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Clean Water Distribution System Performance Evaluation and Improvement in Kupang City

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***Abstract*— *This study aims to assess the performance of the clean water distribution system in Kupang City and make improvements to it. In East Nusa Tenggara's Kupang, this study was carried out. The harbor city of Kupang is home to Kupang, Timor's capital. When creating the perimeter, field restrictions and conditions are taken into account. The only system investigated is the Oesapa Selatan clean water distribution network, which contains 6 neighborhood units (RW) and 16 neighborhood units (RT). using data from the Epanet 2.0 poll. Finding clean water sources in Oesapa Selatan Village, assessing the state of the area, and looking into clean water distribution networks are some of the techniques used.The researcher intends to find out the type of clean water needed by the people of Oesapa Selatan Village, the capacity of the existing clean water discharge, and the current status of the clean water supply system of the Kupang City PDAM distribution network in Oesapa Selatan Village. Only clean water consumers are sampled. The target of this research is PDAM Kota Kupang customers, Oesapa Selatan Village. Slovin's (1960) formula is used in survey research to obtain a representative sample. 152 samples. PDAM Kota Kupang uses three drilled wells to serve the Oesapa Selatan Village with drinking water. Information on the Oesapa Selatan Village with 5,880 people and 245 SRs, Oesapa's capacity is insufficient. In the EPANET simulation, the current velocity under existing conditions is between 0.01 and 1.43 m/s; the existing pipe moves slowly at the farthest service point; pressure during peak hours of water use; the pressure at several junctions has decreased but still has a minimum residual pressure of 90.83 Mh2O or 8.79 atm at the service point; a. Residents of Oesapa District will need 11.84 l/d in 2021 and 15.93 l/d in 2030, but the district will only produce 13.10 l/d. This will lead to 0.10 l/d in 2024 and 2.83 l/d in 2030. Allocating IDR 2,207,200,000,000 to upgrade the distribution system can provide housing connection (SR) services and pump replacement until 2030. Submersible Pumps Grunfos 17-18, with a pump capacity of 5.5 l/s, provides clean water. To ensure that EPANET's simulation of the distribution network can be carried out using EPANET Software to identify the hydraulic conditions of the proposed network, the replacement pump must also meet the 2030 plan water discharge of 15.93 ltr/s. The simulation results (Successful Run) show that the clean water distribution network is expected to run continuously without problems with flow velocities ranging from 0.01 to 1.09 m/s. The lowest is the remote service node. The distribution network design of Permen Pu no.18 of 2007 requires a minimum residual pressure of 103.50 Mh2O or 10 atm at the farthest service point. The maximum simulated pressure complies with Permen PU 18.07, but the drinking pressure does not. Some pipelines lose pressure at nodes by more than 10 m/km due to sudden pipe diameter changes.*

***Keywords*— *Evaluation, Improving the Performance of the Clean Water Distribution System .*

I. Introduction

Background

There are numerous ways to get clean water, including by digging wells or drilling wells that are fed through a pipeline system. The PDAM is one of the BUMNs in charge of clean water distribution. The PDAM uses a variety of clean water sources, including drilled wells, dams, and springs. Clean water is distributed by way of a pipeline network from the source to the homes of those who require it, in this case all PDAM customers.

The Central Bureau of Statistics estimates that Kelurahan Oesapa Selatan's total population in 2020 will be 5880, growing by 0.81% annually. As population grows, so does the demand for water. While the distribution of water to the area of each RT in the South Oesapa sub-district is every 4 times per week with a delivery time of 3–4 hours, there are 245 house connections, which means that 20.83% of the residents of the Oesapa Selatan Village have been served clean water through pipes with a water requirement of 8.17 ltr/sec. Since this is not ideal, it results in indirect losses for the community that uses the service, hence it is intended that water distribution can be 24 hours a day

The problem that arises in PDAM Kota Kupang is the management of clean water resources which is still limited, both in terms of coverage and quality of service. Meanwhile, with the enactment of Law No. 8 of 1999 concerning Consumer Protection, the demands of the community as consumers for the quality and service of PDAMs are increasing, so PDAMs must make several improvements. Therefore, to support Law No. 8, the author wants to examine the Evaluation and Improvement of the Performance of the Clean Water Distribution System in The City of Kupang, so that this topic can be used as evaluation material and input for city planners, especially PDAMs as a means to improve PDAM services.

Formulation of the Problem

1. Are the existing water sources capable of meeting the clean water needs of the residents of Oesapa Selatan Village?
2. What is the condition of the existing clean water supply system for the distribution network of PDAM Kota Kupang in the Oesapa Selatan Village?
3. How is the development of the clean water distribution network of PDAM Kota Kupang in Oesapa Selatan Village?
4. What is the hydraulic condition of the existing and development pipelines using the EPANET 2.0 software analysis?

Research Purposes

1. Knowing the clean water needs of the residents of Oesapa Selatan Village and knowing the available clean water discharge capacity.
2. Knowing the existing condition of the clean water supply system in the distribution network of PDAM Kota Kupang in the Oesapa Selatan sub-district.

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3. Knowing the development of the clean water distribution network of PDAM Kota Kupang in Oesapa Selatan Village.
4. Analyzing the Hydraulic Conditions of existing and Development pipelines using the Epanet 2.0 Software analysis

II. LITERATURE REVIEW

A. Source Of Clean Water

A water source is a crucial element of a clean water supply system that cannot exist without it. Without one, the system will not work. It is intended that by being aware of each water source's features and the variables that affect them, one can better choose raw water for a clean water supply system and more easily move on to choose the type of treatment to create water that satisfies physical quality criteria. bacteriological and chemical. The amount of water on Earth (both above and below ground level) is 1400 x 1015 m3, according to CD. Soemarto (1987)..

