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INVESTIGATING RAINWATER INFILTRATION AND DRAINAGE IN UJUNG KALAK VILLAGE, WEST ACEH

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Abstract

Flood inundation is a critical issue faced by urban areas, particularly in densely populated regions. This study focuses on the Johan Pahlawan District, a sub-district within the West Aceh Regency, encompassing a rapidly growing urban area with a population of 4243. As settlements expand due to the increasing population, the demand for waterways also rises, impacting drainage systems and causing potential flooding and inundation. The inability of the existing drainage system to handle excessive water flow during heavy rainfall exacerbates the problem.

The research examines the specific drainage problem at Simpang Pelor, Iskandar Muda Road, Ujung Kalak Village, where heavy rain with an intensity of 2 hours and an average height of 20 cm to 40 cm results in recurrent flooding during the rainy season. Main roads, residential areas, and shops are submerged, affecting the overall functioning and safety of the community. Despite the recurrent nature of these floods, no previous evaluation of the drainage profile in Ujung Kalak Village has been conducted.

This study aims to evaluate the drainage system in Ujung Kalak Village to understand its capacity, limitations, and shortcomings. By analyzing the drainage infrastructure, including artificial and natural drainage systems, the research seeks to identify the root causes of the flooding problem. Additionally, the study will explore the factors contributing to reduced water absorption into the soil, leading to increased surface runoff during heavy rainfall.

The evaluation results will be of great significance to the Office of Water Resources, providing valuable information and data for future drainage studies. The recommended corrective actions based on this research will aid in enhancing the drainage system's efficiency and

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resilience against flooding, benefiting the urban population in Johan Pahlawan District.

1. Introduction

Johan Pahlawan District is one of the sub-districts in West Aceh Regency. This sub-district includes a densely populated area of 4243 people, which is in the urban area of Meulaboh City. As the population increases, inevitably, settlements will also increase. An increase in the number of payments will affect the waterways because water flow through the channels will also increase due to reduced water catchment areas, which can cause flooding or inundation. In other words, an increase in population can lead to reduced absorption or infiltration of rainwater into the soil, so surface runoff also increases [1].

The cause of flood inundation in an urban area is the lack of drainage or the existing drainage system not functioning correctly. When it rains, the water cannot flow into the sewers and causes rainwater to overflow from the canals [2]. Drainage is designed to facilitate water flow from one location to the next, connected to a drainage network, also known as a drainage system. Drainage systems are designed to remove precipitation and wastewater from metropolitan areas to prevent problems. There are two types of drainage: artificial drainage and natural drainage. Artificial drainage is a ditch-style drainage constructed on the shoulder of the road. Soil is an excellent example of natural drainage because it can absorb water below the surface. Ideally, the water flow will increase if the air passages are large and wide [3].

The specific problem of city drainage at Simpang Pelor, Iskandar Muda Road, Ujung Kalak Village is that rainwatergnates when it rains with an intensity of 2 hours with an average height of 20 cm to 40 cm. These floods are more common when the rainy season arrives. The main roads were submerged, and residential areas and shops were also affected by the rainwater overflow. This study is needed because there has never been an evaluation of the drainage profile in Ujung Kalak Village. The results of this evaluation will be recommended to the Office of Water Resources as information and data on drainage studies and can take corrective action.

Fig 1. Flood inundation conditions at the Simpang Pelor Village of Ujung Kalak

2. Literature Review

2.1. Drainage

Drainage, which means to drain, pollute, or be airborne. Drainage can also be seen as an effort to regulate groundwater quality. Therefore, drainage affects both surface and groundwater [3]. Drainage is to remove excess water from the surface of the soil and reduce and maintain the water table so that nothing happens, preventing adverse effects on the environment and water overflow [4].

Various circumstances can cause floods, but generally, they can be divided into two categories, natural causes and man-made causes [5]. Natural flooding is caused by factors, namely: rainfall, physiographic influences, erosion and deposition, river capacity, drainage capacity, and tides. While the causes of flooding caused by human activities are: the condition of the DPS has changed, illegal settlements, garbage, dams, and other buildings. Flood control buildings are damaged, and flood control systems are not optimal. The factors that most often cause flooding in urban areas are as follows: Development that is not environmentally sound, the absence of a clean lifestyle in the community, the absence of planning and maintenance of a sound drainage system, the lack of consistency of the authorities in the RTRW, the absence of conservation efforts balancing factors for the water environment, the occurrence of land subsidence, and very high rainfall [6].

