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Overview of River over Drainage Channels in the Wailela River Watershed, Teluk Ambon District, Ambon City

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***Keywords* — Peak Discharge, Water Runoff, Rain Intensity**

***Abstract*— *Drainage is a sewer system that functions to drain rainwater runoff, sewage from settlements, factories, industrial wastewater, prevent stagnant water and so on. Thus, if there is stagnant water or runoff in an area, the condition of the local drainage channel needs to be evaluated. Stagnant water that is not immediately drained can cause negative impacts such as disruption to residents' activities, the environment becomes dirty, smells bad, and causes disease. Analysis and discussion of rainfall calculations for 10 years with rational methods based on algebraic mean, Gumbell, Log person III. The purpose of this study is to analyze how much runoff discharge, dirty water discharge discharge and rehabilitate existing drainage channels and drainage runoff handling solutions. By analyzing the rainfall discharge that occurs in the field using return periods of 1.01 years, 2 years, 5 years and 10 years, the peak hours that occur in the drainage area are obtained. For the 0.01 year return period it is 345.597 mm/hour, for the 2 year return period it is 435.094 mm/hour, for the 5 year return period it is 477.044 mm/hour, and for the 10 year return period it is 511.195 mm/hour. The amount of discharge / discharge of dirty water in channel Ka1 = 0.0037 m3/s, for channel Ka 1a = 0.0059 m3/s, for channel Ka 1b = 0.0060 m^3/s, for channel Ka 2 = 0.0058 m^3/ sec , for Ka 2a channel = 0.0039 m3/s, for Ka 2b channel = 0.0034 m3/s, for Ki 3 channel = 0.0056 m3/s, for Ki 3a channel = 0.0010 m3/s, for Ki 3b channel = 0.0012 m3/ sec*

I. INTODUCTION

The current condition of the Watershed is very concerning with the increasing frequency of floods, droughts and landslides. This is proven by the occurrence of floods that often occur in Indonesia. Floods are generally caused by heavy rainfall accompanied by inadequate drainage capacity.

Drainage is a sewer system that functions to drain rainwater runoff, sewage from settlements, factories, industrial wastewater, prevent stagnant water and so on. Thus, if there is stagnant water or runoff in an area, the condition of the local drainage channel needs to be evaluated. Stagnant water that is not immediately drained can cause negative impacts such as disruption to residents' activities, the environment becomes dirty, smells bad, and causes disease.

The Wailela River is one of the rivers in Maluku province, which is located in Rumah Tiga village, Teluk Ambon sub-district, Ambon City, with a length of 2 km and a width of 10 m. In accordance with the results of observations in Rumah Tiga village, Teluk Ambon District, Ambon City, with an area of Rumah Tiga village of 517 hectares. Seeing the rapid rate of population growth, this greatly affects the drainage system in the area which is unable to serve the rate of land use change and the disposal of dirty water from residential areas, resulting in stagnant water in the drainage channels which can cause the environment to become dirty and dirty. dirty, become a breeding ground for mosquitoes and other sources of disease that can reduce the quality of the environment and public health.

Rumah Tiga Village is a low-lying area, so it is inseparable from the problem of stagnant water. Some of the existing drainage channels have been damaged and experienced sedimentation and some other areas do not yet have drainage channels. This condition causes the flow of water in residential areas to be not smooth and the environment to be dirty.

Based on the problems stated above, it is necessary to carry out an analysis of the amount of surface runoff against the discharge of existing drainage channels so that no more flooding occurs in every rainy season.

In connection with the existing problems, the authors conducted a study of Runoff Reviews of Drainage Channels in the Wailela Das, Teluk Ambon District, Ambon City.

II. LITERATURE REVIEWS

2.1. Definition of Drainage

The word Drainage comes from the word Drainage which means to drain or drain. Drainage is a system created to deal with the problem of excess water, both excess water above the ground surface and water below the ground surface. In general, drainage can be defined as the study of efforts to drain excess water in an area.

Urban drainage serves the disposal of excess water in a city by flowing it through the surface (Surface Drainage) or passing below ground level (Sub Surface Drainage), to be discharged into rivers, seas or lakes.AlreadyIt is realized that most of the planning, evaluation and monitoring of civil buildings requires hydrological analysis, as well as in the planning, evaluation and monitoring of drainage network systems in an urban area or region.

2.2. Cycle Hydrology

The hydrologic cycle is the journey of water from the surface of the sea to the atmosphere, then to the surface of the land and back again to the sea which never stops. 2004).

The hydrologic cycle begins with the evaporation of water from the sea. Vapor produced below by moving air. Under favorable conditions, the vapor condenses to form clouds, which can eventually produce precipitation. Precipitation that falls on the earth spreads in different directions in several ways. Most of the precipitation is temporarily retained in the soil near which it falls, and is eventually returned to the atmosphere by evaporation and transpiration by plants.

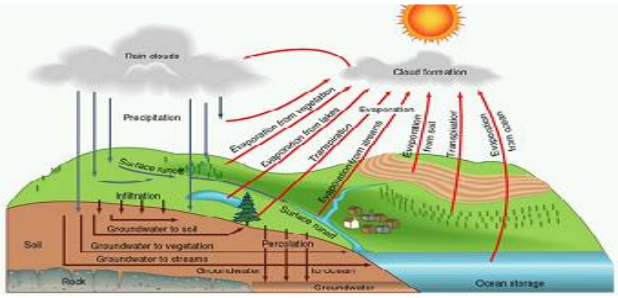


Fig.1: Hydrological Cycle (Source: Sandro Wellyanto Lubis 2009)

2.3. Watershed (DAS)

Watershed abbreviated DAS is water that flows in an area bounded by high points where the water comes from rainwater that falls and collects in the system. The use of the DAS is to receive, store and distribute water Rain that fell on it through river.

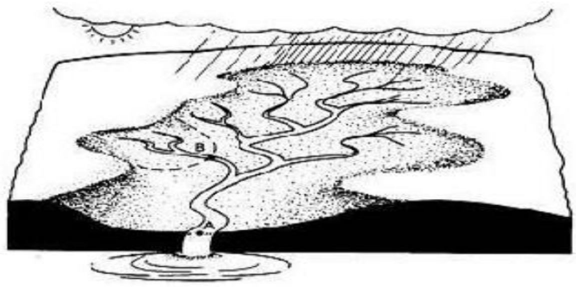


Fig.3: Watershed (Source: M. Aras 2011)

2.4. Rainfall and Rain Intensity

Analysis of rain data is intended to obtain the amount of rainfall and rainfall intensity.

2.4.1. Rainfall

The need to calculate regional rainfall is for the preparation of a water utilization plan and flood control plan (Sosrodarsono & Takeda, 2003). There are 3 ways to determine the average rainfall in a certain area from rainfall data at several rainfall recording stations, namely as follows:

a. Algebraic Average Method (Arithmatic Method).

The formulation of the algebraic average (Arithmetic Mean Method) to obtain the maximum daily average rainfall data is as follows:

$$X_{rerata} = \frac{X_1+X_2+\cdots+X_n}{n} = \sum_1^n \frac{X_i}{n} \quad \text{............................} (2.1)$$

Where :

X_{rerata} = Curah hujan rata − rata daerah

X_1 = Curah hujan disetiap stasiun hujan (1)
X_2 = Curah hujan disetiap stasiun hujan (2)
X_n = Curah hujan disetiap stasiun hujan (n)
n = Jumlah stasiun hujan

b. Thiessen Polygon Method.

In this method it is assumed that rainfall data from an observation point can be used for the drainage area in that place, with the formula, as follows:

$$X_{rerata} = a.A + b.B + c.C + d.D + \cdots \qquad (2.2)$$

Where :

X_{rerata} = Curah hujan rata-rata daerah

A,B,C, = The amount of rain for each station

a,b,c,d = Percentage of the area of each rain area to the area of the entire drainage area.

c. The Isohyet Polygon Method.

