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Drainage Analysis of the West Outer Ring Road Surabaya

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ABSTRACT

The development of West Outer Ring Road, abbreviated as JLLB, to improve the quality of infrastructure in the City of Surabaya. A breakthrough is needed by opening a new existing road section to break down traffic jams leading to the central city's main corridor section. The JLLB area, originally a green open area, was converted into a road area. This condition will cause changes in the sum of rainwater run-off that occur. The JLLB also intersects with the railroad tracks. A drainage system plans to ensure no puddles on the road, even though the railroad tracks. The method of this study follows hydrological and hydraulics analysis of the drainage systems. The results of drainage analysis on West Outer Ring Road, abbreviated as JLLB, there are several typical canal dimensions needed. All velocities can be controlled in the range of permissible velocity. The minimum velocity is 0,4 m/sec, and the maximum is 0,873 m/sec. The maximum planned discharge is 1,381 m3/sec. The capacity of boezem is planned to suit 5,104 hr of rain duration. Based on all that results, the drainage analysis of JLLB would be great if implemented according to plan.

1. Introduction

The drainage system is a component that aims to drain waste or liquid into a body of water through interconnected channels [1][2]. Liquid waste and rainwater, both from domestic and public buildings, as well as the road, will be channelled together to a water disposal site [3]. Within the drainage system, various activities support success in channelling wastewater through controlling, operating and providing the necessary actions. As cities develop and grow, the increase in the number of buildings and roads becomes another problem in the drainage system. Without good road drainage planning, it will have an impact on road inundation which can hamper urban traffic. In fact, cities in various countries are building more roads beside buildings to provide better access in order to reach more for the most distant areas [2]. This means that the application of a road drainage system is important in construction planning [4]. On the other hand, this study will analyze the function of the drainage system and its relationship with rainwater retention ponds [5][6]. Rain conditions change every year in line with the current climate change issue. The retention pond is expected to be able to provide a

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spoon function for the city so that the management of municipal water and waste becomes more manageable.

The development of West Outer Ring Road, abbreviated as JLLB, is one of the government's efforts to improve the quality of infrastructure in the City of Surabaya [7][8]. An imbalance between the length and width of access roads in Surabaya with the number of vehicles causes it. That is the leading cause of congestion and traffic density at every point in the City of Surabaya, especially during the active hours in the morning and the late afternoon when people leave and come home from their activities. It is explained in the spatial planning regulation of Surabaya City that there is a need for a breakthrough by opening a new existing road section to break down traffic jams that lead to the main corridor section of the central city [8].

The problem of flooding and inundation in Indonesia is a national problem that affects all aspects of life public [9]. The flood incident also occurred around the main road or a highway. Proper drainage is a very important consideration in the design of a highway. Inadequate drainage facilities can lead to premature deterioration of the highway and the development of adverse safety conditions such as hydroplaning [10]. One of the comfort factors for road users is the absence of puddles. This puddle will not occur without an excellent drainage system [10]. High rainfall can cause road puddles if the existing drainage system cannot correctly receive rainwater run-off. Even though JLLB is not densely populated, an excellent drainage system analysis is needed. Therefore, it will make it safe and comfortable for all road users.

The JLLB area, originally a green open area, was converted into a road area. This condition will cause changes in the sum of rainwater run-off that occur [11][12]. Initially, the run-off coefficient ranged from 0.3 to 0.5 due to green open land areas [13][14]. Now the land use has changed to roads where the run-off coefficient ranges from approximately 0.90 [13][15]. Therefore, the run-off discharge in the area around the JLLB construction will increase.

The drainage route plan follows the West Outer Ring Road (JLLB) Trace Plan for Surabaya City [8]. This research will take a case study on the JLLB section, which intersects with the railroad tracks, starting from Jalan Raya Sememi, the location of the STA. 00+350 up to STA. 1+250. Planning a drainage system is challenging because the existing drainage system must ensure no puddles on the road, even through the railroad tracks.

In this study, an analysis will be carried out on the amount of design discharge that occurs with a return period of 5 and 10 years. Then it will be planned how many dimensions of the drainage channels are needed. Besides that, it will also consider the boezem or reservoir dimensional needs and how long the reservoir can withstand peak flood times. It must be planned because of the actual condition of JLLB across the railroads.

