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Study on Optimization of Availability and Demand for Clean Water at Regional Drinking Water Companies (PDAM) in Jayapura City

Dwi Cahya Kurniawan[1*], Mujiati[2], Dewi Ana Rusim[3], Ira Widyastuti[4], Harmonis Rante[5]
Universitas Cenderawasih, Indonesia
Email: dwi.cahya@pu.go.id[1*], muji_js@yahoo.com[2], dewianarusim@yahoo.co.id[3], iwidyastuti09@gmail.com[4], harmonisrante72@yahoo.co.id[5]

*Correspondence

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ABSTRACT

PDAM Jayapura is a government agency that operates in the field of providing drinking water services, apart from being a profit institution, it is also a social institution. PDAM Jayapura is tasked with providing clean water for the Jayapura City and Jayapura Regency areas. This research aims to identify the existing condition of the Jayapura City PDAM drinking water distribution system, analyze the availability, needs, and installed (distribution network) clean water needs in Jayapura City, and conduct an analysis of other alternatives in meeting Clean Water Needs in Jayapura City. The results of this research show that the coverage of clean water services by Jayapura City PDAM is still below national standards, using technological innovation to monitor and control the clean water distribution network system in real-time using sensor technology installed at each network point to identify and repair leaks quickly, based on the results of the planet 2.0 analysis, several parts of the pipe have very small velocities, therefore, the discharge coming out of the pipe is very small. The solution that can be made is to reduce the dimensions of the existing pipe so that the flow speed can be met and also by adding water pumps at various points that have a water speed of 0 m/s so that the water in the pipe can flow properly.

Introduction

Jayapura City is an urban area where people cannot be said to enjoy clean water evenly and meet quality requirements. In fact, in Jayapura City, there are many water sources, both in the form of springs, rivers, and lakes (Wegelin, Wensley, McKenzie,

Bhagwan, & Herbst, 2011). This is evidenced by the fact that some people still use rainwater and groundwater whose water quality is not qualified for consumption. The supply of clean water in Jayapura City (North Jayapura District, South Jayapura District, Abepura District, Heram District, and Maura Tami District) is still far from what is needed. The expectation is that the water can flow for 24 hours a day without stopping. However, the water discharge from the river which is the source of spring water has decreased drastically, so that the volume of water in the intake intake or reservoir is very unlikely to flow for 24 hours a day (Tanjung, 2013).

The clean water supply system for most of the city of Jayapura is served by the government through PDAM (Regional Drinking Water Company) which has been renamed PT. Air Mimum (PTAM) Jayapura, and a small part by private and private parties. PDAM Jayapura is a government agency engaged in the field of drinking water service providers, in addition to being a profit institution as well as a social institution. PDAM Jayapura is in charge of providing clean water for the Jayapura City and Jayapura Regency areas. PDAM Jayapura as a BUMD engaged in the provision of clean water is required to be able to provide clean water to meet the needs of clean water. PDAM Jayapura which was established in 1890 serves the needs of clean water for Jayapura City (Sari, 2012).

According to the Director of PDAM Jayapura, Dr. H. Entis Sutisna, SE. MM., he said, the reason for his party is looking for alternatives for the supply of raw water from Lake Sentani. First, because the need for clean water in Jayapura is increasing day by day. Since the last 20 years, there has been almost no increase in production capacity. Meanwhile, the growth rate of the community which has an impact on the demand for clean water consumption is greatly increasing, especially in urban areas (Nurfaiziya, Runiawati, & Muftiadi, 2022).

"Now the number of people in the city area alone has reached 420 thousand people. Meanwhile, our clean water production is only 850 liters per second," he said. So one of the efforts made by PDAM to meet the need for clean water in the city first must optimize the existing water sources in several water intakes that have been produced so far. (pdamjayapura.co.id, 10 *Dec* 2020).

Therefore, this study will examine the availability of PDAM clean water distribution in the city of Jayapura and alternatives to meet the needs of clean water in the city of Jayapura.

