ANALYSIS OF THE IMPACT OF NORMALIZATION ON DOWNSTREAM CONDITIONS IN THE BRINGIN RIVER, SEMARANG CITY

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Abstract. An increase in flood discharge is largely influenced by the change of land use in the watershed. The increase occurred in the Bringin especially in the upstream of which is located in Kecamatan Mijen and the downstream is located in Tugu District of the Northern part of the town and empties into the Java Sea. The purpose of this study was to determine the magnitude of the flood discharge of the River Bringin and identify locations prone to flooding and provide handling solutions. The data required in the form of rainfall data, the data of land use, and the cross-section of the river. Furthermore, the data daily precipitation is distributed into the rain for 12 hours using the distribution of rainfall cumulative PSA 007.The determination of Flood Discharge using the SCS method. Scenario modeling using flood discharge return periods 2, 5, 10, 25, and 50 years. Modeling hydraulics performed using the unsteady flow in the software HEC RAS 6.1.The results showed that the change of land use in the watershed Bringin changes is very significant especially in the upstream area that has been transformed into the residential and industrial, while the downstream region is dominated by housing and the area of the pond.

1. Introduction

The West Semarang River System is under the authority of the Pemali – Juana River Basin Center, precisely located in the administrative area of Semarang City. At this time the condition of the rivers in the West Semarang River system, including the Plumbon, Bringin, Karangayar, Silandak, Siangker rivers has decreased in capacity. These rivers experience silting caused by the slope of the riverbed which is quite gentle. This results in sedimentation thereby reducing the drainage capacity of the West Semarang River System. Land use change is one of the most dominant causes of river quality degradation. The increasing flow of urbanization and population causes an increase in the need for land. With the land area not increasing, there will be land clearing for residence in green areas. The result of land clearing is the reduction of the catchment area which causes flooding in the rainy season.

2. Purpose and Objective

The purpose of the preparation of this study is to determine the morphology of the river that causes flooding in the lower reaches of the Bringin River. The purpose of the preparation of this thesis is to determine the maximum discharge during a flood in the Bringin River, and to examine alternative structural and non-structural approaches in flood management.

3. Problem Limitation

In writing this research has the following limitations:
1. The research area is the Bringin watershed in the city of Semarang
2. Processing of rainfall data from 2000-2019
3. Analyzing the discharge of the 2,5, 10, 25, 50 and 100, 200 and 1000 year return periods
4. The analysis does not take into account rob
5. Sediment data is secondary data from the Pemali Juana BBWS collection.

4. General Description of Area

Astronomically located at 6˚56'20"S - 7˚4'19"S and 110˚17'59"E-110˚20'51"E. Administratively, the Bringin watershed is included in the Mijen District, Ngaliyan District, and Tugu District. The Bringin River is one of the rivers that flow in the West Semarang area, starting from Mijen District and Ngaliyan District and empties into Tugu District (flowing continuously to the north of the Java Sea). The river is flanked by the Kreo River and Blorong River in the east and the Besole River in the west. The length of the Bringin river is approximately 20 km, with a watershed (DAS) of 33 km2.

Based on Table 1, the Bringin and Gondoriyo sub-districts are located in the Bringin watershed, while the other sub-districts have some areas outside the Bringin watershed area. In full this can be seen as follows.

Table 1. Districts on Bringin Watershed

No.	District	Watershed Area (km2)
1	Purwosari	0.02
2	Tambangan	0.01
3	Mijen	1.77
4	Jatibarang	1.58
5	KedungPane	2.8
6	Pesantren	3.79
7	Podorejo	0.55
8	Wates	2.97
9	Bringin	4.6
10	Ngaliyan	2.44
11	Bambankerep	0.24
12	Tambakaji	1.07
13	Gondoriyo	5.33
14	Wonosari	2.9
15	Mangkang Wetan	0.26
16	Mangunharjo	0.03
	total	30.36

View of the topography, Bringin have a condition that is hilly in the upstream areas and has the characteristics of the slope is very flat on the downstream, with the elevation of the land near the water elevation of the sea so that it will complicate the disposal of the water when the tide rises/ high. The width of the river at the bridge area of the national road, about 20 m and gradually decreases toward the downstream up to a width of 10 m in Tangerang, Banten. In this area, the frequency of occurrence of the flood is more often than in other areas, with the depth of the puddle usually approximately 0.5 m and a length of a pool of up to two days.

