The 1st International Conference on Business and Management of Technology (IConBMT)
August 3rd 2019, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia

Evaluation of Drainage System for Inundation Problems at Subdistricts of Lowokwaru, Malang City

Wirda Pratomo Bagus Hermawan[1] and Mas Agus Mardyanto[2]

Abstract*—Malang is a city in East Java with the level of development of rapid settlement areas, the region has grown in areas of land rainwater. The consequence of this development is the emergence of some new inundation in urban areas, one of them in Subdistrict Lowokwaru. Carrying amount inundation problems that occurred during 2018 in the Subdistrict Lowokwaru 4 times. Largely due to the drainage conditions are not maintained and are filled with trash and sediment. The conditions resulted in reduced sewer capacity and are not able to drain rainwater discharge and wastewater. Evaluation of the drainage system in subdistrict Lowokwaru includes analysis of technical and economic. On the technical aspects, hydrology and hydraulic analysis are carried out and evaluates sewer capacity. Economic aspects discuss the funding costs and maintenance operations of the drainage system management, as well as discuss the analysis of feasibility studies by calculating Benefit Cost Ratio and Net Present Value. The analysis showed that there are 21 sewers in condition without sediment that capacity is insufficient and 23 sewers in conditions with sediment are not met or sewer capacity is not technically eligible. It is necessary for a handling plan as an attempt to deal with the sewer capacity to drain the runoff discharge. The evaluation of economic aspects shows that the activity of handling inundation problems in the drainage system in Subdistrict Lowokwaru is feasible. This can be seen from the value of the B / C ratio is 1.83 (greater than 1) and the NPV value is positive.

***Keywords*—Inundation, Subdistrict Lowokwaru, Malang City, Drainage Systems, Sewers.**

I. INTRODUCTION

Malang became one city in East Java with the rapid rate of development, one aspect of the rapidly growing residential area, where the whole corner of the city of Malang is emerging a new residential area and shop. The region is growing in some places, both in the hills and in the area of natural water reservoirs (retarding basin). The area that originally serves as a conservation area that can absorb/accommodate while rainwater is now changed into the area woke up. The consequence of this development is the emergence of some new inundation in urban areas, even on the road.

Subdistrict Lowokwaru is one area that often occurs puddle. Data from Kota Malang Dalam Angka 2018 the carrying amount of inundation problems occurred during 2017 in the Subdistrict Lowokwaru 4 times. Largely due to the drainage conditions are not maintained so many sewers are filled with trash and sediment. The conditions resulted in reduced sewer capacity and are not able to drain rainwater discharge and wastewater. Land-use change is an awakened area that also results in lower catchment areas and rainwater.

The problem of this research is how the technical condition of the drainage system at the location of inundation in Subdistrict Lowokwaru. While the purpose of this study was to evaluate the technical condition of drainage sewers in locations that occur inundation in Subdistrict Lowokwaru by calculating hydrology, discharge runoff and sewer capacity.

II. LITERATUR REVIEW

A. Hydrology

The hydrological analysis is carried out to determine the amount of discharge to flow so that it can determine the dimensions of the drainage channel. Hydrological factors that are very influential in flood control are rainfall and intensity. Rainfall in a plain area is one of the factors that determine the amount of flood discharge that will occur. By knowing the amount of rainfall in the plains area, it can be seen the amount of rainfall intensity in the area, then it can be known how much the flood discharge will occur in the lowland area or inundation area which is the purpose of the flood.

B. Hydraulics

Hydraulics analysis is carried out after the planned discharge is known and carried out to determine the technical planning of the drainage system based on consideration of the existing channel capacity. The following are the steps in hydraulic analysis with the Manning method.

1) Cross-section

The cross-section of the drainage channel is generally rectangular and trapezoidal. The formula for calculating channel crossings is determined based on the shape of each

[1]Wirda Pratomo Bagus Hermawan is with Departement of Environmental Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia. E-mail: wirdap@gmail.com.

