The Study Of Potential And Flood Reduction In The Jragung Watershed System

Wisnu Setyo Pradana, Suseno Darsono, Suharyanto

Abstract- Jragung watershed is located in Demak Regency and Grobogan Regency where this research took place. The purpose of this research is to analyze the reduction of flood discharge through storage area plan at the upstream part either in the form of reservoir or tank. The hydrology method used for the calculation of rainfall-runoff was by using the assistance of HEC-HMS software, and to analyze the hydraulics was by using the assistance of HEC-RAS 2 Dimension for generating the map of flood area. Based on the hydraulics analysis conducted, it obtains existing flood discharge (before there is storage area) in the amount of 699,0 m^3/sec in Wonokerto River as watershed downstream. After added storage area at watershed upstream, then the flood discharge can be reducted to be 606,6 m^3/sec, or the percentage of the flood reduction is 12,53%. While at KB 1 Upstream River can be reducted 19,28%, in S.Cabean can be reducted 7,83%, and in Jragung River can be reducted 17,11%. While the flood area mapping using HEC-RAS in existing condition, it generates flood area in the large of 2,228.84 ha, and after added with the storage area, it decreases to be 2.075,22 ha, with depth of the pool varies between 1 to 5 meter. The reduction of pool large between existing condition and condition after added with the reservoir, it decreases to be 153,62 Ha or around 6,89%.

Keywords: Flood, Pool, HEC-HMS, HEC-RAS 2D, Reduction

1 INTRODUCTION

1.1 Latar belakang

Flood is a disasterwhich cause loss of property and also victims, flood can also damage facilities and infrastructure and endanger people [1, 2]. Based on the development recently that occurred in Demak and Grobogan, the total of water runoff and sediment in the Jragung River System is rising, while the riverbed capacity is limited (BBWSPJ). The rise on water surface and sediment is indicator of land outcrops in the Jragung Watershed (DAS) wider, so that impact to less water catchment and land erosion. The flow of Jragung watershed is relatively straight and twist because some watersheds have been normalized to facilitate the flow of river to the sea. In a hydrological point of view, by looking at the shape of catchment area inJragung watershed, it has relatively moderate flood discharge, but with longer duration due to the shape of the Jragung watershed in bird feathers shape and the relatively gentle slope of riverbed. The part of Jragung watershed start from Gemboyo River to Wonokerto River up to the downstream (estuary of Java Sea) is morphology land unit, due to flat topography and becomea place of residentials with majorityfor business, such as paddy fields and plantation. The more it goes to downstream, Jragung watershed has wider river valley (between 50-100 m) with depths 4-8 meters.

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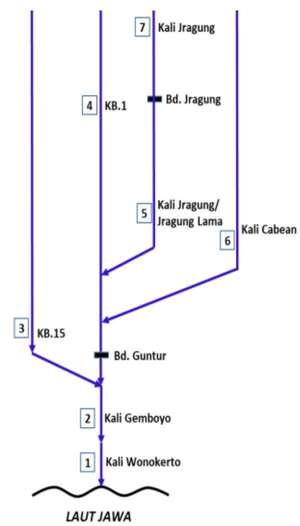


Figure 1 *. JragungWatershed Scheme*

In Jragung River, the flood often happened so that flood happened atresidential, paddy fields, upland areas, including important infrastructures such as Pantura and Negara Street due to several reasons, such as:The Jragung watershed area has now undergone a lot of land conversion which was originally a forest area now being developed for residential and plantation areas.The Jragung river debit is higher due to changes in land use change ofwatershed .

The existence of land by communities in restricted areas / banks will hamper the flow of rivers and flood occurs.In addition, flood in several rivers are occur many timesdue to critical dykes and broken down at certain discharges.Therefore, to cope with flood events in the Jragung watershed, it is necessary to optimize the distribution of flood discharges in each river based on their maximum capacity, and also the potential of storage ponds. It is expected that the findings of this studycan figure out the most effective scenarios which reduce flood existed and control flood in Jragung Watershed.

1.2 The Formulation of Problems

Based on the description of background, the problem is formulated as follows:

The flood discharge in Jragung watershed. The maximum capacity of Kali Jragung Lama, Cabean,KB . 1, KB . 15, Gemboyo andWonokertoin accommodating the flood discharge.If the maximum capacity of river cannot accommodate the flood discharge, how to control flood by the construction of cistern (reservoirs, retention basin and long storage) in the upstream to reduce flood discharge in the downstream .

