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Reduction of the technical losses component of the NRW in water networks in Sultanate of Oman

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ABSTRACT

This paper discusses challenges and solutions to reduce non-revenue water (NRW) and unaccounted for water in water networks in sultanate of Oman by reducing the technical losses. Water supply system is one of the essential subjects for the governments and people in the main cities or rural villages, the water utilities must ensure continuous supply of clean and safe water in distribution with sufficient flow and adequate pressure with minimum failures. The world witnesses many instances of people lacking access to this essential commodity. (Water Partners Jp Co., 2017). This paper highlights the main issues, problems and solutions in water networks which are related to the water technical losses in NRW. Public Authority for Water (PAW/DIAM) is responsible for providing the potable water in all people in Oman as per the international standards. Reducing the water losses in the networks is one of the main challenges in Public Authority for Water. This paper is discussing the successful used methods and technologies in PAW to reduce the technical losses by 33,000,000 cubic meter in 2017 (DIAM, 2017). There are achievements in reducing the losses by controlling and managing the pressure in water networks. There are improvements in updating the specifications and standards of pipes rapiers and installations. Also the leak detection teams in PAW have used advanced technologies to find the invisible leaks in the water networks. The rehabilitation of old pipes is a major factor to reduce NRW. Finally, as a result of the done works in 2017, there are recommendations to ensure the reducing of water losses to reach to the acceptable level of non-revenue water in future.

Keywords: Pressure management; Leaks detection; Pipes rehabilitations; District metering area

1. Introduction

The Public Authority for Water (PAW/DIAM) is responsible for providing drinkable water to all people in Oman. In this paper, we will focus on the methods and tools which caused the reduction of non-revenue water (NRW)/unaccounted for water (UFW) by getting and analyzing the collected data to detect the root causes of main problems with its solutions. This paper attempts to document the experience gained in reducing NRW using best international practices and methodologies. The total number of customers in PAW/DIAM is more than 500,000 in 12 zones with total length of about 18,000 km. The paper will cover and study the main used techniques (DIAM, 2018).

Potable water system has many complicated components such as desalination plant, pumping stations reservoirs, tanker filling stations, networks, and other water supply system components. It is very important to have good monitoring and controlling system to ensure the continuity of supply.

The water supply networks vary in age from old and new systems, and also in terms of water production sources: desalination plants or groundwater wells. In the network, there are many pumping stations and tanker filling stations depending on the needs of the area for the flow and pressure. The PAW supply network serves both domestic and non-domestic costumers.

Based on the IWA, the water supply system components can be divided into authorized consumption and water losses (Fig. 1). NRW consists of the water losses and the unbilled authorized consumption. The water losses are divided to two main categories which are the commercial losses and the real or technical losses. This paper is discussing the technical components to reducing NRW (Bill Kingdom, 2006).

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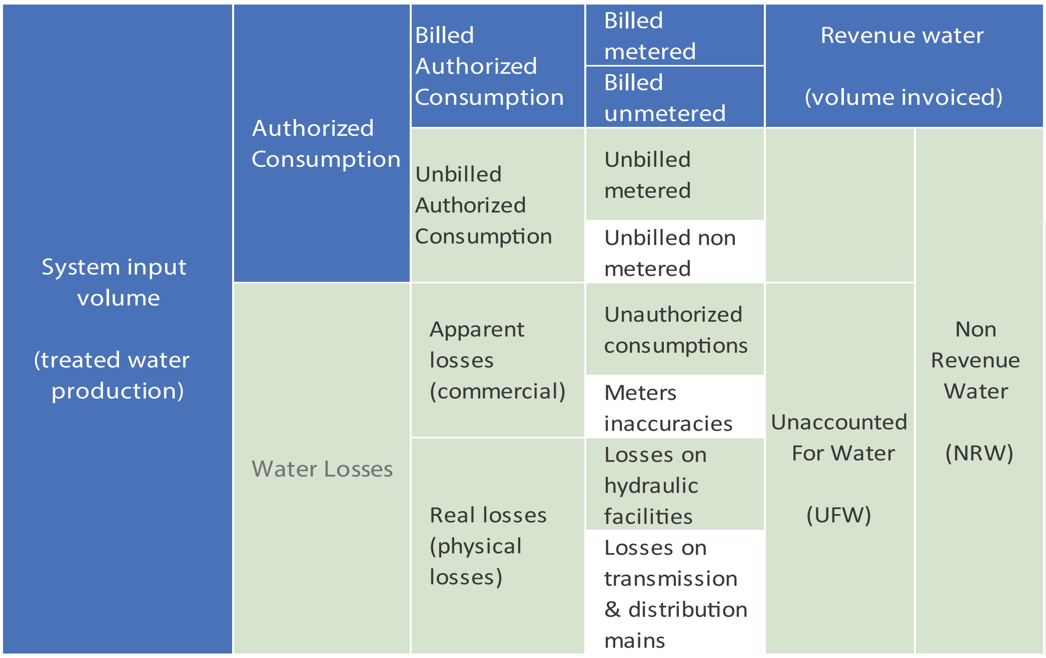


