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Water Loss Reduction—Experiences and Practices

Ilir ABDULLAHU[1], Andrin KËRPAÇI[2],

1. Department of Engineering Construction and Infrastructure, University of Business and Technology, 10000 Prishtina, Republic of Kosovo

2. Department of Hydraulic and Hydro-Technique, Poly-Technical University, 1001 Tirane, Albania

Abstract: Water utility Prishtina (2000km network) distributes water for city of Prishtina, capital of Kosovo, with 500,000 inhabitants. Regional Water Company except the capital of Prishtina, it also supply water to other municipalities: Fushe Kosovo, Drenas, Kastriot, Podujeva, Lipjan, Gracanica, cities which are situated in the central part of the Republic of Kosovo but there is a high amount of water losses (Non-Revenue Water—NRW)—50% of the produced water is lost. There is also lack of rainfalls and climate changes in this part of Balkan Peninsula and Kosovo is facing lack of rainfalls in the last three years and having high temperatures. RWC "Prishtina" has increased alarming on reduction of water losses and at the same time organizing awareness campaigns for saving drinking water. Water loss can be totally avoided but can be managed in order to stand within economical limits. Interest on water loss has come to a focus during the last decade. Water loss in percentage is higher in developing countries comparing to development countries, but the problem is the same: Creation of a Data Monitoring Area (DMA)—Monitoring and evaluation of DMA, assessing further steps on reduction of non-revenue water (NRW), Monitoring of pressure in the zones with high pressure by setting automatic pressure regulator, and Rehabilitation of water supply network in DMA as result of high losses and the age of distribution network. What are benefits of water network rehabilitation?

Key words: Flow, pressure, water losses, Data Monitoring Area (DMA), non-revenue water (NRW).

1. Introduction

Prishtina is the capital city of the Republic of Kosovo, being located at the edge of fertile Highland close to the Silver Mountains. Like Ulpiana it has a convenient geographical position since it is located at the intersection of continental primary roads. Such a geo-strategic position made Prishtina go through many significant historical events.

The city has two rivers which are now dried out (covered with concrete channels). It is surrounded by a hillock crown by Veternik and Matiqan on the southern part, the green wood of Germia in the east and Dragodan (Arberia) in the west.

Prishtina has an average elevation above sea level of 585 to 600 meters. It has a mild continental climate. It is mainly with hot (climate) days and fresh mountain nights.

The current Prishtina, based on relevant ancient data, used to be one of the three important cities of Dardania (as Kosovo used to be called): Justiniana Prima, Justiniana Secunda (Ulpiana) and Justinopolis.

Prishtina was created by the Roman emperors with Ilirian origin born in Dardania-Justiniani (527-565).

Therefore, its name evolves for centuries to Justiniana, Istriana, Istrina, Pri+Istrina, and finally was called Prishtina.

In the middle ages, there was a "rafinatio argenti" in Prishtina, where volumetric and quality treatment of silver was done because mines were close to Novo Berdo (Artana) and Trepça.

In the 17th century, the city bloomed with economical development. It was considered as an inhabitation with more than 3, 000 inhabitants.

Corresponding author: Ilir ABDULLAHU, Ph.D., research fields: water and environmental management, civil engineering. E-mail: ilir.abdullahu@ubt-uni.net.

Now Prishtina is seen as a beautiful and modern city, combined with characteristic traces and features from ancient Illyrian, Roman, Byzantine, and Ottoman cultures.

On the treasure inherited for centuries there is a combination of diverse architectonic buildings: mosques, hamams, churches, monasteries, libraries, museums, etc.

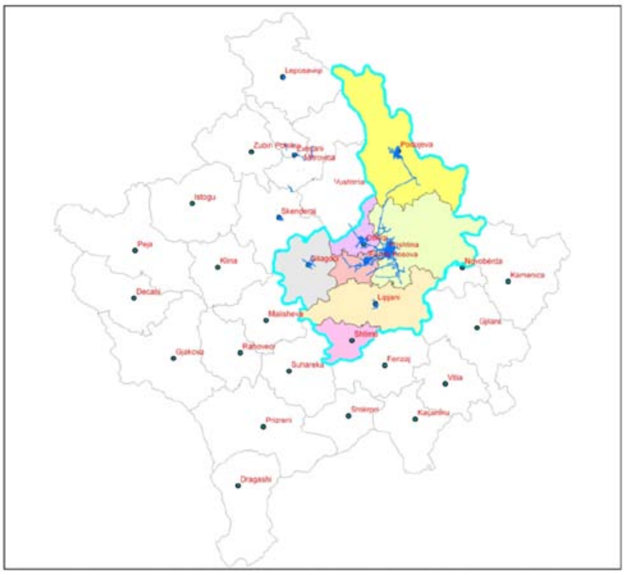


Fig. 1 The approximate covered area with water supply and sewer services incorporated in the map of the Republic of Kosovo is shown in the graph below. This area is bordered with blue line and it contains 8 municipalities located in central Kosovo.

2. Water Loss in General

Water loss = water produced – water consumed.

Water loss occurs in all distribution systems, but the volume of loss varies. This depends on the characteristics of the pipe network and other local factors, the water company's operational practice, and the level of technology and expertise applied to controlling it. With the demands of growing populations, however, realization of the limits on our natural resources and increasing costs form regulations and customer demands have made it increasingly unrealistic to allow water loss to be ignored. It is now evident that the world's water suppliers have not only a need to reduce and manage their losses, but also have the methods and technology to do so effectively. Therefore, water losses in all water supply firms should be minimized as a target in the water distribution networks. Water losses cannot be completely avoided, but they can be managed so that they remain within economic limits. The problems associated with water loss are numerous. High real losses indirectly require water suppliers to extract, treat, and transport greater volumes of water than their customer demand requires. Leaks, bursts, and overflows often cause considerable damage and inflate liability for the supplier. It is evident that reducing water loss would not only improve water supply operations, but would also result in increased revenue. Sound water loss management, therefore, usually generates a direct and rapid payback to water utility. For the vast majority of water distribution systems, leakage is something which cannot be eliminated completely. There will always be a level of leakage which has to be tolerated, and which has to be managed [1-2].

