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FLOOD MANAGEMENT OF GADING TUTUKA, SOREANG AREAUSINGSWMM 5.1 MODELING

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Keywords:Soreang, Flood, Mitigation, Tutuka, Restructure

ABSTRACT
The development of residents and settlements in Soreang City requires the construction of facilities & infrastructures that support especially flood mitigation, such as in the GadingTutuka area. Risks and impacts on the occurrence of floods that often occur in Kabupaten Bandung can be reduced or minimized by preparing and preventing floods. One thing to do is to know and know the areas that have the potential to flood. Therefore, it is necessary to restructure the existing drainage system and add new drainage networks and complementary buildings.

Keywords : Soreang, Flood, Mitigation, Tutuka, Restructure

INTRODUCTION
The development of residents and settlements in Soreang City requires the construction of facilities & infrastructures that support especially flood mitigation, such as in the GadingTutuka area. Risks and impacts on the occurrence of floods that often occur in Kabupaten Bandung can be reduced or minimized by preparing and preventing floods. One thing to do is to know and know the areas that have the potential to flood. Therefore, it is necessary to restructure the existing drainage system and add new drainage networks and complementary buildings.

LITERATURE REVIEW

The topographical conditions at the activity site are quite gentle. On the main road reviewed, the GadingTutukaarea's intersection has a low elevation compared to the end of the way. Water from the rain catchment area in the

GadingTutuka region is piling up at the crossroad.

The catchment area in the work of the Planning of the Drainage System of the GadingTutuka and CPI ResidenceSoreang, Kabupaten Bandung is determined by the following matters:

1. The topography of the location of the activity
2. Existing channel
3. Channel flow patterns in the activity area

Image1. GadingTutuka Catchment Area

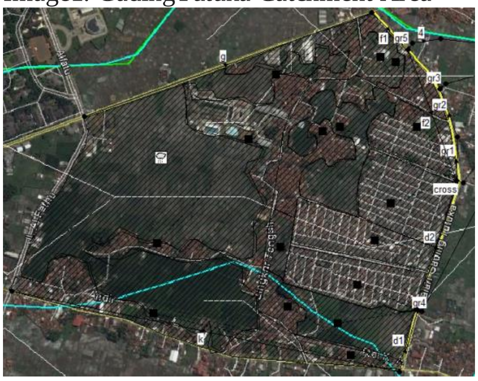

Image2. GadingTutuka Regional Drainage

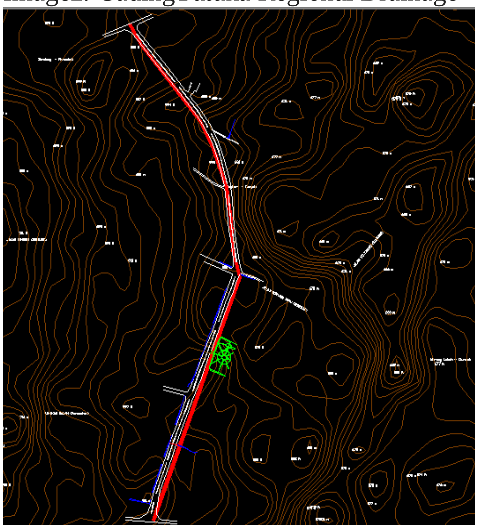

Image3. GadingTutuka Topography Condition

Table 1. GadingTutuka Region Drainage Data

Pt.	Drain	B (m)	H (m)	L (m)	Info
1	D1	0.77	0.7	350	UPPER CHANNEL
2	D2	1	1	360	
3	F1	0.65	1	250	
4	F2	0.65	1	450	
5	G	1.15	0.65	1,150	
6	K	1.05	0.85	1,400	
7	sCPI	2	2	100	
8	GR1	Dia 1.2 m		100	LOWER CHANNEL
9	GR2	Dia 1.5 m		100	
10		Dia 1 m		180	
11	GR3	Dia 1.8 m		20	
12	GR4	0.3	0.3	20	
13	Cross	1	1	20	

METHODOLOGY

The process of completing this research can be explained as follows:

1. Preparatory Work

Preparatory work includes the preparation of work planners and works approach methods. In this preparation phase, we must collect and evaluate secondary data/information available.