Fig. 1. Non-revenue water standard (International Water Association).

2. Discussion

Global water demand is largely influenced by population growth, urbanization, food and energy security policies, and macro-economic processes such as trade globalization, changing diets and increasing consumption. By 2050, global water demand is projected to increase by 55%, mainly due to growing demands from manufacturing, thermal electricity generation and domestic use (UN Water, 2015).

Water Utilities understands the urgency of NRW management. Reducing NRW is one of the critical steps to help cities and countries meet future demands. It is common now to witness big water shortage in cities around the world, sometimes even to cut supply to an entire city due to drought, demand, climate change, population growth, etc. Water Utilities now face tough challenges to ensure sustainable water supply. Maintaining a low NRW is top priority for water utilities. However, achieving low NRW is not an easy task.

According to the International Water Association (IWA), the main parameters for reducing NRW (Fig. 2) are active leakage control, pressure management, networks rehabilitations, and speed and quality of repair (LAMBERT, 2003), the typical losses in water supply system as technical and commercial are shown in Fig. 3 from the production to billing collection (Malcolm Farley, 2011). In this paper, we will show the detailed implementation of each one with more initiatives from the operation teams in public authority for water in Oman.

2.1. Reduction of NRW in Oman (PAW/DIAM)

In 2017 Public Authority for Water (DIAM) has achieved great results of reducing NRW. The water losses reduced from 118.2 to 84.6 million cubic meters with reduction of 33.6 Mm^3. the percentage reduction was from 35.86% to 24%.34 with reduction of 11.5% (Fig. 4). Also although the continuous increase in the number of customers each year, there is reduction in production percentage in 2017 comparing with the previous years which mean there is effective controlling of water losses (Fig. 5). These impressive results have been achieved by using very effective techniques, methods and technologies which will be discussed in this paper.

The water supply system in Oman as shown in Fig. 6 consists of production sites from desalination plants or wells, the pumping station, the transmission lines, tanker filling stations, reservoirs and networks. One of the great achievements in PAW is creating 250 district metering areas (DMA). The DMAs are monitored continuously by SCADA systems (Fig. 7), so in case of any abnormal consumption of water in any area, the system is alerting the operators to take the required actions for investigating the issues.

2.2. Leak detection team's tools and equipment in PAW/DIAM

There are 12 professional teams for leak detection in the public authority of water using advanced equipment, tools and systems for discovering the invisible leaks in the networks as following:

The ground microphones, correlators, listening sticks and the system for monitoring the flow and pressure in the networks are shown in Fig. 8. There is also in Fig. 9 an example of noise loggers' system for leak detection by analyzing the sound in the pipes and data analysis system in Fig. 10.

2.3. Installation standards and quality of repair

Updating the standards and specifications is essential to improve the performance, the following example Figs. 11 and