Traditionally, several different performance indictors to compare water losses, percentage of system input volume or metered water ratio, and per km of mains per day, appear to be the most common. However, these are reliable indicators for comparing performance. Some countries use "per property per day", or "per service connection per day", or "per kilometer of system (main plus services length) per day". The IWA Task Force on Water Losses, with nominated representation from the American Water Works Association, has been considering best practice internationally, and their conclusions strongly suggest that there are more reliable and meaningful performance indicators than percentage of system input and per km of mains [2].

3. Types of Water Losses

The International Water Association (IWA) defines two major categories under which all types of supplier water loss occurrences fall.

3.1 Real Losses

It is the physical escape of water from the distribution system including leakage and overflows prior to the point of end use. i.e., water lost for the distribution system through leaks, tank overflows, or improperly open drains or system blow-offs.

3.2 Apparent Losses

It occurs at the customer destination and penalizes the water supplier at the retail cost—a rate usually much higher than production cost. Water reached a customer or other end use (including beneficial and unauthorized use) but is not properly measured or tabulated. It is essentially “paper” losses and consists of customer use, which is not recorded due to metering error, incorrect assumptions of unmeasured use, or unauthorized consumption.

4. Data Monitoring Area (DMA)

4.1 Purpose of DMA

In large distribution pipe networks, water is often provided by more than one source. This type of system is called an open system. In this type of system, if pipes of network are interlinked, then water from each treatment plant of these sources will mix up and there will be a continual change in system pressure as well as quality of water. Thus, in this type of system, NRW requires knowledge of the precise places where water losses occur, therefore, it is a difficult task to pinpoint them in large networks. Reasons for the necessity of DMA are mentioned in Table 1.

4.2 DMA Survey

A site test survey should be undertaken to identify and map the pipes for their alignment, type of material, size, and length. Such a survey helps to locate pipes and valves that are not on record. This survey is also undertaken to determine the number of consumers, road names, and sources of supply. The objective of this survey is to check the status of the sluice valves-whether they are closed, open, or set for any flow.

4.3 DMA Planning

At the planning stage, one should have knowledge of the entire pipe network. Maps must be accurate. Provisional boundaries should be shown. All of the hydraulic data should be available. Essentially, the following criteria should be met:

(1) Ideally, each DMA should have one source.

(2) Inflow and outflow of every DMA should be measured by bulk meters.

(3) All boundary valves (except DMA inlet valves) must be closed permanently.

(4) Good pipe records should be maintained.

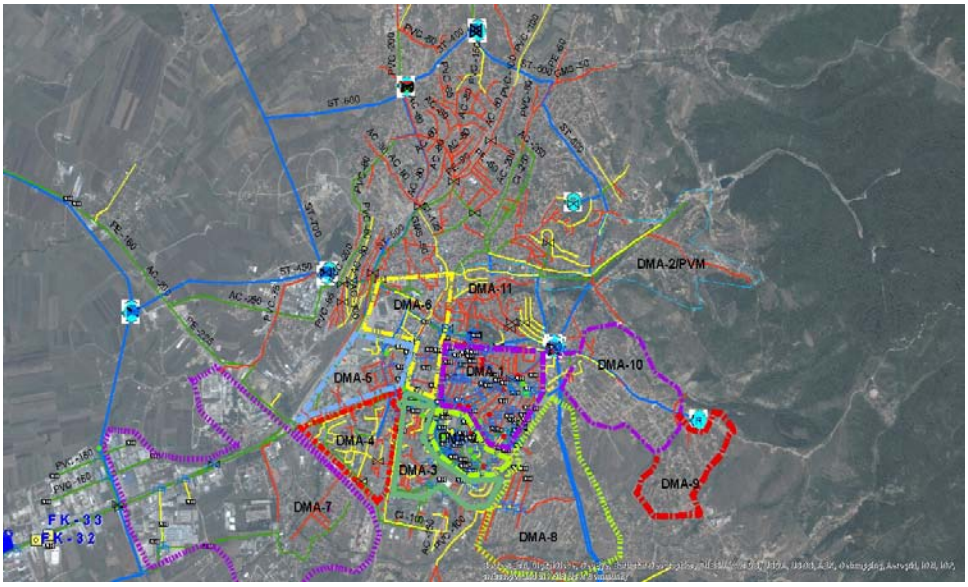


Fig. 2 All landforms with different colors show the zone boundary of DMA in Prishtina city. There are 11 DMAs existing and others are in the process.

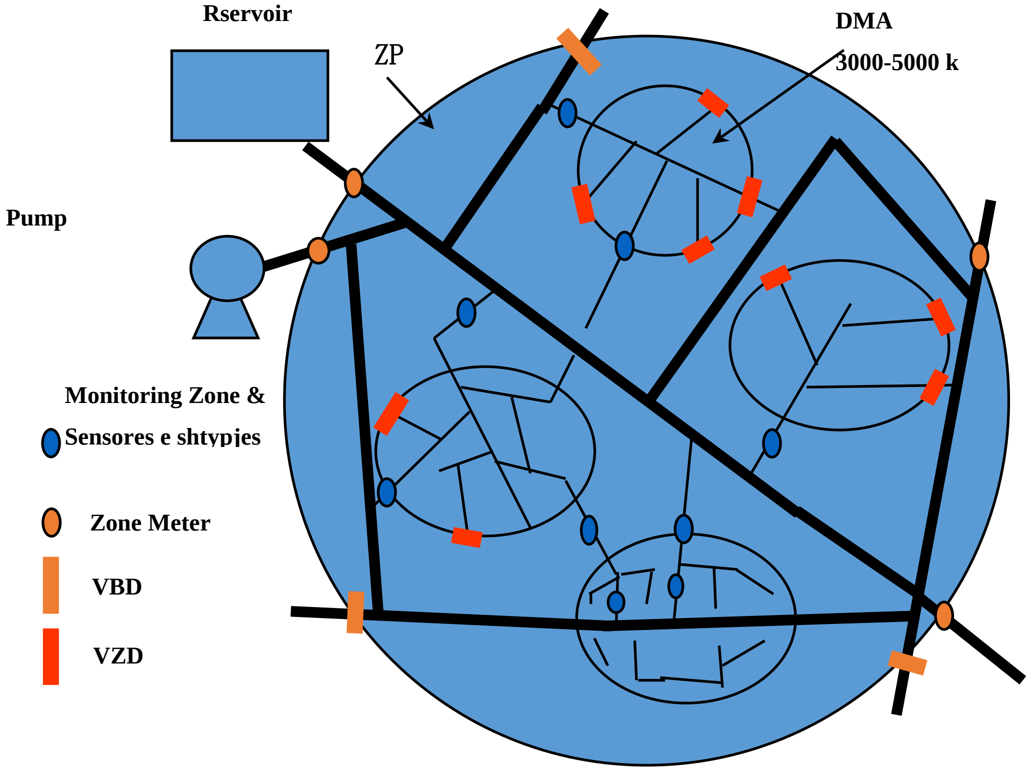
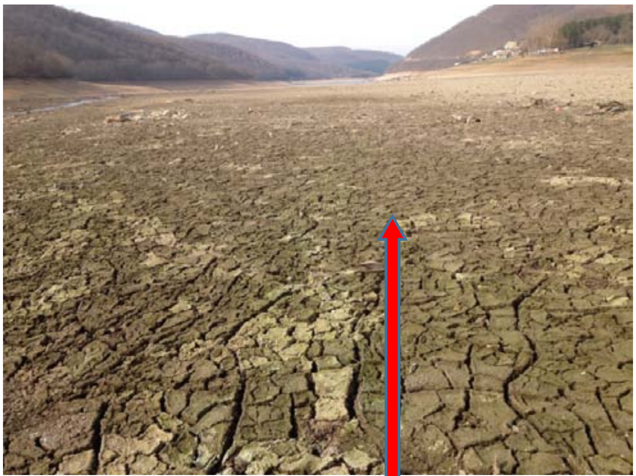


