REPLANNING OF OPEN DRAINAGE ON THE NORTH SIDE OF RUNWAY 28 INSPECTION AT SYAMSUDIN NOOR AIRPORT, BANJARMASIN, SOUTH KALIMANTAN

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ABSTRACT

Syamsudin Noor Airport in Landasan Ulin District, Banjarbaru Regency, South Kalimantan Province, is experiencing flooding problems in the drainage channel along the northern side of runway 28 due to inadequate existing channel conditions. This problem disrupts airport operations and triggers complaints from nearby residents.

To address this issue, an open drainage channel development plan is proposed to enhance flight safety and minimize environmental impacts. The plan begins with the collection of rainfall data to calculate the maximum rainfall intensity for the next 10 years using the Log Pearson III method.

The analysis results show that the maximum rainfall intensity in the catchment area is 8.065 m³/s, with a design discharge of 3.9 m³/s. The planned open channel dimensions are 1.2 m wide and 1.4 m high, with an estimated budget of IDR 1,071,200,000.

***Keywords**: Open Channel, Rainfall, Log Pearson Type III, Channel Dimensions, Cost Estimation*

INTRODUCTION

Indonesia, as the largest archipelagic country in the world with 17,508 islands, has the challenge of continuing to grow and compete internationally. One of the indicators of development is the transportation sector, especially air transportation which is vital for the economy of accessibility in remote areas, and regional development. The demand for air transportation continues to increase, prompting the Indonesian government to improve the quality and services of this sector, including the safety and security of flights that airports must guarantee. Syamsudin Noor Airport Banjarmasin is located in Landasan Ulin District, Banjarbaru City, South Kalimantan, at coordinates 03°26'23" S and 114°45'10" E. Previously known as Ulin Airstrip since 1975, this airport was inaugurated as a civil airfield and its name was changed to Syamsudin Noor Airport on January 13, 1970 to commemorate the services of regional sons who contributed to the progress of South Kalimantan. With a runway of 2500 m long and 45 m wide, this airport is able to accommodate medium-sized aircraft such as Boeing 737-400.To improve services, PT Angkasa Pura Indonesia has built a new terminal which was inaugurated by President Joko Widodo on December 18, 2019, improving capacity from 1.5 million to 7 million passengers per year. The development also includes the expansion of the apron to support large flights such as the

Airbus A330-300. The airport is equipped with four taxiways, each with specific pavement specifications to support operations. In addition, adequate safety and security facilities must be in place at the airport, with limited areas requiring passes for access Physical restrictions must be implemented in accordance with applicable regulations including the availability of inspection roads to inspect facilities on a regular basis. Good drainage is also crucial to prevent inundation that can disrupt airport operations However, the drainage channel on the side of the north inspection road of runway 28 is experiencing problems, with overflows flowing into the surrounding organization The handling of this problem must be done immediately so that it does not become a long-term issue.

BRIEF THEORY

Areas on land and/or waters with certain boundaries that are used as landing and takeoff aircraft, passenger boarding and discharging, loading and unloading of goods, and places of intra and intermodal transportation transfers, which are equipped with aviation safety and security facilities, as well as basic facilities and other supporting facilities [1].

Drainage comes from the English language which means to drain or decompose excess air. Technically, drainage is a science that studies excessive airflow to optimize land use. At airports drainage systems are important for aviation safety, but often inadequate, causing flooding due to poor planning. Natural factors, such as high rainfall and river geophysics, also contribute to this problem, creating challenges in water management and flood management [2]. Natural factors, such as high rainfall and river geophysics, also contribute to this problem, creating challenges in water management and flood management.

RESEARCH METHOD

This study uses a descriptive analysis method to collect information about phenomena or problems, describe relevant events, and present a comprehensive picture to formulate conclusions as a solution.