Based on observations in the region of Bringin watershed, on the part of the upstream has happened to the opening of new land for housing so that it reduces the ability of the catchment areas in the rainwater that happens. As a result, rainwater flows as runoff water which quickly got into the river adds to the flow of the river, then the surface runoff which is large enough certainly causes erosion on the upstream areas that result in the occurrence of sedimentation on the cross-section of the river downstream.

In general, the precipitation in the Bringin watershed tends to increase from year to year. Rainfall intensity was highest from December to February. Slope Bringin varies from flat (0-2%), ramps (2-15%), rather steep (15-25%), and steep (25-40%), as seen in Table 2, about the slope classes. Of the various classes in Bringin watershed, there is a sloping flat (0-2%) with an area of 4.17 km2 located in three districts, namely Kecamatan Ngaliyan, Monument, and Mijen. Slope classes category ramps (2-15%) of to 17.93 km2,its spread in Kecamatan Ngaliyan include Village Bambankerep, Wates, Podorejo, Ngaliyan, Bringin, Tambakaji, Gondoriyo and Mijen District includes the Village Tambangan, Purwosari, Mijen, Boarding schools, Kedungpane. Class slope is rather steep (15-25%) with extensive 6,71 Km2 and is spread in Kecamatan Ngaliyan include Village Bambankerep, Ngaliyan, Bringin, Tambakaji, Gondoriyo, Wonosari, Podorejo and Mijen District includes the Village Kedungpane. The steep slope class (25-40%) with an area of about 1.55 Km2 and is spread in Kecamatan Ngaliyan include Village Bambankerep, Ngaliyan, Bringin, Gondoriyo, Wonosari. Although the area with steep slopes is not very wide, it has another potential hazard, namely the hazard of land landslides.

Table 2. Class Slope of the Van Zuidam [13] Bringin Watershed

No.	slope	classification	area	(Km2)
1	0-2	flat	4.17	
2	2-15	sloping	17.93	
3	15-25	slightly steep	6.71	
4	25-40	steep	1.55	

source : RTRW Semarang city 2011-2031

Characteristics of land use in general in Mijen District are in the form of land use oriented for rural activities (rural). Land use characterized by urban (urban) is spread in the area of the center of activity and along the roads. Areas that are developing quite rapidly include urban areas and service trade in Wonopolo, Mijen, and Cangkiran villages. Changes in land use from undeveloped to built-up land are quite high in the area.

Most of the land uses in Ngaliyan and Tugu sub-districts have urban or urban characteristics. Processing industry activities with a high-intensity scale of activity are the factors causing the rapid growth in the region. The distribution of areas with urban characteristics are in areas directly adjacent to the Semarang-Kendal Pantura Alteri Line access and close to transportation service centers such as Ahmad Yani Airport and ports. Based on table 3, it can be seen that the land use of the Bringin watershed includes gardens by 81.04%, followed by upland 7.41%, rice fields by 6.19%, settlements by 4.45%, swamps by 0.63%, and forests by 0.42%. The largest land use is gardens at 81.04% and the smallest land use is swamp at 0.42%

Table 3. Land use Bringin Watershed

No.	Land used	area (km2)	% area watershed
1	forests	0.12	0.39
2	gardens	24.6	81.04
3	settlements	1.36	4.45
4	swamps	0.15	0.42
5	rice field	1.88	6.19
4	dry land	2.25	7.41