[2]Mas Agus Mardyanto is with Departement of Environment Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia. E-mail: mardyanto@enviro.its.ac.id.

channel with the formula for a rectangular channel as follows:

$$A = b.h \quad (1)$$

$$P = b + 2h \quad (2)$$

As for the trapezoidal channel, the formula used is:

$$A = (b + mh)h \quad (3)$$

$$P = b + 2h\sqrt{1 + m^2} \quad (4)$$

with:
A = Area of wet cross section (m^2)
B = Channel base width (m)
b = Width over channel (m)
h = Water depth (m)
H = channel depth (m)

2) Manning Roughness Coefficient

The Manning roughness coefficient value (n) depends on the physical material forming the channel.

3) Channel slope

The slope of the channel is a comparison between the difference in elevation and the length of the channel [1]. The formula for calculating the slope of the channel is as follows:

$$s_d = \frac{\Delta h}{L_d} \quad (5)$$

with:
Δh = Difference in elevation from the starting point and end of the channel base (m)
Ld = Channel length (m)
Sd = channel base slope

4) Flow

Channel capacity is calculated using the Manning equation. Following is the formula used to calculate drainage discharge:

$$Q = V.A \quad (6)$$

with:
Q = Flowing Debit (m3/sec)
V = Average speed in channel (m/sec)
A = Area of a wet cross-section of the channel (m2)

C. Economic Feasibility Analysis

In general, there are several methods commonly considered to be used in economic feasibility analysis, namely the method of Benefit-Cost Ratio (BCR) and Net Present Value (NPV)

1) Benefit-Cost Ratio (BCR)

Benefit-cost ratio (BCR) is a comparison between benefits and costs calculated based on the present value. If BCR> 1 is obtained, then the project is feasible (feasible) and if BCR <1, the project must be canceled or preliminary engineering carried out to obtain feasibility that matches the eligibility criteria [2].

2) Net Present Value (NPV)

Net Present Value is the difference between the Present Value of the investment and the present value of net cash receipts (operational cash flow and terminal cash flow) in the future. To calculate the present value it is necessary to determine the relevant interest rate. If the NPV> 0 value means that the project can create a cash inflow with a greater percentage than the opportunity cost of invested capital right. If NPV = 0, the project is likely to be accepted because the cash inflow to be obtained is the same as the opportunity cost of the invested capital. So the greater the NPV value, the better for the project to continue [3].

NPV calculations require two important activities, namely Etimating cash flows and Determining interest rates that are deemed relevant. NPV is calculated using the following formula:

$$NPV = \sum_{t=1}^{n} \frac{Bt - Ct}{(1+i)^t} \quad (7)$$

with:
C = Investment costs and operating costs
Bt = Benefit that has been discounted
I = Discount factor t = Year (time)

III. Methodology

This study uses a survey approach, while according to the level of explanation is a descriptive study. This is done to describe the condition of the drainage system performance as well as the influence and develop handle strategies appropriate to the issues raised. Stages of the activities carried out are observation, data collection, analysis, and interpretation of data to determine an indication of the problem as a basis for determining the ideal solution as well as set standards and correlation.

The data used is the data that is both qualitative and quantitative. Sources of qualitative data based on information from respondents who becomes the object of research. While quantitative data in the form of numbers or count are processed based on information from the public, institutions, the management board and the results of field observations obtained during the research process.

IV. Results and Discussion

The research location is in the Subdistrict of Lowokwaru Malang city located in the northern city of Malang and adjacent to the Subdistrict Karangploso Malang. Subdsitrict Lowokwaru has an altitude between 200-499 meters above sea level with slopes on the plateau is quite varied, in some places a plain area with a slope of 2-5%, while the hills of the valley section average slope of 8-15%.

The drainage system in Subdistrict Lowokwaru generally used the river as a sewer for final discharge. In Malang city is traversed by five (5) major rivers namely: Brantas River, Amprong River, Bango River, Metro River, and Sukun River. As for the Watershed is divided into three parts, namely:

1. Metro Watershed
2. Brantas Watershed
3. Bango Watershed

Division of Watershed in the Subdistrict Lowokwaru can be seen in Figure 1.

