EVALUATION OF DISTRIBUTION PIPELINE NETWORK USING EPANET 2.0 PROGRAM IN KARANGSARI PERMAI HOUSING, SIANTAR MARTOBA DISTRICT PEMATANGSIANTAR CITY

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Abstract

Clean water is a basic need for humans, so it is only natural that the clean water sector is given priority in handling and fulfilling it. PDAM as a regional clean water management company should be able to meet this need. With the existing treatment system and piping network system, PDAM is expected to be able to meet the clean water needs of the people in Pematangsiantar City. The purpose of this study was to find out whether it is necessary to increase water production to meet the current clean water needs of PDAM Tirtauli customers, to simulate clean water distribution pipelines in Pematangsiantar City using the EPANET 2.0 program, and to compare the simulation results of clean water distribution pipelines using the program. EPANET 2. 0 with the results of the distribution pipe network system planning for the current existing conditions. Based on the simulation results, the pressure value for the peak hours of water use is 0.2 kg/cm (2 m) for the lowest pressure, while the highest pressure is 2.19 kg/cm (21 m). In addition, a comparison of the pressure value from the simulation results was also carried out with the results of field measurements at Karangsari Permai Housing Complex. From this comparison, the pressure value obtained from the simulation results was 0.2 kg/cm (2 m), while the pressure value for field measurements carried out by the NRW PDAM Tirtauli team in this housing was 0.14 Kg/cm (1.4 m). The difference in pressure values was caused by the age factor. pipes, water leaks, and limited research data. Based on the simulation results, the pressure value for the peak hours of water use is 0.2 kg/cm (2 m) for the lowest pressure, while the highest pressure is 2.19 kg/cm (21 m). In addition, a comparison of the pressure value from the simulation results was also carried out with the results of field measurements at Karangsari Permai Housing Complex. From this comparison, the pressure value obtained from the simulation results was 0.2 kg/cm (2 m), while the pressure value for field measurements carried out by the NRW PDAM Tirtauli team in this housing was 0.14 Kg/cm (1.4 m). The difference in pressure values was caused by the age factor. pipes, water leaks, and limited research data. Based on the simulation results, the pressure value for the peak hours of water use is 0.2 kg/cm (2 m) for the lowest pressure, while the highest pressure is 2.19 kg/cm (21 m). In addition, a comparison of the pressure value from the simulation results was also carried out with the results of field measurements at Karangsari Permai Housing Complex. From this comparison, the pressure value obtained from the simulation results was 0.2 kg/cm (2 m), while the pressure value for field measurements carried out by the NRW PDAM Tirtauli team in this housing was 0.14 Kg/cm (1.4 m). The difference in pressure values was caused by the age factor. pipes, water leaks, and limited research data. In addition, a comparison of the pressure value from the simulation results was also carried out with the results of field measurements at Karangsari Permai Housing Complex. From this comparison, the pressure value obtained from the simulation results was 0.2 kg/cm (2 m), while the pressure value for field measurements carried out by the NRW PDAM Tirtauli team in this housing was 0.14 Kg/cm (1.4 m). The difference in pressure values was caused by the age factor. pipes, water leaks, and limited research data. In addition, a comparison of the pressure value from the simulation results was also carried out with the results of field measurements at Karangsari Permai Housing Complex. From this comparison, the pressure value obtained from the simulation results was 0.2 kg/cm (2 m), while the pressure value for field measurements carried out by the NRW PDAM Tirtauli team in this housing was 0.14 Kg/cm (1.4 m). The difference in pressure values was caused by the age factor. pipes, water leaks, and limited research data.

Keywords:**PDAM Tirtauli, Pipe Network, Pressure, EPANET 2.0**

INTRODUCTION

The drinking water supply system includes: processing, transmission pipe systems, and distribution pipe network systems. The distribution pipe network is a system that functions to distribute water from the reservoir to consumers. In general, distribution pipelines in Indonesia have many problems, such as leaks and insufficient pressure. To obtain a good quality distribution pipeline network system, an evaluation of the existing network is needed, so that the distribution pipeline network can meet K3 standards, namely quality, quantity and continuity.

The problem of pipeline networks is a complicated and complex matter, on the one hand the need for clean water continues to increase in line with urban development and population growth, while on the other hand the planning has not been optimal. With the discovery of software such as EpaNet, WaterCat, WaterNet and others it is very helpful in the analysis of pipeline networks so that the calculations carried out become easier.

