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Canal as a Solution to Reduce a Puddle in the Drainage System of Passo - Ambon City

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***Abstract*— *Due to the low infiltration capacity as the effect of land expansion into buildings / concretization in an area will have an impact on the surface flow rate which results in a drainage system that is not optimal. For this reason, routine flooding / inundation in Passo area is minimized by involving the canal of Passo as a water body that can manage flooding. The average rainfall data of 14 years is used to model the rainfall plan and land use data of 0.4-0.7 in the way tonihatu watershed is a variable of runoff coefficient. For the planned discharge with a 25-year return period of 14.84 m3 / sec with the Nakayasuyang synthetic hydrograph used to model the channel capacity of 46 nodes. From the simulation results of the existing condition, only 3 nodes are safe, after that the flow model and channel capacity are improved according to the channel characteristics requirements, the simulation results show the ability of the safe channel capacity to discharge the planned system.*

Keywords*— *Nakayasu, Canal, Passo, land use.

I. INTRODUCTION

Excessive development in Ambon City has disrupted the balance of the water system which can be seen from the high number of surface runoffs, due to the low infiltration capacity as the result of the expansion of land into buildings / concretization in an area. The direct loss felt is a decrease in soil production capacity, high surface runoff, and sedimentation rates. Existing conditions in the city of Ambon, especially Passo, are experiencing a lot of problems with the urban drainage system that urgently needs to be addressed, including the problem of the malfunctioning of the network system, in this case the canal (long storage) which causes flooding.

In addition, an increase in demographic growth and urbanization has led to an irregular city morphology, slum, and squatter settlement, as the second developing city in Ambon city area, it is feared that in the next 10 years Passo will stagnate, so there is no more land that can be built. Based on the foregoing, a form of handling is needed by increasing / normalizing the urban drainage system so that rainwater flow is expected to be more optimal and shorter drying cycle times in the area.

II. REVIEW OF LITERATURE

The flood estimation equation that will be used for tertiary drainage is calculated based on the Rational formula while for secondary and primary drainage the Nakayasu formula is used.

$$Qp = \frac{1}{3{,}6} CIA \qquad (1)$$

$$\mathbf{I = (R_{24} / 24) * (24 / tc)^{2/3}} \qquad (2)$$

Tc = Concentration time (hour)

R_{24} = Maximum daily rainfall (in 24 hours)

And tc is the concentration time that can be calculated by the equation tc = L/V, dan

$$V = 72\left(\frac{H}{L}\right)^{0{,}6},$$

Where :

L = River length in the flow area (km)

V = Flood creepage speed (km/hour)

H = the height of the furthest point upstream from the observation point (km)

$$Qp = \frac{A.R_0}{3{,}60\,\mathrm{x}\,(0{,}3\mathrm{Tp} + \mathrm{T}_{0{,}3})} \qquad (3)$$

where :

Qp =peak flood discharge (m^3/second)

A = watershed area (km^2)

R_0 = unit rain (mm)

Tp =the time period from the beginning of the rain until the peak of the flood (hour)

$T_{0.3}$ = the time taken by the decline debit, from

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the main discharge to the discharge, 30% of peak discharge (hour)

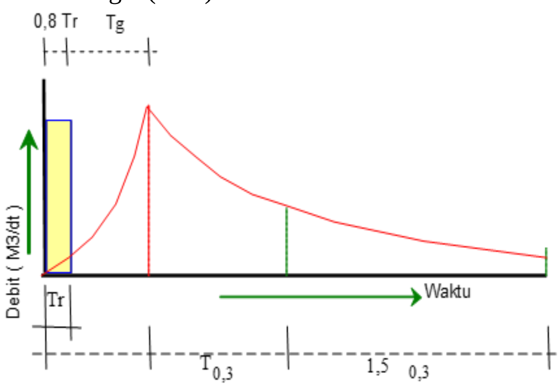

Fig.1: Unit of Hidrograf Nakayasu

$$CAll = \frac{C1.A1 + C2 + A2 + C3 + A3 + ...Cn.An}{A1 + A2 + A3 + ...An}$$

C = flow coefficient from the flow area

A = area of flow (km^2)

