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NORMALIZATION ANALYSIS OF BUARAN RIVER USING THE HEC-RAS APPLICATION (THE BUKIT KENCANA RESIDENTIAL AREA TO JAKARTA CIKAMPEK TOLL)

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ABSTRACT

The channel in the Buaran River area has a channel length of 5.32 km located in the Bukit Kencana Housing Area as the upstream of the Buaran River with the smallest cross-sectional width of 0.9 m and a height of 1 m and the border of the Jakarta Cikampek Toll Road as a downstream with a width of 2.2 m and a height of 3.6 m. one of the areas of the Buaran River which experienced quite severe flooding. This was due to changes or conversion of land functions which were originally water catchment areas to settlements. The large number of buildings that stand on the body of the river makes the current section of the Buaran River unable to function optimally in accommodating flood discharges, besides that there is no public awareness in protecting the environment which can be seen from the many piles of garbage in the body of the river. The purpose of this research is to find out how big the capacity of the existing Buaran cross-section is (starting from the Bukit Kencana Residential Area to the Jakarta Cikampek Toll Road) by modeling the existing cross-section using the help of the Hec-Rass application as well as recording and mapping locations that have the potential to flood. . One of the efforts that have been made by the government in controlling floods is by normalizing the river but in practice, the normalization of the Buaran River cannot be said to be running optimally. Based on hydrological calculations, the planned Q25 flood discharge is 16,307 m3/s. By using the help of the Hec-Ras application we can find out which river profiles need to be treated so that the handling of river normalization as an alternative to flood control can run optimally

Keywords: *flood, river normalization, Hec-Ras*

1. PRELIMINARY

The channel in the Buaran River area has a channel length of 5.32 km located in the Bukit Kencana Residential Area as the upstream of the Buaran River with the smallest cross-sectional width of 0.9 m and a height of 1 m and the border of the Jakarta Cikampek Toll Road as a downstream with a width of 2.2 m and a height of 3.6 m. The average plaster construction uses river stone. The condition of the Buaran River is that it is located close to the border of Jakarta as the capital of the Republic of Indonesia. The condition of the river has narrowing in several segments and there is a lot of sedimentation in the body of the river which is caused by the plaster structure of the river stone which has not been plastered as a whole and the volume of waste which is quite a lot due to the fact that many people throw garbage in the river.

In addition to the high intensity of rainfall, the cross-section of the river that has not been ideal due to the increase in rainfall every year coupled with crossing times on the toll road is a major factor in the occurrence of flooding in the Buaran River. Development around the Buaran River which is very rapid (changes in land use) causes the water catchment area to decrease.

The process of analyzing normalization of the river generally uses a rational method by determining the value of rainfall intensity, cachmant area, and the value of the run-off coefficient so that the discharge value is generated from rain, while the cross-sectional value of the channel / river uses modeling using the Hecras method

Based on the background above, the authors want to analyze the cross section of the Buaran River using the help of the Hec Ras application. The Hec-Rass application itself is used to model the existing cross-section of the river, in accommodating the planned flood discharge after modeling it can be recorded and mapped at locations that have the potential for flooding so that river normalization as a flood control effort can run effectively and effectively.

2. THEORETICAL BASIS

Definition Of Flood

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

1. Characteristics of heavy rain, namely the distribution of rain intensity in time and space.
2. Catchment area characteristics such as: area, shape, channel system and land slope, type and distribution of soil layers as well as geological and geomorphological structures

In the broad scope of the discussion, we can see flooding as a part of the hydrological cycle, namely the part of the water on the earth's surface that moves into the sea. rate of infiltration of water into the soil.

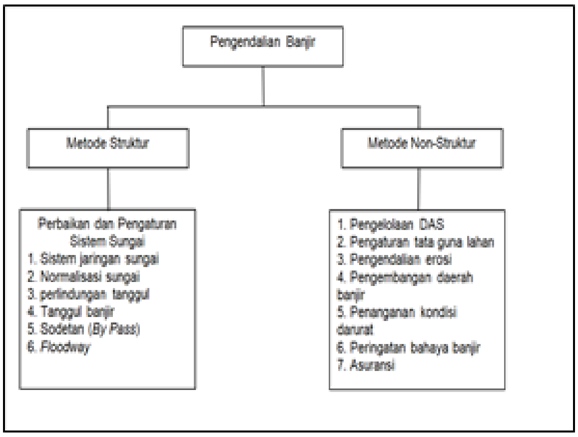
From the above understanding it can be concluded that flooding is an event that occurs when excessive water flow dampens the land. Floods can also occur in rivers when their flow exceeds the capacity of the waterways.