1.3 The Meaning and Objectives of Study

The objective of this study is to optimize the river capacity to accommodate flood discharge in the Jragung watershed and considering the potential of water reservoirs in upstream areas to reduce flood discharge in the downstream. The objectives to be achievedof this study are:

- Calculate plan flood discharge for each river.
- Analyzing the existing capacity of the Jragung Watershed to accommodate flood discharge.
- Analyzing the potential locations of water reservoirs in the Jragung Watershed.
- Analyzing models of flood hydrographs.
- Analyzing the reduction of flood discharge through the planning of reservoirs in the upstream (retention basin)

1.4 The Hypothesis of Study

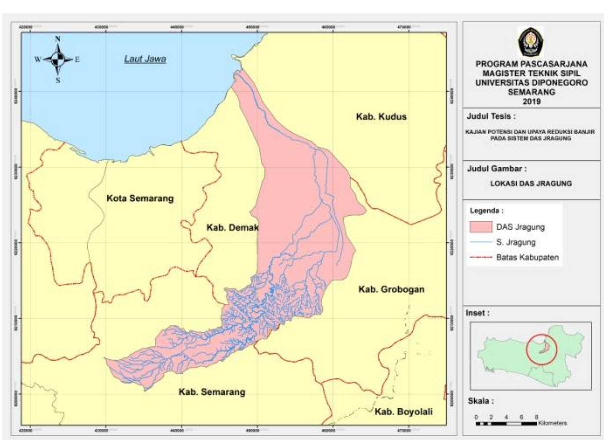
The hypothesis of this study is the highest discharge in Jragung watershed has exceeded the river capacity so that a control system is needed to prevent flood or to reduce it.

1.5 Problems Limitation

In order to focus on problem solving, this study needs to be limited to focus on flood control patterns. Based on the background and identification of the problems above, the problem limitation of this study are:The study was conducted in the Jragung watershed which consisted of Jragung Lama River, Cabean, KB . 1, KB . 15, Gemboyo and Wonokerto.Not discussing sedimentation.Not discussing social and economic aspects of the study location.

1.6 TheLocation of Study

Jragung watershed is located in the Demak and Grobogan. Jragung watershed is included in the Jratunseluna River.



Source: BBWS Pemali Juana, 2019 .

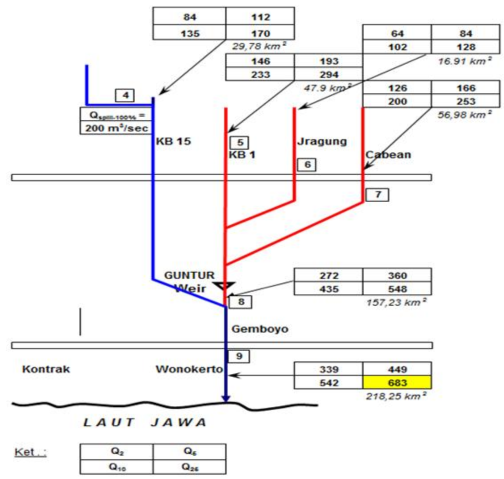
***Figure 2.** Jragung Watershed Scheme*

2 LITERATURE REVIEW

2.1 Previous Studies

2.1.1 The Study of Jragung Watershed Design by Geodynamics Company, 2008

The initial scenario of the discharges distribution in Jragung watershed refers to the scheme below, but the distribution does not provide sufficient portion for each river where river capacities in the downstream cannot accommodate these debits yet.



Source: Geodinamik Company, 2008

***Figure 3**. Discharge Distribution Scheme in the Jragung Watershed*

2.1.2 FS Study and Pre Design of Jragung Dam in Demak, 2014.

FS Study and Pre Design of Jragung Dam in Demak 2014 stated the results of flood discharge analysis in the Jragung watershed using the Gama-1 method for return periods of 10 years, 25 years, 50 years, 100 years and 1000 years, as presented in the following table.

***TABLE 1** . FLOOD DISCHARGE OF JRAGUNG DAM PLAN*

PER. ULANG	10	25	50	100	1000	PMP
Qmak (m^3/dt)	245.33	275.33	298.36	322.01	407.33	874.42

Source: FS and Pre Design of Jragung Dam in Demak, 2014

2.2 Flood Control

Flood control is part of specific water resources management in order to control rainfall and floods through flood control dams, or improving the carrier systems (rivers, drainage) and prevent the potentially damage with managing land use and flood areas (flood plains) [3-5]. The engineering dimension involves many engineering disciplines including: Hydrology, hydraulics, watershed erosion, river engineering, river morphology & sedimentation, flood control system engineering, urban drainage systems, water structures, etc[3].

There are four basic strategies in managing flood areas, such as[3]:

- Modification of flood vulnerability and loss (marking zones or land use management).
- Modification of floods reduction by control buildings (reservoirs) or river normalization.
- Modify the impact of floods by using mitigation techniques such as insurance, flood proofing .
- Arrangements to improve natural capacity to be preserved such as planting.

The Jragung River flood control concept that was once integrated with the integrated Tuntang River flood control effort, such as explaining the main problem in the Jragung System downstream is the lack of drainage and bottleneck capacity in the Guntur Dam, cause inundation in the upstream of dam inwide area and in long time (based on the information of the citizen, inundation is more than 2 months).