B. Existing Conditions of Clean Water Supply System

1. Pipe Network System Components

Water can be moved from water sources to reservoirs and from reservoirs to customers via pipes, which make up the majority of the clean water distribution network system. Pipes have a varied diameter circular cross section:

1. Pipe Type
    a. Cast Iron Pipes (Cast Iron)
    b. Galvanized Iron Pipe
    c. Plastic Pipe (PVC)
    d. Steel Pipe
    e. Concrete Pipe (Concrete Pipe)
f. HDPE (High Density Polyethylene) Pipe

2. Clean water pipe network criteria

To comply with the pipeline network planning, the following criteria must be met so that during operation it can run according to existing standards:

Table 1. Hazen-Williams Pipe Roughness Coefficient (Chw)

Criteria	Changes _ _ _ _ _ _
1. speed 0.3 – 4,5 m / d e t	- speed < 0.3 m / d e t a . Measure an diametrer minimized pipe plus cotton above the pump c . the elevation of the head of the pipe will be higher (adapted to field conditions - spees> 4,5 m / det a . Measure a n d iametre r enlarged pipe b. the elevation height of the upstream pipe is too large _ _ compared to the downstream
2. *Headloss Gradient* 0 – 15 m/km	- *Headloss Gradient* > 15 m/km *a*. Measure a n d iametre r enlarged pipe plus cotton above the pump *b*. The upstream pipe elevation is too big compared to _ hilirpipa
3. pressure 0.5 – 8 at m	pressure< 0.5 at m a . Measure an diametre r enlarged pipe plus cotton above the pump b . the pipe fitting to the two above , _ _half or ouch all of you are long and long _ pipa- pressure > 8 at m a . Measure an diametrer pipe is reduced b. added building as a releases tekan- Pemasangan *Pressure Reducer Valve (PRV)*

- Questionnaire

creating and completing a survey to determine the degree of client satisfaction with the performance of the clean water distribution system carried out by PDAM Kota Kupang, as well as the preferences of those directly involved in providing clean water in Oesapa Selatan Village, specifically from the client directly regarding the anticipated system (Erlyna Dewi. 2020).

In the study there were two kinds of respondents, with the grouping of respondents as follows:
1. Respondents to determine the level of performance of the clean water distribution network by PDAM Kota Kupang in Kelurahan Oesapa Selatan
2. Respondents for analysis of Customer Satisfaction Levels on the production quality of the Clean Water Distribution Network by PDAM Kupang City in Oesapa Selatan Village.

Purposive sampling, in which sample selection solely took into account people/parties directly associated to clean water services, in this case consumers, resulted in the selection of respondents. PDAM Kota Kupang, Kelurahan Oesapa Selatan consumers are the respondents in this set of homes. In survey research, where samples are typically very large, the number of samples is determined using the Slovin formula (1960). A formula is required to obtain a small sample that is representative of the total population. The formula below is used to determine the number of samples (Slovin, 1960):

$$n = \frac{N}{1+N\,e^2} \quad (2.1)$$

Dimana :
n = sample size
N = Population
e = Margin of error
jadi jumlah sample kuisioner adalah

$$n = \frac{245}{1+245\;0.05^2}$$

$$n = \frac{245}{1+245\;0.0025^2}$$

$$n = \frac{245}{1+0.6125}$$

$$n = 151.937 \;\approx 152\; customer$$

C. Clean Water Distribution Network Development

- Clean Water Needs

1 The average need for clean water is the average need for water that is used every day by people for activities.
2. Maximum daily requirement, is the highest water requirement of the average daily requirement for a period of one week. The maximum day requirement serves to calculate the amount of clean water required through the transmission pipeline. Maximum daily requirement = 1.15 x average water requirement
3 The peak demand at certain hours of the day is called the peak hour water demand and when calculating the demand for clean water flowing in the transmission pipeline. Water demand at peak hours = 1.56 x average water demand

- Population Projection
    1. geometric Method,

The population growth of an area can be calculated using the geometric method as follows (Muliakusumah, 2000):

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$$P_n = P_0 x (1+r)^n \text{..........} (2.3)$$

with:
P_n = Population in year n (people)
P_o = Total population in the initial (base) yearn = Jumlah tahun proyeksi (tahun)
r = Number of projected years (years)

2. Arithmetic Method

Population projections are calculated using the arithmetic method which is formulated: (Muliakusumah, 2000):

$$P_n = P_o + (1 + rn) \text{..........} (2.4)$$

dengan:

3. P_n = Population in year n (people)
4. P_o = Total population in the initial (base) year
5. r = Number of projected years (years)
6. *L e ast square e Method*,

Population projections are calculated using the Least Square method which is formulated: (Muliakusumah, 2000):

$$Y = a + bX \text{..........} (2.5)$$

The values of a and b are determined by equations 2.6 and 2.7 below

$$a = \frac{\sum Y.\sum X^2 - \sum X.\sum XY}{n . \sum X^2 - (\sum X)^2} \text{..........} (2.6)$$

$$b = \frac{n . \sum Y.X - \sum X.\sum Y}{n . \sum X^2 - (\sum X)^2} \text{..........} (2.7)$$

Dimana :
Y = Number of Users in the nth year
X = Total data plus predictions for the next year
a = Constant;
b = Coefficient of linear regression direction.q =

$$\frac{\text{Jumlah Persentase}}{n-1} \text{..........} (2.8)$$

Dimana:
q = User development level.
n = Difference in years from the base year.