Flood Control System (Flood Control System)

According to Kondoatie, Robert J., and Sugiyanto (2002), a flood control system in an area needs to be made properly and efficiently, taking into account the existing conditions and the development of the utilization of future water sources. In preparing a flood control system, it is necessary to evaluate and analyze or pay attention to the following matters:

1. Analysis of flood control methods that exist in the area or are currently underway.
2. Evaluation and analysis of flood inundation areas, including data on flood losses.
3. Evaluation and analysis of land use in the study area, especially in the floodplain area.
4. Evaluation and analysis of existing residential areas and future developments.
5. Paying attention to the potential and development of future water resources.
6. Pay attention to resource utilization

By taking into account the matters 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 methods can be carried out structurally and non-structurally. For more details, see Figure 1



Source: Kondoatie, Sugiyanto (2002)

Figure 1 Flood control with structural and non-structural methods

Normalization of Rivers and Embankments

Flood control efforts with normalization are intended to increase the channel's drainage capacity. These activities include:

1. 1 Normalized cross sections
2. Improvement of channel bottom slope
3. Reduce the roughness of the channel groove wall
4. Reconstruct buildings along channels that are not suitable and disrupt flood drainage.
5. Stabilize the channel flow.
6. Construction of 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, planning a stable channel against erosion and sedimentation processes at the bottom of the canal as well as cliff erosion and flood water level.

Flood Modeling Using the Hec-Ras Application

Hydraulics calculations are very complicated, bearing in mind the shape of the cross-section of the river in each section is not uniform and with a large number of sections. Analysis will be very difficult if not assisted by software. Therefore, to support the river hydraulics analysis process, an application program (software) package, namely HEC-RAS, will be used. This application program is used with the intention that the accuracy of calculations and analysis can be maintained (to reduce the factor of "human error" to a minimum and at the same time keep up with trends in this information age.

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 iterations which are carried out repeatedly with certain parameters to find certain variables in both steady flow and steady flow conditions. non-permanent conditions (unsteady flow).

Research sites

This research focuses on the location of the Buaran River starting from the Bukit Kencana Residential Area to the Jakarta Cikampek Toll Road, the length of the channel is 5.32 km

Figure 2. Research Locations

Data collection technique

1. Preparation Stage

   At this stage what is done in preparation for the research is to find data from various sources, such as documents, articles, and make direct observations at the research location. In addition, also look for research literature that has been done before.

2. Data Collection

   a. Primary data

   The primary data used in this study is used to determine the current condition of the Buaran River starting from the Bukit Kencana Residential Area to the Jakarta Cikampek Toll Road.

   b. Secondary Data

   Secondary data used in this study are:

   -Rainfall data (in this study, rainfall data was taken for the last 15 years (from 2006 to 2020) from the rainfall recording station Halim Station.

   The geometry of the river, the situation and material conditions of the river are derived from the measurement results.

3. RESULTS AND DISCUSSION

Analysis of Rainfall Data

Maximum monthly rainfall data is obtained from the Meteorology and Geophysics Agency via bmkg.go.id with attached rainfall data.

At the rainfall data analysis stage, the average rainfall, standard deviation (Sd), coefficient of variation (Cv), sloping coefficient (Cs) and kurtosis coefficient (Ck) must be calculated.

