Ciliwung river normalization analysisusing HEC-RAS application (TB. Simatupang Bridge to Bidara Cina)

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ABSTRACT

Ciliwung River area which starts from TB. Simatupang Bridge to Bidara Cina is one of the areas that experienced severe flooding.This is caused by changes or conversion of land functions which were originally a water catchment area into settlements. Buildings that stand along the river body makes the current cross section of the Ciliwung River unable to function optimally in accommodating flood discharges. In addition, there is no public awareness in protecting the environment, it can be seen from the large piles of garbage on the riverside of the Ciliwung River.One of the efforts made by the government in flood control is river normalization, but in practice the normalization of the Ciliwung River can be said to be not running optimally. The purpose of this research is : the Author want to know how big the capacity of Ciliwung River existing cross section (starting from TB Simatupang Bridge to Bidara Cina) using Hec-Ras software application to modeling the river's cross section existing and so does recording and mapping ofpotentialflood locations. Based on the hydrology calculation, known that flood discharge plan $Q_{25}$is 404.3m^3/s, while the hydraulic Q is only 79.03 m3/s, the Q total is 483,38 m^3/s. The results of modeling using the *Hec-Ras* river cross section existingcannot accommodate the planned flood discharge so that river normalization efforts are needed. Recording and mapping flood locations are useful to get the effectivity of River's normalization according to flood controlling at Ciliwung River (specific at TB Simatupang Bridge to Bidara Cina).

Keywords: flood; river normalization; hec-ras; hydraulic; river cross.

INTRODUCTION

Jakarta as the capital city of Republic Indonesia is a city prone to severe flooding. This is because40 percent of Jakarta's land area is below the sea level and is passed by 13 rivers that cross Jakarta.Seeing these conditions makes Jakarta often experience disasters caused by rain, the problem of flooding due to rainfall that occurs with high intensity.Rainfall is not the only cause of flooding, but there are other causes.For example,drainage that is not functioning properly, high tides rising above normal sea level, the construction around Jabodetabek growing fast (changes in land use) which causes the water catchment area to decrease.

One of the main rivers that cross Jakarta is the Ciliwung River. To control flooding in the Ciliwung River, besides from non-physical efforts, it is also necessary to make physical efforts from construction technology and carefully select flood control buildings (considering advantages, disadvantages, benefits and constraints).The government's efforts to control flooding in Jakarta, especially on the Ciliwung River is river normalization. However, in its implementation there are still technical and non-technical obstacles that is:

1 The process of implementing river normalization is disturbed due to unresolved land problems so that the implementation of the work is not optimal as planned.
2 Besides to land issues, the budget needed for the implementation of the work is quite large.
3 From the plan for handling the Normalization of the Ciliwung River along 19.90 km with a planned embankment length of 33.69 km, only 16.19 km can be realized so that there are still remaining 17.50 km of the embankment that has not been implemented.

4 The public's lack of awareness to keep the river clean from garbage is proven by the large amount of garbage in the Ciliwung River that gets stuck in the garbage filter at the Manggarai FloodGate.

5 There is a narrowing of the river body with the establishment of houses on the river body which should be part of the cross section of the river such as on the right side of the river flow on the bridge section MT. Haryono – BidaraCina

Based on the above background, the writer wants to analyze the cross section of the existingCiliwung river (TB. Simatupang to BidaraCina) using Hec-Ras application. The application is used to model the existing river cross section to accommodate the planned flood discharge after modelling it can be recorded and mapped locations that have potential for flooding so that river normalization as an effort to control flood can run effectively.

Efforts to deal with flooding have been done very often. Both central government and local government. Flood is a natural event that is difficult to predict (Alam MP, Lutfi M, 2016; Satriadi I, 2017; Immamuddin MI, Larasati L, 2021; Barid B, Afanda BO, 2022). However, floods can be mapped with a pattern of decreasing rainfall that repeats every year. This rainfall pattern will affect the annual flood activities that have frequently hit most parts of our country (Parwati LPG te.al, 2022; Astuti GYD, Hariati F, 2016; Hasibuan AF, Hariati F, 2017; Suhadi MZ, Namara I, 2017). Developing countries are frequently hit by rain. Rain is good, delivery wants local rain. This activity is very influential on the system that applies in Indonesia Farodhiyah SN, Chayati N, 2016; Imamuddin M, Cahyanto D, 2020).

