The Effect Of Staging Development Structural Flood Design On Sediment Transport Process Along Bringin River

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Abstract

Floods that often occur make the government build a flood prevention embankment on the Bringin river, it is hoped that the embankment can prevent flooding to the maximum, in addition to the embankment, normalization of the Bringin river is also carried out by widening the river to 25-45 m [1], but it is important to note that widening the river has a positive impact. for the community but has a negative impact on the Bringin river itself, river widening can damage or disrupt the flow speed and slope of the riverbed [2]. The slowing velocity causes the fall velocity of sediment grains to reach the riverbed first before they can flow into the estuary [3], the HEC-RAS simulation results show that for 5 years the riverbed changes with sediment heights ranging from 0.12 to 1.10 m [4], besides that sedimentation can reduce effectiveness Bringin river embankment [5], simulation results show that for 5 years the capacity of the flood control embankment has decreased to 24%. while the simulation results for 10 years of sediment height ranged from 0.44 to 1.39 m with a reduced capacity of the flood control embankment by 31.83%.

1. Introduction

The Bringin River is located in Central Java Province, Semarang City, has a river length of 19 km with a watershed area of 34 km2 and empties into the north of the Java Sea. In the downstream part of the river control construction to prevent flooding, the research location is located at coordinates 6°57'29.30"LS and 110°18'47.71"BT. Flood control in the Bringin River uses a variety of constructions, ranging from soil embankments, retaining concrete walls, and sheet piles (CCSP) [1]. The embankment aims to prevent flooding that occurs every rainy season, in addition to the construction of flood prevention embankments, one of the methods used is by normalizing the Bringin river, normalization can be in the form of increasing river capacity in the form of river widening. The Bringin River, which was originally 10-16 m wide, was widened to 25-35 m and the embankment height increased to ± 5 m, although flooding can be overcome, it is necessary to know that in order to extend the life of a building and its function to remain effective, it must always be carried out operation and maintenance (OM). If the OM is not implemented it will have a negative impact on buildings that are already in operation, please note that normalization on the river will have a positive impact on the people living around the river, but river widening will also have an adverse impact on the river, which will cause new problems such as sedimentation in the Bringin river. This sedimentation can reduce the river's capacity in the long term, until it reaches the capacity of the embankment which is no longer able to accommodate floods because the capacity is filled with sediment [5].

Figure 1. Location of the Bringin watershed.

2. Problem Identification

The problem that often arises in the Bringin River is the problem of flooding, due to the reduced capacity of the Bringin River, this is due to the very gentle slope of the riverbed of approximately 0.0002 and this results in a reduced sediment transport rate so that the river flow does not perfectly transport material suspended load to the coast [3]. The occurrence of sedimentation is exacerbated by the influence of the tides that hinder the flow so that the material is stuck downstream of the river which will accumulate and form a collection of material that settles in the middle and bottom of the river. Changes in the riverbed can be seen from the geometry measurements in 2018 and geometry in 2020.