Fig. 3 Standard schematic structure of the DMA.



Picture 1 Batllava Lake in February, 2014.

Picture 2 Batllava Lake in April-2014.

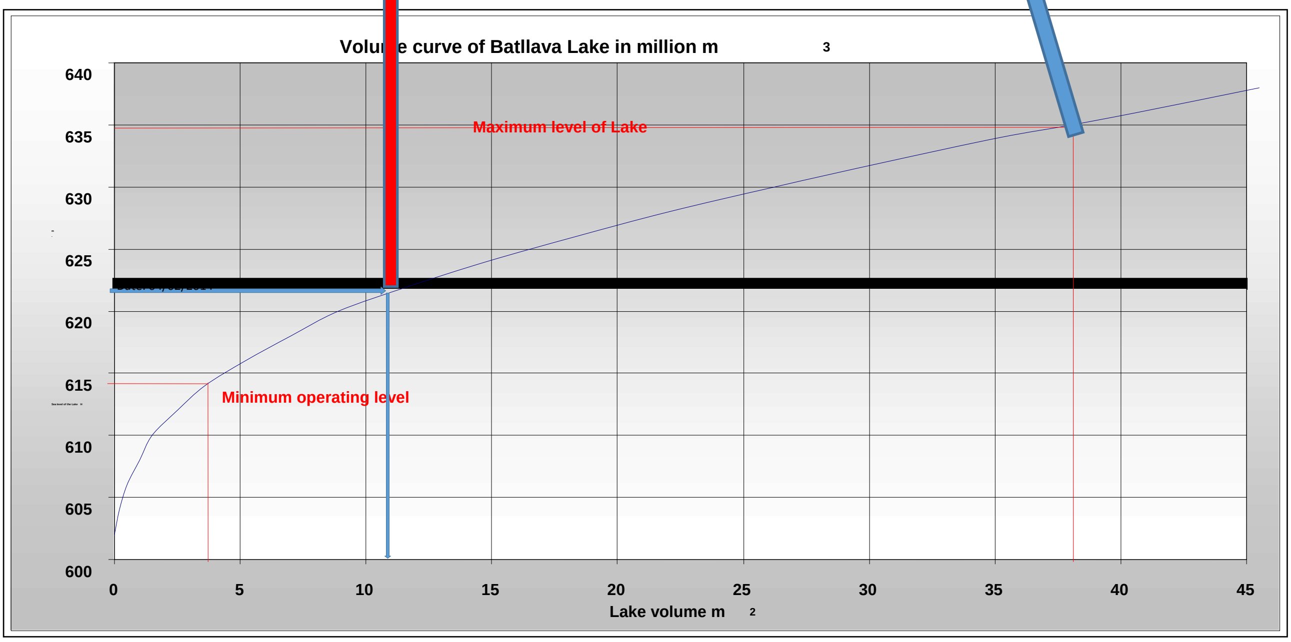


Fig. 4 Presentation of water reservoirs in emergency situations for drinking water supply, where as result of climate changes in Prishtina, there are also minimum levels of the accumulations of superficial Lakes Batllava and Badovc. Reserves till the minimum level of operation were approximately 10MI/m3 with water supply for only 4 more months.

Results from ZMD, in monitoring of measurements zones of the district in urban areas, where after analysis and leak repair, the Company decides that there is an urgent need of rehabilitation of networks as reparations have higher costs than replacement of network, so that with our own funds, with grants and loans we are in the implementation phase and we believe that after these investments there will be minimum physical losses and regulation of a sustain hydraulic parameters. The following photo and analysis show the situation of distribution networks.

Pictures (3, 4, 6) represent the pipes which do not fulfill the required standards, therefore, the manufacturers are causing loses to the companies and the consumers. Picture 5—The newest type of pipes, resistant to damages during placement in the trench.

Picture 7 and 8 represent the corroded steel and galvanizes pipes.

Picture 3 Presentation of Plan—Setting of DMA Prishtina City

Table 1 Reasons for necessity of DMAs.

SN	Before DMA	After DMA
1	Flows could be measured only at water treatment plants and at district boundaries.	Flows can be measured continually at all entry points of DMAs. Flows and pressure can be logged at DMA meters.
2	There was insufficient knowledge of the water distribution network.	Hydraulic knowledge of the water distribution network is improved. With DMA meters, head loss around the system can be ascertained as fixed continuous reference points. Thus, performance of the network model is improved.
3	There was limited ability to prioritize the leak repairs program	Analysis of DMA data is available, which helps to prioritize leakage detection and repair programs.
4	Leakage control was passive. It was reactive, as only visible leaks were removed.	Leakage control is active. Even invisible leaks and bursts are identified and repaired in a timely manner.
5	The system could not give feedback on results. Thus, the morale of the leakage operator was quite low.	DMA data gives good feedback and helps to keep staff updated regarding the effects of leak repairs. Thus, the morale of the staff is high.
6	There was no control of flow observation.	DMA meters allow leakage engineers to find the minimum night flow, which helps to reduce the leakages.