Table 1. Calculation of distribution for rainfall

No	Rangking Data	(R - Rrata-rata)	(R - Rrata-rata)^2	(R - Rrata-rata)^3	(R - Rrata-rata)^4
1	59.80	(63.91)	4084.914178	-261080.4815	16686523.84
2	66.00	(57.71)	3330.828844	-192233.2354	11094420.79
3	72.00	(51.71)	2674.268844	-138295.3562	7151713.852
4	88.50	(35.21)	1239.978844	-43663.78838	1537547.535
5	88.50	(35.21)	1239.978844	-43663.78838	1537547.535
6	89.60	(34.11)	1163.719511	-39698.35159	1354243.101
7	91.60	(32.11)	1031.266178	-33117.39452	1063509.929
8	95.00	(28.71)	824.4555111	-23672.86591	679726.8898
9	101.20	(22.51)	506.8501778	-11410.887	256897.1027
10	111.60	(12.11)	146.7328444	-1777.423856	21530.52764
11	120.8	(2.91)	8.487511111	-24.72694904	72.03784486
12	136.1	12.39	153.4295111	1900.480211	23540.61488
13	140.4	16.69	278.4448444	4646.316304	77531.5314
14	217.6	93.89	8814.706178	827583.3807	77699045
15	377	253.29	64154.13551	16249387.14	4115753103
Jumlah	1,855.7	-	16242.99378	-788613.5727	41,383,661.10
Rata-Rata	123.71				

1. Average Rainfall

The average rainfall is obtained by the following calculation:

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

= (1855,7/15)

= 123,71

2. Standard Deviation

The standard deviation is obtained by the following calculation:

Standard Deviation (Sd) $= \frac{\sum_{i=1}^{n}(Xi - \bar{X})^2}{n-1}$

=(16.242,99/14)^0.5

= 34,06

3. Slope Coefficient

The slope coefficient is obtained by the following calculation:

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

= (15x-788613,5727) / (14x13x34,063)

= -1,64

4. Kurtosis Coefficient

The kurtosis coefficient is obtained by the following calculation:

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

= (152x41.383.661,1)/ (14x13x12x34,064)

= 3,17

5. Coefficient of Variation

The coefficient of variation is obtained by the following calculation:

(Cv) = (34,06/123,71) = 0,28

Distribution Method

Based on the parameters obtained, then look for a distribution method that is in accordance with the requirements. The following table results of calculations to determine the distribution method.

Table 2. Distribution Method Requirements

No	Distribution	Requirement	Results	Conclusion
1	**Gumbel**	**Cs ≈ 1,1396**	**Cs = -1.64**	ok
		Ck ≈ 5,4002	**Ck = 3.17**	ok
2	Normal	Cs ≈ 0	Cs = = -1.64	Not ok
		Ck ≈ 3	Ck = 3.17	Not ok
3	Log Normal	Cs ≈ 3 atau 3Cv	Cs = -1.64	Not ok
			Ck = 3.17	Not ok
4	Log Pearson III	Tidak Memiliki Syarat	Cs = = -1.64	Not ok
			Ck = 3.17	Not ok

Source: SNI 2415 : 2016

Based on calculations and analysis of rainfall data, the method that meets the requirements is Gumbel

Rainfall Plan Gumbel Method

By using the Gumbel method, first look for the possibility of planned rainfall in accordance with the return period of T years to determine the magnitude of the planned flood discharge that will occur.

1. The year of the planned return period is 25 years because the catchment area of the study area is 2.97 km2 and this is based on Table 5.4 but based on the appropriate provisions in table 5.4, namely the smallest return period is> 10 years, then the next analysis and calculation uses a period 25 year anniversary.

Table 3. Return period table

Luas Catchment Area (km2)	Tahun Periode Ulang (tahun)
< 0,1	2
0,1 −1,0	5
1,0 −3,0	10
> 3,0	>10

(Source: JICA (Japan International Coorporation Agency) 2000)

2. Determine the value of Sn (Reduced Standard Deviation) and Yn (Reduced Mean) using the table

Table 4. Table of reduced standard deviation (Sn)

N	0	1	2	3	4	5	6
10	0,9496	0,9676	0,9833	0,9971	1,0095	***1,0206***	1,0316
20	1,0628	1,0628	1,0754	1,0811	1,0864	1,0915	1,0961
30	1,1124	1,1159	1,1193	1,1226	1,1255	1,1285	1,1313
40	1,1413	1,1436	1,1458	1,148	1,1499	1,1519	1,1538

50	1,1607	1,1623	1,1638	1,1658	1,1667	1,1681	1,1696
60	1,1747	1,1759	1,1770	1,1782	1,1793	1,1803	1,1814
70	1,1854	1,1863	1,1873	1,1881	1,1890	1,1898	1,1906
80	1,1938	1,1945	1,1953	1,1959	1,1967	1,1973	1,1980
90	1,2007	1,2013	1,2020	1,2026	1,2032	1,2038	1,2044
100	1,2065	1,2069	1,2073	1,2077	1,2081	1,2084	1,2087

