JOURNAL OF WORLD SCIENCE
https://jws.rivierapublishing.id/index.php/jws
Volume 5 No. 8 August 2026
P-ISSN: 2828-8726
E-ISSN: 2828-9307

Establishment of a District Metered Area (DMA) and Water Loss Analysis in Pilang Setrayasa Cirebon

M Rifki[1], Ohan Farhan[2]
Universitas Swadaya Gunung Jati, Indonesia
Email: rifkycirebon515@gmail.com

Keywords
district metered area; establishment; water loss

Abstract
Based on customer complaints in the Pilang–Sertayasa area, several issues related to suboptimal water pressure were identified. These issues were attributed to high levels of water loss. This study aimed to determine the level of water loss through the establishment of District Metered Areas (DMA). A descriptive-quantitative research design was employed to evaluate the level of Non-Revenue Water (NRW) through the implementation of a District Metered Area (DMA) in Pilang–Sertayasa, involving a study population of 217 active customers. The instrument used to assess water loss was the DMA method. Water loss analysis was conducted using data loggers, with the collected data analyzed through step-test calculations. The findings revealed that the water loss level, or Non-Revenue Water (NRW), within the Pilang–Sertayasa DMA reached 48.43%. The step-test analysis indicated that Step 1 (0.0125 dQ/Dsr), Step 6 (0.0206 dQ/Dsr), and Step 7 (0.0437 dQ/Dsr) were categorized as high-loss areas. Therefore, immediate interventions, such as leak detection and further evaluation, were required for these steps to reduce water losses and improve distribution system efficiency.

INTRODUCTION

Water loss, or Non-Revenue Water (NRW), is currently a major challenge in the management of piped clean water and drinking water supply systems, both in Indonesia and globally (AbuEltayef et al., 2023; Espinoza & Huacho, 2025; Fadina et al., n.d.; Suliaman, 2022). This issue can cause significant financial losses for regional water utilities (Perusahaan Daerah Air Minum/PDAM) and directly affect consumers. The impacts of water loss include reduced utility revenue, decreased water availability and pressure, and deterioration in the quality of drinking water delivered to customers (Ahmed et al., 2022; Berglund et al., 2022; Santos, 2024; Tchórzewska-Cieślak et al., 2024; Unto, 2024).

Water loss remains a critical factor affecting the ability of water utilities to provide optimal distribution services (Ahmad, 2025; Islam et al., 2022; Parvaze et al., 2023; Ramos et al., 2023). Losses within clean water and drinking water distribution networks occur due to pipeline leakage, which can be categorized into two types: physical losses and apparent losses. Physical losses are primarily caused by leakage from pipes, connections, and network infrastructure, often resulting from inadequate planning, construction, maintenance, or operational issues. Meanwhile, apparent losses arise from administrative inaccuracies, measurement errors, data recording issues, and unauthorized water consumption (Akdeniz, 2022; Duan et al., 2025; Gacu et al., 2025; Rahman et al., 2026; Rajan & Li, 2025).

An effective water loss control program, or NRW management strategy, requires an appropriate and measurable approach (Bouramdane, 2023; Doost et al., 2024; Farouk et al., 2023; Mathye, 2023; van Thienen et al., 2025). One widely applied method is the establishment of distribution network zones known as District Metered Areas (DMAs). A DMA functions by isolating a specific area within the distribution network and comparing the water volume recorded by the master meter with the authorized consumption measured through customer meters to identify potential water losses.

The urgency of this research is driven by the financial and service impacts associated with high NRW levels. When water utilities are unable to manage water losses effectively, they experience increased operational costs, reduced revenue, and limited capacity to invest in service improvements. Ultimately, these challenges may affect consumers through increased tariffs and declining service quality. Based on the Infrastructure Leakage Index (ILI) analysis data from Perumda AM TGN Cirebon, the ILI value reached 70 in 2024, placing it in performance category D, which indicates very high leakage levels and the urgent need for prioritized leakage reduction programs. This research contributes to the utility's proactive NRW management strategy by establishing a DMA in the Pilang–Sertayasa area and analyzing water loss levels to identify distribution segments requiring immediate intervention.