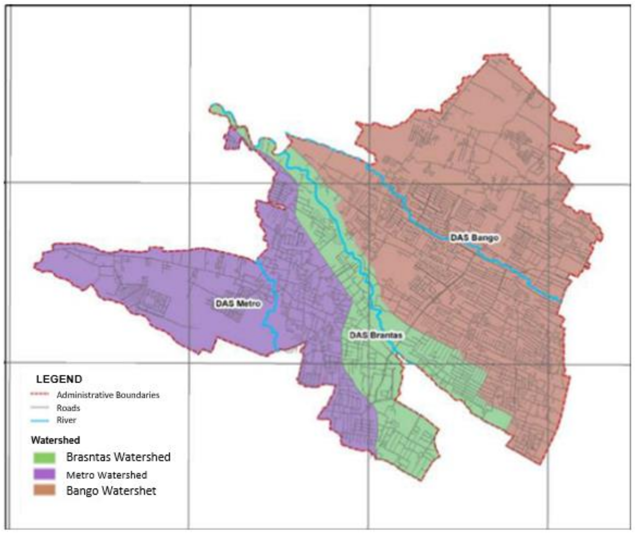

Figure 1. Watershed Map in the Subdistrict Lowokwaru.

A. *Hydrology*

Rainfall data used is the data maximum precipitation affecting the five weather stations with the research site over the past 10 years.

TABLE 1.
MAXIMUM DAILY RAINFALL DATA EACH WEATHER STATION

No.	Years	Weather Station (mm)			
		Karangploso (ST.1)	**Dau (ST.2)**	**Sukun (ST.3)**	**Ciliwung (ST.4)**
1	2008	104	110	130	95
2	2009	69	110	108	73
3	2010	68	144	178	186
4	2011	91	85	83	113
5	2012	108	97	169	138
6	2013	77	85	101	97
7	2014	105	100	134	125
8	2015	67	65	170	96
9	2016	97	94	122	64
10	2017	93	105	132	104
Average		88	100	133	109

The analysis of these data consistency and homogeneity of the data for accuracy and ensure that data is not contained significant deviations.

1) *Average rainfall analysis*

The analysis was calculated using the Thiessen Polygon method, the analysis is done from the calculation Thiessen coefficient obtained by dividing each area influence rainfall station (Figure 2).

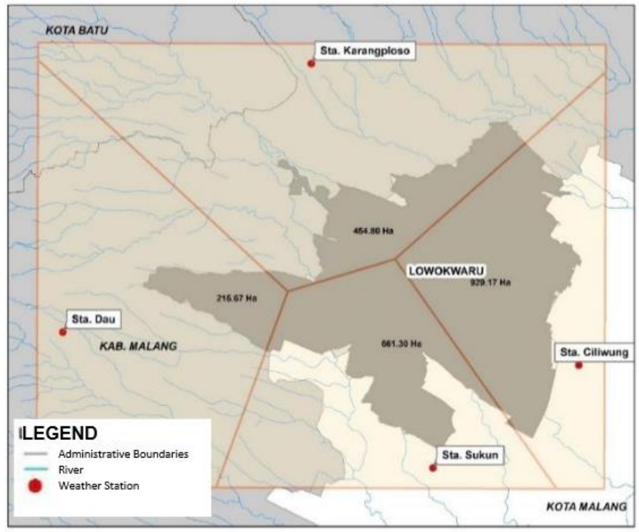

Figure 2. Map Thiessen Polygon Subdistrict Lowokwaru.

2) *The maximum daily rainfall plan analysis*

The maximum daily rainfall plan analysis is done by using two methods: Method Gumbel and Log Person III. From this method were analyzed Goodness of fit test using the Chi-square test and Smirnov-Kolmogorov test thus concluded that the appropriate distribution is the Gumbel method.

3) *Rain intensity distribution analysis*

Results distribution Gumbel method then calculate the rainfall intensity analysis by 3 methods: Van Breen, Bell, and Hasper Weduwen Method. Calculation Result elected rain intensity distribution is Van Breen Method of calculation with the PUH 5 years for the secondary sewer.