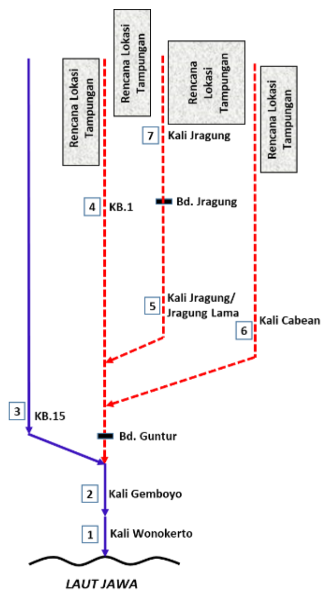


***Figure 4** . Jragung Watershed Design Scheme*

2.3 Retention Basin

Retention basin is a small reservoir that functions to collect water during excess water in rainy season and is used when there is lack of water in dry season for many purposes, such as drinking water, irrigation, tourism, flood control etc. [6, 7].The retention basin planning criteria are as followsKasiro and Wanny-Rusli [6]:

- Maximum reservoir height = 10.00 m for the fill type, and 6.00 m for the gravity or composite type; where the height of the reservoir body is measured from the surface of the deepest foundation excavations to the top of the reservoir body.
- Maximum reservoir capacity is 100,000 m^3
- Maximum rainfed area is 100 ha = 1 km^2
- Dam in this limit is small retention basin

2.4 Criteria for the Selection of Retention Basin Locations

Based on the selection of retention basin locations as water reservoirs when the excess water in rainy season is based on 2 (two) aspects, such as technical aspects and non-technical aspects with certain parameters on each aspect. These parameters are explained in the following Table 2.

***TABLE 2 .** POND LOCATION SELECTION PARAMETERS*

No.	Parameter Pemilihan Lokasi Embung							
	Aspek Teknis					Non Teknis		
	Topografi	**Geologi**	**Hidrologi**	**Efektifitas Embung**	**Aksesibilitas**	**Sosial Dan Lingkungan**	**Biaya**	**Benefit**
1	Vegetasi area genangan embung	Jenis tanah dasar pondasi	Debit banjir rencana	Lama operasi	Jarak *quarry* dari *site* embung	Jumlah penduduk yang harus dipindahkan	Biaya pembebasan lahan	Cakupan daerah irigasi
2	Volume material timbunan		Volume tampungan efektif	Biaya air/m³	Akses jalan menuju *site* embung	Status lahan di *site* dan genangan	Biaya konstruksi embung	Manfaat air baku
3	Luas daerah yang akan dibebaskan		Volume sedimen			Respon masyarakat sekitar	Biaya OP	
4	Kemiringan *abutment* (bukit tumpuan)		Luas DTA embung			Infrastruktur yang dipindahkan		

Source: Anjasmoro, Suharyanto and Sangkawati [8]

2.5 Hydrological Review

Generally, hydrological analysis is a preliminary analysis part in the design of water. It can be define that it is the information and quantities obtained in the hydrological analysis are important input in further analysis.

2.5.1 Regional Average Rainfall

2.5.1.1 Algebra Average Method

The average height of rainfall is conducted by the arithmetic mean of rain measurements at the rain gauge in the area. The average regional rainfall of the algebraic method can be calculated by this following equation [9, 10]:

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

with:
d = high average regional rainfall
d_1, d_2,...d_n = high rainfall at measurement posts 1,2,... n
n = number of measurement posts

2.5.1.2 Thiessen Polygon Method

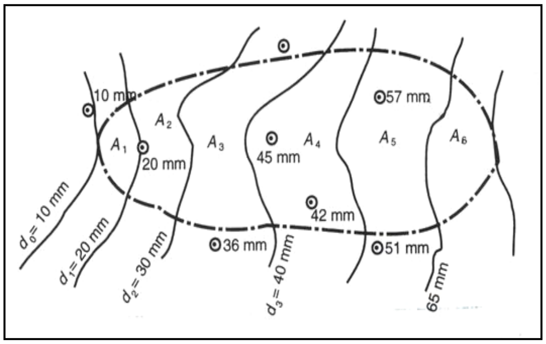
The average regional rainfall of Thiessen polygon method can be calculated by this following equation [9, 10]:

$$d = \frac{A_1 d_1 + A_2 d_2 + ... + A_n d_n}{A_1 + A_2 + ... + A_n} = \sum_{i=l}^{n} \frac{A_i d_i}{A_i} = \sum_{i=l}^{n} \frac{A_i d_i}{A}$$

with:
A = total area
d = high average rainfall area
d_1, d_2, ... d_n = high rainfall in post 1,2, ... n
A_1, A_2, A_3, ... A_n = the area of effected posts 1, 2, 3, ..., n

2.5.1.3 Isohyet Method

By using this method, the contour with the same rain height (isohyet) must be drawn first, as in Figure 2-6 below.