source : RTRW Semarang city 2011-2031

5. Method

Flow chart of the method in the research process can be seen in figure 1

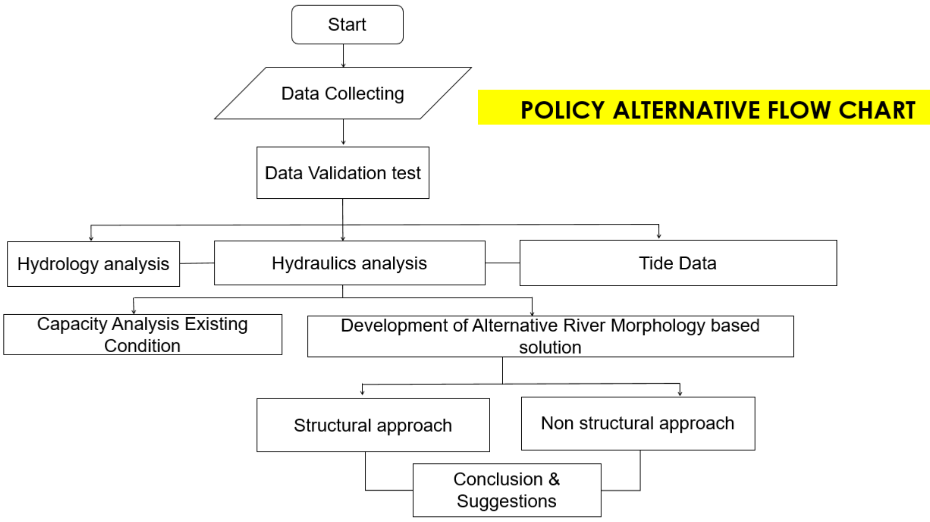

Figure 1. Flow Diagram Research

6. Data Analysis

First of all, is to make the delineation of the watershed with the results of the digitization of DEMNAS. Obtained the following data :
1. Average slope of watershed = 0.0259
2. Extensive watershed = 32,74 km2
3. The length of the River = of 20.69 km

In the calculation of this study rainfall station in the area that will be reviewed is not evenly distributed so the method used is the method of Thiessen Polygons.
The method of Thiessen assumes that the rainfall data from somewhere observations can be used for drainage areas around that place. This way is used if the observation points in the area do not spread evenly, then carried out by taking into account the area of influence of each observation point with the average rainfall drainage area in the plains of the conditions are not the same (Soemarto, 1986).

6.1 The Maximum Daily Rainfall Annual

The rainfall analysis plan maximum at the study site using the data is derived from the 3 Pos Rainfall series data year 2000-2019 (Pos Mangkang Waduk – Plumbon, Post Gunung Pati, Pos Simongan)

Table 4. The Maximum Daily Rainfall Annual Bringin Watershed

No.	Periode	Station		
		41 C Mangkang Waduk - Plumbon	46 Gunung Pati	42 Simongan
1	2000	177	127	203
2	2001	179	87	147
3	2002	115	136	82
4	2003	124	147	122
5	2004	118	147	163
6	2005	115	89	121
7	2006	213	174	198
8	2007	116	305	162
9	2008	107	114	169
10	2009	295	108	216
11	2010	134	165	110
12	2011	99	200	83
13	2012	94	99	80
14	2013	119	146	111
15	2014	124	148	125
16	2015	127	106	177
17	2016	82	152	98
18	2017	84	110	126
19	2018	142	85	123
20	2019	105	130	105

6.2 Rain Frequency Analysis

From the rainfall data used for the past 20 years, the analysis of the frequency distribution of Gumbel and Pearson III was calculated. The following is a recapitulation of the results of the calculation of the frequency analysis for each return period.

Table 5. Recapitulation of the analysis frequency

No.	Return Period	Metode Gumbel	Metode Log Pearson III
1	2	128.80	124.57
2	5	170.62	157.30
3	10	198.30	182.80
4	25	233.29	219.60
5	50	259.24	250.60
6	100	285.00	284.90
7	200	310.67	323.02
8	1000	370.12	429.43

From the calculation of the analysis of the frequency of each distribution, then tested the suitability of the chi-square and Kolmogorov-Smirnov.

Table 6. Analysis Recapitulation

CHI-SQUARE			
Method	X^2	Xcr^2	status
Log Pearson III	2.00	5.992	Acceptable
Gumbel	8.00	5.992	Unacceptable

SMIRNOV KOLMOGOROV			
Method	X^2	Xcr^2	Status
Log Pearson III	0.16	0.294	Acceptable
Gumbel	0.09	0.294	Acceptable

Furthermore, the results of the Log Pearson III method will be used to calculate the planned rain discharge. The rainfall value obtained from the calculation is assumed that the rain occurs evenly throughout the watershed area. So a regional reduction factor is needed or called the Area Reduction Factor (ARF).

ARF = 1.152 – 0.1223 Log A

= 1.152 – 0.1223 Logs (33.79)

= 0.96

So that the ARF value is multiplied by the planned rainfall value for each return period, the value of the Bringin watershed planning rain will be obtained for each return period.