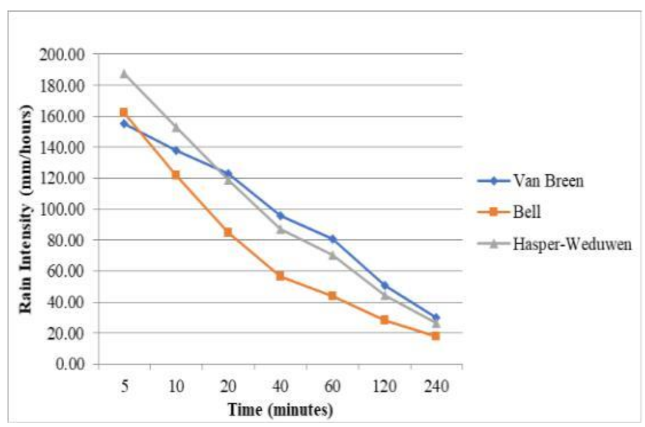

Figure 3. Comparison Graph of Rain Intensity PUH 5 Years.

4) *Rain intensity curve analysis*

Rain Intensity Curve Analysis using a method Talbot, Sherman and Ishiguro. The calculation of the three methods has a method that has the greatest rainfall intensity arch.

TABLE 3.
DIFFERENCE IN RAIN INTENSITY OF THE TALBOT, SHERMAN, AND ISHIGURO METHODS FOR PUH 5 YEARS.

t (minutes)	I (mm/hours)	I Talbot	I - I Talbot	I Sherman	I - I Sherman	I Ishiguro	I - I Ishiguro
5	165,47	161,44	4,03	199,69	34,22	197,50	32,03
10	140,87	147,65	6,78	148,37	7,50	151,48	10,61
20	127,46	126,11	1,35	110,25	17,21	113,94	13,52
40	97,27	97,62	0,35	81,92	15,35	84,37	12,90
60	81,62	79,63	1,99	68,85	12,77	70,36	11,26
120	50,31	51,28	0,97	51,16	0,85	51,17	0,86
240	30,19	29,95	0,23	38,01	7,82	36,93	6,74
Total	693,19		15,70		95,72		87,93
Average			2,24		13,67		12,56

Talbot method was chosen as a rain intensity formula because has a delta (A) smallest and can give optimum results. So that the formula used to calculate the amount of rain intensity using the equation:

$I=8864,48/(t+52,55)$

B. Hydraulics

1) Analysis of Existing Debit

Hydraulics analysis is used to determine the ability of the sewer to accommodate the runoff discharge. The analysis is done based on existing data obtained from the primary data and secondary data. The primary data is a length, the width of the base, the width of the surface, the depth of the sewer, and sediment. Calculation of sewer discharge conducted with two types of conditions that the sewer conditions without sediment and with sediment. Sewer discharge is obtained from the calculation of flow velocity multiplied by the channel cross-sectional area.

2) Discharge rainwater runoff analysis

Discharge rainwater runoff is influenced by land use in the catchment area, the variables that influence is runoff length, runoff slope, manning coefficient, assumption of water velocity in a sewer, drainage time, selected rainfall intensity PUH 5 years, and drainage coefficient.

3) Wastewater discharge analysis

Subdistrict Lowokwaru drainage system is a mixed drainage system between rainwater and wastewater. Based on the number of residents in the catchment area as well as the extent of the need of clean water per person per day plus non-domestic water needs, it can be calculated the amount of wastewater into the sewer.

4) Evaluation of drainage system capacity

Evaluation of the capacity of the drainage system is reviewed based on the total discharge amount of rainfall-runoff and wastewater discharge on existing conditions and then compared to sewer discharge. Evaluation of the capacity of the drainage system needs to be done to determine whether the condition of the existing sewer is still in accordance with the requirements or necessary for the development.

The evaluation results indicate the sewer capacity there are 21 sewers in condition without sediment that capacity is insufficient and 23 sewers in conditions with sediment are not met or sewer capacity is not technically eligible. It is necessary for a handling plan as an attempt to deal with the sewer capacity to drain the runoff discharge.

