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Reviewing DMA in the Mojolangu Zone for NRW Reduction (Case Study: Malang City PDAM)

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Abstract: ***Population growth in Malang City resulted in an increase in the need for drinking water. To ensure the availability of drinking water, PeMalang City is trying to reduce Non Revenue Water (NRW). NRW data from the annual water balance of 28.57% or water equivalent which does not become an income of about 80 billion per year. The purpose of this study is to examine the condition of DMA in the Mojolangu Zone, analysis of investment feasibility and operational costs of DMA in the Mojolangu Zone area, strategic analysis in increasing the share of water loss against NRW reduction. The result of this study is the use of HDPE pipes one of the efforts to suppress leaks. The cause of NRW is caused by unmetered water consumption of 17.28%, physical water loss of 16.39% and non-physical water loss of 4.72%.***

Keywords: DMA, HDPE, NRW

1. Introduction

Water loss is one of the components contained in Non Revenue Water (NRW), while NRW is water loss coupled with official consumption of non-revenue based on the water balance by the International Water Association (IWA). The lost revenue opportunity is due to Non Revenue Water (NRW) based on the cost of water prices at that time of (Rp 5,769 per m3), while production was 48,388,026 m3 per year, resulting in a loss cost of 80 billion in a year. The large value of the cost of loss due to NRW is an extraordinary motivation behind why efforts need to be made to reduce the level of NRW. In addition, the benefits of reducing NRW can increase water volume so that it can increase service coverage, increase revenue and reduce company operational costs.

One of the measures in order to control water loss by a fairly well-known method is Steptest, which is a technique for searching for the location or area with the largest amount of water loss within the DMA [3]. This study will examine the DMA in the Mojolangu Zone as one of the efforts to reduce NRW. The reason for choosing the Mojolangu Zone is that there is a DMA whose Non Revenue Water (NRW) level is below 25% aimed at obtaining best practices in the formation of DMA so that variables are obtained that are used in reducing NRW in DMA with the lowest NRW level that can be applied in increasing DMA performance as an effort to reduce NRW.

2. Literature Survey

a) Non Revenue Water(NRW)

Non Revenue Water (NRW) is the amount of water that is not rekened. NRW is calculated by subtracting the water input in the system against the affected water. Based on the NRW Component Water Balance consists of official consumption of non-revenue and loss of water. [1].

b) Physical Water Loss

Physical water loss is the loss of a certain amount of drinking water in the process of providing, distributing and servicing PDAM drinking water which is shown by the physical flow of water coming out of the distribution pipeline system and PDAM services. The causes of physical water loss are [1]:

1) Technical Factors, namely Water loss in distribution pipes and their equipment, Water loss in official pipes and installation components of House Connections (SR) before water meters, Use of fire hydrants, draining pipelines, use of production installation water. Non-piping systems that distribute drinking water not through distribution pipelines, but rather use transportation to transport water from production units to customers, such as tank cars, wheelbarrows, and others.
2) Non-Technical Factors, namely Unregistered/Illegal Connections, Water theft, Customer fraud (installation of by-pass pipes in Home Connection installations).

c) NonPhysical Water Loss

Non-physical water loss is the loss of a certain amount of drinking water in the process of distributing and servicing drinking water to PDAM customers which is not shown by the physical flow of water coming out of the distribution pipeline system and PDAM services. The causes of non-physical water loss are [1]:

1) Technical Factor is Inaccurate water meter

One of the most commonly encountered causes of commercial water loss is the accuracy of the meter. Mechanical water meters, in which there are wheels or teeth made of plastic material, over age will wear out, and cause the water meter to record lower than it should be. Therefore, the meter must be periodically re-calibrated (re-calibrated) Ultrasonic and magnetic type water meters are not too affected by the accuracy by the age of the meter. Poor water quality is also one of the causes of the decline in the performance of water meters. It can deteriorate faster if the water is aggressive. The deposition of dirt can affect the mechanics of the meter, so the meter fails to record the flow.