The novelty of this research lies in the integration of DMA establishment with comprehensive step-test analysis in the Pilang–Sertayasa area, which had not previously been examined as an independent analysis zone. Although previous studies have investigated DMA implementation in other areas of Cirebon, including the IAIN DMA and Bumi Kepongpongan Indah DMA, the Pilang–Sertayasa area represents a distinct service zone with different network characteristics and customer consumption patterns requiring specific evaluation. This research provides a systematic analysis of water losses within the Pilang–Sertayasa DMA by applying the step-test method to identify pipeline segments with significant leakage potential. The findings are expected to support targeted intervention strategies for reducing water losses and contribute to achieving the national NRW reduction target of 25%.

Customer complaints regarding suboptimal water service quality have frequently been reported in relation to the distribution pipeline network in Pilang–Sertayasa. This condition indicates potential inefficiencies within the distribution system, particularly concerning water losses. Therefore, based on established water loss management principles, this research addressed the issue by implementing NRW control measures through the establishment of a District Metered Area (DMA) and conducting a water loss analysis in the Pilang–Sertayasa area.

METHOD

This study employed a descriptive-quantitative research design to evaluate the level of Non-Revenue Water (NRW) through the establishment of District Metered Areas (DMAs) in Pilang–Sertayasa. This approach was selected because it enabled quantitative measurement of hydraulic parameters, including pressure, flow rate, and water loss, while supporting the identification of issues within the existing distribution network. The study also incorporated hydraulic analysis using operational data from the regional water utility (Perusahaan Daerah Air Minum/PDAM).

The study applied a total sampling technique, involving the entire population of active customers within the Pilang–Sertayasa DMA, consisting of 217 active customers.

The research was initiated based on customer complaints regarding declining water supply services in the Pilang–Sertayasa area, which were suspected to be associated with pipeline leakage and NRW. Customer data were collected to determine the DMA boundaries and identify the appropriate location for DMA establishment. After the DMA was established, data loggers were installed to collect flow and pressure data. The collected data were subsequently analyzed using the step-test method to determine the level and location of potential water losses. The results of the analysis provided a basis for implementing corrective measures, such as leak detection and other interventions, to reduce water losses and improve water distribution services in the Pilang–Sertayasa DMA.

RESULTS AND DISCUSSION

1. Research site.

This study focuses on the water distribution pipeline network in the Pilang Setrayasa area of Cirebon'

Figure 1 Map of the Pilang Setrayasa Area

2. Establishment of the District Meter Area (DMA)

The first stage in the establishment of the District Metered Area (DMA) and the analysis of water loss involves collecting the data required for DMA planning, specifically the distribution pipeline network map and customer data for the Pilang Setrayasa area.

Figure 2 Pilang Setrayasa distribution network map

Schematic map of the pipeline network, including details on pipe diameters and types, in Pilang Setrayasa.

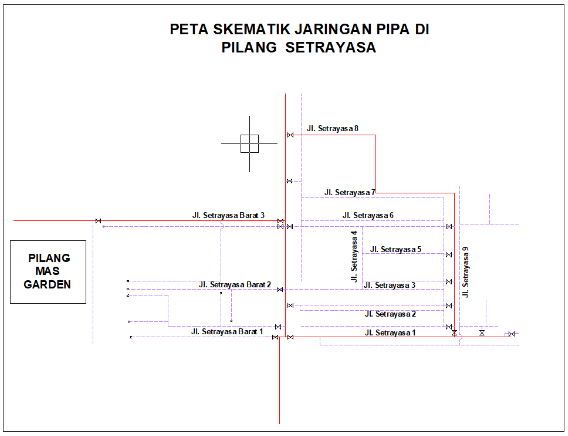

Figure 3 Schematic map of the Pilang Setryasa distribution pipeline network.