5) Alternative Treatment

Based on the evaluation result in conditions with sediment to maximize sewer capacity and reduce the inundation, it needs to dredge sediment and calculated sewer dimensions based on the rainwater runoff. The following sewer handling plan in the form of ideal sewer dimensions in Table 4 to 6.

C. Economic Feasibility Analysis

1) Investment Costs

Investment costs are costs allocated in the context of implementing development which includes construction costs, technical consultants, compensation, administration, and taxes. These investment costs must be provided at the beginning of the construction or before the project is implemented, if the investment costs are too large then construction can be carried out in a period of multi-years. The total investment cost of channel construction in Lowokwaru District is 8 billion rupiah.

2) Operation and Maintenance Costs (O&M)

Operational and maintenance costs (O&M) are costs required to carry out periodic maintenance of all drainage systems in Subdistrict Lowokwaru so that the channel capacity can be maintained properly and the channel can function to drain water. O&M fees are incurred if the construction has been completed and has started operation. Because construction is carried out in stages, O&M costs are calculated in the following year assuming the construction has been operated. Operation and maintenance costs include the cost of cleaning the channel and dredging the channels from the sediment. The amount of drainage channel O&M costs in Subdistrict Lowokwaru is 600 million rupiah.

TABLE 4.
SEWER HANDLING PLAN FOR THE BRANTAS WATERSHED

Sewer Code		Sewer Name	Sewer Length (m)	Existing dimensions (M)				Q (m3/s)	Evaluation	Dimensions Plan (M)				Q (m3/s)	Evaluation
				B	b	H	H water max			B	b	H	H water max		
BR.S	1	MT Haryono	1478.87	0.50	0.80	1.10	0.93	1.92	Not Qualify	1.00	1.50	1.00	0.83	4.32	Qualify
BR.S	2	MT Haryono	978.69	0.50		1.10	1.05	1.63	Not Qualify	1.00		1.00	0.95	4.08	Qualify
BR.S	3	Sukarno Hatta	866.43	0.65	0.83	0.44	0.24	0.36	Not Qualify	1.00	1.65	1.00	0.80	4.04	Qualify
BR.S	4	Sukarno Hatta	463.61	0.50		0.50	0.40	0.64	Not Qualify	1.50		1.00	0.90	8.31	Qualify
BR.S	5	Bungur	990.37	1.00	1.50	1.50	1.28	3.40	Qualify	1.00	1.50	1.50	1.28	3.40	Qualify
BR.S	6	Gajayana	479.95	0.40	0.50	0.40	0.19	0.14	Not Qualify	1.00	1.50	1.40	1.19	6.35	Qualify
BR.S	7	Sumbersari	1187.55	0.50		0.50	0.48	0.34	Not Qualify	1.50		1.50	1.48	6.57	Qualify
BR.S	8	Veteran	1532.74	0.40		1.00	0.98	0.85	Not Qualify	1.40		1.00	0.98	5.30	Qualify
BR.S	9	Bungur	615.21	1.50		1.50	1.35	7.48	Qualify	1.50		1.50	1.35	7.48	Qualify
BR.S	10	sarangan	704.58	0.65		0.50	0.45	0.73	Not Qualify	1.65		1.00	0.95	6.85	Qualify
BR.S	11	Mayjend Panjaitan	284.94	0.50	1.00	0.80	0.71	1.94	Qualify	0.50	1.00	0.80	0.71	1.94	Qualify
BR.T	1	Kumis Kucing	887.00	0.50		0.50	0.38	0.42	Not Qualify	1.00		1.00	0.88	3.18	Qualify
BR.T	2	Dewandaru	421.69	0.75	0.60	0.50	0.33	0.44	Not Qualify	0.75	1.60	1.00	0.83	1.42	Qualify
BR.T	3	Surabaya	749.86	0.35	0.50	0.50	0.41	0.35	Not Qualify	0.50	1.00	1.00	0.91	2.16	Qualify
BR.T	4	Jakarta	499.64	0.40		0.50	0.40	0.18	Not Qualify	1.00		1.00	0.90	1.84	Qualify