This method is the most accurate method for determining average rainfall, but requires skill and experience. by formulaas follows:

$$X_{rerata} = \frac{A_1\ R_1 + A_2R_2 + \cdots + A_nR_n}{A_1 + A_2 + \cdots + A_n} \qquad (2.3)$$

Where :

X_rerata = Regional average rainfall

A_1,A_2,A_n = The area of the sections between the isohyet lines

R_1,A_2,A_n = Average rainfall in section A1…An

2.4.2. Frequency Analysis

Frequency analysis is an analysis of hydrological data using statistics that aims to predict a certain amount of rainfall or discharge with a certain return period. In statistics, there are several types of frequency distribution methods that are widely used in hydrology, namely: Normal Distribution Method, Normal Log Method, Pearson Type III Log Method.

Of the three existing methods, the method used to calculate the design rainfall for return periods of 1.01 years, 2 years, 5 years and 10 years is the Log Pearson Type III method.

- **Distribution of Log-Pearson Type III.**

The important parameters in the Pearson Log Type III are the average value, standard deviation, and slope coefficient. If the sloping coefficient is zero then the distribution returns to the Log Normal distribution. The density function of the Log-Pearson type III distribution has the following equation:

$$Y_T = \bar{Y} + K_T\ .S \qquad (2.4)$$

Where the magnitude of the value depends on the coefficient of stiffness G. Table 1 shows prices for various values of stiffness G. If the value of G is zero, the distribution returns to the Log Normal distribution.$K_T K_T$

Table.1: Values for the Pearson III Log Distribution.K_T

Koef. G	Interval kejadian (periode ulang)							
	1,0101	1,2500	2	5	10	25	50	100
	Persentase perluang terlampaui							
	99	80	50	20	10	4	2	1
3,0	-0,667	-0,636	-0,396	0,420	1,180	2,278	3,152	4,051
2,8	-0,714	-0,666	-0,384	0,460	1,210	2,275	3,114	3,973
2,6	-0,769	-0,696	-0,368	0,499	1,238	2,267	3,071	2,889
2,4	-0,832	-0,725	-0,351	0,537	1,262	2,256	3,023	3,800
2,2	-0,905	-0,752	-0,330	0,574	1,284	2,240	2,970	3,705
2,0	-0,990	-0,777	-0,307	0,609	1,302	2,219	2,892	3,605
1,8	-1,087	-0,799	-0,282	0,643	1,318	2,193	2,848	3,499
1,6	-1,197	-0,817	-0,254	0,675	1,329	2,163	2,780	3,388
1,4	-1,318	-0,832	-0,225	0,705	1,337	2,128	2,706	3,271
1,2	-1,449	-0,844	-0,195	0,732	1,340	2,087	2,626	3,149
1,0	-1,588	-0,852	-0,164	0,758	1,340	2,043	2,542	3,022
0,8	-1,733	-0,856	-0,132	0,780	1,336	1,993	2,453	2,891
0,6	-1,880	-0,857	-0,099	0,800	1,328	1,939	2,359	2,755
0,4	-2,029	-0,855	-0,066	0,816	1,317	1,880	2,261	2,615
0,2	-2,178	-0,850	-0,033	0,830	1,301	1,818	2,159	2,472

Advanced

Koef. G	Interval kejadian (periode ulang)							
	1,0101	1,2500	2	5	10	25	50	100
	Persentase perluang terlampaui							
	99	80	50	20	10	4	2	1
0,0	-2,326	-0,842	0,000	0,842	1,282	1,751	2,051	2,326
-0,2	-2,472	-0,830	0,033	0,850	1,258	1,680	1,945	2,178
-0,4	-2,615	-0,816	0,066	0,855	1,231	1,606	1,834	2,029
-0,6	-2,755	-0,800	0,099	0,857	1,200	1,528	1,720	1,880
-0,8	-2,891	-0,780	0,132	0,856	1,166	1,448	1,606	1,733
-1,0	-3,022	-0,758	0,164	0,852	1,128	1,366	1,492	1,588
-1,2	-2,149	-0,732	0,195	0,844	1,086	1,282	1,379	1,449
-1,4	-2,271	-0,705	0,225	0,832	1,041	1,198	1,270	1,318
-1,6	-2,388	-0,675	0,254	0,817	0,994	1,116	1,166	1,197
-1,8	-3,499	-0,643	0,282	0,799	0,945	1,035	1,069	1,087
-2,0	-3,605	-0,609	0,307	0,777	0,895	0,959	0,980	0,990
-2,2	-3,705	-0,574	0,330	0,752	0,844	0,888	0,900	0,905
-2,4	-3,800	-0,537	0,351	0,725	0,795	0,823	0,830	0,832
-2,6	-3,889	-0,490	0,368	0,696	0,747	0,764	0,768	0,769
-2,8	-3,973	-0,469	0,384	0,666	0,702	0,712	0,714	0,714
-3,0	-7,051	-0,420	0,396	0,636	0,660	0,666	0,666	0,667

(Source: Suripin, 2004)

The following are the parameters that will be used in the frequency analysis:

1. Average value

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i \qquad (2.5)$$

2. Standard deviation

$$S = \left[\frac{1}{n-1}\sum_{i=1}^{n}(X i - \bar{X})^2\right]^{\frac{1}{2}} \qquad (2.6)$$

3. Coefficient of Variation (Cv)

$$C_v = \frac{S}{\bar{X}} \qquad (2.7)$$

4. Skewness coefficient

$$C_s = \frac{n\ \sum_{i=1}^{1}(X_i - \bar{X})^3}{(n-1)(n-2)S^3} \qquad (2.8)$$

5. Kurtosis Coefficient

$$C_k = \frac{n^2 \sum_{i=1}^{n} (X_i - \bar{X})^4}{(n-1)(n-2)(n-3)S^4} \quad (2.9)$$

2.4.3. Rain Intensity

Rain intensity is the amount of rainfall in a certain period expressed in mm/hour. Duration is the length of a rain event.

In this study, the empirical formula for calculating rain intensity in determining peak discharge with the Rational method, uses the Mononobe formula as the following equation:

$$I = \frac{R_{24}}{24}\left(\frac{24}{t}\right)^{\frac{2}{3}} \quad (2.10)$$

With :

I = Rain intensity (mm/hour)

t =Rain duration (hours)

R_{24} = Max. rainfall daily in 24 hours (mm)

If the available data is short-term rainfall data, it can be calculated using the Talbot formula:

$$I = \frac{a}{t+b} \quad (2.11)$$

With : I = Rain intensity (mm/hour)

t =Rain duration (hours)

a and b = constants that depend on the duration of rain that occurs in the watershed

2.4.4. Concentration Time

According to Suripin (2004), concentration time is the time required by falling rainwater to flow from the farthest point to the watershed outlet (control point) after the soil becomes saturated.

The concentration time formula can be written as follows:

$$t_c = \left(\frac{0.87 \, x \, L^2}{1000 \, x \, S_0}\right)^{0.385} \quad (2.12)$$

With:

tc = time of concentration (hours)

L = length of the main canal from upstream to drain (km)

So = average channel slope

2.5. Run Off

Surface runoff is rainwater that cannot be retained by soil, vegetation or basins and eventually flows directly into rivers or seas.

- **Factors Affecting Runoff**

According to Suripin (2004), the factors that affect runoff are divided into 2 groups, namely meteorological factors and characteristics of the catchment area or watershed (DAS).

a. Meteorological Factors

The factors included in the group of meteorological elements are as follows:

1. Rainfall intensity.
2. Rain duration.
3. Precipitation distribution.

b. Das Characteristics.

1. Das area and shape.
2. Topography.
3. Land use.

2.6. Rational Method

The Rational method is widely used to estimate peak discharge caused by heavy rains in small catchment areas (Das).

The general form of the Rational method formula is as follows:

$$Q = 0.02785.C.I.A \quad (2.13)$$

With :

Q = Peak surface (discharge) flow rate(m^3/det)

C = Runoff coefficient ($0 \leq C \leq 1$)

I = Rain intensity

A = Watershed Area (ha)

2.6.1. Runoff Coefficient

The runoff coefficient is the percentage of the amount of water that can run over through the soil surface from the total rainwater that falls on an area. The more impermeable a soil surface, the higher the value of the flow coefficient.