Method

This study uses qualitative and quantitative descriptive analysis methods. This means that this method will describe various facts in the field so that it can carry out an analysis that is seen from the various assessments identified. This is done to describe the performance condition of the clean water network system in various things that affect it and develop a handling strategy that is by the problems that occur. The stages of activities carried out are data collection, primary and secondary data processing, and literature review from previous research from universities and related agencies.

The preparation of this research was carried out in the Jayapura City area. This research includes the identification of water needs in the distribution system of PDAM Jayapura, and analyzing the reservoir capacity and the implementation of DMA from technical, financial, and institutional aspects.

The stage of collecting data is divided into 2 (two), namely primary data and secondary data.

Primary Data is data obtained from:

1. Field Survey
2. Interview with PDAM Jayapura City and customers
3. Water usage patterns of PDAM Jayapura City

Secondary data is data obtained from related agencies in the form of documentation, maps, statistical data, and so on. Secondary data includes:

1. Distribution piping network map
2. Water tariff data per category
3. Customer data and SR
4. Administrative map and contours
5. Data on the quarterly report of PDAM Jayapura City

Results and Discussion

Population Projection Results

The data sources used in projecting the population in Jayapura City for the next 10 years in the preparation of this report are population data from 2010-2018 data from BPS Jayapura City and data for 2019-2022 from the Jayapura City Dukcapil Office (Fajri, Sundaya, & Rahmi, 2020). Based on the population projection method above, the population projection of Jayapura City for the next 10 years is as follows:

Tabel 1

Jumlah Penduduk Kota Jayapura Per Jenis Kelamin Tahun 2023

No	Kecamatan	Jumlah penduduk Kota Jayapura menurut Kecamatan dan Jenis Kelamin (Jiwa)								
		Laki-Laki			Perempuan			Total		
		2021	2022	2023	2021	2022	2023	2021	2022	2023
1	Muara Tami	9.566	9.732	9.896	8.848	9.071	9.295	18.414	18.803	19.191
2	Abepura	66.306	67.749	69.186	57.505	58.941	60.379	123.811	126.690	129.565
3	Heram	36.551	37.328	38.102	31.556	32.333	33.110	68.107	69.661	71.212
4	Jayapura Selatan	52.874	53.429	53.964	47.307	47.974	48.623	100.181	101.403	102.587
5	Jayapura Utara	49.749	50.118	50.465	43.742	44.177	44.591	93.491	94.295	95.056
	Kota Jayapura (Total)	**215.046**	**218.356**	**221.613**	**188.958**	**192.496**	**195.998**	**404.004**	**410.852**	**417.611**

Source : BPS Jayapura City (2022)

Table 2
Jayapura City Population Projection in 2034

No	Kecamatan	Tahun Proyeksi					
		2024			2034		
		Aritmatik	Geometrik	Ekponensial	Aritmatik	Geomatrik	Ekponensial
1	Muara Tami	19.587	19.587	19.591	23.547	24.026	24.081
2	Abepura	132.505	132.505	132.539	161.908	165.839	166.298
3	Heram	72.798	72.798	72.815	88.653	90.730	90.972
4	Jayapura Selatan	103.785	103.785	103.792	115.763	116.560	116.645
5	Jayapura Utara	95.823	95.823	95.826	103.495	103.843	103.880
	Kota Jayapura (Total)	**424.481**	**424.481**	**424.537**	**493.183**	**499.717**	**500.443**

Source: Data Analysis, 2024

From the results of the projection calculation, the researcher took the largest number of projections, namely the results of the projection calculation using the Exponential method.

Table 3
Results of Jayapura City Population Projections in 2034 with Exponential Method

No	District	Total Population 2034
1	Muara Tami	24.081
2	Abepura	166.298
3	Heram	90.972
4	South Jayapura	116.645
5	North Jayapura	103.880
	Total	500.443

Quantity and Continuity of Clean Water of PDAM Jayapura City

Current Condition of Clean Water Quantity

The drastic decrease in water discharge in several water sources (intake) greatly affects the smooth distribution of water to customers. Based on data obtained from PDAM Jayapura, several intakes have experienced a decrease in water discharge, so that some affected service areas are not smooth, water entering the reservoir is only 50 percent of the normal capacity (Fery, 2023). As in the Borgonji intake, the discharge of 50 liters/second is now only 30 liters/second, and the Entrop I and II Intake with a discharge of 120 is now only 50 liters/second. As a solution, PDAM Jayapura has prepared 4 tank cars to serve customers whose areas are affected. As in the final 2022 production report (Nelwan, Kekenusa, & Langi, 2013).