TABLE 5.
SEWER HANDLING PLAN FOR THE METRO WATERSHED

Sewer code		Sewer name	Sewer Length (m)	Existing dimensions (M)				Q (m3/s)	Evaluation	Dimensions Plan (M)				Q (m3/s)	Evaluation
				B	b	H	H water max			B	b	H	H water max		
MS	1	Joyo Suryo	664.57	1.50		1.00	0.93	4.02	Qualify	1.50		1.00	0.93	4.02	Qualify
MS	2	Joyo Suryo	427.07	1.00		0.75	0.65	2.21	Qualify	1.00		0.75	0.65	2.21	Qualify
MS	3	Puncak Mandala	558.30	1.00	1.50	1.00	0.88	2.86	Qualify	1.00	1.50	1.00	0.88	2.86	Qualify
MS	4	Mertojoyo	893.88	1.50		1.00	0.95	6.16	Qualify	1.50		1.00	0.95	6.16	Qualify
MS	5	Sunan Kalijaga	1135.72	0.50		0.75	0.72	0.59	Not Qualify	1.50		0.75	0.72	2.77	Qualify
MS	6	Bend. Sutami	874.80	2.00		1.50	1.38	9.36	Qualify	2.00		1.50	1.38	9.36	Qualify
MS	7	Joyo Agung	2357.95	1.00		1.20	1.16	9.01	Qualify	1.00		1.20	1.16	9.01	Qualify
MS	8	Simpang Gajayana	344.18	0.50		0.60	0.51	0.31	Not Qualify	1.50		1.00	0.91	3.06	Qualify
MT	1	Joyo Sari	80.06	0.59	0.76	0.85	0.80	1.78	Qualify	0.59	0.76	0.85	0.80	1.78	Qualify
MT	2	Joyo Sari	224.69	0.60		0.60	0.48	1.02	Qualify	0.60		0.60	0.48	1.02	Qualify
MT	3	Joyo Grand	577.03	0.40	0.50	0.47	0.38	0.21	Qualify	0.40	0.50	0.47	0.38	0.21	Qualify
MT	4	Simpang Gajayana	589.48	0.50		0.60	0.50	0.59	Not Qualify	1.50		0.60	0.50	2.61	Qualify
MT	5	Bend. Sigura-Gura	232.56	0.30		0.30	0.29	0.08	Not Qualify	1.30		0.50	0.49	1.19	Qualify
MT	6	Bend. Sigura-Gura	248.12	0.86		0.50	0.47	0.89	Not Qualify	1.50		0.50	0.47	1.84	Qualify
MT	7	Bend. Sigura-Gura	545.90	0.50		0.50	0.38	0.31	Not Qualify	1.50		1.00	0.88	4.12	Qualify
MT	8	Mertojoyo	389.82	0.30		0.30	0.26	0.04	Not Qualify	1.00		0.52	0.46	0.39	Qualify