Definition of Flood

Flood comes from runoff that flows through rivers or become puddles. Runoff is the flow of water flowing on the ground surface caused by rainfall after the water infiltrates and evaporates, then flows into the river(Hadisusanto, Nugroho. 2011)(Suripin, 2004) explains that flooding is a condition where the water cannot be accommodated in the drain canal, so that it overflows the surrounding area (flood plain). The shape of the flood hydrograph in a catchment area is determined by 2 (two) things :

1 Characteristic Characteristics of heavy rain isthe distribution of rain intensity in time and space

2 characteristics of the catchment area such as: area, shape, canal system and land slope, type and distribution of subsoil as well as geological structure and geomorphological.

In this topic, we can see flooding as a part of the hydrological cycle, namely the part of the water on the earth's surface that moves to the sea. Inhydrological cycle, we can see that the volume of water flowing on the earth's surface is dominant determined by the level of rainfall and the rate of infiltration of water into the soil.

From the above, it can be concluded that flooding is an event that occurs when excessive water flow dampens the land. Floods can also occur in rivers when the flow exceeds the capacity of the waterways

Flood Control System

According to Kondoatie, Robert J., and Sugiyanto (2002), flood control system in an area needs to be made properly and efficiently, with pay attention to the existing conditions and the development of future use of water resources. In the preparation of a flood control system, it is necessary to evaluate and analyze or pay attention to the following things:

1 Analysis of existing flood control methods in the area or currently running.

2 Evaluation and analysis of flood inundation areas, including data on losses due to flooding.
3 Evaluation and analysis of land use in the study area, especially in floodplain areas.
4 Evaluation and analysis of existing settlement areas and future developments.
5 Pay attention to the potential and future development of water resources
6 Pay attention to resource utilization.

By taking into account the things mentioned above, a flood control system can be planned by adjusting the existing conditions, in various ways from upstream to downstream which may be implemented. Flood control can be carried out structurally and non structurally.

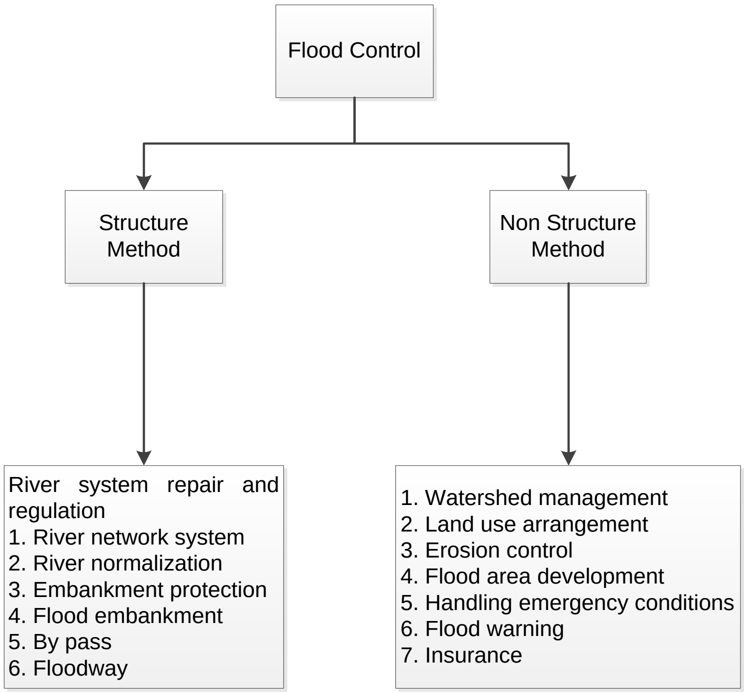

Figure 1. Flood Control with Structure Method and Non StructureMethod

Source: Kondoatie, Robert J., andSugiyanto (2002)

River Normalization and Embankment

Flood control efforts with normalization is intended to increase the drainage capacity of the canal. These activities include:

1 Normalization cross section
2 Repairing the slope of the canal base
3 Minimizing the roughness of the canal wall
4 Reconstruction buildings along canal which is not suitable and interferes flood drainage.
5 Stabilizes the canal flow.
6 Making flood embankments.