(Source from the book Sustainable Urban Drainage Systems)

From the observation of rainfall for 15 years, the value of Sn is obtained according to table 5.5. is = 1.0206

Table 5. Table of reduced mean (Yn)

N	0	1	2	3	4	5	6
10	0,4952	0,4996	0,5035	0,507	0,51	***0,528***	0,5157
20	0,5236	0,5252	0,5268	0,5283	0,5296	0,509	0,5332
30	0,5362	0,5371	0,538	0,5388	0,8396	0,503	0,5418
40	0,5436	0,5442	1,5448	0,2453	0,5458	0,563	0,5468
50	0,5485	0,5489	0,5493	0,5497	0,5501	0,504	0,5508
60	0,5521	0,5524	0,5527	0,5530	0,5533	0,535	0,5538
70	0,5548	0,5550	0,5552	0,5555	0,5557	0,559	0,5561
80	0,5569	0,5570	0,5572	0,5574	0,5576	0,578	0,5580
90	0,5586	0,5587	0,5589	0,5591	0,5592	0,593	0,5595

(Source from the book Sustainable Urban Drainage Systems)

From the observation of rainfall for 15 years, the value of Yn is obtained which is in accordance with table 6. is = 0.5128

Table 6 Reduced Variate (Yt) Table

Periode Ulang	Reduced Variate
2	0.3665
5	1.4999
10	2.2502
20	2.9606
25	3.1985
50	3.9019
100	4.6001

(sumber : CD Soemarto, 1999)

Analysis of the 25 year return period plan according to table 3.8. is

Ytr = 3.1985

3. After the S, Sn, YTr and Yn values are obtained, then proceed with analyzing the next maximum daily rainfall

Table 7. Maximum return period rainfall calculation table

Tahun	Sn	Yn	Sx	Xrata2	Ytr Tabel	(Yt - Yr)/Sn	Xtr
2	1.021	0.5128	34.06	123.71	0.3665	(0.14)	118.83
5	1.021	0.5128	34.06	123.71	1.4999	0.967176171	156.66
10	1.021	0.5128	34.06	123.71	2.2502	1.702331962	181.70
20	1.021	0.5128	34.06	123.71	2.9606	2.398393102	205.41
25	1.021	0.5128	34.06	123.71	3.1985	2.63149128	213.35
50	1.021	0.5128	34.06	123.71	3.9019	3.32069371	236.82
100	1.021	0.5128	34.06	123.71	4.6001	4.004801097	260.12

Calculating Concentration Time (TC)

The formula for finding the time of concentration is:

Tc = 0.0195x L 0.77 x S -0.385

Where :

Tc = Concentration time (minutes)

L = Length of water path from the furthest point to the point considered (km)

S = average slope of the waterway area

So the concentration time is obtained as follows:

Tc = (0.0195 x (1000) 0.77)/(0.001) -0.385

Tc = 5.58 Hours

Calculating Rainfall Intensity (I)

mononobe formula as follows:

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

Where :

I : Rainfall Intensity (mm/hour)

Tc : Rain Concentration Time (hours)

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

Table 8. Rainfall Intensity Calculation Table

t	R24					
	R2	*R5*	*R10*	*R25*	*R50*	*R100*
	118.831	156.657	181.698	213.347	236.823	260.125
1	41.196	54.310	62.991	73.963	82.102	90.
2	25.952	34.213	39.682	46.594	51.721	56.
3	19.805	26.110	30.283	35.558	39.470	43.
4	16.349	21.553	24.998	29.352	32.582	35.788
5	14.089	18.574	21.543	25.295	28.078	30.841
6	12.476	16.448	19.077	22.400	24.865	27.311
7	11.258	14.842	17.214	20.212	22.436	24.644
8	10.299	13.578	15.748	18.491	20.525	22.545
9	9.521	12.552	14.559	17.094	18.975	20.842
10	8.875	11.701	13.571	15.935	17.688	19.429
11	8.329	10.980	12.736	14.954	16.599	18.233
12	7.860	10.362	12.018	14.111	15.664	17.205
13	7.451	9.823	11.393	13.378	14.850	16.311
14	7.092	9.350	10.844	12.733	14.134	15.525
15	6.773	8.929	10.357	12.161	13.499	14.827
16	6.488	8.553	9.920	11.648	12.930	14.202
17	6.231	8.214	9.528	11.187	12.418	13.640
18	5.998	7.907	9.171	10.769	11.954	13.130
19	5.786	7.627	8.847	10.388	11.531	12.665
20	5.591	7.371	8.549	10.038	11.143	12.239
21	5.412	7.135	8.276	9.717	10.786	11.848
22	5.247	6.917	8.023	9.420	10.457	11.486
23	5.094	6.715	7.789	9.145	10.152	11.150
24	4.951	6.527	7.571	8.889	9.868	10.839