Calculating the standard deviation and correlation coefficient of the three approaches is important to decide which projection method formula should be used to calculate the population. The approach selected is the one with the highest correlation coefficient and the least standard deviation (Permen PU No 18, 2007). The standard deviation (SD) value is calculated using the following formula, namely in equation 2.9 (Muliakusumah, 2000)

$$SD = \sqrt{\frac{\sum (Xi - Xmean)^2}{n}} \text{..........} (2.9)$$

Where:
SD = Standard deviation
Xi = Independent variable (Number of users)
Xmean = The mean value of Xi
n = Number of samples (amount of data)

The selection of the three population growth projection methods mentioned above was carried out through statistical tests, namely based on the correlation coefficient. This correlation coefficient shows the strength or not of the linear relationship between the 2 existing variables. The correlation coefficient that is close to +1 is an indicator that the correlation between the 2 variables is positive or very strong. The following is the correlation coefficient formula (Muliakusumah, 2000):

$$r = \frac{n(\sum XY) - (\sum X)(\sum Y)}{\sqrt{\{(n\sum X^2 - (\sum X)^2)(n\sum Y^2 - (\sum Y)^2)\}}} \text{..........} (2.10)$$

with:
X = population data per year (people)
Y = total population per year as a result of the projection (people)
r = correlation coefficient
n = amount of data

- The user projection calculation approach that yields the lowest standard deviation and highest correlation coefficient value is the most suited. The data will be more uniform (homogeneous) if the standard deviation is lower, and more diverse if the standard deviation is higher (Furqon, 2008).Leakage/Loss of Water

1. Planned loss of water = for smooth operation and maintenance of drinking water supply facilities. Loss of water is useless. Loss of water which concerns the component aspects of drinking water supply facilities, both in management, operation and uncontrolled use by consumers
2. Incidental water loss
   i. Physical Leak
      a. Leaks in transmission and distribution pipes
      b. Leakage in the service pipe
      c. Leaks in the Reservoir / Tank
   ii. Non-Physical Leaks
      a. Inaccurate water meter
      b. Consumer water use that is not recorded by the water meter because it is damaged or inaccurate
      c. Water theft by irresponsible persons
      d. Incorrect water account creation by management (Fallis et al, 2010)

- Planning Criteria

Table 2. Planning Criteria

No	Description	Not asi	Criteria
1	Debit Peren plan _ _	Q even c a k	Ke need an a ir j a m even cak Qpeak = F peak x Qrata - rata
2	Factor Maximum days	F even c a k	1 . 15 – 3
3	speed flow in the pipe a) speed minimum b) speed maximum - Pipe PVC _ or ACP - Pipe _ baja atau D C IP	Vm in V m a ks V m a ks	0 . 3 - 0 . 6 m / d e tick 3 . 0 - 4 . 5 m / d e tick 6 . 0 m / d e tick
4	Water pressure in the pipe a) minimum pressure b) maximum pressure - Pipe _ PVC _ - Pipa D C IP - Pipa P.E _ 100 - Pipa P.E _ 80	Hm in h m a ks hm a ks h m a ks h m a ks	(0 . 5 - 1 . 0) a t m , at the point of furthest reach 6 - 8 a tm 1 0 a tm 12 . 4 M p a 9 . 0 M p a

D. Hydraulic Conditions and Development Using Epanet 2.0

- Press Height Loss
  - ❖ Major Losses

Friction with the pipe cross section is what leads to the majority of the energy loss. Because water has a viscosity and the pipe's cross section is not entirely smooth, friction causes energy to be lost (Triatmadja, 2009). To determine this, a number of empirical equations are used. The Hazen Williams equation is employed in this investigation. When using SI units, the Hazen-Williams equation is as follows (Priyantoro, 1991):

$$Q = 0,85 * C_{HW} * A * R^{0,63} * S^{0,54} \quad (2.11)$$

$$V = 0,85 * C_{HW} * R^{0,63} * S^{0,54} \quad (2.12)$$

where:
Q = flow rate in the pipe (m3/sec)
V = velocity in the pipe (m/s)
K = constant (0.85 for SI units and 1.318 for US units)
CHW = HazenWilliams roughness coefficient
A = flow cross-sectional area (m2)
R = hydraulic radius (m), where,

$$R = \frac{A}{P} = \frac{\frac{1}{4}\pi D^2}{\pi . D} = \frac{D}{4}$$

S = the slope of the hydraulic line, where,

$$S = \frac{h_f}{L}$$

For Q = V * A, the formula for major head loss is obtained:

$$h_f = k.Q^{1,852} \quad (2.13)$$

$$k = \frac{10,7\,L}{C_{HW}^{1,852}.\,D^{4,87}} \quad (2.14)$$

where:
hf = Major head loss (m)
D = Pipe diameter (m)
k = Pipe characteristic coefficient
L = Length of pipe (m)
Q = Flow rate in the pipe (m3/sec)
CHW = HazenWilliams roughness coefficient

Table 3. Hazen-Williams Pipe Roughness Coefficient (Chw)

No	Bahan Pipa	Nilai Koefisien Hazen Williams (C_{hw})
1	*concrete or concrete lined*	
	- Steel forms	140
	- Wooden forms	120
	- Sentrifugally spun	135
2	*Galvanized iron*	120
3	*Glass*	140
4	*Lead*	130-140
5	*Plastic*	140-150
6	*PVC*	130-150
7	*Steel*	
	- Coal - tarenamel lined	145-150
	- New unlined	140-145
	- Riveted	110

- ❖ Technicians frequently employ this technique while analyzing pressure pipe systems (Bentley, 2007). Additionally, because it is not in a graph like other ways, the calculation of the roughness coefficient for each type of pipe material is also made simpler in order to reduce the amount of inaccuracy in the roughness value
- ❖ Minor Losses

a. Minor head loss due to pipe narrowing
b. Minor head loss due to pipe widening
c. Minor head loss due to pipe bends
d. Minor head loss due to valves and pipe fittings

In long pipes (L/D more than 1000), this minor head loss is often neglected without causing significant errors, but becomes important when in short pipes.