Source: [9, 10]
***Figure 5.** Isohyet Method*

2.5.2 Artificial Precipitation

Distribution of Frequency

1) Normal Method ,
2) Normal Log Method ,
3) Pearson III Log Method ,
4) Gumbel Method

Rain Data Alignment Test

Alignment Test Method:

1) Match test with Chi Square Distribution Test
2) Smirnov test - Kolmogorov

Rain intensity

2.5.3 Analysis of Flood Discharge Planning

The hydrological analysis of this study activity is to estimate flood discharge from rainfall data and estimate reliable discharge. Flood discharge with return period of 1000 years, 10,000 years and PMF which is estimated by statistical methods based on observable daily rainfall data. Flood discharge was analyzed by using HEC HMS software version 4.1 specifically the SCS hydrograph unit technique. Topographic maps, maps of soil types and maps of land use are needed to analyze flood discharge. Flood routing analysis is needed to analyze the maximum reservoir water elevation in PMF flood discharge conditions. Thus it can be predicted the elevation position of the dam's peak and the overflow dimensions that are safe from PMF flooding. Flood routing analysis will utilize or assist with HEC HMS software version 4.1. This model or software can analyze the magnitude of flood discharge and simulate flood tracking in reservoirs.

2.6 Flood Inundation Analysis

The 2-D model to establish maps of flood inundation areas, and determine evacuation locations and routes [11]. The 2D hydraulic model is used to analyze or map inundation areas, flood flow velocity, and flood arrival times. Floods with a 1 percent chance per year or 100 year return period are the regulatory standards for determining inundation areas. If the dam collapse study includes the path and location of the flood evacuation, additional information such as the speed of the flood, the time of the flood and the extent of the inundation and the depth of the flood inundation. The effective and quick HEC-RAS method in analysis illustrates the zone of potential dam outbreaks that is reasonable and effective. By using the simple set, but effective techniques, zones of dam outbreaks can be defined to protect lives and property [11, 12]. It is important to know that although some communities choose to use HEC-RAS as flood risk management tool, the main purpose of these maps is to determine the level of accuracy of flood and flood area management.

3 RESEARCH METHODS

3.1 Data Collection.

***TABLE 1** . SECONDARY DATA NEEDS*

No.	Type of Data	Sources of Data
1.	Water Discharge on Jragung Watershed	- PSDA Central Java Province - BPSDA Jragung Tuntang
2.	Rainfall	- PSDA Central Java Province - BPSDA Jragung Tuntang - BBWS Pemali Juana
3.	The watershed map	- BBWS Pemali Juana
4.	The Tide	- BMKG
5.	River cross section (pot. transverse, lengthwise, layout)	- BBWS Pemali Juana
6.	Data of AWLR at Bendung Jragung	- BBWS Pemali Juana
7.	The Pattern and the plan of WS Jratunseluna Management	- BBWS Pemali Juana

3.2 Method of Analysis

The schemeof this research is as follows:

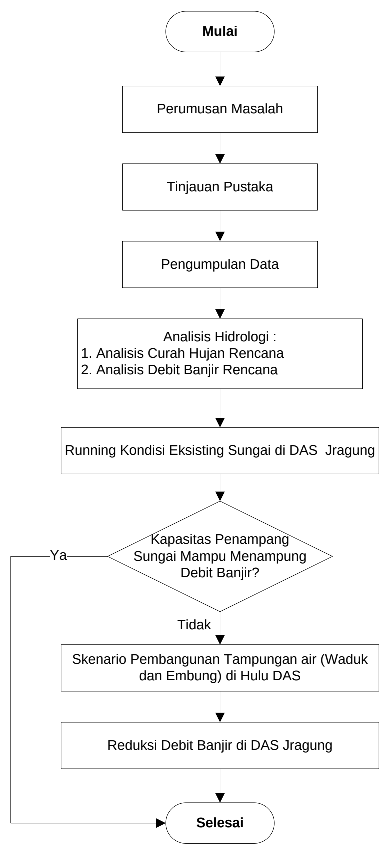


***Figure 6.** Research Flow Chart*

3.2.1 Hydrological Analysis

Before conducting hydrological analysis, it is needed to determine the rain station, rain data and catchment area. In the hydrological analysis will discuss steps to determine the flood discharge plan. The steps of flood discharge determination are to calculate regional average rainfall, plan rainfall, conduct alignment tests to determine methods that meet the distribution test, calculate rainfall intensity and plan flood discharge.

3.2.1.1 Calculation of Regional Average Rainfall

Rainfall data analysis was performed using the Thiessen Polygon method. The thiessen polygon method is used when the area of influence and average rainfall for each station is different, the rain recording data uses the Tanjung Mas Maritim rain station. This method takes into account the area that represents the relevant rain posts, to be used as important factor in average rainfall calculation.