It is admitted by the PDAM that the water source managed by the PDAM is in the Cycloop mountainous area which is currently damaged due to forest encroachment. In addition to forest damage, the factor of pipe leakage due to old piping and water theft also affects water discharge (Messakh, Sabar, Hadihardaja, & Chalik, 2015). The efforts made by PDAM currently are to rotate directly at the water source so that everyday officers from morning and evening manage directly at the water source, then clean the filter or filter at the water source so that it will facilitate the distribution of water from the transmission pipe to the reservoir, as well as cleaning the intake from materials and rocks. In addition, the impact of the opening of public access to water catchment areas, trees in forest buffer areas, and even above water sources have become plantation areas, and many timbers are cut down to be used as firewood (Rembulan, Luin, Julianto, & Septorino, 2020).

Current Flow Continuity Conditions

The problem of flow continuity is a problem that is still faced by PDAM Jayapura, the flow hours are erratic and still below 20 hours, even though some service areas are below 8 hours. If PDAM is able to be consistent with the daily discharge time at the same time/hour even with a duration of less than 4 hours, customers will actually be served and meet their daily needs for clean water (Sundarningsih, Mahmudy, & Sutrisno, 2017).

According to the assistant production manager and water discharge laboratory, the current water discharge is insufficient for the water needs of the people of Jayapura city, this is evidenced by the fact that several service areas are concentrated on 24-hour distribution, but it has started to drop and cannot be 24 hours. As with the government's program for the affordability of clean water and 24-hour clean water service, PDAM has a discourse in collaboration with the Ministry of Public Works and Public Housing (PUPR) to process Lake Sentani as a new source of clean water, because the current water discharge into the intake is not able to meet optimal clean water needs. The optimal intake is currently 14, but some intakes have small water discharge, for example, the entropy intake water quality is not good because the community is approaching the water catchment area.

Decrease in Quantity Due to Forest Encroachment in Upstream Water Sources

Environmental sustainability of water resources greatly affects the availability of water resources. The effect of damaging a forest is the destruction of the Water Catchment Area in the upstream part. Naturally, the upstream area will catch rainwater through its vegetation and then infiltrate and store rainwater in its groundwater system. This underground water system will later appear to the surface as a source of springs. This important function is the reason why this area is often referred to as a production area, namely producing water from captured rain, production of sediment / natural erosion, and production of nutrients that are washed from the land surface and into the river flow. Changes in land use in this area will have major implications for the production produced so this upstream area has a high level of vulnerability to hydrological function disturbances. Overexploitation of land has the potential to increase surface runoff, erosion, and pollutants into river bodies/watersheds. Exacerbated by extreme climate change factors that are also the cause of hydrological dysfunction, flooding is a problem that has recently occurred in the Cyloop mountainous region. Very high rainfall in the Cyclops Mountains exacerbated the disaster.

Hydrological disasters are the estuary of the destruction of watersheds. A healthy watershed can store water so that flooding does not occur in the rainy season and can provide water in the dry season. Our current watersheds are partially unable to carry out these hydrological functions. During the rainy season, it is unable to store water, making groundwater and springs in the dry season. This means that our watersheds are not in a healthy condition. The inability to store water is what causes a decrease in the quantity of water which is a source of raw water for PDAM Jayapura.