The equation is as follows (Mahardika, 2015):

$$h_{LM} = k.\frac{V^2}{2g} \quad (2.15)$$

where:
h_{LM} = Minor head loss (m)
k = Coefficient of minor head loss
V = Average velocity in the pipe (m/dt)
g = Acceleration of gravity (m/dt^2)

Table 4. Coefficient of Minor Pressure Loss

Fitting	Nilai k	Fitting	Nilai k
Pipa masuk	0.03 - 0.05	90º Smooth Bend	
Bellmouth	0.12 - 0.25	Bend Radius /D = 4	0.16 - 0.18
Rounded	0.50	Bend Radius /D = 2	0.19 - 0.25
Sharp Edged	0.80	Bend Radius /D = 1	0.35 - 0.40
Projecting		Bend	
Pipa Menyempit Tiba-Tiba		Ø = 15º	0.05
D_2/D_1 = 0.80	0.18	Ø = 30º	0.10
D_2/D_1 = 0.50	0.37	Ø = 45º	0.20
D_2/D_1 = 0.20	0.49	Ø = 60º	0.35
Pipa Menyempit Mengerucut		Ø = 90º	0.80
D_2/D_1 = 0.80	0.05	Tee	
D_2/D_1 = 0.50	0.07	Aliran Lurus	0.30 - 0.40
D_2/D_1 = 0.20	0.08	Aliran Cabang	0.75 - 1.80
Pipa Melebar Tiba-Tiba		Persimpangan	
D_2/D_1 = 0.80	0.16	Aliran Lurus	0.50
D_2/D_1 = 0.50	0.57	Aliran Cabang	0.75
D_2/D_1 = 0.20	0.92	45º Wye	
Pipa Melebar Mengerucut		Aliran Lurus	0.30
D_2/D_1 = 0.80	0.03	Aliran Cabang	0.50
D_2/D_1 = 0.50	0.08		
D_2/D_1 = 0.20	0.13		

- Epanet 2.0 Application in Clean Water Distribution Network Analysis

The distribution system's initial design was the only task for which the distribution network software was initially employed. Operators are hesitant to employ distribution software to analyze network conditions since it is not user pleasant. However, distribution software has advanced in tandem with technical advancements to become more user-friendly. Operators can simulate different network activities using distribution software without interfering with the continuity of client service. The operator only needs to go to the field to collect the least amount of data possible in order to understand the distribution network, which is user-friendly and extensively used to analyze network distribution systems, as opposed to the past when the operator had to go to the field and gather as much data as possible in order to get an overview of the network.

EPANET 2.0 is a Windows-based computer program which is a simulation program of the time development of the hydraulic profile and the treatment of clean water quality in a distribution pipeline network, which consists of pipe points/nodes/junctions, pumps, valves (accessories) and reservoirs both ground reservoir and tower reservoir.

The output of the EPANET 2.0 program includes discharge flowing through the pipes, water pressure from each point/node/junction, which can be analyzed to determine how installations, pumps, and reservoirs operate, as well as the amount of concentration of chemical elements distributed in

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clean water, which can be used as a simulation to pinpoint the source's location and the direction of development.

EPANET 2.0 is designed as a tool to determine the development and movement of water and the degradation of chemical elements contained in water in clean water distribution pipes, which can be used for analysis of various distribution systems, design details, hydraulic calibration models, residual chlorine analysis and several other elements.

III. Research Methods

A. *Description Of The Research Area*

1. *Research sites*

1. Zone 1 covers Lasiana, Oesapa, Penfui, Lilba, Naimata, South Oesapa Villages
2. Zone 2 covers Fatululi Village, Oesapa Barat, Nefonaek, Pasir Panjang, Oebobo, Kayu Putih, Tuak Daun Merah, Kelapa Lima
3. Zone 3 includes Fatukoa, Belo, Sikumana, Oepura, Maulafa, Oebufu, Naikolan, Naikoten 1, Bakunase 2, Kolhua, Naioni Villages
4. Zone 4 includes Kelurahan Kuanino, Fontein, Mantasi, Tear, LLBK, Nunleu, Oetete, Solor, Bonepoi, Fatubesi
5. Zone 5 covers Manulai 2 Village, Alak, Nunbaun sabu (NBS), Pekase Oeleta

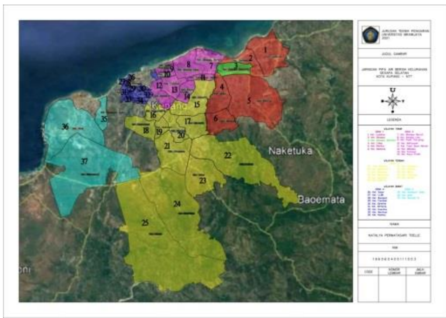

Figure 1. Map of PDAM City of Kupang

The research location was carried out in Zone 1 in the South Oesapa Village which is included in Zone 1 of the Kupang City PDAM service

Figure 2. Map of the existing pipeline network of Oesapa Selatan Village

As for the existing pipeline network for PDAM Kota Kupang, Oesapa Selatan Village, it can be seen in Figure 3.4 where the existing pipeline serves 16 RTs and the water sources used are Marturia drilled wells, Marthen drilled wells, and Herman drilled wells in Oesapa Selatan Village. Only 1 sub-district was taken from the research location so that the analysis was carried out in more detail at 16 RTs .