Factors that need to be considered in this method are the use of a double cross section with dominant discharge for the bottom section, stable canal planning against erosion and sedimentation of the canal bottom as well as cliff erosion and flood water level elevation.

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Flood Modeling Using Hec-Ras Application

Hydraulic calculations are very complicated, considering the shape of the cross section of the river for each sectionis not uniform and the number of sectionsis not small.The analysis will be very difficult if it is not assisted by a software.Therefore, to support the river hydraulics analysis process, an application program package (software) will be used, namely HEC-RAS. This program application is used with the intention that the accuracy of calculations and analysis can be more maintained (to reduce the "human error" factor to a minimum and at the same time follow trends.

Analysis of river behavior is an analysis that is not only complex, but quite complicated, where In the analysis of this system, it is necessary to carry out repeated iterations with certain parameters to look for certain variables, bothsteady flow andunsteady flow

RESEARCH METHODS

Research Location

This research is focused on the location of Ciliwung River starting from TB. Simatupang bridge to BidaraCina± 15,33km

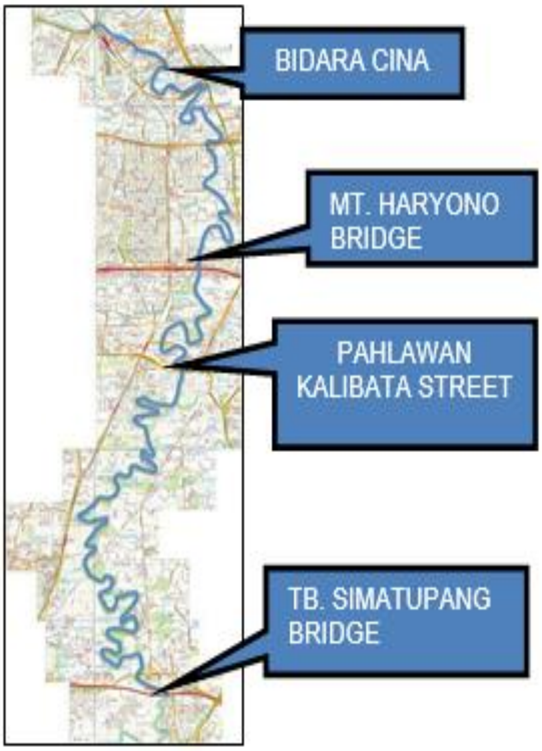

Figure 2. Research Locations

Research Time

Research time is 6 months starting from January to June 2020.

Data Collection Techniques

At this stage, in research preparation is to find data from various sources, such as document, article, and direct observations in research location. On the other hand, it is also looking for literature study of research that has been done previously.

1 Data Collection

a. Primary Data

Primary data in this research is used to determine the current conditions on the Ciliwung River starting from the TB. Simatupang Bridge to Bidara Cina.

b. Secondary Data

Secondary Data in this research are:

- Rainfall Data (in this research, rainfall data were taken for the last 14 years (starting from 2007 to 2020) from rainfall recording station in Cawang Station.
- River geometry, situations and conditions material river comes from the MinisterFor Public Works and Human SettlementsCiliwungCisadane River Area Great Hall

RESULTS AND DISCUSSION

A. Ranfall Data Analysis

Maximum monthly rainfall data is obtained from the CiliwungCisadane River Area Great Hall with the observation location of Cawang Station (rainfall data attached).