2. Research Method

2.1 Drainage System

The research procedure of JLLB's drainage analysis is as in drainage research in general. First of all, the catchment area of the drainage following the network of drainage plan must be defined. The flow direction and drainage network plans are based on the existing elevation area. If the slope is too steep, there will be a plan for excavation and embankment so that the elevation is safe for the allowable flow speed in the drainage canal. The problem is that this JLLB crosses the railroad tracks. This drainage analysis should ensure the railroad is safe from inundation. The siteplan of JLLB STA. 00+350 up to STA. 1+250 is shown in **Figure 1**.

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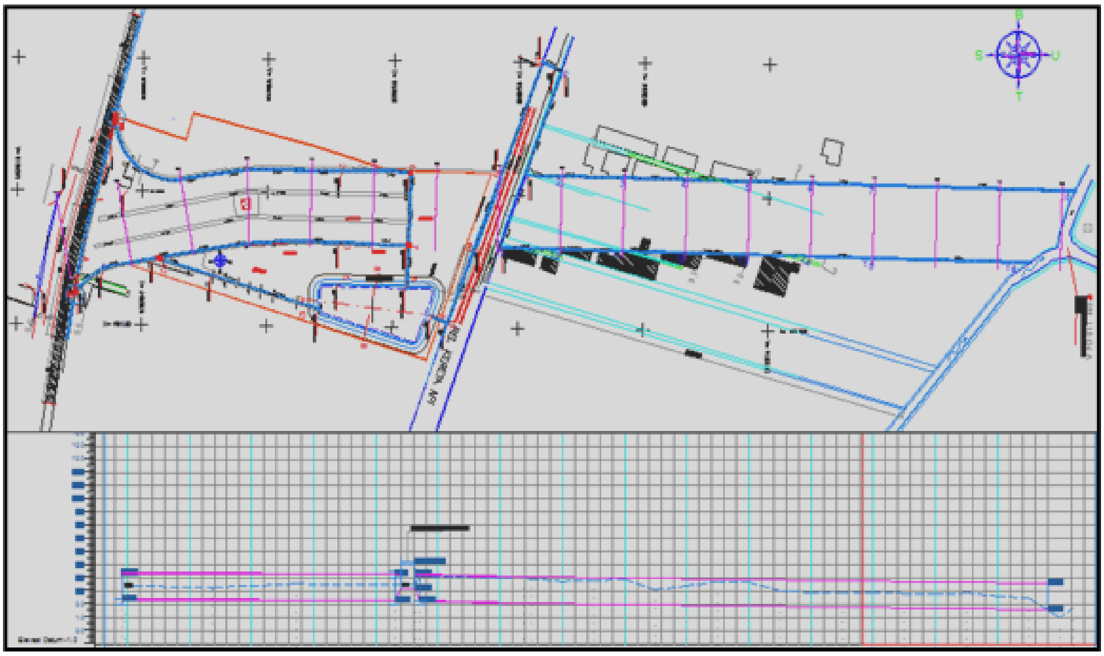
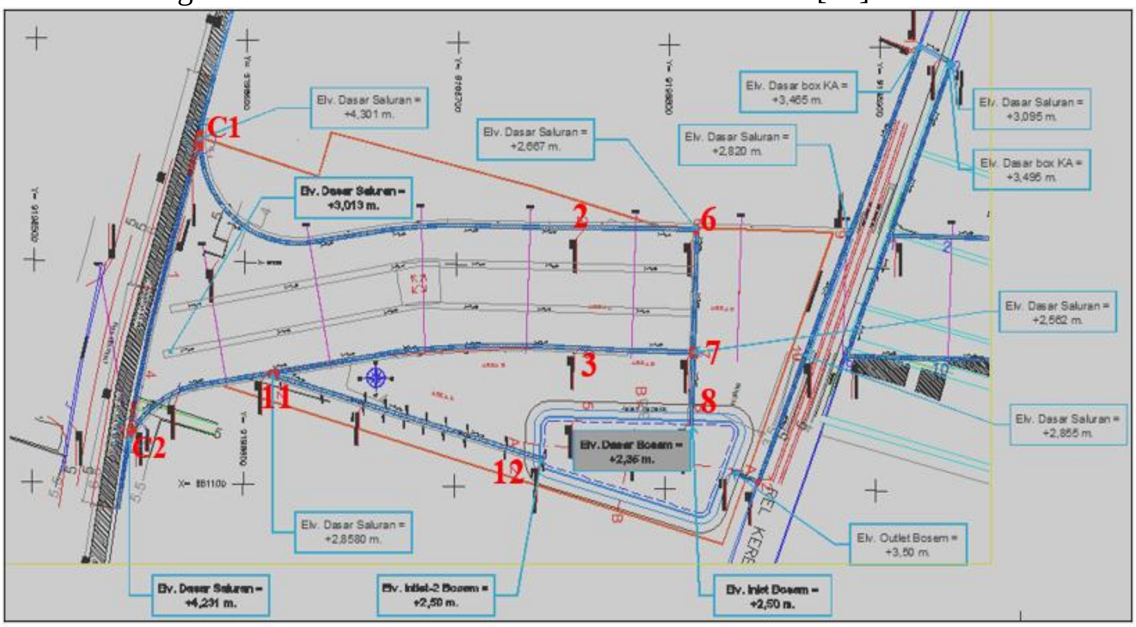