Figure 3. Administrative Map of Oesapa Selatan Village

2. *Research Area Limits*

1. The research was only carried out in the service area within the Oesapa Selatan sub-district consisting of 6 Community Units (RW) and 16 Neighborhood Units (RT)
2. Research was conducted on the clean water distribution network system.

B. *Research Data and Equipment*

a) *Research data*

1. Data on the number of residents in the Oesapa Selatan sub-district obtained from BPS Kota Kupang and the local Ward Office are used as a reference in calculating consumer water needs
2. Well Technical Data obtained from BWS NT 2 and PDAM KUPANG KOTA is used as a guideline and for determining the depth of groundwater
3. Distribution service map data obtained from PDAM Kota Kupang is used as a guide and determination in the distribution network
4. Distribution Network Schematic Data obtained from PDAM Kota Kupang is used as a guide and determination in the distribution network.
5. Questionnaire data obtained from consumers in the Oesapa Selatan sub-district are used to draw conclusions about the performance of the distribution system.

b) *Research Equipment*

1. EPANET 2.0 software is used in the basic distribution system analysis.
2. The SPPS program is used to calculate customer satisfaction from the questionnaire

C. *Research Stages*

1. Knowing the Sources of Clean Water in Oesapa Selatan Village
    1. Well Technical Data from BWS NT 2 and PDAM
    2. Calculating the amount of discharge in 3 units of drilled wells
    3. Analyzing the amount of data on potential sources of clean water and the data used is the water discharge for

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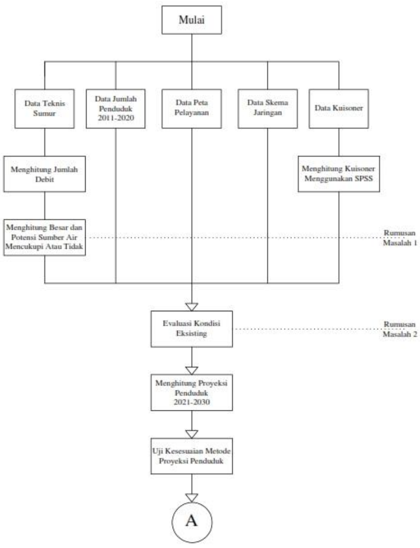
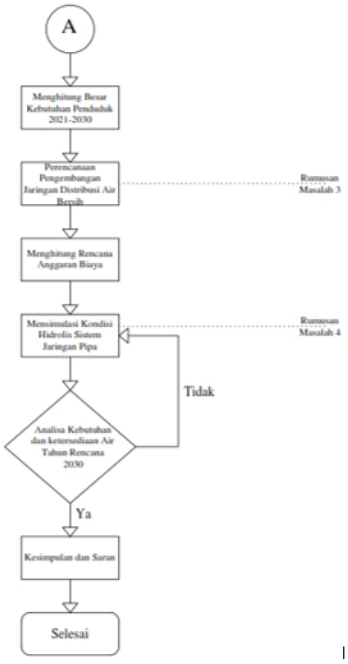
2020 contained in PDAM Kota Kupang. The data is analyzed to be used as water availability data.

2. Evaluation of Existing Conditions in Oesapa Selatan Village
   1. Population data for 10 years in Oesapa Selatan Village
   2. Schematic data of the distribution network in Oesapa Selatan Village
   3. Distribution network layout data in Oesapa Selatan Village
   4. Questionnaire data to determine the level of customer satisfaction with the performance of the clean water distribution system carried out by PDAM Kota Kupang.
   5. Calculating the customer satisfaction questionnaire on PDAM clean water distribution using the SPSS application
   6. Simulating Existing Conditions in EPANET 2.0
3. Analyzing the Development of Clean Water Distribution Network
   1. Data on the number of residents and customers
   2. Calculating the projected population
   3. Determination of population projection methods, namely: arithmetic, geometric and least square methods
   4. Test the suitability of the population projection method with the standard deviation of each method
   5. Calculating the amount of clean water demand based on the projected population up to 2030
   6. Calculating the availability of clean water until the end of the plan year
   7. Planning the development of a clean water distribution network
   8. Calculating the development budget plan
4. Analyzing Hydraulic Conditions Using EPANET 2.0
   1. Determine the type of pump used or replaced
   2. Simulating a piping network system, planning a clean water network and hydraulic analysis using EPANET 2.0. From the program, flow velocity, pressure, and pressure loss will be obtained.

D. Water Diagrams





IV. Results and Discussion

Water Sources

In order to provide the population of Oesapa Selatan Sub-district with clean water, PDAM Kota Kupang uses three drilled wells, which are shown in Table below. These wells have a combined discharge of 13.1 liters.17 liters/second and normal water quality.

