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Evaluation of Drainage Network System (Case Study of Pangkajene Kepulauan State Agricultural Polytechnic Campus Area)

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ABSTRACT

The purpose of this research is to identify the condition of highway drainage channels and evaluate the existing highway drainage network system in accommodating runoff discharge, channel dimensions and flow direction in channels that occur inundation in the Pangkajene Islands State Agricultural Polytechnic Campus area which is expected to help solve flooding problems in the area. The research method used is descriptive quantitative, which is a method of calculation and description of the results of field data processing. Secondary data collection includes; rainfall data for the last 10 years, obtained from the Department of Resources; topographic maps, drainage network maps and situation maps, obtained from the Politani Pangkep Campus planning section. Primary data collection is obtained from direct measurements in the field using a Waterpass measuring instrument to measure elevation and channel length. The results of this study found that the drainage capacity < 2-year and 5-year return period Plan Flood Discharge, so planning is needed to increase drainage capacity

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INTRODUCTION

The word drainage comes from the word drainage which means to drain or drain. Drainage is defined as the study of efforts to drain excessive water in an area and a system made to deal with the problem of excess water both water above ground level and water below ground level, Excess water can be caused by high rain intensity or as a result of long rain duration (Yudi Mardiansyah, et al., 2009), In general, drainage can be interpreted as a series of water buildings that function to remove or reduce excess water from a place or land so that the land can be used optimally.

The Pangkajene Islands State Agricultural Polytechnic Campus, hereinafter referred to as Politani Pangkep, is located in Mandalle District, Pangkajene and Islands Regency. To the east of the campus location there are mountains and residential areas while to the west is directly adjacent to the Makassar Strait, with the location of the campus in the middle between the mountains and the sea, the campus area is openly a water overflow path if the drainage system is managed properly.

On February 13, 2023, there was a flood or inundation that was quite extensive and the height ranged from ± 20-30 cm in the courtyard of the rectorate building and its surroundings, resulting in disruption of comfort in activities in the campus environment, where in general the main causes of inundation are changes in land use, rainfall, inadequate drainage capacity and improper flood control system planning (Andrianto, J. et al., 2021) from the results of observations in the field In addition to sedimentation problems, damaged channel conditions are also one of the causes of inundation, inundation that occurs on the road surface, this can cause damage to road construction. Therefore, research was conducted on the performance of existing drainage channels in the Pangkajene Islands State Agricultural Polytechnic campus area, so as to maximize the function of the drainage channels.

The purpose of this research is to identify the condition of the drainage channel of the Pangkajene Islands State Agricultural Polytechnic Campus and evaluate the existing Campus drainage network system in accommodating runoff discharge, channel dimensions and flow direction in channels that occur inundation in the Campus Environment.

LITERATUR REVIEW

Drainage comes from the English word "drainage" which means to drain, drain, dispose of or drain water. Drainage can also be defined as a series of water structures that function to reduce and/or remove excess water from an area or land, so that the land can be optimally utilized. Drainage is also defined as an effort to control groundwater quality in relation to salinity (H. Tangkudung, L. et al., 2013).

Channel Classification when viewed in physical terms (hierarchical arrangement of channels) urban drainage systems are classified on primary, secondary, tertiary channels and so on.

a. Primary Channels
   Channels that utilize rivers and creeks. Primary channels are the main channels that receive flow from secondary channels.
b. Secondary channels
   Channels that connect tertiary channels with primary channels (built with concrete / cement plaster).
c. Tertiary channels
   Channels for draining household waste into secondary channels, in the form of stucco, pipes and soil.
d. Kwarter Channel
   Collector channel of the local drainage network.

Hydrology is the science related to water on earth, both regarding its occurrence, circulation and distribution, its properties and relationships with its environment, especially with living things. The science of hydrology is strongly influenced by hydrological parameters in an area such as rain intensity, climatological conditions (wind, air temperature, air humidity, and solar irradiation), land conditions (watershed) such as soil type, land use, land slope, and so on. The hydrological analysis used in this planning is using the Modified Rational method. This method can be used because it is in accordance with the existing data and field conditions. This method is used with the assumption that DTA has a wide area (C. Deva, et al., 2021). Factors considered in the calculation of the average maximum regional rainfall are the number of rain gauge posts and watersheds (Andrianto, J. et al., 2021).