From data from the Papua Natural Resources Conservation Center, encroachment in Jayapura City covers an area of ± 418.44 hectares and Jayapura Regency covers an area of ± 640.49 hectares. The discovery of residential areas and the opening of gardens in locations that indicate encroachment, the conversion of timber forest land into agricultural land for food crops, livestock, and other land-use activities. Throughout 2020, the Papua Natural Resources Conservation Center found 20 forest burning points in the Cycloop Nature Reserve area. This is by secondary data obtained from the Papua Natural Resources Conservation Center in the following table:

Table 4
Vast CA Encroachment Data. Cyclops Mountains

NO	Tahun	Jenis Perambahan	Versi SMART Patrol	Versi Smart Patrol + Analisis Citra Satelit	TOTAL (Ha) Versi SMART Patrol	Total (Ha) Versi Smart Patrol + Analisis Citra Satelit
1	2016	Bangunan Non permanen dan Permanen	70.35 Ha	46.99 Ha	70,46	93,01
		Aktivitas Kebun	0.11 Ha	46.02 Ha		
2	2017	Bangunan Non permanen dan Permanen	40 Ha	46.99 Ha	167,21	111,83
		Aktivitas Kebun	27.21 Ha	64.84 Ha		
3	2018	Bangunan Non permanen dan Permanen	2.13 Ha	46.99 Ha	414,28	140,72
		Aktivitas Kebun	12.15 Ha	93.73 Ha		
4	2019	Bangunan Non permanen dan Permanen	15.13 Ha	46.99 Ha	214,73	148,98
		Aktivitas Kebun	199.6 Ha	101.98 Ha		
Total					866,68	494,54

Sumber : Balai Besar KSDA Papua, 2023

Eksistensi Pegunungan Cycloop sangat penting bagi sumber air bersih, oleh karena itu diperlukan adanya konsistensi terpadu dan upaya serius untuk seluruh pemangku kepentingan sehingga mengantisipasi degradasi atau kerusakan hutan diwilayah ini. Jika terjadi kerusakan di Pegunungan Cycloop maka akan berdampak dan berakibat kerugian besar bagi layanan PDAM Jayapura. Namun Saat ini sudah terjadi kerusakan cukup parah di Pegunungan Cycloop yang berdampak ke sumber air. Mulai dari pembukaan lahan secara masif, penebangan pohon secara liar dan aktivitas gangguan lainnya. Indikasi perambahan ditaksir sebesar 1058,93 Ha. Berikut Gambar Peta yang menggambarkan indikasi perambahan kawasan pegunungan Cycloop.

Water Needs Analysis

Water demand projections are carried out for the next 10 years. By taking 2024 as the beginning of the plan, the water demand in Jayapura City is projected to be until 2034.

Table 5
Water Needs in Jayapura City

No	Keterangan	Satuan	Tahun									
			2024					2034				
			Jayapura Utara	Jayapura Selatan	Heram	Abepura	Muara Tami	Jayapura Utara	Jayapura Selatan	Heram	Abepura	Muara Tami
1	Jumlah Total Penduduk	Jiwa	95,826	103,792	72,815	132,539	19,591	103,880	116,645	90,972	166,298	24,081
2	Kebutuhan air untuk tiap 1 orang per hari	lt/hr/org	60	60	60	60	60	60	60	60	60	60
3	Kebutuhan air domestik Kd) (Jml Pend. x Keb. Air)	lt/dt	66.546	72.078	50.566	92.041	13.605	72.139	81.003	63.175	115.485	16.723
4	Kebutuhan air non domestik (15% x Kd)	lt/dt	9.982	10.81	7.58	13.81	2.04	10.82	12.15	9.48	17.32	2.51
5	Kebutuhan air baku rata-rata	lt/dt	89.837	97.31	68.26	124.26	18.37	97.39	109.35	85.29	155.90	22.58
6	Kebutuhan harian maksimum	lt/dt	103.312	111.901	78.504	142.894	21.122	111.996	125.758	98.079	179.290	25.962
7	Kebutuhan air pada jam puncak	lt/dt	140.146	151.796	106.492	193.838	28.652	151.925	170.593	133.047	243.211	35.218

Table 6
Recapitulation of Clean Water Needs in 2034

No	District	Unit	Sum
1	North Jayapura	lt/dt	97.388
2	South Jayapura	lt/dt	109.355
3	Vikram (Waena)	lt/dt	85.286
4	Abepura	lt/dt	155.904
5	Muara Tami	lt/dt	22.576
	TOTAL	**lt/dt**	**470.509**

Source: Data Analysis, 2024

Hydraulic Analysis

The piping network is limited to a steady flow or its claim called *steady* flow in a closed conduit. Steady flow in closed conduit includes:

(1) Energy loss formulas (pipe friction formulas)
(2) Energy gradient and pressure gradient (hydraulic gradient)
(3) Series pipes & equivalent pipes
(4) Parallel pipe
(5) Branched pipe
(6) Pipeline

In this study, the hydraulic analysis uses the help of the Epanet 2.0 application so that the hydraulic equations can be fulfilled in terms of provisions. The following are the results obtained along with the provisions of the pipeline network distribution design in Jayapura City.