3.2.1.2 Rain Frequency Analysis

- Normal Method ,
- Normal Log Method ,
- Pearson III Log Method
- Gumbel Method

3.2.1.3 Rain Data Alignment Test

Alignment Test Method:

- Match test with Chi Square Test
- Smirnov test - Kolmogorov

3.2.1.4 Rain intensity

Analysis of Flood Discharge Plans
HEC-HMS software is to calculate the rain flow process in watershed system. This software was developed by the Hydrologic Engineering Center (HEC) of the US Army Corps of Engineering
Generally, the procedure for using the HEC-HMS software is as follows.
Creating new project ,
Creating the Component Models
1) Basin Model , 2) Meteorologic Model , 3) Control Specification
Creating Time Series Data , such as:
1) Time series rain data , 2) Time series data discharge
Creating Paired Data (if necessary), such as:
1) Unit hydrograph , 2) Relationship to elevation-volume
After the Component models are finished, the next process isfilling components of each model.1) Creating Basin Models , 2) Selecting and filling Basin Models , 3) Filling the Meteorologic Model , 4) Filling the Control Specification , 5) FillingTime-series Data , 6) Filling the Paired Data , 7) Checking The Data, 8) Simulation , 9)Calibration (if debit data is available)

3.2.2 Flood Inundation Analysis

Steps to modeling 2D flow:
The Terrain data setup of Ras Mapper.
The objective of this preparation is to create images and projections by input terrain data in the Ras Mapper, and the result is an image which already match with the location of study.

2-dimensional flow area setup.

The objective of this preparation is making the mesh by digitizing around the river to form a closed polygon. To determine the Mesh size generated computation points on regular intervals with all breaklines, if error occurs, deleting the error points with the remove pointscan be done. The result of this process is a mesh with number of cells depending on grid size.

Preparation of boundary conditions .

The objective of this preparation is making the boundaries upstream and downstream in the simulation using the SA / 2D area BC line generated from this process are upstream and downstream .
Selection of Flow ScenariosThe objective of this selection is determining the scenario used for simulation. There are 2 flow scenarios used in the HEC-RAS Software, such assteady flow and unsteady flow .
Running processThe objective of this process is to conduct a simulation, while the resulting model is a pool that will occur. In this case, the simulation in the process of running data is unsteady simulation which used for 24 hours.

3.2.3 The Scenario of Water Basin Construction

Scenario of making water reservoirs (reservoirs and retention basin) in the upstream which serve as temporary water reservoir to reduce flood. Retention Basin is a small reservoir that was builtto hold and store excess water in case of heavy rain, and drain downstream afterwards. The analysis of the construction of water reservoirs (reservoirs, and long storage reservoirs) is done from topographic data, hydrological analysis, flood tracking, and discharge simulations by using the HEC-RAS software.

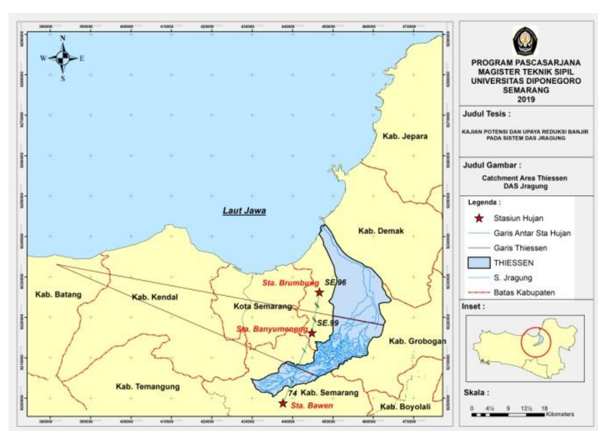
4 ANALYSIS

4.1 Hydrological Analysis

Hydrological analysis for planning the repair of the Jragung Riveris needed. Hydrological analysis has the function to obtain the magnitude of the planned flood discharge . The calculation steps are as follows.

4.1.1 Regional Rainfall Distribution (Watershed Area)

Based on checking experiments on the 3 closest stations such as Bawen, Banyumeneng, and Brumbung which using the Thiessen method supported by ArcGIS 10.5 software, the division and extent influence of rain station on each section using the Thiessen method:



Source: Analysis Results, 2019 .
Figure 5 . *Jragung Watershed Catchment Area*

Based on the picture above, the coefficient / weight obtained for the catchment area is as follows.

***TABLE 1 .** EXTENT OF RAIN STATION EFFECT ON THEBANGER RIVER BASIN .*

Catchment Area (CA)	Large of CA (Ha)	Coefficient of Thiessen
CA Brumbung	19.787,87	0.49
CA Banyumeneng	14.800,28	0.36
CA Bawen	6.157,07	0.15
Jragung Watershed	40.745,24	1.00

Source: Analysis Results, 2019

TABLE 2 . REGIONAL MAXIMUM RAINFALL AT THE MARITIME RAIN STATION .

Year	Maximum CH
2003	63,92
2004	51,93
2005	50,99
2006	87,88
2007	64,01
2008	73,03
2009	70,36
2010	75,75
2011	59,01
2012	55,95
2013	54,45
2014	123,20
2015	93,74
2016	117,96

Source: Results of Analysis, 2019

4.1.2 Rain Frequency Analysis

Frequency analysis in this study uses A Prob software version 4.1 which was developed by Ir. Istiarto, M.Eng., Ph.D as staff lecturer at Gajahmada University[13].
Based on the analysis, it can be concluded that the rain data alignment test meets the distribution requirements of Log Pearson III distribution with the smallest maximum difference is 0.090. It was proven in Smirnov-Kolmogorof and Chi-Square test, the distribution of Pearson III Log data was passed. The magnitude of rain return is as follows.

