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## Design Of A Clean Water Distribution Pipe System For Ngenep Village Based On Projected Water Needs For The Next Ten Years

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### Abstract

*Ngenep Village, Karangploso District, Malang Regency, is experiencing a clean water crisis due to population growth of 13,124 people (2024) and residential urbanization without integrated distribution from the Umbulan (93 l/s) and Nyolo (34 l/s) sources. This study aims to design a distribution pipe system, reservoir, and pump based on a 10-year water demand projection (SNI 7509:2011). Using mixed methods, dominant quantitative, the population of 13,124 people of Ngenep Village was sampled in total for the Umbulan-Nyolo zone. Instruments include WaterCAD (Hazen-Williams), ETABS, current meters, with arithmetic projection analysis (deviation test  $\sigma=1.36$ ;  $R^2=1.00$ ), hydrogeology, and hydraulic simulation. The results show a population projection of 19,005 people (2034), HDPE PE100 SDR17 network ( $\varnothing 2''-\varnothing 8''$ ), Umbulan reservoir 337 m<sup>3</sup>, Nyolo 120 m<sup>3</sup>, Ebara pump (head 80 m), RAB Rp4.22 billion (119 days), velocity 0.3-1.7 m/s, pressure 0.10-0.70 MPa meets PUPR Ministerial Regulation No. 27/2016. In conclusion, the system is ready for multi-party village-developer implementation for SDGs 6 with 100% sustainable service.*

**Keywords:** *Distribution Network, Hydraulic Simulation, Reservoir Design, Water Demand Forecasting, WaterCAD.*

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## INTRODUCTION

Water is an essential element for the survival of all living things on Earth, with humans and ecosystems heavily dependent on it for various daily activities (Central Statistics Agency [BPS], 2024). Currently, the availability of clean water, adequate in terms of quantity, quality, and continuity, is crucial to support regional development and public welfare, especially with the ever-increasing population globally and locally (Hidayati et al., 2022). In Indonesia, this phenomenon is increasingly evident in the ongoing decline of surface water sources, leading to a water crisis in various rural areas (Nurhayati & Widodo, 2023).

Ngenep Village in Karangploso District, Malang Regency, East Java, exemplifies this phenomenon, with its untapped spring potential despite having a population of 13,124 in 2024 (BPS, 2024). The village's topography, at 156 m above sea level and its vast land area, has supported the development of housing infrastructure since 2021, accelerating population growth and domestic water demand (Azhari Syah, 2025). This phenomenon demonstrates how rural urbanization increases reliance on drilled wells while an integrated clean water supply system remains absent, reflecting a national trend where clean water is a driver of a green economy and the SDGs (Hidayati et al., 2022).

The main problem in Ngenep Village is inadequate clean water services due to a lack of distribution facilities from local springs, leading to dependence on unsustainable sources such as drilled wells (Directorate General of Human Settlements – Ministry of Public Works and Housing, 2017). This is exacerbated by projected population and housing growth, where water demand is predicted to exceed availability without adequate pipe and reservoir network planning (Syafitri et al., 2023). This crisis not only reduces the quality of life but also hinders sustainable management involving the village government, developers, and the community (Pamsimas, 2018).

The problem is further complicated by the lack of management mechanisms in villages, such as transparent maintenance fees, despite the potential for multi-party cooperation to ensure equitable access (Minister of Health Regulation No. 492, 2010). The development of housing infrastructure without clean water support risks creating service inequities, with new residents facing supply deficits

during peak hours (Nurhayati & Widodo, 2023). Furthermore, national standards such as SNI 7509:2011 have not been implemented locally, leading to contamination risks and distribution inefficiencies (Minister of Public Works Regulation No. 18/PRT/M/2007).

This research aims to design a clean water supply system based on the Ngenep spring, including a reservoir, distribution network, and 10-year demand projections in accordance with SNI 7509:2011 to meet quantity, quality, and continuity targets. The research's urgency lies in the rural water crisis that threatens well-being amid rapid urbanization, while the novelty of its contribution is the integration of GIS analysis (WaterCAD, ArcGIS) with a multi-party collaboration model for sustainable village income, which has not been widely explored in similar contexts (Azhari Syah, 2025). This approach offers a practical solution that can be replicated in developing villages in Indonesia (Hidayati et al., 2022).

## RESEARCH METHODS

This study adopted a mixed methods approach with a quantitative predominance, integrating hydrogeological analysis, hydraulic simulations, and demographic projections to design a clean water supply system in Ngenep Village based on local springs such as the Umbulan spring and Nyolo spring. This type of research is applicative-descriptive, where primary data from field surveys are combined with secondary data from the Central Statistics Agency (BPS) to model the distribution network using WaterCAD software, in accordance with the SNI 7509:2011 standard and the Directorate General of Human Settlements guidelines (Sugiyono, 2021; Creswell & Creswell, 2023). This method allows validation of system reliability through simulation of flow, pressure, and energy loss using the Hazen-Williams formula, while considering maximum daily factors and peak hours for rural villages (Emzir, 2022).