Based on the distribution pipeline network map for Pilang Setrayasa, it is evident that the network is not yet isolated from the Pilang Mas Garden area; establishing a District Metered Area (DMA) requires pipeline network isolation work. The map showing the network isolation points is provided below:

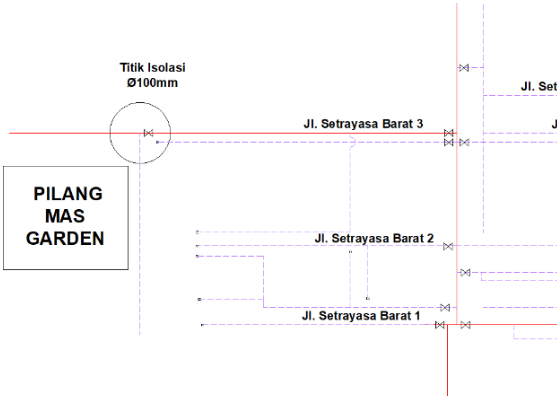

Figure 4 Schematic map of isolation points for DMA formation.

The next step, following the isolation of the pipeline network in Pilang Setrayasa, is the installation of a Ø100mm PVC master meter on the input line located at the entrance to Pilang Setrayasa. Below is a map showing the DMA water meter location:

Figure 5 Schematic map of DMA master meter points

Once the master meter is installed, flow rate and pressure measurements can be conducted over a 24-hour period by installing a data logger designed to record the flow and pressure data from the DMA master meter. The data obtained is as follows:

Table 1 Date DMA

Date and Time	Meter Stand	Pressure (bar)	Cubic		Debit
08/06/2026 00:00:00	543270.9	0.801	202	-	
08/06/2026 01:00:00	543290.9	0.814	200	20	5.56
08/06/2026 02:00:00	543310.2	0.801	193	19.3	5.36
08/06/2026 03:00:00	543328.8	0.776	186	18.6	5.17
08/06/2026 04:00:00	543346.3	0.674	175	17.5	4.86
08/06/2026 05:00:00	543362.8	0.547	165	16.5	4.58
08/06/2026 06:00:00	543379.9	0.483	171	17.1	4.75
08/06/2026 07:00:00	543399.8	0.432	199	19.9	5.53
08/06/2026 08:00:00	543419.1	0.483	193	19.3	5.36
08/06/2026 09:00:00	543438.9	0.509	198	19.8	5.50
08/06/2026 10:00:00	543459.7	0.547	208	20.8	5.78
08/06/2026 11:00:00	543481	0.585	213	21.3	5.92
08/06/2026 12:00:00	543502.4	0.56	214	21.4	5.94
08/06/2026 13:00:00	543522.3	0.598	199	19.9	5.53
08/06/2026 14:00:00	543541.3	0.611	190	19	5.28
08/06/2026 15:00:00	543559.6	0.623	183	18.3	5.08
08/06/2026 16:00:00	543577.8	0.547	182	18.2	5.06
08/06/2026 17:00:00	543596.2	0.496	184	18.4	5.11
08/06/2026 18:00:00	543614.1	0.445	179	17.9	4.97
08/06/2026 19:00:00	543632.5	0.534	184	18.4	5.11
08/06/2026 20:00:00	543650	0.534	175	17.5	4.86
08/06/2026 21:00:00	543668.8	0.585	188	18.8	5.22
08/06/2026 22:00:00	543685.7	0.623	169	16.9	4.69
08/06/2026 23:00:00	543702.3	0.687	166	16.6	4.61
09/06/2026 00:00:00	543721	0.738	187	18.7	5.19
	Total discharge (m3)			450.1	
	Average Debit				5.21

To analyze water loss levels in the Pilang Setrayasa DMA, a step test must be conducted to identify the pipeline segments with the most significant physical leaks. The step test setup begins with the decommissioning of pipes that are no longer relevant and would only incur additional maintenance costs (specifically for leak repairs). The following details the decommissioning points for the Ø 100mm PVC pipe located between Jalan Setrayasa 8 and Jalan Setrayasa 9. Decommissioning is carried out by installing blind flanges; the specific locations are listed below:

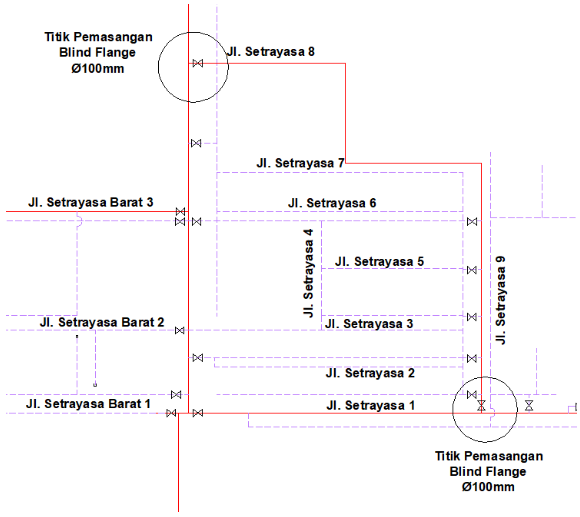

Figure 6 Installation of a blind flange for the deactivation of a Ø 100 mm pipe.

The next step is to ensure that all sections are isolated and to mark the gate valves used for the step test on the map.

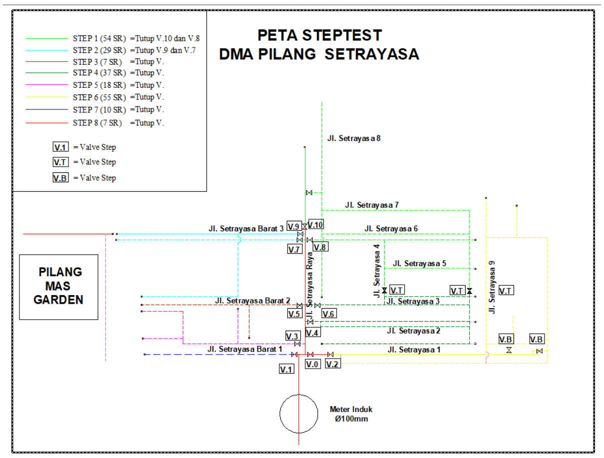

Figure 7 Valve numbering map for the step test

3. WATER LOSS ANALYSIS

By comparing the volume of water distributed through the master meter with customer consumption, the difference between the two is classified as water loss or Non-Revenue Water (NRW). Water loss in the Pilang Setrayasa DMA for the month of June stood at 48.43% (High).

Table 2 Results of Water Loss or NRW Calculations

PERIODE	METER AIR INDUK (M3)		METER AIR CABANG (M3)		JML PEL (SR)	NRW (%)
	M3	L/d	M3	L/d		
JUNI 2026	13.503	5,58	6.964	2,88	216	**48,43%**

Given the water loss—or Non-Revenue Water (NRW)—level of 48.43% in the Pilang Setrayasa DMA, further analysis using the step test method is required. The step test was conducted during the minimum usage period (at 01:00) at a pressure of 0.814 bar. The steptest data obtained is as follows:

Table 3 Steptest Results

No	Step	Volume ukur		Debit
		waktu (detik	Liter	
1	Awal (SEMUA)	29.06	100	3.441
2	Step 1	43.43	100	2.303
3	Step 2	51.07	100	1.958
4	Step 3	45.52	100	2.197
5	Step 4	54.68	100	1.829
6	Step 5	60.81	100	1.644
7	Step 6	173.93	100	0.575
8	Step 7	72.30	10	0.138
9	Step 8			0.138

The obtained data were then analyzed by comparing the difference in flow rate at each step with the number of household connections (SR) at that step; the results were then evaluated against standards to determine the level of water loss. The dQ/dSR standard (flow rate divided by household connections) is as follows:

1. 0.001 – 0.004 = Low water loss
2. 0.005 – 0.01 = Moderate water loss
3. > 0.02 = High water loss