TABLE 3 THE RAIN BANGER WATERSHED

Repeated Time	Log Pearson III
2	69
5	90
10	105
20	121
50	144
100	163
200	184
500	214
1000	240

Source : Analysis Results, 2019

4.1.3 Concentration Time (tc)

The duration of tc is determined by the channel length by the channel flows and slope. The duration of tc can be calculated by several formulas, one of them is Kirpich formula.

TABLE 2 . TC ON THE JRAGUNG WATERSHED

Sub Watershed	Length of The River (km)	Slope	tc (jam)
Wonokerto	15,67	0,000223	1,31
KB 1 Hilir	7,056	0,00112	0,81
Cabean	9,82	0,001151	0,97
KB 15	17,941	0,000256	1,44
Central KB 1	3,505	0,000656	0,60
Old Jragung	11,634	0,000988	1,07
Jragung	20,634	0,000385	1,60
Jragung Hulu	10,915	0,000522	1,03
Ploso	15,418	0,00037	1,29
Kliteh	19,149	0,000209	1,51

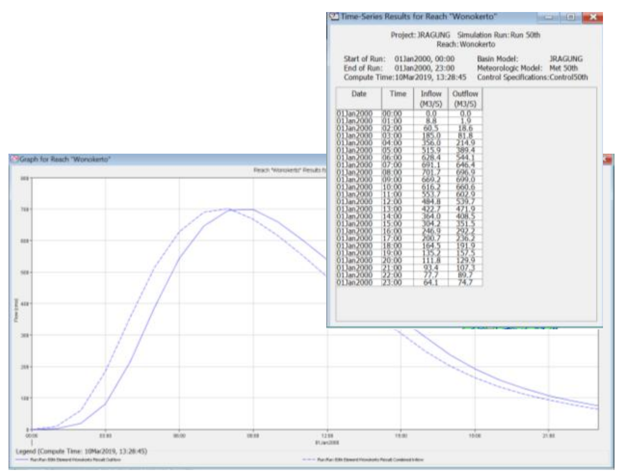
Source: Results of Analysis, 2019

Based on the tcvalue as Table 4.18, the total of rain as input in HEC-HMS model to divide the amount of rain at the time of re-election (50 years) of 144 m divided by the longest duration of tc is 2 hours. Therefore, the rain input for the HEC-HMS model (on Precipitation Gage) is 72 mm each for 2 hours.

4.2 Analysis of Flood Discharge Plans

4.2.1 Flood Plan Model for Existing Conditions

In the running model of HEC-HMS on the existing condition, it conducted in the Jragung watershed without reservoir (existing condition). Observation of running model result was taken at the Wonokerto River as downstream of Jragung watershed.



Source: Analysis Results, 2019 .

***Figure 8 .** Existing Condition of S. Wonokerto Flood Hydrograph*

In Figure 8 it can be seen that the top discharge of S. Wonokerto is 699.0 m^3/s.

4.2.2 Model Flood Plan with the Reservoir

As planning, the addition of reservoirs including Jragung Reservoir, Central KB retention basin 1, and Jragung retention basin. The location is as follows.

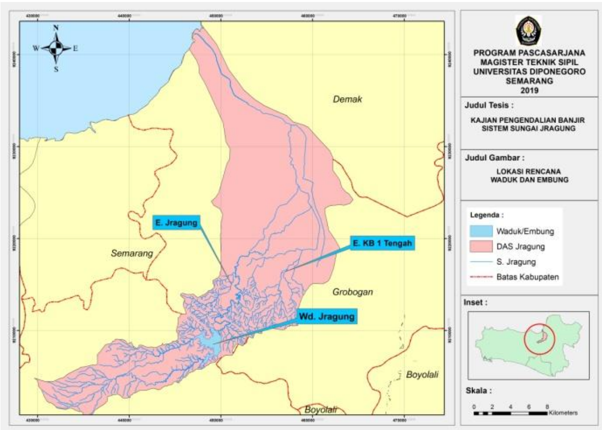
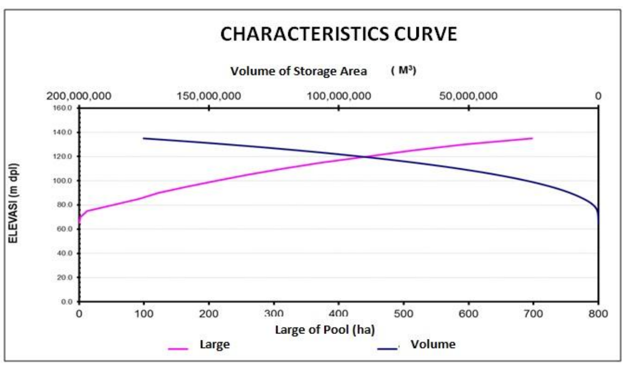
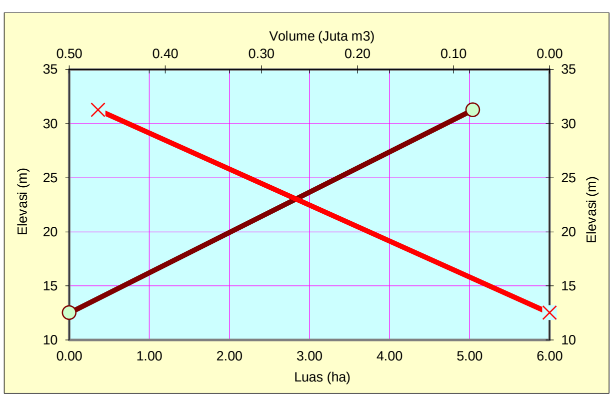


