Capacity and performance evaluation of the drainage system Jati Pinggir - Petamburan Central Jakarta

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Abstract. Flood problems become a crucial problem in the city of Jakarta. Jati Pinggir - Petamburan area is one of the affected floods. The density of the population and the narrower open land for water absorption causes the accumulation of standing water. The increased flow of water inundation affects channel capacity. For this reason, it is necessary to examine the ability to exist flood control buildings such as drainage canals, reservoirs and pump houses to deal with flooding with a 10-year return flood discharge in Jati Pinggir - Petamburan. Analysis of regional rainfall data, 10-year return period flood discharge, existing channel dimensions, the capacity of the pond and pump needs were used in this study.

1. Introduction
Jakarta is the nation's capital that has always regained the city due to population development and increasing urbanization. Along with the increase in the population of the city, the community's need for housing, offices and socio-economic facilities is increasing. Along with these changes, increasing the application of increased area of reinforcement is supported by soil conditions in the area of Jati Pinggir - Petamburan which is relatively related to the basin associated with flooding. Handling flood problems that occur in the area has been carried out by making 2 (two) pump house systems and several air gates. When the face water flows, the west channel is high and rain occurs at the sluice gate and the pumping system works, but the problem of flood inundation on the edge Jati Pinggir - Petamburan is still happening at the scene which needs to be reviewed.

1.1. Problem Statement
Is the drainage channel on the edge of the Jati Pinggir - Petamburan suitable and safe for the planning of flood discharge Q_{10} with the volume capacity of the pool and pump house in the event of flood conditions.

1.2. Scope of Analysis
The calculation of analysis with extreme conditions where flooding occurs due to local rainfall with flood water levels of high western canals, sluice gates closed and existing pumping systems works. Checks were
carried out on the pump capacity ($Q_p$) and the volume capacity of the reservoir pool ($V_t$) in Jati Pinggir - Petamburan.

2. Research Method

Data that has been collected is then processed and analyzed in a calculation to get conclusions from the purpose of this study, the stages of analysis include:

2.1. Hydrology data analysis

At this stage, the average rainfall analysis uses the Algebraic Average Method by calculating the value of rain intensity by using Mononobe Equations followed by frequency analysis to calculate statistical parameters using selected distributions based on the Chi-square test and Smirnov Kolmogorov in obtaining the planned flood discharge value using the rational method.

There are three different ways to determine the average rainfall height in certain areas at several points of rainfall checkpoints, including the Algebraic Average Method, Thiessen Polygon Method and Isohyet Line Method, this study uses the Average Algebraic Method in determining rainfall Area.

$$d = \frac{d_1 + d_2 + d_3 + \ldots + d_n}{n} = \frac{\sum_{i=1}^{n} d_i}{n}$$

(1)

2.2 Frequency analysis

The hydrological system is sometimes influenced by extraordinary events, such as heavy rain, floods and droughts. The magnitude of extreme events is inversely proportional to the frequency of occurrence, very extreme events are very rare. Frequency analysis is a way to determine the amount of rain or flood discharge of a certain return design based on statistical properties to obtain the probability of rainfall or discharge in the future (Sri Harto, 2000). As one way to estimate the amount of rain or discharge design with a certain return, frequency analysis is done through a statistical approach. Statistical parameter is used as a basis for determining suitable theoretical probability distributions for the existing data.

2.3 Design discharge

The determination of planned flood discharge is used when there are hydrological data that have quite a number of variables that affect discharge, while empirical formulas are generally correlations of several variables so that it is not possible to obtain reliable results by itself. Rational methods are widely used to estimate the peak discharge caused by heavy rainfall in small catchments (watershed) < 2.5 km². A watershed is considered small if the distribution of rain can be considered similar in space and time, and usually the duration of rain exceeds the concentration time. The rational methods can be explained by the following equation:

$$Q = 0.278 \times C \times I \times A$$

(2)

3. Results and Outputs

Jati Pinggir is located in the Petamburan Sub-District of Tanah Abang Subdistrict - Central Jakarta, located at 6º12 'South Latitude and 106º48' East Longitude in the western canal flood drainage system with the development of the drainage catchment area as shown below. The rainfall data used in the analysis of flood handling is the maximum rainfall data of 2 (two) rainfall posts, namely the rain station Rubber Water Door and the rain station Manggarai Water Gate. Based on the suitability test of the distribution with the Chi-Square method, the Smirnov Kolmogorov method and the type of distribution chosen are then used to determine the rain value of the plan. Gumbel distribution is used to determine the amount of rain planned for a 10-year return period. Gumbel distribution is used to determine the amount
of rain planned for a 10-year return period. Table 1 below is the rain value of the plan based on the selected distribution of 174.71 mm. The rain value of this plan will be used to calculate the flood discharge using the Rational Method.