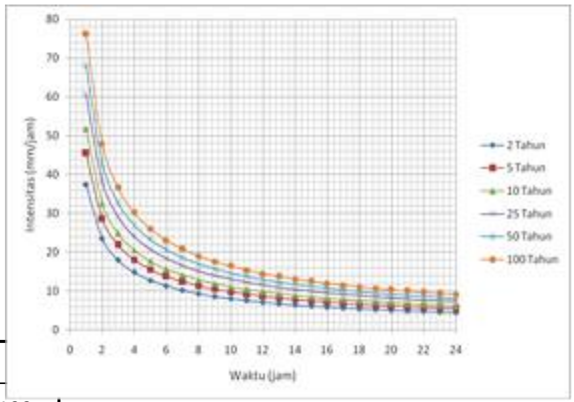


Figure 1. Graph of Rainfall Intensity

Table 9. Rain intensity (I)

Periode Ulang (T) Tahun	Curah hujan rencana (Antilog X_t = R_{24}) mm	Waktu konsentrasi (T_c) Jam	Intensitas Hujan (I) mm/jam
2	118,23	5,58	13.096
5	156,66	5,58	17,27
10	181,70	5,58	20,02
25	213,35	5,58	23,51
50	236,82	5,58	26,10
100	260,12	5,58	28,67

Sehingga di dapatkan Intensitas hujan (I) untuk periode ulang 25 tahun adalah: 23,51 mm/jam

Debit Akibat Curah Hujan (Qt)

Debit hujan rencana dihitung dengan rumus utama:

Qt = 0,278 x C x I x A

Dimana:

Q = Debit puncak limpasan permukaan (m3/det)

C = Angka pengaliran

A = Luas daerah pengaliran (Km^2)

I = Intensitas curah hujan (mm/jam)

karena Kali Buaran yang menjadi lokasi penelitian ini berada didaerah perkotaan maka koefisien *run off* yang digunakan adalah 0,84 berdasarkan tabel 5

Table 10. Flow Coefficient

Deskripsi Lahan/Karakter Permukiman	Koefisien Pengaliran (C)
Bisnis : - Perkotaan - Pinggiran	- 0,70 – 0,95 - 0,50 – 0,70
Perumahan : - Rumah tinggal - Multiunit, terpisah - Multiunit, tergabung - Perkampungan - Apartemen	- 0,30-0,50 - 0,40-0,60 - 0,60-0,75 - 0,25-0,40 - 0,50-0,70
Perkerasan : - Aspal dan beton - Batu bara, paving	- 0,70-0,95 - 0,50-0,70
Halaman Berpasir : - Datar (2%) - Curam (7%)	- 0,05 – 0,10 - 0,15 - 0,20
Halaman tanah : - Datar (2%) - Curam (7%)	- 0,13 – 0,17 - 0,18 - 0,22
Deskripsi Lahan/Karakter Permukiman	**Koefisien Pengaliran (C)**
Hutan : - Datar 0 – 5% - Bergelombang 5 – 10% - Berbukit 10 – 30%	- 0,10 – 0,40 - 0,25 - 0,50 - 0,30 – 0,60