2.2. Rainfall Plan

Rainfall is an essential hydrological element in flood discharge analysis. To calculate the flood discharge in question, it is necessary to estimate rainfall if flood discharge data and sufficient observation time intervals are unavailable [6]. One method of hydrological data analysis that uses statistics to predict how much rain or discharge will fall during a specific return period is frequency analysis. Rainfall frequency estimates the probability that the rainfall will be equal to or greater than expected. On the other hand, the return period is when rain or discharge occurs more than once in a given time [7].

Rainfall frequency analysis is needed to determine the type of distribution, which has the following statistical parameters: average rainfall (*X*), standard deviation (*Sd*), asymmetrical coefficient (*Cs*), coefficient of variation (*Cv*), and kurtosis coefficient (*Ck*), by using the following equation:

(1)

$$\overline{X} = \frac{\sum_{i}^{n}=1 X}{n} \quad (2)$$

$$S_d = \sqrt{\frac{\sum_{i=1}^{n}(X-\overline{X})^2}{n-1}}$$

$$a = \frac{n}{(n-1)(n-2)}\sum_{i}^{n}=1(X_i - \overline{X})^3$$

$$C_s = \frac{a}{s^3} \quad (3)$$

(4)

$$C_v = \frac{S_d}{\bar{X}}$$

(5)

$$C_k = \frac{n^2 \sum_{i=1}^{n}(X_i - \bar{X})^4}{(n-1)(n-2)(n-3)S^3}$$

Where : (6)

Cs = asymmetrical coefficient; *Cv* = coefficient of variation;

a = the best estimate of population asymmetry;

Sd = standard deviation;

$\bar{X}$ = Average rainfall (mm);

Xi = rainfall i (mm); *n* = amount of data.

1. Normal Distribution

The normal distribution is also called the Gauss distribution. In simple terms, the normal distribution equation can be written as follows:

$$XT = X + KT \times S \quad (7)$$

Where:

XT = The expected value estimate occurs with a return period of T year;

X = The average value of the variant count;

S = Standard deviation variant value;

KT = The frequency factor is a function of the probability or return period.

2. Log Normal Distribution

The formula used in the calculation of this method is as follows :

$$Rt = Xr + Kt \,.\, Sx \quad (8)$$

Where:

Rt = The amount of rainfall that may occur in the birthday period of T years;

R = Average Rainfall;

Kt = Standard variable for the return period.

Sx = Deviation Standard.

For more details, the K Frequency factor table in the 3-parameter Log Normal distribution, Standard Variable.

3. Gumbel Distribution

The formulas used in calculating the planned rainfall with the Gumbel method are as follows :

$$Xt = Xr + (K \,.\, Sx) \quad (9)$$

Where:

Xt = Rain in the return period; Xr = Average price.

K = Frequency Factor.

The frequency factor (K) value is calculated using equation 10.

$$K = \frac{Yt - Yn}{Sn} \quad (10)$$

Where :

Yt = Reduce variate;

Yn = Average price reduce variate; n = Amount of data;

Sx = Deviation Standard.

$$Sx = \sqrt{\sum_{n-1}^{n} \frac{(Xi - Xr)^2}{n-1}} \quad (11)$$

4. Log Pearson III Distribution

When described on logarithmic probability paper, the Log Person type III method will form a straight-line equation to be expressed as a mathematical model with the following equation:

$$Y = Y + k \,.S \quad (12)$$

Where :

Y = Arithmetic mean (preferably geometric mean) of values Y; S = Deviation standard Y value; K = Characteristics of the log-Pearson type III probability distribution.

For more details, see the table of K prices and G prices for the Pearson III Log distribution method. Parameter requirements are used following Table 1 to determine the appropriate type of distribution,

Table 1. Distribution Requirements

Distribution Type	Requirements
Normal	Cs ≈ 0
	Ck ≈ 3
Log-Normal	$Cs = Cv^3 + 3\ Cv$
	Ck = Cv8 + Cv6 + 15 Cv4 + 16 Cv2 + 3
Gumbel	Cs ≈ 1,14
	Ck ≈ 5,4
Log Pearson Type III	Apart from the values above

Source: Triatmojo, 2008

2.3. Hydrological Analysis

In this case, among other methodologies, hydrological analysis is used in the rainfall analysis design. Daily rainfall is used as rainfall data [8]. The purpose of hydrological research is to find reliable discharge. The flow rate will be used for the primary flood or design discharge. There are several processes to obtain an exact clearance, including calculating the average annual rainfall of the watershed and conducting reliable discharge analysis [9].