Table.2: Run Off Coefficient

Land description / surface character	C runoff coefficient
business	
• Urban	0.70 – 0.95
• edge	0.50 – 0.70
Housing area	
• Single house	0.30 – 0.50
• Multiunit, separate	0.40 – 0.60
• Multiunit, combined	0.60 – 0.75
• Village	0.25 – 0.40
• Apartment	0.50 – 0.70
Industry	
• Light	0.50 – 0.80
• Heavy	0.60 – 0.90

Pavement • Asphalt and concrete • Bricks, paving	0.70 – 0.95 0.50 – 0.70
Roof	0.75 – 0.95
Yard, sandy soil • Flat, 2% • Average, 2-7% • Steep, 7% Yard, heavy earth • Flat, 2% • Average, 2-7% • Steep, 7%	0.05 – 0.10 0.10 – 0.15 0.15 – 0.20 0.13 – 0.17 0.18 – 0.22 0.25 – 0.35
Rail yard	0.10 – 0.35
Playground park	0.20 – 0.35
Gardens, cemeteries	0.10 – 0.25
Forest • Flat, 0-5% • Corrugated 5-10% • hilly, 10-30% • Shrubs	0.10 – 0.40 0.25 – 0.50 0.30 – 0.60 0.15 – 0.30

(Source:McGuen, 1989 in Suripin, 2004)

2.7. Channel Cross Section

In general, the type of flow through open channels is turbulent, because the flow velocity and wall roughness are relatively large. Flow through an open channel will be turbulent if the Reynolds number Re> 2,000 and laminar if Re < 500. The Reynolds formula can be written as follows:

$R_e = \frac{V.L}{\upsilon}$……………………………….………… (2.14)

With : V = Flow rate (m/s)

L = Characteristic length (m), at the free water level channel L = R

υ = kinematic viscosity(m^2/det)

The value of R can be found using the following formula:

$R = \frac{A}{P}$……………………………………….…...... (2.15)

With : R = Hydraulic radius (m)

A = Wet cross-sectional area(m^2)

P = Circumference of wet cross section (m)

To find the flow velocity value, you can use the Manning formula which can be written as follows:

$V = \frac{1}{n} . R^{\frac{2}{3}} . S^{\frac{1}{2}}$…………………….……….....……..…... (2.16)

With : R = Hydraulic radius (m)

I = bottom slope of the channel

n = Manning's coefficient

The value of the Manning coefficient can be found by looking at Table 3 below:

Table.3: Manning Coefficient Values

Bahan	Koefisien Manning n
Besi tuang dilapis	0,014
Kaca	0,010
Saluran beton	0,013
Bata dilapis mortar	0,015
Pasangan batu disemen	0,025
Saluran tanah bersih	0,022
Saluran tanah	0,030
Saluran dengan dasar batu dan tebing rumput	0,040
Saluran pada galian batu padas	0,040

To find the flow rate in the channel, you can use the formula:

$Q_{ext} = V.A$ …………………………………….... (2.17)

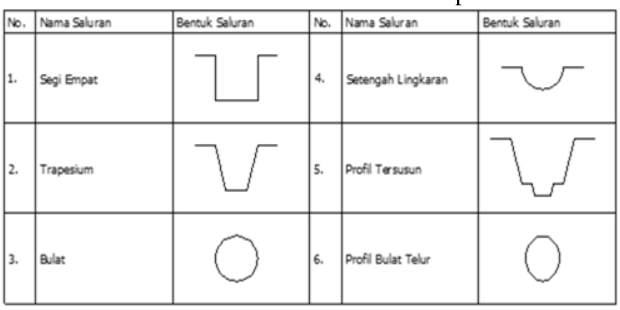
With : = Flow discharge in the channel$Q_{ext}(m3/det)$

V = Flow rate (m/s)

A = Wet cross-sectional area of the channel(m^2)

The most economical channel cross-section is the channel that can pass the maximum discharge for a certain wet cross-sectional area, roughness, and bottom slope.

Table.4: Channel Section Shape



No.	Nama Saluran	Bentuk Saluran	No.	Nama Saluran	Bentuk Saluran
1.	Segi Empat		4.	Setengah Lingkaran	
2.	Trapesium		5.	Profil Tersusun	
3.	Bulat		6.	Profil Bulat Telur	

Source: BPKM, Urban Drainage, 1996

2.8. The Most Economical Form Of Channels

The most economical channel cross-section is the channel that can pass the maximum discharge for a certain wet cross-sectional area, roughness, and base slope. One of them is a trapezoidal channel.

❖ **Channel Dimension Calculation**

As for calculating the dimensions of the channel, it can use the Manning formulation method, as follows:

V = $1/n. R^{2/3}$. S1/2 ……………………….............. (2.18)

Q = A.V = A.(1/n . R2/3 . S1/2)………...…….... (2.19)

$$R = A/P \quad (2.20)$$

$$A = (b+mh)h \quad (2.21)$$

$$P = b + 2h\sqrt{1 + m2} \quad (2.22)$$

$$Q = (b + mh)h\left[\frac{1}{n}\right]\left[\frac{(b+mh)h}{b+2h\sqrt{1+m^2}}\right]^{2/3} .S^{1/2} \quad (2.23)$$

With:
- n = Channel roughness figures (table 3)
- R = Channel hydraulic radius, (m)
- S = The slope of the channel bottom
- Q = Channel discharge, (m3/sec)
- h = Water height in channel (m)
- m = tiltloud
- b = Channel base width(m)
- V = Flow speed (m/s)
- A = Wet cross-sectional area of the channel (m^2)

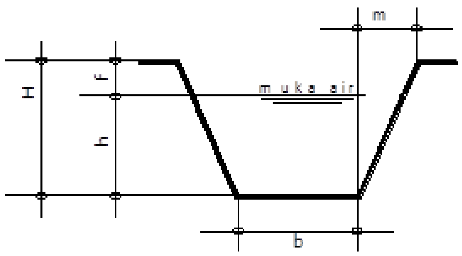


Fig.3: Trapezoidal Channel Section

III. METHODOLOGY

3.1. Preliminary studies

Preliminary studies are carried out before conducting research, with the aim of knowing what will be done in conducting research and what data is needed. Activities which include literature study in the form of collecting libraries as a support for this research.

3.2. Research sites

The location reviewed in this study is in the village of Rumah Tiga, Teluk Ambon District, Ambon City.

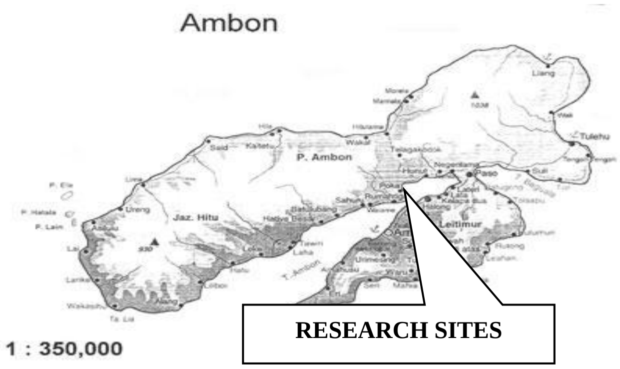


Fig.4: Research Locations

3.3. Data Type

The types of data used by research are as follows:

a. Primary data
   1. Visualization Data, in the form of: Recorded data of research objects in the form of observational photographs to determine the conditions that occur in Rumah Tiga Village.
   2. Library Data, in the form of: data obtained from books.

b. Secondary Data
   1. Topographic data, in the form of: Land use data and river area.
   2. Rainfall data, in the form of: Maximum rainfall data for the BMKG Pattimura Ambon area.
   3. Population data, in the form of: Data on the population of the Rumah Tiga village.

3.4. Data source

The data obtained and used in this study include:

1. Ambon City Regional and River Service Office (BWS).
2. Ambon City Meteorology, Climatology and Geophysics Agency (BMKG) Station.
3. Rumah Tiga Village Office.
4. Other related agencies.
5. Source Google (Internet).

3.5. Data Collection Techniques

The techniques used by the author in data collection include:

1. Primary data.
   a. Observation Techniques
   b. Literature Engineering
2. Secondary Data.
   a. Topographic Data.
   b. Research Location Map.