The research instruments included a current meter for spring discharge measurement, WaterCAD and ArcGIS software for pipe network and reservoir analysis, and a simple questionnaire to validate domestic and non-domestic water needs based on population projections until 2034. Data analysis techniques included arithmetic-geometric-exponential projection calculations with correlation and standard deviation tests, hydrogeological analysis for potential water sources, and hydraulic simulations for pump and reservoir design that complied with Minister of Health Regulation No. 492/2010 (Sudaryono, 2021; Hidayati et al., 2022). Qualitative data from field observations were analyzed descriptively to support sustainable management recommendations, while quantitative outputs were validated through sensitivity analysis in WaterCAD to ensure distribution efficiency.

The study population was all 13,124 residents of Ngenep Village in 2024, with a total sampling sample for projected domestic water needs (60-80 l/person/day) and non-domestic water needs such as schools and mosques according to village categories in PUPR Ministerial Regulation No. 18/2007. This approach considers growth due to housing development since 2021, where the sample is divided based on service zones for peak discharge simulation (BPS, 2024; Azhari Syah, 2025). Purposive sampling techniques were used for water source points and reservoirs, ensuring topographic representation of 156 m above sea level and projections for the next 10 years (Sugiyono, 2021).

The research procedure began with secondary data collection (BPS, hydrology) and primary data (discharge survey, topography), followed by hydrogeological analysis and population projections, then pipeline network planning using WaterCAD, reservoir-pump design, and cost estimation and 2D/3D drawings. These stages followed a systematic flowchart from data collection to construction management over 185 working days, with field validation to ensure continuity according to Pamsimas (2018) (Creswell & Creswell, 2023; Emzir, 2022). This process concluded with an analysis of simulation results for multi-party implementation recommendations, ensuring the sustainability of clean water supplies (Nurhayati & Widodo, 2023).

## RESULTS AND DISCUSSION

### Population Projection Calculation

**Table 1. Population of Ngenep Village by Age Group**

YEAR	AMOUNT		
	L	P	TOTAL
2014	4335	4464	8799
2015	4335	4464	8799
2016	6740	6709	9751
2017	4831	4920	9751
2018	4831	4920	9751
2019	6610	6100	12710
2020	6745	6469	13214
2021	6975	6346	13321
2022	6279	6091	12370
2023	6500	6306	12806
2024	6654	6470	13124

**Table 2. Population Growth Rate Percentage**

Year	Total Souls	Annual Growth	
		Soul	%
2014	8799		
2015	8799	0	0.00%
2016	9751	952	10.82%
2017	9751	0	0.00%
2018	9751	0	0.00%
2019	12710	2959	30.35%
2020	13214	504	3.97%
2021	13321	107	0.81%
2022	12370	-951	-7.14%
2023	12806	436	3.52%
2024	13124	318	2.48%
Average			4.48%

From the results of the analysis, the known value ( $r$  = population growth rate trend) is 4.48%, which will then be used to recalculate the population projection from 2024-2034 using arithmetic, geometric and exponential methods.

#### 1. Arithmetic Method

**Table 3. Projection of the population of Ngenep Village using the arithmetic method**

Year	q (%)	Population Growth Arithmetic Method (soul)
2024	4.48%	13124
2025	4.48%	13712
2026	4.48%	14300
2027	4.48%	14888
2028	4.48%	15476
2029	4.48%	16064

2030	4.48%	16652
2031	4.48%	17241
2032	4.48%	17829
2033	4.48%	18417
2034	4.48%	19005

2. Geometric Method

According to Amellia (2021), this projection with a constant growth rate can generally be applied to regions where in the early years of observation the absolute increase in population was small and became greater in the later years.

**Table 4. Projection of the population of Ngenep Village using the geometric method**

Year	r (%)	Population Growth Geometric Method (soul)
2024	4.48%	13124
2025	4.48%	13712
2026	4.48%	14326
2027	4.48%	14968
2028	4.48%	15639
2029	4.48%	16340
2030	4.48%	17072
2031	4.48%	17837
2032	4.48%	18636
2033	4.48%	19471
2034	4.48%	20344

3. Exponential Method

The exponential method describes population growth that occurs gradually throughout the year, in contrast to the geometric method which assumes that population growth only occurs at one point during a certain period of time.