Source: Drawing Design for JLLB (2019).

Figure 1. Siteplan of JLLB STA. 00+350 up to STA. 1+250

The drainage system will be divided into two, that is, the north and the south of the railroads. Figure 2 is the drainage system on the south side of the railroads, while Figure 3 is on the north side of the railroads. Cause the slope of the area is average from south to north, the flow direction of the drainage system will be planned like that too. The south side of the railroads is equipped with boezem, which aims to accommodate run-off water before it is channelled through the culvert under the railroads to the north side[16].



Source: Drawing Design for JLLB (2019).

Figure 2. Siteplan of the Drainage System on the South Side of the Railroads

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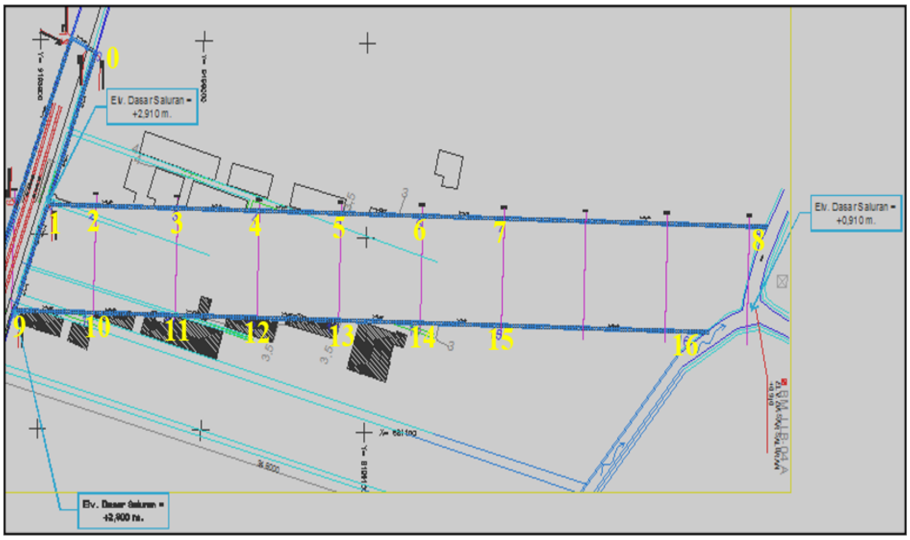

Source: Drawing Design for JLLB (2019).

Figure 3. Siteplan of the Drainage System on the North Side of the Railroads

After the drainage system is defined, a basic inventory is made of the channel's name, the channel's length, the channel's slope, and each channel's catchment area. The further step is finding the initial flow length (L_0) from the land through the canal to know the flow's concentration time. These data will be used in the calculation of the hydraulics of the channel.

2.2 Hydrology Analysis

Meanwhile, rainfall data is needed for hydrological calculations to determine the planned discharge for the return period—the data required for at least the past ten years. The rainfall data will be analyzed for the Pearson Type 3 frequency distribution[17]. Then a goodness of fit test will be conducted to determine if the frequency distribution method is suitable [18]. For the JLLB drainage analysis, a planned discharge for a return period of 5 and 10 years will be sought following standard provisions from the government[19].