III. METHODOLOGY

Fig.2: Passo canal situation

Fig.3: Research Site

Based on the Ambon city spatial plan (RTRW) in 2011-2031 against SWP (development area unit) Passo and surrounding areas are service areas that are quite extensive to include Ambon Inner Bay (TAD)

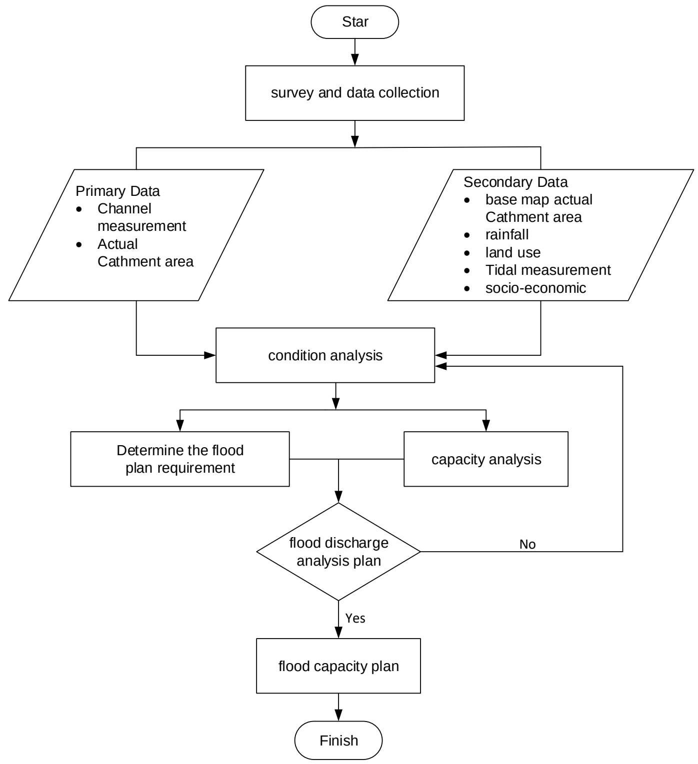

Fig.4: Research Flow Chart

IV. RESULT AND DISCUSSION

- Hidrology Analysis

Regional rainfall has been calculated by the Arithmetic method and has produced a maximum annual daily rainfall as in Table

Table 1. Requirements for Distribution Selection Frequency

Type of distribution	Condition	Results	Information
Normal	Cs = 0	0.004 > 0	not accepted
Log Normal	Cs = 3Cv + Cv^2	1.226<0,167	not accepted
Log Pearson III	Cs ≠ 0	0,004 > 0	not accepted
Gumbel	Cs ≤ 1,1396	0,004 < 1,1396	not accepted
	Ck ≤ 5,4002	1.991 < 4,4002	be accepted

From the distribution test results for dk = 3 and α = 5%, then from the chi square test table obtained X2 = 7.815 From the above calculation obtained x2 = 4,571 this value is smaller when compared with the critical value of x2 with degrees of freedom (dk) = 3 the critical f2 value is 7,815. then the Gumbel distribution can be accepted.

- **Land Use**

In calculating the flood discharge the plan needs to be determined in advance the value of the drainage coefficient, the amount of which depends on the designation of the land

(land use). At the research location found a land use coefficient of 40-70

• Tidal Data

Tidal data used as modeling input used observations for 14 days. Taken on the upstream canal.

• Runoff discharge analysis

For the purposes of the analysis of the drainage system, the maximum rainfall data used for the planned return period of the drainage system is 5 years. To determine the dimensions of the drainage channel it is assumed that the condition of water flow is in a normal condition (steady uniform flow) where the flow has a constant velocity with respect to distance and time.