The rational method is widely used to estimate the peak discharge caused by heavy rain in the catchment area; the rational method is based on the following equation:

$$Q = 0{,}00278\ C.CS.I.A \qquad (13)$$

Where:

Q = Flood discharge (m3/ det) ;

A = Flow area (Ha);

I = Rainfall intensity in (mm/ jam);

C = Flow Coefficient;

CS = Storage coefficient

$$Cs = \frac{2\ T_c}{2\ T_c + T_d} \qquad (14)$$

Where:

Cs = Storage coefficient;

Tc = Time of Concentration (hours);

Td= The time the water flow flows in the canal from upstream to the place of measurement (hours).

$$tc = t0 + td \qquad (15)$$

Where:

tc = Time of Concentration; t0 = Time required for water to flow through the ground surface to the nearest canal (minutes).; td = Time required for water to flow in the canal to the planned location (minutes).

$$I_t = \frac{R_t}{24} \times \left(\frac{24}{t}\right)^{2/3} \qquad (16)$$

Where:

R_t = Design rainfall for different return periods (mm); t = Concentration time (hours) for units in minutes t multiplied by 60; I_t = Rain intensity for various return periods (mm/hour).

Table 2. Flow Coefficient on Various Types of Land Cover (C)

Types of Land Cover	Flow Coefficient	Types of Land Cover	Flow Coefficient
Trading center	0,70 – 0,95	Asphalt Surface	0,70 – 0,95
Surrounding environment	0,5 – 0,70	Concrete Surface	0,80 – 0,95
Residential Houses	0,30 – 0,50	Artificial Stone Surface	0,70 – 0,85
Cluster area	0,40 – 0,60	Gravel Surface	0,15 – 0,35
Outskirts	0,25 – 0,40	Footpath	0,10 – 0,85
Apartment	0,50 – 0,70	Roof	0,75 – 0,95
Growing Industry	0,50 – 0,80	Sandy Soil Land	0,05 – 0,10

2.4 Channel Discharge (Qs)

The various types of drainage are categorized into five, according to the history of its formation, the location of the building, its function, its construction, and its network pattern. According to the shapes, drainage consists of natural and artificial drainage. Drainage, according to the location of the building, consists of surface drainage and underground drainage. Drainage, according to its function, consists of single-purpose and multi-purpose drainage. Meanwhile, according to its construction, drainage is open and closed channels. To calculate the drainage discharge, can use the following equation.

$$A_e = (b + m.h)h \quad (18)$$

$$P = b + 2h\sqrt{(1+m^2)} \quad (19)$$

$$R = \frac{A_e}{P} \quad (20)$$

Where: b = Channel width (m); h = Channel height (m);
m = Comparison of the slope of the retaining wall;
R = Hydraulic radius (m);
P = Wet circumference of the channel (m); Ae = wet cross-sectional area (m2).

Wet section based on water discharge (Q) and velocity (V). Channel dimensions are calculated using the Manning formula as follows:

$$Q = V.A \quad (21)$$

$$V = \frac{1}{n}(r)^{\frac{2}{3}}(I)^{1/2} \quad (22)$$

Where:
Q = Water debit in the channel (m3/det); V = Velocity of water in the channel (m/det); n = Wall roughness coefficient; I = Bottom slope of the channel

3. Method

This research is located in Ujung Kalak Village, Johan Pahlawan District.

Fig. 2 The study location is at the Simpang Pelor Jalan Iskandar Muda

The primary data needed in this study are as follows:

a. conducted Field surveys to determine conditions in the field and identify initial problems encountered in the area and see possible solutions proposed
b. Data dimensions of the width and height of the canal, the type and length of the drainage canal were obtained by field survey in the following manner:
a. Preparation of tools for measuring the drainage channel's dimensions and the drain-base channel's length.
b. The tools used to take measurements are 5m and 100m meters.
c. The next step is to measure the drainage using a meter from the starting point of the Raja Ampat hamlet drainage to the processing of the total length of the drainage to be evaluated.
d. Measurements were made on the previous drainage to obtain channel dimension data. Measurements were made on the width and height of the drainage.
e. Channel elevation data obtained from the GPS (Global Positioning System) application. The data is received by synchronizing with MDPL (Meters Below Sea Level) data on the GPS (Global Positioning System). GPS (Global Positioning System) is also used to get the slope of the channel

The secondary data is the annual maximum rainfall data for ten years obtained from the BMKG Cut Nyak Dhien, Nagan Raya Regency, and a land cover map of Meulaboh.

