0.025^{\frac{1}{2}}$$

$$= 5.5054\ m/second$$

Debit saluran (Qs)
Qs = A x V
Qs = 3.125 X 5.5054

Qs = 9.178 m / second

a. Comparison analysis of Qr with Qs

Based on the data of rain discharge and the existing channel capacity can be compared to secondermine whether the capacity of the channel is able or not to accommodate the rain discharge.

Table 9. Comparison Of Channel Capacity With Rain Discharge Of Each Channel

Drainage	Rain Discharge Plan (Qr)	Discharge Channel Existing (Qs)	Description
A-B	1.15414	9.17833	OK
B-C	0.36482	12.1287	OK
B-D	1.21872	15.7929	OK

Calculating Pump Capacity

Calculation of pump capacity can be calculated using the following formula :

$$V = \frac{1}{3.6} C\ R\ A\ T$$

Where :

V = Volume of surface water (m3)

C = coefficient of runoff

I = maximum rainfall intensity (mm / h)

A = area (m^2)

T = drain time (seconds)

a. Pump Volume

The volume of pumps on the line in the Kartini Volume Pump House area is as follows:

C = 0.8

I = 567.7745 mm/hours

A = 0.048 km^2

T = 1 hours = 3600 second

$$V = \frac{1}{3.6} C\ R\ A\ T$$

$$Vpump = \frac{1}{3.6} 0.8\ x\ \ 567.745\ x\ 0.048\ x\ 3600$$

V_{pump} = 21704.22 m^3

b. Drainage Volume

The volume of Drainage in the Kartini Volume Pump House area is as follows :

$V_{drainage}$ = (374x4.8)+(126x2.65)+(80x 3.125)

$V_{drainage}$ = 2379.1 m^3

c. Reservoir Pool Volume

The Volume of the reservoir in Rumah Pompa Kartini V is as follows :

Length = 2 m

Width = 3 m

Depth = 3 m

$V_{container\ Pool}$ = 2 x 3 x 3

$V_{container\ pool}$ = 18 m^3

d. The volume of water to be pumped

The Volume of water to be pumped in the Kartini Volume Pump House is as follows :

Vair to be pumped = V_{pump} -$V_{drainage}$ - $V_{reservoir\ pool}$

$V_{air\ to\ be\ pumped}$ = 21704.22 – 2379.1 – 18

$V_{air\ to\ be\ pumped}$ = 19307.12 m^3

e. Pump Capacity

The pump capacity in the Kartini Volume Pump House that will be drained within 1 hour is as follows :

$$Pump\ Capacity = \frac{19307.12}{1\ x\ 3600} = 2.682\ m3/second$$

The existing pump capacity of the pump gate in the Kartini Volume Pump House is 1 x 2

m^3 / second and the pump house is 2 x 0.5 m^3 / second.

4. CONCLUSIONS AND SUGGESTIONS

From the above discussion, it can be concluded that some things are as follows :

a. Drains with a size of 300 x 160 cm with a capacity of 6.96 m^3/sec can accommodate a maximum rain discharge of 0.021 m^3/sec.
b. The water channel with a size of 265 x 100 cm with a capacity of 9.37 m3/sec can accommodate a maximum rain discharge of 0.007 m^3/sec.
c. Drains with a size of 250 x 125 cm with a capacity of 12.04 m^3/sec can accommodate a maximum rain discharge of 0.023 m^3/sec.
d. The pump capacity in the Kartini Volume Pump House is 2,682 m^3 / second with a drain time of 1 hour.
e. The existing pump capacity of the pump gate in the Kartini Volume Pump House is 1 x 2 m^3/second and the pump house is 2 x 0.5 m^3 / second and is still able to accommodate rain discharge in the area.
f. The puddle does not come from the capacity and capacity of the pump, so the puddle in the area is caused by garbage that narrows the channel capacity.

The suggestions that the author can convey are as follows :

1. Repairs and maintenance of drainage Drainage are carried out regularly to minimize the presence of garbage that enters the drainage Drainage which can later lead to blockages in the Drainage and can result in puddles or floods in the Kartini Volume Pump House area.
2. Periodically check the pump at the Kartini Volume Pump House so that there is no damage to the pump.

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