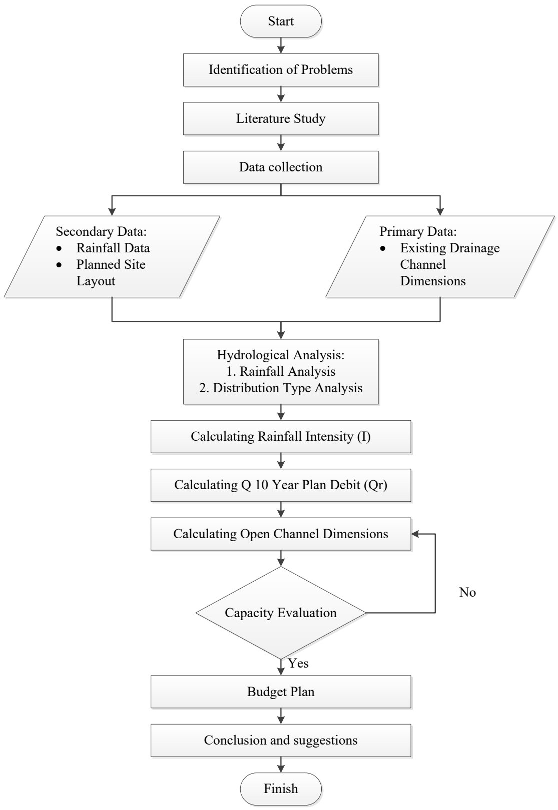

Figure 1. Flow chart

A. Hydrology Analysis

Hydrology analysis is important for the design of drainage systems, assessing surface flow, and providing information for water infrastructure and other development [3]. Annual maximum rainfall analysis was carried out in Banjarmasin for 10 years, comparing statistical distributions to design a drainage system and flood control based on rainfall data. Then, using rainfall frequency analysis, rainfall frequency describes the probability of a certain rainfall, while the return period shows the expected duration to reach that amount. Frequency analysis uses statistical parameters for more accurate results. The frequency distribution of hydrology data analysis uses formulas and statistical parameters:

a. Standard Deviation (Sd)

$$Sd = \frac{\sqrt{\sum(X - Xbar)^2}}{n-1}$$

b. *Coeffisient of Skewness* (Cs)

$$Cs = \frac{\sum(X - Xbar)^3}{Sd^3}\frac{n}{(n-1)(n-2)}$$

c. *Coeffisient of Kurtosis* (Ck)

$$Ck = \frac{\sum(X - Xbar)^4}{Sd^4}\frac{n^2}{(n-1)(n-2)(n-3)}$$

Information:

X = maximum rainfall

X̄ = average maximum rainfall (mm)

n = number of years

Sd = *Standard Deviation*

Cs = *Coeffisient of Skewness*

Ck = *Coeffisient of Kurtosis*

- Rainfall Intensity Analysis

Rainfall intensity is a number that shows the high amount of rainfall in an area and is expressed in units of time ($^{mm}/_{hour}$):

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

Information:

I = Rainfall intensity ($^{mm}/_{hour}$)

Tc = Duration of rainfall (hours)

R = The rainfall that may occur based on a certain return period (maximum rainfall in 24 $^{hours}/_{mm}$)

The Gumbel method is a technique for calculating extreme values used to analyze maximum data, including rainfall frequency analysis.

$$P = (X \leq x) = e^{(-e)^{-y}}$$

P = Gumbel distribution

X = Continuous variable

e = natural number with a value of 2.71828

Y = Gumbel reduction factor

The Log-Pearson Type III distribution is commonly used in hydrology analysis, especially to examine extreme values in maximum (flood) and minimum (low discharge). The calculation of Log Pearson Type III is as follows:

$$\text{Log}\, R = \text{Log}\, R + K.Sd \ \log R$$

Information:

- Log R = average annual maximum rainfall
- Log R = mean value
- K = log pearson type III distribution factor which is the magnitude of Cs
- Sd log R = standard deviation of the log R variable

Based on the explanation, the concentration time of a water channel in a rainy area consists of the time required for runoff to flow water on the ground surface to reach the nearest channel (to) and then the time for the rainwater to flow along the channel (td). The calculation of the rain concentration time can be calculated using the following formula:

$$Tc = To + Td$$

Information:

- To = time for rainwater to flow to the surface (hours)
- Td = time for rainwater to flow along the flow (hours)

To find the values of To and Td, the following formula is used:

$$To = Cross - Sectional\ Distance / Vo$$
$$Td = L/Vd$$

Information:

L = length of the drainage catchment area (km)

V = average velocity in the channel ($^{m}/_{second}$)

S = run off slope

α = run off coefficient.

B. Hydraulic Analysis

The purpose of hydraulic analysis is to establish the standard hydraulic dimensions of the drainage channel and additional structures, where water flow in a channel can occur as open channel flow or flow in a closed channel [4]. The trapezoidal cross-section is effective for large flows in drainage, waste, and irrigation.