Hydraulic Analysis of Jayapura City

The following is a map of the distribution of pipeline networks in Jayapura City.

Figure 1
Map of PDAM Clean Water Distribution in Jayapura City

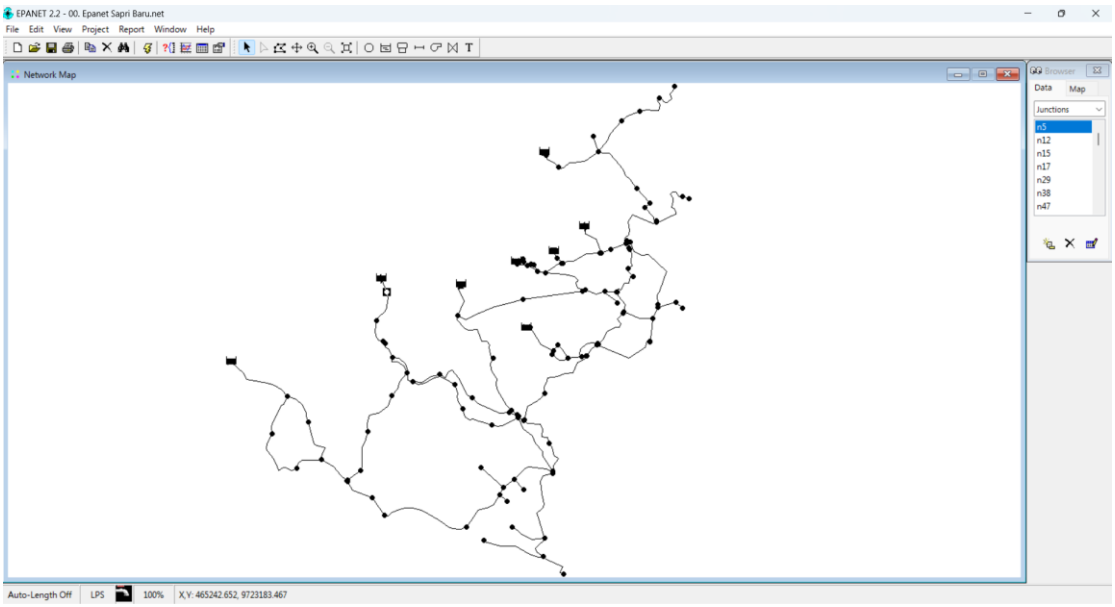

Figure 2
Jayapura City Epanet Plan

Based on the results of the epanet for the distribution area in Jayapura City that has been presented, there are several small water velocities, therefore, an epanet analysis is needed where if the water velocity is less than 0.3 m/s, the pipe will experience wear and deposition. Therefore, the dimensions of various pipes need to be done so that the water speed in the pipes is safe.

The following is a picture of the pressure at each node and the speed at each pipeline in Jayapura City.