- **Discharge flood plans**

The amount of the planned flood discharge is determined by adding up the amount of surface runoff and dirty water discharge. In this study the surface runoff (rainwater) discharge used is a discharge with a return period of 25 years, as shown in table 2

Table 2 Discharge system plan

No	Channel	Channel segment	Qrain (m^3/det)	Q accumulative (m^3/det)	Qdesign (m^3/det)
1	A	a0-a1	0.8663	0.0034	0.8697
2	B	b0-b1	0.8663	0.0006	0.8669
3	C	c0-c1	0.9531	0.0053	0.9584
4	D	d0-d1	0.4754	0.0032	0.4786
5	E	e0-e1	0.2640	0.0016	0.2656
6	F	f0-f1	0.4998	0.0022	0.5020
7	G	g0-g1	0.2416	0.0016	0.2431
8	H	h0-h1	1.5761	0.0026	1.5788
9	I	i0-i1	0.9289	0.0022	0.9310
10	J	j0-j1	0.7114	0.0015	0.7129
11	K	k0-k1	1.1430	0.0017	1.1446
12	L	l0-l1	0.4906	0.0012	0.4918
13	M	m0-m1	0.2289	0.0009	0.2299
Total					9.2734

- **Design Flood Hydrograph**

For the purposes of the calculation of the flood hydrograph, it is necessary to have a base flow calculation.

Table 3. Nakayasu Synthetic Hydrograph Unit

Time t (Hr)	Curved up	Curved Down			Total Koef.	Debit Hydrograph Unit Qt m^3/dt
	$0 < t < Tp$	$Tp < t < T_{0,3}$	$T_{0,3} < t < 1,5T_{0,3}$	$1,5T_{0,3} < t < 24$		
	$(t/Tp)^{2.4}$	$\frac{(t-Tp)}{T_{0,3}}$	$\frac{(t-Tp+0.5T_{0,3})}{(1.5T_{0,3})}$	$\frac{(t-Tp+1.5T_{0,3})}{(2T_{0,3})}$		
1	2	3	4	5	6=2+3+4+5	7
0.00	0.00				0.00	0.0000
0.37	1.00				1.00	0.0991
1.00		0.910			0.91	0.0331
2.00		2.354			2.35	0.0058
3.00			2.865		2.87	0.0031
4.00				3.37	3.37	0.0017
5.00				4.09	4.09	0.0007
6.00				4.81	4.81	0.0003
7.00				5.54	5.54	0.0001
8.00				6.26	6.26	0.0001
9.00				6.98	6.98	0.0000
10.00				7.70	7.70	0.0000
11.00				8.42	8.42	0.0000
12.00				9.15	9.15	0.0000
13.00				9.87	9.87	0.0000
14.00				10.59	10.59	0.0000
15.00				11.31	11.31	0.0000
16.00				12.03	12.03	0.0000
17.00				12.76	12.76	0.0000
18.00				13.48	13.48	0.0000
19.00				14.20	14.20	0.0000
20.00				14.92	14.92	0.0000
21.00				15.64	15.64	0.0000
22.00				16.36	16.36	0.0000
23.00				17.09	17.09	0.0000
24.00				17.81	17.81	0.0000