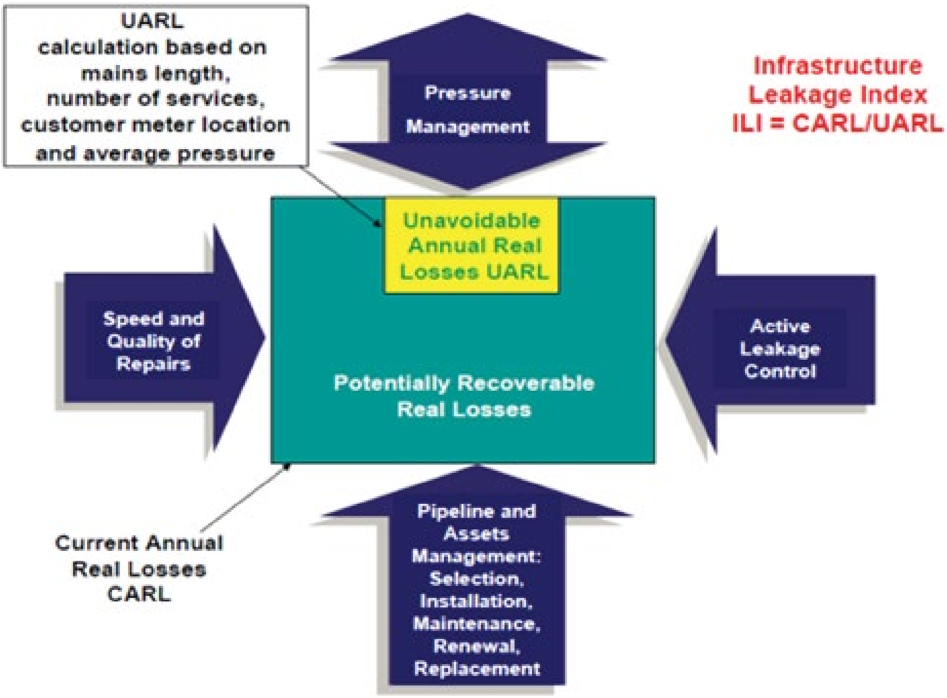


Fig. 2. IWA standard for reducing NRW/water technical losses.

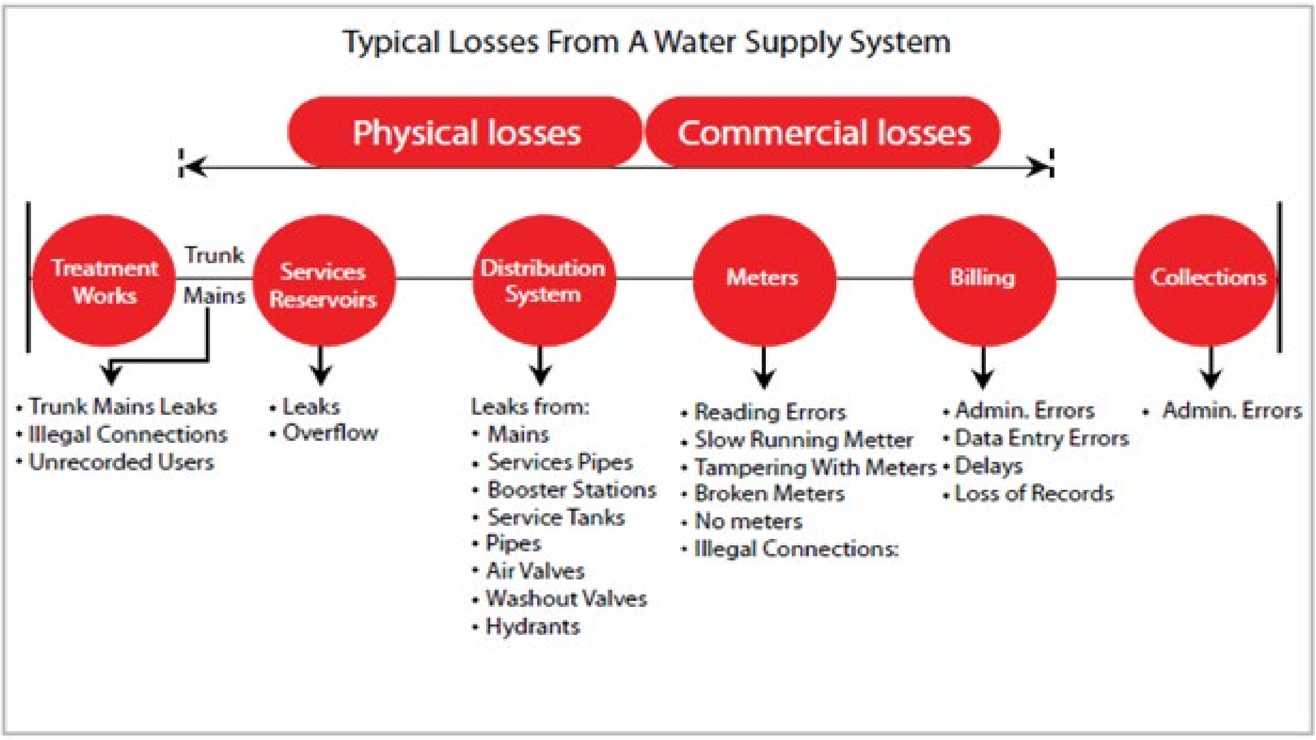
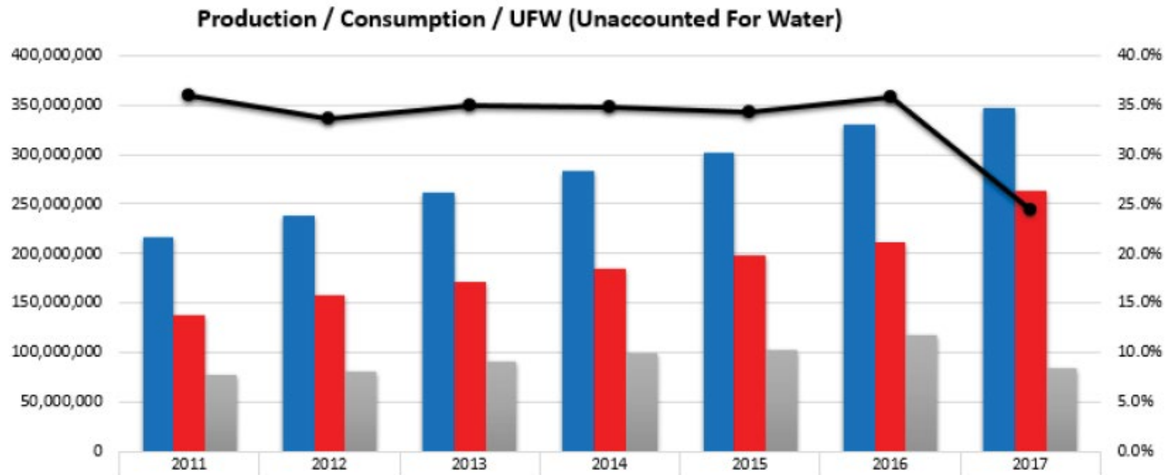