Table 5. Water sources used by PDAM Kupang city, South Oesapa village

No	**Source**	**Location**	**debit**	**Pump Capacity**	**Well Depth (Meters)**
1	SB Mr Marten	-10.162066° 123.646791° South Oesapa Cooperative Gang	6.3	5.5L/D SP 17-18	84
2	SB Marturia Church	-10.156911° 123.654137° Jl. Matahari Oesapa Selatan	6.3	3.8L/D SP 14-25	80
3	SB Mr. Herman	-10.163061° 123.653157° Liliba Pharmacy Street	6.3	3.8L/D SP 14-25	85

Existing Conditions of Clean Water Supply System

- Population Data

The population of Oesapa Selatan Village, which consists of 6 RW and 16 RT, was 3579 in 2011, according to data from the Central Bureau of Statistics (BPS) for the City of Kupang.
Table shows the Rw and Rt populations in Oesapa Selatan Village, which were utilized in the analysis to determine the predicted population growth at the time of writing, together with the area and population density can be seen in Table.

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Table 6. Total Population of Oesapa Selatan Village in 2011 – 2020

No	RT	Jumlah Penduduk di Kelurahan Oesapa Selatan									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	1	222.00	230.00	250.00	258.00	267.00	287.00	291.00	303.00	312.00	365.00
2	2	400.00	416.00	450.00	466.00	482.00	517.00	526.00	547.00	562.00	658.00
3	3	203.00	211.00	229.00	237.00	245.00	263.00	267.00	278.00	286.00	334.00
4	4	200.00	208.00	225.00	233.00	241.00	259.00	263.00	273.00	281.00	329.00
5	5	372.00	386.00	418.00	433.00	448.00	480.00	489.00	508.00	522.00	611.00
6	6	174.00	180.00	195.00	202.00	209.00	224.00	228.00	237.00	244.00	285.00
7	7	279.00	289.00	313.00	324.00	335.00	360.00	366.00	381.00	391.00	458.00
8	8	240.00	249.00	270.00	280.00	289.00	310.00	315.00	328.00	337.00	395.00
9	9	182.00	189.00	204.00	212.00	219.00	235.00	238.00	248.00	255.00	299.00
10	10	209.00	216.00	235.00	243.00	251.00	269.00	274.00	285.00	293.00	343.00
11	11	195.00	202.00	221.00	227.00	235.00	252.00	256.00	266.00	274.00	321.00
12	12	332.00	345.00	373.00	386.00	400.00	429.00	436.00	453.00	466.00	545.00
13	13	90.00	94.00	101.00	105.00	108.00	116.00	118.00	123.00	126.00	148.00
14	14	77.00	80.00	86.00	89.00	92.00	99.00	101.00	105.00	108.00	126.00
15	15	295.00	307.00	332.00	344.00	355.00	381.00	388.00	403.00	415.00	485.00
16	16	109.00	113.00	122.00	126.00	131.00	140.00	143.00	148.00	152.00	178.00
Σ		3579	3715	4024	4165	4307	4621	4699	4886	5024	5880

Table 7. Percentage of Area and Population Density in Oesapa Selatan Village

No	RT	Jumlah Penduduk (Jiwa)	Luas Wilayah (km2)	Kepadatan per Km2	Presentasi Luas Wilayah
(1)	(2)	(3)	(4)	(5= 3 / 4)	(6= (4/Σ4) x 100)
1	1	365	0.0259	14093	2.15
2	2	658	0.0400	16450	3.31
3	3	334	0.0982	3401	8.13
4	4	329	0.0456	7215	3.78
5	5	611	0.0942	6486	7.80
6	6	285	0.0937	3042	7.76
7	7	458	0.0917	4995	7.60
8	8	395	0.0847	4664	7.02
9	9	299	0.0533	5610	4.42
10	10	343	0.0462	7424	3.83
11	11	321	0.0551	5826	4.56
12	12	545	0.0478	11402	3.96
13	13	148	0.2100	705	17.40
14	14	126	0.1090	1156	9.03
15	15	485	0.0445	10899	3.69
16	16	178	0.0673	2645	5.57
Σ		5880.00	1.2072	106010.60	100.00

Based on Table 7 above, the percentage of area and population density in the South Oesapa sub-district is obtained according to Figure 4 and Figure 5 below

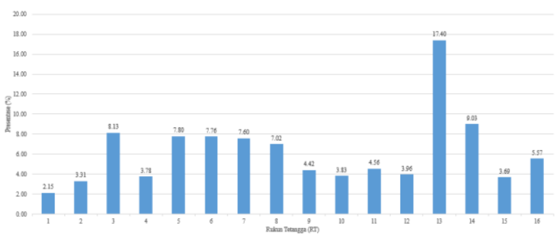

Figure 4. Area Presentation Graph

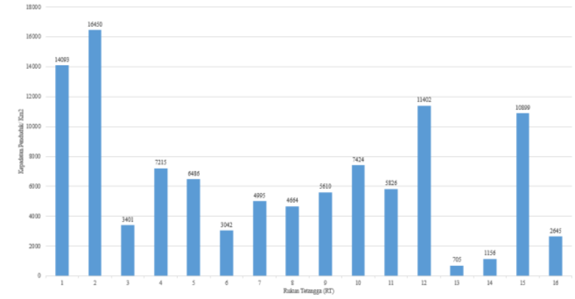

Figure 5. Graph of South Oesapa Population Density

- Piping Network

Clean water supply in Oesapa Selatan Village based on data on house connection services (SR) from PDAM Kota Kupang at the end of 2020 amounted to 245 house connections assuming one SR = 5 people (Merpen PUPR no 27/PRT/M/2016; regarding the implementation of the supply system drinking water) The total population of Oesapa Selatan Village is 5880 people with a service capacity of 20.83%.