The dimensions of the drainage channel will be planned according to the scheduled flood discharge after the rainfall data is assessed using a logical formula to produce the scheduled flood discharge. The stages of data analysis in this study are as follows:

1. Hydrological analysis the following techniques are used in the hydrological analysis:
a. Calculation of the frequency of rainfall using a method that follows regulations and will be used to determine the planned discharge.
b. Calculates the anticipated rainfall using a technique that meets the criteria for calculating the frequency of rain and will be used if it passes the frequency suitability test.
c. The analysis of the frequency suitability test used the chi-square test and the Smirnov-Kolmogorov test. The accepted methodology will be applied in this calculation discharge.
d. The logical formula is used in the calculation of the projected discharge. The analysis of the planned release will use a method that meets the requirements and is accepted in the frequency feasibility test.
2. Hydraulics Analysis, this will produce: based on hydraulics analysis.
a. Channel dimensions

Wet cross-sectional area, wet circumference, and hydraulic radius will be determined using the results of channel dimension planning.

b. Channel debit

The calculation of the channel discharge is based on the results of the channel dimension planning. The development of the channel discharge must be greater than the design discharge so that the channel dimensions can accommodate a larger, more extensive capacity to avoid inundation.

4. Result and Discussion

The results of a survey of the field obtained several problems with drainage at the Pelor Intersection of Ujung Kalak Village, namely as follows: There are at least drainage holes in the drainage, the drainage channels are filled with garbage, so rainwater cannot drain into other media, there are several drainage structures that area was damaged, and the debris fell into the canal, thus blocking the flow of water in the canal, there were several drainages covers whose conditions were destroyed, and at several points, there was garbage and sedimentation in the canal, which made the channel not function properly. This problem requires a more in-depth study. The following shows an overview of drainage conditions in Ujung Kalak Village. Research activities are needed by observing the relationship between Green Open Space and social movements of the city community as users to find the identity of the place so that the character is seen as the cause of the site to exist.

Fig. 3 There is much garbage in the drainage channel, and there is damage to t

Fig. 4 Sedimentation in the drainage can block the flow.

4.1. Hydrological Analysis

The hydrological analysis includes analysis of frequency, design rainfall, flow coefficient, and design flood discharge using rational methods. Design rainfall is calculated in return periods of two years, five years, ten years, 25 years, and 50 years. This plan's rainfall calculation is based on data obtained for the past ten years, from 2011 to 2020.

Table 3. Frequency analysis of rainfall data

No	Distribution Type	Requirement	Calculation Result	Conclusion
1	Normal	Cs ≈ 0 Ck = 3	Cs = -0,537 Ck = 3,608	does not meet therequire- ments
2	Log-Normal	Cs ≈ 3 Cv + Cv3	Cs = -1,081 Ck = 4,367	does not meet therequire- ments
3	Gumbel	Cs ≈ 0 Ck = 3	Cs = -0,537 Ck = 3,608	does not meet therequire- ments
4	Log Person III	Apart from the values above	Cs = -1,081	meet the requirements

Frequency analysis of monthly maximum annual rainfall data was carried out, and the Pearson III log distribution met the requirements. Then proceed with the study of design rainfall return periods of two years, five years, ten years, 25 years, and 50 years.

Table 4. Design rainfall using Log Person III

T	**PT**	**KT**	**KT x s**	**Log XT**	**XT**
(years)	(%)				(mm)
2	50	0,170	0,025	2,255	179,810
5	20	0,934	0,139	2,369	233,762
10	10	1,244	0,185	2,415	259,957
25	4	2,451	0,365	2,595	393,457
50	2	1,552	0,231	2,461	288,954

The runoff coefficient is the ratio of rainwater that flows or overflows above the ground (sur- face runoff) with the amount of rainwater that falls from the atmosphere. The coefficient value ranges from 0 to one depending on the type of soil, type of vegetation, and structures on the soil surface. The land cover analysis results show that housing/settlements dominated Ujung Kalak Village. The average flow coefficient (C) study results in this village are 0.58.

