

EVIDENCE-BASED WATER LOSS MANAGEMENT: DEVELOPMENT AND DEPLOYMENT OF A MOBILE TESTING UNIT

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Water Loss → Energy Loss

Water distribution systems (WDSs) consume a considerable amount of energy as treated water is lifted to overcome elevation differences, moved through vast piping networks which offer frictional

resistance, and pressurized to service consumers. Pumping alone is fraught with inefficiencies, where an average of 30 per cent of the power input to a pump's motor is eroded before it is used to energize the water to service system demand.¹ As a

result, energy consumption often accounts for the largest line item on a municipality's operating budget, attributing to nearly 40 per cent of annual costs.²

In addition to pumping inefficiencies, water loss contributes to needless energy

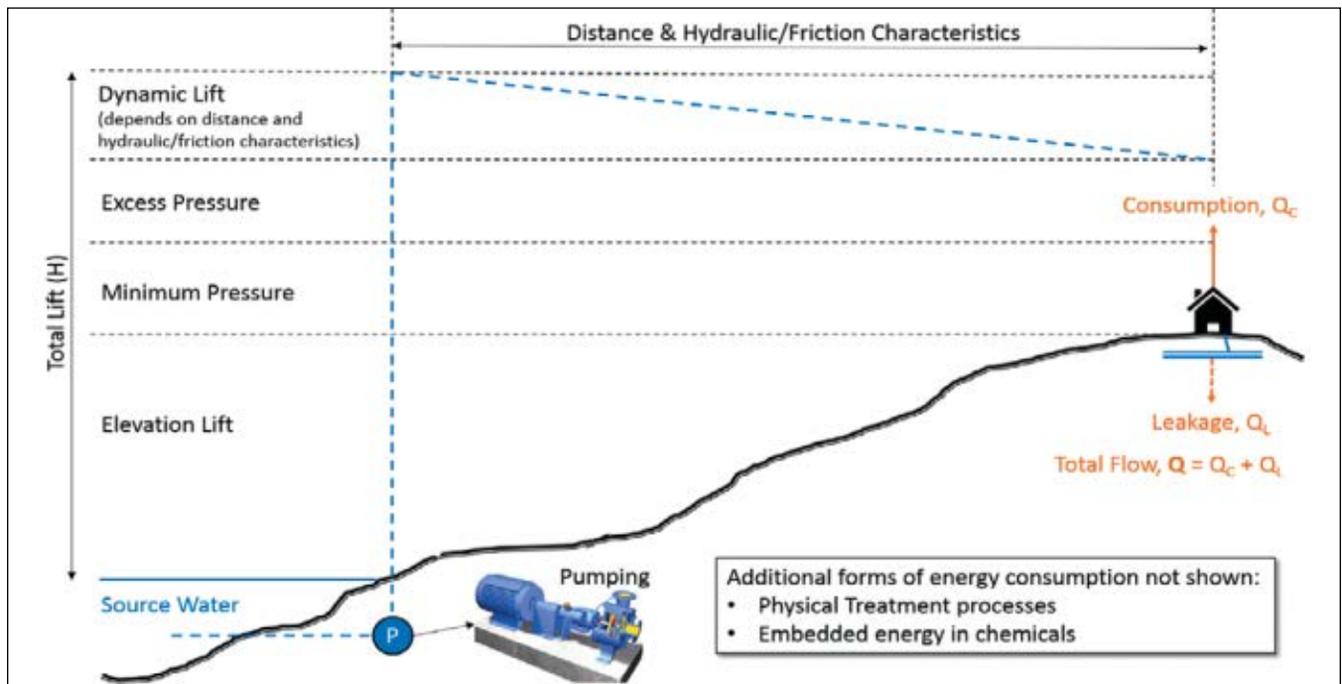


Figure 1. Energy Consumption in Water Distribution Systems

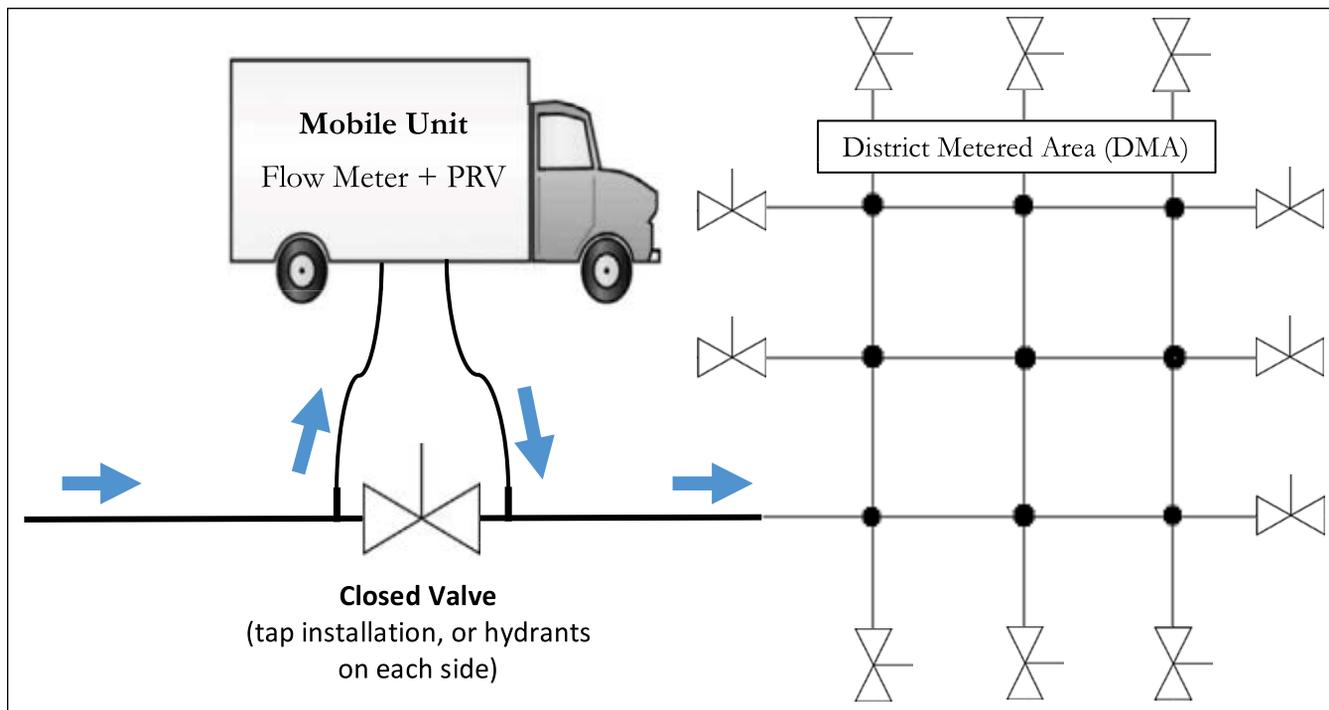


Figure 2. Temporary DMA: Mobile Testing Unit Concept

consumption and adds financial stress on the water utility in addition to water and energy resources. Evidently, leakage, the primary mechanism for physical losses within the definition of “water loss,” can be a key indicator of system underperformance. While system leakage rates vary across municipalities, in 2017 the Environmental Commissioner of Ontario³ reported average leakage at 10 per cent of total system input, of which 75 per cent is estimated to be recoverable.⁴ **Figure 1** illustrates the connection between energy consumption and WDSs, noting that pumping energy is proportional to the total system flow (consumption plus leakage).

Project Introduction

In recognition of the synergy between water loss reduction and energy conservation, the Independent Electricity System Operator (IESO), formerly the Ontario Power Authority, is supporting a multi-year water loss management project through its Grid Innovation Fund to catalyze behavioural changes in the water industry. This cross-sectoral collaboration, which realizes broader energy efficiency gains by transcending typical municipal jurisdictional boundaries is being led by HydraTek & Associates in collaboration with the Ontario Clean Water Agency (OCWA),

the Ontario Water Works Association (OWWA), the University of Toronto and several municipalities.