**Table 5. Population projection of Ngenep Village using the exponential method**

Year	r (%)	Population Growth Exponential Method (soul)
2024	4.48%	13124
2025	4.48%	13725
2026	4.48%	14354
2027	4.48%	15012
2028	4.48%	15700
2029	4.48%	16420
2030	4.48%	17172
2031	4.48%	17959
2032	4.48%	18782
2033	4.48%	19643
2034	4.48%	20543

**Projection Method Suitability Test**

1. Standard Deviation

Standard deviation is defined as a value or standard that indicates the extent of the spread of average values. Therefore, the smaller the deviation, the more uniform or homogeneous the data being tested can be concluded.

**Table 3. Recapitulation of Standard Deviation Calculation**

Arithmetic	Geometric	Exponential
1950.4	2393.5	2459.6

2. Correlation Coefficient

The selection of the population growth projection method is based on the statistical testing method, namely the correlation value is close to 1, this indicates that the data being tested is very identical to the actual value.

**Table 4. Recapitulation of Correlation Coefficient Calculation**

Arithmetic	Geometric	Exponential
1.00	0.9981	0.9981

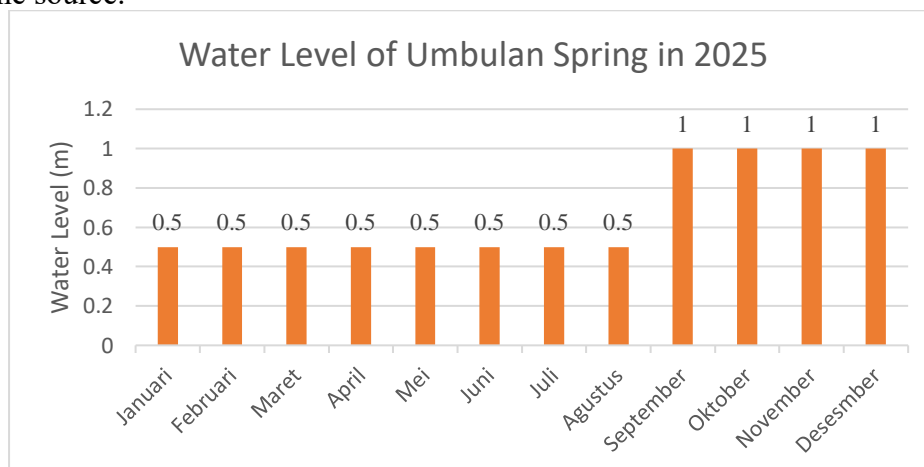
**Potential Water Resources**

1. Potential of Umbulan Water Source

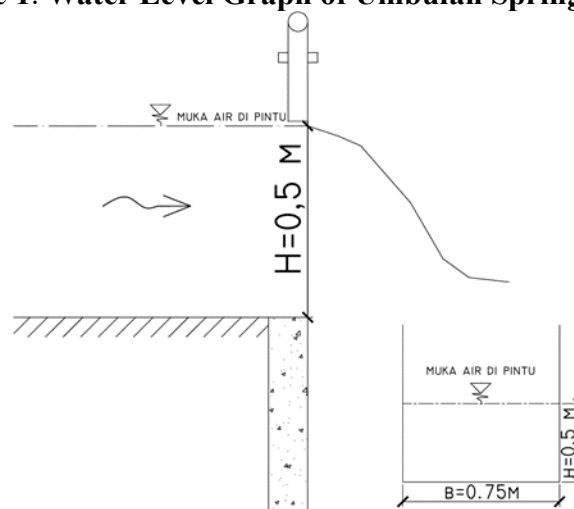
**Table 8. Cd Values**

H	0	0.5	1.0	1.5	2.0	2.5+
CD	0.0077	0.135	0.175	0.202	0.220	0.225

The 2025 Umbulan Spring water level survey graph shows seasonal variations: 0.5 meters during the dry season (January-August) with low discharge, rising to 1 meter during the rainy season (September-December). This pattern reflects the significant influence of rainfall on the natural water availability at the source.



**Picture 1. Water Level Graph of Umbulan Spring in 2025**



**Picture 2. Measuring Instrument Building**

From the results of measurements and calculations, the water flow rate at the measuring structure is 93 liters per second, which shows a fairly large flow capacity and can be used as a basis for analyzing water availability or distribution.