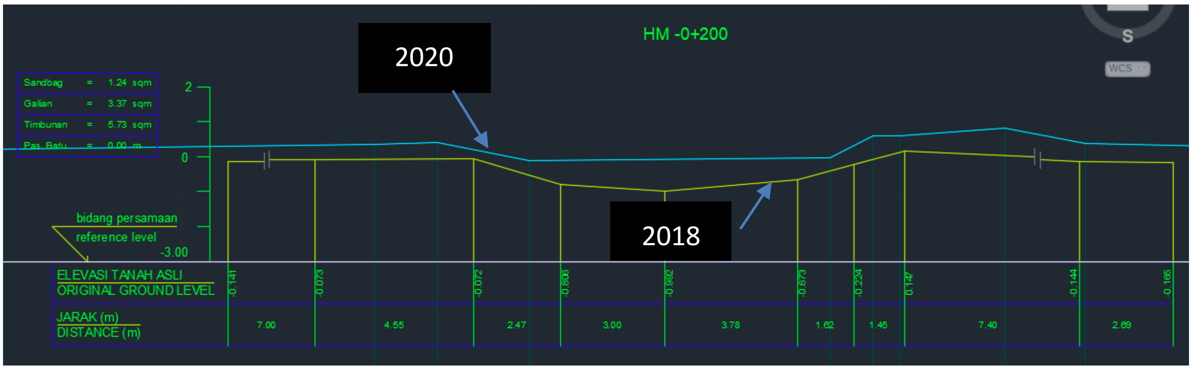


Figure 2. Comparison of the Bringin Riverbed in 2018 and 2020 at Sta -0+200

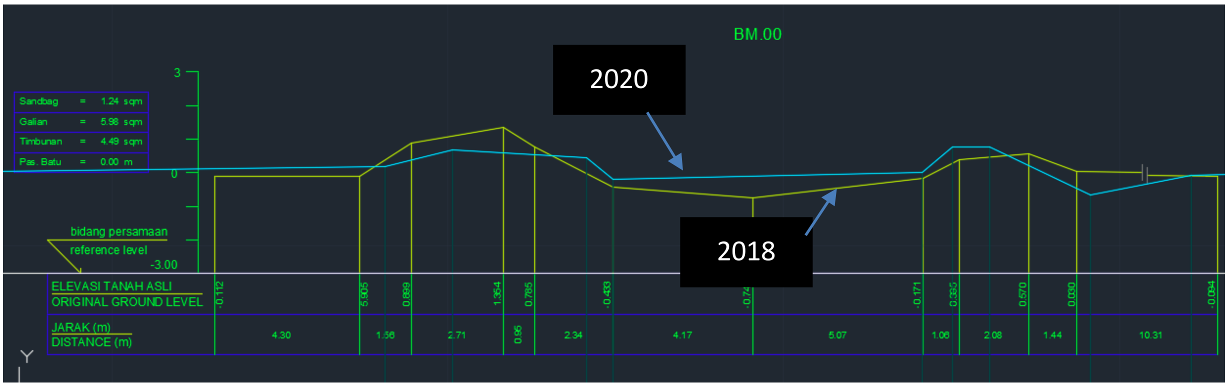


Figure 3. Comparison of the Bringin Riverbed in 2018 and 2020 at Sta 0+000

3. ANALYSIS STAGE

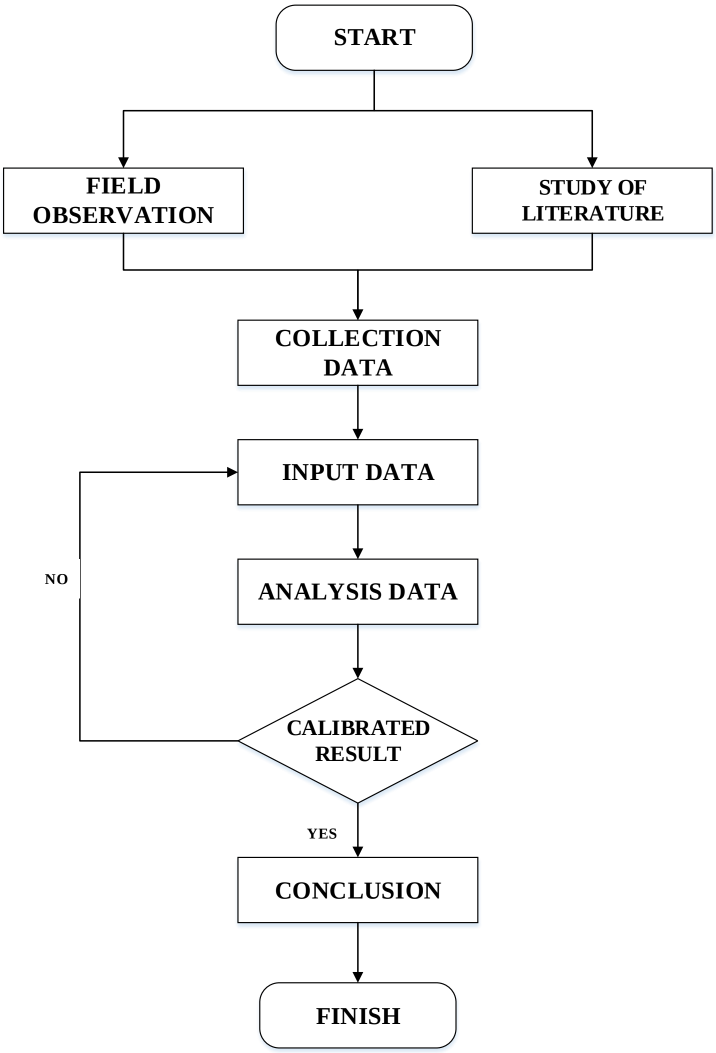


Figure 4. Flowchart Sediment Analysis

The analysis carried out in this study uses secondary data. Secondary data uses sediment data obtained from the Pemali Juana River Basin Organization in the form of suspended load data and water level. The next data is daily river discharge data for simulation, grain size data on the Bringin river. The grain size data on the Bringin river is only in the river section under review, namely the downstream river.