The distribution pipeline network at PDAM Tirtauli in Karangsari Permai Housing, to ensure the adequacy of pressure and availability of discharge for customers, the authors want to evaluate the distribution pipeline network at Karangsari Permai Housing so that the actual conditions of the distribution pipeline network can be known.

This evaluation can be used as a basis for corrective actions to be taken or as one of the considerations for increasing the number of house connections. The evaluation was carried out by modeling the distribution pipeline network of PDAM Tirtauli, precisely in Karangsari Permai housing, using the Epanet 2.0 program.

LITERATURE REVIEWS

Piping Network

The distribution pipe network system is the most expensive part for a clean water company. For this reason, the planning of a piping network system must be designed as carefully as possible so that the system can work efficiently and optimally.

According to Al-Layla et al. (1977) water can be supplied to consumers by means of gravity, pumps, or a combination of the two.

Epanet 2.0 program

The calculation of hydraulic flow in the pipeline in this study uses EPANET software, which is a computer program that describes hydraulic simulations and trends in the quality of water flowing in pipelines. The network itself consists of pipes, nodes (pipe connection points), pumps, valves, and water tanks or reservoirs. EPANET tracks the flow of water in each pipe, the condition of the water pressure at each point and the condition of the concentration of chemicals flowing in the pipe during the flow period. In addition, water age and source tracing can also be simulated.

EPANET designed as a tool to achieve and realize an understanding of the movement and fate of drinking water content in distribution networks. Also can be used for various analysis of various distribution network applications. For example for designing, calibrating hydraulic models, residual chlorine analysis, and customer analysis. EPANET can assist in managing strategies for realizing water quality in a system

METHODS

Location and Time of Research

Research sites

Administratively the research area is located in Siantar Martoba District, Tambun Nabolon Village, Karangsari Permai Housing Complex, Pematangsiantar City.

The research was conducted at PDAM Tirtauli Pematangsiantar and the location was chosen purposively. The time of the research was carried out in August 2018 for data collection and continued data processing and data analysis in August 2018 to September 2018.

Research Stages

The stages of this research include:

a. Literature review

The literature study in question is collecting and studying literature related to the research title.

b. Data collection and research

The data needed in this study are primary data and secondary data. Primary data is data obtained directly in the field, such as data on fluctuations in water demand. While secondary data is data taken from related agencies. The data in question are as follows:

1) Water availability data

For servants at the research location, Karang Sari Permai Housing, the source of the water used is from the Habonaran Spring to serve the North zone, including the Tambun Nabolon Sub-District and specifically for the Karangsari Permai Housing research area, assisted from deep wells with an average discharge of 7 l/second.

2) Fluctuations in water use

Observe the water meter per unit time in 24 hours at the distribution meter or zone meter.

3) Pressure fluctuation
   This data can be obtained simultaneously with data collection on fluctuations in water use, by observing the manometer. Samples were taken at places that were considered representative, namely at the farthest point, the closest point, the midpoint, the place with the highest elevation, the lowest elevation, and the most densely populated.
4) Total discharge (water meter)
   This data can be obtained by reading the main meter at the outlet of the reservoir, or by looking at the amount of decrease in reservoir volume divided by the amount of time.
5) Valve opening setting.
   This data can be obtained by asking questions to the officer.
6) Data needs function to determine the amount of water needed by the community. Water demand data is obtained from PDAM customers' water usage accounts.
7) The existing network map is very important data to know the characteristics of the network, from this data a network image is made and evaluated with the Epanet 2.0 program.

c. Stages of data processing

From the data obtained, an analysis was carried out using*Epanet 2.0 software*. the stages are as follows:

1) Describe the existing network by entering data on pipe length, pipe diameter, pipe type, pipe roughness, water availability, demand for each node, demand fluctuations, pump data and elevation data.
2) Running the existing network, so that problems in the existing network can be identified, and technically and economically whether it is still feasible to be developed.
3) Analyze the possibility of using the tank (existing/addition).
4) Make a good network alternative and able to serve up to the desired planning year.

d. Solution to problem

From the results of the analysis with Epanet 2.0, it can be seen that the problems that occur in the existing network conditions and then steps are taken to solve these problems.

In carrying out the simulation using the EPANET 2.0 software, several assumptions were made:

1) water quality is considered good.
2) Network conditions are considered good
3) The pipe roughness used is the pipe hardness available in Epanet 2.0.