The distribution network is useful for distributing water to consumers. Distribution pipe system, main distribution pipe average 4" (100 mm) diameter, 3" (80 mm) diameter pipe, 2" (50 mm) diameter pipe 1" (25 mm) diameter pipe and ¾" diameter pipe 19mm) The distribution pipe uses a GIP (Galfanis Iron Pipe) type pipe

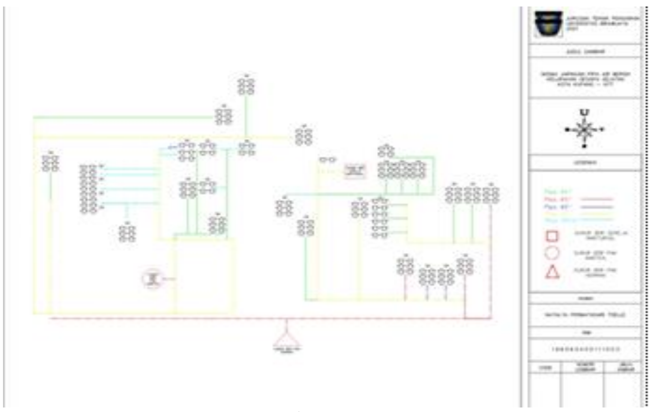

Figure 6. Schematic of the Existing Piping Network

Figure 7. Existing Distribution Network Layout

- Questionnaire

To ascertain the degree of customer satisfaction with the effectiveness of the clean water distribution system and the caliber of production carried out by PDAM Kota Kupang, questionnaire data with a total of 152 respondents were used. Based on survey responses from 152 customers, it appears that customers do not believe that PDAM clean water distribution is routine or available around-the-clock, with 69% strongly disagreeing and 17% agreeing. However, they do believe that the quality of PDAM clean water is suitable for consumption, with 43% strongly agreeing and 47% agreeing.

Clean Water Network Development

- Population Analysis

The need for clean water is analyzed based on the number of people living in the area, taking into account population growth and regional development plans so that the need for water use in the future can be identified. Analysis of population growth in the Oesapa Selatan Village is calculated based on the population using the selected projection method.

Population projections are used to estimate the number of residents in service areas included in the planning area. Population projections are carried out over the next 10 years from 2021 to 2030. An example of calculating the population growth rate for Oesapa Selatan Village

r = total population (2012-2011)
= 3715 - 3579
= 136 people (Population increased by 136 people)
r (%) = r / total population (2011)
= 12 / 3579
= 3.799 % (rate of population growth)

- Determination of Population Projection Method

Three methods—the arithmetic technique, the geometric approach, and the Least Square method—are used to calculate population projections. The projection method is chosen based on the projection results for each method, the correlation coefficient value (r), and the smallest standard deviation value, with the criteria for selecting the population projection method based on the biggest correlation coefficient value approaching +1.

The number of residents annually from 2011 to 2020 is computed from the population statistics for 2020 using the arithmetic, geometric, and Least Square methods to select the best approach for computing population forecasts for the following 20 years.Population Projection Arithmetic Method

Counting down the population using the arithmetic method. Example of counting down the population of Oesapa Selatan Village in 2020:

Pn = 365 souls (Year 2020)
Pn =P0 – Ka (Ta - T0)
P2011 =365 – 15.89 (2020-2011)
=221.99 ≈ 222 souls

- Planned Year End Water Needs

The need for clean water can be calculated based on the level of water consumption and the population. In this case, the need for clean water can be calculated based on the level of water consumption,

- Domestic Needs

Domestic demand is the need for water used for household purposes. Based on several factors, from geographical location as well as socio-economic conditions, the study area is included in the small town group (population in 2030 is 7670 people) with the assumption that the need for clean water is 120 liters/person/day.

SR=100% x 463 x 120
= 55,560 liters/day
= 0.64 ltr/sec

So, the total domestic water demand for Oesapa Selatan Village RT 1 in 2021 is 0.64 ltr/sec. The domestic net need for Oesapa Selatan Village in 2030 is 10.65 liters/second.

- non domestic,

Non-domestic needs are the need for clean water for various public facilities, such as places of worship, educational facilities, health facilities and others. Based on the Minister of Public Works Regulation regarding the implementation of SPAM development, the level of water service for non-domestic needs is 30% of domestic demand.

- Loss of water

Water loss can be defined as a percentage number that shows the ratio between the volume of water supplied (supplied water) and the volume of water consumed (consumed water) or the use of water sold (revenued water). Loss of water obtained from non-revenue water or ATR has 2 types:

- Non Physical Loss (Commercial)

Loss of water that is not physically visible, but can be known from the calculation. This is due to unofficial consumption such as illegal connections and unpaid water use as well as customer meter inaccuracies and data errors.

- Physical/Technical loss

Physical losses are caused by leaks and overflow in the reservoir tank and leaks in the distribution pipe up to the customer's meter

Distribution Network Planning and Development

Based on the results of the population growth analysis, the projected population of Oesapa Selatan Village Rt 1 in 2030 is 7670 people. The need for clean water for the residents of Oesapa Selatan Village is 11.84 ltr/sec in 2021 and 15.93 ltr/sec in 2030. The water discharge at 3 water sources serving the water needs of the people of Oesapa Selatan Village obtained a production discharge of 13.10 ltr/sec.

The results of the analysis and several calculations above show the availability of clean water discharge (Q) to meet clean water needs at the beginning of the plan year (2021) of 11.84 ltr/sec until 2024 of 12.75 ltr/sec but from 2025 to the end of the plan year (Year 2030) of 15.93 ltr/sec so that an additional debit capacity (Q) of 2.83 ltr/sec is needed to meet the clean water needs of villages/kelurahans in Oesapa Selatan Subdistrict until the end of the plan year.