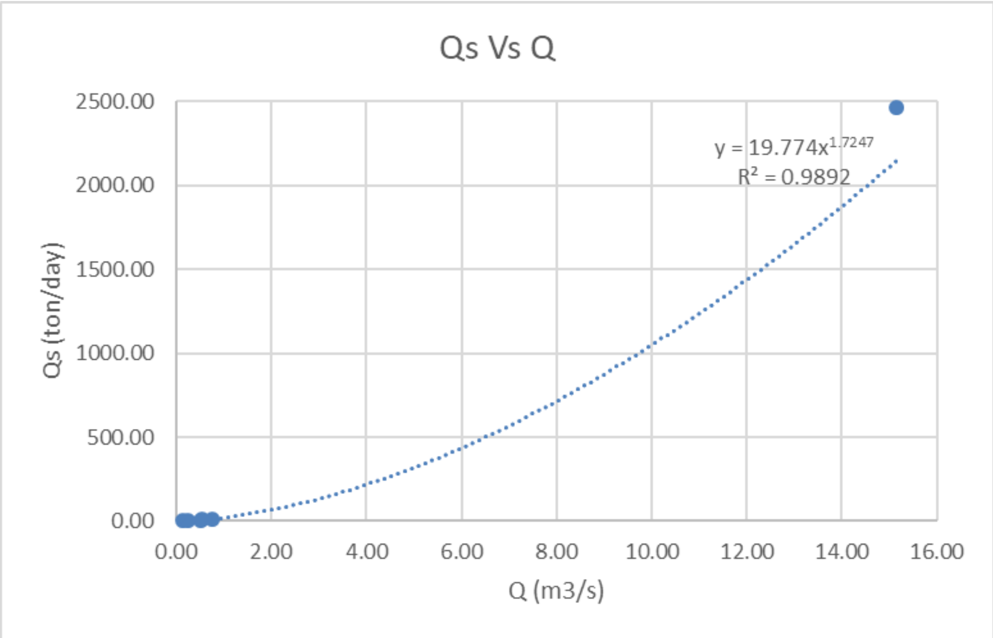


Figure 5. Graph of Relationship of Qs to Q

Figure 6. Location of data collection

In general, from the three samples combined, the sediment material found in the lower reaches of the Bringin River is 8.60% coarse sand, 38.33% fine sand, 43.73% silt and 9.33% clay so that the sediment type is more dominantly cohesive [4].
The data input in HEC-RAS is the data grain size as shown in Figure 7.

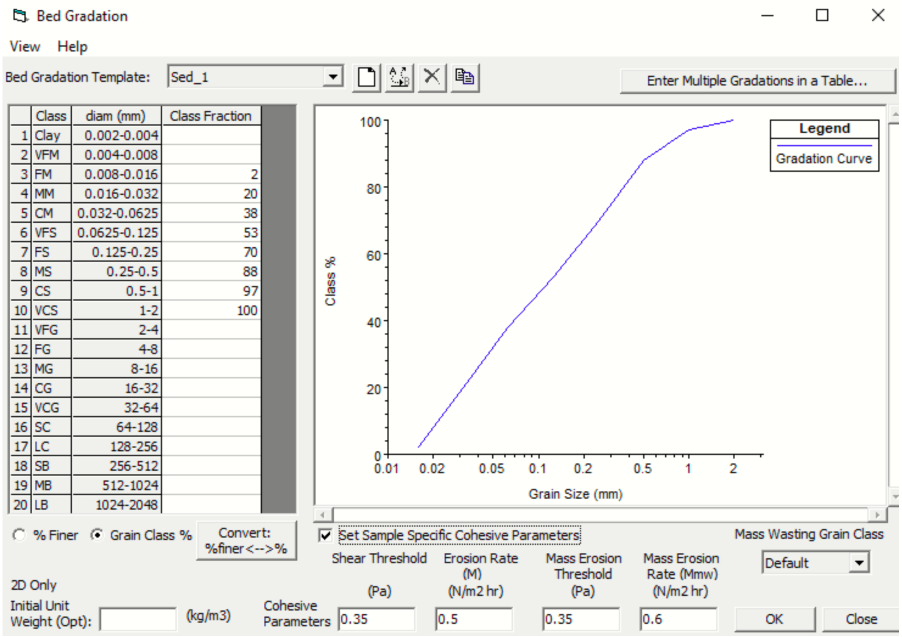
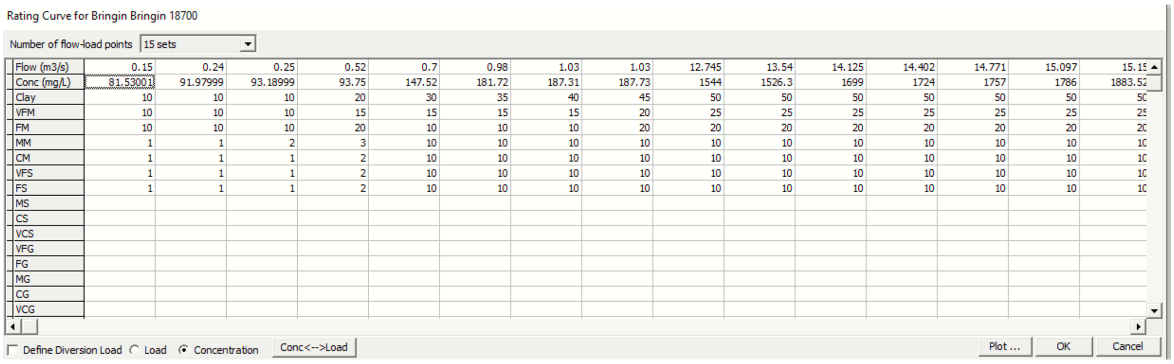


Figure 7. Bed Gradation at Point Location 1

next inputting suspended load data with river discharge that has been carried out during sediment data collection, can be seen in Figure 8.



Flow (m3/s)	0.15	0.24	0.25	0.52	0.7	0.98	1.03	1.03	12.745	13.54	14.125	14.402	14.771	15.097	15.15
Conc (mg/L)	81.53001	91.97999	93.18999	93.75	147.52	181.72	187.31	187.73	1544	1526.3	1699	1724	1757	1786	1883.52
Clay	10	10	10	20	30	35	40	45	50	50	50	50	50	50	50
VFM	10	10	10	15	15	15	15	20	25	25	25	25	25	25	25
FM	10	10	10	20	10	10	10	20	20	20	20	20	20	20	20
MM	1	1	2	3	10	10	10	10	10	10	10	10	10	10	10
CM	1	1	1	2	10	10	10	10	10	10	10	10	10	10	10
VFS	1	1	1	2	10	10	10	10	10	10	10	10	10	10	10
FS	1	1	1	2	10	10	10	10	10	10	10	10	10	10	10
MS															
CS															
VCS															
VFG															
FG															
MG															
CG															
VCG															

Figure 8. Input sediment data and discharge data

Inputting data on upstream and downstream boundary conditions, on upstream boundary conditions the data used is daily river discharge data and on the downstream boundary conditions the data used is tidal data [6]. The input for the upstream boundary condition can be seen in Figure 9 and the input for the downstream boundary condition can be seen in Figure 10 [7].