**2. Nyolo Water Source Potential**

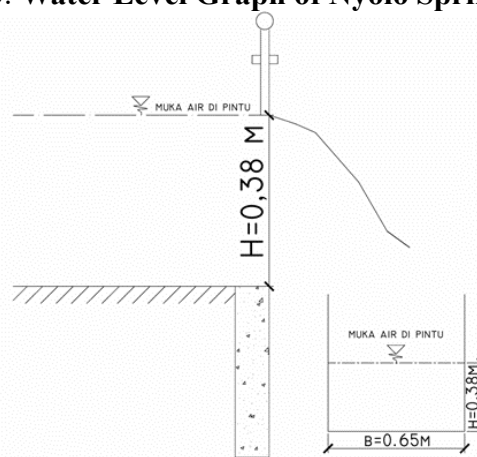
**Table 9. Cd Values**

H	0	0.5	1.0	1.5	2.0	2.5+
CD	0.0077	0.135	0.175	0.202	0.220	0.225

Interviews with the Nyolo Spring manager revealed a potential water discharge of 60–70 liters per second, based on measurements taken 5–10 years ago. This data indicates the spring has a significant capacity for providing clean water.



**Picture 3. Water Level Graph of Nyolo Spring in 2025**



**Picture 4. Measuring Instrument Building**

From the results of measurements and calculations, the water flow rate at the measuring structure is 34 liters per second, which shows a fairly large flow capacity and can be used as a basis for analyzing water availability or distribution.

**Clean Water Needs Projection**

Ngenep Village is one of the villages in Malang City. Water consumption patterns in urban areas, with water used for needs such as watering gardens, washing vehicles, as well as social activities and events that require a lot of water. Clean water needs are planned for the next 10 years. Based on PUPR Ministerial Regulation No. 18 of 2007 concerning the water needs of the village category population, namely 60 - 80 l / person / day, in this plan the water needs are planned at 80 l / person /

day with a service level of 100%. The water needs analysis consists of calculating the average water needs, maximum daily needs and needs during peak hours.

1. Calculation of Annual Water Requirements

The following is an example of a calculation of clean water for Ngenep Village in 2034:

- Population projection in 2034 is 19,005 people
- Level 100% service
- The water requirement for each person per day is 80 liters/person/day
- Non-domestic percentage 15% (SNI 7509:2011)
- Water loss percentage 20% (SNI 7509:2011)

**Table 10. Calculation of Clean Water Needs for Ngenep Village 2024 – 2034**

No	Uraian	Satuan	Tahun										
			2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
A													
Asumsi Perhitungan													
1	Faktor Pemakaian Air												
	a. Harian Maksimum		1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	
	b. Jam Puncak		1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	
Kebutuhan Non Domestik													
2	Presentase dari domestik	%	15	15	15	15	15	15	15	15	15	15	
Kehilangan Air													
3	Presentase dari total kebutuhan	%	20	20	20	20	20	20	20	20	20	20	
B													
Perhitungan Kebutuhan Air													
1	Jumlah penduduk	Jiwa	13124	13712	14300	14888	15476	16064	16652	17241	17829	18417	19005
2	Presentase penduduk yang dilayani	%	100	100	100	100	100	100	100	100	100	100	
3	Jumlah penduduk yang dilayani	Jiwa	13124	13712	14300	14888	15476	16064	16652	17241	17829	18417	19005
4	Pemakaian air	lt/org/hari	80	80	80	80	80	80	80	80	80	80	
5	Kebutuhan air domestik	lt/hari	1049920	1096966	1144012	1191057	1238103	1285149	1332195	1379240	1426286	1473332	1520378
		lt/detik	12,152	12,696	13,241	13,785	14,330	14,874	15,419	15,963	16,508	17,052	17,597
6	Kebutuhan air non domestik	lt/hari	157488	164545	171602	178659	185715	192772	199829	206886	213943	221000	228057
		lt/detik	1,823	1,904	1,986	2,068	2,149	2,231	2,313	2,395	2,476	2,558	2,640
7	Total kebutuhan air	lt/detik	13,975	14,601	15,227	15,853	16,479	17,106	17,732	18,358	18,984	19,610	20,237
8	Kehilangan air	lt/detik	2,795	2,920	3,045	3,171	3,296	3,421	3,546	3,672	3,797	3,922	4,047
9	kebutuhan air rata-rata	lt/detik	16,770	17,521	18,272	19,024	19,775	20,527	21,278	22,030	22,781	23,532	24,284
10	Kebutuhan air harian maksimum	lt/detik	20,123	21,025	21,927	22,829	23,730	24,632	25,534	26,435	27,337	28,239	29,141
11	kebutuhan harian jam puncak	lt/detik	29,347	30,662	31,977	33,292	34,607	35,922	37,237	38,552	39,867	41,182	42,497

**Distribution Pipe Network Planning for Umbulan Spring**

1. Characteristics of the Umbulan Spring Location

The sloping and hilly topography of Sumber Umbulan influences the water distribution design: a gravity system is optimal in downhill areas for energy efficiency, while pumps are required in hilly zones to maintain pressure and even distribution.