Picture 3 HDPE PIPE PE 100 PN-10

Picture 4 HDPE PIPE PE 100 PN-10

Picture 5 HDPE PIPE PE 100 PN-10 RC PAS 1075

Picture 6 HDPE PIPE PE 100 PN-10

Picture 7 Water leakage from the steel pipes

Picture 8 Galvanized pipe inside the building

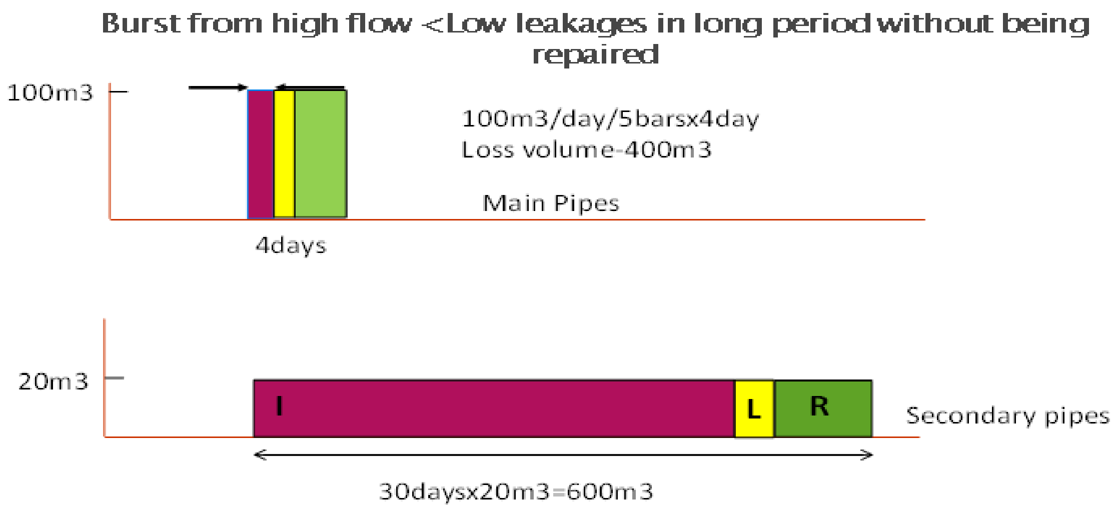


Fig. 5 The influence of leak runs time on leakage levels [3].

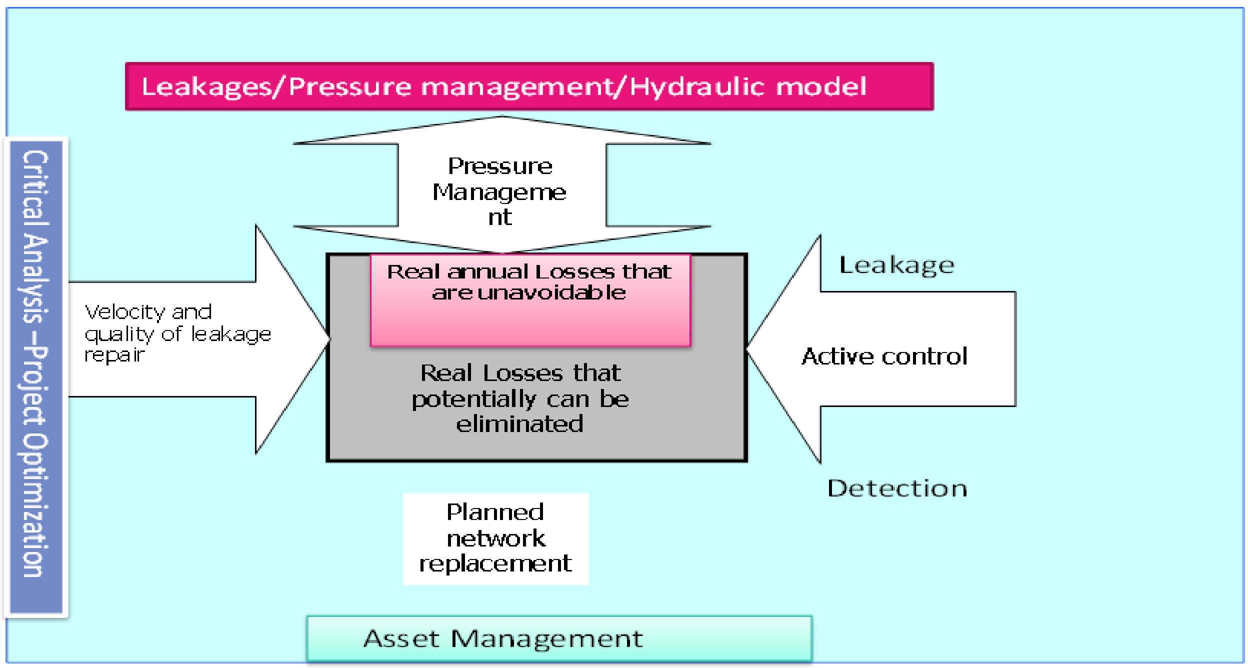


Fig. 6 The four basic methods of managing real losses [3].

Leaks and breaks on customer service pipes can run for several weeks, and even months, before they are repaired. Consequently, although the flow rate from any burst may be relatively small, the total volume of leakage from customer supply pipes is usually a significant proportion of the total leakage. Fig. 6 illustrates the difference between awareness, location, repair times and the relative volumes lost, from high flow/short duration and low flow/long duration leaks. The former is typical of a burst distribution main, which would normally be repaired or shut off immediately. The latter is typical of a service pipe leak, which, if underground, could go undetected for months.

Size of ZMD: ZMD may be small or big, depending on the number of connections. Usually a typical ZMD has 500 up to 3000 connections. Smaller ZMD has an advantage because location of leakage or bursts can be localized faster. In this way, the reaction time (awareness, location and reparation) is improved and duration of leakage is short.

Depending if ZMD is part of a project for water supply in a rural or urban area, the size may change.

For example, number of connections in rural zones can be smaller than in urban zones where there is more inhabitants' concentration. Size of ZMD depends also from natural borders as roads, rivers and main water supply pipes.