3.6. Data Processing Techniques

This study uses the data obtained, with the aim of obtaining an effective approach based on theoretical studies.

The research steps are as follows:

1. Preliminary studies.

   Preliminary study is the process of collecting data to support this writing.
2. Library Studies.

   This is done by collecting references related to writing support, which is a theoretical study.
3. Data Compilation.

   Data compilation, basically is a process of collecting, processing and reporting data to get the final result in the form of half-baked data that is ready to be processed at the data analysis stage.
4. Data Processing and Analysis.

Data processing is an activity to change the raw data that has been obtained into a standard format that is approached by theoretical studies. Data analysis is the process of describing the research as a whole according to existing data. Data processing and analysis is carried out as quickly as possible, because the possibility of errors will be identified and corrected more quickly, and can determine other alternative solutions related to the study being carried out.

3.7. Research Flowchart

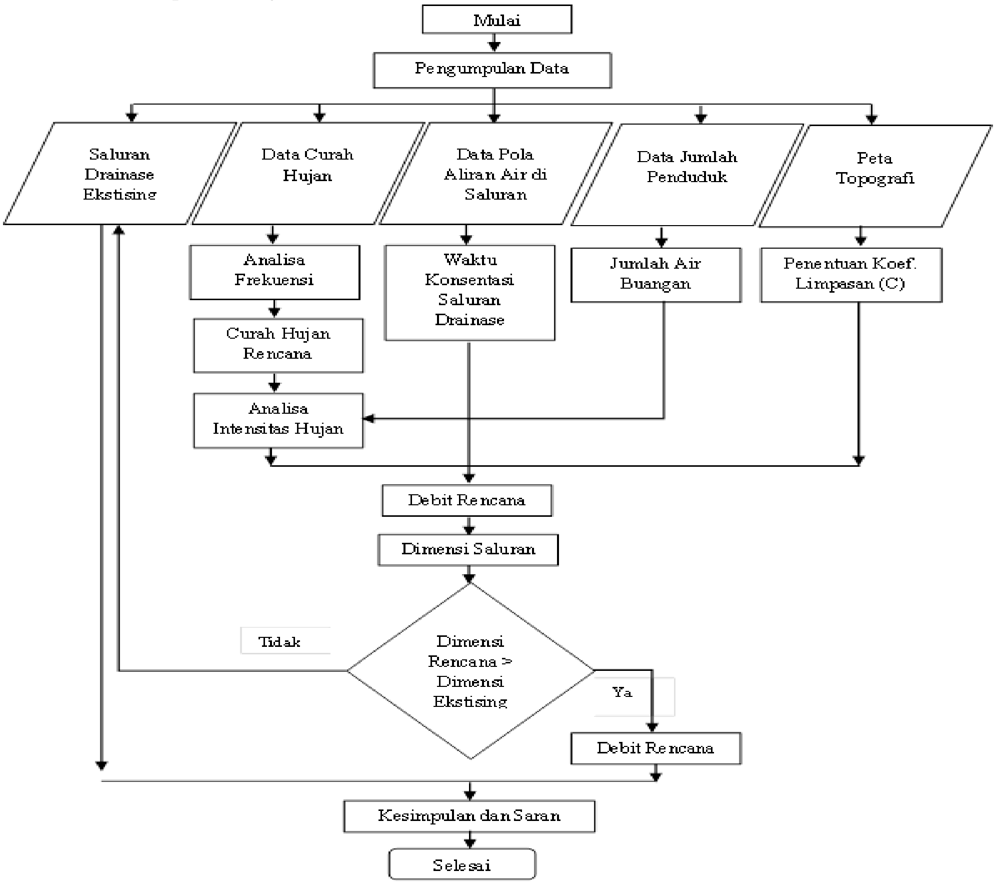


Fig.5: Research Flowchart

IV. ANALYSIS AND DISCUSSION

4.1 Hydrological Analysis

Rain is water that falls to the surface of the earth and is water vapor in the atmosphere that condenses and falls in the form of water droplets. Today's drainage system is more focused on handling surface water, this is because most of the water that enters the drainage canal is rainwater.

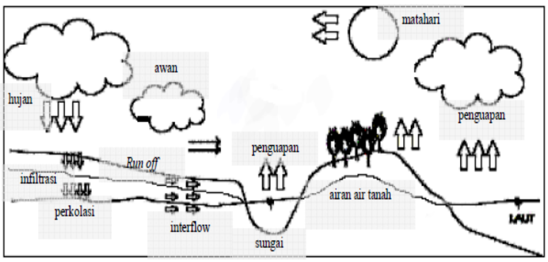


Fig.6: Hydrological Cycle.(Source: Sri Harto, Applied Hydrology, 1994)

4.2 Rainfall Data Processing

Rainfall data processing is intended to obtain rainfall data that is ready to use for a planning distribution system. This data processing can be done by several methods, one of which is the Gumbel method, which is a method based on the normal distribution (extreme price distribution). Gumbel assumes that the distribution of hydrological variables is unlimited, so the distribution of the largest values (maximum prices) must be used.

The following is the regional average maximum rainfall data from the BMKG Pattimura Ambon Station.

Table.5: Maximum Rainfall Data for Pattimura Ambon Station

Year	Month											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**dec**
2004	0.8	0.2	5	56	73	130	48	12	57	99	18	19
2005	29	31	69	53	77	32	101	59	43	55	55	65
2006	47	53	25	45	59	166	69	35	38	2	10	47
2007	31	32	32	59	84	263	39	75	160	95	23	57
2008	53	45	21	61	91	83	170	117	161	48	40	61
2009	36	31	30	19	97	42	77	43	41	49	30	36
2010	28	9	33	22	88	224	195	187	55	32	52	59
2011	78	49	35	134	183	153	188	146	41	59	31	16
2012	31	47	79	17	185	222	360	348	116	118	23	31
2013	54	28	35	56	74	65	432	70	84	49	25	44

(Source: BMKG Pattimura Ambon)

From the existing rainfall data, it will be sorted regularly to getregional average maximum rainfall as shown in Table 6

Table.6: Regional Average Max Rainfall

No	Year	Xi(mm)	CH Average
1	2004	43	43
2	2005	56	56
3	2006	50	50
4	2007	79	79
5	2008	79	79
6	2009	44	44
7	2010	82	82
8	2011	93	93
9	2012	131	131
10	2013	85	85

(Source: Analysis Results)

4.3 Planned Rain Frequency Analysis

There are several types of statistical distributions that can be used to determine the magnitude of the design rainfall, such as the Gumbel distribution, Pearson III Log, Normal Log, and several other methods. These methods should be tested which can be used in the calculation of the test by measuring dispersion.

In calculating the design rainfall frequency, the formula used is the Log Pearson III method.

The calculation steps with the Pearson III Log Method include:

1. Cs = -1.20 changes the annual maximum daily rainfall data in logarithmic form (previously the rainfall data has been sorted from small to large).
2. Calculating the empirical probability (p) in % with the Weibull formula (Soewerno, 1995: 114).

   P%= x 100 % = x 100 % = 9.09$\frac{m}{n+1}\frac{1}{10+1}$
3. Rainfall analysis with algebraic mean method.

   R = 1/n [R1 + R2 + … + Rn]

   With :

   R: Evenly distributed rainfall [mm].

   N: Number of observation points or posts.

   R1, R2, Rn : Rainfall every second.
4. Calculating the average price (log X) with the formula:

   $$Logx = \frac{\sum_{i=1}^{n} logx_i}{n}$$

   With : logX = logarithm of average rainfall

   n = amount of data

   Logs = = 74.2$\frac{742}{10}$
5. Calculating the price of standard deviation / standard deviation (in logs) with the formula:

   $$S = \frac{\sqrt{\sum_{i=1}^{n}(LogXi - Log)^2}}{n-1}$$

   $$S = \sqrt{\frac{0{,}22307}{9}}$$

   S = 0.05
6. Calculating the slope coefficient (in logs) with the formula:

   $$Cs = \frac{\sum_{i=1}^{n}(logx_i - Log)^3}{(n-1)(n-2)S^3}$$

$$Cs=\frac{(0{,}00227)}{(9).(8).0{,}05^3}$$

$$Cs=\frac{0{,}00227}{72.0{,}05^3}$$

$$Cs=\frac{0{,}00227}{0{,}0466605}$$

Cs= 0.04

The following is a planned rainfall calculation and distribution calculation using the Pearson III Log Method, as shown in the tables below.