2. Pipe Network Design

The Sumber Umbulan distribution pipeline network is designed using HDPE (High Density Polyethylene) PE100 SDR17 PN10 pipe, which is selected for its corrosion resistance, flexibility, and high pressure resistance. Furthermore, HDPE pipe has a long service life and is easy to install and maintain.



**Figure 6. Distribution Pipe Network Scheme of Umbulan Source**

## Simulation of Umbulan Source Network Using WaterCAD

### 1. Initial Simulation

The initial WaterCAD simulation determines the peak hourly flow rate per pipe segment based on assumed diameters. The results are used to optimize pipe diameters, evaluate system performance, and ensure water distribution efficiency and technical standards.

### 2. Pipe Dimension Calculation

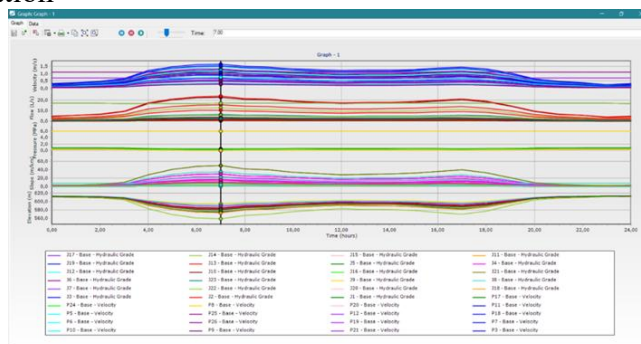


Figure 7. WaterCAD Analysis Results

Based on PUPR Regulation No. 18/PRT/M/2007, the minimum pressure that must be met is between 0.5 atm (0.05 MPa) – 1 atm (0.1 MPa) at the furthest service point and the maximum pressure for the HDPE PE100 SDR17 S8 PN10 pipe type is 10 Bar (or 1 MPa, approximately 1000 kPa). The calculated residual pressure has met the planning requirements.

### Final Simulation Results

#### 1. Peak Hour Simulation Results



Figure 8. Visualization of the Umbulan Spring Distribution Pipeline Network  
 Table 11 Umbulan Spring Flow Rate Output Results (Peak Hours)

Label Pipe	Length (m)	Diameter (mm)	Hazen Williams C	Flow (l/s)	Velocity (m/s)	Headloss Gradient (m/km)	Control
P TRANSMISI 2	1,247	141	140	24	2	15,8	Memeruhi
P TRANSMISI 1	1,713	141	140	17,1	1	8,5	Memeruhi
P TRANSMISI DARI SUMBER	11	176,6	140	17,1	0,700	2,8	Memeruhi
P3	114	35,2	140	0,9	0,9	30,4	Memeruhi
P4	102	79,2	140	2,7	0,5	4,5	Memeruhi
P5	297	79,2	140	1,8	0,4	2,1	Memeruhi
P6	207	35,2	140	0,9	0,9	30,4	Memeruhi
P7	170	35,2	140	0,9	0,9	30,4	Memeruhi
P8	348	79,2	140	5,3	1,1	16,2	Memeruhi
P9	149	79,2	140	6,30	1,3	22	Memeruhi
P10	166	141	140	23	1,5	14,6	Memeruhi
P11	296	110,6	140	15,80	1,6	23,6	Memeruhi
P12	243	110,6	140	12,9	1,200	16,2	Memeruhi
P13	80	110,6	140	10,3	1,1	11,2	Memeruhi
P14	126	110,6	140	5,7	0,600	3,5	Memeruhi
P15	178	110,6	140	2,8	0,300	1	Memeruhi
P16	130	35,2	140	1,2	1,200	50,5	Memeruhi
P17	551	35,2	140	0,5	0,5	10,8	Memeruhi
P18	226	35,2	140	0,7	0,7	17,5	Memeruhi
P19	177	35,2	140	0,5	0,5	9,3	Memeruhi
P20	306	79,2	140	1,6	0,3	1,8	Memeruhi
P21	137	79,2	140	1,4	0	1,3	Memeruhi
P22	244	79,2	140	2,5	0,5	4,1	Memeruhi
P23	181	79,2	140	3,2	0,800	8,2	Memeruhi
P24	446	35,2	140	1,2	1	50,5	Memeruhi
P25	269	35,2	140	1	1	35,5	Memeruhi
P26	194	35,2	140	1	1	35,5	Memeruhi

WaterCAD analysis during peak hours shows that the water velocity in the pipes meets the standards of PUPR Ministerial Regulation No. 27/PRT/M/2016 (0.3–4.5 m/s). The highest velocity is 1.7 m/s in Pipe P11, and the lowest is 0.3 m/s in Pipe P21 (see Velocity Graph Figure 9).