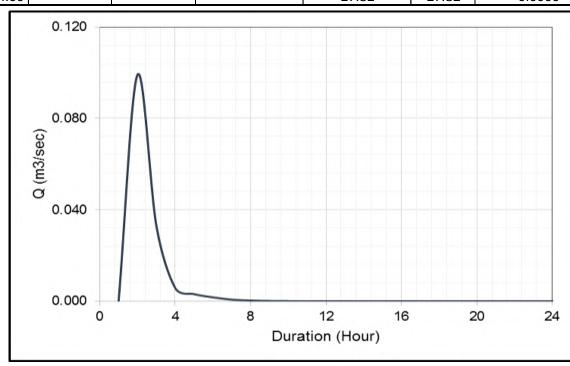

Fig.5: Nakayasu Hydrograph of the Passo Canal

- **Hydraulics Analysis**

For the cross-section analysis in this study the HEC – RAS 4.1 program was used

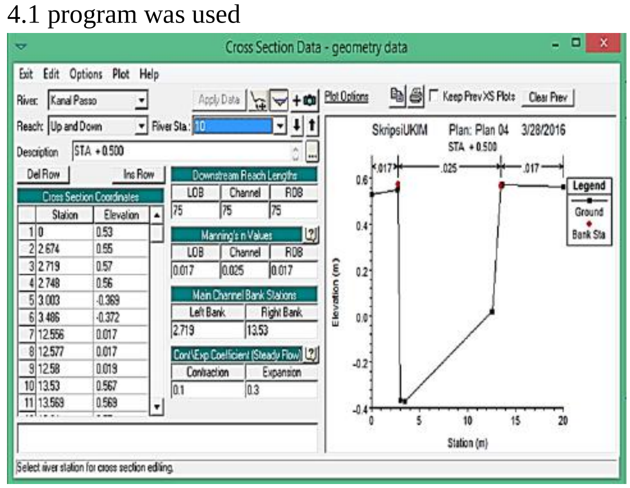

Fig.6: Geometry Data Input

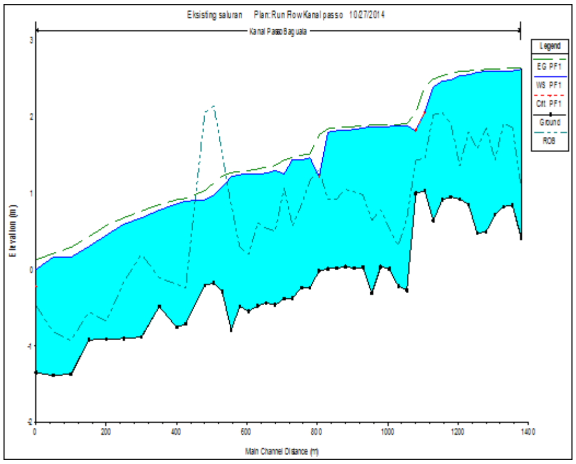

Fig.7: Existing Qdesign 25 Year + Tidal

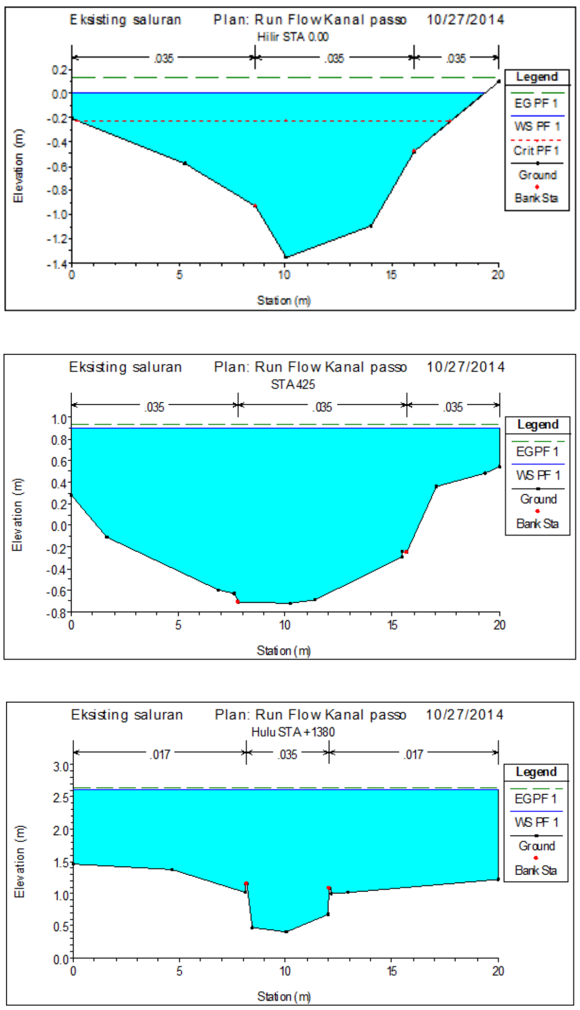

Fig.8: Simulation of Existing Channel

Table 4. Condition of existing channels

Node	Total Debit	Elevation (m)		Doen elv	Water level	Velocity	Top width	Informatinon
	(m3/sec)	left	Right	(m)	(m)	(m/sec)	(m)	
46	14.84	1.15	1.08	0.41	2.46	0.37	20	overflowed
45	14.84	1.85	1.85	0.83	2.45	0.41	20	overflowed
44	14.84	1.91	1.92	0.82	2.45	0.42	20	overflowed
43	14.84	1.23	1.43	0.72	2.44	0.52	20	overflowed
42	14.84	1.94	1.85	0.49	2.44	0.39	20	overflowed
41	14.84	1.56	1.57	0.47	2.43	0.52	20	overflowed
40	14.84	1.97	1.8	0.85	2.4	0.88	20	overflowed
39	14.84	1.42	1.36	0.92	2.39	0.6	20	overflowed
38	14.84	1.91	1.92	0.94	2.35	0.99	20	overflowed
37	14.84	2.05	2.05	0.91	2.32	1.13	20	overflowed
36	14.84	2.09	2.03	0.64	2.23	1.54	20	overflowed
35	14.84	1.61	1.45	1.03	1.94	2.19	12.41	overflowed
34	14.84	1.51	1.43	1	1.73	1.76	20	overflowed
33	14.84	0.97	0.66	-0.28	1.63	0.63	20	overflowed
32	14.84	0.33	0.31	-0.22	1.63	0.45	20	overflowed
31	14.84	0.87	0.53	0.01	1.62	0.41	20	overflowed
30	14.84	0.79	0.78	0.04	1.62	0.53	20	overflowed
29	14.84	0.7	0.63	-0.31	1.62	0.47	20	overflowed
28	14.84	1.04	0.97	0.02	1.6	0.61	20	overflowed
27	14.84	1.03	1.01	0.02	1.58	0.8	20	overflowed
26	14.84	1.03	1.05	0.03	1.56	0.73	20	overflowed