This study analyzes the data that has been obtained qualitatively. Processing and analysis of data is done manually and using a computer with a program*Epanet 2.0*.

Success :

- ➢ If successful with the report, then return to input data
- ➢ Success without a report, then proceed to system analysis

Ideal: According to the requirements of the remaining pressure of 10 mka at the far end of the pipe and more than 10 mka for the primary and secondary networks.

RESULTS AND DISCUSSION

Results

Network Simulation Modeling

This distribution pipeline network simulation was carried out using the Epanet 2.0 program from existing secondary data such as pipe length data, pipe diameter, number of customers, water usage patterns and primary pressure data in the Karangsari Permai housing distribution network.

*Epanet*is a computer program that describes hydraulic simulations and trends in the quality of water flowing in pipelines.

Network simulation with EPANET 2.0 aims to find out whether the current existing network has flow to each SR.

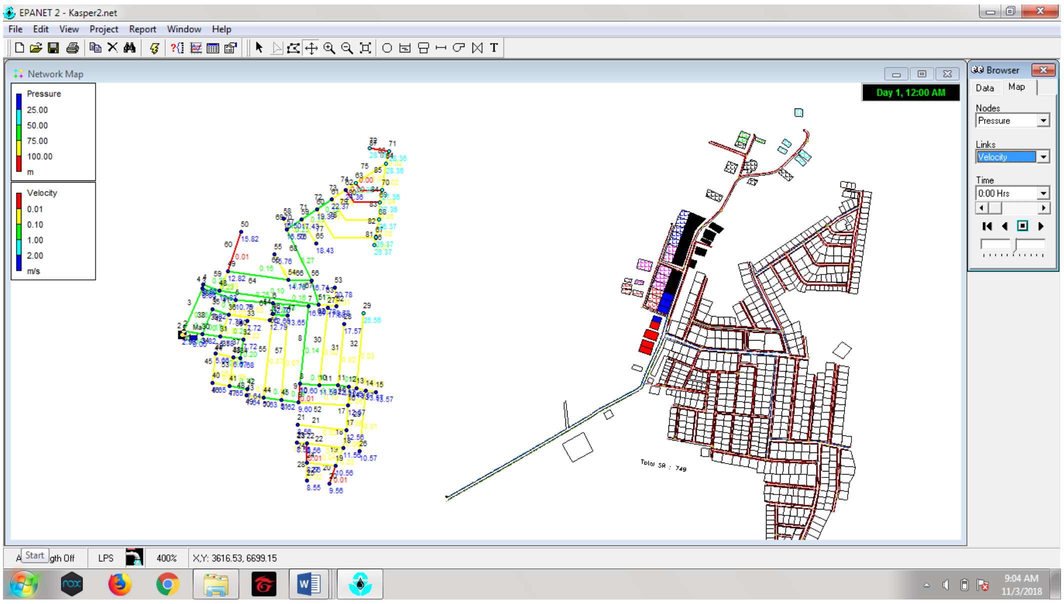


Figure of the existing Distribution Network Model of Epanet Housing Karangsari Permai

a. Link Data

For links, the input data is:

- ▪ Pipe Diameter

- Longpipe

Property	Value
*Valve ID	44
*Start Node	2
*End Node	5
Description	
Tag	
*Diameter	50
*Type	FCV
*Setting	0
Loss Coeff.	0
Fixed Status	Open
Flow	0.74
Velocity	0.38
Headloss	0.00
Quality	0.00
Status	Open

Example of Pipe Data Input

a. Data valves

For valves, the input data is:

- Valve diameters
- Type : FCV (Flow Control Valve)
- Fixed Status :Open

Junction 6

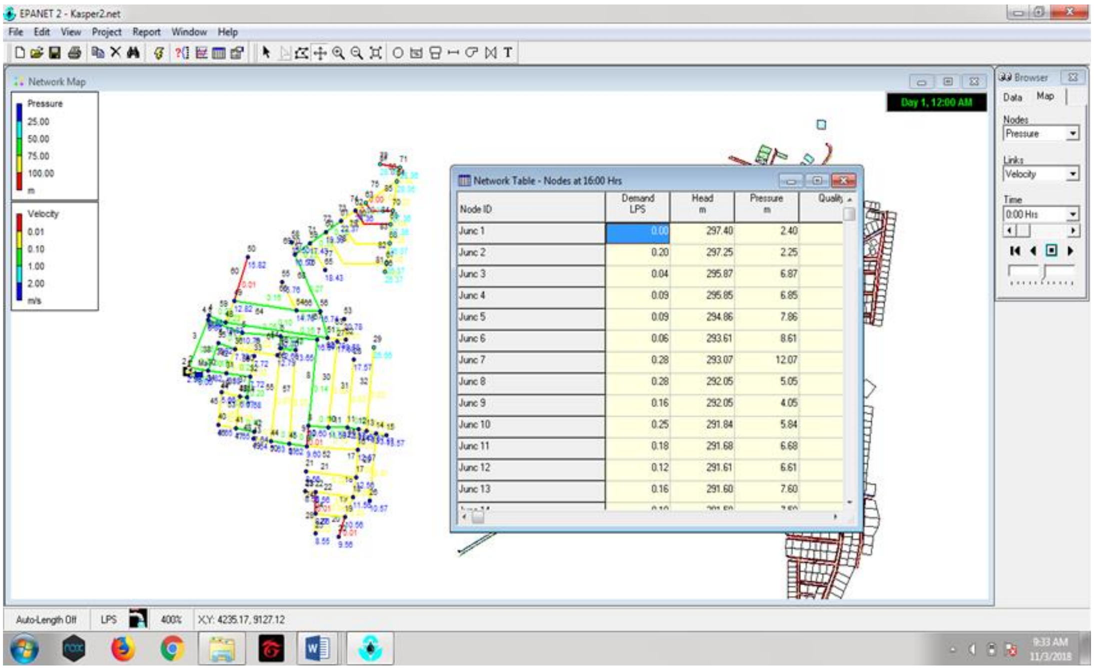
Property	Value
*Junction ID	6
X-Coordinate	7326.12
Y-Coordinate	5301.39
Description	
Tag	
*Elevation	688
Base Demand	0.028
Demand Pattern	
Demand Categories	1
Emitter Coeff.	
Initial Quality	
Source Quality	
Actual Demand	0.02
Total Head	762.59
Pressure	74.59
Quality	0.00

Image of Valve Data Input Example

a. Pressure

Based on the results of running Epanet 2.0, the remaining press is available in the Perum network. Karangsari Permai is ideal (10 m). This can be seen in the report table for each node the results of running can be seen in the table below.

Epanet Report Result Table for Node at 16 : 00



a. Speed

Based on the simulation results of the EPANET 2.0 program, it shows that there are several pipes whose speed does not meet the required criteria, namely 0.3 - 3 m/s at peak hours.

Table of Epanet Report Results for Pipes at 5: 00

Link ID	Length m	Diameter mm	Roughness	Flow LPS	Velocity m/s	Unit Headloss m/km
Pipe 1	350	75	100	2.49	0.56	9.56
Pipe 2	100	75	100	0.15	0.03	0.05
Pipe 3	200	75	100	0.00	0.00	0.00
Pipe 4	1	50	100	2.34	1.19	61.54
Pipe 5	106	50	100	0.11	0.05	0.20
Pipe 6	194	40	100	0.05	0.04	0.16
Pipe 7	28	50	100	2.23	1.14	56.49
Pipe 8	100	40	100	0.08	0.06	0.35
Pipe 9	6	50	100	2.15	1.10	52.81
Pipe 10	100	40	100	0.09	0.07	0.47
Pipe 11	24	50	100	2.06	1.05	48.67
Pipe 12	100	40	100	0.09	0.07	0.47
Pipe 13	6	50	100	1.97	1.00	44.67
Pipe 14	100	40	100	0.09	0.07	0.47
Pipe 15	24	50	100	1.88	0.96	40.84
Pipe 16	100	40	100	0.05	0.04	0.17
Pipe 17	6	50	100	1.82	0.93	38.72
Pipe 18	100	40	100	0.08	0.06	0.35
Pipe 19	24	50	100	1.74	0.89	35.64
Pipe 20	6	50	100	1.52	0.77	27.55
Pipe 21	6	50	100	1.13	0.58	16.00
Pipe 22	96	40	100	0.16	0.13	1.26
Pipe 23	4	50	100	0.97	0.49	12.07
Pipe 24	96	40	100	0.17	0.14	1.46

Flow velocity during peak hours in pipes 2,3,5,6,8,10,12,14,16,18,22,23,24,26,28,30,32,33,34,37,39, 40,41,42 and 43 under the speed criterion, namely 0.3 m/s.