2) Non-Technical Factors, including:
a) Error reading of numbers on the Home Connection

water meter.

b) Error recording of the results of the reading of the House Connection water meter.

c) Miscalculation of the results of the reading of the House Connection water meter.

d) Estimated readings of the House Connection water meter.

e) The Home Connection water meter is not read.

f) Customer cheating (water meter pasted magnit, pierced by a needle, dripped with saline solution, tilted, turned over etc.).

The accuracy of the production discharge and water inlet (flow meter) is decisive for calculating the NRW of the system. There are different types of meters that have varying accuracy can be seen in Table 1.

Table 1: Indicative Accuracy of Meters [2]

Peralatan/Metode	Kisaran Perkiraan Keakuratan
Meter Air Elektromagnetik	<0,15 -0,5%
Meter Air Ultrasonik	0,5 - 1%
Insertion Meter	<2%
Meter Mekanik	1,0 - 2%
Meter Venturi	0,5-3%
Meas Weir di saluran terbuka	10-50%
Volume dihitung dengan kurva pompa	10-50%

Catatan: Keakuratan meter sesungguhnya akan tergantung pada banyak faktor (seperti profil aliran, kalibrasi, pemasangan meter, perawatan) dan harus diverifikasi kasus per kasus

d) DMA Formation Criteria

The following are the steps for the criteria for the formation of DMA carried out by the City PDAM:

1) Network Map Analysis (as built drawing)

Creating a DMA Limit Plan Point (DMA Concept) number of customers 500 – 2000 SR.

2) Hydraulics Modeling

Analyze the network with hydraulics software.

3) Perfect DMA Analysis

a) Analyze the results of the Logger data.

b) Blind / DMA limit installation is performed.

4) Pressure Analysis In The Field

a) Installation of DMA limit Valve.

In order to divide one large system into a series of DMA, it is important to close the valves in order to isolate one particular Area and install a water meter. This process can have an impact on system stresses, both within a particular DMA as well as in the surrounding region. Drinking water companies must thus ensure that the water supply for all customers is not sacrificed in relation to pressures and service hours [5].

e) Distribution system

The distribution system is a system that is able to distribute water to each consumer in the form of a house connection or connection through a public tap [6]. In the distribution system of note is the maximum pressure limit at the farthest point to be served. This is necessary so that at the farthest point can obtain an adequacy (head / pressure) of optimal water availability [4].To distribute drinking water to consumers with sufficient quantity, quality, and pressure requires a good piping system, reservoir, pump, and other equipment. The types of drinking water jetting systems are as follows [7]:

Gravity system

The gravity system allows it to be used when the elevation of the water source or distribution reservoir is higher than that of the service area, so that the pressure is sufficient to drain the water to the residential area at the very end of the service area. This system is the most economical system. In gravity flow, the reservoir used is a ground reservoir or coupled with an elevated reservoir as a pressure enhancer to serve at maximum usage time in the farthest service area that does not get water.

Pumping system

In this pumping system the pump is used to increase the pressure necessary to distribute water from the distribution reservoir to the consumer. This system is used if the elevation between the water source or treatment plant and the service area cannot provide sufficient pressure. Pumping of water from the reservoir to the consumer is carried out according to the desired pressure. The fluctuating use of water results in the need for a means to balance the flow, for example by installing a hydrophore or regulating the number of pumps used.

Combined System

Dual system is a combination of gravity system and pumping system. Excess water due to the use of water that cannot be accommodated in the reservoir which will later be used to supply water at the time of water use will be a lot. Sometimes an additional pump is needed, for example to supply directly when a fire occurs.