25	14.84	0.99	0.92	0.01	1.55	0.72	20	overflowed
24	14.84	1.01	0.91	0.01	1.53	0.86	20	overflowed
23	14.84	1.32	1.3	-0.02	1.14	2.66	5.4	overflowed
22	14.84	0.87	1.17	-0.24	1.34	0.6	20	overflowed
21	14.84	0.7	0.85	-0.24	1.32	0.94	20	overflowed
20	14.84	0.86	0.57	-0.37	1.32	0.65	20	overflowed
19	14.84	1.02	1.06	-0.39	1.16	1.83	19.09	overflowed
18	14.84	0.41	0.5	-0.46	1.21	0.75	20	overflowed
17	14.84	0.55	0.54	-0.44	1.18	0.95	20	overflowed
16	14.84	0.51	0.61	-0.47	1.17	0.89	20	overflowed
15	14.84	0.35	0.19	-0.55	1.17	0.59	20	overflowed
14	14.84	0.33	0.29	-0.48	1.16	0.64	20	overflowed
13	14.84	0.78	0.84	-0.79	1.14	0.88	20	overflowed
12	14.84	1.07	1.51	-0.29	1.06	1.31	9.53	safe
11	14.84	2.07	2.14	-0.18	1.01	1.31	10.54	safe
10	14.84	2.03	2.05	-0.21	0.99	1.08	12.3	safe
9	14.84	-0.71	-0.25	-0.72	0.98	0.68	20	overflowed
8	14.84	-0.31	-0.19	-0.76	0.97	0.79	20	overflowed
7	14.84	-0.27	-0.11	-0.49	0.94	0.83	20	overflowed
6	14.84	-0.27	0.2	-0.89	0.91	0.88	16.79	overflowed
5	14.84	-0.56	-0.17	-0.91	0.89	0.77	20	overflowed
4	14.84	-0.36	-0.68	-0.92	0.86	0.85	20	overflowed
3	14.84	-0.36	-0.56	-0.93	0.85	0.72	20	overflowed
2	14.84	-0.62	-0.93	-1.37	0.84	0.66	20	overflowed
1	14.84	-0.98	-0.83	-1.39	0.84	0.47	20	overflowed
0	14.84	-0.93	-0.48	-1.35	0.83	0.58	20	overflowed

- **Cross-section Planning**

Normalization of the Passo channel with a single cross section is planned with the Manning formula. The type of cross section used follows the maximum cross section capacity because the channel dimension capacity that can be changed in maximum conditions is depth only.

