Evaluation of Gadjah Mada University Yogyakarta Campus Drainage System Using Environmental Protection Agency Storm Water Management Model 5.1 (EPA SWMM 5.1)

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Abstract. The drainage system is an infrastructure which controls the water to prevent the flood and to maintain the public health. There are two concepts of the drainage system, conventional drainage and eco drainage. Universitas Gadjah Mada still using the concept of conventional drainage. In this final project, the writer evaluates the drainage system at Universitas Gadjah Mada Yogyakarta using EPA SWMM 5.1 software. The methodology used by the author is the research methods used in this final project are interviews, observation, participation, and literature. The analysis using in this final project are hydrology analysis, land-use analysis, hydraulic analysis, and management and maintenance analysis. The evaluation of the drainage system will use the calculation of the area is based on the location of the rain station with the calculated average method. Hydrology analysis using frequency analysis and SCS-CN rainfall effective method. Land-use change analysis in the Universitas Gadjah Mada area. Hydraulic analysis using EPA SWMM 5.1, and the management and maintenance analysis of drainage system of Gadjah Mada University. Based on the result of the simulation scenario, installation of the low impact development using permeable pavement that provides a significantly reduced runoff. The runoff coefficient using permeable pavement is 0.23. The peak of runoff using permeable pavement is very slowest than another. Permeable pavement installation is considered very effective.

1. Introduction
Special Region of Yogyakarta is one of the province in Indonesia with an increasing population every year. The causes of the increased population are whereabouts of students who live and live and study especially in Gadjah Mada University. Gadjah Mada University Yogyakarta address at Bulaksumur, Caturtunggal subdistrict, Depok district, Sleman regency, Special Region of Yogyakarta. Gadjah Mada University has 18 faculty and 2 colleges. The rate of development of educational facilities and infrastructure in Gadjah Mada University from year to year continues to increase [1]. It makes land use at Gadjah Mada University. The land use can make an increase in surface runoff and potential flooding [2]. The flood happened in several varied locations based on area, height, duration, and frequency of events. The flood problem caused the drainage system is very poor [3]. The EPA SWMM is a physically based, deterministic model that simulates water inflows, outflows, and storages within a subcatchment. The SWMM’s runoff component functions as a collection of subcatchment areas that receive precipitation and generate runoff and pollutants [4].

2. Study area
The present study area is Gadjah Mada University Yogyakarta, which is shown in Figure 1. There are 18 faculties and 2 colleges and divided into 11 blocks.
Figure 1. Gadjah Mada University study area in google earth

3. Methodology
In this research, the authors are using some methodology. There are the method of collecting data and data analysis.

3.1 Data Collection
There are primary data and secondary data for this research. Primary data were obtained from field surveys consist of conditions and drainage dimensions. The surveys start from 15th August 2020 to 08th September 2020. The secondary data in rainfall, land use form, and location of the puddle in Universitas Gadjah Mada.

3.2 Hydrology analysis
Hydrology analysis is to get the planned rainfall intensity [2]. Hydrology analysis starts from calculating the regional rainfall using the average rain method, calculate the rain distribution using, testing of goodness of fit, calculate the land-use using Soil Conservation Service (SCS)-Curve Number (CN), and calculate the hourly rainfall using Alternating Block Method (ABM).

3.3 Land use analysis
Land use analysis is to get the differences in Gadjah Mada University land from 2005 to 2020. Land use analysis starts from comparing the development in every year and plan of development in Gadjah Mada University.

3.4 Hydraulica analysis
Hydraulic analysis in this research using EPA SWMM 5.1. The hydraulic analysis starts from modeling the subcatchment, junction, and conduit on EPA SWMM 5.1 according to the geometry data obtained, input the hourly rainfall, and then performing the simulation results of EPA SWMM 5.1.

3.5 Management and maintenance analysis
Management and maintenance analysis in this research starts from the survey of the drainage system in Gadjah Mada University and then record the problems of the drainage system in each block.
3.6 Flowchart of methodology

The steps of this research are shown in Figure 2.