- Slope of the Cross-Section (m):
$$m = \frac{(T - B)}{2}$$
- Cross-Sectional Area (A):
$$A = (B \times mh)h$$
- Wet Perimeter (P):
$$P = B + 2h\sqrt{m^2 + 1}$$
- Hydraulic Radius (R):
$$R = \frac{A}{P}$$
- Channel Bed Slope (S):
$$S = \frac{H}{L}$$
- Flow Velocity (V):
$$V = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$
- Existing Channel Discharge (Q):
$$Q = V \times Fs$$

The determination of channel dimensions depends on the requirement that the discharge that must be handled by the channel (Qs in $^{m^3}/_{sec}$) must be greater than or equal to the design discharge generated by the design rain (QT in $^{m^3}/_{sec}$) [5].

This condition is expected to be in accordance with the following equation:

$$Qs \geq QT$$

The discharge that the channel can hold (Qs) is obtained with the following equation:

$$Qs = V \text{ x } Fs.$$

Information:

- Qs = flow discharge in the channel ($^{m^3}/_{sec}$)
- Fs = wet cross-sectional area (m^2)
- V = flow velocity ($^{m}/_{sec}$)
- QT = channel discharge in T design years

RESULTS AND DISCUSSION

A. Hydrology Analysis

Daily rainfall data was obtained from the Syamsudin Noor Meteorological Station in Banjarmasin for the period of 2015-2024.

Drainage is a network of channels to drain rainwater from open spaces and built-up areas, designed to collect and move water to receiving bodies.

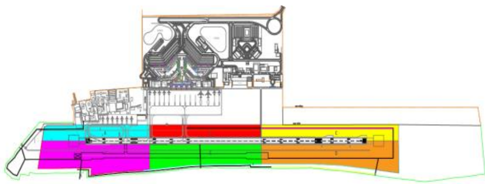

Figure 2. Catchment Area Layout at Syamsudin Noor Banjarmasin Airport

The identification of the catchment area for the drainage on the north side of runway 28.

Table 1. Catchment Area at Syamsudin Noor Airport

Catchment Area	m2	Percentage
A	119654	11%
B	126424	12%
C	156310	15%
D	247538	23%
E	194781	18%
F	227620	21%
TOTAL	1072327	100%

Based on the amount of catchment area needed in the drainage planning for this study, which is 15%, which is catchment area C.

- Frequency Analysis

The distribution of rainfall is determined by calculating the skewness and kurtosis coefficients.

Table 2. Analysis of Rainfall Distribution Parameters

Year	Xi	Log Xi	Log (Xi-Xrat)	Log $(Xi - Xrat)^2$	Log $(Xi - Xrat)^3$	Log $(Xi - Xrat)^4$
2015	546.7	2.74	0.0594	0.00352	0.00021	0.00001
2016	439.7	2.64	-0.0352	0.00124	-0.00004	0.00000
2017	401.5	2.6	-0.0747	0.00558	-0.00042	0.00003
2018	705.5	2.85	0.1701	0.02893	0.00492	0.00084
2019	359.8	2.56	-0.1223	0.01497	-0.00183	0.00022
2020	261.9	2.42	-0.2603	0.06774	-0.01763	0.00459
2021	898.3	2.95	0.2750	0.07564	0.02080	0.00572
2022	467.2	2.67	-0.0089	0.00008	0.00000	0.00000
2023	404.7	2.61	-0.0713	0.00508	-0.00036	0.00003
2024	558	2.75	0.0682	0.00466	0.00032	0.00002
Total	5043.3	26.784	0.0000	0.20743	0.00597	0.01146
Average	504.33	2.678				

The data displayed above shows the planned discharge values over the last 10 years. Information:

X = Maximum rainfall value

$\bar{X}$ = Average maximum rainfall value for the 10-year period

= 5043,3/10

= 504,33 mm.

The calculation of the average rainfall in logarithm (Log $\bar{X}$) can be seen as follows:

Log $\bar{X}$ = 26,78/10

= 2,67 mm

Determining the appropriate distribution type for the rainfall data is done by calculating the values for Mean (x), Standard Deviation (Sd), Coefficient of Skewness (Cs), and Coefficient of Kurtosis (Ck). Then, based on the calculated values of X, Sd, Cs, and Ck, the distribution provisions that meet the requirements can be adjusted, as presented in the following table.