At rainfall data analysis stage, it is necessary to calculate the average rainfall$(\overline{X})$, standard deviation (Sd), variant coefficient (Cv), skewness (Cs) dankurtosis coefficient (Ck).

Table1. Calculation Distribution for Rainfall

Year	Xi	Xi-X	$(Xi-\overline{X})^2$	$(Xi-\overline{X})^3$	$(Xi-\overline{X})^4$
2007	195	59	3426,43	200568,52	11740421,50
2008	32,50	-104	10808,57	-1123705,54	116825243,90
2008	99	-37	1403,57	-52583,85	1970016,34
2010	121	-15	239,14	-3698,19	57189,92
2011	55	-81	6636,43	-540632,02	44042201,11
2012	103	-33	1119,86	-37475,26	1254082,88
2013	149	13	157,14	1969,91	24694,28
2014	138,00	2	2,36	3,62	5,56
2015	130,00	-6	41,79	-270,12	1746,15
2016	146,00	10	90,93	867,08	8268,24
2017	330,00	194	37456,07	7249087,79	1402957382,41
2018	195,00	59	3426,43	200568,52	11740421,50
2019	109,00	-27	754,29	-20715,95	568948,86
2020	108,00	-28	810,22	-23062,21	656449,26
Total	1910,50	0	66373	5850922	1591847072
Average	**136,46**				

1 Rainfall Average

Rainfall average is obtained by the following calculation:

$$\text{Average}(\overline{X}) = \frac{\sum_{i=1}^{n} Xi}{n}$$

$$= \frac{1910{,}50}{14}$$

$= 136{,}45$ m

2 Standard Deviation

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Standard deviation is obtained by the following calculation:

Standard deviation (Sd)= $\frac{\sum_{i=1}^{n}(xi-\bar{x})^2}{n-1}$

$$= \frac{6.3736}{14-1}$$
$$= 71{,}45$$

3 Skewness
Skewness is obtained by the following calculation:

(Cs)= $\frac{n\sum_{i=1}^{i}(xi-\bar{x})^3}{(n-1)\,x\,(n-2)\,x\,(Sd)^3}$

$$= \frac{14\,x\,5.850.922}{(14-1)\,x\,(14-2)\,x\,(71{,}45)^3}$$

$$= 1{,}44$$

4 KurtosisCoefficient
Kurtosis coefficientis obtained by the following calculation:

(Ck)
$$= \frac{n^2\sum_{i=1}^{i}(xi-\bar{x})^4}{(n-1)\,x\,(n-2)\,x\,(n-3)x\,(Sd)^4}$$

$$= \frac{14^2\,x\,1.591.847.072}{(14-1)\,x\,(14-2)\,x\,(14-3)x\,(71{,}45)^4}$$

$$= 6{,}97$$

5 Variant Coefficient
Variant coefficientis obtained by the following calculation:

(Cv) $= \frac{71{,}45}{136{,}45}$

$$= 0{,}52$$

B. Distribution Method

Based on the parameters obtained, then look for a distribution method that fits the requirements. The following table calculates the results to determine the distribution method.

Table 2. Distribution Method Requirements

No	Distribution	Terms	Results	Description
1	Gumbel	Cs ≈ 1,1396	Cs = 1,44	Not Qualify
		Ck ≈ 5,4002	Ck = 6,97	Not Qualify
2	Normal	Cs ≈ 0	Cs = 1,44	Not Qualify
		Ck ≈ 3	Ck = 6,97	Not Qualify
3	Log Normal	Cs ≈ 3 atau 3Cv	Cs = 1,44	Not Qualify

			Ck = 6,97	Not Qualify
4	**Log Pearson III**	**No Requirements**	**Cs = 1,44**	**Qualify**
			Ck = 6,97	**Qualify**

Source: SNI 2415: 2016

Based on the calculation and analysis of rainfall data, the method that meets the requirement is Log Pearson III

C.Rainfall Planned Log Pearson III Method

Log Pearson III Method does not have specific criteria for skewness and kurtosis coefficient to calculate the rainfall plan. The steps for calculating rainfall plan with Log Pearson III Method.