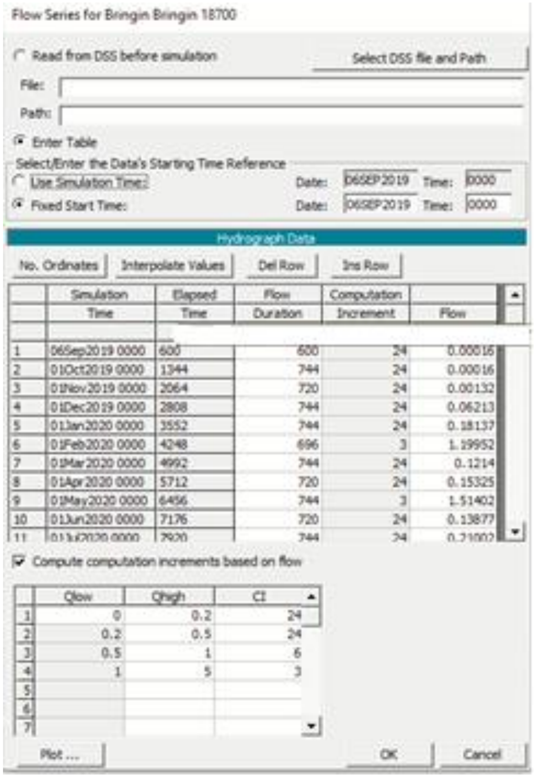


Figure 9. Flow Series (Upstream Boundary Condition)

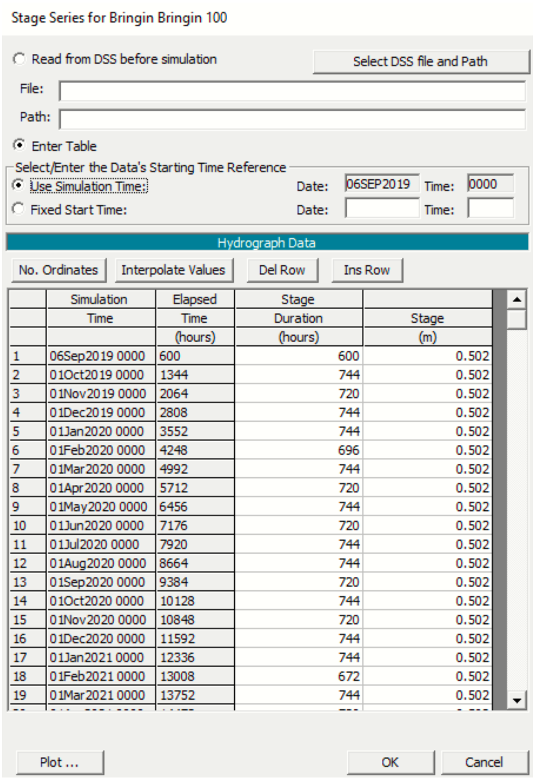


Figure 10. Stage Series (Downstream Boundary Condition)

4. HEC-RAS Simulation Result

To calibrate a model, it must have comparison data to find out changes or the model is close to the reference data, for data input used geometric data in 2018 and the reference data for comparison is 2020. After 2018 data is inputted in HEC-RAS, the input data boundary is upstream using daily discharge data and downstream boundary data using tidal data. After that, a model simulation is carried out to see the pattern of river bed changes.