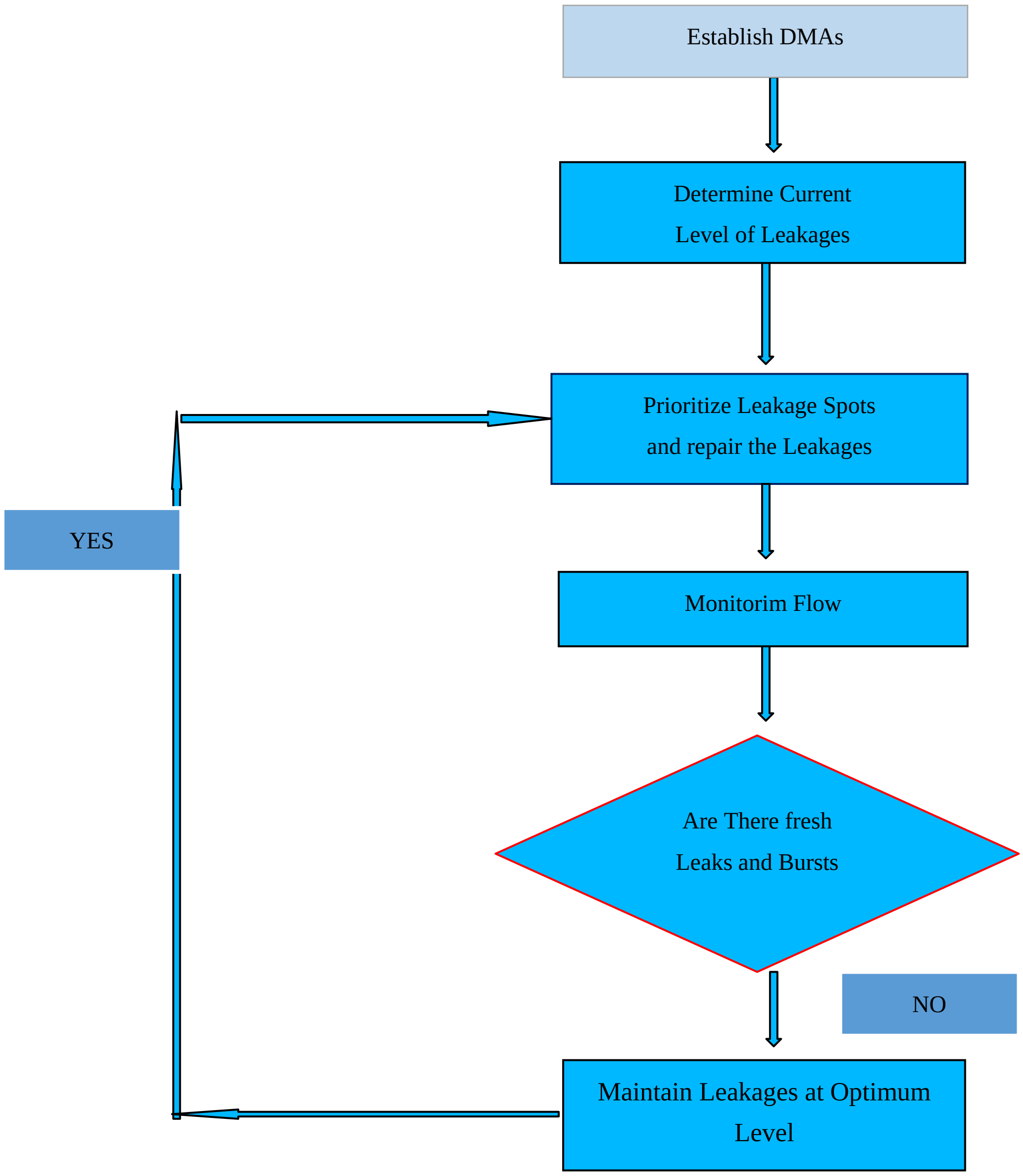


Fig. 7 Algorithm (steps) of determining flow level and reparations.

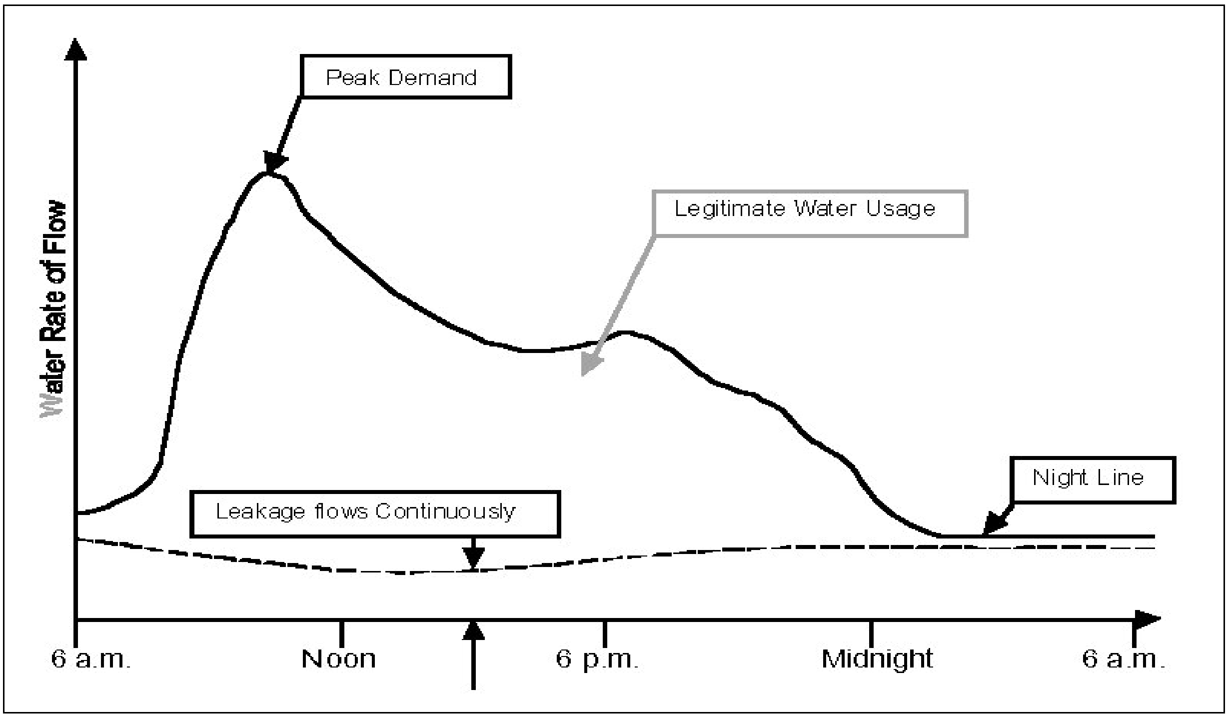


Fig. 8 Typical Dta Flow Profil.