The calculation of planned flood discharge is compared to the calculation of the existing drain capacity. The recapitulation of drain capacity occurs a runoff on Petamburan drains of 1, 2, 3, 5 and Jati Pinggir can be seen in the table as follows:

Table 1. The recapitulation of the existing capacity and planned flood discharge.

| Segment                  | Existing Debit (m³/s) | Debit Plan (m³/s) | Information |
|--------------------------|-----------------------|-------------------|-------------|
| Drainage channel (Petamburan 1) |                       |                   |             |
| 82d (Right)              | 0.096                 | 0.452             | overflow    |
| Drainage channel (Petamburan 2) |                       |                   |             |
| 184 (Left)               | 0.389                 | 0.442             | overflow    |
| 181 (Left)               | 0.427                 | 0.509             | overflow    |
| 178 (Left)               | 0.420                 | 0.780             | overflow    |
| 184 (Right)              | 0.218                 | 0.252             | overflow    |
| 181 (Right)              | 0.099                 | 0.554             | overflow    |
| 178 (Right)              | 0.146                 | 0.600             | overflow    |
| Drainage channel (Petamburan 3) |                       |                   |             |
| 45 (Right)               | 0.386                 | 0.699             | overflow    |
| 226 (Left)               | 0.052                 | 0.249             | overflow    |
| Segment                  | Existing Debit (m$^3$/s) | Debit Plan (m$^3$/s) | Information |
|-------------------------|--------------------------|----------------------|-------------|
| 226 (Left)              | 0.052                    | 0.249                | overflow    |
| Drainage channel (Petamburan 5) |                          |                      |             |
| 248 (Right)             | 0.231                    | 0.737                | overflow    |
| 246 (Right)             | 0.380                    | 0.737                | overflow    |
| 244 (Right)             | 0.290                    | 1.050                | overflow    |
| 250 (Left)              | 0.257                    | 0.422                | overflow    |
| 246 (Left)              | 0.283                    | 0.422                | overflow    |
| 243 (Left)              | 0.156                    | 0.930                | overflow    |
| Drainage channel (Jati Pinggir) |                          |                      |             |
| 113                     | 0.195                    | 0.566                | overflow    |
| 110                     | 0.472                    | 0.566                | overflow    |
| 92a/39                  | 0.770                    | 1.017                | overflow    |
| w92                     | 0.475                    | 1.017                | overflow    |
| w89                     | 0.527                    | 1.493                | overflow    |
| w55                     | 0.420                    | 1.715                | overflow    |
| 44                      | 0.441                    | 1.716                | overflow    |
| 41/w/r1                 | 0.628                    | 1.716                | overflow    |
| 26a                     | 0.911                    | 1.716                | overflow    |
| 26w                     | 1.548                    | 1.716                | overflow    |

3.1. Analysis of pump systems and retention ponds
Although the Jati Pinggir - Petamburan settlements have had several flood control buildings, the floods still occur. There are 2 pump houses in the Jati Pinggir - Petamburan area, where each pump house has 2 pumping machines and 1 pumping pool which is different in size and volume. The analysis was carried out when the flood conditions of the west canal were high and the existing sluice gates were closed so that the discharge from the drain led to the pool of reservoirs and was pumped towards the flood of the western canal.
Based on table 2, there is no critical flow in the study area, the flow is greater than the planning based on the time of concentration and volume of the pond and the pump capacity that can be used is the pump capacity of 0.5 m$^3$/s with the pool volume obtained 56321.10 m$^3$ and capacity pump 1.5 m$^3$/s, with a pool volume of 42795.00 m$^3$ obtained.