Calibration Data

For calibration data here are:

b. Pressure

Calibration of the results of the simulations on the EPANET 2.0 program was carried out to find out what the suitability of the EPANET 2.0 simulation results is with the measured data in the field. Calibration is carried out if the running results are successful.

Following are the calibration results between field data and EPANET 2.0 simulation results.

Table of Manometer Reading Results

No.	Street Name	nodes	Reading Hours	Pressure (Kg/cm2)	Pressure (m)
1	Block A	23 23 23	05:00 10:00 19:30	0.3 1 2,5	3 10 25
2	Block B	17 17 17	10 : 15 19 : 00 21:00	1.5 3,5 4	15 35 40
3	Block C	40 40 40	08:00 17 : 15 21 : 15	2 3,3 4	20 33 40
4	Block C	43 43 43	07 : 15 19 : 15 23:15	4 4,5 6	40 45 60
5	Main road	7 7 7	07:30 12:00 23:10	4 6 6	40 60 60

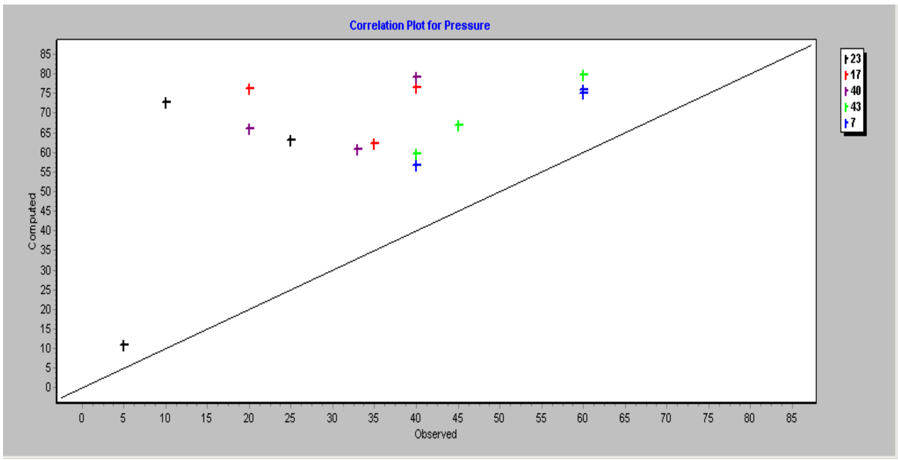
Field Observation Source 06/08/2018

Table. Calibration results at several field measurement points

Calibration Statistics for Pressure

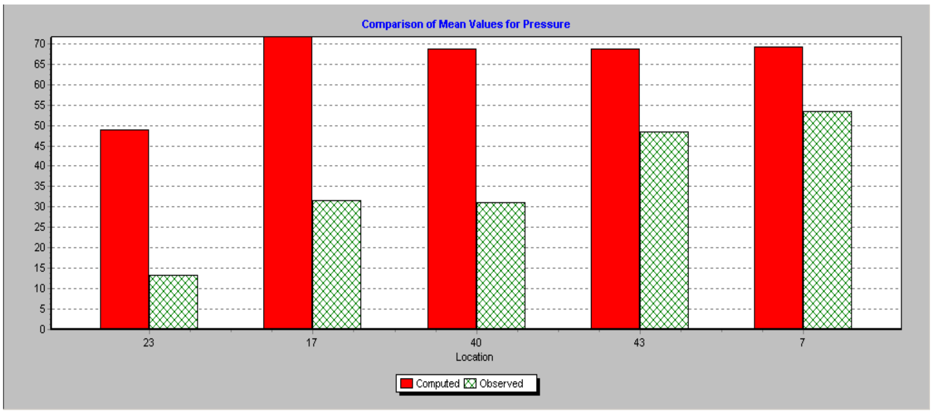
Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
23	3	13.33	48.83	35.496	42.448
17	3	31.67	71.72	40.050	41.847
40	3	31.00	68.70	37.697	38.462
43	3	48.33	68.81	20.476	20.500
7	3	53.33	69.16	15.830	15.846
Network	15	35.53	65.44	29.910	33.775

Correlation Between Means: 0.738



Source: EPANET 2.0 program calculations

Picture. Graph of correlation plot of calibration results



Bar chart image of calibration results

After calibration by taking pressure samples at 5 points in the service area at Karangsari Permai Housing, the statistical value of the correlation obtained is 73.8%. This figure is good enough because the ideal number is close to 1. However, in the correlation plot, the location of the sample points is still far from the diagonal line. This shows that the difference between the simulation results and the measurement results in the field is quite large. There are several contributing factors, including:

Age of the piping network used.