Distribution analysis is generally divided into two: Discrete distribution is Poisson method and binomial method, while continuous distribution is Normal method, Log Normal method, Log Pearson method and Gumbel method. This frequency analysis is based on the statistical properties of past event data to obtain the probability of future rainfall amounts.

Flow in open channels and closed channels that have free surfaces is called free surface flow or open channel flow. In closed drainage channels in the form of culverts, there is a possibility of free flow during normal times and during flooding due to sudden rainfall the water will fill the culverts so that the flow is depressed. Channel capacity aims to determine the ability to channel / pass water (discharge). Channel dimensions are determined based on maximum Q, flow velocity, channel slope, and the type of channel material to be used (Muhamad Arifin., 2018).

METHODOLOGY

This research was conducted in July-October 2023 in the Pangkajene Islands State Agricultural Polytechnic Campus Area.

The tools used in this research are Waterpass, Meter, Peg, Unting-unting, GPS, Geographic Information System Application, stationery and documentation tools. The materials used are 4/6 blocks for making stakes.

The research method used is descriptive quantitative, which is a method of calculation and description of the results of field data processing.

a. Secondary Data
   1) Rainfall data for the last 10 years, obtained from the Department of Resources.
   2) Topography Map, Drainage Network Map and Situation Map, obtained from Politani Pangkep Campus Planning Section.

b. Primary Data
   1) Survey of channel base elevation and channel slope
      The channel base elevation survey aims to determine the slope of the channel so that it can later be used to calculate channel hydraulics.
   2) Survey of channel length, channel shape and channel material

This survey aims to determine the channel manning coefficient for channel hydraulics calculations.

Data Collection Method

Secondary data collection is obtained from related agencies while primary data collection is obtained from direct measurement in the field of the research location using a Waterpass measuring instrument to measure elevation and channel length.

Data Analysis

Analysis of research results using descriptive analysis in the form of tabulations and images.

Data Analysis of Elevation Measurement and Drainage Length

Optical Distance Measurement [7]:

D = 100 (BB - BA) .... (1)

D = Optical Distance

BB = Tool Bottom thread reading

BA = Tool Upper Thread Reading

Calculation of Height Difference

ΔH = Tool Height- Center Thread .... (2)

Elavation Calculation

H = Initial Elavation +Δh... (3)

Calculation of error tolerance on Waterpass measurement

go-back formula = $8\sqrt{\Sigma d}$ .... (4)

In this case, the sum of distances (Σd) is in units of m.