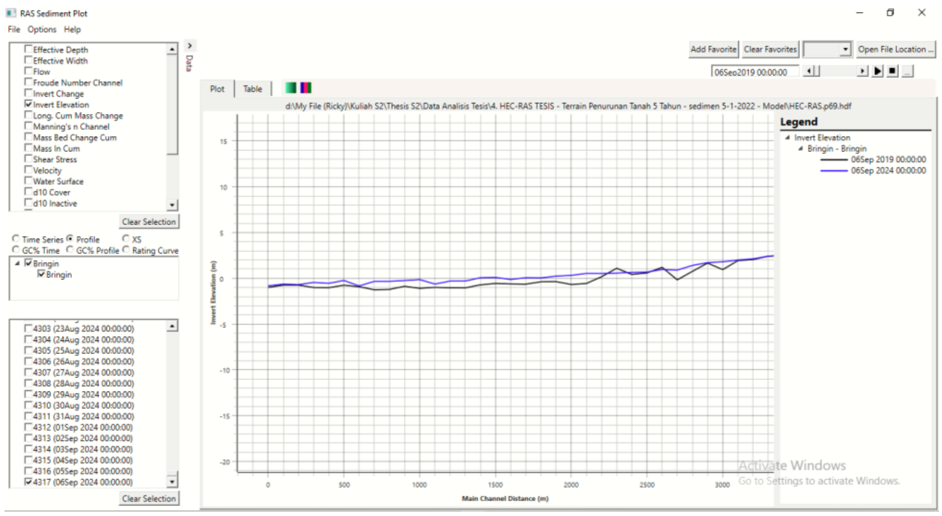


Figure 11 HEC-RAS Simulation Results Display

					Δ 2020
1	*2*	*3*	*4*	*5 = 3 - 2*	*6 = 4 - 2*
1	-0.992	-0.850	-0.104	0.142	0.888
2	-0.748	-0.649	0.137	0.099	0.885
3	-0.747	-0.695	-0.205	0.053	0.542
4	-1.003	-0.504	0.056	0.499	1.059
5	-1.023	-0.718	0.036	0.305	1.059
6	-0.756	-0.318	-0.005	0.438	0.751
7	-0.924	-0.897	0.337	0.027	1.261
8	-1.246	-0.394	0.156	0.852	1.402
9	-1.209	-0.545	-0.011	0.665	1.198
10	-0.872	-0.262	0.130	0.610	1.002
11	-1.097	-0.140	-0.096	0.957	1.001
12	-0.987	-0.629	0.250	0.358	1.237
13	-1.039	-0.414	-0.061	0.625	0.978
14	-1.049	-0.468	0.022	0.581	1.071
15	-0.712	-0.013	-0.697	0.699	0.015
16	-0.563	-0.015	-0.069	0.548	0.494
17	-0.614	-0.128	0.528	0.486	1.142
18	-0.641	-0.184	-0.065	0.457	0.576

No.	2018	Model	2020	Δ model	Δ 2020
19	-0.375	-0.081	-0.102	0.294	0.273
20	-0.358	0.105	0.040	0.463	0.398
21	-0.675	0.336	0.079	1.011	0.754
22	-0.566	0.446	0.118	1.012	0.684
23	0.172	0.424	0.128	0.252	-0.044
24	1.100	0.517	0.237	-0.583	-0.863
25	0.416	0.689	0.677	0.273	0.261
26	0.588	0.678	1.006	0.090	0.418
27	1.198	1.043	1.201	-0.155	0.003
28	-0.170	1.000	1.493	1.171	1.663
29	0.765	1.480	1.322	0.715	0.557
30	1.665	1.695	1.837	0.030	0.172
31	0.951	1.793	2.447	0.842	1.496
32	1.933	2.069	2.404	0.136	0.471
33	2.052	2.221	2.432	0.169	0.380
34	2.414	2.414	2.560	0.000	0.146
35	2.500	2.567	2.732	0.067	0.232
36	2.469	2.949	2.786	0.480	0.317
37	2.864	2.913	3.918	0.049	1.054
38	3.600	3.409	3.245	-0.191	-0.355
39	3.165	3.656	3.500	0.491	0.335
40	3.398	3.919	4.390	0.521	0.992
41	3.448	4.220	4.445	0.773	0.997
42	4.081	4.396	4.018	0.315	-0.063

Table 1 shows the elevation and height differences from the 2018 geometry data, 2020 and the results of the HEC-RAS simulation model. Furthermore, it describes the comparison of geometric data in 2018, 2020 and the results of the simulation model. For example as in Figure 12.