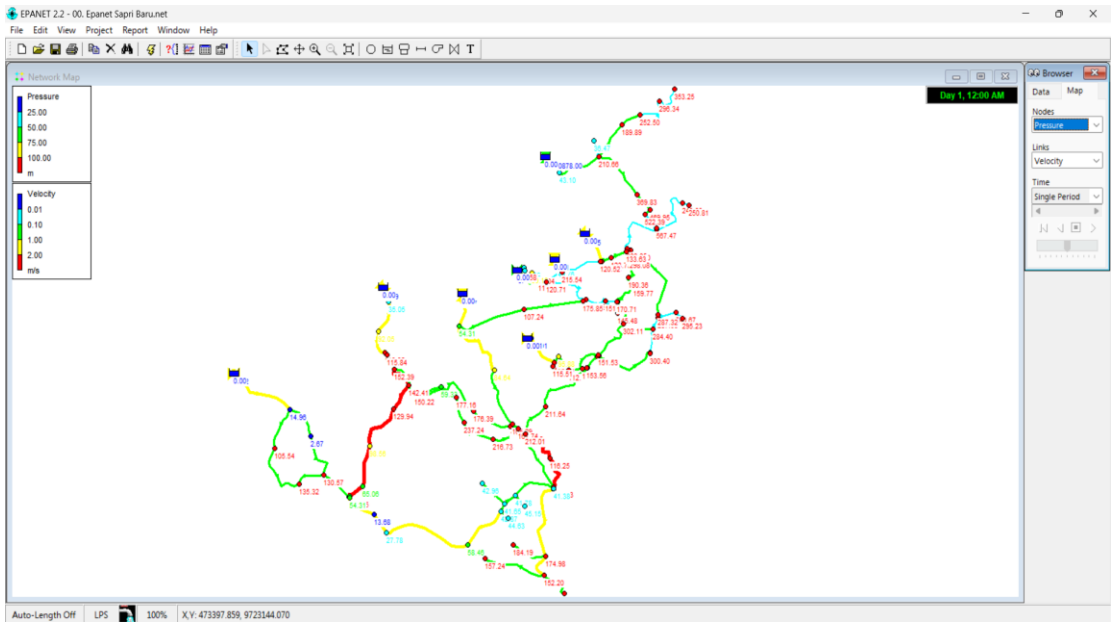

Figure 3
Pressure and Speed of Pipes in Each Node of Jayapura City

Koya Hydraulics Analysis

The following is a map of the distribution of pipelines in Koya.

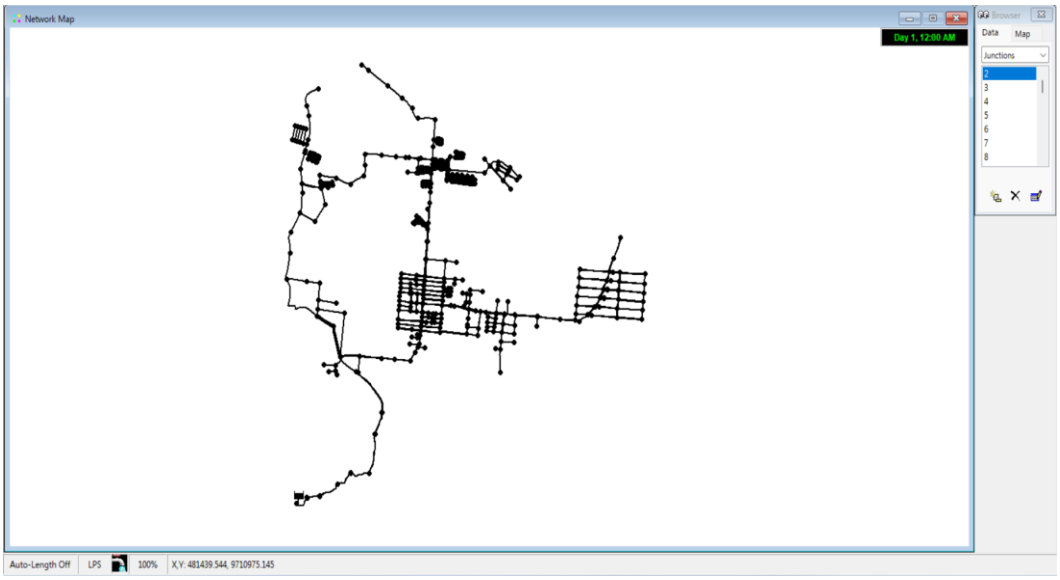

Figure 4
Jayapura City Epanet Plan

Based on the results of the planet for the distribution area in Koya that has been presented, several water velocities are small and even reach 0 m/s. Therefore, an epanet analysis is needed where if the water velocity is less than 0.3 m/s, the pipe will wear out and sedimentation occurs. If the speed of the pipe reaches 0 m/s, the water in the pipe does not flow, so it is useless to plan a clean water network in the area. Therefore, the dimensions of various pipes need to be done so that the water speed in the pipe is safe and sufficient so that the pipe speed is not less than 0.3 m/s or even 0 m/s.