The project involves the development and deployment of a mobile testing unit to affordably, accurately and reliably measure minimum night flows into district metered areas and to test the effectiveness of pressure reduction on water loss reduction. Field-testing will be undertaken across 20 locations in Ontario, and the final results will be made publicly available to provide a valuable reference in assisting the advancement of water loss management practices.

Temporary District Metered Area & Mobile Testing Unit

An established method to assess leakage is to measure the minimum night flow (MNF) – the lowest demand in the system which typically occurs between midnight and 6 a.m. – into sectorized zones of the WDS, known in the industry as district metered areas (DMAs). The MNF can be a valuable indicator of leakage as it represents an instance in the system when leakage constitutes the highest fraction of total flow. Performance metrics, such as MNF plotted against various DMA characteristics (e.g., number of serviced units, length of watermain, system pressure, etc.), or the ratio of MNF to the average billed

demand (ABD), can be derived to provide meaningful benchmarking metrics to ultimately accommodate informed water loss management decision-making.

Conventionally, permanent DMAs are contrived to capture flow characteristics such as the MNF, and more commonly, the diurnal demand profile and consumption volumes over time which allow for trend analysis. While permanent DMA infrastructure promotes long-term informed decision-making, it can come at great cost and thus, a temporary DMA monitoring solution is often favoured as a logical initial step to test performance. Temporary measures typically consist of insertion or clamp-on type flow meters that are relatively inexpensive to implement, but may sometimes be unable to reliably measure the MNF as a result of very low flow velocities (below technology detection limit). Accordingly, as DMAs become smaller in size, reliable data becomes increasingly difficult to obtain.

Inspired by previous work of the National Research Council (NRC) and the City of Ottawa,^{5,6} HydraTek developed a mobile testing unit that accurately and reliably measures MNF at a much-reduced cost over permanent DMA infrastructure. Essentially, flow is rerouted on the upstream side of a closed valve and through the mobile

unit which houses an inline flow meter and pressure reducing valve (PRV), before connecting back to the system and into an isolated DMA as illustrated in **Figure 2**. In addition to measuring low MNFs, the mobile unit can directly test the effectiveness of pressure reduction on leakage reduction through control of the PRV. This feature does not exist in other temporary metering solutions or permanent DMAs which only include flow monitoring capabilities. Directly measuring the correlation between pressure and leakage provides the municipality with data unique to the local situation (evidence), reducing uncertainty and promoting evidence-driven decision-making.

Project Structure & Schedule

Project participation involves four components as defined below, and each participating municipality will receive individual results and recommendations for each of its test sites in addition to the overall results generated at the end of the project.

The project runs from 2019 to 2021, with testing being undertaken during two seasonal periods to avoid inconsistent water use over irrigation months:

Period 1: c. October 2019 to c. May 2020

Period 2: c. October 2020 to c. May 2021

Inaugural Mobile Unit Deployment

After receiving funding approval from IESO in late February of this year, successful assembly and testing of the mobile unit was conducted for functionality and performance verification. Around this time, a municipality retained HydraTek & Associates to design and implement a permanent pressure management area

(PMA) for a selected sector of their system consisting of old metallic pipe and suffering from a higher than average history of watermain breaks. While studies show that numerous system characteristics influence leakage (e.g., pipe age, material, diameter, system pressure, etc.), no reliable site-specific data was available upon which to justify, from an evidence-based perspective, the appreciable investment of a PMA. This presented itself as the perfect opportunity to showcase the intended purpose and application of the mobile testing unit, and so, the project's first test site was established. The mobile unit set-up is shown in **Figure 3**.