2. Field Survey

The main activity at this stage is to collect field data to meet the primary needs of the Flood Inundation analysis. The field survey included:

a. Survey of areas that cause flooding

b. Contour mapping using Drone

c. Survey existing drainage capacity

3. Analisisof Flood Inundation

RESULTS AND DISCUSSION

4.1. General Situation of Research Location

The study was conducted in Soreang District, Bandung City. Precisely in GadingTutuka Housing Complex. The topographical conditions at the activity site are quite gentle. On the main road reviewed, the intersection of the GadingTutuka complex has a lower height compared to the end of the road.

4.2. Annual Rainfal Analysis

Rainfall data collected from geophysical and meteorological stations, in general, are not always complete. There is data missing in particular months or within a specified period. Therefore, it is necessary to fill in the analysis of rainfall data missing so that each station's data be used for further analysis. The following is the initial rain data for each rain station.

Table 2. Maximum daily rainfall data in 18 years

Year	Station			Regional Rain (mm/day)
	Cisondari	Cililin	Ciherang	
1991	54.0	105.0	111.5	90.2
1992	83.0	60.0	99.7	80.9
1993	74.0	50.0	86.4	70.1
1994	63.0	46.0	76.0	61.7
1995	73.0	99.0	120.4	97.5
1996	67.0	54.0	84.4	68.5
1997	54.0	45.0	69.1	56.0
1998	74.0	57.0	91.3	74.1
1999	84.0	68.0	106.0	86.0
2000	71.0	50.0	84.3	68.4
2001	95.0	91.0	100.0	95.3
2002	83.0	50.0	93.3	75.4
2003	90.0	76.0	80.0	82.0
2004	106.0	94.0	80.4	93.5
2005	87.0	75.0	75.0	79.0
2006	53.0	45.0	77.0	58.3
2007	50.0	101.0	115.5	88.8
2008	29.0	90.0	169.0	96.0

Based on the hydrological data that has been collected, then an analysis of the planned rainfall, where the planned rainfall is taken for the return period of 2, 5, 10, 50, and 100 years.

Table 3. Results of rainfall analysis plans

m	P = m/(N+1)	Year	CH (mm/day)	Ln CH (mm/day)
1	0.053	1995	97.459	4.579
2	0.105	2008	96.000	4.564
3	0.158	2001	95.333	4.557
4	0.211	2004	93.467	4.538
5	0.263	1991	90.177	4.502
6	0.316	2007	88.833	4.487
7	0.368	1999	86.005	4.454
8	0.421	2003	82.000	4.407
9	0.474	1992	80.888	4.393
10	0.526	2005	79.000	4.369
11	0.579	2002	75.433	4.323
12	0.632	1998	74.113	4.306
13	0.684	1993	70.128	4.250
14	0.737	1996	68.464	4.226
15	0.789	2000	68.439	4.226
16	0.842	1994	61.658	4.122
17	0.895	2006	58.333	4.066
18	0.947	1997	56.021	4.026
		Data amount	18	18
	Average Value (Mean)		78.986	4.355
	Standard Deviation		13.246	0.174
	Skewness Coefficient		-0.226	-0.465
	Kurtosis Coefficient		-1.094	-0.830
	Variation Coefficient		0.168	0.040
		Middle Value	79.944	4.381

The result calculation of maximum rainfall is done using several methods, namely, Normal Method, Normal Log Method, Gumbel Method, and Pearson III Log Method. The calculation of the planned rainfall value of each method has different values, so they must be tested for compatibility with the nature of each type of distribution. This is done by conducting a review of the boundary parameters for each statistical parameter. Determination of the type of distribution can be seen from the statistical parameters of field observation data, namely the values of Cs and Ck. A comparison of probability distribution parameters can be seen in Table 3.