Thus, the following data were obtained :

Table 4 Analysis of steptest results

STEP	UKUR (dtk)	VOL UKUR (Lt)	DEBIT (L/dt)	SELISIH dQ (L/dt)	dSR	dQ/Dsr	KETERANGAN
Awal (SEMUA)	29.06	100	3.441	3.44	220	0.0156	Sedang
Step 1	43.43	100	2.303	1.139	53	0.0215	Tinggi
Step 2	51.07	100	1.958	0.34	38	0.0091	Sedang
Step 3	52.11	100	1.919	0.04	7	0.0056	Sedang
Step 4	54.68	100	1.829	0.09	36	0.0025	Sedang
Step 5	60.81	100	1.644	0.18	17	0.0108	Sedang
Step 6	173.93	100	0.575	1.07	52	0.0206	Tinggi
Step 7	72.30	10	0.138	0.437	10	0.0437	Tinggi
Step 8	–	–	0.138	0.1383	7	0.0198	Sedang

CONCLUSION

Based on the research findings, the water loss level, or Non-Revenue Water (NRW), within the Pilang–Sertayasa DMA was measured at 48.43%, which significantly exceeded the national NRW target of 25%. This high NRW level indicated systemic challenges within the water distribution network, including aging infrastructure, insufficient maintenance, and limited proactive leak detection programs. The step-test analysis showed that Step 1 (0.0125 dQ/Dsr), Step 6 (0.0206 dQ/Dsr), and Step 7 (0.0437 dQ/Dsr) were categorized as high water-loss segments requiring immediate intervention. Step 7 recorded the highest dQ/Dsr value and should be prioritized for leak detection and repair, followed by Step 6 and Step 1. The establishment of the DMA provided a functional framework for continuous monitoring and management of water losses in the Pilang–Sertayasa area, enabling the water utility to monitor NRW levels over time and evaluate the effectiveness of implemented interventions.

Immediate actions, including leak detection and further evaluation, were required in these segments to reduce water losses and restore optimal water distribution services in the area.

Future research should conduct empirical assessments of DMA implementation and step-test methodologies across various service zones within the Perumda Air Minum Tirta Giri Nata service area to further validate and improve water loss reduction strategies. Comparative studies examining the influence of network characteristics, customer consumption patterns, and management practices on NRW levels and intervention effectiveness would provide valuable insights for both theoretical development and practical applications. Furthermore, future studies could explore the institutional and financial aspects of sustainable NRW management, including the effectiveness of performance-based contracting, capacity development, and technology adoption in supporting water loss reduction efforts. Longitudinal research examining the long-term effects of DMA establishment and water loss reduction interventions on service quality, customer satisfaction, and utility financial performance would also provide evidence to support future policy formulation and investment decisions. Overall, this study demonstrated the importance of proactive water loss management through DMA implementation and step-test analysis in improving water utility performance and service quality in Indonesia.

REFERENCES

AbuEltayef, H. T., AbuAlhin, K. S., & Alastal, K. M. (2023). Addressing non-revenue water as a global problem and its interlinkages with sustainable development goals. *Water Practice & Technology*, *18*(12), 3175–3202.

Ahmad, N. R. (2025). Urban water service delivery in emerging economies: Fiscal sustainability, cost recovery, and governance performance. *International Journal of Business and Economic Affairs*, *10*(3), 70–85.

Ahmed, T., Sipra, H., Zahir, M., Ahmad, A., & Ahmed, M. (2022). Consumer perception and behavior toward water supply, demand, water tariff, water quality, and willingness-to-pay: A cross sectional study. *Water Resources Management*, *36*(4), 1339–1354.

Akdeniz, T. (2022). A case study on integrated management of water losses in Antalya, Turkey. *Water Practice & Technology*, *17*(10), 2023–2030.

Berglund, E. Z., Buchberger, S., Cunha, M., Faust, K. M., Giacomoni, M., Goharian, E., Kleiner, Y., Lee, J., Ostfeld, A., & Pasha, F. (2022). Effects of the COVID-19 pandemic on water utility operations and vulnerability. *Journal of Water Resources Planning and Management*, *148*(6), 4022027.