The following is a picture of the pressure at each node and the speed at each pipeline in Jayapura City.

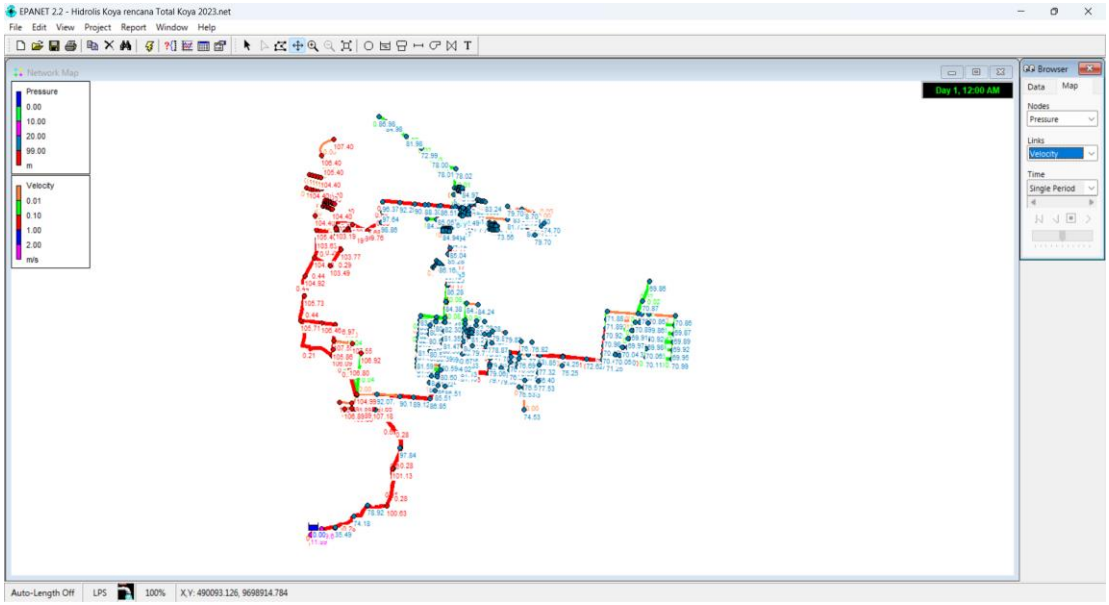

Figure 5
Pressure and Speed of Pipes in Each Koya Node

Alternatives in Meeting Jayapura City's Clean Water Needs

Based on the results of the pipeline hydraulic analysis that has been carried out, several alternatives have been carried out in meeting the needs of clean water in the city of Jayapura, namely:

1. Jayapura City has a good topography so the clean water distribution system can use a gravity system, based on the results of the planet 2.0 analysis, several sections of the pipeline have a very small speed, therefore, the discharge that comes out of the pipe is very small. The solution that can be made is to reduce the dimensions of the existing pipe so that the flow speed can be fulfilled so that water can flow to the house connection properly. If the water demand is greater, an alternative can be made by reducing the service time from 24 hours to 8 hours.
2. For the problem in Koya, Koya has a topographic area that tends to be flat. Therefore, water cannot flow properly. The solution that can be suggested is to add water pumps at various points that have a water speed of 0 m/s so that the water in the pipe can flow properly.

Conclusion

Based on research on optimizing the availability and need for clean water in PDAM Jayapura City, several conclusions were found. First, the coverage of clean water services by PDAM is still below national standards, with a service achievement of 89% in 2022, while the national target in 2024 is 100%. Second, the high rate of water loss due to pipe leaks and theft requires PDAMs to implement technological solutions that can monitor the water distribution network in real-time, so that leaks can be identified and repaired faster, reducing operational costs. Third, based on the hydraulic analysis of the pipeline, it was found that Jayapura City with a hilly topography can

utilize the gravity system for water distribution, although some pipes need dimensional adjustment to increase flow. In Koya, which has a flat area, the suggested solution is to add pumps at points where the flow is stagnant so that the water is more evenly distributed.

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