Table.7: Design Rain Calculations

No	Year	Xi(mm)	P (%)
1	2004	43	9.09
2	2005	56	18,18
3	2006	50	27,27
4	2007	79	36,36
5	2008	79	45,45
6	2009	44	54.55
7	2010	82	63,64
8	2011	93	72,73
9	2012	131	81,82
10	2013	85	90,91

(Source: Analysis Results)

Table.8: Distribution Calculations Using the Log Person Method III

No	Year	Xi(mm)	P (%)	Log Xi	Log Xi - Log X	$(Log\ Xi - Log\ X)^2$	$(Log\ Xi - Log\ X)^3$
1	2004	43	9.09	1.64	-0.21	0.04389	-0.00919
2	2005	56	18,18	1.75	-0.10	0.00982	-0.00097
3	2006	50	27,27	1.70	-0.15	0.02234	-0.00334
4	2007	79	36,36	1.90	0.05	0.00294	0.00016
5	2008	79	45,45	1.90	0.05	0.00298	0.00016
6	2009	44	54.55	1.65	-0.20	0.03946	-0.00784
7	2010	82	63,64	1.91	0.07	0.00468	0.00032
8	2011	93	72,73	1.97	0.12	0.01500	0.00184
9	2012	131	81,82	2,12	0.27	0.07507	0.02057
10	2013	85	90,91	1.93	0.08	0.00690	0.00057
Amount		742		18.45		**0.22307**	**0.00227**
Average		74,2		1.84			
stands. Dev				0.05			
Kemen coefficient (Cs)				0.048			

(Source: Analysis Results)

After finishing calculating the planned rainfall and rainfall distribution, the next step is to calculate the logarithm of the planned rainfall with a certain return period (extreme value). The formula used to calculate the logarithm of the planned rainfall includes:

Log X = Log X + K . (S .Log X)

Information :

Log X =The logarithm is usually the rainfall for the birthday period T years

logs =Average of the logarithm of precipitation.

K =The characteristic factor of the distribution of Log Person Type III which is a function of the coefficients.

Disadvantage (Cs) of the return period or probability (p). The value of K depends on the value of Cs Positive or negative. The determination of the value of K is done by means of interpolation.

S =Standard deviation (standard deviation)

$LogX \quad = LogX + K.(SLogX).$

For example, the birthday is 1.01 years

1.84+ (-2.178) . (0.05)=

= 1.74

Looking for anti-log X to get a planned rainfall with a certain return period, for example, at a return period of 1.01 years.

Anti-log X (1.74) = 54.95 mm.

The following is the calculation of design rainfall with various specific return periods (Tr), namely 0.01 year return period, 2 year return period, 5 year return period and 10 year return period. For more details, see the return period (Tr) calculation table below.

Table.9: Design Rainfall Calculations with Various Return Periods

No	Return Period (Tr)	Average	std. Dev	dumbfounded	Opportunity	K	CH Plan (R)	
	(Year)	(Logs)	(S)	(Cs)	(%)		Logs	mm
1	1.01	1.84	0.05	0.048	99	-2.178	1.74	54.95
2	2	1.84	0.05	0.048	50	-0.033	1.84	69,18
3	5	1.84	0.05	0.048	20	0.830	1.88	75.85
4	10	1.84	0.05	0.048	10	1,301	1.91	81,28

(Source: Analysis Results)

Information:

[1] = Number

[2] = Repeat Period

[3] = (S . Log Xi) / n

[4] = (Σ (Log Xi-Log) / (n-1)

[5] = (n.Σ (Log Xi-Log)³) / (n-1) (n-2) (Slog x³)

[6] = (1/Tr) * 100

[7] = Table of the characteristic factor of the distribution of log person III based on Cs values and probability or return period.

[8] = Log X + K . S Log X

[9] = anti-log from Log X

4.4 Runoff Debt Analysis

The runoff coefficient is a number that shows the ratio of the amount of surface runoff to the intensity of rainfall that occurs in each catchment area.

The following will describe the Runoff Coefficient C, in the Wailela Watershed in terms of land use in the area.

Table.10: Runoff Coefficient C

No	Land use	Koef C	Area (m²)	Area (Ha)	Pers. (%)
1	Jungle	0.10	1092330	109,2	21,12
2	Plantation	0.40	3758400	375.8	72,67
3	Settlement	0.25	5400	0.5	0.10
4	Moor/Field	0.15	315900	31,6	6,11
Amount			5172030	517	100

(Source: Analysis Results)

4.5 Rain Intensity

In this study, the empirical formula for calculating rain intensity in determining peak discharge with the Rational method, uses the Mononobe formula as the following equation:

$$I = \frac{R_{24}}{24}\left(\frac{24}{t}\right)^{\frac{2}{3}}$$

$$I = \frac{54{,}95}{24} x \left(\frac{24}{0{,}188}\right)^{0{,}6667} = 292.206 \text{ mm/hour}$$

With :

I = Rain intensity (mm/hour)

t =Rain duration (hours)

R_{24} = Daily maximum rainfall in 24 hours (mm)

$$t_c = \left(\frac{0,87\ x\ L^2}{1000\ x\ S_0}\right)^{0,385}$$

$$t_c = \left(\frac{0,87x0,43^2}{1000x0,0123}\right)^{0,385}$$

$t_c = 0{,}188$ O'clock.

With:

tc = time of concentration (hours)

L = length of the main channel from upstream to drain (m)

So = average channel slope

Table.11: Rain Intensity Calculation Drainage Area

Return Period (T)	R (mm)	tc (O'clock)	I (mm/h)
1.01	54.95	0.188	292,206
2	69,18	0.188	367,877
5	75.85	0.188	403,345
10	81,28	0.188	432,220

(Source: Analysis Results)

4.6 Condition of Existing Drainage System

Existing channel data (channels that already exist) were obtained from survey results around the Wailela Watershed Drainage area. There are 16 existing canals which will affect the hydrology and hydraulics of the canals. The list of existing channels is attached in the following table.

Table.12: Existing Channel Conditions in the Wailela Basin Drainage System

No	Channel Name	Information	Long Channel (m)	slopes Channel	Coefficient manning	Base Width Channel (b)	Water level (h)	DPS area (Ha)
1	Sal Parent Ka 1	Already available	285	0.0200	0.025	0.8	0.8	0.09
2	Sal Main Ka 2	Already available	500	0.0225	0.025	0.9	0.8	0.10
3	Sal Main Ka 3	Already available	102	0.0225	0.025	0.9	0.6	0.09
4	Sal Main Ki 1	Already available	352	0.0125	0.025	0.5	0.7	0.07
5	Sal Main Ki 2	Already available	120	0.0175	0.025	0.7	0.6	0.08
6	SalKa 1	Already available	80	0.0125	0.025	0.5	0.4	0.06
7	Sal Ka 1a	Already available	220	0.0075	0.025	0.3	0.7	0.09
8	Sal Ka 1b	Already available	100	0.0075	0.025	0.3	0.7	0.09
9	SalKa 2	Already available	215	0.0125	0.025	0.5	0.45	0.09
10	Sal Ka 2a	Already available	98	0.0075	0.025	0.3	0.6	0.06
11	Sal Ka 2b	Already available	85	0.0075	0.025	0.3	0.6	0.05
12	Sal Ki 1	Already available	20	0.01	0.025	0.4	0.6	0.02
13	SalKi 2	Already available	40	0.0075	0.025	0.3	0.4	0.02
14	SalKi 3	Already available	278	0.0100	0.025	0.4	0.4	0.08
15	Sal Ki 3a	Already available	10	0.01	0.025	0.4	0.3	0.02
16	Sal Ki 3b	Already available	12	0.01	0.025	0.4	0.3	0.02
Amount			**2517**					**1.02**

(Source: Survey Results and Analysis)

Channel Slope = bxn

Where :

b = channel bottom width,

n = Manning's coefficient

4.7 Runoff Discharge (Rain Water) in DPS Drainage

To calculate runoff discharge (rainwater) in a DPS, it is necessary to have accuracy and what method will be used. So in this writing, the Modified Rational Method is used to calculate runoff discharge (Rainwater) in the Wailela Drainage DPS.