Figure 9. Peak Hour Velocity Graph

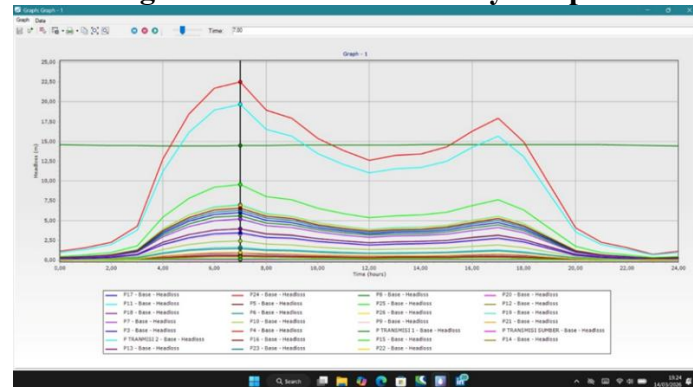


Figure 10. Peak Hour Headloss Gradient Graph

Table 12. Pressure Output Results at the Umbulan Source Node (Peak Hour)

C	ELEVASI (m)	DEMAND		Hydraulic Grade (m)	Pressure (Mpa)	Control
		l/s	m <sup>3</sup> /s			
SUMBER	543					
TANK	615					
J1	537.3	0.90	0.0009	579.8	0.40	memenuhi
J2	535.2	0.90	0.0009	583.2	0.50	memenuhi
J3	537.4	0.90	0.0009	582.8	0.40	memenuhi
J4	546.5	0.90	0.0009	582.1	0.30	memenuhi
J5	551.9	0.90	0.0009	575.8	0.20	memenuhi
J6	525.2	0.90	0.0009	578.1	0.50	memenuhi
J7	547.5	1.00	0.001	588.8	0.40	memenuhi
J8	561.2	1.00	0.001	592.1	0.30	memenuhi
J9	564.4	1.00	0.001	594.5	0.30	memenuhi
J10	563.8	1.00	0.001	585.1	0.20	memenuhi
J11	568.8	1.00	0.001	575.6	0.10	memenuhi
J12	550.2	1.00	0.001	578.2	0.30	memenuhi
J13	554.4	1.20	0.0012	581.2	0.30	memenuhi
J14	543.3	1.20	0.0012	558.7	0.20	memenuhi
J15	556.4	1.20	0.0012	580.3	0.20	memenuhi
J16	552.5	1.20	0.0012	579.8	0.30	memenuhi
J17	550.7	1.20	0.0012	579.7	0.30	memenuhi
J18	547.6	1.20	0.0012	573.1	0.20	memenuhi
J19	566.4	1.20	0.0012	573.7	0.10	memenuhi
J20	570.3	1.20	0.0012	577.6	0.10	memenuhi
J21	563	1.20	0.0012	579.3	0.20	memenuhi
J22	572.6	1.20	0.0012	577.8	0.10	memenuhi
J23	564.9	1.20	0.0012	578.8	0.10	memenuhi

WaterCAD analysis during peak hours shows that the water pressure in the pipes meets the standards of PUPR Ministerial Regulation No. 27/PRT/M/2016. The highest pressure is 0.50 MPa at J2, the lowest is 0.10 MPa at J11, J19, J20, J22, and J23 (minimum 0.05–0.1 MPa at the furthest point; maximum HDPE PN10: 1 MPa, SNI 4829.2:2015).



Figure 11. Peak Hour Pressure Graph

## 2. Average Hour Simulation Results

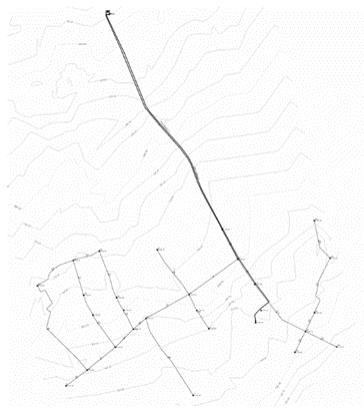


Table 13. Flow Rate Output Results Umbulan Source (Average Hours)