5. Pressure Management

Water Supply in developing countries throughout the globe and in many cities in the industrialized world faces the mutual problem on water loss. There is a clear relation between pressure, losses and cracks occurrences. As the pressure is high, losses are higher and also the number of cracks in pipes. Thus, reducing pressure is an effective method in the cost and reduction of leakages, and reducing cracks in pipes is more important.

Further below we will present our field work in the pilot zone at one of the town districts named "Kolovica". The water supply network in this district was one of the highest pressure zones of the town and consequently we had very high water loses.

Figures presented below show the initial effects prior and after the setting of the valve for reducing pressure PRV.

Table 2 Zone information (Zone Name: Kolovica Small Area Measurement).

No. of Domestic Properties	**150**	nr
No. of Non-Domestic Properties	**5**	nr
Total No. of Properties	155	nr
No. of Service Connections	**150**	nr
Length of Mains	**3**	km
Connection Density	50	nr/km
Background Losses @ ICF = 1.0	1.16	l/conn/d/m
Domestic Consumption at Minimum Night Flow	**3.00**	l/conn/hr
	0.13	l/s
Non-Domestic Consumption at Minimum Night Flow	**3.00**	l/conn/hr
	0.00	l/s

Table 3 First baseline data (4/12/14, Thursday).

Time of Minimum Night Flow	**4:00**	
Pressure at Minimum Night Flow	110	Mh
Minimum Night Flow	1.78	L/S
Consumption at Minimum Night Flow	0.13	L/S
Total Losses at Minimum Night Flow	1.65	L/S
Infrastructure Condition Factor	**5**	
Background Losses at Minimum Night Flow	0.61	L/S
Burst Losses at Minimum Night Flow	1.04	L/S

Table 4 Second baseline data (8/12/14, Monday).

Time of Minimum Night Flow	4:00	
Pressure at Minimum Night Flow	58.10	mH
Minimum Night Flow	0.80	l/s
Consumption at Minimum Night Flow	0.13	l/s
Total Losses at Minimum Night Flow	0.67	l/s
Infrastructure Condition Factor	5	
Background Losses at Minimum Night Flow	0.59	l/s
Burst Losses at Minimum Night Flow	0.09	l/s

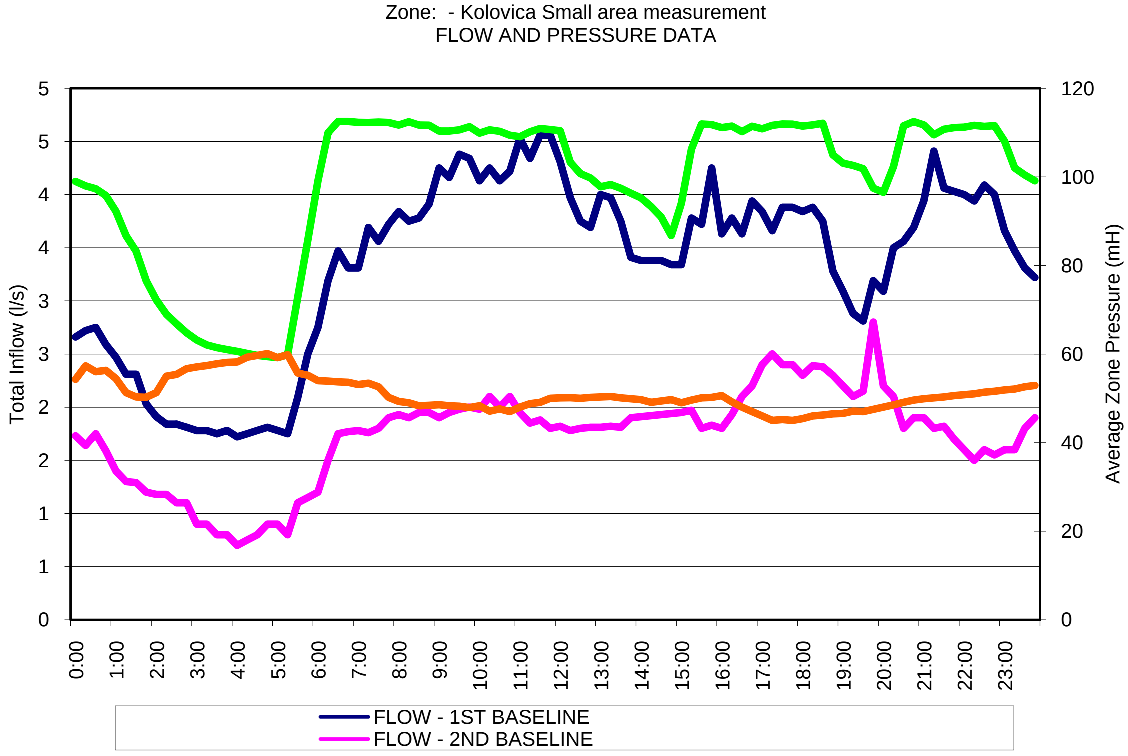


Fig. 9 Blue line represents leakages in the respective zone before installation of the RPV and magneta line represents leakages after installation of the RPV. Green line represents pressure in the respective zone before installation of the RPV and orange line represents leakages after installation of the RPV.