The discharge is calculated using the rational formula shown in Formula 1 below [20] [21]:

Q = 0,278 x C x I x A

Whereas:

Q = flood discharge (m^3/sec)
C = run-off coefficient [13]
I = rainfall intensity calculated with mononobe's formula (mm/hr) [18]
A = drainage area watershed (km^2)

2.3 Hydraulics Analysis

The capacity of the drainage channel will be analyzed by hydraulic analysis. Based on the data that has been collected, namely data on the slope of the canal plan and typical dimensions of the available culverts. First, we will determine how deep the water is at the design discharge with our chosen culvert dimensions. Then we will control the design flow rate within the allowable speed range for open channels.

The capacity of the drainage channel is calculated using Manning's Formula and Continuity's Formula [21], shown below:

Manning's formula $v = \frac{1}{n} R^{2/3} I^{1/2}$

The Continuity's formula Q = v x A

Whereas:

Q = capacity discharge (m^3/sec)
v = velocity (m/sec)
A = wet area cross-section (m^2)

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R = hydraulics radius
I = channel's slope

3. Results and Discussions

3.1 Design Rainfall Calculation

The initial step of the hydrological calculation is to process the maximum daily rainfall data obtained for 16 years from 2015 to 2022 in Table 1. This step aims to obtain a design rainfall for a return period of 5 and 10 years. To obtain the design rainfall, calculations are carried out using The Pearson Type III Frequency Distribution.

Table 1. Maximum Daily Rainfall Data in Perak Meteorological Station

No	Tahun	R (mm)
1	2015	139,6
2	2020	133,9
3	2013	129,3
4	2017	119
5	2016	114,5
6	2010	114
7	2019	103,5
8	2014	102,7
9	2011	102
10	2021	102
11	2012	93,7
12	2022	88
13	2007	83
14	2008	81
15	2009	81
16	2018	46,3

Source : BMKG Perak (2015-2022)

The results of calculating statistical parameters for rainfall data obtained an average value (R_{ave}) is 102.09 mm, a standard deviation (Stdev) is 23.63 mm, and a coefficient of skewness (Cs) is –0.5154. The results of the calculation of the design rainfall (R_T) for the return period (T) of 5 and 10 years can be seen in **Table 2**. The Pearson Coefficient of each return period, it can be found by looking at the value of Cs in the Pearson Table Type III [17] [18][21].

Table 2. Rainfall Design in Period Return using The Pearson Type III Distribution

T	R_{ave}(mm)	Cs	The Pearson Coef.	Stdev (mm)	R_T (mm)
(1)	(2)	(3)	(4)	(5)	(6) = (2) + (4) x (5)
5	102,09	-0,515	0,856	23,63	122,32
10			1,217		130,86

Source : Research Data (2023)

Furthermore, a goodness of fit test was carried out on the frequency distribution method used using the Smirnov Kolmogorov test and the chi-square test. The results of the test showed that the design rainfall by the calculation of the Pearson Type III frequency distribution was acceptable.

3.2 Calculation of The Flow's Time Concentration (tc)

Before calculating the rain intensity, determine the timing of the flow from the farthest and highest channel elevation to the drainage outlet. The flow's time concentration (tc) is

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obtained from the sum of the initial flow's time (to be used) plus the flow's time while in the channel (tf)[12]. The to used is the largest value between the to from the road or the land compared to tc from the previous canal. The following is an example of calculating tc on one of the drainage canal's sections on the south side of the railroad tracks, and the complete calculation is shown in **Tables 3** and **4**.

Is known:

nd road = 0,025 [16][13]
nd land = 0,020 [16][13]
Lo road = 6,00 m (shop drawing's data)
Lo land = 363,15 m (topographical's data)
L canal = 134,45 m (project's data)
S road = 0,02 (shop drawing's data)
S land = 0,0045 (topographical's data)
v = 0,77 m/det (hydrological's data)

The calculation:

to road = 1,44 x (0,025 x 6/√0,02)0,467
= 1,480 menit
to land = 1,44 x (0,020 x 363,15/√0,0045)0,467
= 12,866 menit
to used = 12,866 menit
tf = 134,45/(60 x 0,77)
= 2,923 menit
tc = 12,866 + 2,923
= 15,789 menit = 0,263 jam

Table 3. Calculation of tc for The Drainage's Canal on the South Side of the Railroads