Table 3. Planned Channel Distribution Analysis

Distribution	Condition	Calculation Results		Information
Normal	Cs = 0	Cs	0.237	Not eligible
	Ck = 3.0	Ck	5.709	
Gumbel	Cs ≤ 1.1396	Cs	0.237	Not eligible
	Ck ≤ 5.4002	Ck	5.709	
Log Normal	$Cs = Cv^2 + 3Cv$	Cs	0.237	Not eligible
	Cs = 0.8325	Ck	5.709	
Log Pearson Type III	Cs ≠ 0	Cs	0.237	Eligible
		Ck	5.709	

From the calculations above, we can conclude that the Log Pearson Type III distribution method meets the requirements. Furthermore, the results of the planned rainfall calculations for periods of 2, 5, 10, 25, 50, and 100 years are presented in a table as described in the following equation:

$$Log\ Xt = Log\ X + Kt.\ Sd$$

Repeat Time in 2nd Year

$X_{2\ year}$ = Log (Log X + Kt.Sd)

$X_{2\ year}$ = Log (2,68 + -0,033. 0,15)

$X_{2\ year}$ = Log (2,67)

$X_{2\ year}$ = 471,40

Dst…

Table 4. Maximum Planned Rainfall Based on the Log Pearson III Method

Curah Hujan Maksimum Rencana				
PUH	**Cs**	**Kt**	**Log Xt**	**Xt**
2	0,237	-0,033	2,67	471,40
5	0,237	0,830	2,80	637,39
10	0,237	1,301	2,88	751,47
25	0,237	1,818	2,95	900,33
50	0,237	2,159	3,01	10143,1
100	0,237	2,472	3,05	1131,59

- Rainfall Intensity Analysis

The maximum planned rainfall (Xt) for the next 10 years is 751.47 mm and the rational method can be used to estimate the minute rainfall by converting the daily rainfall.

Repeat Time in 2nd Year

Repeat 5 minute

$$I = \frac{471,40}{24} \times \left(\frac{24}{0,0833}\right)^{\frac{2}{3}}$$

$$I = 872,91\ ^{mm}/_{hours}$$

Dst...

Based on the previous calculation results, a summary in table form using the Log Pearson III method is also obtained, as follows:

Table 5. Maximum Rainfall Intensity Log Pearson III

Maximum Rain Intensity at Various Return Periods							
Time		Rain Intensity Based on Pearson Log Distribution Table III					
Minute	Hours	On Repeat 2 Tahun	On Repeat 5 Tahun	On Repeat 10 Tahun	On Repeat 25 Tahun	On Repeat 50 Tahun	On Repeat 100 Tahun
5	0.0833	872.91	1180.286	1391.531	1667.179	1878.243	2095.416
10	0.167	548.63	741.818	874.587	1047.833	1180.488	1316.983
20	0.333	344.817	466.237	549.684	658.57	741.945	827.733
30	0.5	262.79	355.325	418.92	501.904	565.445	630.825
50	0.833	186.625	252.341	297.504	356.436	401.561	447.992
60	1	165.165	223.324	263.294	315.45	355.386	396.478
90	1.5	125.874	170.198	200.66	240.408	270.844	302.161
120	2	103.807	140.361	165.482	198.263	223.362	249.189
150	2.5	89.392	120.869	142.502	170.73	192.345	214.585
180	3	79.113	106.971	126.116	151.098	170.227	189.91

B. Hydraulic Analysis

The channel capacity analysis at Syamsudin Noor Banjarmasin Airport calculates the hydraulic value and uses the Manning formula to assess the channel's ability to handle the 10-year planned flood discharge.

- Channel Cross Section Slope

$$m = \frac{(T-B)}{2}$$

$$= \frac{(1,6-1)}{2}$$

$$= 0,3 \text{ m}$$

- Wide Wet Cross Area

$$Fs = (B + m.h)h$$

$$= (1 + 0,3.\ 1)1$$

$$= 1,3 \text{ m}^2$$

- Around Wet Cross Area

$$Ps = B + 2h\sqrt{1.m^2}$$

$$= 1 + ((2.\ 1) \times ((1+(0,3^2))\ \text{^}0,5))$$

$$= 4,24 \text{ m}$$

- Hydraulic Spokes

$$Rs = \frac{Fs}{Ps}$$

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

$$= 0,31 \text{ m}$$

- Channel Slope

$$S = \frac{\Delta h}{L}$$

$$= \frac{21-18}{1170}$$

$$= 0,002 \text{ m}$$

- Average Channel Speed

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

$$= \frac{1}{0,03} \times 0,31^{\frac{2}{3}} \times 0,002^{\frac{1}{2}}$$

$$= 0,67 \ ^{\text{m}}/_{\text{second}}$$

- Existing Channel Discharge

$$Q = V \times Fs$$

$$= 0,67 \times 1,3$$

$$= 0,88 \ ^{\text{m}^3}/_{\text{second}}$$

Known:

T = Top width of the channel (1.6 m)
B = Bottom width of the channel (1.0 m)
H = Channel height
W = Freeboard height
h = Wet cross-section channel height (1.0 m)
m = channel cross-section slope
A = Wet cross-sectional area
P = Wet cross-sectional perimeter
R = Hydraulic radius
V = Average velocity
Q = Flow discharge

The calculated rainfall intensity values are used to evaluate whether the current dimensions of the drainage channel on the north side of runway 28 are adequate and to identify the required dimensions.

The following is known:

Xt = R10 = 751,47
A = 0,161 km^2
L = 1170 m^2
S = 0,2 %

Transverse distance = 150 m^2

Vo = 0,9 $^{m}/_{second}$

Vd = 0,4 $^{m}/_{second}$

α = 0,3

β = 1

Therefore, the value of tc can be found using the following equation:

$$to = \frac{Jarak\ Melintang}{Vo}$$

$$= \frac{150}{0{,}9}$$

= 166,67 $^{m}/_{second}$

$$td = \frac{L}{Vd}$$

$$= \frac{1170}{0{,}4}$$

= 2925

$$tc = to + td$$

= 166,67 + 2925

= 3091,7 second

= 0,85 hours

By calculating the tc value, the intensity value for the 10-year period can then be determined, as follows:

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

$$I10 = \frac{751{,}47}{24} \times \left[\frac{24}{0{,}85}\right]^{2/3}$$

= 290,33 $^{mm}/_{hours}$

= 8,065 $^{m^3}/_{second}$

and the runoff Q can also be calculated, as follows:

$$Q = \propto .\, \beta . I.\, A$$

Q = 0,3. 1. (290,33/1000/3600). (0,161. 1000000)

= 3, 9 $^{m^3}/_{second}$

Through the calculation of the existing channel discharge at Syamsudin Noor Airport, which is 0,88 m³/second, it can be compared with the planned discharge calculated above, which is 3,9 m³/second. The channel requirements are as follows:

$Q_{saluran} < Q_{10}$ = Insufficient

$Q_{saluran} > Q_{10}$ = Sufficient

0,88 $^{m^3}/_{second}$ < 3,9 $^{m^3}/_{second}$

The drainage system at Syamsudin Noor Banjarmasin Airport does not meet the 10-year rainfall standard and needs to be repaired. Various methods have been used through trial and error to produce a solution with different methods by considering the drainage capacity, as follows:

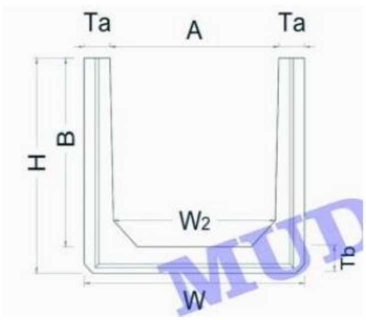

Figure 3. Example of 2D U-ditch Drawing

The drainage system is designed to use concrete U-ditches with a design width of 1,2 m and a height of 1,4 m. After determining the design dimensions, the next step is to calculate the channel's discharge to determine its capacity.

The design width is 1,2 m and the design height is 1,4 m.

$$Qs = b \times h \left[\frac{1}{n} \times \left(\frac{b\,.\,h}{b+2h}\right)^{\frac{2}{3}} \times S^{\frac{1}{2}}\right]$$

$$Qs = 1{,}2 \times 1{,}4 \left[\frac{1}{0{,}013} \times \left(\frac{1{,}2\,.\,1{,}4}{1{,}2 + 2.\ 1{,}4}\right)^{\frac{2}{3}} \times 0{,}002^{\frac{1}{2}}\right]$$

Qs = 4, 32 $^{m^3}/_{second}$

3,9 $^{m^3}/_{second}$ < 4, 32 $^{m^3}/_{second}$ (Sufficient)

The construction used is U-ditch concrete, a U-shaped reinforced concrete system for drainage. U-ditches offer high lateral strength, weather resistance, and reduced damage. They are easy to install and require minimal maintenance without a curing process. The concrete used meets the K350 standard, in accordance with KP 14 of 2021.