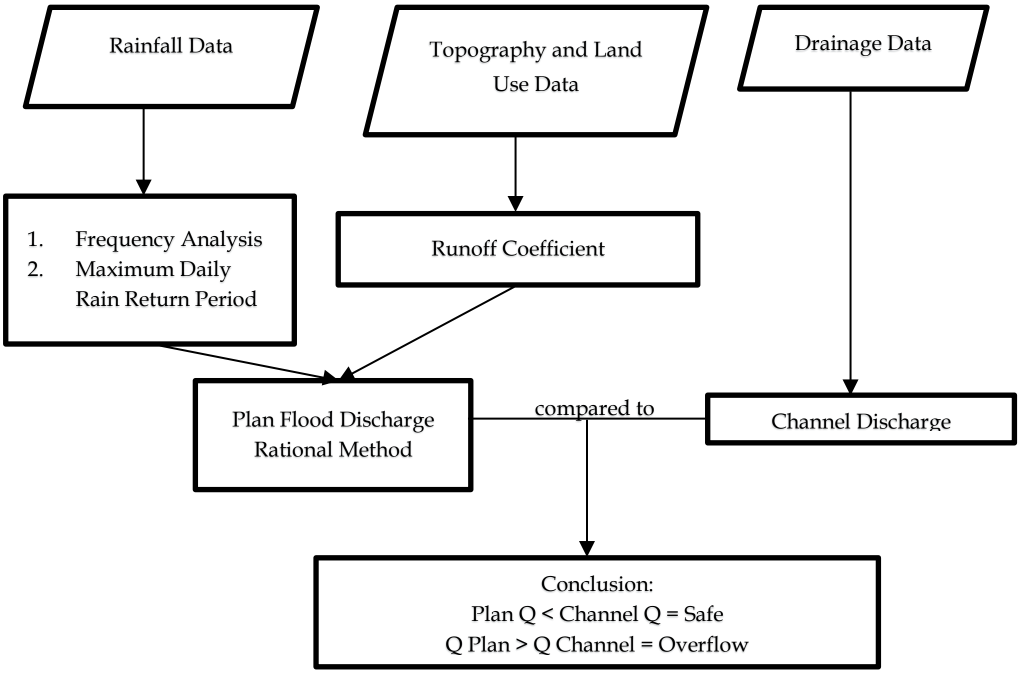

Figure 1: Research flow

RESULTS AND DISCUSSION

Maximum Daily Rainfall Data

Rainfall data to be used is Ralla station rainfall data, this is obtained from the results of dividing the area using the tiessen polygon method by involving several rainfall stations, namely: Ralla Rainfall Station, Padaelo Rainfall Station, Tabo-tabo Rainfall Station, and Pangkajene Rainfall Station. It can be seen in Figure 3 that the research area is in the Ralla Station rainfall coverage area.

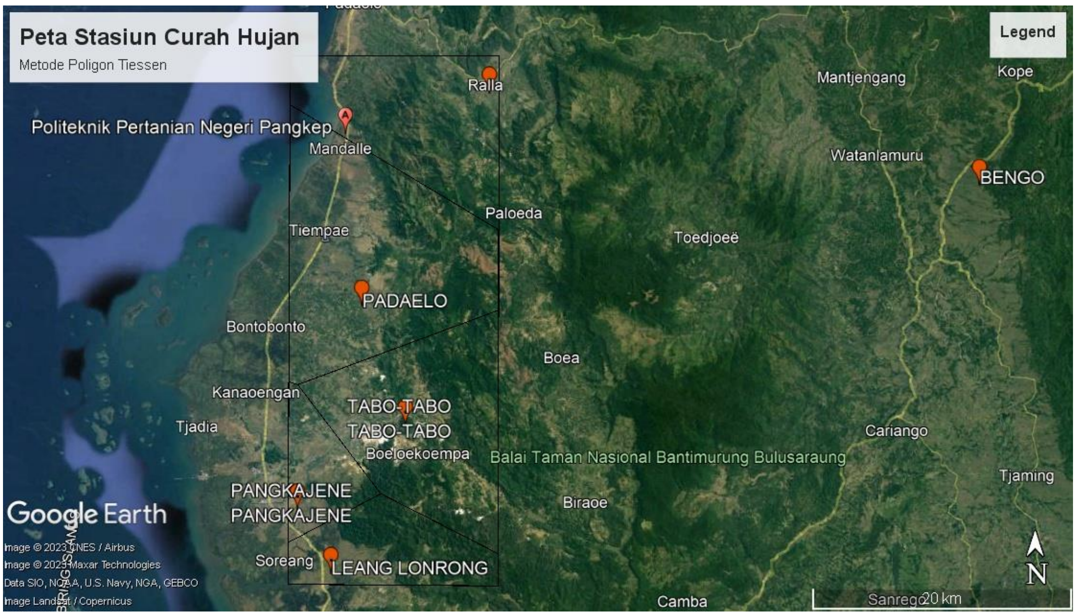

Figure 2: Rainfall Station Map

In this research to calculate the design flood discharge, namely by using rainfall data for 10 years (2013-2022) obtained from the Department of Natural Resources, Cipta Karya and Spatial Planning Prov. South Sulawesi and UPT Je'neberang. The daily rain data for 10 years (2013-2022) obtained is then sought for the maximum value in each year. Maximum daily rainfall data can be seen in table 1.

Table 1. Maximum Daily Rainfall Data of Ralla Station

Year	Rainfall											
	Jan	Feb	Mar	Apr	May	Jun	Jul	August	Sep	Oct	Nov	Des
2013	119	66	92	91	26	80	24	-	41	19	59	63
2014	205	93	61	157	70	59	33	3	-	48	97	162
2015	121	35	62	207	49	49	55	5	-	14	63	124
2016	168	70	97	61	44	50	30	2	37	106	40	185
2017	73	30	60	70	75	25	25	15	24	26	74	86
2018	71	78	112	62	5	7	5	12	5	7	57	129
2019	192	33	93	64	5	2	-	-	-	37	50	75
2020	97	105	92	40	37	20	13	4	3	50	65	98
2021	142	81	115	92	33	24	24	65	67	58	157	189
2022	95	205	100	100	100	-	-	170	100	147	75	130

Determination of Distribution Type

Distribution type analysis is carried out with the aim of determining rainfall estimates with a certain return period using a statistical approach based on past rainfall data can be seen in table 2.