Fig. 3. Typical losses in water supply system.



	2011	2012	2013	2014	2015	2016	2017
Production	215,900,000	238,200,000	262,199,120	283,135,760	301,008,112	329,787,928	347,684,307
Accounted Consumption	138,290,000	158,010,000	170,609,120	184,625,760	197,668,112	211,522,119	263,051,772
UFW	77,610,000	80,190,000	91,590,000	98,510,000	103,340,000	118,265,809	84,632,536
UFW%	35.9%	33.7%	34.9%	34.8%	34.3%	35.86%	24.34%

Fig. 4. Production, consumption and UFW/NRW in Public Authority of water (DIAM) in Oman.

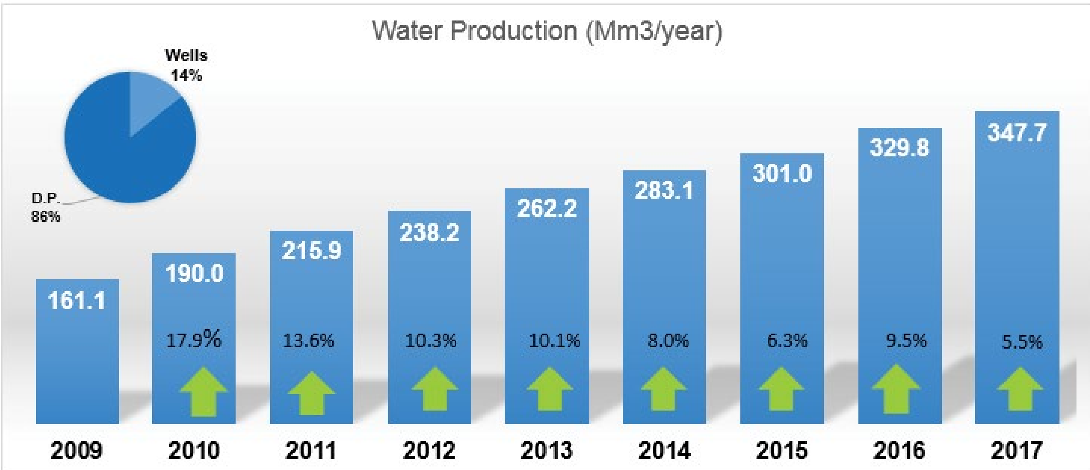


Fig. 5. Water production increasing in Oman.