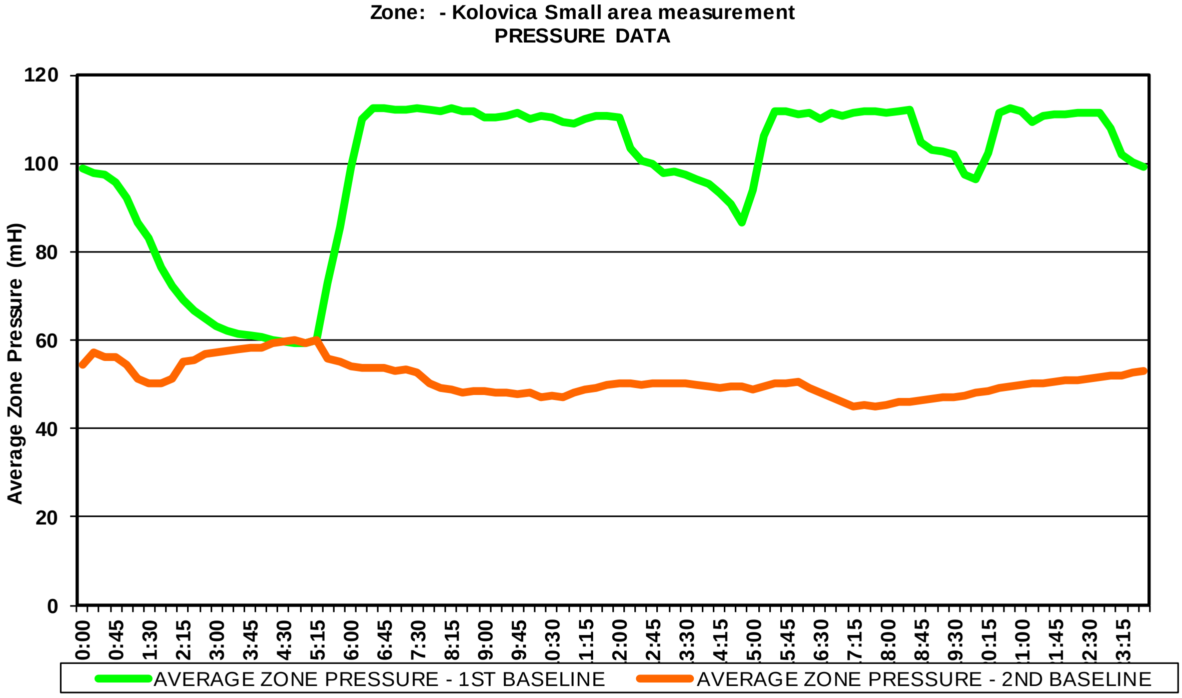


Fig. 10 Green line represents leakages in the respective zone before installation of the RPV and brown line represents leakages after installation of the RPV.

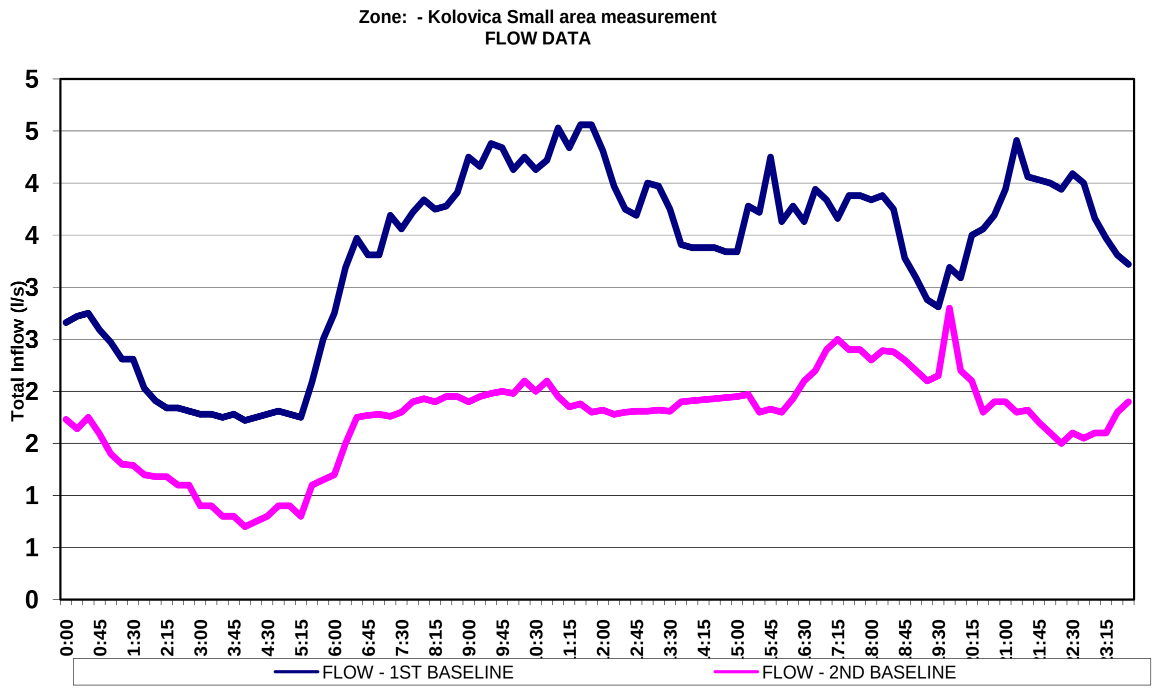


Fig. 11 Blue line represents leakages in the respective zone before installation of the RPV and magneta line represents leakages after installation of the RPV.