TABLE 6.
SEWER HANDLING PLAN FOR THE BANGO WATERSHED

Sewer Code	Sewer Name	Sewer Length (m)	Existing Dimensions (M)				Q (m3/s)	Evaluation	Dimensions Plan (M)				Q (m3/s)	Evaluation
			B	b	H	H water max			B	b	H	H water max		
BS 1	Ikan Kakap	458.17	1.80	2.40	1.70	1.54	14.012	Qualify	1.80	2.40	1.70	1.54	14.01	Qualify
BS 2	Sukarno Hatta	707.22	0.60		0.50	0.38	0.521	Not Qualify	1.60		1.00	0.88	5.93	Qualify
BS 3	Sukarno Hatta	638.94	0.70		0.60	0.57	1,005	Not Qualify	1.70		0.60	0.57	3.30	Qualify
BS 4	Jendral Suprapto	490.70	0.80		0.55	0.48	0.838	Not Qualify	1.80		0.55	0.48	2.40	Qualify
BS 5	Borobudur	830.13	0.80		0.80	0.74	1,577	Not Qualify	1.80		0.80	0.74	4.78	Qualify
BS 6	Terminal Suryo	512.18	0.93		1.07	0.94	3.128	Qualify	0.93		1.07	0.94	3.13	Qualify
BS 7	Semanggi	4287.90	3.00		1.00	0.88	10.316	Qualify	3.00		1.00	0.88	8.61	Qualify
BS 8	Balean	888.39	1.60		1.00	0.79	5,264	Qualify	1.60		1.00	0.79	3.86	Qualify
BS 9	Kedawung	2500.02	2.00		1.50	0.83	4,895	Qualify	2.00		1.50	0.83	4.89	Qualify
BS 10	Kedawung	1673.14	1.60		1.00	0.96	6,441	Qualify	1.60		1.00	0.96	6.44	Qualify
BS 11	Papa kuning	1948.13	2.20		1.30	1.28	11.565	Qualify	2.20		1.30	1.28	11.57	Qualify
BS 12	Tunjung sekar	1822.97	2.50	3.00	1.50	1.09	10.79	Qualify	2.50	3.00	1.50	1.09	10,79	Qualify
BS 13	Tunjung sekar	2079.07	3.00		2.00	1.63	19.375	Qualify	3.00		2.00	1.63	19.38	Qualify
BS 14	Ikan Mujaer Raya	951.11	1.70		0.50	0.39	1,286	Not Qualify	1.70		1.00	0.89	4.06	Qualify
BS 15	Perum G.Sejahtera	1538.37	2.00		1.50	1.38	10.848	Qualify	2.00		1.50	1.38	10.85	Qualify
BS 16	Akordion barat	1535.25	0.60		1.00	0.98	1,009	Not Qualify	1.00		1.00	0.98	2.15	Qualify
BS 17	Suhat kiri	679.28	0.45		0.80	0.77	0,829	Not Qualify	1.00		0.80	0.77	2.67	Qualify
BS 18	Cengger Ayam	554.26	1.00		1.50	1.29	2,697	Qualify	1.00		1.50	1.29	2.70	Qualify
BS 19	Kendalsari	1128.93	1.50	2.00	1.00	0.85	4.692	Qualify	1.50	2.00	1.00	0.85	4.69	Qualify
BS 20	Kendalsari	1668.41	1.50	2.00	1.00	0.46	1.822	Not Qualify	1.50	2.00	2.00	1.46	8.59	Qualify
BS 21	Taman borobudur	3931.12	1.40	2.00	1.10	0.76	2,581	Qualify	1.40	2.00	1.10	0.76	2.58	Qualify
BS 22	Ikan lodan	3201.32	1.50		0.60	0.57	2,967	Qualify	1.50		0.60	0.57	2.97	Qualify
BS 23	Sarangan	694.51	0.50	1.00	0.70	0.69	1,154	Not Qualify	0.50	1.50	1.00	0.99	2.74	Qualify
BS 24	Tirtonadi	398.73	0.95	1.50	1.55	1.48	7.075	Qualify	0.95	1.50	1.55	1.48	7.07	Qualify
BS 25	Ters.Wijayakusuma	815.53	0.75	1.00	0.50	0.48	1.292	Not Qualify	0.75	1.00	1.00	0.98	3.18	Qualify
BT 26	Sanan	194.35	2.00		1.50	1.38	10.367	Qualify	2.00		1.50	1.38	10.37	Qualify
BT 1	Kalpataru	1527.80	0.60		0.60	0.33	0.472	Not Qualify	1.60		1.00	0.73	5.03	Qualify
BT 2	Kedawung	747.73	0.60		0.60	0.52	0,568	Not Qualify	1.60		1.00	0.92	4.60	Qualify
BT 3	Kedawung	748.33	0.50		0.65	0.62	0,829	Not Qualify	1.50		0.65	0.62	3.82	Qualify
BT 4	Kalpataru	686.45	0.60		0.60	0.59	1,148	Not Qualify	1.60		0.60	0.59	4.37	Qualify
BT 5	Suhat	453.44	0.50		0.5	0.43	0.335	Not Qualify	1.50		1.00	0.93	3.44	Qualify
BT 6	Bulutangkis	1196.84	1.00		0.5	0.49	1,579	Qualify	1.00		0.50	0.49	1.58	Qualify
BT 7	Letjen Sutoyo	1087.84	0.80		0.56	0.55	1,162	Not Qualify	1.00		0.56	0.55	1.58	Qualify
BT 8	Simpang akordion	433.87	1.00		0.8	0.77	4,010	Qualify	1.00		0.80	0.77	4.01	Qualify