Table 2. Calculation of Statistical Approach

Years	xi	xi - $x_{average}$	$(xi - x)^2$	$(xi-x)^3$	$(xi-x)^4$
2017	86,00	-76,20	5806,44	-442450,73	33714745,47
2020	105,00	-57,20	3271,84	-187149,25	10704936,99
2013	119,00	-43,20	1866,24	-80621,57	3482851,74
2018	129,00	-33,20	1102,24	-36594,37	1214933,02
2016	185,00	22,80	519,84	11852,35	270233,63
2021	189,00	26,80	718,24	19248,83	515868,70
2019	192,00	29,80	888,04	26463,59	788615,04
2014	205,00	42,80	1831,84	78402,75	3355637,79
2022	205,00	42,80	1831,84	78402,75	3355637,79
2015	207,00	44,80	2007,04	89915,39	4028209,56
Total	1622,00	0,00	19843,60	-442530,24	61431669,71
Averages	162,20	0,00	1984,36	-44253,02	6143166,97

S, Cv, Cs, Ck Values:

$$Sx = \sqrt{\frac{\sum(Xi-XR)^2}{n-1}} = 46{,}96$$

$$a = \frac{n}{(n-1)(n-2)}\sum[Xi-XR]^3 = -61.462{,}53$$

$$CS = \frac{a}{Sx^3} = -0{,}59$$

$$CK = \frac{\frac{1}{n}\sum(Xi-XR)^4}{Sx^4} = 1{,}26$$

$$CV = \frac{Sx}{XR} = 0{,}29$$

Table 3. Determination of Rainfall Distribution

No	Distribution	Requirements	Calculation Result	Description
1	Normal	Cs = 0	-0,59	not accepted
		Ck = 3	1,26	
2	Log Normal	$Cs = Cv^3+3Cv = 0.89$	-0,59	not accepted
		$Ck = Cv^8 + 6Cv^6 + 15Cv^4 +16Cv^2 + 3 = 4{,}45$	1,26	
3	Gumbel	Cs = 1,14	-0,59	not accepted
		Ck = 5,4	1,26	
4	log pearson III	Other than the above/flexible values	-0,59 1,26	accepted

Source: Bambang Triatmojo

From the analysis of the statistical approach, the type of distribution used is the Log Pearson III distribution.

Log Pearson III Distribution Plan Rainfall Analysis

The following results of the frequency distribution calculation for the Log Pearson III distribution can be seen in Table 4.

Table 4. Log Pearson III Distribution Plan Rainfall Analysis

No.	**Years**	**Xi**	**Log Xi**	**(Log Xi - Log X Averages)**	**(Log Xi - Log X Averages)²**	**(Log Xi - Log X Averages)³**	**(Log Xi - Log X Averages)⁴**
1	2017	86,0	1,9345	-0,2563	0,0657	-0,0168	0,0043
2	2020	105,0	2,0212	-0,1696	0,0288	-0,0049	0,0008
3	2013	119,0	2,0755	-0,1153	0,0133	-0,0015	0,0002
4	2018	129,0	2,1106	-0,0802	0,0064	-0,0005	0,0000
5	2016	185,0	2,2672	0,0763	0,0058	0,0004	0,0000
6	2021	189,0	2,2765	0,0856	0,0073	0,0006	0,0001
7	2019	192,0	2,2833	0,0925	0,0086	0,0008	0,0001
8	2014	205,0	2,3118	0,1209	0,0146	0,0018	0,0002
9	2022	205,0	2,3118	0,1209	0,0146	0,0018	0,0002
10	2015	207,0	2,3160	0,1251	0,0157	0,0020	0,0002
Total		1622,0	21,9082	0,0000	0,1808	-0,0164	0,0062

Log X Averages	=	2,1908
Standard Deviation (S . Log X)	=	0,1417
CS	=	-0,8003
CK	=	-0,9890
CV	=	0,0647

G = The frequency factors (probability functions and Cs values) are presented in Table 5 below:

Table 5. Log Pearson III Distribution for Coefficient of Skewness

Cs Values	**Turning Time (Years)**														
	1,01	1,05	1,11	1,25	1,667	2	2,5	5	10	20	25	50	100	200	1000
	Opportunities (%)														
-0,8003	99	95	90	80	60	50	40	20	10	5	4	2	1	0,5	0,1
-0,8	-2,9	-1,8	-1,3	-0,8	-0,2	0,1	0,4	0,9	1,2	1,4	1,4	1,6	1,7	1,8	2,0
-0,9	-3,0	-1,9	-1,3	-0,8	-0,2	0,1	0,4	0,9	1,1	1,4	1,4	1,5	1,7	1,7	1,9

The following is an example of the calculation of planned rainfall analysis with the Log Pearson III distribution using equation (14) For a return period (T) of 2 years.

