Analysis of UNNES embung floor capacity

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Abstract. The purpose of this study was to analyze the capacity of the reservoir to the change in land use around the Unnes campus. The research method used is the flood hydrograph routing method in the reservoir using the Storm Water Management Model (SWMM) program to obtain the maximum capacity of the reservoir flood discharge, after which a comparison of the planned flood discharge of the reservoir to the flood discharge in the existing conditions of the reservoir is carried out to assess the capacity of the Unnes reservoir against land use change. Based on the results of the study, it was found that there was a change in the bottom depth of the reservoir at the beginning of the planning was 4.00 meters and in the current condition it became 3.00 meters, which means that the capacity is reduced by 1.00 meters with the ability to pass the flood discharge inflow which is still adequate and there is no overflow of flood.

1. Introduction
Currently global warming has an impact on system changes in the ecosystem on earth, including extreme climate change, changes in the pattern and amount of precipitation, as well as the melting of ice causing sea levels to rise [1].

Embung is a small reservoir located on agricultural land (small farm reservoir). The purpose of the construction of an embung is to accommodate excess rainfall during the rainy season that meets the criteria for clean water. Embung found in Indonesia are generally in the form of small reservoirs and irrigation reservoirs. In general, the problem of small farm water reservoirs is the occurrence of functional degradations which is marked by reduced water capacity, sedimentation, seepage, the growth of wild plants on the bodies of the weir / embankment, erosion, and several other problems [2]. Basically, the effectiveness of reservoirs as water reserves in the dry season depends on the magnitude of the value of water loss through evaporation, side seepage and percolation [3].

Semarang State University (Unnes) as one of the state universities in Semarang City, precisely in Gunung Pati District, on its way to make itself a university with a conservation perspective in Indonesia, this is very possible because of the location of the Unnes campus which is in the southern region Semarang City and located in a hilly location, where the southern side of Semarang City has been designated as a water catchment area or area for the City of Semarang.

In 2010, Semarang State University built a reservoir with an area of 900 m² and a depth of 3 meters. The embung construction was carried out to the east of the Language and Arts Faculty (FBS). This is based on the results of the analysis that the arena is the lowest point on the west campus of Unnes, so that the waterways from the central Library, Auditorium, Faculty of Mathematics and Natural Sciences (FMIPA), the Rectorate and the Faculty of Language and Arts (FBS) can be directly streamed to the reservoir.
Many indirect benefits are felt for residents around Unnes. One of them is reducing the intensity of flooding in the area around Unnes. The Sekaran and Banaran areas are in highland areas so that aquifer water or rock layers below the soil surface that contain water and can be infiltrated by water is very far and difficult. With this reservoir, when it rains, the water will be collected in the reservoir, then the water will seep into the ground.

In the development of the embung on the Unnes campus, currently there is a lack of maintenance at the embung, this can be seen by the condition of the reservoir water which is increasingly cloudy and smelly and the amount of inorganic waste floating on the surface of the reservoir water. In addition, when the rainy season enters, there are many puddles on the roads in the Unnes campus area, so that the tagline of Unnes as a conservation university does not resonate with the academic community.

There are several factors that can cause changes in the condition of the reservoir, including changes in land use change in the campus environment, so that the ability to absorb water into the soil is reduced, so that the runoff when it rains is getting bigger and because at this time, the Unnes campus has become the center of economic activity in addition to the education center on Mount Pati, especially in the Sekaran area, resulting in a change in people's behavior in consumptive activities around the campus which results in a higher volume of waste generation.

In orders to keep the carrying capacity of the reservoir in accordance with the initial purpose of its development, it is necessary to conduct a study of the storage capacity of the reservoir for changes in land use change within the campus.

2. Methods
The research method used is the flood hydrograph routing method in the reservoir using the Storm Water Management Model (SWMM) program to obtain the maximum capacity of the reservoir flood discharge, after which a comparison of the planned flood discharge of the embung to the flood discharge in the existing conditions of the reservoir is carried out to assess the capacity of the Unnes reservoir against land use change [4-7].

3. Results and Discussion
The area or the catchment area of Embung Unnes is mostly located in the West side of the Unnes Campus. At the research location, using the Sigotek Sumur Jurang rain station that represents the rain catchment area.
Figure 1. Catchment area embung Unnes.

The Sigotek Sumur Gorge rain station was chosen because it has an influence on Embung Unnes and has the most complete rain data compared to other rain stations around the Embung Unnes catchment area. Rainfall data used in this analysis include daily rainfall data with the 2001 - 2015 observation period. The 2009 - 2011 observation year period was chosen because the observation data for that year were the most complete. Daily rainfall data that occurred in the Unnes Embung in the period of the observation year can be seen in the attachment section of this thesis.