Table 7. Results of Analysis of Rainfall Plan for Return (ARF)

No.	Return Period	Log Pearson III
1	2	120.02
2	5	151.56
3	10	176.13
4	25	211.59
5	50	241.45
6	100	274.50
7	200	311.23
8	1000	413.75

6.3 Planned Rain Analysis

The effective rain obtained is then distributed hourly based on PSA-007.

Table 8. Effective Rain with distribution PSA-007

hour to-	coeff.	Return Period							
		2	5	10	25	50	100	200	1000
		120.02	151.56	176.13	211.59	241.45	274.50	311.23	413.75
0	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.0200	2.40	3.03	3.52	4.23	4.83	5.49	6.22	8.28
2	0.0200	2.40	3.03	3.52	4.23	4.83	5.49	6.22	8.28
3	0.0300	3.60	4.55	5.28	6.35	7.24	8.23	9.34	12.41
4	0.0500	6.00	7.58	8.81	10.58	12.07	13.72	15.56	20.69
5	0.0900	10.80	13.64	15.85	19.04	21.73	24.70	28.01	37.24
6	0.4500	54.01	68.20	79.26	95.21	108.65	123.52	140.05	186.19
7	0.1500	18.00	22.73	26.42	31.74	36.22	41.17	46.68	62.06
8	0.0700	8.40	10.61	12.33	14.81	16.90	19.21	21.79	28.96
9	0.0500	6.00	7.58	8.81	10.58	12.07	13.72	15.56	20.69
10	0.0300	3.60	4.55	5.28	6.35	7.24	8.23	9.34	12.41
11	0.0300	3.60	4.55	5.28	6.35	7.24	8.23	9.34	12.41
12	0.0100	1.20	1.52	1.76	2.12	2.41	2.74	3.11	4.14
Total		120.02	151.56	176.13	211.59	241.45	274.50	311.23	413.75

Table 9. Calculation Results of Planned Rainfall Period

No.	Return Period	SCS	ITB 1
1	**2**	87.00	87.87
2	**5**	117.88	119.29
3	**10**	142.04	143.86
4	**25**	177.16	179.56
5	**50**	206.73	209.63
6	**100**	239.46	242.90
7	**200**	275.83	279.89
8	**1000**	377.37	383.12

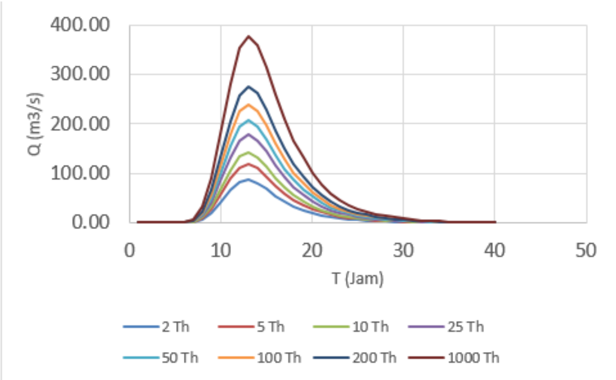

Figure 2. SCS Method

6.4 Hydraulic Analysis

Hydraulic analysis was carried out for modeling flood conditions in the Lower Bringin River. The modeling was carried out using Hec-Ras software for the unsteady flow type.

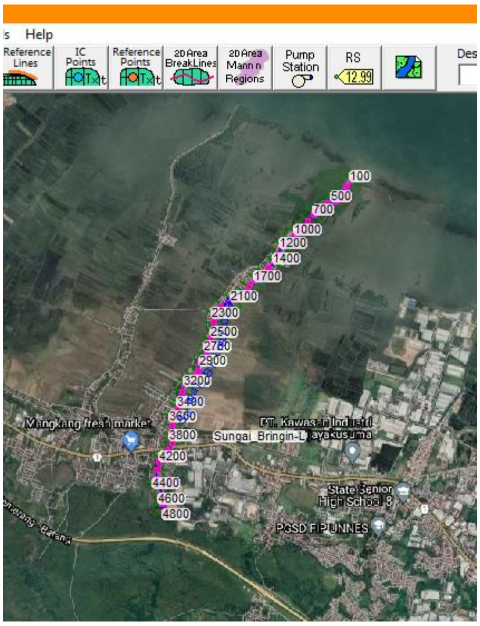

Figure 3. River Cross Section Geometric

Following the results of the Flood Plan Q2 with no tidal coupling.