***Figure 9** . Location Map of the Basin*

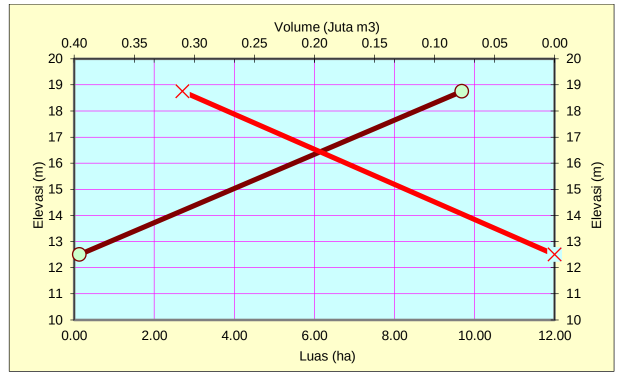
This following figuresis the storage capacity of reservoirs and retention basin in the S. Jragung system. The reservoir capacity of Jragung Reservoir is 142.8 Million m^3 , the Jragung Retention Basin 0.47 Million m^3 , and the Central KB Retention Basin 1 0.31 M^3 .



Source: BBWS Pemali Juana, 2019 .
***Figure 10 .** Characteristics Curves of Jragung Reservoir*

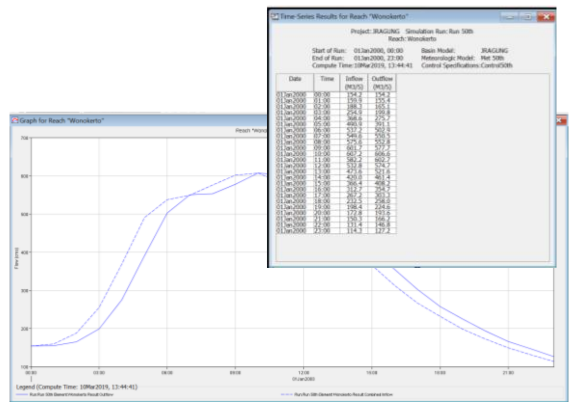


Source: BBWS Pemali Juana, 2019 .
***Figure 11 .** Curve Embedded Characteristics Curve .*



Source: BBWS Pemali Juana, 2019 .
***Figure 12** . Characteristics Curve of the KB Embankment 1 Middle.*

In running HEC-HMS model on the condition after add the number of reservoir. Observation of the results of the running model was taken in Wonokerto River which is downstream of Jragung watershed.



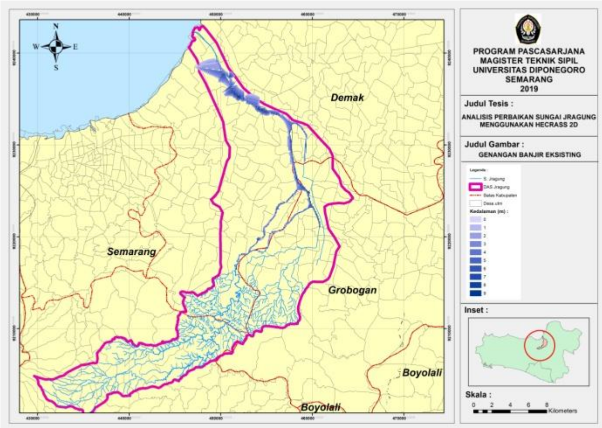
Source: Results of Analysis, 201 9.
***Figure 13** . S. Wonokerto Flood Hydrograph with reservoir*

In Figure 13, it can be seen that the top discharge of S. Wonokerto is 699.0 m^3/s. Flood reduction in S. Wonokerto was 12.53%. Whereas in KB 1 downstream river it can be reduced by 19.28%, in S. Cabean is reduced by 7.83%, and in S. Jragung by 17.11%.

4.3 Dimensional Flood Inundation Analysis

4.3.1 Existing Condition

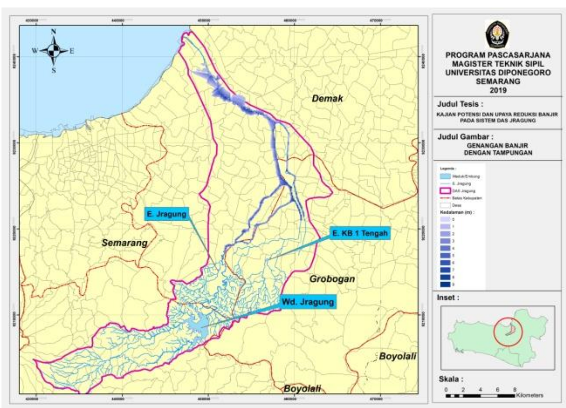
Based on the results of flood inundation analysis using HECRASS 5.03, the total area of flood inundation without reservoirs is 2,228.84 ha with the majority inundation areas downstream of watershed or Wonokerto River with depths range from 1 to 5 meters.