Table 3. Rainfall Plan Log Pearson III Method

Year	Xi	Log Xi	(LogXi-LogX)^2	(LogXi-LogX)^3
2007	195, 00	2,290	0,045	0,009
2008	32,50	1,512	0,321	-0,182
2009	99,00	1,996	0,007	-0,001
2010	121,00	2,083	0,000	0,000
2011	55,00	1,740	0,115	-0,039
2012	103,00	2,013	0,004	0,000
2013	149,00	2,173	0,009	0,001
2014	138,00	2,140	0,004	0,000
2015	130,00	2,114	0,001	0,000
2016	146,00	2,164	0,007	0,001
2017	330,00	2,519	0,193	0,085
2018	195,00	2,290	0,045	0,009
2019	109,00	2,037	0,002	0,000
2020	108,00	2,033	0,002	0,000
Total	**1910,50**	**29,104**	**0,755**	**-0,117**
Average	**136,46**	**2,079**		

1 Log $\bar{X}$

Log $\bar{X}$ is obtained by the following calculation:

$$\text{Log } \bar{X} = \frac{\sum_{i=1}^{n} Log\ Xi}{n}$$
$$= \frac{29.104}{14}$$
$$= 2{,}08$$

2 Standard Deviation Log Pearson III

Standard deviationfrom Log x is obtained by the following calculation:

$$\text{Sd log x} = \left[\frac{\sum_{i=1}^{n} (\log Xi - \log \bar{X})^2}{n-1}\right]^{0,5}$$
$$= \left[\frac{0{,}755}{14-1}\right]^{0,5}$$

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$$= 0{,}24$$

3 Skewness (Cs)

Skewness is obtained by the following calculation:

$$Cs = \frac{n\sum_{i=1}^{n}(Log\ Xi - Log\ \bar{X})^3}{(n-1)(n-2)S^3}$$

$$= \frac{14x\ (-0{,}117)}{(14\ -\ 1)(14\ -\ 2)0{,}24^3}$$

$$= -\ 0{,}0211$$

To find KT frequency factor in Log Pearson III distribution, first determine K frequency based on return period and the skewness. To K frequency is taken based on the table 3 as follows:

Table 4. KT Score

Period (T)	Cs	Score (KT)
2	-0.0211	0
5	-0.0211	0.842
10	-0.0211	1.282
25	-0.0211	1.751
50	-0.0211	2.054
100	-0.0211	2.326
200	-0.0211	2.576

Then KT value for Q25 is: 1,751

4 Maximum Rainfall Return Period

In this research, the maximum rainfall for the 25 years return period is calculated with Log Pearson III distribution, while the calculation is:

$$Log\ X_{T25} = Log\ \bar{X} + K_T\ x\ Sd\ \log X$$

$$Log\ X_{T25} = 2{,}08 + (\ 1{,}751\ x\ 0{,}24)$$

$$Log\ X_{T25} = 2{,}50$$

The formula for calculating rainfall for a return period of 25 years is the inverse of log XT or antilog XT.

X_{T25} = antilog XT25

X_{T25} = 316,80

D. Calculating TimeConcentration (TC)

The formula to find the concentration time is:

$Tc = 0{,}0195x\ L^{0{,}77} x\ S^{-0{,}385}$

Information:

Tc = Time concentration (minute)

L = Length of water path from the farthest point to the point under attention. (km)

S = Average slope the waterway area

So that the time concentration is obtained as follows:

Tc = $0,0195 \times 15.330^{0,77} \times 0,00808^{-0,385}$

Tc = 3,47 Hour

E. Calculating Rainfall Intensity (I)

Rainfall intensity is calculated using the mononobe formula as follows:

$$I = \frac{R_{24}}{24}\left(\frac{24}{Tc}\right)^{2/3}$$

Information:

I : Rainfall Intensity (mm/hour)