Bouramdane, A.-A. (2023). Optimal water management strategies: paving the way for sustainability in smart cities. *Smart Cities*, *6*(5), 2849–2882.

Doost, Z. H., Alsuwaiyan, M., & Yaseen, Z. M. (2024). Runoff management based water harvesting for better water resources sustainability: a comprehensive review. *Knowledge-Based Engineering and Sciences*, *5*(1), 1–45.

Duan, B., Gao, J., Cao, H., & Hu, S. (2025). Energy-efficient management of urban water distribution networks under hydraulic anomalies: A review of technologies and challenges. *Energies*, *18*(11), 2877.

Espinoza, G., & Huacho, J. (2025). The Challenge of Non-revenue Water: A Soon-To-Be an Exhausted Resource. In *Equalizing the Three Pillars of Sustainability: Exploring Social Responsibility in Context* (pp. 71–91). Springer.

Fadina, A. S., Oginni, F. A., & Opatade, J. A. (n.d.). *A Review of Non-Revenue Water in Urban Water Supply Systems: Causes, Impacts, Detection Techniques and Control*

Strategies.
Farouk, A. M., Rahman, R. A., & Romali, N. S. (2023). Non-revenue water reduction strategies: a systematic review. *Smart and Sustainable Built Environment*, *12*(1), 181–199.
Gacu, J. G., Monjardin, C. E. F., Mangulabnan, R. G. T., Pugat, G. C. E., & Solmerin, J. G. (2025). Artificial intelligence (AI) in surface water management: a comprehensive review of methods, applications, and challenges. *Water*, *17*(11), 1707.
Islam, M. R., Azam, S., Shanmugam, B., & Mathur, D. (2022). A review on current technologies and future direction of water leakage detection in water distribution network. *IEEE Access*, *10*, 107177–107201.
Mathye, R. P. (2023). *Development of an Integrated Water Loss Management Model*. University of Johannesburg (South Africa).
Parvaze, S., Kumar, R., Khan, J. N., Al-Ansari, N., Parvaze, S., Vishwakarma, D. K., Elbeltagi, A., & Kuriqi, A. (2023). Optimization of water distribution systems using genetic algorithms: A review. *Archives of Computational Methods in Engineering*, *30*(7), 4209–4244.
Rahman, A., Chung, G. C., & Ng, Y. H. (2026). Applications, Challenges, and Future Trends of Artificial Intelligence of Things (AIoT)-Enabled Water Quality and Resource Management. *Water (20734441)*, *18*(8), 919.
Rajan, G., & Li, S. (2025). A systematic literature review on flow data-based techniques for automated leak management in water distribution systems. *Smart Cities*, *8*(3), 78.
Ramos, H. M., Kuriqi, A., Besharat, M., Creaco, E., Tasca, E., Coronado-Hernández, O. E., Pienika, R., & Iglesias-Rey, P. (2023). Smart water grids and digital twin for the management of system efficiency in water distribution networks. *Water*, *15*(6), 1129.
Santos, E. (2024). Beyond leakage: non-revenue water loss and economic sustainability. *Urban Science*, *8*(4), 194.
Suliaman, I. S. (2022). *Non-Revenue Water (NRW): Strategy on Reducing and Managing Water Losses in Johor*.
Tchórzewska-Cieślak, B., Szpak, D., Żywiec, J., & Rożnowski, M. (2024). The concept of estimating the risk of water losses in the water supply network. *Journal of Environmental Management*, *359*, 120965.
Unto, P. B. (2024). The effect of water loss on demand–supply departure of Addis Ababa, Ethiopia. *Discover Water*, *4*(1), 89.
van Thienen, P., Steffelbauer, D. B., & Vertommen, I. (2025). Water loss management in Europe: perceptions, drivers, responses/strategies, and results. *Water Practice & Technology*, *20*(9), 1921–1938.