Rain data from the Sigotek Sumur Jurang rain station will be used to determine the frequency of rainfall in the Embung Unnes catchment area. The selected rainfall frequency data will be used in the calculation of Flood Discharge. In this study, to determine the rainfall frequency that was selected using the Kolmogorov Smirnov Test Result Method. The maximum daily rainfall data for the period 2001 - 2015 at the Sigotek Sumur Gorge Rain Station are shown in Table 1.

| No. | Year | $R_{24}$ Max (mm) |
|-----|------|-------------------|
| 1   | 2001 | 110.00            |
| 2   | 2002 | 157.00            |
| 3   | 2003 | 154.00            |
| 4   | 2004 | 103.00            |
| 5   | 2005 | 70.00             |
| 6   | 2006 | 60.00             |
| 7   | 2007 | 157.00            |
| 8   | 2008 | 165.00            |
| 9   | 2009 | 35.00             |
| 10  | 2010 | 121.00            |
| 11  | 2011 | 90.00             |
| 12  | 2012 | 55.00             |
| 13  | 2013 | 124.00            |
| 14  | 2014 | 72.00             |
| 15  | 2015 | 79.00             |
| Σ   |      | 1552.00           |

The maximum daily rainfall data is then processed to obtain the selected rainfall frequency which will be used as data for determining the amount of flood discharge at the Unnes Embung. The calculation of the return period rain can be done using the normal distribution. The calculation of return period rain using the normal distribution method is influenced by the value of the Gauss reduction variable. The log normal distribution method is like the normal method, except that the log normal distribution method uses logarithmic values. The calculation of return period rain using the Log Pearson III uses logarithmic values. The calculation of return period rain with the Log Pearson III distribution method is influenced by the k value for the Log Pearson III distribution. The calculation of return period rain using the Gumbel distribution method is influenced by many variables, namely reduced variable, reduced mean, reduced standard deviation [8,9].

From the results of the analysis of the frequency of rainfall using the Kolmogorov Smirnov test model, it was found that the appropriate rainfall distribution was the Gumbel Distribution method so
that the planned rainfall which is then used for the planned discharge analysis is the rainfall plan for the Gumbel Distribution. This is because the results of calculations with the Gumbel method obtained $d_{\text{max}} < d_{\text{critical}}$ values [10-12]. Calculation of the rainfall distribution method by means of the Kolmogorov Smirnov Test can be seen in the attachment to this Research Report. Below is a table of the results of the analysis of determining the distribution of rain using the Kolmogorov Smirnov Method, as shown in Table 2.

**Table 2.** Kolmogorov Smirnov test results for determination of rainfall frequency distribution.

| No | Methods       | $D_{\text{max}}$ (%) | $D_{\text{cr}}$ (%) | Terms     | Information |
|----|---------------|------------------------|---------------------|-----------|-------------|
| 1  | Normal        | 13.182                 | 34.00               | $D_{\text{max}} < D_{\text{cr}}$ |             |
| 2  | Log Normal    | 10.227                 |                     |           |             |
| 3  | Log Pearson III | 11.150               |                     |           |             |
| 4  | Gumbel        | 8.159                  |                     |           | Used        |

Determination of the amount of flood discharge at the Unnes Embung is influenced by Land Use at the Unnes Campus, especially those on the west side of the campus. The condition of the catchment area of the Unnes Embung is very different when it was during the construction period. Currently, the Unnes reservoir has reduced water catchment areas due to the construction of new buildings around the campus. There are two water infiltration areas, namely impermeable and pervious areas. Below is a table comparing the water catchment area when the embung was planned and the existing conditions, as shown in Table 3.

**Table 3.** Table comparison of pervious and impervious areas in the catchment area of the unnes embung.

**Existing Conditions in 2020**

| Subcatchment | Area (Ha) | Pervious Area | Pervious Percentage | Impervious Area | Impervious Percentage |
|--------------|-----------|---------------|---------------------|-----------------|-----------------------|
| 1            | 1.39      | 1.03          | 74%                 | 0.36            | 26%                   |
| 2            | 0.79      | 0.27          | 34%                 | 0.52            | 66%                   |
| 3            | 1.43      | 0.43          | 30%                 | 1.00            | 70%                   |
| 5            | 1.28      | 1.28          | 100%                | 0.00            | 0%                    |
| 10           | 2.75      | 0.85          | 31%                 | 1.90            | 69%                   |
| 11           | 0.93      | 0.46          | 49%                 | 0.47            | 51%                   |
| 20           | 0.82      | 0.22          | 27%                 | 0.60            | 73%                   |