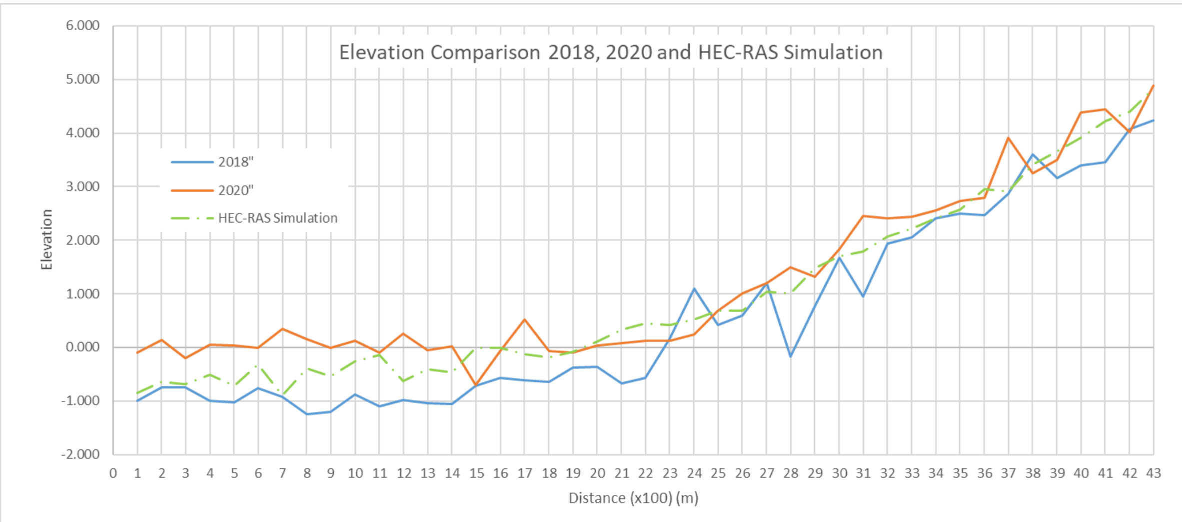


Figure 12 elevation comparison between HEC-RAS simulation and geometry data

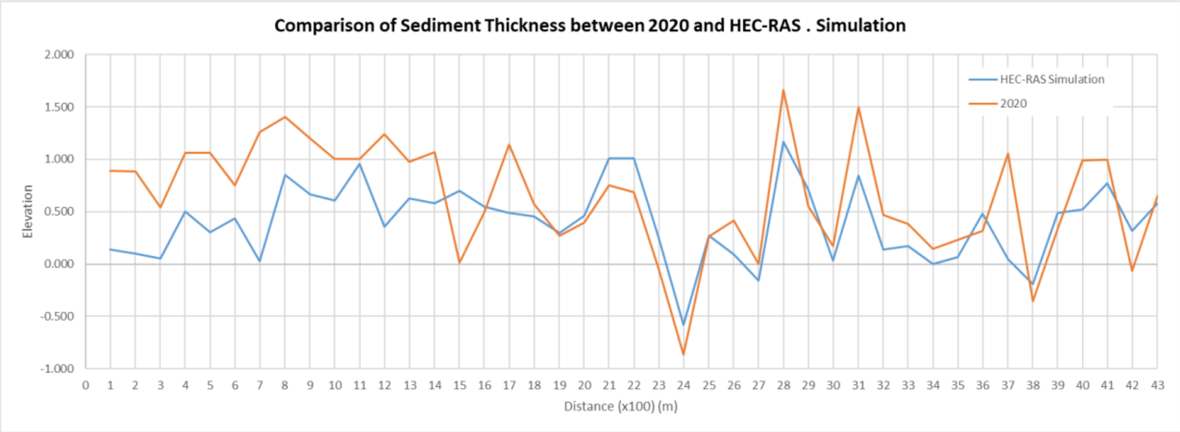


Figure 13 Comparison of Sediment Thickness between 2020 and HEC-RAS Simulation

From Figure 12 it can be seen that the bottom flow pattern of the Bringin River changes every year due to sedimentation in the lower reaches of the Bringin River, the results of the HEC-RAS simulation are close to the basic pattern of geometric measurements in 2020. While Figure 13 shows the thickness of sedimentation between the HEC-RAS simulation and geometric measurements. in 2020, from the results of the comparison of sedimentation thickness in Figure 13, a correlation value of 0.62 is obtained.

After the parameters in HEC-RAS have been obtained, then input data on the embankments in HEC-RAS which will later be known how much sedimentation affects the capacity of the Bringin River flood control embankment. The results to be obtained are how much sediment thickness occurs in the Bringin River if there is a flood control building and what percentage of flood control buildings can operate optimally until the planned time limit, the HEC-RAS simulation is run for 5 years and 10 years to see changes riverbed due to sedimentation. After that, a flood discharge simulation was carried out in the Q50 year return period to see if the Bringin River flood control building was still effective in tackling flood discharge. flood hydrograph using the HSS ITB 2 method [8], as shown in the figure 14