The Boring Well of the Marturia Church, Pak Marten's Drilling Well, and Pak Herman's Boring Well can only flow a maximum amount of water at a rate of about 13.10 liters per second, according to the results of the hydraulic simulation of the existing distribution network. However, if water services are provided in rotation, the current network conditions still meet the standard. because the discharge that is now offered cannot satisfy the demands for continuous satisfaction (24 hours each day).

Based on the results of observations and interviews with PDAM officers, the existing distribution network has not been properly connected and has not yet reached the entire Oesapa Selatan Village and in line with the development of the Kelurahan, it is necessary to provide a pipeline network and develop a pipeline network to areas within the Oesapa Selatan Kelurahan area that have not been served.

Hydraulic Condition Using Epanet 2.0

- Changes to Pump Specifications

The distribution network plan and development during the simulation show unsuccessful results because the available water debit cannot meet water needs with a service distribution time of 24 hours/day at each node/junction. To overcome the unsuccessful planning and development network simulation, the pump specifications were replaced at two drilled well points by taking into account the existing water discharge in each well.

Simulation results on the distribution network that are displayed are conditions during peak hours of water use (07.00-08.00). The results of the planned distribution network simulation are explained as follows:

- Flow Speed (Velocity)

The simulation results show a low flow velocity in the pipe where the flow velocity ranges from 0.01 – 1.09 m/s on average the existing pipe has a low speed at the furthest service point. In the simulation it does not meet the minimum speed criteria but meets the maximum speed criteria in the distribution network planning in Permen Pu no.18 of 2007

- Pressure

The simulation results show that pressure conditions at existing nodes are influenced by pipe specifications and the amount of water needed so that during peak hours of water usage the pressure at some junctions has decreased but still has a minimum residual pressure of 103.50 meters of water column (Mh2O) or the equivalent of 10.00 atm at the service point farthest (Junc N6-1). In the simulation results the drinking pressure does not meet the distribution network planning criteria, but the maximum pressure meets the distribution network planning criteria in Permen PU no.18 of 2007

- Press Loss (Headloss)

The average pressure loss is below 10 m/km, but there are several pipes that have a pressure loss above 10 m/km. The large pressure loss is caused by a drastic change in pipe dimensions, causing the pressure at the node to decrease.

V. CLOSING

1. Water sources utilized by PDAM Kota Kupang to meet needs Clean water for the residents of Oesapa Selatan Sub-District comes from 3 units of drilled wells which are sufficient with a debit of 13.10 liters/second.
2. The existing conditions of the Oesapa Selatan Sub-district include: data on the population of 10 years in the Oesapa Selatan sub-district, namely 2011-2020. The population of the Oesapa sub-district is 5,880 people with a service capacity of 20.83% and 245 SRs, based on observations of the supply of clean water from the PDAM every year. 4 times a week with a service time of 3-4 hours so it is not optimal. In the EPANET simulation, the existing conditions flow velocity ranges from 0.01 – 1.43 m/s, the average existing pipe has a low speed at the farthest service point, the pressure during peak hours of water use the pressure at several junctions has decreased but still has a minimum residual pressure of 90.83 meters of the water column (Mh2O) or the equivalent of 8.79 atm at the service point
3. Development analysis includes the results of population growth analysis, the population of Oesapa Selatan Village in 2030 is 7670 people, with an average population growth using the Least Square method of 1.92%/year. The total need for clean water for the population of Oesapa Selatan Sub-District is 11.84 liters/second in 2021 and 15.93 liters/second in 2030, while the water production discharge currently used is 13.10 liters/second, resulting in a shortage water by 0.10 liters/second in 2024 and 2.83 liters/second at the end of the 2030 plan year. An alternative for handling and developing the distribution network is developing the network so that it can meet the needs for house connection services (SR) and replacing pumps with sufficient capacity up to in 2030 and the planned budget for its development is 2,207,200 billion rupiah.
4. Hydraulic Conditions To meet the demand for clean water is carried out by changing the pump specifications for the Submersible pump Grunfos SP14 – 25 with a capacity of 3.8 liters/sec to Submersible Pump Grunfos 17-18 with a pump capacity of 5.5 liters/second at two water sources, the available flow rate is 16.50 liters/second. The specifications for this pump to be replaced also function to meet the needs for a water discharge in the 2030 plan of 15.93 ltr/s, so that EPANET simulations can be carried out thoroughly on the distribution network using EPANET Software to find out the hydraulic conditions of the planned network. The simulation results show success (Run was Successful), which means that there are no problems with the planned distribution network so that it is concluded that the clean water distribution network runs continuously without any problems with flow velocities ranging from 0.01 – 1.09 m/s, the average of the existing pipes has the same speed. low is at the farthest service point. In the simulation it does not meet the minimum speed criteria and meets the maximum speed criteria in the distribution network planning in Permen Pu no.18 of 2007, the pressure during peak hours of water usage has decreased in several junctions but still has a minimum residual pressure of 103.50 meters of water column (Mh2O) or the equivalent of 10 atm at the farthest service point (Junc N6-1). In the simulation results the drinking pressure does not meet the distribution network planning criteria, but the maximum pressure meets the distribution network planning criteria in Permen PU no.18 of 2007, and the average pressure loss is below 10 m/km but there are several pipes that have

pressure losses above 10 m/km, a large pressure loss is caused by a drastic change in pipe dimensions which causes the pressure at the node to decrease.

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