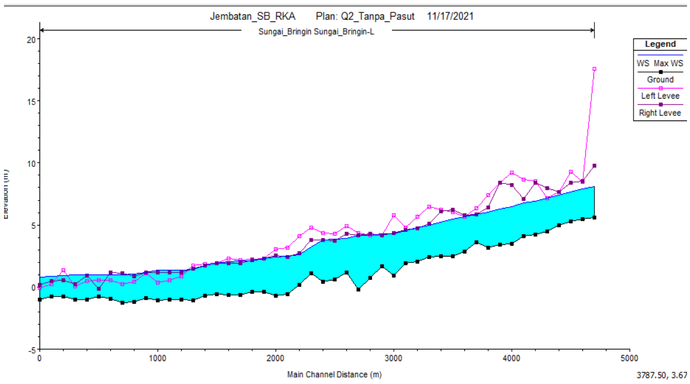

Figure 4. Long Section Q2 Return Period
(without tides)

The following are the results of the Q2 Plan Flood with Tidal coupling. It can be seen with the tidal variable, there is an increase in the water level above from the left and right levees.

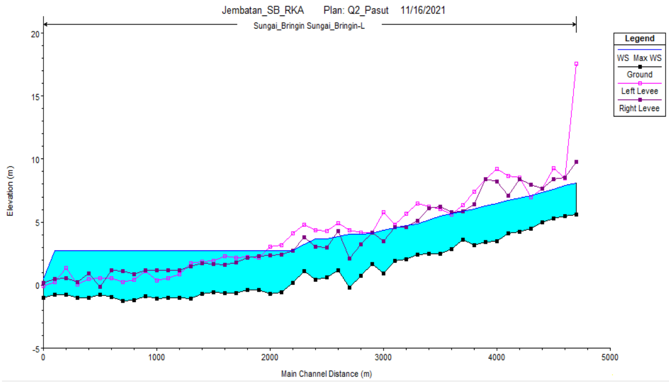

Figure 5. Long Section Q2 Return Period (*coupling tides*)

While the results of the Q50 Plan Flood with Tidal coupling are as follows:

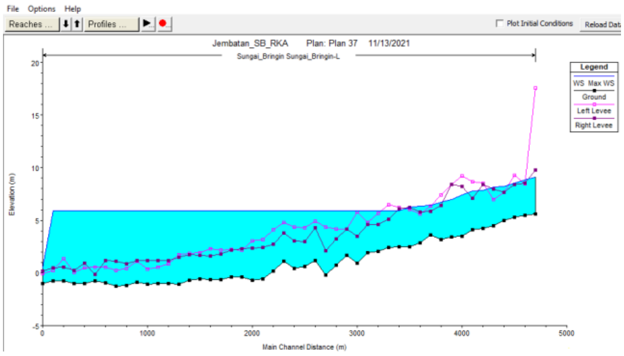

Figure 6. Long Section Q50 Return Period (*coupling tides*)

Following the appearance of the cross section with the Q2 and Q50 years with conditions existing before the normalization.

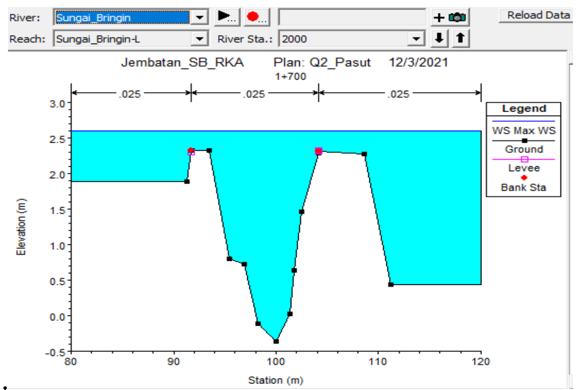

Figure 7. Cross section Q2 Return Period + tides (2 km)