Table4. Chi–Square Test Resumes

CH (mm/hari)	m	P = m/(N+1)	NORMAL		LOG-NORMAL		GUMBEL		LOG-PEARSON III	
			P(x >= Xm)	Do	P(x >= Xm)	Do	P(x >= Xm)	Do	P(x >= Xm)	Do
97.459	1	0.053	0.082	0.029	0.099	0.046	0.090	0.037	0.086	0.034
96.000	2	0.105	0.099	0.006	0.115	0.010	0.102	0.003	0.105	0.001
95.333	3	0.158	0.109	0.049	0.123	0.035	0.109	0.049	0.114	0.044
93.467	4	0.211	0.137	0.073	0.148	0.063	0.129	0.081	0.143	0.068
90.177	5	0.263	0.199	0.064	0.200	0.063	0.173	0.090	0.205	0.059
88.833	6	0.316	0.229	0.087	0.225	0.091	0.195	0.121	0.234	0.082
86.005	7	0.368	0.298	0.070	0.285	0.084	0.248	0.121	0.302	0.066
82.000	8	0.421	0.410	0.011	0.384	0.037	0.343	0.079	0.411	0.010
80.888	9	0.474	0.443	0.031	0.414	0.059	0.373	0.101	0.443	0.031
79.000	10	0.526	0.500	0.027	0.468	0.059	0.429	0.097	0.498	0.028
75.433	11	0.579	0.606	0.027	0.573	0.006	0.547	0.032	0.602	0.023
74.113	12	0.632	0.644	0.012	0.612	0.019	0.593	0.038	0.639	0.008
70.128	13	0.684	0.748	0.064	0.727	0.043	0.734	0.050	0.744	0.059
68.464	14	0.737	0.787	0.050	0.771	0.034	0.789	0.052	0.782	0.045
68.439	15	0.789	0.787	0.002	0.771	0.018	0.790	0.000	0.783	0.007
61.658	16	0.842	0.905	0.062	0.910	0.068	0.951	0.108	0.903	0.061
58.333	17	0.895	0.941	0.046	0.952	0.057	0.984	0.089	0.941	0.046
56.021	18	0.947	0.959	0.011	0.971	0.023	0.994	0.047	0.960	0.012
DKritik = 0.310				**0.087**		**0.091**		**0.121**		**0.082**
				Diterima		**Diterima**		**Diterima**		**Diterima**

Ket. : m = Peringkat
P = Peluang di lapangan
Do = Selisih peluang lapangan dengan peluang teoritis

Kesimpulan : 1. Uji Smirnov-Kolmogorov menggunakan nilai Delta Kritik 0.310
2. Menurut Uji Smirnov-Kolmogorov, Distribusi yang terbaik adalah LOG-PEARSON III
3. Dengan nilai Delta Maksimum adalah 0.082

Table 5. Smirnov-Kolmogorov Test Resumes

P(x >= Xm)	T	Karakteristik Hujan (mm/hari) Menurut Probabilitasnya							
Probabilitas	Kala-Ulang	NORMAL		LOG-NORMAL		GUMBEL		LOG-PEARSON III	
		X_T	K_T	X_T	K_T	X_T	K_T	X_T	K_T
0.9	1.1	62.011	-1.282	62.312	-1.259	64.411	-1.100	61.897	-1.320
0.5	2.	78.986	0.000	77.892	-0.083	76.810	-0.164	78.944	0.077
0.2	5.	90.134	0.842	90.187	0.846	88.516	0.719	90.401	0.855
0.1	10.	95.962	1.282	97.368	1.388	96.267	1.305	96.346	1.221
0.05	20.	100.774	1.645	103.728	1.868	103.701	1.866	101.191	1.503
0.025	40.	104.948	1.960	109.579	2.310	110.993	2.416	105.327	1.733
0.02	50.	106.190	2.054	111.383	2.446	113.324	2.592	106.543	1.799
0.01	100.	109.801	2.326	116.798	2.855	120.535	3.137	110.036	1.984
0.001	1,000.	119.920	3.090	133.417	4.109	144.363	4.936	119.418	2.454