The factor of the age of the pipe will affect the Hazen William coefficient as the age of the pipe increases, the roughness of the pipe increases so that the head loss along the pipe increases.

- Leaks in the distribution network pipes can cause a reduction in residual pressure.
- Completeness of filling in existing data such as:
- Completeness of the distribution network: valves, accessories, water meters and others that have not been filled in completely.

Alternative possible causes of non-conformity:

a Enter the leakage coefficient number

*Loss coefficient*is a proportional constant between minor loss and the velocity head of water flowing through the pipe/valve (v2/2g) whose value depends on the geometry and type of fitting. Minor head loss can be referred to as local loss which is associated with the addition of turbulence that occurs at bends, fittings, water meters, junctions and valves. From the results of the input loss coefficient on several pipes by trial and error, the calibration results are obtained as follows:

Table. Calibration results at several field measurement points

Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
23	2	17.50	18.71	11.006	11.071
17	3	31.67	37.30	12.297	13.846
40	3	31.00	40.60	9.635	12.701
43	3	56.67	72.20	15.532	16.175
7	3	53.33	65.51	12.180	12.616
Network	14	39.50	48.88	12.210	13.540

Correlation Between Means: 0.996

Source: Results of simulation calculations for the EPANET 2.0 program

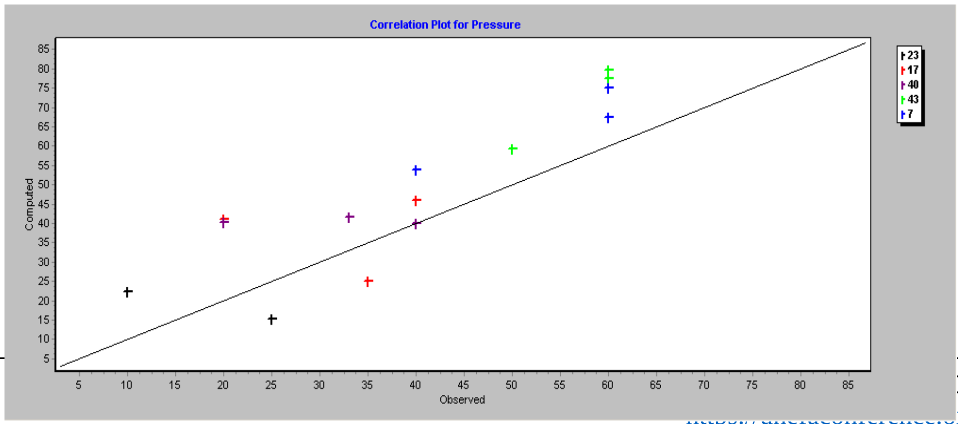


Fig. Graph of correlation plot of calibration results

Based on the results of the calibration after entering the number the correlation statistical coefficient is 99.6%. It turns out that in the correlation plot, the sample points are located closer to the diagonal line. This shows that pipe leakage is one of the causes of discrepancies between the simulation results and field measurements.