The following is an example of calculating runoff discharge in the primary channel. The main canal is located in sub DAS 1, so the runoff discharge is calculated as follows:

Q = 0.02785.(CIA)

Where :

C = Flow Coefficient

I = Rain Intensity

A = Area DPS Drainage

Example to calculate the runoff occurring for Q 10 yr (for Ka1 Main Canal) = 0.02785 x (0.7 x 432.220 x 0.09) = 0.7204 m/s.

More details can be seen in the following table.

Table 13: Runoff Discharge (Rain Water) in Dps Drainage

No	Channel ID	Channel Name	DPS Drainage	Rain Discharge (m / sec)			
				Q 1.01 yrs	Q 2 yrs	Q 5 yrs	Q 10 yrs
1	I	Sal Parent Ka 1	0.09	0.4871	0.6132	0.6723	0.7204
2	II	Sal Main Ka 2	0.10	0.5697	0.7172	0.7863	0.8426
3	III	Sal Main Ka 3	0.09	0.5229	0.6584	0.7218	0.7735
4	IV	Sal Main Ki 1	0.07	0.4010	0.5049	0.5536	0.5932
5	V	Sal Main Ki 2	0.08	0.4785	0.6024	0.6605	0.7078
6	HE	SalKa 1	0.06	0.3190	0.4016	0.4403	0.4719
7	A1	Sal Ka 1a	0.09	0.5013	0.6311	0.6920	0.7415
8	A2	Sal Ka 1b	0.09	0.5127	0.6455	0.7077	0.7584
9	IB	SalKa 2	0.09	0.4899	0.6168	0.6762	0.7246
10	B1	Sal Ka 2a	0.06	0.3350	0.4217	0.4624	0.4955
11	B2	Sal Ka 2b	0.05	0.2905	0.3658	0.4010	0.4297
12	II A	Sal Ki 1	0.02	0.1139	0.1434	0.1573	0.1685
13	II B	SalKi 2	0.02	0.1367	0.1721	0.1887	0.2022
14	II C	SalKi 3	0.08	0.4751	0.5981	0.6558	0.7027
15	C1	Sal Ki 3a	0.02	0.0854	0.1076	0.1179	0.1264
16	C2	Sal Ki 3b	0.02	0.1025	0.1291	0.1415	0.1517
Amount			**1.02**				

(Source: Analysis Results)

4.8 Dirty water discharge analysis

Calculation of discharge of dirty water or waste water for DPS Wailela Drainage, is calculated based on the needs of people per day. Before determining the amount of dirty water discharge that occurs in the Wailela Drainage DPS, the first thing is to first determine the projection of population growth.

The following is data on the population growth rate of DPS Wailela in 2010-1014, as shown in the table below.

Table.14: Population Growth Rate 2010-2024 (Geometry Method)

district	Village	Area (Ha)	Number of Population in 2010 - 2014				
			2010	2011	2012	2013	2014
		517	3019	3645	4108	4789	5611

Ambon Bay	House Three					
Growth rate (r) in %		0.172	0.113	0.142	0.146	0.277

(Source: Rumah Tiga Village Office and Analysis Results)

So the projected population growth in 2024 in the Wailela drainage DPS can be seen in the table below.

Table.15: Projection of Population in 2024

Village	district	Wide (Ha)	Growth rate r in (%)	Total population	
				2014	2024
House Three	Ambon Bay	517	0.277	5611	5768,376
Wailela Drainage DPS		49,71	0.277	56,11	59993

(Source: Rumah Tiga Village Office and Analysis Results)

The following is an example of calculating the dirty water that is made every km^2 for the channel can be calculated with the following equation:

a) The area of Rumah Tiga Village = 517 Ha = 5172030 m^2

b) Population Growth Rate (r) 2010 – 2011
$= (\frac{3645-3019}{3645}) x\ 100\% \ = 0.172\ \%$

c) Population growth rate (r) average for 4 years = 0.277%

d) Projected population growth in 2024 in Rumah Tiga Village:

P_n =Po(1+r)n
= 5611.(1+0.00277)n (2024-2010)
= 5611.(1+0.0027)^10 =5768,376 soul

e) Projected population growth in 2024 at the Wailela Drainage DPS

P_n =5768,376x $(\frac{517}{5172030})$ = 59993Soul

- Needs used = 120 ltr / person / day
- Waste water = 85% = 0.85

$$Q\ ak = \frac{Pn.\ q}{A}$$

$Q\ ab$ = 120 x 0.85 = 102 lt/day/person

$= (\frac{(\frac{102}{1000})}{24*60*60)})$ = 0.00000118 m3/s

P_n =5768,376 for the Wailela Drainage DPS area, for the Ka1 main channel of the Wailela Drainage DPS, namely:

P_n = 5768,376x$(\frac{517}{5172030})$ = 59993soul

Qk = (2024 population projection x Q ab)/ $\sum_{i=1}^{n} Luas\ DPS$

$Qk = \frac{59993\ X\ 0{,}00000118}{1{,}02}$ =0.0693 m^3/sec

$Qki = Qk.$ DPS area

Q ki = 0.0693 x 0.09 = 0.0057 m3/s

A more complete calculation is described in Table 16 below.

Table.16: Calculation of Dirty Water Discharge

No	Channel ID	Channel Name	DPS Area (Ha)	Population Projection Year 2024	Q k (m3/sec/dy)	Q ki (m3/sec)
1	I	Sal Parent Ka 1	0.09	59993	0.0693	0.0059
2	II	Sal Main Ka 2	0.10	59993	0.0693	0.0069
3	III	Sal Main Ka 3	0.09	59993	0.0693	0.0064
4	IV	Sal Main Ki 1	0.07	59993	0.0693	0.0049
5	V	Sal Main Ki 2	0.08	59993	0.0693	0.0058
6	HE	SalKa 1	0.06	59993	0.0693	0.0039
7	A1	Sal Ka 1a	0.09	59993	0.0693	0.0061
8	A2	Sal Ka 1b	0.09	59993	0.0693	0.0062
9	IB	SalKa 2	0.09	59993	0.0693	0.0060
10	B1	Sal Ka 2a	0.06	59993	0.0693	0.0041
11	B2	Sal Ka 2b	0.05	59993	0.0693	0.0035
12	II A	Sal Ki 1	0.02	59993	0.0693	0.0014

13	II B	SalKi 2	0.02	59993	0.0693	0.0017
14	II C	SalKi 3	0.08	59993	0.0693	0.0058
15	C1	Sal Ki 3a	0.02	59993	0.0693	0.0010
16	C2	Sal Ki 3b	0.02	59993	0.0693	0.0012
Amount			**1.02**			

(Source: Analysis Results)

4.9 debitWailela Watershed Drainage System Plan

In the calculation to find out the value of the planned flood, it is usually determined by adding up the runoff discharge or rainwater discharge, which is used is the discharge with a return period of 10 years in the Ka1 main canal.