$X_2 = 10^{\log 2,2095-0,8003+(-0,8003 x 0,1320)} = 162,0095$ mm

Table 6. Log Pearson III Distribution Plan Rainfall Analysis

T	P(%)	Cs	G	Log X	X (mm)
2	50	-0,8003	0,1320	2,2095	162,0095
5	20	-0,8003	0,8560	2,3122	205,1910

Rainfall Distribution Fit Test

The probability distribution test is used to determine whether the selected probability distribution equation can represent the statistical distribution of the data sample being analyzed. In this case, the Smirnov-Kolmogorof Test method is used. The following are the results of the distribution suitability test analysis, can be seen in table 7:

Table 7. Smirnov-Kolmogorof Test

NO.	X	**Log X**	**G**	**m**	**S_n (X)**	**Pr**	**Px (X)**	**D** I P_X (X) - S_n (X)
1	86,000	1,934	-1,808	1,000	0,091	0,949	0,051	0,040
2	105,000	2,021	-1,197	2,000	0,182	0,875	0,125	0,057
3	119,000	2,076	-0,813	3,000	0,273	0,806	0,194	0,079
4	129,000	2,111	-0,566	4,000	0,364	0,730	0,270	0,093
5	185,000	2,267	0,539	5,000	0,455	0,366	0,634	0,179
6	189,000	2,276	0,604	6,000	0,545	0,345	0,655	0,110
7	192,000	2,283	0,652	7,000	0,636	0,329	0,671	0,035
8	205,000	2,312	0,853	8,000	0,727	0,201	0,799	0,072
9	205,000	2,312	0,853	9,000	0,818	0,201	0,799	0,019
10	207,000	2,316	0,883	10,000	0,909	0,189	0,811	0,098
							D Max.	**0,179**

Log X Averages	=	2,1908
Deviation Standard (S)	=	0,1417
D Max.	=	0,1792
N (total data)	=	10
a (degrees of confidence)	=	5%

D Criticalx = 0,409
0

D Ma. < D Critical, then the theoretical distribution used to determine the distribution equation is acceptable.

Surface Runoff Coefficient

The surface runoff coefficient is obtained from the combined average of the area and runoff coefficient of each land use in each sub-drainage basin. To obtain the surface runoff coefficient, it is necessary to first classify the land use in the Sub-DTA in each drainage channel. The drainage channel service scheme and the condition of the water catchment area in the Politani Campus area can be seen in Figure 3, Figure 4, and Figure 5.