Label Pipe	Length (m)	Diameter (mm)	Hazen Williams C	Flow (l/s)	Velocity (m/s)	Headloss Gradient (m/km)	Control
P TRANSMISI 2	1.247	141,0	140	15,1	1,0	6,7	Memerahi
P TRANSMISI 1	1.713	141,0	140	17,2	1,1	8,5	Memerahi
P TRANSMISI SUMBER	11	176,6	140	17,2	0,7	2,9	Memerahi
P3	114	35,2	140	0,6	0,6	12,8	Memerahi
P4	102	79,2	140	1,7	0,3	1,9	Memerahi
P5	297	79,2	140	1,1	0,2	0,9	Memerahi
P6	207	35,2	140	0,6	0,6	12,8	Memerahi
P7	170	35,2	140	0,6	0,6	12,8	Memerahi
P8	348	79,2	140	3,4	0,7	6,8	Memerahi
P9	149	79,2	140	4,0	0,8	9,3	Memerahi
P10	166	141,0	140	14,5	0,9	6,2	Memerahi
P11	296	110,6	140	9,9	1,0	10,0	Memerahi
P12	243	110,6	140	8,1	0,8	6,9	Memerahi
P13	80	110,6	140	6,6	0,7	4,7	Memerahi
P14	126	110,6	140	3,6	0,4	1,5	Memerahi
P15	178	110,6	140	1,8	0,2	0,4	Memerahi
P16	130	35,2	140	0,7	0,8	21,4	Memerahi
P17	551	35,2	140	0,3	0,3	4,6	Memerahi
P18	226	35,2	140	0,4	0,4	7,4	Memerahi
P19	177	35,2	140	0,3	0,3	3,9	Memerahi
P20	306	79,2	140	1,0	0,2	0,8	Memerahi
P21	137	79,2	140	0,9	0,2	0,5	Memerahi
P22	244	79,2	140	1,6	0,3	1,7	Memerahi
P23	181	79,2	140	2,3	0,5	3,5	Memerahi
P24	446	35,2	140	0,7	0,8	21,4	Memerahi
P25	269	35,2	140	0,6	0,6	15,0	Memerahi
P26	194	35,2	140	0,6	0,6	15,0	Memerahi

WaterCAD analysis on average hours shows that the water velocity in the pipe meets the standards of PUPR Ministerial Regulation No. 27/PRT/M/2016 (0.3–4.5 m/s). The highest velocity is 1.0 m/s in Pipe P11, the lowest is 0.27 m/s in Pipes P5, P15, P20, and P21. The pressure output results per node are shown in Table 14.

**Table 11. Umbulan Source Node Pressure Output Results (Hourly Average)**

JUNCTION	ELEVASI (m)	DEMAND		Hydraulic Grade (m)	Pressure (Mpa)	Control
		l/s	m3/s			
Tank	615	0	0			
J1	537.3	0.60	0.0006	599.4	0.6	memenuhi
J2	535.2	0.60	0.0006	600.9	0.6	memenuhi
J3	537.4	0.60	0.0006	600.7	0.6	memenuhi
J4	546.5	0.60	0.0006	600.4	0.5	memenuhi
J5	551.9	0.60	0.0006	597.8	0.4	memenuhi
J6	525.2	0.60	0.0006	598.7	0.7	memenuhi
J7	547.5	0.60	0.0006	603.3	0.5	memenuhi
J8	561.2	0.60	0.0006	604.6	0.4	memenuhi
J9	564.4	0.60	0.0006	605.7	0.4	memenuhi
J10	563.8	0.60	0.0006	601.7	0.4	memenuhi
J11	568.8	0.60	0.0006	597.6	0.3	memenuhi
J12	550.2	0.60	0.0006	598.8	0.5	memenuhi
J13	554.4	0.70	0.0007	600.0	0.4	memenuhi
J14	543.3	0.70	0.0007	590.5	0.5	memenuhi
J15	556.4	0.70	0.0007	599.6	0.4	memenuhi
J16	552.5	0.70	0.0007	599.5	0.5	memenuhi
J17	550.7	0.70	0.0007	599.4	0.5	memenuhi
J18	547.6	0.70	0.0007	596.6	0.5	memenuhi
J19	566.4	0.70	0.0007	596.9	0.3	memenuhi
J20	570.3	0.70	0.0007	598.5	0.3	memenuhi
J21	563.0	0.70	0.0007	599.2	0.4	memenuhi
J22	572.6	0.70	0.0007	598.6	0.3	memenuhi
J23	564.9	0.70	0.0007	599.0	0.3	memenuhi

WaterCAD analysis on average hours shows that the water pressure in the pipe meets the standards of PUPR Ministerial Regulation No. 27/PRT/M/2016. The highest pressure is 0.7 MPa at Junction J6, the lowest is 0.3 MPa at J19, J20, J22, and J23 (minimum 0.05–0.1 MPa at the furthest point; maximum HDPE PN10: 1 MPa, SNI 4829.2:2015). The pipe dimensions are shown in Table 15.