Table 6. Maximum Rain Return Data

1. Aplikasi NORMAL

Kelas	P(x >= Xm)		Ef	CH (mm/hari)	Of	Ef - Of	$(Ef-Of)^2 / Ef$
5	0.200	0 < P <= 0.2	3.600	90.134	5.000	1.400	0.544
	0.400	0.2 < P <= 0.4	3.600	82.342	2.000	1.600	0.711
	0.600	0.4 < P <= 0.6	3.600	75.630	3.000	0.600	0.100
	0.800	0.6 < P <= 0.8	3.600	67.838	5.000	1.400	0.544
	0.999	0.8 < P <= 0.999	3.600	38.053	3.000	0.600	0.100
			18.000		18.000	Chi-Kuadrat =	2.000
						DK =	2
Distribusi NORMAL Diterima						Chi-Kritik =	5.991

2. Aplikasi LOG-NORMAL

Kelas	P(x >= Xm)		Ef	CH (mm/hari)	Of	Ef - Of	$(Ef-Of)^2 / Ef$
5	0.200	0 < P <= 0.2	3.600	90.187	4.000	0.400	0.044
	0.400	0.2 < P <= 0.4	3.600	81.406	4.000	0.400	0.044
	0.600	0.4 < P <= 0.6	3.600	74.530	3.000	0.600	0.100
	0.800	0.6 < P <= 0.8	3.600	67.273	4.000	0.400	0.044
	0.999	0.8 < P <= 0.999	3.600	45.476	3.000	0.600	0.100
			18.000		18.000	Chi-Kuadrat =	0.333
						DK =	2
Distribusi LOG-NORMAL Diterima						Chi-Kritik =	5.991

3. Aplikasi GUMBEL

Kelas	P(x >= Xm)		Ef	CH (mm/hari)	Of	Ef - Of	$(Ef-Of)^2 / Ef$
5	0.200	0 < P <= 0.2	3.600	88.516	6.000	2.400	1.600
	0.400	0.2 < P <= 0.4	3.600	79.963	3.000	0.600	0.100
	0.600	0.4 < P <= 0.6	3.600	73.928	3.000	0.600	0.100
	0.800	0.6 < P <= 0.8	3.600	68.110	3.000	0.600	0.100
	0.999	0.8 < P <= 0.999	3.600	53.065	3.000	0.600	0.100
			18.000		18.000	Chi-Kuadrat =	2.000
						DK =	2
Distribusi GUMBEL Diterima						Chi-Kritik =	5.991

4. Aplikasi LOG-PEARSON III

Kelas	P(x >= Xm)		Ef	CH (mm/hari)	Of	Ef - Of	$(Ef-Of)^2 / Ef$
5	0.200	0 < P <= 0.2	3.600	90.401	4.000	0.400	0.044
	0.400	0.2 < P <= 0.4	3.600	82.391	3.000	0.600	0.100
	0.600	0.4 < P <= 0.6	3.600	75.511	3.000	0.600	0.100
	0.800	0.6 < P <= 0.8	3.600	67.641	5.000	1.400	0.544
	0.999	0.8 < P <= 0.999	3.600	40.393	3.000	0.600	0.100
			18.000		18.000	Chi-Kuadrat =	0.889
						DK =	1
Distribusi LOG-PEARSON III Diterima						Chi-Kritik =	3.841

Ket : Chi-Kuadrat = Harga Chi-Kuadrat
Ef = Frekuensi sesuai pembagian kelasnya
Of = Frekuensi dengan aplikasi distribusi frekuensi
DK = Derajat Kebebasan

Kesimpulan : 1. Menurut Uji Chi-Kuadrat, Distribusi yang terbaik adalah LOG-NORMAL
2. Dengan nilai Chi-Kritik = 5.991
3. Dan nilai Chi-Kuadrat adalah 0.333

From the suitability test of the maximum rainfall analysis method above, it can be seen that the Log-Pearson III method has the smallest deviation of the other methods. It can be seen in the table that the value of max max = 0.082 <criticism = 0.310. So the rainfall analysis uses the Log-Pearson III Method is used as a rainfall plan for drainage system planning. The next calculation is to predict the distribution of hourly rains that occur in GadingTutuka using the Mononobe method.