Fig 5. Land Cover in Ujung Kalak River

After the average flow coefficient value is obtained, followed by flood discharge analysis using the Rational method to get the value of the flood discharge, data on the channel slope, storage coefficient, concentration time, channel length, and average speed are needed.

To find the length of each channel segment from the outlet point to the channel segment, necessary to create a flow service area. In this village, eight watersheds were created (Figure 6). The flow pattern and direction are also included in the flow area to make it easier to obtain the slope value of the channel.

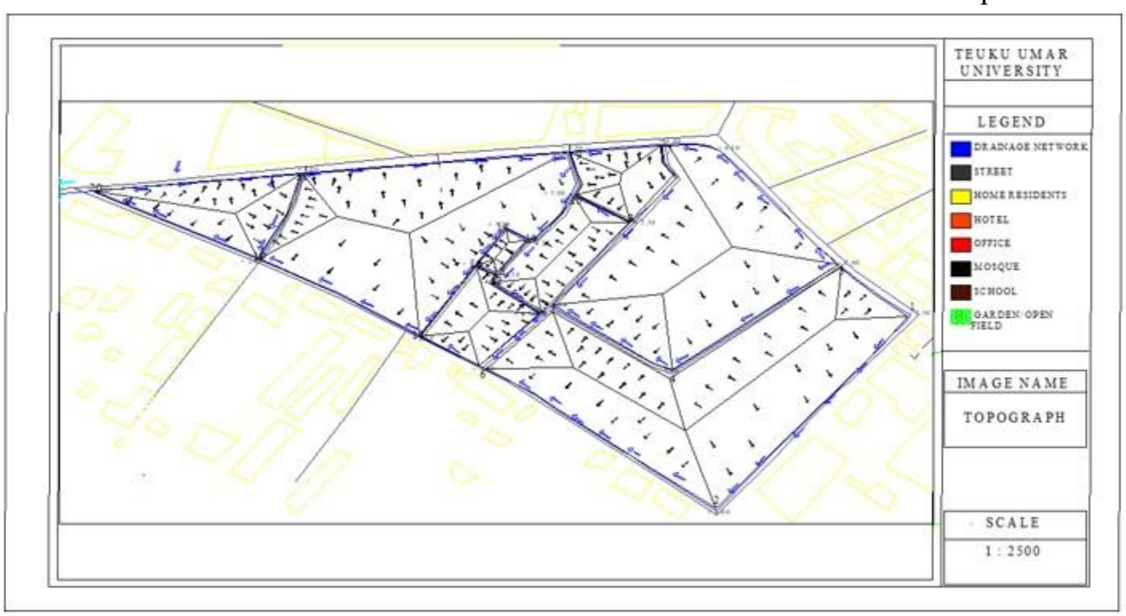

Fig 6. Flow patterns and drainage basins in Ujung Kalak Village

4.2. Calculation of Flow Discharge (Q)

The flood discharge at the study site was analyzed using the rational method after obtaining the runoff coefficient values, rainfall intensity, catchment area, and catchment coefficient. Elevation in each channel segment is taken from survey data. The planned rainfall taken as a reference for calculating flood discharge in urban areas is the 5-year return period with a value of 233.76 mm. this value is needed to analyze the value of rain intensity.