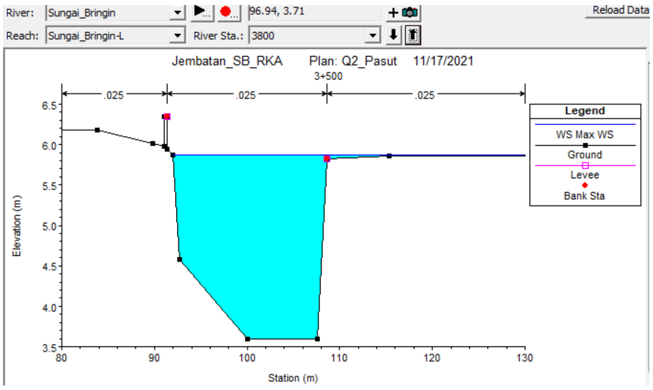

Figure 8. Cross section Q2 Return Period + tides (3,8 km)

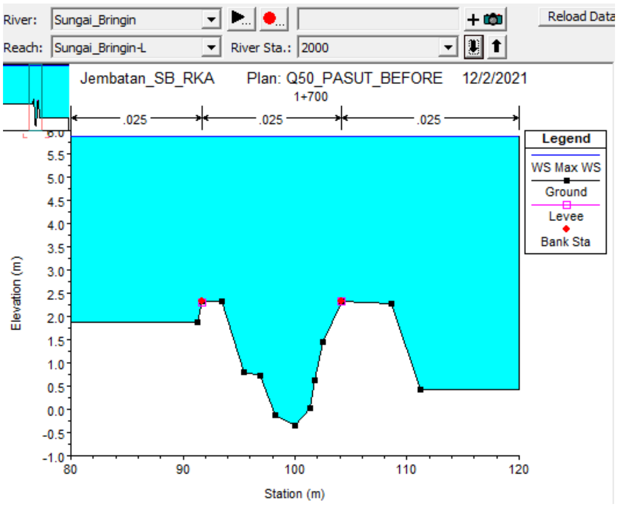

Figure 9. Cross section Q50 Return Period + tides (2 km)

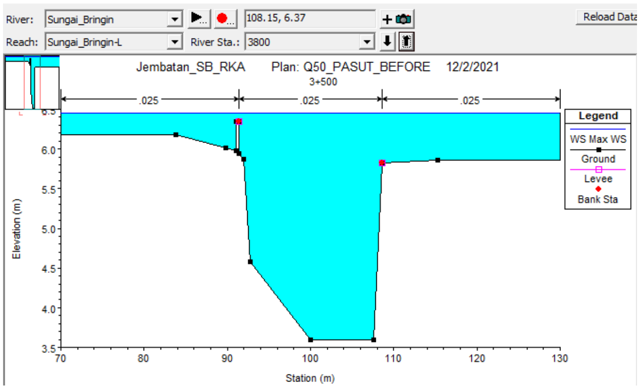

Figure 10. Cross section Q50 Return Period + tides (3,8 km)

From the analysis of Figure 9, the water level above the surface appears to be around 3.5 m, but in fact the actual conditions in the field are only about 2-2.5 m due to the transverse barrier of the model.

After normalization, the conditions of the longitudinal and transverse sections are as follows:

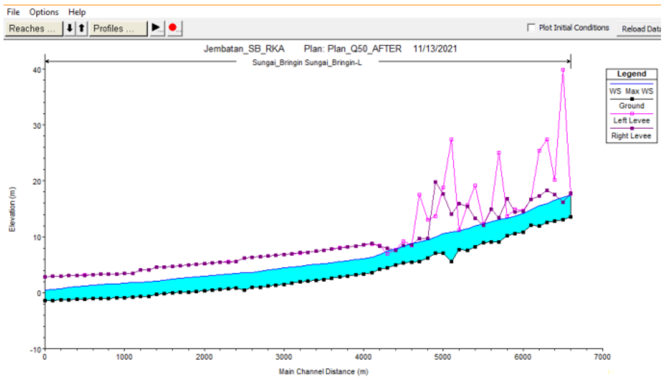

Figure 11. Long Section Q50 Return Period + tides (*normalization*)