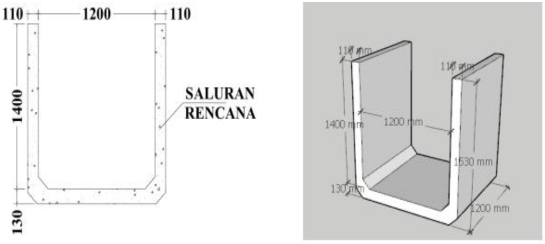

Figure 4. Layout 2D & 3D of Open Channel Plan Dimensions

C. Cost Budget Plan Analysis

Determining the volume of each task within a construction project is crucial to aid in budget planning[6]. In this case, the unit price analysis refers to the 2025 Banjarbaru Regency Unit Price for Basic Activities and follows the general guidelines outlined in PM 78 of 2014.

From the results of the unit price analysis and the included volume calculations, the budget plan can be determined, as shown in the table above.

Table 6. Budget Recapitulation

COST BUDGET PLAN					
Work : DESIGN OF OPEN DRAINAGE CHANNELS ON THE ROAD SIDE INSPECTION					
Location : SYAMSUDIN NOOR AIRPORT, BANJARMASIN					
NO.	WORK ITEMS	UNIT	VOLUME	UNIT PRICE	AMOUNT PRICE
a	b	c	d	e	f = (d x e)
I	PREPARATORY WORK				
1	Directors Quarter Construction Wor	m2	1638	Rp15,640.40	Rp25,618,975.20
2	Project Signage Work	Unit	1	Rp1,024,867.35	Rp1,024,867.35
3	Mobilization and Demobilization	Ls	1	Rp18,000,000.00	Rp18,000,000.00
				SUBTOTAL I :	Rp44,643,842.55
II	EARTHWORKS				
1	Clearing Work	m2	1404	Rp24,000.00	Rp33,696,000.00
2	Excavation Work	m3	1273.25	Rp87,739.63	Rp111,714,483.90
3	Landfill Work (T = 0,5 m)	m3	166.14	Rp442,154.80	Rp73,459,598.47
4	Landfill Work Again	m3	152.57	Rp31,200.00	Rp4,760,184.00
				SUBTOTAL II :	Rp223,630,266.37
III	CONSTRUCTION WORK				
1	U-Ditch Installation Work in Cachtment Area C	bh	975	Rp714,630.00	Rp696,764,250.00
				SUBTOTAL III :	Rp696,764,250.00
AMOUNT (I+II+III)					Rp 965,038,358.92
PPN 11%					Rp 106,154,219.48
TOTAL AMOUNT					Rp 1,071,192,578.40
ROUND UP					Rp 1,071,200,000.00
SPELLED: *One Billion Seventy One Million Two Hundred Thousand Rupiah*					

CONCLUSION

Based on the planning discussion through the analysis in chapter 4, the following conclusions can be drawn:

1. The rainfall intensity level for the next 10 year period at Syamsudin Noor Airport is 8,065 $^{m^3}/_{second}$.
2. The channel discharge on the north side of runway 28's inspection road for the next 10-year period at Syamsudin Noor Airport is 3,9 $^{m^3}/_{second}$.
3. The required open channel dimensions on the north side of runway 28's inspection road to accommodate the channel discharge at Syamsudin Noor Airport are a width of 1,2 m and a height of 1,4 m.
4. The required Cost Budget Plan for the drainage construction planning at Syamsudin Noor Airport is Rp. 1,071,200,000.

To support further development, the author provides constructive input, including:

1. It is hoped that maintenance of the open drainage channel on the north side of runway 28's inspection road will be carried out routinely andperiodically, given that this area is the only access for inspection activities by the AVSEC unit at Syamsudin Noor Airport.
2. The next research can plan using a closed channel with other latest materials, for longer use and to be stronger in withstanding pressure.
3. The next research can add a Method Of Working Plan (MOWP) to support the implementation of work and work safety at the airport.

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