Table 5 Improve Channels

Node	Total Debit	Elevation (m)		Doen elv	Water level	Velocity	Top width	Informatinon
	(m3/sec)	left	Right	(m)	(m)	(m/sec)	(m)	
46	14.84	2.52	2.52	0.65	2.02	1.09	10	safe
45	14.84	2.48	2.48	0.61	1.98	1.08	10	safe
44	14.84	2.45	2.45	0.59	1.95	1.09	10	safe
43	14.84	2.42	2.42	0.55	1.92	1.08	10	safe
42	14.84	2.39	2.39	0.51	1.89	1.08	10	safe
41	14.84	2.35	2.35	0.48	1.85	1.08	10	safe
40	14.84	2.32	2.32	0.43	1.82	1.06	10	safe
39	14.84	2.29	2.29	0.39	1.79	1.06	10	safe
38	14.84	2.27	2.27	0.34	1.77	1.04	10	safe
37	14.84	2.24	2.24	0.3	1.74	1.03	10	safe
36	14.84	2.21	2.21	0.26	1.71	1.02	10	safe
35	14.84	2.19	2.19	0.21	1.69	1.01	10	safe
34	14.84	2.17	2.17	0.1	1.67	0.95	10	safe
33	14.84	2.16	2.16	-0.23	1.66	0.78	10	safe
32	14.84	2.14	2.14	-0.13	1.64	0.84	10	safe
31	14.84	2.12	2.12	0.01	1.62	0.92	10	safe
30	14.84	2.09	2.09	0.04	1.59	0.96	10	safe
29	14.84	2.09	2.09	-0.31	1.59	0.78	10	safe
28	14.84	2.05	2.05	0.03	1.55	0.97	10	safe
27	14.84	2.03	2.03	0.02	1.53	0.98	10	safe
26	14.84	2	2	0.04	1.5	1.02	10	safe
25	14.84	1.97	1.97	0.01	1.47	1.02	10	safe
24	14.84	1.94	1.94	0.01	1.44	1.04	10	safe
23	14.84	1.91	1.91	-0.02	1.41	1.04	10	safe
22	14.84	1.9	1.9	-0.24	1.4	0.91	10	safe
21	14.84	1.87	1.87	-0.22	1.37	0.93	10	safe
20	14.84	1.82	1.82	0.02	1.32	1.14	10	safe
19	14.84	1.81	1.81	-0.32	1.31	0.91	10	safe
18	14.84	1.8	1.8	-0.41	1.3	0.87	10	safe
17	14.84	1.77	1.77	-0.26	1.27	0.97	10	safe
16	14.84	1.74	1.74	-0.21	1.24	1.02	10	safe
15	14.84	1.73	1.73	-0.55	1.23	0.84	10	safe
14	14.84	1.71	1.71	-0.47	1.21	0.88	10	safe
13	14.84	1.68	1.68	-0.32	1.18	0.99	10	safe
12	14.84	1.65	1.65	-0.29	1.15	1.03	10	safe
11	14.84	1.6	1.6	-0.18	1.1	1.16	10	safe
10	14.84	1.55	1.55	-0.21	1.05	1.18	10	safe
9	14.84	1.53	1.53	-0.72	1.03	0.81	12	safe
8	14.84	1.52	1.52	-0.76	1.02	0.8	12	safe
7	14.84	1.46	1.46	-0.49	0.96	0.98	12	safe
6	14.84	1.44	1.44	-0.83	0.94	0.8	12	safe
5	14.84	1.42	1.42	-0.91	0.92	0.78	12	safe
4	14.84	1.39	1.39	-0.92	0.89	0.78	12	safe
3	14.84	1.37	1.37	-0.93	0.87	0.79	12	safe
2	14.84	1.36	1.36	-1.37	0.86	0.64	12	safe
1	14.84	1.35	1.35	-1.39	0.85	0.63	12	safe
0	14.84	1.33	1.33	-1.31	0.83	0.66	12	safe