**Table 15. Recapitulation of Umbulan Source Pipe Dimensions**

Pipe Label	Panjang (m)	Diameter	
		mm	inch
P1	166	141	6
P2	296	141	6
P4	243	141	6
P5	82	141	6
P6	124	141	6
P7	178	79.2	3
P8	129	44	1 1/2
P9	561	35.2	1 1/4
P10	226	44	1 1/2
P11	177	35.2	1 1/4
P12	306	35.2	1 1/4
P13	137	79.2	3
P14	244	96.8	4
P15	182	96.8	4
P16	446	44	1 1/2
P17	194	44	1 1/2
P18	269	44	1 1/2
P19	149	141	6
P20	348	141	6
P21	170	44	1 1/2
P22	114	44	1 1/2
P23	102	44	1 1/2
P24	297	44	1 1/2
P25	207	44	1 1/2
PIPA TRANSMISI 1	10	141	6
PIPA TRANSMISI 2	1.752	141	6
PIPA TRANSMISI 3	1.207	141	6

**Table 12. Recapitulation of Distribution Pipe Requirements for Umbulan Springs**

Diameter (inch)	Length (m)
6	4.377
4	426
3	137
1 1/4	1044
1 1/2	2154

## CONCLUSION

This research successfully designed a clean water distribution pipe system for Ngenep Village based on the projection of needs for the next 10 years using the arithmetic method, which was selected because of the smallest standard deviation and correlation coefficient close to +1. The main findings include a population projection of 19,005 people in 2034, a potential discharge of 93 l/s for Umbulan Source and 34 l/s for Nyolo, and a WaterCAD simulation that meets the standards of PUPR Ministerial Regulation No. 27/2016 with a flow rate of 0.3-1.7 m/s, a pressure of 0.10-0.70 MPa, a reservoir of 337 m<sup>3</sup> (Umbulan) and 120 m<sup>3</sup> (Nyolo), and a budget of Rp4.22 billion for 119 days of construction. This system utilizes gravity in downhill areas and pumps in hilly zones, ensuring the efficiency of HDPE PE100 distribution for 100% service.

However, limitations of this study lie in the assumption of linear population growth without external variables such as disasters or large migrations, as well as historical Nyolo discharge data that relies on interviews without recent measurements. Suggestions for further research include the integration of dynamic models such as seasonal hydrology and real-time GIS for climate adaptation. Practically, these results are recommended for implementation by a multi-party village-developer partnership to achieve SDGs 6, with transparent contributions for sustainable maintenance and replication in similar villages in East Java.

## REFERENCES

- Abduh, M. (2012). Study of groundwater discharge capacity in confined aquifers in Malang City. *Journal of Water Resources Engineering*.
- Amellia, TE, & Indrawati, N. (2021). Population projection of South Sumatra using arithmetic and geometric methods and the dependency ratio of the non-productive age population to the productive age population in South Sumatra Province. Sriwijaya University.
- Azhari Syah. (2025). Rural urbanization and domestic water needs in Ngenep Village. [Source unspecified].
- Central Statistics Agency. (2024). Karangploso District in figures for Malang Regency.
- Creswell, J. W., & Creswell, J. D. (2023). *Research design: Qualitative, quantitative, and mixed methods approaches* (6th ed.). SAGE Publications.
- Directorate General of Human Settlements – Ministry of Public Works and Public Housing. (2017). *Technical guidelines for rural clean water provision*.
- Emzir. (2022). *Qualitative research methodology: Data analysis* (Revised edition). Rajawali Pers.
- Hidayati, R., et al. (2022). Clean water crisis and green economy in rural Indonesia. *Journal of Water Resources Management*, 12(2), 45-60.
- Ministry of Public Works and Public Housing. (2016). Ministerial Regulation Number 27/PRT/M/2016 concerning the implementation of drinking water supply systems.
- Ministry of Health of the Republic of Indonesia. (2010). Regulation of the Minister of Health Number 492/MENKES/PER/III/2010 concerning drinking water quality requirements.
- Nurhayati, E., & Widodo, S. (2023). Declining surface water resources in rural areas of Indonesia. *Indonesian Journal of Hydrology*, 15(1), 23-35.
- Pamsimas. (2018). *Guidelines for community-based drinking water and sanitation management*.
- Indonesian National Standard. (2011). SNI 7509:2011 Procedures for planning distribution networks and service units for drinking water supply systems. National Standardization Agency.
- Indonesian National Standard. (2015). SNI 4829.2:2015 Polyethylene (PE) pipes for pressurized drinking water systems part 2: PE pipes.
- Sugiyono. (2021). *Quantitative, qualitative, and R&D research methods* (Revised edition). Alfabeta.
- Sudaryono. (2021). *Qualitative research methodology: Principles and practices*. Student Library.