Over the first two nights, flow was collected to determine a consistent and reliable value for the MNF, a key performance indicator for leakage in the study. The established MNF along with DMA characteristics, such as the number of residential units and ABD, were assessed to compare against preliminary benchmarking metrics developed from previously tested sites by HydraTek as well as other industry resources (**Figure 4**). In addition to establishing the MNF, the system pressure was reduced on nights three and four through control of the PRV. This allowed for an approximation of the effectiveness of pressure reduction on leakage reduction and, therefore, energy conservation for the municipality.

From these results, it is evident that the tested DMA's departure from the conceptual MNF frontiers (approximations for healthy systems) is notably higher, indicating the potential for realizable water and energy savings should

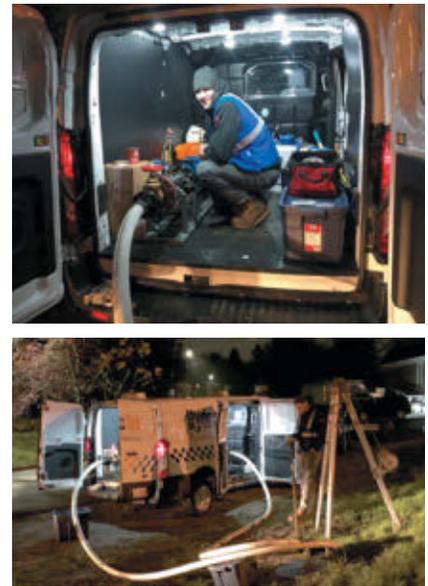


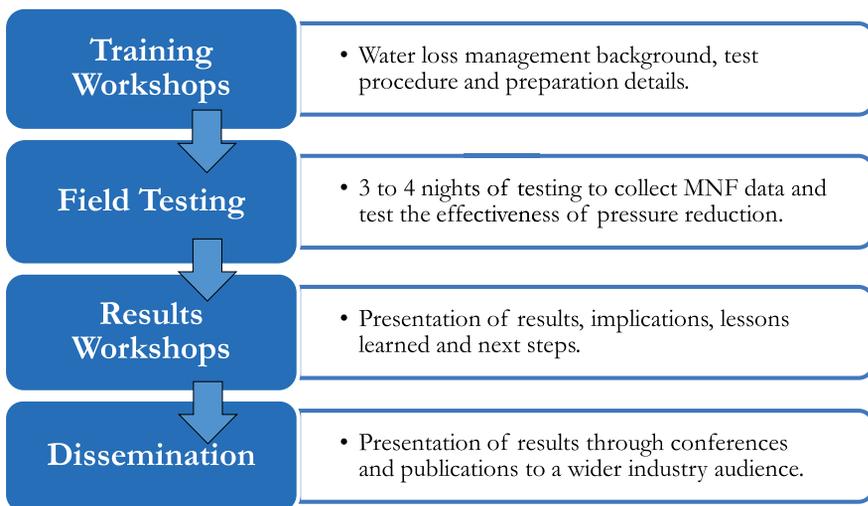
Figure 3. Case Study Photographs: Mobile Unit Interior (left); and Connection Set-up (right)

system improvements be implemented. **Table 1** below summarizes estimates for energy and financial savings based on the benchmarking results. Furthermore, there are additional benefits associated with pressure management that accrue and should be considered in investment decision-making. Particularly, employing pressure reduction has the effect of lowering stress on watermain pipes and appurtenances through both lower operating pressures (obviously) and the significant dampening and/or elimination of dynamic pressure fluctuations, including hydraulic transients. Accordingly, the business case can be enhanced by accounting for the future reduction in leaks and pipe breaks associated with this practice.

Quite importantly, the testing demonstrates the value in using a reliable temporary monitoring solution, such as the mobile testing unit, as an approach with logical progression toward supported investment decisions from the collected data (evidence). As it relates to the overall success of the project, the results from this test site, as well as from the remaining locations, will strengthen benchmarking metrics and performance indicators available to the industry as a whole in order to better inform investment decisions.