**Planning Period Conditions in 2009**

| Subcatchment | Area (Ha) | Pervious Area | Pervious Percentage | Impervious Area | Impervious Percentage |
|--------------|-----------|---------------|---------------------|-----------------|-----------------------|
| 1            | 1.39      | 1.39          | 100%                | 0.00            | 0%                    |
From the table above, it is clear there is an additional watertight area in the Unnes Embung Catchment Area. At the time of planning there were several Subcatchment Areas whose conditions were still 100% watertight (pervious) easily, but in the existing conditions this condition has changed to be reduced between 25.90% to 73.17% to watertight areas (impervious).

After the Rainfall Distribution data and Embung Measurement Data are obtained, then the Flood Discharge is calculated using the Storm Water Management Model (SWMM) Program. EPA SWMM (Environment Storm Water Protection Agency Management Model) is a software designed to create a dynamic rain-runoff simulation model. This software can simulate in a simulation rain-runoff effect of an area on the drainage system for long short and long term at once have alternative facilities for anticipating flood problems [13-16]. From the results of the flood hydrograph routing using the SWMM program, the results show that the inflow (inflow) when flooded to the Unnes Embung is 3.52 m$^3$ / s and the outflow can be flowed at 2.22 m$^3$ / s with a water depth in this condition, peak (flood) 2.20 meters.

|   |   |   |   |   |   |
|---|---|---|---|---|---|
| 2 | 0.79 | 0.79 | 100% | 0 | 0% |
| 3 | 1.43 | 0.85 | 59% | 0.58 | 41% |
| 5 | 1.28 | 1.28 | 100% | 0 | 0% |
| 10 | 2.75 | 0.85 | 31% | 1.9 | 69% |
| 11 | 0.93 | 0.93 | 100% | 0 | 0% |
| 20 | 0.82 | 0.56 | 68% | 0.26 | 32% |

Figure 2. Hydrograph of existing condition of unnes embung flood.
In order to compare the current conditions with the planning conditions, a flood hydrograph routing is also required during the planning conditions. From the results of the routing, the results show that the inflow that occurs is 1.98 m$^3$/s and the outflow of the reservoir is 1.69 m$^3$/s with a water depth of 1.17 meters in peak conditions.

With a flood discharge magnitude of 3.52 m$^3$/s with a 10-year rain return period at the Unnes reservoir there has been no flood or water runoff that exceeds the cross-sectional surface of the reservoir. From this, it can be seen the current condition of the Unnes Embung is still able to accommodate flooding around the Unnes Campus area.
From the results of the data analysis above, it can be seen the capacity of the Unnes Embung to accommodate flooding from the catchment area is still adequate and there has not been water runoff that exceeds the surface of the reservoir. However, from the results of surveys and field investigations there are still inundation at certain location points when it rains, this is apparently due to the following reasons:

1. A geometric cross section of a road in the Unnes environment that does not or does not meet technical principles in road planning. There are several points of the road that are in the shape of a basin, so that the potential for inundation when it rains.
2. Drainage channel as one of the main components in channeling runoff water when it rains, field the slope of the existing channel is not sufficient to drain water, so that at certain points there is water flow that cannot enter the reservoir.
3. The operation and maintenance of drainage channels in the Unnes campus environment is less than optimal, this can be seen from the amount of sediment or sediment in the drainage channels, so this can reduce the capacity of the channel
4. The cross-sectional dimensions of the drainage channel are too minimal and the routing of the drainage channels that enter the reservoir needs to be improved to accommodate the development of building construction around the Unnes campus. There is a need for further studies on the dimension and routing of drainage channels.

The things above are one of the reasons why puddles or floods occur at certain locations when it rains, while at the Unnes reservoir, which functions as a water reservoir, there is no overflow or water runoff when it rains around the Unnes campus. it can also be caused by the behavior of residents or local communities who do not understand the importance of drainage channels, with the habit of local resident throwing garbage or liquid waste into drainage channels carelessly.

In order to optimize the operation and maintenance of the Unnes reservoir, from the results of the field survey it is necessary to add a Pile Scale to read the water level of the reservoir that can be installed near the floodgates. This is necessary to assist the embung operational officers in anticipating in the event of a flood which would have the potential for water overflow or runoff from the reservoir.

4. Conclusion
From the results of the analysis above, it can be concluded that the existing reservoir capacity is still able to accommodate the flood discharge from the UNNES campus catchment area, especially the one on the west side.

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