For,

Qt25 = 0,278 x 0,84 x 23,51 x 2,97

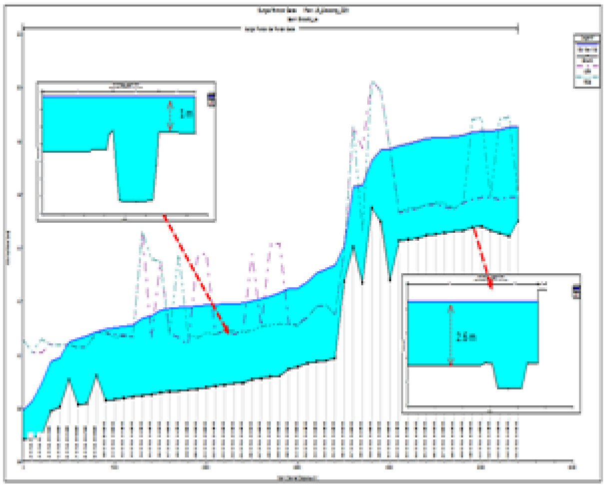
Qt25 = 16,307 m3/det

so that the rainfall discharge obtained is: 16.307 m3/sec.

Modeling With the Help of Hec-Ras

Running results for a return period of 25 years with Q=16,307 m3/sec in the existing conditions show the following results:

Figure 2. Cross-section of times that have not been normalized

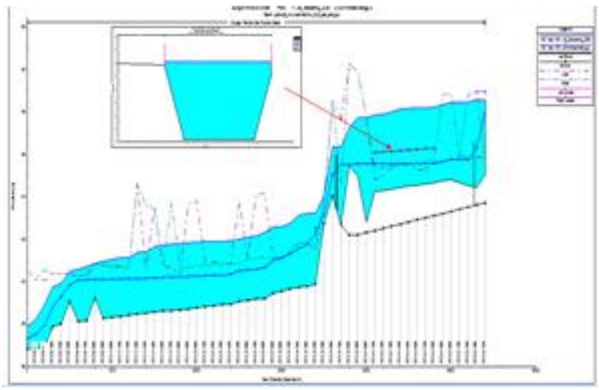


From the results of the runing data, an overflow occurs

on the upstream side of Jalan Jatimakmur with an overflow height of 2.63 m due to which there are still several locations where there is narrowing. The downstream side of Jalan Jatimakmur was overflowing with an average height of 1 m which was caused by the volume of water from the upstream of Jalan Jatimakmur

Modeling the addition of a Box Culvert upstream measuring 2.5x2 m2 and Jalan Jatimakmur measuring 2x2 m2, normalizing the canal with a design width of 4 meters and a depth of 2 meters and constructing an embankment as high as 1 m

Figure 3. Cross Section After Normalization

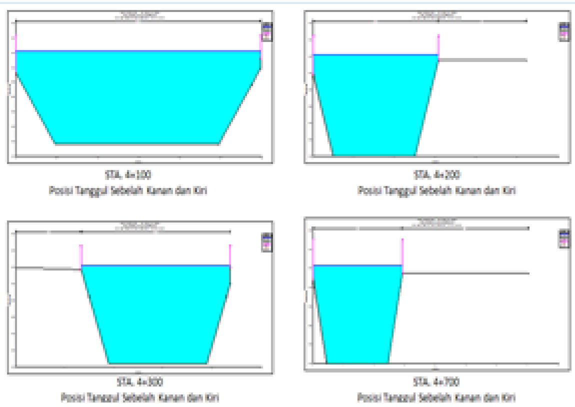


With the combination of scenarios plus embankments, the channel is able to accommodate the Q25 flood discharge load.

With a note, Normalization is only carried out in the upstream of the canal, and the dimensions of the upstream bypass are 2.5 x 2 meters

Flood conditions can be seen in the figure after raising the 1 m high embankment upstream as follows:

Figure 4. Cross-section of Times Has Been Normalized



4. RESULTS AND DISCUSSION

The conclusions from the studies that have been conducted are:

1. Flood management in Buaran River is carried out by raising the embankment by 1 m on the upstream side of Jalan Jatimakmur, using box culverts with a size of 2.5 x 2 m2 in the Upper Kali Harun to Kali Sunter, making a channel with box culverts measuring 2 x 2 m2 on Jalan Jatimakmur to Kali Sunter and normalizing the canal on the upstream side of Jalan Jatimakmur with a size of 4 m x 2 m can reduce flooding in that location by 100%
2. The need for strict sanctions against misuse of the canal/river bank area.
3. Promote the role of society to love the environment by not throwing garbage into rivers or canals.
4. Drain the canals that have sedimentation and garbage

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