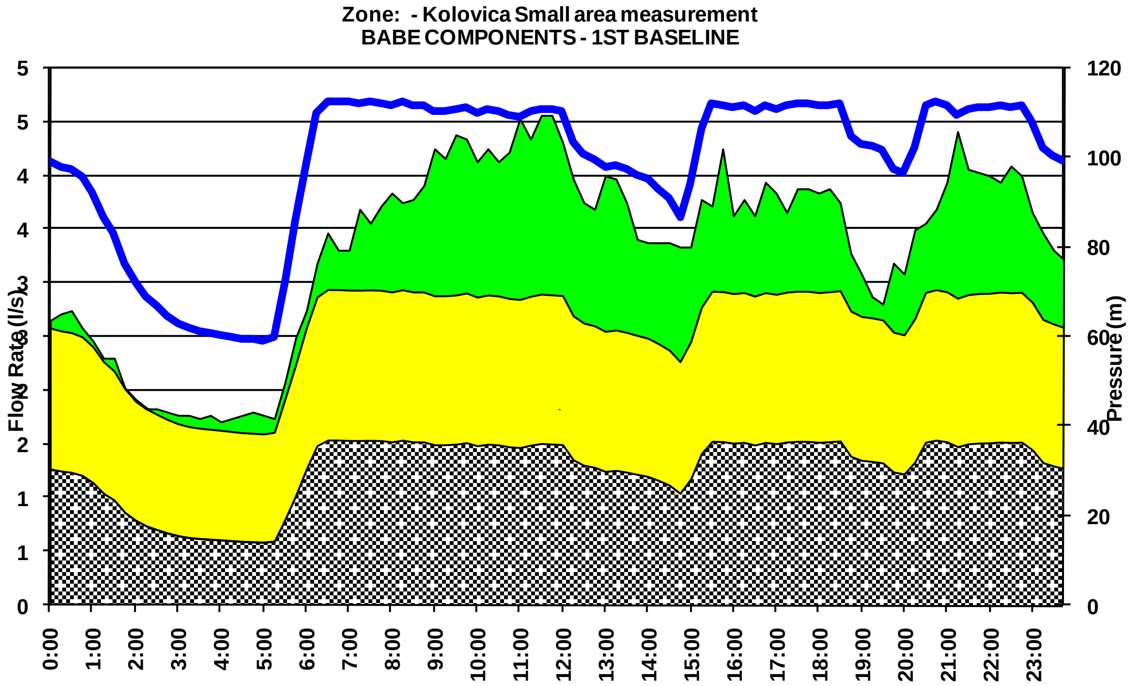


Fig. 12 Gray layer represents unidentified losses, yellow line represents physical losses, green line represents consumption.

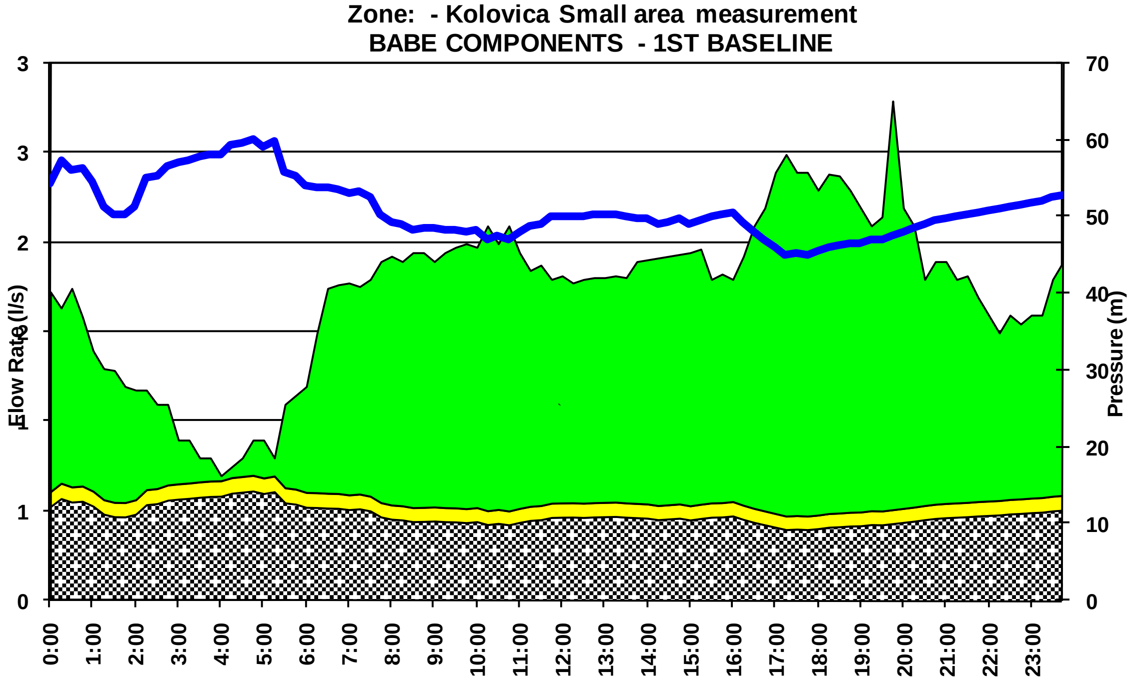


Fig. 13 Layers represent reduction of water losses and consumption after installation of the RVP.

Table 5 Water balance according to IWA.

Water Balance in m3 for a period of 365 Days				
Home System Input Volume 37,555,000 [m3] Error Margin [+/-]: 5.0%	Authorized Consumption 19,102,000 [m3] Error Margin [+/-]: 0.0%	Billed Authorized Consumption 19,102,000 [m3]	Billed Metered Consumption 19,102,000 [m3]	Revenue Water 19,102,000 [m3]
			Billed Unmetered Consumption 0 [m3]	
		Unbilled Authorized Consumption 0 [m3] Error Margin [+/-]: 0.0%	Unbilled Metered Consumption 0 [m3]	Non-Revenue Water 18,453,000 [m3] Error Margin [+/-]: 10.2%
			Unbilled Unmetered Consumption 0 [m3] Error Margin [+/-]: 0.0%	
	Water Losses 18,453,000 [m3] Error Margin [+/-]: 10.2%	Commercial Losses 6,458,781 [m3] Error Margin [+/-]: 20.7%	Unauthorized Consumption 5,765,832 [m3] Error Margin [+/-]: 22.7%	
			Customer Meter Inaccuracies and Data Handling Errors 692,949 [m3] Error Margin [+/-]: 36.7%	
		Physical Losses 11,994,219 [m3] Error Margin [+/-]: 19.2%		

6. Conclusion:

RW "Prishtina" sh.a after the war had a very high NRW approx. 75% but thanks to the dedicated engagement and development of the strategy for reduction of water losses, by applying methodologies of the developed Countries has managed to reduce water losses to 49%, with further objectives to reduce the water losses to 35%. This will be achieved by applying the efficient DMA and monitoring the water pressure and rehabilitation of networks covering whole service area. Real challenge will be the indoor water supply networks of the residential buildings due to the very old networks of more than 50 to 60 years, galvanized pipes are continuously increasing level of corrosion and the consumption is expected to increase for our customers, global climate changes are negatively influencing the existing low water resources forcing us to invest in any possible way to reduce water losses and use of our water resources in a more efficient manner.

Acknowledgements

I would like to express my deepest gratitude to department of water loss detection at RWC, Pristina; for their tireless work on site (Kolovica area). This would have not been possible without their professional work on this field.

References

[1] M. Farley, S. Trown, Losses in water distribution networks: A practitioner's guide to assessment, monitoring and control, London: IWA, 2003.

[2] M. Farley, G. Wyeth, The Manager's Non-Revenue Water Handbook, Ranhill Utilities Berhad and USAID, 2008.

[3] Z. Wu, M. Farley, D. Turtle, Z. Kapelan, J. Boxall, S. Mounce, Y. Kleiner, Water Loss Reduction, Exton, PA: Bentley Institute, 2011, p. 198.