![Flowchart of methodology](image-url)

**Figure 2.** Flowchart of methodology

4. Result and Discussion

4.1 Hydrology analysis

The hydrology analysis using the rainfall starts from 2005 to 2019 at Gemawang, Nyemengan, and Santan rain station. The distribution of rainfall from 2005 to 2019 is shown in Table 2.

| Year | Average (mm) | Year | Average (mm) |
|------|--------------|------|--------------|
| 2005 | 127.33       | 2013 | 87.70        |
| 2006 | 139.67       | 2014 | 102.17       |
| 2007 | 98.33        | 2015 | 102.87       |
| 2008 | 68.50        | 2016 | 119.23       |
| 2009 | 87.83        | 2017 | 311.20       |
| 2010 | 66.50        | 2018 | 131.57       |
| 2011 | 90.33        | 2019 | 154.57       |
| 2012 | 107.00       |      |              |
After knowing the average of rainfall for 15 years and then analyzing frequency distribution using the Log Pearson Type III method. The calculation from frequency analysis using Log Pearson Type III method is shown in Table 2.

**Table 2. Log Pearson Type III rainfall data**

| Repeated time | Rainfall data |
|---------------|---------------|
| 2             | 102.04        |
| 5             | 144.44        |
| 10            | 182.76        |
| 25            | 245.22        |

The frequency analysis using Log Pearson Type III will be testing the goodness of fit using the Smirnov-Kolmogorov test. The maximum delta value is 0.134 and the critical delta value is 0.338. The result is the maximum delta value is smaller than the critical value, so the result is acceptable. After knowing the result of testing of goodness of fit, then calculate the Soil Conservation Service (SCS) Curve Number (CN), the curve number value is 71,183 and the value of potential retention is 102,828. The result of effective rainfall is shown in Table 3.

**Table 3. Effective rainfall**

| Repeated Time | Effective Rainfall (mm) |
|---------------|-------------------------|
| 2             | 36,019                  |
| 5             | 67,685                  |
| 10            | 99,259                  |
| 25            | 154,111                 |

The effective rainfall is converted into an alternating block method (ABM) to get the hourly rain. The hyetograph analysis in this research is shown in Table 8.

**Table 4. Hyetograph analysis**

| t (minutes) | t (hours) | 2 years | 5 years | 10 years | 25 years |
|-------------|-----------|---------|---------|----------|----------|
| 0           | 0.00      | 1.39    | 2.61    | 3.82     | 5.93     |
| 20          | 0.33      | 1.66    | 3.12    | 4.57     | 7.10     |
| 40          | 0.67      | 2.12    | 3.99    | 5.85     | 9.08     |
| 60          | 1.00      | 3.16    | 5.93    | 8.70     | 13.51    |
| 80          | 1.33      | 17.32   | 32.54   | 47.72    | 74.09    |
| 100         | 1.67      | 4.50    | 8.46    | 12.40    | 19.26    |
| 120         | 2.00      | 2.51    | 4.72    | 6.93     | 10.75    |
| 140         | 2.33      | 1.86    | 3.49    | 5.11     | 7.94     |
| 160         | 2.67      | 1.51    | 2.83    | 4.15     | 6.45     |
| 180         | 3.00      | 0       | 0       | 0        | 0        |
4.2 Land-use change analysis

In this research, the author's comparisons of land-use change from 2005 to 2020. The land-use change especially in Universitas Gadjah Mada. Every year, Gadjah Mada University builds several facilities and infrastructures to make the student comfortable. The difference in land-use change in 2005 and 2020 is shown in Table 5.

| Year  | Project                                                                 |
|-------|-------------------------------------------------------------------------|
| 2005  | Mini hospital of medical faculty, graduate college, gate of Universitas Gadjah Mada |
| 2006  | Bulaksumur Residence                                                   |
| 2007  | Bulaksumur Residence                                                   |
| 2008  | -                                                                       |
| 2009  | -                                                                       |
| 2010  | Library unit 1, administration building and graduate college of forestry faculty, |
| 2011  | New bulding of economics and business faculty                          |
| 2012  | Pertamina tower                                                        |
| 2013  | -                                                                       |
| 2014  | Dharmaputra kinanthi dormitory                                         |
| 2015  | Pancasila building                                                      |
| 2016  | R.Soegondo building of cultural science faculty                         |
| 2017  | -                                                                       |
| 2018  | Buliding of law faculty                                                |
| 2019  | Sendowo dormitory                                                      |
| 2020  | IFFLC forestry faculty, TILC vocational college, APSCL pharmacy faculty, ALC agriculture faculty, DLC dentistry faculty |