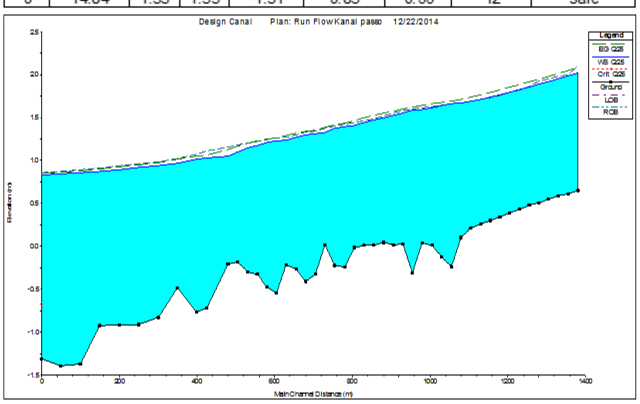

Fig.9: Improved Channel Lengthening

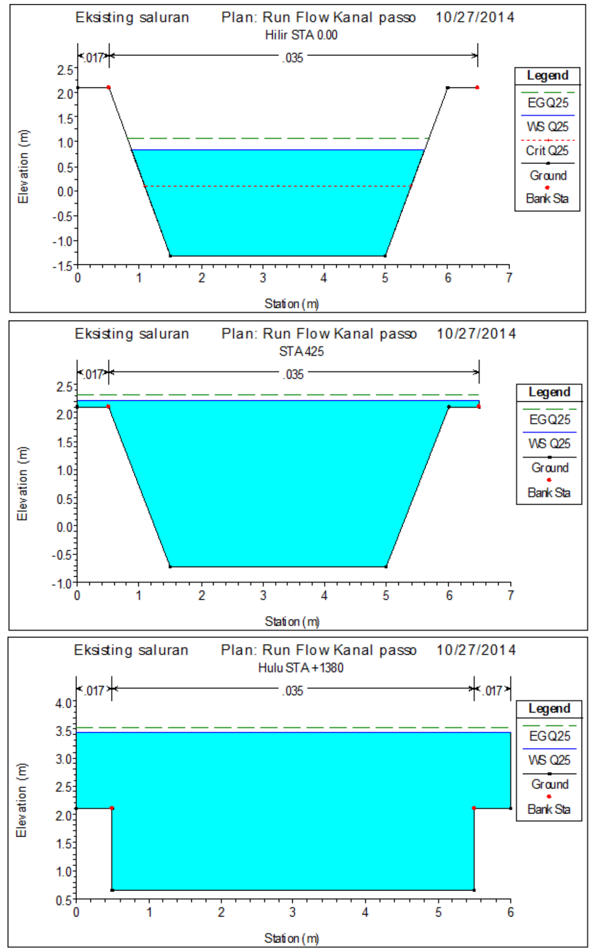

Fig: 10Simulation of Cross Section Improvement

Normalization of the Passo channel with a single cross section is planned with the Manning formula. The type of cross section used follows the maximum cross section capacity because the channel dimension capacity that can be changed in maximum conditions is only depth.

V. CONCLUSION

1) In Sub-watersheds that contribute to the flow in the Passo city drainage system that discharges the flow in the canal, the flow will be directed so that the Passo Canal system is no longer burdened with part of the discharge from the micro drainage system according to the Hydrological and Hydrolytic plan criteria.
2) For the channel dimensions in the existing condition the channel capacity is sufficient to accept the flood load of the planned 25-year return period, while the plan conditions for the channel dimensions that pass through the access road still follow the channel dimensions of the exciting conditions.

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