3. Methods

The flow of this study was by choosing DMA with the lowest NRW rate below 25% and DMA with NRW above 25%. The purpose of choosing the DMA with the lowest NRW is to examine the condition of the DMA in the implementation of the DMA so that best practices are obtained. By obtaining DMA best practices, variables will be obtained - variables used in lowering NRW so that it can be applied to increase DMA performance as an effort to reduce NRW which is still high above 25%. The following is the preliminary data obtained from the DMA parent water balance for the January 2021 period to determine the NRW level which can be seen in Table 2.

Table 2: DMA Main Water Balance Meter for the January 2021 Period

Location	Service DMA	Customer	NRW		
			m^3	%	m^3/day
Mojolangu Zone					
Jl. Taman Borobudur	Mojo 2B	2.184	23.794	40	768
Tandon Mojolangu 2	Mojo 2	4.460	15.516	17	501
Jl. Candi Mendut	Mojo 1F, 1F-A, 1F-C	1.151	12.236	39	395
Jl. Simpang Borobudur (Waing)	Mojo 2B4	497	6.936	45	224
Jl. Tombro Lapangan	Mojo 3E	502	3.852	32	124
Jl. Kendalsari	Mojo 1B	1.117	3.202	15	103
Jl. Sukarno Hatta (Tambal Ban)	Mojo 1D	360	3.103	28	100
Jl. Simpang Candi Mendut	Mojo 1F	1.004	2.503	13	81
Jl. Sukarno Hatta (Krida Budaya)	Mojo 1E	35	395	38	13
Jl. Tombro Polowijen	Mojo 3D	921	146	1	5

Then analyze the factors causing the high number of Non Revenue Water (NRW) and the continuity of drinking water flow that is less than optimal in the District Meter Area (DMA) in the Mojolangu Zone area with a water balance, the method of finding water loss using a step test, conducting a search for commercial losses. From this analysis, results were obtained in the form of conclusions and recommendations.

4. Discussions

The condition of NRW and water loss in each DMA during the study was averaged during January to August 2021 which can be seen in the diagram in Figure 1Average Percentage of NRW and the diagram in Figure 2 Average NRW Volume.

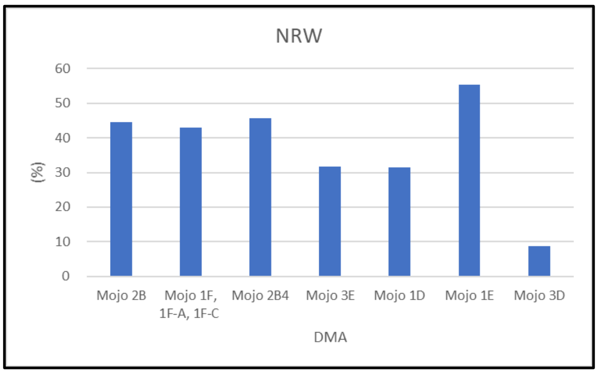

Figure 1: Average Percentage of NRW

From the percentage of NRW in Figure 1, mojo 1E is obtained the highest level of NRW in percentage. However, the divided volume of NRW water loss and official consumption of non-revenue in Figure 2 is obtained by Mojo 1E to be the lowest, due to the influence of the number of home connections seen in Table 3.