Table 4. Analysis of Flow Discharge

Channel	large (A) m2	L1 (m)	ELEVATION (m)	H2	H1	C	LO	TD (hour)	I	Qb

Channel	m2	L1 (m)	(m)	H2	H1	C	(hour)	TC	CS	(mm/hour)	(m3/second)
1	2	3	4			8	15	16	17	18	19
1-2.	12661.76	262.10	888.22	7.50	7.00	0.530	0.40	65.18	0.99	3.900	0.072335
1-3.	1600.04	81.46	872.76	7.50	6.00	0.469	0.40	41.99	0.99	5.236	0.010821
3-4.	16613.33	178.88	791.30	7.00	5.50	0.502	0.40	37.54	0.99	5.644	0.129577
4-5.	8346.49	123.66	612.42	5.50	4.00	0.582	0.40	28.02	0.99	6.866	0.091431
5-6.	2164.07	85.16	488.76	4.50	4.00	0.429	0.40	32.90	0.99	6.166	0.015737
2-6.	8094.60	250.94	626.12	6.00	4.00	0.529	0.40	25.77	0.98	7.263	0.085164
3-7.	6747.09	205.52	689.83	7.00	6.00	0.665	0.40	37.45	0.99	5.653	0.069803
7-5.	9196.88	207.83	668.17	6.00	4.50	0.480	0.40	30.95	0.99	6.424	0.077880
11-6.	1610.54	75.32	450.50	4.50	3.50	0.443	0.40	23.05	0.98	7.826	0.015250
7-8.	1778.54	97.47	703.35	6.00	5.50	0.452	0.40	49.88	0.99	4.666	0.010335
8-10.	1229.10	56.52	509.27	5.50	5.00	0.492	0.40	34.48	0.99	5.976	0.009928
9-10.	971.06	48.02	452.75	5.50	5.00	0.440	0.40	30.15	0.99	6.538	0.007667
7-9.	971.83	79.58	484.31	6.00	5.50	0.366	0.40	32.56	0.99	6.210	0.006072
8-11.	2491.63	119.70	605.88	5.50	4.50	0.409	0.40	32.29	0.99	6.243	0.017471
10-12.	2456.51	107.19	530.36	5.00	4.00	0.454	0.40	27.75	0.99	6.911	0.021131
11-	676.93	53.32	486.18	4.50	4.00	0.427	0.40	32.70	0.99	6.191	0.004917

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12.											
13-14	91.67	22.20	471.78	4.50	3.20	0.485	0.40	21.99	0.98	8.076	0.000981
13-15	324.03	45.14	468.31	4.50	3.50	0.334	0.40	24.09	0.98	7.599	0.002252
14-16	293.47	45.98	449.58	3.20	3.00	0.417	0.40	42.39	0.99	5.203	0.001755
15-16	99.23	19.57	423.17	3.50	3.00	0.579	0.40	27.91	0.99	6.884	0.001084
11-16.	850.61	82.58	486.18	4.50	3.50	0.525	0.40	25.13	0.98	7.385	0.009021
16-17	1883.30	87.89	403.60	3.00	2.50	0.543	0.40	26.45	0.99	7.137	0.019983
6-17.	754.45	59.47	375.18	3.50	2.50	0.567	0.40	18.74	0.98	8.992	0.010471
9-17.	9629.27	285.88	601.59	5.50	2.50	0.586	0.40	21.12	0.98	8.297	0.127776
9-18.	8931.84	226.11	404.73	5.50	3.00	0.522	0.40	14.46	0.97	10.694	0.134789
17-19.	8568.20	158.73	315.71	2.50	2.00	0.469	0.40	20.02	0.98	8.602	0.094255
18-19.	3679.39	97.38	254.36	3.00	2.00	0.532	0.40	12.10	0.97	12.049	0.063429
19-20.	2535.81	156.98	156.98	2.00	1.00	0.473	0.40	7.10	0.95	17.222	0.054417
18-20	3108.43	178.62	178.62	3.00	1.00	0.486	0.40	6.36	0.94	18.547	0.073246

The analysis results show that the most significant flood discharge is in channel segments 19-20. The flood dis- charge value obtained for each piece is followed by channel discharge analysis. In this study, the type of channel with a square shape and the kind of material cast concrete is used so that the manning coefficient taken is 0.015. For the overall flow of rainwater to be accommodated in the drainage, the flood discharge must be greater than the channel discharge.

Dimensional values (width and channel height) were analyzed based on the calculated flood discharge. Each channel has a different flood discharge because of the flow area, the flow coefficient value, the distance between the flow's concentration, and the channel's slope, so the channel's dimensions are also different.

4.3. Channel Dimension Calculation

In determining the shape and dimensions of the channel to be used in constructing a new pipeline and improving the existing channel section, one of the essential things to consider is the availability of land. Building a canal with a large capacity in rural areas is not a problem because of the large amount of vacant land. Still, it can undoubtedly be a significant problem in dense urban areas because of limited land. The following is a table of dimensions of a rectangular channel cross-section.