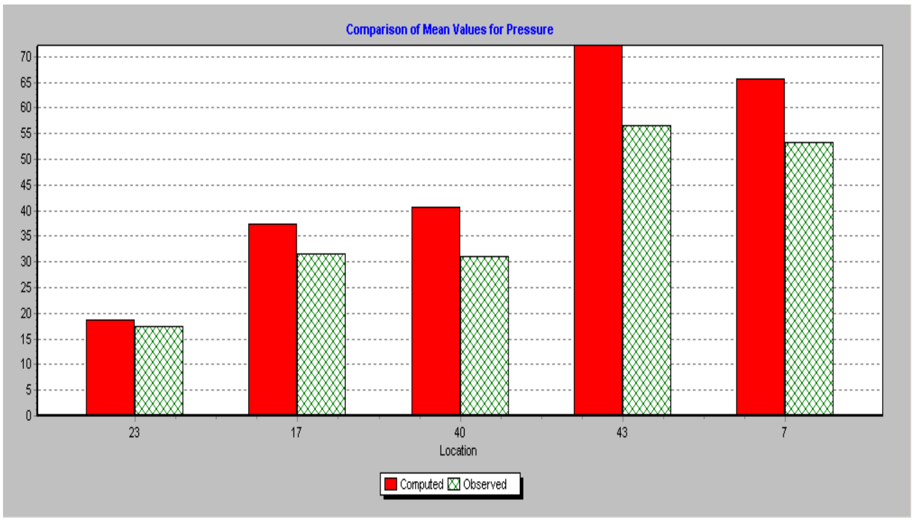


Fig. Bar Chart Comparison of the average pressure value of the calibration results

In the results of the EPANET simulation calibration with pressure data measured in the field, it must be higher than the EPANET simulation or parallel between the diagonal lines, even if there is a significant difference, this can be caused by several factors, including:

- Leaks in the distribution network pipes can cause a reduction in residual pressure.
- Completeness of filling in existing data such as:
  - Completeness of the distribution network map
  - Length and type of pipe installed
  - Completeness of the distribution network: valves, accessories, water meters.
  - The number of customers in one service area

Discussion

a. Measurements at several points in the field show that the pressure is available at several nodes in the distribution network of the Perum service area. Karangsar Permai is ideal above 10 m in accordance with the planning criteria for clean water distribution pipelines.

b. Based on data in the field obtained during the implementation of street vendors and after entering the data into the Epanet 2.0 program, the result is that the pressure in the pipeline during peak hours or during the highest usage there are several service areas that have pressures below 10 meters column water i.e. at Node 23,25,27,29

c. In the Epanet 2.0 simulation, it is known that the speed of water flow in almost all pipelines (links) does not meet the required criteria, namely 0.3 to 3 meters/second

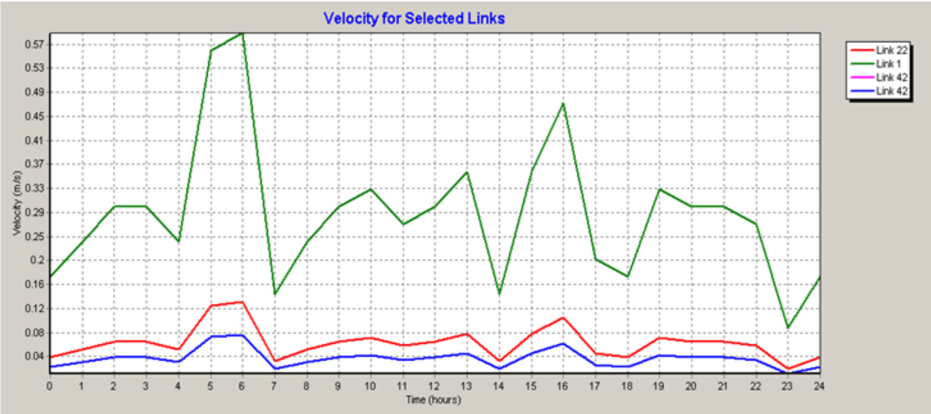


Figure 5.13. Epanet 2.0 simulated Flow Velocity Graph

Based on the simulation results of the Epanet 2.0 program, it shows that there are several pipes whose speed does not meet the required criteria, namely 0.3 to 3 meters / second during the highest usage hours.

There are several things that cause them, including:

- Service debit (base demand) that is too small.
- Installed pipe diameter is too large.

The following is an example of velocity analysis for several pipes with speeds below 0.3 m/s:

Discussion of Calibration Data

From the results of pressure calibration after inserting the loss coeff into the pipe, after calibration by taking pressure samples at 5 points in the service area at Karangsari Permai Housing, the statistical value of the correlation obtained is 99.6%. However, in the correlation plot, there are several sample points that are far from the diagonal line. This shows that the difference between the simulation results and the measurement results in the field is still very far. There are several contributing factors, including:

- Age of the piping network used.

  The factor of the age of the pipe will affect the Hazen William coefficient as the age of the pipe increases, the roughness of the pipe increases so that the head loss along the pipe increases.

- Leaks in the distribution network pipes can cause a reduction in residual pressure.
- Completeness of filling in existing data such as:
  - Completeness of the distribution network: valves, accessories, water meters and others that have not been filled in completely.