Formula :

$$R_T = \left\{\frac{R_{24}}{t}\right\} \cdot \left\{\frac{t}{T}\right\}^{2/3}$$

Information :

R_T = Average Rain Intensity in T Hours (mm / hour)
R_T = Effective Rainfall in One Day (mm)
T = Rainy Time (hours)
t = Rain Concentration Time (hours)
(For Indonesia t = 6 hours)

Table7.Average Rain Intensity in T Hours (mm / hour)

No.	T (jam)	R_T (mm/jam)
A.	1	0.5503 R_{24}
B.	2	0.3467 R_{24}
C.	3	0.2646 R_{24}
D.	4	0.2184 R_{24}
E.	5	0.1882 R_{24}
F.	6	0.1667 R_{24}

Distribution of Rainy Times

Formula

$$R_t = (t \cdot R_T) - \{(t-1) \cdot (R_{T-1})\}$$

Information :

R_t = Percentage of Average Rain Intensity (in t hours)

Table8. Percentage of Average Rain Intensity (in t hours)

Point	t (hours)	Rt
A.	1	0.55032
B.	2	0.14304
C.	3	0.10034
D.	4	0.07988
E.	5	0.06746
F.	6	0.05896

Table9. Value of Rainy Times Distribution

Rainy Times	Rain Distribution
Hours	%
1	55.032%
2	14.304%
3	10.034%
4	7.988%
5	6.746%
6	5.896%

Table10. Calculation of Rainy Hour

t	Rt	Hujan (R, mm) dengan Kala Ulang (Tahun)						
		2	5	10	20	40	50	100
		78.944	90.401	96.346	101.191	105.327	106.543	110.036
(Jam)	(%)	Hujan Jam-jaman = Rn x Rt						
1	55.032%	43.445	49.750	53.021	55.688	57.963	58.633	60.555
2	14.304%	11.292	12.931	13.781	14.474	15.066	15.240	15.740
3	10.034%	7.921	9.071	9.667	10.153	10.568	10.690	11.041
4	7.988%	6.306	7.221	7.696	8.083	8.413	8.511	8.790
5	6.746%	5.325	6.098	6.499	6.826	7.105	7.187	7.423
6	5.896%	4.655	5.330	5.681	5.967	6.210	6.282	6.488

4.3.Drainage Network Model

4.3.1 Existing Condition

After calculating the planned rainfall data, a drainage network will then be made using SWMM 5.1. The data needed as input for the SWMM 5.1 program is obtained by taking measurements at flood handling locations. The treatment area is divided into several sub-catchments (DTA) based on the drainage channel's boundaries. In addition, there are also the same sub-DTA characteristics in each sub-DTA. These characteristics are percent slope (% slope), Manning's constant values for impervious and pervious regions (N-Imperv and N-Perv), depth of depression storage in impervious and pervious regions (Dstore-Imperv and Dstore-Perv), percent of impervious regions do not have depression storage (% zero imperv), and the value of the curve number and the length of the day drying time (drying time).

The rainfall plan used in handling this flood is the two-year plan rainfall.
A compilation of sub-DTA characteristics inputted into the SWMM program is shown in the following table.