Table 6. Comparison of drainage evaluation results (calculations and surveys)

No	Channel	Analysis Results		Survey Result		Recommendation
		B (m)	H (m)	B (m)	H (m)	
1	1-2	1.80	1.60	1.30	0.75	Channel enlarged Channel Restoration.
2	1-3	0.75	0.67	1.30	0.75	Channel Safe
3	3-4	1.80	1.60	1.00	1.00	Channel enlarged Channel Clearance.
4	4-5	1.95	1.73	1.00	0.90	Channel enlarged
5	5-6	2.85	2.53	1.20	1.00	Channel enlarged
6	2-6	1.65	1.47	1.30	0.90	Channel enlarged
7	3-7	1.50	1.33	1.30	0.75	Channel enlarged
8	7-5	1.80	1.60	1.30	0.80	Channel enlarged
9	11-6	1.65	1.47	1.20	1.00	Channel enlarged
10	7-8	1.80	1.60	1.00	0.90	Channel enlarged
11	8-10	1.80	1.60	1.00	0.90	Channel enlarged Channel Clearance.
12	9-10	1.65	1.47	1.20	1.00	Channel enlarged Channel Clearance.
13	7-9	1.65	1.47	1.30	0.75	Channel enlarged Channel Clearance.
14	8-11	1.65	1.47	1.10	1.00	Channel enlarged
15	10-12	2.10	1.87	1.30	0.75	Channel enlarged
16	11-12	0.75	0.67	1.30	0.80	Channel Safe
17	13-14	0.60	0.53	0.60	0.60	Channel Safe
18	13-15	0.45	0.40	0.58	0.40	Channel Safe

19	14-16	0.75	0.67	0.50	0.45	Channel enlarged
20	15-16	0.75	0.67	0.50	0.45	Channel enlarged
21	11-16	0.75	0.67	0.50	0.45	Channel enlarged, Channel Clearance
22	16-17	1.20	1.07	1.30	1.00	Channel Safe
23	6-17	3.00	2.67	1.30	1.00	Channel enlarged, Channel Clearance
24	9-17	1.80	1.60	1.00	1.00	Channel enlarged
25	9-18	1.65	1.47	1.30	0.75	Channel enlarged, Channel Restoration
26	17-19	3.45	3.07	1.20	0.80	Channel enlarged, Channel Restoration
27	18-19	1.95	1.73	1.00	0.70	Channel enlarged Channel Restoration.
28	19-20	3.00	2.67	1.20	0.70	Channel enlarged
29	18-20	1.65	1.47	1.30	0.75	Channel enlarged

There are eight watersheds with a total of 29 canal segments. The survey results have been carried out by measuring the width and height of the existing canals and identifying damage and causes of blocked flow. Of the 29 segments, four-channel segments following the count include segments 1-3, 11-12, 13-14, 13-15, and 16-17. The channel is safe, meaning that the five segments do not experience flooding when it rains. There are 24 segments whose channel dimensions need to be enlarged; out of the 24 segments, six elements need to be cleaned of garbage and sedimentation, which makes the water flow stagnant, and four parts need to be repaired so that the effectiveness of the flow continues to flow smoothly. The following are some pictures of the rectangular channel cross-sections planned for the drainage of Ujong Kalak Village.

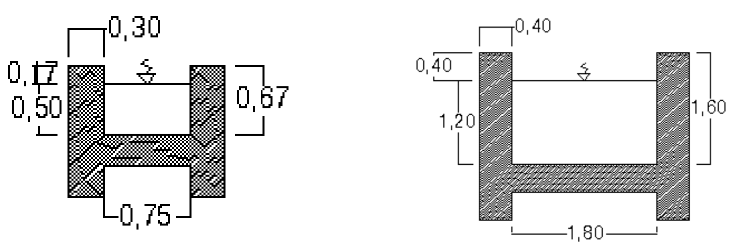

Fig. 7 Rectangular channel plan

5. Conclusion

Ujung Kalak Village, where 80 percent of its land cover consists of settlements and residents' houses, problems often occur with rainwater inundation. After conducting a study and evaluating the drainage profile by comparing the results of the survey and the analysis results, it is necessary to widen the dimensions of the channel. In addition, it is also required to clean up sediment and garbage regularly so that the gutters are not clogged, and water can flow smoothly. Of the 29 segments, 4 of the canal segments are by the calculations; there are 24 segments whose channel dimensions need to be enlarged (of the 24 elements, six pieces need to be cleaned of garbage and sedimentation, which makes the water flow stagnate, and four segments need to be repaired so that the effectiveness of the flow continues to flow smoothly.

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