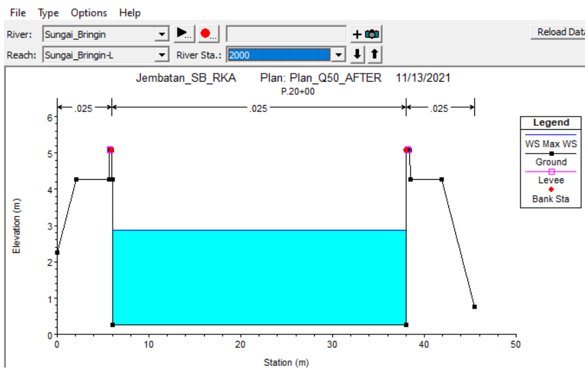

Figure 12. Cross Section 2 km

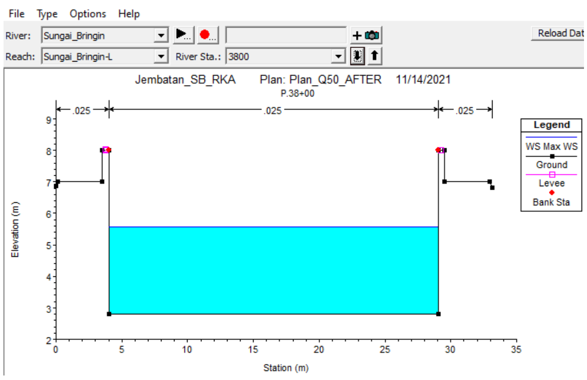

Figure 13. Cross Section 3,8 km

7. Conclusions and Suggest

7.1 Conclusions

From the results of studies that have been carried out on flood control in the lower reaches of the Bringin River, it can be concluded that several things are as follows:

1. The existing capacity of the Bringin River has decreased and can't accommodate the flood discharge for Q2 years, so handling is needed, especially in the downstream area (5 km from the estuary) to be safe during flooding.
2. In the hydraulic modeling, it can be seen that the existing condition of tidal influence is up to 2 km from the estuary
3. If the Planned Flood Discharge Q50 is included in the model that has not been handled, then there will be flooding up to 4 km from the estuary where there are already residential areas.
4. After the model was given normalization treatment with dimensional adjustments, the 4 km area was safe with Q50, but locations above 4 km that had not been treated there were still some inundated points.
5. The recommended type of Infrastructure Handling is in the form of a concrete embankment as in the current handling conditions.
6. The results of this analysis have been calibrated with real conditions that occur in 2021 where the water level is in a certain section.

7.2 Suggests

1. Normalization and mitigation measures are carried out only about 4 km from the estuary but have not accommodated flooding from housing drainage puddles, so an integrated drainage system and a pump system are needed to flow into rivers/temporary storage ponds.
2. The location after handling 4 km has the potential for flooding in Q50 at several points so it is necessary to plan for immediate handling for that location.
3. Flood management must be carried out comprehensively and involve many stakeholders so that the form of coordination carried out must be structured and the division of responsibilities clear. For example, giving land permits to be used as housing, especially for those around river borders, is very important to pay attention to.
4. Conduct socialization regarding flooding, sanitation, and related waste/garbage management to the community in the area downstream of the Bringin river to create sensitivity in protecting the environment and existing river buildings.
5. Considerations for land acquisition around the lower reaches of the Bringin river, especially areas that are often affected by floods

References

[1] Bloschl, G., & Grayson, R. (2000). Spatial Observation and Interpolation In : R Grayson and G Blöschl (eds), Spatial Pattern in Catchment Hydrology: Observation and modelling. Cambridge: Cambridge University Press.

[2] Chow, V. t., Maidment, D. R., & Mays, L. W. (1988). Applied Hydrology. Singapore: Mc-Graw Hill Book Company.

[3] Van Zuidam, et, al 1983. Guide to Geomorphologic aerial photographic interpretation and mapping.

[4] Prasetyo Wahyu, Suripin, Sri Sangkawati. (2020*). Pengelolaan Daerah Aliran Sungai Bringin (Orbith* ***Vol.16 No.1****)*

[5] Putra, Dimaz Pradana., Suharyanto, Hari nugroh. (2014). *Perencanaan Normalisasi Sungai Bringin di Kota Semarang Jurnal Karya Teknik Sipil,* ***Volume 3, Nomor 4***

[6] Putra, Muhammad Rifqi., Dewi Liesnoor Setyowati & Suroso. (2017). *Analisis Spasial Debit Puncak Daerah Aliran Sungai Bringin dengan Metode* Rasional *(Jurnal Jurusan Geografi, Fakultas Ilmu Sosial, Universitas Negeri Semarang, Indonesia)*