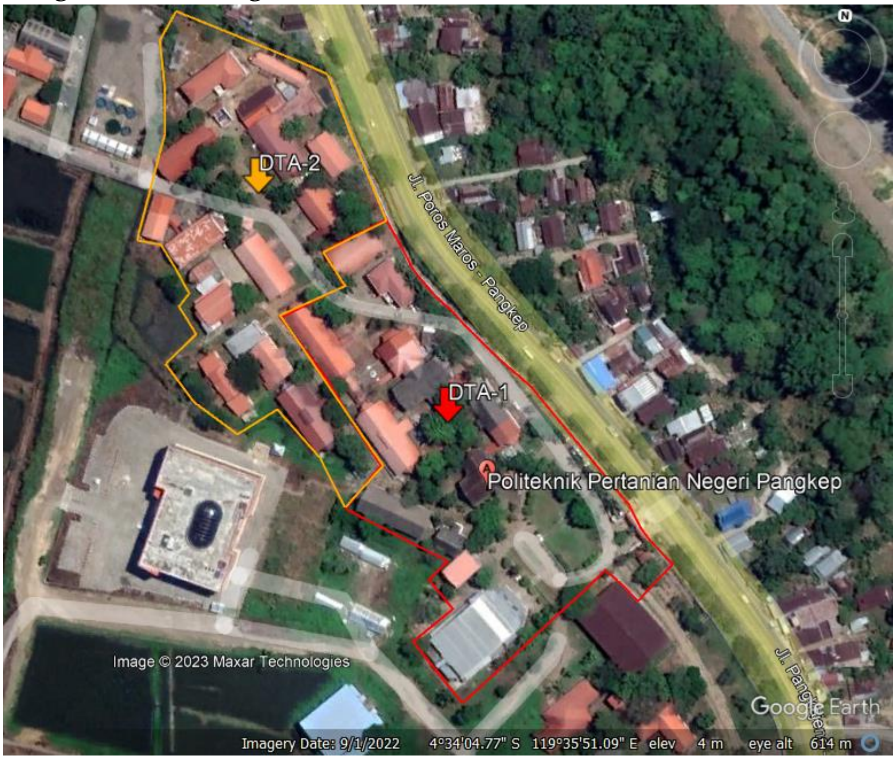

Figure 3. Water catchment area

Two catchment areas DTA-1 and DTA-2 were obtained with the catchment area boundaries seen from the topography of the study site, namely the highest elevation ridge of the study area.