3) Benefit Component (Benefit)

The value of project benefits is estimated at the value of losses due to flooding, where poor drainage will have the opportunity to produce physical damage to the city's facilities and infrastructure as well as financial losses caused by overflowing canals. Losses due to flooding are physical losses incurred due to the occurrence of puddles in a particular area including indirect losses or non-tangible losses which are all marginalized in the rupiah value. According to [4] the number of losses due to flooding that is calculated consists of:

1. Direct physical loss
2. Indirect damage to the commercial
3. Non-tangible non-market damage
4. Expansion and development of land in the future The amount of losses due to flooding is the sum of the total values of l, 2, 3 and 4.

In addition to the losses that can be calculated, there are also losses that cannot be calculated such as feeling anxious during the rain, time wasted on cleaning the house and yard after the flood, unable to work, damage to private vehicles, additional transportation costs (Travel costs), delays in travel or delays in travel, medical and health expenses and others. From the results of calculations that have been done the amount of losses per year caused by flooding that occurred in the amount of Rp. 1,156,834,639.08.

4) Investment Feasibility Assessment

An investment feasibility assessment is conducted to assess whether the project activity is feasible or not from the financial aspect. The technical life of the drainage system to be built is estimated to be 15 years. O&M fees begin to be issued in the 1st year after the entire project is completed. The benefit is obtained from the reduction of floods/inundations that began to be obtained starting in the 1st year with the completion of all project activity plans, where the value of benefits will increase every year in accordance with the assumed inflation rate of 5%. The interest rate commonly used in irrigation projects is 12%, to adjust to the current economic conditions, the interest rates (10%) are used in the drainage system development project in Subdistrict Lowokwaru.

Based on the results of the financial analysis that has been carried out above, it can be concluded that the repair and construction of drainage systems carried out to overcome flooding in the drainage system in Subdistrict Lowokwaru Subdistrict are financially feasible. This can be seen from the value of the Benefit Cost Ratio (BCR) whose value is 1.83 (> 1) and the value of the Net Present Value (NPV) whose value is Rp. 135,811,920,851 (positive). Seeing the high costs needed to tackle floods in the drainage system in Subdistrict Lowokwaru, as well as looking at the financial capabilities of Malang City so far, the Malang City government is actually quite capable of funding these activities. But because flood management programs in other locations also require substantial funds, it is necessary to think of other alternative funding sources.

V. Conclusion

According to analysis carried out on the evaluation of drainage system for inundation problems at Subdistricts Lowokwaru, it can be concluded as follows:

a. Sewer problems in the Subdistrict Lowokwaru form of sewer blockage due to garbage, sediment at the bottom of the sewer, and sewer inlet which is higher than the road.
b. Based on the evaluation result of the sewer there are 21 sewers in condition without sediment that capacity is insufficient and 23 sewers in conditions with sediment are not met or sewer capacity is not technically eligible.
c. The handling plan is in the form of cleaning and dredging of trash and sediment, as well as the calculation of the ideal sewer dimensions to drain the discharge runoff accordingly.

VI. Acknowledgment

This publication based on Master Program Thesis which conducted in 2019, entitled “Evaluation of Drainage System for Inundation Problems at Subdistricts of Lowokwaru Malang City”.

References

[1] H. S. Masduki, *Perencanaan Sistem Drainase Perkotaan*. Bandung, Indonesia: Institut Teknologi Bandung, 1988.
[2] S. Suripin, *Sistem Drainase Perkotaan yang Berkelanjutan.* Yogyakarta: Andi Offset, 2004.
[3] F. Rangkuti, *Analisis SWOT Teknik Membedah Kasus Bisnis*. Jakarta: Gramedia Pustaka Utama, 2004.
[4] R. J. Kodoatie, *Rekayasa dan Manajemen Banjir Kota*. Yogyakarta, Indonesia: Andi Offset, 2013.