Discussion of discharge of existing pipes in the field

Based on the results of observations in the field, the debit for the service area of Perum. Karangsari Permai is still sufficient but at nodes whose elevation is higher than the other nodes, especially at nodes 23,25,27,29 . This can be seen when during peak hours, customers in higher areas do not get enough water supply. Therefore, it is necessary to find a special route so that services in that area can get water 24 hours even during peak hours

The thing identified that can cause high leakage is the high elevation from the spring to the service area. The high pressure in some regions can also be caused by limited demand. To overcome this, the way that can be taken by the PDAM in Tambun Nabolon Village is to add pipe connections, especially in areas that have the shortest distance between nodes, but have sufficient pressure difference to fulfill the service area. In addition, by changing the distribution channel in addition to increasing the flow capacity. In overcoming the problem of head loss that is too high, try changing the pipe dimensions. In this way, the head loss on the entire network will be below 10 m/km, thus fulfilling the maximum pressure loss requirement.

Corrective Action

a. Pressure Analysis with EPANET 2.0

MJudging from the simulation results obtained, the pressure at Karangsari Permai Housing is quite safe, it meets the criteria, namely 1 atm or 10 mka at the farthest nodes such as nodes 33, 42 and 43

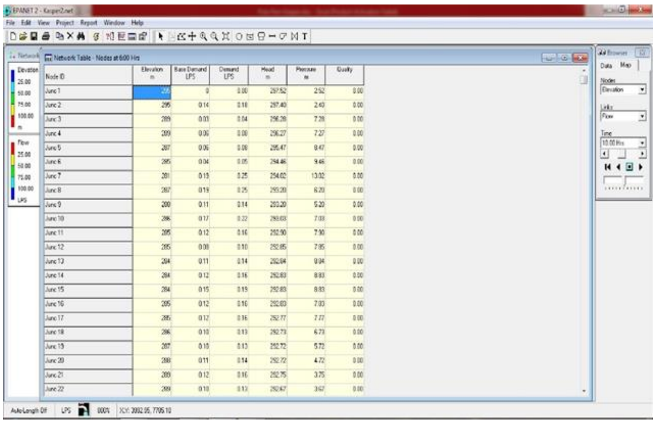


Figure 5.14. Pressure and Speed in Distribution Networks
source: Epanet 2.0 Simulation Results

CLOSING

Conclusion

a. Based on measurements in the field (for several nodes observed during peak hours) currently available pressure at Perum. Karangsari Permai already meets the ideal criteria (10 m).

b. Based on the analysis with Epanet 2.0 simulation, the condition of the existing network shows that the water flow to all nodes is running well with relatively high pressure. While the reality in the field, there are several nodes whose pressure is still below 10 mka (water column face).

c. Epanet 2.0 simulation results with the field

From the pressure data calibration using Epanet 2.0, a correlation value of 73.8% is obtained for the current account and the pressure calibration results. The meaning of the correlation value is that calculations using the Epanet 2.0 program are not close to field conditions because the ideal value is close to 1, but judging from the correlation plot the location of the sample points is far from the diagonal line (figure 5.10) after trial & error with coeff. losses in the pipe, the location of the sample points is close to the diagonal line with a correlation value of 99.6%. This could be due to field conditions that are not ideal due to changes that occur in the distribution pipeline network, both pipe narrowing by scale and leaks that occur in the network (55 %)

- In the calibration results of the Epanet 2.0 simulation with pressure data measured in the field, there is still a difference, this is caused by several factors, including:
  - Leaks in the distribution network pipes can cause a reduction in residual pressure.
  - Completeness of filling in existing data such as:
    - Completeness of the distribution network map
    - Length and type of pipe installed
    - Completeness of the distribution network: valves, accessories, water meters.
    - The number of customers in one service area
- Action From the simulation results, the pressure is low and the pressure is high, namely by adding house connections and replacing pipes at certain nodes.

Suggestions and Acknowledgments (if any)

a. High relative pressure is very beneficial for future network development, but caution is needed because a relative high pressure that is too large can damage the network, such as loose pipe connections or broken pipes. This can be used to reduce pressure.

b. There needs to be a leak test on the Perum network. Karangsari Permai because from the results of calculations and simulations by Epanet 2.0, the water loss in Karangsari Permai housing is 55%.

c. From the corrective action carried out by simulating heat exchanger at high pressure, it is necessary to change the pipe from a large diameter to a small diameter, and replace the small diameter with a large diameter.

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