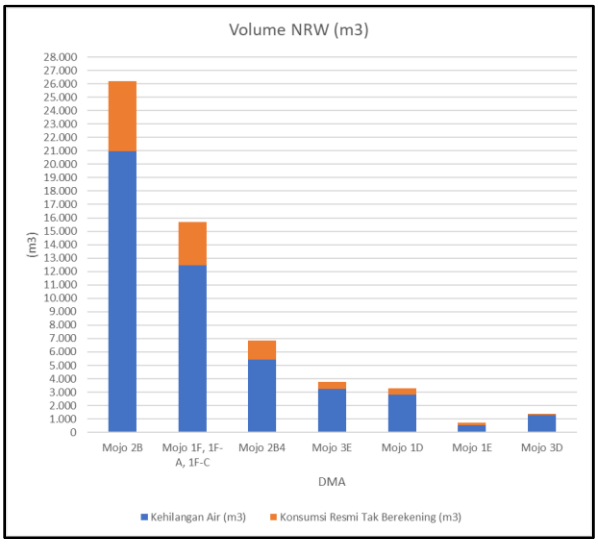

Figure 2: Average NRW Volume

Table 3: Number of Home Connections

No	DMA	Number of Home Connections
1	Mojo 2B	2.183
2	Mojo 1F, 1F-A, 1F-C	1.154
3	Mojo 2B4	497
4	Mojo 3E	503
5	Mojo 1D	361
6	Mojo 1E	24
7	Mojo 3D	931

Therefore, from these conditions, a selection of DMA criteria was carried out with a comparison of the number of house connections of 500 - 2000 SR. Here's Table 4 that meets the DMA criteria based on the number of home connections (SR).

Table 4: DMA meeting the criteria

No	DMA	Number of Home Connections
1	Mojo 1F, 1F-A, 1F-C	1.154
2	Mojo 2B4	497
3	Mojo 3E	503
4	Mojo 3D	931

Here are the pipe lengths on each pipe diameter (Ø) which can be seen in Table 5 and the pipe types in Table 6.

Table 5: Pipe Lengths

No	DMA	Pipe Length(m)					
		Ø 250 mm	Ø 200 mm	Ø 150 mm	Ø 100 mm	Ø 75 mm	Ø 50 mm
1	Mojo 2B	1.154,82	1.585,38	1.511,23	1.658,32	1.828,66	16.228,6
2	Mojo 1F, 1F-A, 1F-C		12,84	905,46	275,98	2.281,55	9.649,55
3	Mojo 2B4		605,53		727,33	547,49	3.737,31
4	Mojo 3E				1.247,38	827,99	3.348,5
5	Mojo 1D		604,19		856,33	549,33	2.333,89
6	Mojo 1E				161,36	232,5	350,34
7	Mojo 3D				2.275,46	417,65	7.159,8
Jumlah		1.154,82	2.807,94	2.416,69	7.202,16	6.685,17	42.807,99

Table 6: Types of Pipes

No	DMA	Pipe Type					
		Ø 250 mm	Ø 200 mm	Ø 150 mm	Ø 100 mm	Ø 75 mm	Ø 50 mm
1	Mojo 2B	HDPE	PVC	PVC	PVC	PVC	PVC
2	Mojo 1F, 1F-A, 1F-C		PVC	PVC	PVC	PVC	PVC
3	Mojo 2B4		PVC		PVC	PVC	PVC
4	Mojo 3E				PVC	PVC	PVC
5	Mojo 1D		HDPE		PVC	PVC	PVC
6	Mojo 1E				PVC	PVC	PVC
7	Mojo 3D				PVC	HDPE	HDPE

Here is a recapitulation of the pipe lengths on each DMA and the volume of physical water loss that can be seen in Table 7.

Table 7: Recapitulation of Pipe Length and Volume of Physical Water Loss

No	DMA	Sum Pipe Length (m)	Volume Loss Physical Water (m^3)
1	Mojo 2B	23.967	19.546
2	Mojo 1F, 1F-A, 1F-C	13.125	11.562
3	Mojo 2B4	5.618	5.040
4	Mojo 3E	5.424	3.085
5	Mojo 1D	4.344	2.678
6	Mojo 1E	744	484
7	Mojo 3D	9.853	1.293

Based on the data on pipe length and pipe diameter above, then a DMA selection was carried out based on a handbook of water loss mitigation techniques, namely the condition of the pipe length is recommended to be between 3000 - 8000 meters and the diameter of the pipe < 200 mm for secondary and tertiary pipes [1].

Here's Table 8 that meets the DMA criteria based on pipe length and pipe diameter.