4.3 Hydraulic analysis

There are some priority areas in Gadjah Mada University and the surrounding area. Parameters of priority area determination using regulation Ministry of public works and housing 12/PRT/M/2014. The total score priority is shown in Table 6.

One of the priority areas is UGM boulevard, with the 2nd highest score in the table. It is shown in Figure 6. Hydraulic analysis using EPA SWMM 5.1 will be simulation in the UGM boulevard and to get the runoff value of this area. Figure 7 description of block 6 and block 10 where that’s the subcatchment effect to UGM boulevard. There are 44 subcatchments, 45 junctions, and 51 conduits. There is scenario of simulations using EPA SWMM 5.1 as shown in Table 7.

Table 6. Total score of priority areas
| Location                      | Total  |
|-------------------------------|--------|
| Kaliurang street              | 512.50 |
| UGM boulevard                 | 432.50 |
| Prof.DR. DRS. Notonagoro street | 376.25 |
| Klitren sub-district          | 351.25 |
| Belik river                   | 272.50 |
| Olahraga street               | 223.75 |
| Bulaksumur housing            | 213.75 |

**Figure 3.** UGM boulevard area in google earth and sub-catchment UGM boulevard with EPA SWMM 5.1

**Table 7.** Scenario of simulations

| Low Impact Development       | Simulation scenario |
|------------------------------|---------------------|
|                              | 1  | 2  | 3  | 4  | 5  | 6  | 7  |
| Existing                     | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |
| Permeable Pavement           |    | ✓  |    |    |    | ✓  |    |
| Vegetative Swale             |    |    | ✓  |    |    | ✓  | ✓  |
| Green Roof                   |    |    |    | ✓  |    | ✓  | ✓  |
| Rain Barrel                  |    |    |    |    | ✓  | ✓  | ✓  |

This research using some low impact development. There are permeable pavement, vegetative swale, green roof, and rain barrel using to decrease the runoff in the UGM boulevard area. The permeable pavement is installed all the way, especially Pancasila street and UGM boulevard. The
A vegetative swale is installed in the channel, green lines, and road median. The green roof is installed in Koesnadi Hardjasoemanti arts center, Directorate of Information System and Resources, Block H and Block J of Bulaksumur Housing, and the student arena. The rain barrel is installed in Bulaksumur Housing in Figure 4.

![Low impact development installation map](image)

**Figure 4. Low impact development installation map**

Based on the result of the simulation scenario, installation of the low impact development using the permeable pavement as an alternative for road material, provides a significantly reduced runoff. The runoff coefficient using permeable pavement is 0.23. The peak of runoff is very slowest than another. Permeable pavement installation is considered very effective. The runoff graphic is shown in Figure 5.

![Runoff graphic](image)

**Figure 5. Runoff graphic**
4.4 Management and maintenance analysis

Management and maintenance of drainage systems in Gadjah Mada University are not optimal. That’s can make an increase in runoff every year. Because of it, the drainage system required periodic drain cleaning, periodic water inlet cleaning in the road, and use the low impact development to decrease runoff in every subcatchment, especially in the priority area.

5. Conclusion
The hydrological condition, especially the rainfall from 2005 to 2019 has changed significantly. The condition of land use on the campus of Gadjah Mada University and the surrounding area has changed too, there are developments every year. The condition of the drainage system after simulation using EPA SWMM 5.1 is not optimal. The runoff when it rains is still high. Therefore, it needs to the installation of low impact development. After installation of low impact development, the results are permeable pavement is a very effective low impact development to reduce the runoff. the management and maintenance of the drainage system need to be improved. It likes cleaning periodically the channel to make the function optimally.

Acknowledgments
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