Tc : Rain time concentration (hour)

R24 : Maximum rainfall in 1 day (mm/hour)

$$I = \frac{316,80}{24}\left(\frac{24}{3,47}\right)^{2/3}$$

$$= 47,92 \text{ mm/hour}$$

So that the rain intensity (I) for a return period of 25 years: 47.92 mm/hour

F. Rainfall Discharge (Qt)

The planned rain discharge is calculated by the main formula:

Qt = 0,278 x C x I x A

Information:

Q = Flood discharge (m3/s)

C = Run off coefficient

A = Catchment area (Km^2)

I = Rainfall intensity (mm/hour)

because the Ciliwung River is the location of this research(TB. Simatupang s/d PA. Manggarai) is located in an urban area, the run offcoefficient is 0.95 based on table 5

Table 5. Run Off Coefficient

Land Description/Character of Settlement	Run Off Coefficient (C)
Business :	
- Urban	- 0,70 – 0,95
- Suburbs	- 0,50 – 0,70
Housing :	
- House	- 0,30-0,50
- Separate Multiunit,	- 0,40-0,60
- Merged Multiunit	- 0,60-0,75
- Village	- 0,25-0,40

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- Apartment	- 0,50-0,70
Pavement :	
- Asphalt and concrete	- 0,70-0,95
- Coal, paving	- 0,50-0,70
Sand yard:	
- flat (2%)	- 0,05 – 0,10
- Steep (7%)	- 0,15 - 0,20
Ground yard:	
- Flat (2%)	- 0,13 – 0,17
- Steep (7%)	- 0,18 - 0,22
Forest:	- 0,10 – 0,40
- Flat 0 – 5%	- 0,25 - 0,50
- Wavy 5 – 10%	- 0,30 – 0,60
- Hilly 10 – 30%	

Then,

Qt_{25} = 0,278 x 0,95 x 47,92 x 31,95

Qt_{25} = 404,30 m^3/s

So that the rainfall discharge obtained is: 404.30 m^3/sec.

G. Existing River Discharge (Qs)

Discharge on existing river is calculated by the following approximate formula:

Lower River Width (b) : 24,863 m

Water Depth (h) : 6,45 m

Slope (i) ` : 0,00808

CoeffRoughness Manning (n) : 0,04

Taludslope (m) : 1/1,25

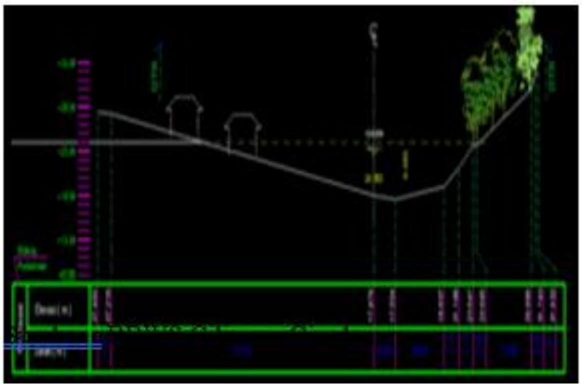

Figure 3. Existing River Cross Section Sumber: BBWS CiliwungCisadane

1 Wet Cross-section Canal Area

$Ae = m \, x \, h^2$

$= 0{,}8 \; x \; 6{,}45^2$

$= 25{,}99$

2 Circumference Canal

$p \; = 2 \; x \; h \sqrt{(1 + m^2)^2}$

$= 2 \; x \; 5{,}45 \; \sqrt{(1 + 0{,}8^2)^2}$

$= 16{,}52 \; m$

3 hydraulic radius

$R \; = \frac{Ae}{p}$

$= \frac{25{,}99}{16{,}52}$

$= \; 1{,}573$

4 Flow Rate

$V \; = \frac{1}{n} \; x \; R^{\frac{2}{3}} \; x \; s^{\frac{1}{2}}$

$= \frac{1}{0{,}04} \; x \; 1{,}573^{\frac{2}{3}} \; x \; 0{,}00808^{\frac{1}{2}}$