The Drainage's Canal	Initial Flow's Time					To used (min)	Canal Flow's Time			tc (min)	tc (hr)
	the land use	nd	Lo (m)	S	to (min)		L (m)	v (m/sec)	tf (min)		
(C-1) - 2	road	0,025	6	0,020	1,48	3,80	300,0	0,48	10,36	14,16	0,24
	land	0,020	26,73	0,005	3,80						
2-6	road	0,025	6	0,020	1,48	14,16	50,0	0,52	1,61	15,76	0,26
	land	0,020	86,74	0,010	5,46						
6-7	road	0,025	6	0,020	1,48	15,76	55,0	0,58	1,59	17,36	0,29
	land	0,020	187,68	0,025	6,32						
(C-2) - 11	road	0,025	6	0,020	1,48	6,81	77,0	0,56	2,28	9,08	0,15
	land	0,020	196,72	0,020	6,81						
11-3	road	0,025	6	0,020	1,48	9,08	144,0	0,69	3,50	12,58	0,21
	land	0,020	201,76	0,010	8,10						
3-7	road	0,025	6	0,020	1,48	12,58	75,0	0,73	1,71	14,29	0,24
	land	0,020	214,68	0,010	8,33						
7-8 (inlet boezem)	road	0,025	6	0,020	1,48	17,36	31,4	0,78	0,67	18,02	0,30
	land	0,020	223,14	0,010	8,49						
11-12 (inlet boezem)	road	0,025	6	0,020	1,48	12,84	134,5	0,73	3,08	15,92	0,27
	land	0,020	363,15	0,005	12,84						

Source: Research Data (2023)

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Table 4. Calculation of tc for The Drainage's Canal on the North Side of the Railroads

The Drainage's Canal	Initial Flow's Time					To used (min)	Canal Flow's Time			tc (min)	tc (hr)
	the land use	nd	Lo (m)	S	to (min)		L (m)	v (m/sec)	tf (min)		
0-1	road	0,025	6	0,020	1,48	1,83	83,8	0,40	3,49	5,33	0,09
	land	0,020	22,21	0,070	1,83						
1-9	road	0,025	6	0,020	1,48	5,33	59,0	0,45	2,18	7,51	0,13
	land	0,020	35,68	0,090	2,16						
1-2	road	0,025	6	0,020	1,48	5,33	40,0	0,42	1,58	6,91	0,12
	land	0,020	25,76	0,010	3,10						
2-3	road	0,025	6	0,020	1,48	6,91	50,0	0,45	1,86	8,77	0,15
	land	0,020	29,27	0,010	3,29						
3-4	road	0,025	6	0,020	1,48	8,77	51,0	0,48	1,77	10,54	0,18
	land	0,020	44,21	0,020	3,39						
4-5	road	0,025	6	0,020	1,48	10,54	52,0	0,50	1,73	12,27	0,20
	land	0,020	53,96	0,030	3,38						
5-6	road	0,025	6	0,020	1,48	12,27	53,0	0,53	1,68	13,95	0,23
	land	0,020	58,63	0,030	3,52						
6-7	road	0,025	6	0,020	1,48	13,95	54,0	0,54	1,65	15,60	0,26
	land	0,020	62,71	0,030	3,63						
7-8	road	0,025	6	0,020	1,48	15,60	160,6	0,59	4,57	20,17	0,34
	land	0,020	64,25	0,030	3,67						
9-10	road	0,025	6	0,020	1,48	7,51	50,0	0,50	1,68	9,19	0,15
	land	0,020	65,27	0,050	3,28						
10-11	road	0,025	6	0,020	1,48	9,19	51,0	0,53	1,60	10,79	0,18
	land	0,020	80,35	0,060	3,47						
11-12	road	0,025	6	0,020	1,48	10,79	52,0	0,56	1,54	12,32	0,21
	land	0,020	94,16	0,080	3,49						
12-13	road	0,025	6	0,020	1,48	12,32	53,0	0,60	1,48	13,81	0,23
	land	0,020	112,8	0,110	3,53						
13-14	road	0,025	6	0,020	1,48	13,81	54,0	0,62	1,45	15,26	0,25
	land	0,020	118,2	0,090	3,78						
14-15	road	0,025	6	0,020	1,48	15,26	100,0	0,65	2,56	17,81	0,30
	land	0,020	115,7	0,040	4,52						
15-16	road	0,025	6	0,020	1,48	17,81	125,0	0,70	2,96	20,77	0,35
	land	0,020	167,2	0,080	4,56						

Source: Research Data (2023)