The following is an example for calculating the main channel Ka1, with a rain discharge of 0.7204m3/s and dirty water discharge is 0.0059 m3/s, then:

Design debit = rain discharge + gross debit

= 0.7204+0.0059 = 0.7264m3/sec

Table.17: Planned Discharge in the Drainage System

No	Channel ID	Channel Name	DPS Area (Ha)	Rain Debt (m^3/s)	Gross Debt (m^3/s)	Plan Debt (m^3/s)
1	I	Sal Parent Ka 1	0.09	0.7204	0.0059	0.7264
2	II	Sal Main Ka 2	0.10	0.8426	0.0069	0.8495
3	III	Sal Main Ka 3	0.09	0.7735	0.0064	0.7799
4	IV	Sal Main Ki 1	0.07	0.5932	0.0049	0.5981
5	V	Sal Main Ki 2	0.08	0.7078	0.0058	0.7136
6	HE	SalKa 1	0.06	0.4719	0.0039	0.4757
7	A1	Sal Ka 1a	0.09	0.7415	0.0061	0.7476
8	A2	Sal Ka 1b	0.09	0.7584	0.0062	0.7646
9	IB	SalKa 2	0.09	0.7246	0.0060	0.7306
10	B1	Sal Ka 2a	0.06	0.4955	0.0041	0.4995
11	B2	Sal Ka 2b	0.05	0.4297	0.0035	0.4333
12	II A	Sal Ki 1	0.02	0.1685	0.0014	0.1699
13	II B	SalKi 2	0.02	0.2022	0.0017	0.2039
14	II C	SalKi 3	0.08	0.7027	0.0058	0.7085
15	C1	Sal Ki 3a	0.02	0.1264	0.0010	0.1274
16	C2	Sal Ki 3b	0.02	0.1517	0.0012	0.1529

(Source: Analysis Results)

The system design discharge is the accumulation of channel discharge originating in the upstream channel plus the discharge in the drainage channel. To calculate the discharge capacity that must be discharged on each channel, the calculation used is the system design discharge.

The following is an example of the calculation for the main channel Ka1 at DPS Wailela Drainage.

Qr system = I+IA+A1+A2

= 0.726 + 0.476 + 0.747 + 0.764 = 2,714 m3/sec.

For complete calculations can be seen in the following table.

Table.18: Planned Discharge in the Wailela Basin Drainage System

No	Channel ID	Channel Name	DPS Area (Ha)	Plan Debt (m^3/s)	Discharge From Channels (ID)	System Discharge
1	I	Sal Parent Ka 1	0.09	0.726	I+IA+A1+A2	2,714
2	II	Sal Main Ka 2	0.10	0.849	II+IB+B1+B2	2,512
3	III	Sal Main Ka 3	0.09	0.780	III	0.780
4	IV	Sal Main Ki 1	0.07	0.598	IV+IIA+IIB	0.972
5	V	Sal Main Ki 2	0.08	0.713	V	0.713
6	HE	SalKa 1	0.06	0.476	IA+A1+A2	1,987
7	A1	Sal Ka 1a	0.09	0.747	A1	0.747
8	A2	Sal Ka 1b	0.09	0.764	A2	0.764
9	IB	SalKa 2	0.09	0.730	IB+B1+B2	1,663
10	B1	Sal Ka 2a	0.06	0.499	B1	0.499
11	B2	Sal Ka 2b	0.05	0.433	B2	0.433
12	II A	Sal Ki 1	0.02	0.170	IIA	0.170
13	II B	SalKi 2	0.02	0.204	IIB	0.204
14	II C	SalKi 3	0.08	0.708	IIC+C1+C2	0.989
15	C1	Sal Ki 3a	0.02	0.127	C1	0.127
16	C2	Sal Ki 3b	0.02	0.153	C2	0.153

(Source: Analysis Results)

4.10 CapacityExisting Drainage Channel

Existing channel data (canals that already exist) were obtained from survey results around the Wailela Drainage DPS. There are 16 (sixteen) existing canal segments that will affect the hydrology and hydraulics of the canal.

Therefore, to facilitate the calculation of the existing channel is assumed to be in the form of a trapezoid.

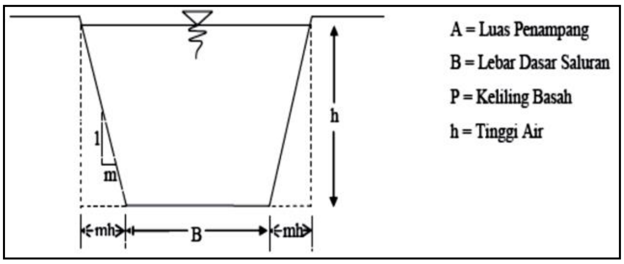


Fig.7: Trapezoidal Channel Cross Section

The cross-sectional shape of the drainage channel can be an open channel or a closed channel depending on the conditions of the area. The formula for the average velocity in the calculation of the channel cross-sectional dimensions uses the Manning formula (Chow, 1992).

V = 1/n. R2/3 . S1/2

Q = AV = A .1/N. R2/3. S1/2

With : Q = channel discharge (m^3/sec)

V = Flow rate (m/s)

A = Wet cross-sectional area of the channel (m^2)

n = channel roughness number (m)

R = Hydraulic radius of the channel (m)

S = Base slope of the channel

1. Calculations on the main channel Ka1 (I):

   Is known :

   B = 0.8 m H = 0.8 m

   n = 0.025 S = 0.0200

The cross-sectional shape of the main channel Ka 1 is trapezoidal.

A = (B + mH) x H → m = 1

= (0.8 + 0.8) x 0.8 = 1.28 m2

P = B + 2H$\sqrt{1 + m^2}$

$= 0.8 + (2 \times 0.8 \times)\sqrt{1 + 1^2}$

$= 0.8 + (2 \times 0.8) \times 1.41 = 3.06$ m

$R=A/P = \frac{1,28}{3,06} = 0.42$m

$V=R\frac{1}{n}\, x\ ^{2/3} \times S^{1/2}$

$= \frac{1}{0,025}\ x$ 0.422/3 x 0.02001/2

$= \frac{1}{0,025}\ x$ 0.420,6667x 0.02000,5

$= \frac{1}{0,025}\ x\ 0.56 \times 0.14$

$= \frac{1}{0,025}\ x\ 0.0784 = 3.17$ m/s

Q = A . V = 1.28 x 3.17 = 4.05 m3/sec.

2. Calculations on the main channel Ka2 (II):

Is known :

B = 0.9 m H = 1.2 m

n = 0.025 S = 0.023

The cross-sectional shape of the Ka2 main canal is square.

A = B . H = (0.9 x 1.2) = 1.08 m2

P = B + 2H = 0.9 + (2 x 1.2) = 2.10 m

R = A/P

$= \frac{1,08}{2,10} = 0.51$m

$V=R\frac{1}{n}\, x\ ^{2/3} \times S^{1/2}$

$= \frac{1}{0,025}\ x$ 0.512/3 x 0.0231/2

$= \frac{1}{0,025}\ x$ 0.510.6667x 0.0230.5

$= \frac{1}{0,025}\ x\ 0.63 \times 0.15$

$= \frac{1}{0,025}\ x\ 0.0945 = 3.85$ m/s

Q = A . V = 1.08 x 3.85 = 4.16 m3/sec.

For complete calculations, see the following table.

Table.19: Capacity of Existing Drainage Channels in the Wailela Basin

No	Channel ID	Channel Name	L (m)	S	n	B (m)	h (m)	A (m2)	P (m)	R (m)	V (m/s)	Q (m3/s)
1	I	Sal Parent Ka 1	285	0.0200	0.025	0.8	0.8	1.28	3.06	0.42	3,17	4.05
2	II	Sal Main Ka 2	500	0.023	0.025	0.9	1,2	1.08	2,10	0.51	3.85	4,16
3	III	Sal Main Ka 3	102	0.0225	0.025	0.9	0.6	0.90	2.59	0.35	2.96	2.67
4	IV	Sal Main Ki 1	352	0.0125	0.025	0.5	0.7	0.84	2.47	0.34	2,18	1.83
5	V	Sal Main Ki 2	120	0.018	0.025	0.7	0.6	0.42	1.90	0.22	1.93	0.81
6	HE	SalKa 1	80	0.013	0.025	0.5	0.4	0.20	1.30	0.15	1.28	0.26
7	A1	Sal Ka 1a	220	0.0075	0.025	0.3	0.8	0.24	1.90	0.13	0.87	0.21
8	A2	Sal Ka 1b	100	0.008	0.025	0.3	0.8	0.24	1.90	0.13	0.87	0.21
9	IB	SalKa 2	215	0.0125	0.025	0.5	0.4	0.20	1.30	0.15	1.28	0.26
10	B1	Sal Ka 2a	98	0.0075	0.025	0.3	0.6	0.18	1.50	0.12	0.84	0.15
11	B2	Sal Ka 2b	85	0.0075	0.025	0.3	0.6	0.18	1.50	0.12	0.84	0.15
12	II A	Sal Ki 1	20	0.01	0.025	0.4	0.6	0.60	2.09	0.29	1.74	1.04
13	II B	SalKi 2	40	0.0075	0.025	0.3	0.4	0.28	1.43	0.20	1.17	0.33
14	II C	SalKi 3	278	0.0100	0.025	0.4	0.4	0.16	1.20	0.13	1.04	0.17
15	C1	Sal Ki 3a	10	0.01	0.025	0.4	0.3	0.12	1.00	0.12	0.97	0.12
16	C2	Sal Ki 3b	12	0.01	0.025	0.4	0.3	0.12	1.00	0.12	0.97	0.12

(Source: Analysis Results)

4.11 Evaluation Drainage Channel Capacity

The ability of the drainage channel capacity to be safe against the system's design discharge can be known if the drainage channel capacity is safe against the system's planned discharge, it can be known if the existing drainage channel capacity is greater than the calculated system design/plan discharge. Channel evaluation is intended to find out how much discharge can be accommodated by the channel with the current (existing) dimensions.