$= \; 3{,}04 \; m/det$

5 Discharge (Qs)

$Qs \; = Ae \; x \; V$

$= 25{,}99 \; x \; 3{,}04$

$= 79{,}03 \; m^3/det$

6 Discharge Total

$Qtotal \; = Q25 + \; Qinflow$

$= 404{,}34 + \; 79{,}03$

$= 483{,}38 \; m^3/det$

H. Modelling with Hec Ras

From the results of modeling using the help of Hec-Ras on the Ciliwung River (TB. Simatupang to Bidara China) the following results are obtained:

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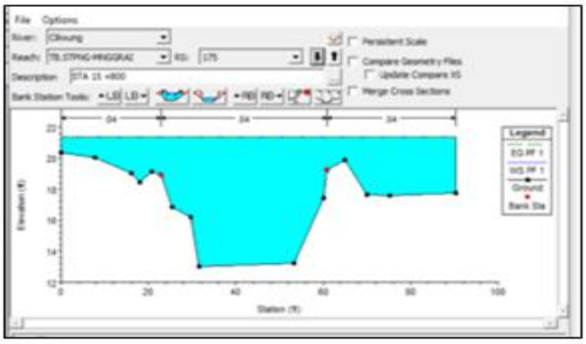

Figure 4. River Cross Section That Has Not Been Normalized

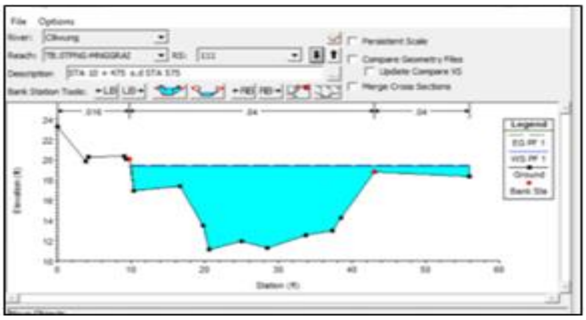

Figure 5. River Cross Section on One Side Has Been Normalized

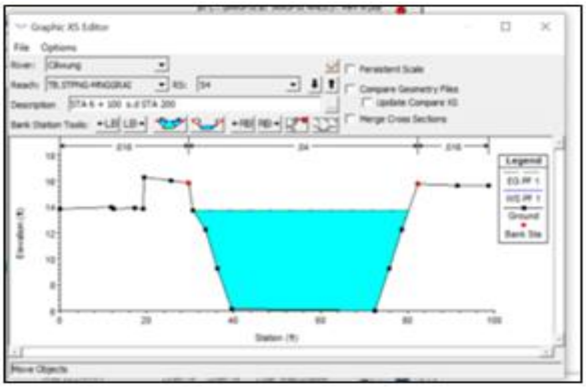

Figure 6. Normalized River Cross Section

I. Mapping of Flood Locations Based on Hec-Ras Application Modeling

From the modeling results through the Hec-Rass application, then mapping of puddles areas is carried out to determine the area who need river normalization.

Figure 7. Flood Location in Tb. SimatupangtoCondet Bridge

Figure 8. Flood Location inCondetBridge toKalibata Bridge

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Figure 9. Flood Location in Kalibata BridgetoBidaraCina

CONCLUSION

The hydrological calculation results show that the planned flood discharge Q_{25} is 404.3 m3/s while the Q inflow is 79.03 m3/s so that the total Q is 483.38 m3/s. Based on the modeling results using the Hec-Rass application, the following results are obtained: There is runoff (flooding) on the river profile that has not been normalized, on the river profile that has just been normalized on one side shows runoff on the side that has not been normalized, while on the river profile that has been normalized shows no runoff (flooding). From the modeling results, it can be concluded that the *existing* river cannot accommodate the planned flood discharge so that river normalization is needed as an effort to control flooding, especially at the location of the Ciliwung river (TB. Simatupang Bridge to Bidara Cina).

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