3.3 Rainfall Intensity Calculation (I)

Rainfall intensity is calculated using the mononobe formula (citation); the complete calculation can be seen in **Table 7.** and **Table 8**. Meanwhile, the calculation example below for the drainage canal (C-1) – 2 on the south side of the railroads:

$$I = \frac{R}{24} x \left[\frac{24}{tc}\right]^{2/3}$$

$$= \frac{122,32}{24} x \left[\frac{24}{0,263}\right]^{2/3}$$

$$= 111,061 \text{ mm/hr}$$

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3.4 Calculation of Combined Run-off Coefficient (Cgab) and Watershed Area (A)

The area around JLLB is still open land, so the drainage catchment area comes from the road itself and the open land in the JLLB area. The coefficient of run-off depends on the coverage area. For the open land, the value is 0,5, while for the road, the value is 0,95. The complete calculation of Cgab can be seen in Table 5 and Table 6. Meanwhile, the calculation example below for the drainage canal (C-1) – 2 on the south side of the railroads:

$$Cgab = \frac{Aroad \; x \; Croad + Aland \; x \; Cland}{Atotal}$$

$$= \frac{0{,}0018 \; x \; 0{,}95 + 0{,}0080 \; x \; 0{,}5}{0{,}010}$$

$$= 0{,}582$$

Table 5. Calculation of Cgab and A for The Drainage's Canal on the South Side of the Railroads

The Drainage's Canal	A (km)			Cgab
	road	land	total	
(C-1) - 2	0,0018	0,0080	0,010	0,582
2-6	0,0021	0,0124	0,014	0,565
6-7	0,0024	0,0227	0,025	0,544
(C-2) - 11	0,0005	0,0151	0,016	0,513
11-3	0,0013	0,0442	0,046	0,513
3-7	0,0018	0,0603	0,062	0,513
7-8 (inlet boezem)	0,0044	0,0900	0,094	0,521
11-12 (inlet boezem)	0,0013	0,0640	0,065	0,509

Source: Research Data (2023)

Table 6. Calculation of Cgab and a for the Drainage's Canal on the North Side of the Railroads

The Drainage's Canal	A (km)			Cgab
	road	land	total	
0-1	0,0005	0,0019	0,002	0,596
1-9	0,0009	0,0040	0,005	0,580
1-2	0,0007	0,0029	0,004	0,592
2-3	0,0010	0,0044	0,005	0,587
3-4	0,0013	0,0066	0,008	0,576
4-5	0,0017	0,0094	0,011	0,567
5-6	0,0020	0,0125	0,015	0,561
6-7	0,0023	0,0159	0,018	0,557
7-8	0,0033	0,0262	0,029	0,550
9-10	0,0012	0,0072	0,008	0,562
10-11	0,0015	0,0113	0,013	0,551
11-12	0,0018	0,0162	0,018	0,544
12-13	0,0021	0,0222	0,024	0,539
13-14	0,0024	0,0286	0,031	0,535
14-15	0,0030	0,0402	0,043	0,531
15-16	0,0038	0,0611	0,065	0,526

Source: Research Data (2023)

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3.5 Calculation of Discharge Planned (Q_5 and Q_{10})

The Discharged Planned is calculated using the rational formula (citation); the complete calculation can be seen in **Tables 7. and 8**. Meanwhile, the calculation example below for the drainage canal (C-1) – 2 on the south side of the railroads:

$$Q = \frac{1}{3,6} CIA$$

$$= \frac{1}{3,6} 0,582 \times 111,061 \times 0,010$$

$$= 0,176 \ m^3/sec$$

Table 7. Calculation of Q for the Drainage's Canal on the South Side of the Railroads

The Drainage's Canal	A (km) total	Cgab	tc (hours)	I_5 (mm/hours)	I_{10} (mm/hours)	Q_5 (m^3/sec)	Q_{10} (m^3/sec)
(C-1) - 2	0,010	0,582	0,236	111,061	118,807	0,176	0,189
2-6	0,014	0,565	0,263	103,377	110,588	0,235	0,251
6-7	0,025	0,544	0,289	96,959	103,722	0,368	0,393
(C-2) - 11	0,016	0,513	0,151	149,315	159,729	0,332	0,356
11-3	0,046	0,513	0,210	120,176	128,558	0,780	0,834
3-7	0,062	0,513	0,238	110,396	118,096	0,976	1,044
7-8 (inlet boezem)	0,094	0,521	0,300	94,543	101,137	1,291	1,381
11-12 (inlet boezem)	0,065	0,509	0,265	102,722	109,887	0,947	1,013