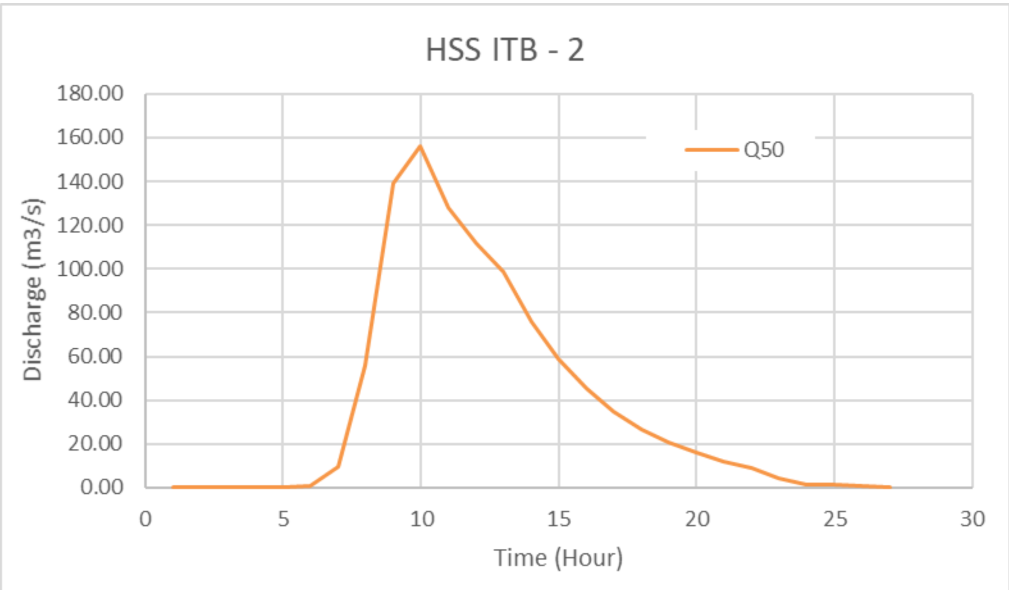


Figure 14 flood hydrograph HSS ITB 2 Method

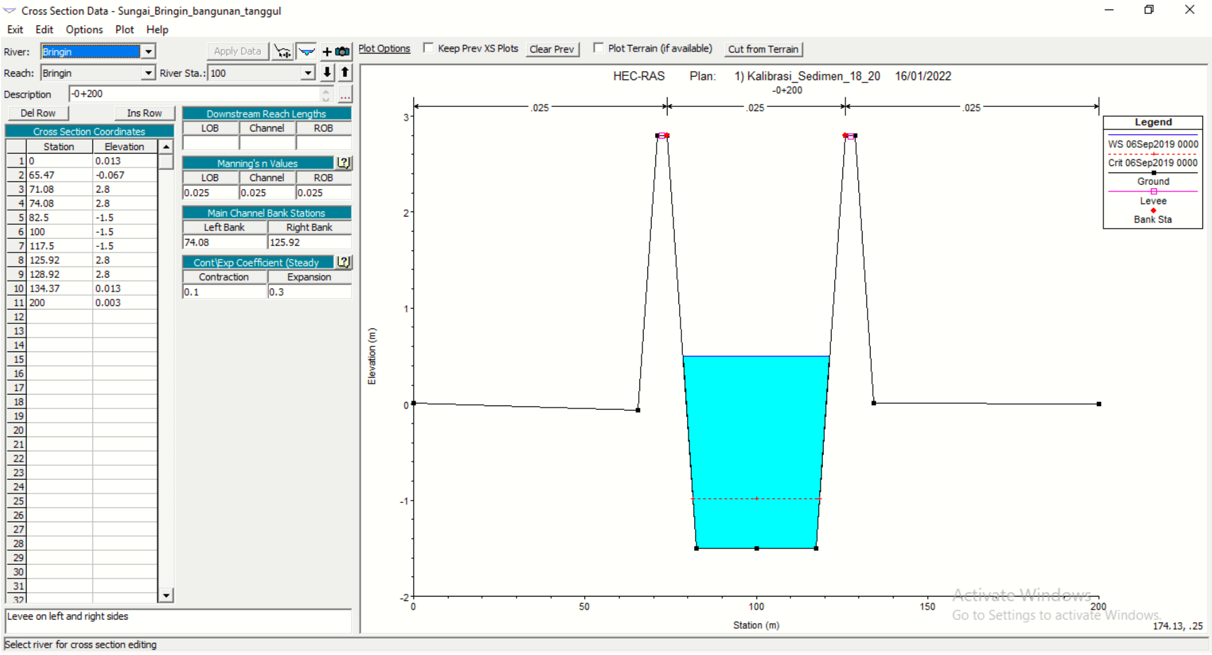


Figure 15. HEC-RAS display using flood control building

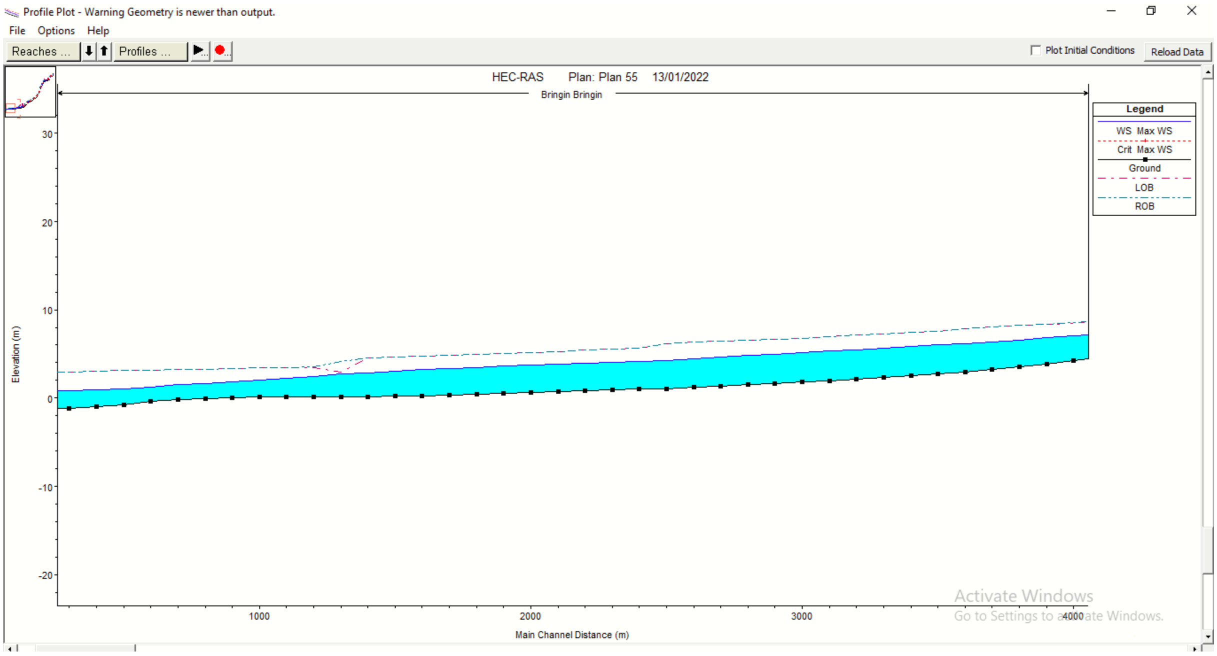


Figure 16. Profile Sungai Bringin in HEC-RAS

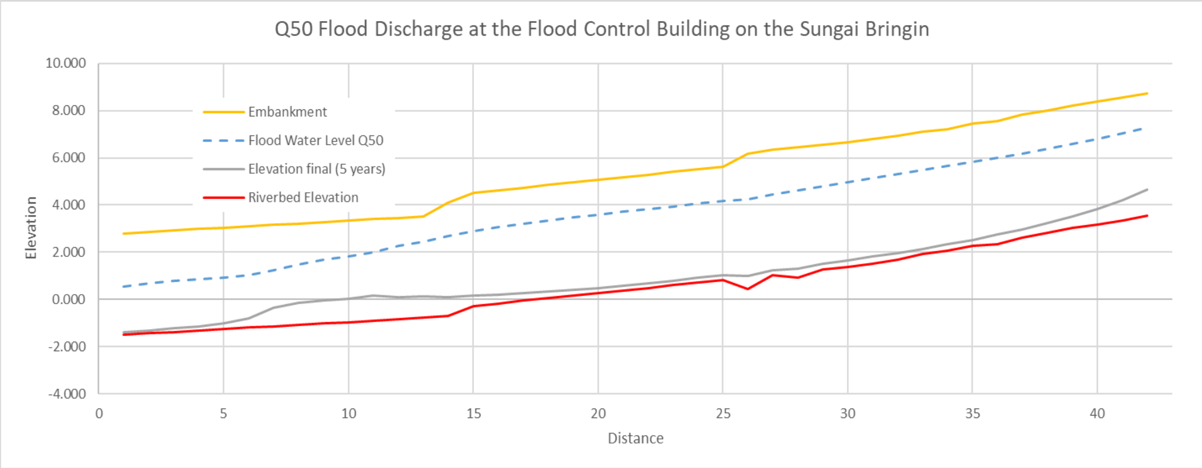


Figure 1. riverbed change with 5 years simulation using HEC-RAS

From Figure 17, a simulation was carried out for 5 years, it is known that downstream of the Bringin river is experiencing sedimentation with a sedimentation height of 0.121 - 1,108 m, then a simulation is carried out using a plan flood discharge of Q50 = 156.08 m3/s, the capacity of the Bringin embankment has decreased by 24%.

Simulations are also carried out with a time of 10 years to see changes in the riverbed that will occur, the simulation results can be seen in figure 18.

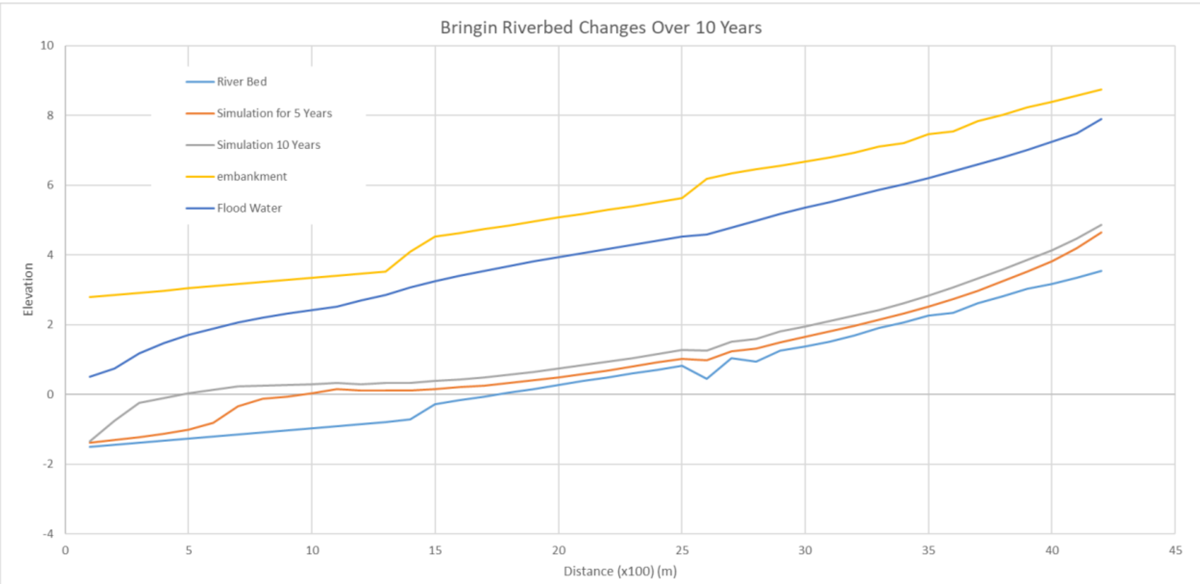


Figure 2. riverbed change with 10 years simulation using HEC-RAS

From figure 18, it is known that downstream of the Bringin river is experiencing sedimentation with a sedimentation height of 0.029 - 1.056 m, then a simulation is carried out using the Q50 return flow rate of = 156.08 m3/s. from the results of the analysis based on the thickness of the sedimentation it is known that the capacity of the bringin embankment has decreased by 32%

5. Conclusion

From the results of the study obtained; 1. Based on the HEC-RAS simulation, sediment calibration was obtained with a correlation value of 0.62. namely comparing the 2020 measurement data with the HEC-RAS simulation results; 2. In the HEC-RAS simulation, 5 years and 10 years are used. In the 5-year simulation, sedimentation in the downstream of the Bringin river was 0.12 – 1.10 m and the 10-year simulation 0.44 – 1.39 m; 3. Based on the simulation results, the capacity of the Bringin river flood embankment decreased by 24% for 5 years and 31.83% for 10 years; 4. Based on the analysis of sediment transport modeling, there is a vertical change in river morphology due to sedimentation.

6. References

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