Table 11. GadingTutuka Sub-DTA Characteristics

Name	Land Cover Type	Area(Ha)	Wide (m)	Slope	Flow Coefficient
GT1	Housing	6.11	200	0.029	0.75
GT2	Housing	8.6	240	0.030	0.75
GT3	Housing	6.81	160	0.026	0.75
GT4	Housing	7.33	155	0.027	0.75
SWH1	Rice Fields	7.45	475	0.031	0.25
SWH2	Rice Fields	6.27	145	0.022	0.25
SWH3	Rice Fields	2.67	175	0.025	0.25
SWH4	Rice Fields	1.69	215	0.014	0.25
SWH5	Rice Fields	5.47	180	0.025	0.25
SWH6	Rice Fields	47.6	850	0.018	0.25
RMH1	Housing	2.1	57	0.021	0.60
RMH2	Housing	3.45	145	0.019	0.60
RMH3	Housing	1.72	80	0.029	0.60
RMH4	Housing	7.6	300	0.033	0.60
RMH5	Housing	8.52	110	0.022	0.60
RMH6	Housing	16.6	800	0.022	0.60

Calculation of Rainy Hour

While the sub-DTA division model at the handling location is shown in Image 4 In addition to the sub-DTA data, other data needed is drainage channel data. In the treatment of this drainage system, drainage channels are divided into three objects: junction, conduit, and diversion. Input data for each channel is shown in Image 5. The results of the modeling of drainage channels using SWMM are shown in Image 6

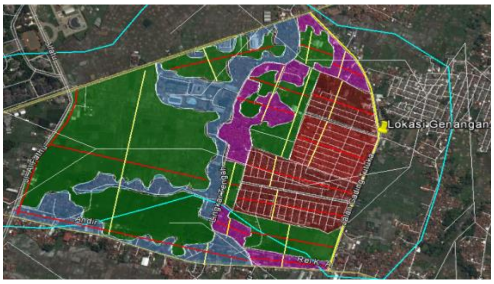

Image 4. Model of Sub-DTA Distribution at Handling Location

Table 12. Channel Input Data in theGadingTutuka Region

Pts.	Channe	B (m)	H (m)	L (m)	Information
1	D1	0.77	0.7	350	UPPER CHANNEL
2	D2	1	1	360	
3	F1	0.65	1	250	
4	F2	0.65	1	450	
5	G	1.15	0.65	1,150	
6	K	1.05	0.85	1,400	
7	sCPI	2	2	100	
8	GR1	Dia 1.2 m		100	LOWER CHANNEL
9	GR2	Dia 1.5 m		100	
10		Dia 1 m		180	
11	GR3	Dia 1.8 m		20	
12	GR4	0.3	0.3	20	
13	Cross	1	1	20	

Image 6.The results of the simulation of the existing condition network model

A total of 44.93 mm of average rainwater from total rainfall flows as runoff, while the rest is lost absorbed by the soil as infiltration.

Runoff discharge that flows in each channel varies depending on the location of the channel, channel elevation, channel roughness, and channel dimensions. Of the 17 channels in this model, the largest maximum flow rate is in the "cross" channel (channel under the intersection of GadingTutuka road) of 6,426 m3 / s. This channel has a maximum flow rate between the existing channels because the "cross" channel is a gathering place for runoff from all surfaces in the GadingTutuka catchment area.
Following the planned scheme, the debit on the "cross" channel is diverted to the sewers (gr1, gr2, and gr3) so that it can be seen in the simulation results of channel gr1 and gr2 overflow (exceeding capacity).

Table13.Maximum Discharge on the Channel

No	Channel	Max. Discharge (m3/s)
1	4	0.183
2	5	0.193
3	7	0.114
4	8	0.167
5	cross	6.426
6	dl	0.804
7	d2	1.054
8	fi	3222
9	f2	2.942
10	g	1.889
11	gr1	0.274
12	gr2	0.115
13	gr3	0.114
14	gr4	0.912
15	gr5	0.282
16	k	0.496
17	sCPI	6.416

Table14. Full Length of Channel (Existing Condition)

Pts.	Channel	Full Length Channel (hours)
1	4	0.38
2	8	0.59
3	d2	1.96
4	f1	0.33
5	f2	0.48
6	gr1	3.91
7	gr2	3.92
8	gr4	0.47

The simulation results are seen from several channels that cannot accommodate the overflow, causing water to overflow. Channels that overflow indicated by yellow and red lines. Yellow and red colors indicate the flow at that capacity exceeds its capacity. Based on previously published results, it is estimated that there was an overflow in several channels. According to these results, it is necessary to improve drainage channels to cope with flooding by changing the dimensions so that the volume can control the maximum amount of discharge. Changing the dimensions of this channel can consist of channel width, channel boundaries, or a complete combination. The selection of assistance to increase needs must be adjusted to the needs. Channel widening, for example, affects a part of the land around the channel. This can mean the taking of most of the people's houses or narrowing the width of the road body. The addition of channel depth must also pay attention to the volume that must be done as well as the most crucial slope of the channel.