Participation

Funding is available to support up to 20 testing locations and, although some of



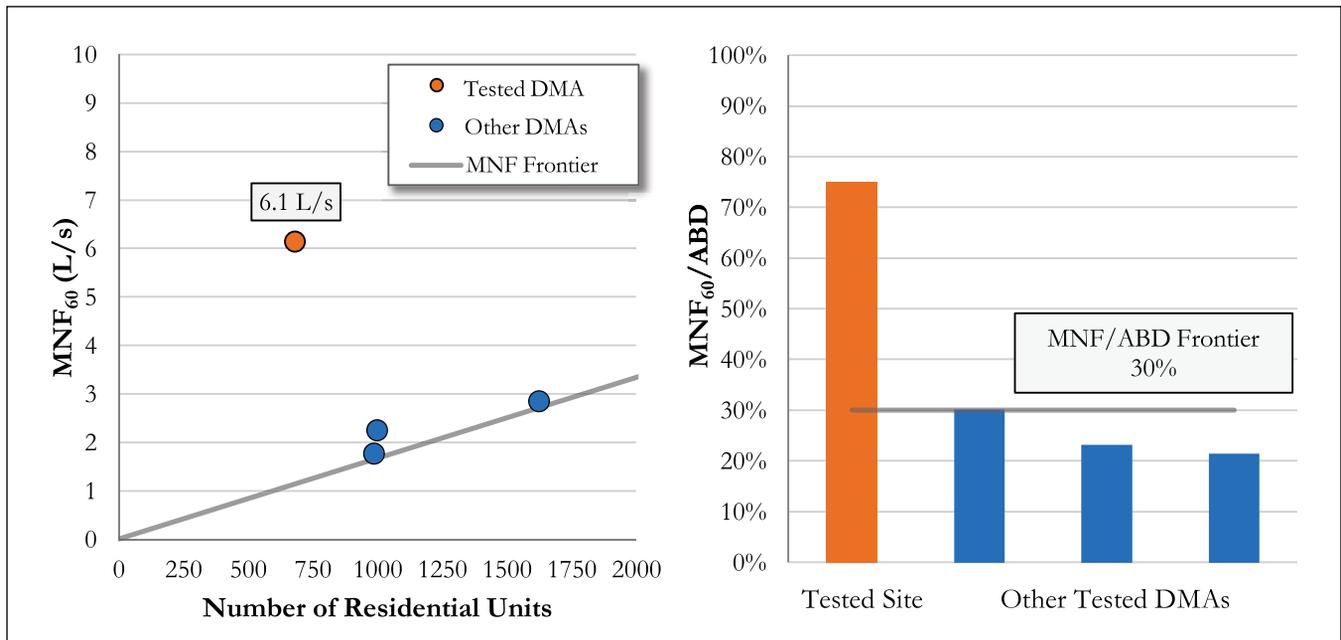


Figure 4. Case Study Results: MNF plotted against DMA Size (left); and the Ratio of MNF to ABD (right)

Table 1. Summary of Case Study Results

Test Results Assessment	Overall Potential Recoverable Leakage	Estimated Recoverable Leakage from Pressure Reduction Only*
Estimated Leakage Recovery	1.25 L/s or 75 L/min	0.52 L/s or 31 L/min
Energy Consumption Reduction**	27,000 kWh/y	12,000 kWh/y
Equivalent Annual GHG Emissions***	1.1 tonnes of CO ₂ /y	0.5 tonnes of CO ₂ /y
Financial Savings (due to reduction in bulk water purchases)	\$121,000/y	\$45,000/y

* Pressure in the DMA maintained above 40 psi.

** Based on an average wire-to-water pumping energy consumption estimate of 4,000 kWh/Mm³/m.⁷

*** Based on national findings.⁸

this allocation has been granted to early supporters of the project, there remain opportunities for interested municipalities to participate. Participation involves in-kind contributions in the form of operator support in preparation for, and during, testing as well as a financial contribution that is considerably less than the cost of such testing outside of the project. Although the results of the program will be summarized in a report to be made available for public consumption, the individual municipality results will remain anonymous.

Expressions of interest in participation are welcome!

Acknowledgements

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