Source: Research Data (2023)

Table 8. Calculation of Q for the Drainage's Canal on the North Side of the Railroads

The Drainage's Canal	A (km) total	Cgab	tc (hours)	I_5 (mm/hours)	I_{10} (mm/hours)	Q_5 (m^3/sec)	Q_{10} (m^3/sec)
0-1	0,002	0,596	0,089	213,130	227,996	0,083	0,089
1-9	0,005	0,580	0,125	169,526	181,351	0,132	0,141
1-2	0,004	0,592	0,115	179,223	191,724	0,107	0,115
2-3	0,005	0,587	0,146	152,876	163,539	0,135	0,144
3-4	0,008	0,576	0,176	135,218	144,649	0,172	0,184
4-5	0,011	0,567	0,204	122,187	130,709	0,213	0,228
5-6	0,015	0,561	0,232	112,183	120,008	0,254	0,271
6-7	0,018	0,557	0,260	104,103	111,364	0,293	0,314
7-8	0,029	0,550	0,336	87,704	93,821	0,395	0,423
9-10	0,008	0,562	0,153	148,151	158,484	0,194	0,207
10-11	0,013	0,551	0,180	133,136	142,422	0,261	0,279
11-12	0,018	0,544	0,205	121,822	130,319	0,332	0,355
12-13	0,024	0,539	0,230	112,938	120,815	0,411	0,439
13-14	0,031	0,535	0,254	105,663	113,033	0,487	0,521
14-15	0,043	0,531	0,297	95,297	101,944	0,607	0,650
15-16	0,065	0,526	0,346	86,011	92,011	0,815	0,872

Source: Research Data (2023)

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3.6 Channel's Dimensions

The hydraulics calculation aims to know the proper dimensions needed for drainage. In this study, planned rectangular cross section in all channels. The complete calculation can be seen in **Table 9.** and **Table 10**. Meanwhile, the calculation example below for the drainage canal (C-1) – 2 on the south side of the railroads:

Planned Dimension: Box Culvert 0,80 x 0,80

B = 0,80 m
H = 0,80 m
hair = 0,50 m (*trials*)
w = H – hair
= 0,80 – 0,50
= 0,30 m
A = B x hair
= 0,80 x 0,50
= 0,40 m^2
P = B + 2 x hair
= 0,80 + 2 x 0,50
= 1,80 m
R $= \frac{A}{P}$
$= \frac{0,40}{1,80}$
$= 0,222\ m$
S = 0,0005
n = 0,017
v $= \frac{R^{2/3}\ x\ S^{1/2}}{n}$
$= \frac{0,222^{2/3}\ x\ 0,0005^{1/2}}{0,017}$
$= 0,483\ ^{m}/_{sec}$ (OK)
Q = A x v
= 0,40 x 0,483
= 0,193 $^{m^3}/_{sec}$
ΔQ = 0,193 – 0,189
= 0,004 (OK)

The dimensions approved if ΔQ close to 0 m^3/sec and the permissible velocity is between 0,3 to 1,0 m/sec

Table 9. Calculation of Dimensions for the Drainage's Canal on the South Side of the Railroads

The Drainage's Canal	B (m)	hair (m)	w (m)	H (m)	A (m^2)	P (m)	R (m)	S	v (m/sec)	Q (m^3/sec)
(C-1) - 2	0,80	0,50	0,30	0,80	0,40	1,80	0,222	0,0005	0,483	0,193
2-6	1,00	0,49	0,51	1,00	0,49	1,98	0,247	0,0005	0,518	0,254
6-7	1,00	0,69	0,31	1,00	0,69	2,38	0,290	0,0005	0,576	0,398
(C-2) - 11	1,00	0,64	0,36	1,00	0,64	2,28	0,281	0,0005	0,564	0,361
11-3	1,20	1,02	0,19	1,20	1,22	3,23	0,377	0,0005	0,687	0,836
3-7	1,40	1,02	0,38	1,40	1,43	3,44	0,415	0,0005	0,732	1,045
7-8 (inlet boezem)	1,50	1,18	0,32	1,50	1,77	3,86	0,459	0,0005	0,782	1,384
11-12 (inlet boezem)	1,40	1,00	0,40	1,40	1,40	3,40	0,412	0,0005	0,728	1,019