Source: Analysis Results, 2019 .
***Figure 14** Flood Inundation Map Existing Condition*

4.3.2 Conditions with Reservoir

Based on the analysis of flood inundation using HECRASS 5.03 with reservoir can reduce the area of flood inundation from 2,228.84 hectares to 2,075.22 hectares with depths range from 1 to 5 meters. Thus the inundation area can be reduced by 153.62 hectares or around 6.89%.



Source: Analysis Results, 2019 .
***Figure 15 .** Map of Flood Inundation Conditions with Reservoir*

5 CONCLUSIONS AND SUGGESTIONS

5.1 Conclusions

- The design of rainfall used in this analysis is 50-year return period with rainfall intensity about 144 mm.
- The analysis of flood discharge using HEC-HMS of existing conditions impact to the flood discharge about 699.0 m^3/s in Wonokerto River as watershed downstream. After additional reservoir to the upper watershed area, the flood discharge can be reducedto 606.6 m^3/s, or flood reduction is 12.53%. Whereas in KB 1 downstream river it can be reduced up to 19.28%, in Cabean river reduced up to 7.83%, and in Jragung riverreduced up to 17.11%.
- The analysis of flood inundation mapping using HEC-RAS in existing conditions is 2,228.84 ha, and after additional reservoir, it reduced up to 2,075.22 ha, with inundation depth range between 1 to 5 meters.
- The reduction of inundation area between the existing condition and the condition after additional reservoir reduced up to 153.62 Ha or about 6.89%.

5.2 Suggestions

- The management of prevention and early warning of flood, particularly in Jragung river system, the improvement is needed.
- The socialization to community about the importance of clean riveris needed.
- Preserve the vegetation in the upstream of watershed area is important to reduce land conversion so that erosion which makes river sedimentation does not happened.
- It is necessary to continuously check the flow capacity of Jragung river system.
- Building reservoirs and retention basin immediately in the upstream area of Jragung watershed.
- It is necessary to optimize the operation and maintenance of rivers and reservoirs to have well maintained infrastructures.

REFERENCES

[1] Sosrodarsono, S., Tominaga, M., and Gayo, M.Y.: 'Perbaikan dan Pengaturan sungai' (PT Pradnya Paramita, 1994. 1994)
[2] Harto, S.: 'Hidrologi: Teori, masalah, penyelesaian', Yogyakarta: Nafiri Offset, 2000
[3] Kodoatie, R.J., and Sjarief, R.: 'Tata ruang air' (Penerbit Andi, 2010. 2010)
[4] Chow, V.T., Maidment, D.R., and Mays, L.W.: 'Applied hydrology' (1988. 1988)
[5] Christiansen, E., and Hamblin, K.W.: 'Earth's Dynamic Systems', in Editor (Ed.)^(Eds.): 'Book Earth's Dynamic Systems' (Prentice Hall, 2003, edn.), pp.
[6] Kasiro, I.-A., and Wanny-Rusli, B.S.-N.: 'Pedoman Kriteria Desain Embung Kecil untuk Daerah Semi Kering di Indonesia' (1997. 1997)
[7] Takeda, K., and Sosrodarsono, S.: 'Hidrologi untuk Pengairan', Editor Sosrodarsono, S. PT Pradnya Paramita: Jakarta, 2003
[8] Anjasmoro, B., Suharyanto, S., and Sangkawati, S.: 'Analisis Prioritas Pembangunan Embung Metode Cluster Analysis, AHP dan Weighted Average (Studi Kasus: Embung di Kabupaten Semarang)', Media Komunikasi Teknik Sipil, 2016, 21, (2), pp. 101-112
[9] Soemarto, C.: 'Hidrologi Teknik' (Penerbit Erlangga, 1999. 1999)
[10] Soemarto, C.: 'Hidrologi Teknik Edisi 1', Surabaya: Penerbit Usaha Nasional, 1986
[11] Juliastuti, S.: 'Dam break analysis and flood inundation map of Krisak dam for emergency action plan', in Editor (Ed.)^(Eds.): 'Book Dam break analysis and flood inundation map of Krisak dam for emergency action plan' (2017, edn.), pp.
[12] Asdak, C.: 'Hidrologi dan pengelolaan daerah aliran sungai' (Gadjah Mada University Press, 2018. 2018)
[13] Istiarto: 'Modul Pelatihan "Simulasi Aliran 1 Dimensi dengan Bantuan Paket Program Hidrodinamika HEC-RAS". ' (Universitas Gadjah Mada, 2014. 2014)