| t   | Cumulative (m$^3$) | 0.5 m$^3$/s | 1.5 m$^3$/s | Cumulative pump (m$^3$) | Line 1 | Line 2 |
|-----|--------------------|-------------|-------------|--------------------------|--------|--------|
| 10  | 479.40             | 300         | 900         | 179.40                   | -420.60|        |
| 20  | 1917.60            | 600         | 1800        | 1317.60                  | 117.60 |        |
| 30  | 4314.60            | 900         | 2700        | 3414.60                  | 1614.60|        |
| 40  | 7670.40            | 1200        | 3600        | 6470.40                  | 4070.40|        |
| 50  | 1186.20            | 1500        | 4500        | 10363.20                 | 7363.20|        |
| 60  | 16413.60           | 1800        | 5400        | 14613.60                 | 11013.60|       |
| 70  | 20964.00           | 2100        | 6300        | 18864.00                 | 14664.00|       |
| 80  | 25514.40           | 2400        | 7200        | 23114.40                 | 18314.40|       |
| 90  | 29928.60           | 2700        | 8100        | 27228.60                 | 21828.60|       |
| 100 | 34070.70           | 3000        | 9000        | 31070.70                 | 25070.70|       |
| 110 | 37941.00           | 3300        | 9900        | 34641.00                 | 28041.00|       |
| 120 | 41539.50           | 3600        | 10800       | 37939.50                 | 30739.50|       |
| 130 | 44866.20           | 3900        | 11700       | 40966.20                 | 33166.20|       |
| 140 | 47921.10           | 4200        | 12600       | 43721.10                 | 35321.10|       |
| 150 | 50704.20           | 4500        | 13500       | 46204.20                 | 37204.20|       |
| 160 | 53215.50           | 4800        | 14400       | 48415.50                 | 38815.50|       |
| 170 | 55455.00           | 5100        | 15300       | 50355.00                 | 40155.00|       |
| 180 | 57422.70           | 5400        | 16200       | 52022.70                 | 41222.70|       |
| 190 | 59118.60           | 5700        | 17100       | 53418.60                 | 42018.60|       |
| 200 | 60542.70           | 6000        | 18000       | 54542.70                 | 42542.70|       |
| 210 | 61695.00           | 6300        | 18900       | 55395.00                 | 42795.00|       |
| 220 | 62575.50           | 6600        | 19800       | 55975.50                 | 42775.50|       |
| 230 | 63184.20           | 6900        | 20700       | 56284.20                 | 42484.20|       |
| 240 | 63521.10           | 7200        | 21600       | 56321.10                 | 41921.10|       |

Based on table 3 there is no critical flow in the study area, the flow is greater than the planning based on the concentration and volume of the pond and the pump capacity that can be used is the pump capacity
of 0.5 m³/s with the pool volume obtained 5722.20 m³ and pump capacity 1.0 m³/s, with the pool volume being collected 2592.54 m³.

| t (minute) | Cumulative pump (m³) | Cumulative retention ponds (m³) |
|------------|----------------------|-------------------------------|
| 10         | 265.50               | -34.50                        |
| 20         | 1062.00              | 462.00                        |

Table 3. Pool volume and pump needs

| t (minute) | Cumulative pump (m³) | Cumulative retention ponds (m³) |
|------------|----------------------|-------------------------------|
| 30         | 2199.30              | 1299.30                       |
| 40         | 3411.90              | 2211.90                       |
| 50         | 4564.86              | 3064.86                       |
| 60         | 5599.08              | 3799.08                       |
| 70         | 6515.10              | 4415.10                       |
| 80         | 7312.92              | 4912.92                       |
| 90         | 7992.54              | 5292.54                       |
| 100        | 8553.96              | 5553.96                       |
| 110        | 8997.18              | 5697.18                       |
| 120        | 9322.20              | 5722.20                       |

4. Conclusion

Based on the results of data processing and data analysis, the conclusions can be drawn as follows: the existing drains capacity in Petamburan 1, Petamburan 2, Petamburan 3, Petamburan 5, and Jati Pinggir are not safe for the existing flood discharge and volume capacity of each pool the pump is not enough to control flooding. The volume analysis of the pool and the better pump capacity for Pump House 1 using the Pump 1.5 m³/s; V, 42795.00 m³ with 3 machines 0.5 m³/s; alternative for pump house 2 uses pump capacity of 1.0 m³/s; V, 2592.54 m³ with 2 pieces of machine 0.5 m³/s.

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