If the existing drainage channel capacity is greater than the system's design discharge, the drainage channel is still feasible and no change in channel dimensions is required. On the other hand, if the planned debit of the system is greater than the capacity of the existing drainage channel, then the existing drainage channel is no longer feasible, so it is necessary to rehabilitate the channel.

Examples of calculations for Ka1 (IA) channels include:

Debt Difference = Existing Debit – Planned Debit

= 0.257 – 1.987 = -1.731 m3/sec

Evaluation of Existing Canal Capacity in the Wailela Watershed Drainage system for more details can be seen in the table below.

Table.20: Evaluation of Existing Channel Capacity in the Drainage System

No	Channel ID	Channel Name	Channel Plan Debit (m3/s)	Existing Debt Q (m3/s)	Difference in Debit (m3/sec)	Channel Capacity Analysis
1	I	Sal Parent Ka 1	2,714	4,053	1,340	Fulfil
2	II	Sal Main Ka 2	2,512	4,159	1,647	Fulfil
3	III	Sal Main Ka 3	0.780	2,668	1,888	Fulfil
4	IV	Sal Main Ki 1	0.972	1,828	0.857	Fulfil
5	V	Sal Main Ki 2	0.713	0.812	0.099	Fulfil
6	HE	SalKa 1	1,987	0.257	-1,731	Does not meet the
7	A1	Sal Ka 1a	0.747	0.209	-0.538	Does not meet the
8	A2	Sal Ka 1b	0.764	0.209	-0.555	Does not meet the
9	IB	SalKa 2	1,663	0.297	-1,366	Does not meet the
10	B1	Sal Ka 2a	0.499	0.152	-0.348	Does not meet the
11	B2	Sal Ka 2b	0.433	0.152	-0.281	Does not meet the
12	II A	Sal Ki 1	0.170	1,044	0.874	Fulfil
13	II B	SalKi 2	0.204	0.327	0.124	Fulfil
14	II C	SalKi 3	0.989	0.167	-0.822	Does not meet the
15	C1	Sal Ki 3a	0.127	0.117	-0.011	Does not meet the
16	C2	Sal Ki 3b	0.153	0.117	-0.036	Does not meet the

(Source: Analysis Results)

4.12 Drainage Channel Rehabilitation Plan

Drainage channel repair plan is used to prevent overflow of water from the channel which causes inundation. The existing channel has been repaired so that it can accommodate the 10 year return period system discharge plan.

1. Calculations on the Ka1 channel (IA), include:

   Is known :

   B = 0.5 m (Existing); 0.9 (rehab)

   H = 0.4 m (Existing); 1.1 (rehab)

   n = 0.025

   S = 0.013

   The cross-sectional shape of the Ka1 channel is square.

   A = B . H

   = (0.9 x 1.1) = 0.99 m2

   P = B + 2H

   = 0.9 + (2 x 1.1) = 3.10 m

   R = A/P

   $= \frac{0,99}{3,10} = 0.32$m

   $V = R\frac{1}{n}\ x\ ^{2/3} \text{ x } S^{1/2}$

$= \frac{1}{0,025}$ x 0.322/3 x 0.0131/2

$= \frac{1}{0,025}$ x 0.320,6667x 0.0130.5

$= \frac{1}{0,025}$ x 0.46 x 0.11

$= \frac{1}{0,025}$ x 0.0506 = 2.09 m/s

Q = A . V

= 0.99 x 2.09 = 2.07 m3/s.

The capacity of the drainage canal after rehabilitation must be greater than the calculated system design discharge in order to avoid overflow occurring in the canal. The calculation of the capacity of the drainage channel after rehabilitation must be greater than the calculated system design discharge in order to avoid overflow that occurs in the channel.

The following are the dimensions of the drainage channels that have been rehabilitated, as shown in the following table.

Table.21: Drainage Channel Dimensions and Plans on Dps Drainage

No	Channel ID	Channel Name	Exit Dimension		Plan Dimensions		Channel Capacity		Channel Capacity Analysis
			B (m)	h (m)	B (m)	h (m)	Q Exiting (m3/s)	Q Plan (m3/s)	
1	I	Sal Parent Ka 1	0.8	0.8	0.8	0.8	4,053	2,714	Fulfil
2	II	Sal Main Ka 2	0.9	1,2	0.9	1,2	4,159	2,512	Fulfil
3	III	Sal Main Ka 3	0.9	0.6	0.9	0.6	2,668	0.780	Fulfil
4	IV	Sal Main Ki 1	0.5	0.7	0.5	0.7	1,828	0.972	Fulfil
5	V	Sal Main Ki 2	0.7	0.6	0.7	0.6	0.812	0.713	Fulfil
6	HE	SalKa 1	0.5	0.4	0.9	1,1	2,068	1,987	Fulfil
7	A1	Sal Ka 1a	0.3	0.8	0.7	0.9	0.871	0.747	Fulfil
8	A2	Sal Ka 1b	0.3	0.8	0.6	1,1	0.872	0.764	Fulfil
9	IB	SalKa 2	0.5	0.4	0.8	1,1	1,737	1,663	Fulfil
10	B1	Sal Ka 2a	0.3	0.6	0.6	0.7	0.514	0.499	Fulfil
11	B2	Sal Ka 2b	0.3	0.6	0.5	0.8	0.459	0.433	Fulfil
12	II A	Sal Ki 1	0.4	0.6	0.4	0.6	1,044	0.170	Fulfil
13	II B	SalKi 2	0.3	0.4	0.3	0.4	0.327	0.204	Fulfil
14	II C	SalKi 3	0.4	0.4	0.7	1.0	1.138	0.989	Fulfil
15	C1	Sal Ki 3a	0.4	0.3	0.5	0.4	0.230	0.127	Fulfil
16	C2	Sal Ki 3b	0.4	0.3	0.5	0.4	0.230	0.153	Fulfil

(Source: Analysis Results)

V. CONCLUSION

1. With the analysis of rainfall discharge that occurs in the field using return periods of 1.01 years, 2 years, 5 years and 10 years, the peak hours that occur in the drainage area are obtained. For the 0.01 year return period it is 345.597 mm/hour, for the 2 year return period it is 435.094 mm/hour, for the 5 year return period it is 477.044 mm/hour, and for the 10 year return period it is 511.195 mm/hour.
2. The amount of discharge / discharge of dirty water in channel Ka1 = 0.0037 , for channel Ka 1a = 0.0059 , for channel Ka 1b = 0.0060 , for channel Ka 2 = 0.0058 , for channel Ka 2a = 0.0039 , for channel Ka 2b = 0.0034 , for Ki 3 channel = 0.0056 , for Ki 3a channel = 0.0010 , for Ki 3b channel = 0.0012 . $m^3/dtkm^3/dtkm^3/dtkm^3/dtk\ m^3/dtkm^3/dtkm^3/dtkm^3/dtkm^3/dtk$
3. The results of drainage calculations using the Manning formula produce a new rectangular drainage to accommodate the 10-year return period discharge.

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