Table 8: DMA criteria by pipe length and pipe diameter

No	DMA	Sum Pipe Length (m)	Maximum Pipe Diameter
1	Mojo 3E	5.424	100

Aside from physical water volume loss, here is a recapitulation of the replacement of commercial water meters related to commercial water loss in each DMA which can be seen in Table 9.

Table 9: Recapitulation of Water Meter Replacements related to Commercial Water Loss

No	DMA	Grand Total	Replacement of Water Meters per SR	Commercial Water Volume (m^3)
1	Mojo 2B	63	0,04	786
2	Mojo 1F, 1F-A, 1 F-C	49	0,04	532
3	Mojo 2B4	6	0,01	65
4	Mojo 3E	6	0,01	39
5	Mojo 1D	12	0,03	94
6	Mojo 1E	2	0,05	25
7	Mojo 3D	48	0,05	68

From the PDAM data obtained that commercial water loss related to meter replacement affects NRW, the more water meter replacements will make NRW low. Inorder to search for pipe leaks, an active leakage control (ALC) search is carried out with the steptest method, which is a technique to search for techniques to search for locations or areas with the largest amount of water loss in the DMA. The technical implementation of the steptest is to monitor the DMA inlet discharge which will be steptested to record the water flow, then the valves in each DMA section are closed systematically and sequentially based on the steptest blank fill. An indication of leakage in the Mojo 1D DMA can be seen in Figure 3 with the medium to high leaking category being in the PVC pipe type, while the low leaking category is in the HDPE pipe type.

STEP	V1	V2	V3	V4	V5	V6	V7	V8	MONITORED PIPE LEAKS	TIME HOUR	DEBIT (L/dtk)	WATER LOSS (L/dtk)	dSR	dQ/dSR	LEAKY CLASSES	PIPE TYPES
BEGIN	O	O	O	O	O	O	O	C		22:40	1,78					
STEP 1	C	O	O	O	O	O	O	C	1	22:50	1,76	0,020	14	0,0014	Low	HDPE
STEP 2	C	C	O	O	O	O	O	C	2	23:00	1,69	0,070	55	0,0013	Low	HDPE
STEP 3	C	C	C	O	O	O	O	C	3	23:10	1,21	0,480	67	0,0072	Medium	PVC
STEP 4	C	C	C	C	O	O	O	C	4	23:20	0,69	0,520	60	0,0087	Medium	PVC
STEP 5	C	C	C	C	C	O	O	C	5	23:30	0,62	0,070	3	0,0233	High	PVC
STEP 6	C	C	C	C	C	C	O	C	6	23:40	0,62	0,000	1	0,0000	Low	HDPE
STEP 7	C	C	C	C	C	C	C	C	7	23:50	0,62	0,000	1	0,0000	Low	HDPE
STEP 8	C	C	C	C	C	C	C	C	8	00:00	0,62	0,000	7	0,0000	Low	HDPE
FINISH	O	O	O	O	O	O	O	O					253			

Figure 3: Steptest DMA Mojo 1D Fill Blanks

From the step test data, it can be concluded that the type of HDPE pipe is more reliable than PVC in reducing leakage, where HDPE pipes have advantages in excellent strength and flexibility and a very low crack rate.

The water balance data seen in Table 10 is obtained from the DMA water balance, including inlet discharge, well-known water consumption, NRW discharge and other component details, an approach to the percentage of water balance in 2020 PDAM Malang City. So that this DMA water balance data is not the actual data of field conditions due to the limitations of data collection on each DMA.

Table 10: Consolidated Water Balance Sheet

	Water Loss				
No.	DMA	Physical (m^3)	Non-Physical (m^3)	Official Consumption of Unaccount (m^3)	Account (m^3)
1	Mojo 2B	19.546	1.432	5.237	32.830
2	Mojo 1F, 1F-A, 1F-C	11.562	887	3.243	18.472
3	Mojo 2B4	5.040	385	1.410	8.077
4	Mojo 3E	3.085	149	545	8.010
5	Mojo 1D	2.678	127	463	7.112
6	Mojo 1E	484	53	195	504
7	Mojo 3D	1.293	16,52	60,44	12.598

It can be concluded that several factors - the factors causing NRW from the three components are physical, non-physical water loss and official consumption of non-revenue which can be seen in Table 11 as follows.