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Source: Research Data (2023)

Table 10. Calculation of Dimensions for The Drainage's Canal on the North Side of the Railroads

The Drainage's Canal	B m	hair m	w m	H m	A m^2	P m	R m	S	v (m/sec)	Q (m^3/sec)
0-1	0,60	0,38	0,22	0,60	0,23	1,36	0,168	0,0005	0,400	0,091
1-9	0,70	0,47	0,23	0,70	0,33	1,64	0,201	0,0005	0,451	0,148
1-2	0,60	0,46	0,14	0,60	0,28	1,52	0,182	0,0005	0,422	0,116
2-3	0,70	0,46	0,24	0,70	0,32	1,62	0,199	0,0005	0,448	0,144
3-4	0,80	0,49	0,31	0,80	0,39	1,78	0,220	0,0005	0,480	0,188
4-5	0,80	0,57	0,23	0,80	0,46	1,94	0,235	0,0005	0,501	0,228
5-6	0,90	0,58	0,32	0,90	0,52	2,06	0,253	0,0005	0,527	0,275
6-7	0,90	0,65	0,25	0,90	0,59	2,20	0,266	0,0005	0,544	0,318
7-8	1,00	0,73	0,27	1,00	0,73	2,46	0,297	0,0005	0,585	0,427
9-10	1,00	0,43	0,57	1,00	0,43	1,86	0,231	0,0005	0,495	0,213
10-11	1,00	0,53	0,47	1,00	0,53	2,06	0,257	0,0005	0,532	0,282
11-12	1,00	0,64	0,36	1,00	0,64	2,28	0,281	0,0005	0,564	0,361
12-13	1,20	0,62	0,58	1,20	0,74	2,44	0,305	0,0005	0,596	0,443
13-14	1,20	0,71	0,50	1,20	0,85	2,61	0,324	0,0005	0,621	0,525
14-15	1,20	0,84	0,37	1,20	1,00	2,87	0,349	0,0005	0,652	0,653
15-16	1,40	0,89	0,51	1,40	1,24	3,17	0,391	0,0005	0,704	0,874

Source: Research Data (2023)

From **Table 9** and **Table 10**, the box culvert dimensions varied from 0,60 x 0,60 to 1,50 x 1,50 m. The maximum flow discharge is 1,384 m^3/sec on canal 7-8 towards boezem on the North Side of the Railroads.

3.7 Boezem's Dimensions

There is a possibility of flooding overflow through the railroad from the south to the north side. A reservoir is planned as a boezem to prevent the flood. The existing land area can be used as a boezem of about 1,000 m^2. At the same time, the depth of the boezem can be planned around 2 – 2.5 meters, including the freeboard. So, it is necessary to calculate how long the reservoir can withstand the peak discharge under extreme rainy conditions with a planned return period of 10 years.

In known:

H boezem = 2,5 m
w boezem = 0,3 m
h boezem = 2,2 m
A boezem = 1000 m^2

Calculation:

Qinlet = $Q_{7\text{-}18} + Q_{11\text{-}12}$
= 1,381 + 1,013
= 2,395 m^3/sec

Vol. max = h x A
= 2,2 x 1000
= 2200 m^3

T max = $\frac{2 \; x \; Vol}{Qinlet}$

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$$= \frac{2 \, x \, 2200}{2{,}395 \, x \, 3600}$$
$$= 5{,}104 \text{ hr}$$

The average rain duration in the east java area stands for 5 hours. If the reservoir lasts more than 5 hours, it is pretty good. It will be great if more than that, but it will need more space to be the reservoir.

4. Conclusion

The results of drainage analysis on West Outer Ring Road, abbreviated as JLLB, there are several typical canal dimensions needed. The box culvert dimensions varied from 0,60 x 0,60 to 1,50 x 1,50. All velocities can be controlled in the range of permissible velocity. The minimum velocity is 0,4 m/sec, and the maximum is 0,873 m/sec. The maximum planned discharge is 1,381 m^3/sec on the south side of the railroads. The capacity of boezem is planned to suit 5,104 hr of rain duration. Based on all that results, the drainage analysis of JLLB would be great if implemented according to plan. Suggestions for further research, a study should be carried out to adjust the optimization of the use of boezem so that it does not cause inundation automatically.

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