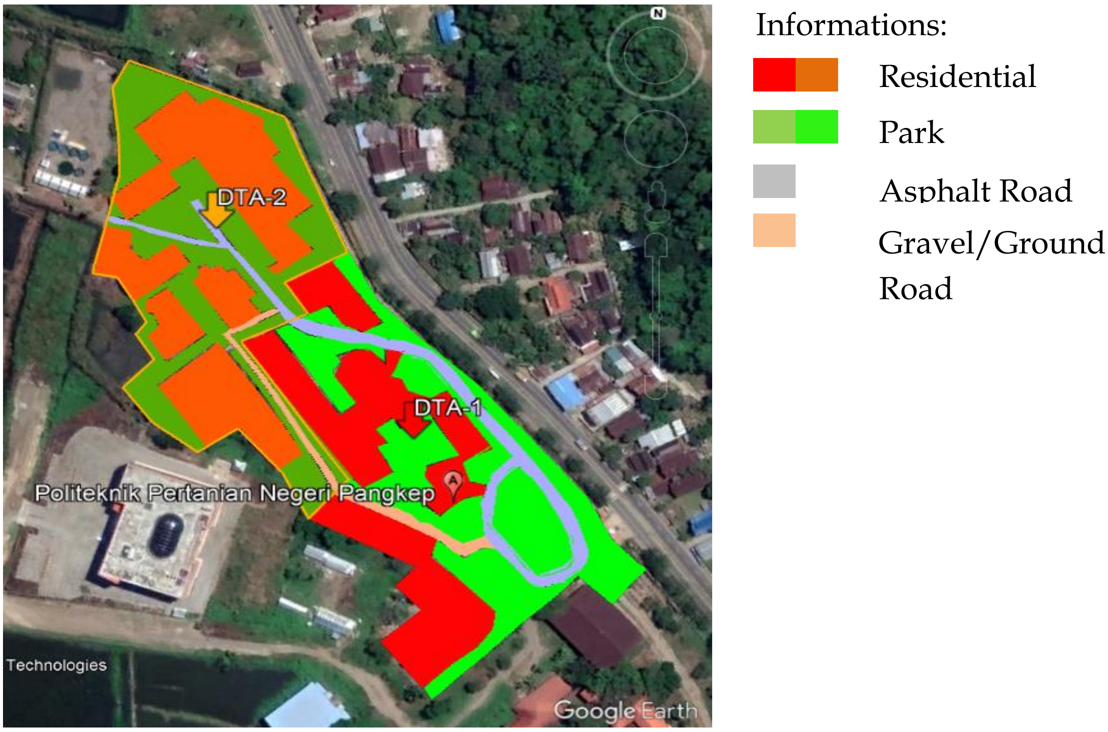

Figure 4. Land Use Classification

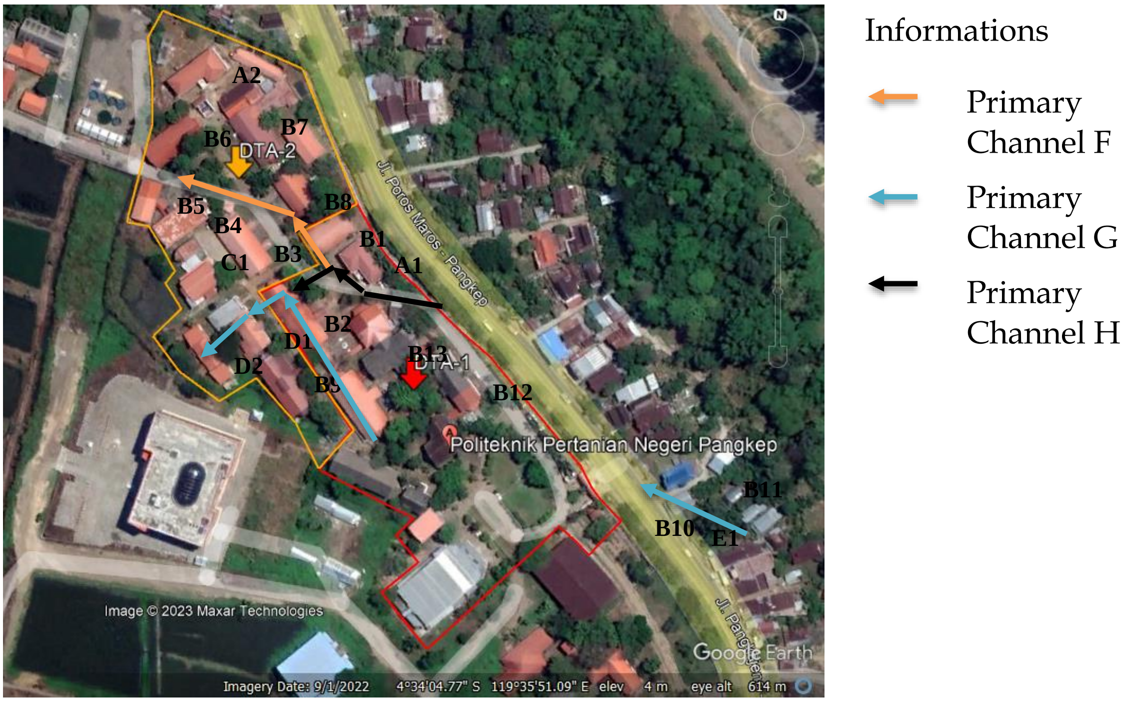

Figure 5. Drainage Service Scheme

Based on the calculation of the average multiplication of land use area and Runoff coefficient, the composite coefficient of 0.325 can be seen in Table 8.

Table 8. Calculation Result of Composite Runoff Coefficient

Classification	Channel	Land Use System	C	A(Ha)	C x A
DTA-1	A1;B1;B2;B10;B11;B12;B13;D2;E1	Residential	0,4	0,930	0,372
		Park/Garden	0,2	1,038	0,208
		Asphalt Road	0,7	0,190	0,133
		Gravel/Ground Road	0,4	0,052	0,021
DTA-2	A2;B3;B4;B5;B6;B7;B8;B9;C1;D1;D2	Residential	0,4	0,950	0,380
		Park/Garden	0,2	0,893	0,179
		Asphalt Road	0,7	0,058	0,041
		Gravel/Ground Road	0,4	0,045	0,018
Total				4,155	1,350
C Composite				0,325	

Channel Dimensions and Slope

Table 9. A1 Channel dimensions and slope

No.	Channel Cross Section Shape	Channel	From	To	Height Difference Δh	L	S	
					(m)	(m)		
1.	Square	A1	1	2	0,03	13,36	0,002	0,006
			2	3	0,03	18,76	0,002	
			3	4	0,05	27,81	0,002	
			4	5	0,02	1,25	0,016	
			6	7	0,05	5,57	0,009	
			7	5	0,04	13,72	0,003	

Source: Analysis Result

The calculation of the channel slope is obtained from the drainage length divided by the height difference from the waterpass measurement results.

CONCLUSION

Based on the results of the analysis on the evaluation of the politani pangkep campus drainage network, it can be concluded that:

a. Drainage capacity < Flood Discharge Plan for 2 years and 5 years, so there is a need for planning in increasing drainage capacity.
b. The results of the calculation and analysis show that the drainage channel needs to be redesigned by increasing the width and height dimensions that can accommodate the 2-year return period design discharge. modification is done by replacing the drainage with precast concrete materials considering the ease of work.

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