4.3.2 Flood Management Concept

The concept proposed in the context of handling the GadingTutuka flood is as follows.

1. Replacing the 1.2 m culvert with 1.5 m culvert
2. Normalize the culvert diameter 1.5 m
3. Replace 1 m diameter culverts with U-ditch sizes of 1.5 m
4. Manholes used for O&R should be installed every 12.5 m
5. At the entrance of GadingTutuka, the concrete is replaced with a metal grating, to facilitate the O&R process
6. Create a sediment storage pond beside the entrance of GadingTutuka
7. On the GadingTutuka main road, two crossing channels need to be made. It is Located near Ampera Restaurant (size 1 m) and near Administration Services Office (size 1 m)

Table15. Proposed Suggested Dimensions

Pts	Channel	B (m)	H (m)	L (m)	Information
1	D1	0.77	0.7	350	UPPER CHANNEL
2	D2	1	1	360	
3	F1	0.65	1	250	
4	F2	0.65	1	450	
5	G	1.15	0.65	1,150	
6	K	1.05	0.85	1,400	
7	sCPI	2	2	100	
8	GR1	Dia 1.5 m		100	LOWER CHANNEL
9	GR2	Dia 1.5 m		100	
10	GR2	1.5	1.5	180	
11	GR3	Dia 1.8 m		20	
12	GR4	0.3	0.3	20	
13	GR5	1	1	20	
14	Cross	1	1	20	

The results of the flood management concept that were simulated with the SWMM 5.1 program can be seen in the following Image.

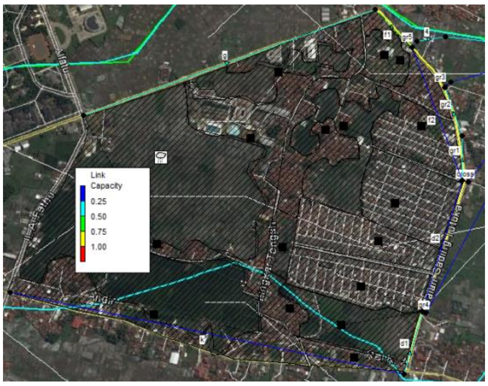

Image7. Simulation results after handling and changing dimensions

Table16. Full Length of Channel (Flood Handling Conditions)

Pts.	Channel	Full Length Channel (hours)
1	f1	0.76
2	gr1	0.06

Based on the simulation results after handling and dimensional changes, it is known that the channel capacity can be sufficient and drain the runoff. From the simulation results, it can be seen that the planned channel of handling can accommodate runoff.

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Based on the analysis conducted, several things can be concluded in handling the floods that occurred in GadingTutuka. The concept proposed in the context of handling the GadingTutuka flood is as follows.

1. Replacing the 1.2 m culvert with 1.5 m culvert

2. Normalize the culvert diameter 1.5 m
3. Replace 1 m diameter culverts with U-ditch sizes of 1.5 m
4. Manholes used for O&R should be installed every 12.5 m
5. At the entrance of GadingTutuka, the concrete is replaced with a metal grating, to facilitate the O&R process
6. Create a sediment storage pond beside the entrance of GadingTutuka
7. On the GadingTutuka main road, two crossing channels need to be made. It is Located near Ampera Restaurant (size 1 m) and near Administration Services Office (size 1 m)

5.2 Recommendations

Care must be taken to maintain and clean each channel so that it can accommodate runoff as planned.

It is also important to note the cleanliness of the drainage holes on the road so that no roads are flooded due to the closure of drainage holes by garbage and sediment.

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