Table 11: Factors causing NRW

Physical Water Loss	Non Water Loss	Official Consumption of Unaccount	
		Unconcerned Beremeter Consumption	Unmeterd Consumption
Broken Accessories	Broken Meters	Reduction	Change Meter
Broken Accessories	Meters with unsuitable class	Batu City Compensation	Pipeline Projects
Packing/ Rubber Damaged	Jammed Meter	Wendit County Compensation	Flushing Water Quality
Porous Pipe		DLH SU 1 Compensation	Cop Leaks
Ruptured Pipe		Gor Ken Arok Tank Help	Reopen

Official unemployed consumption data was obtained from the percentage of water balance in 2020. The following are the total components of official consumption that are not known based on the percentage of the water balance in 2020 which can be seen in Table 12.

Official Consumption of Uninhabited	
Unconcerned Bermeter Consumption	Unmetered Consumption
Reduction= 951m^3	Change Meter= 51 m^3
Batu City Compensation= 4808 m^3	Pipeline Projects= 639 m^3
Wendit County Compensation= 3106 m^3	Flushing water quality= 695 m^3
DLH SU 1 Compensation= 23 m^3	Cop Leaks= 20 m^3
Gor Ken Arok Tank Help= 9 m^3	Reopen= 853 m^3
Total= 11.154 m^3	

The following is a recapitulation in the form of a percentage of the components causing NRW in each DMA which can be seen in Figure 4.

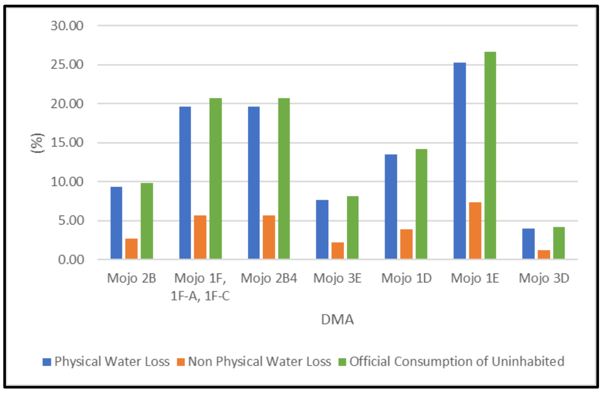

Figure 4: Percentage of Components Causing NRW

The percentage of components causing NRW contained in Figure 4 is Official Unneeded Consumption of 17.28% (11,154 m3), Physical Water Loss of 16.39% (43,687 m3), NonPhysical Water Loss of 4.72% (3,049 m3).

5. Conclusions

DMA One of the successes in minimizing leaks in the 3D

Mojo DMA which is the best practice with the lowest NRW level is the use of HDPE Pipe Types in service pipes with a diameter of 75 mm and 50 mm. In DMA Mojo 1D, an indication of leakage with a medium to high category is obtained in pvc pipe lines and low categories in HDPE pipelines. So that the type of HDPE pipe is more reliable than PVC in reducing the leakage rate.

The Causative Factors of NRW are divided into Official Unincorporated Consumption of 17.28% (11,154 m3), Physical Water Loss of 16.39% (43,687 m3), Non-Physical Water Loss of 4.72% (3,049 m3).

The calculation of the DMA water balance is carried out with the approach of the percentage of the water balance in 2020 PDAM Malang City. After calculating the water balance, a leak search survey was carried out, here are the types of findings of monitoring activities, including physical leaks in the SR pipe during steptest activities, leaks found during tracing, meters stuck during zero usage surveys and inappropriate groups when the usage survey soared.

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