12 is updating the standard of house connections to reduce the leaks.

2.4. Pressure management

The pressure is the first factor which causes leaks and breakdown in water networks, so it is very important to keep the pressure in the system within the best range, in PAEW many pressure reducing valves have been installed recently, the results were great and direct in the number of leaks and the losses of water (Figs. 13 and 14).

2.5. Pipes rehabilitation

In all water networks, the renewal and rehabilitation is continuous process, because the pipes have operating life, after the period pipes start deteriorating and break finally (Fig. 15).

The basis of pipes rehabilitations should be based on technical data analysis such as the number of leaks, age of the networks and the operation pressure (Fig. 16).

2.6. Leaks reasons

The major factors of technical losses are the leaks in the networks, the main identified reasons are as following:

- High pressure
- Age of the pipes
- Poor quality of materials
- Poor quality of installation
- Wrong storing of the materials

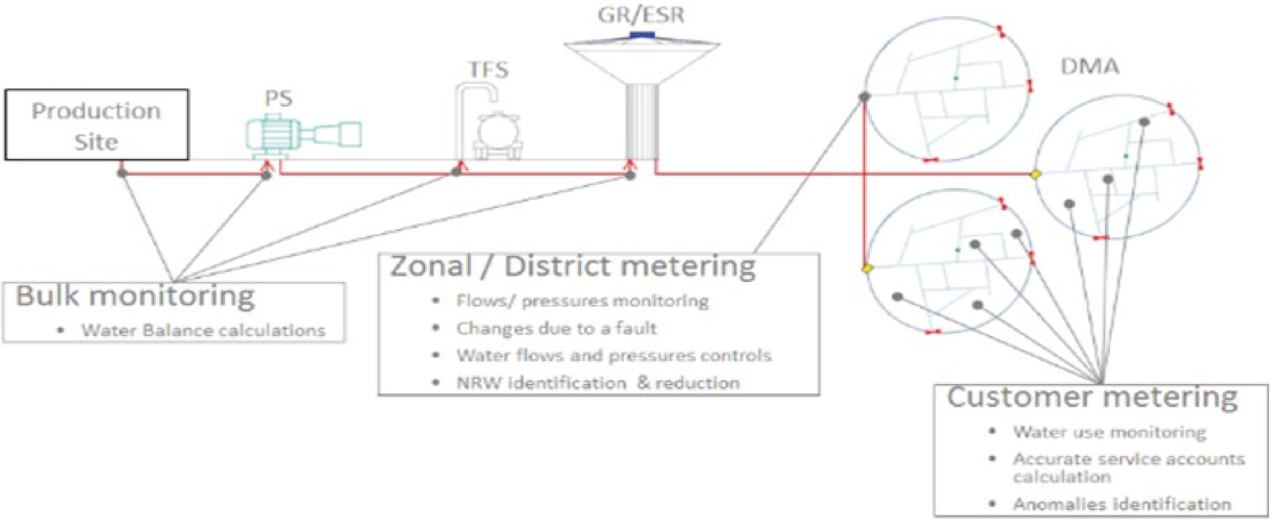


Fig. 6. Water supply system in Oman.

Fig. 7. PAW/DIAM SCADA system.

- Wrong selection of the materials
- Wrong design (no hydraulic modeling)
- Wrong operation
- Poor maintenance
- Water quality
- Corrosion
- Soil condition and load

2.7. Main factors of reducing technical losses

The main identified factors of reducing the leaks and increasing the operational performance are as following:

- Improve networks designs
- Improve installation standards and quality of repair

Sr.	Tool & Equipment Name
1	Correlators
2	Ground Microphone
3	Listening sticks
4	Metal Detector
5	Plastic pipe Detector
6	Pressure Transducer
7	Pressure Gauge
8	Insertion probe flow meter
9	Clamp on flow meter
10	Noise loggers
11	Pressure Data loggers
12	Flow Data loggers
13	Helium gas detector
14	Softwares

Fig. 8. Used leak detection tools and softwares.

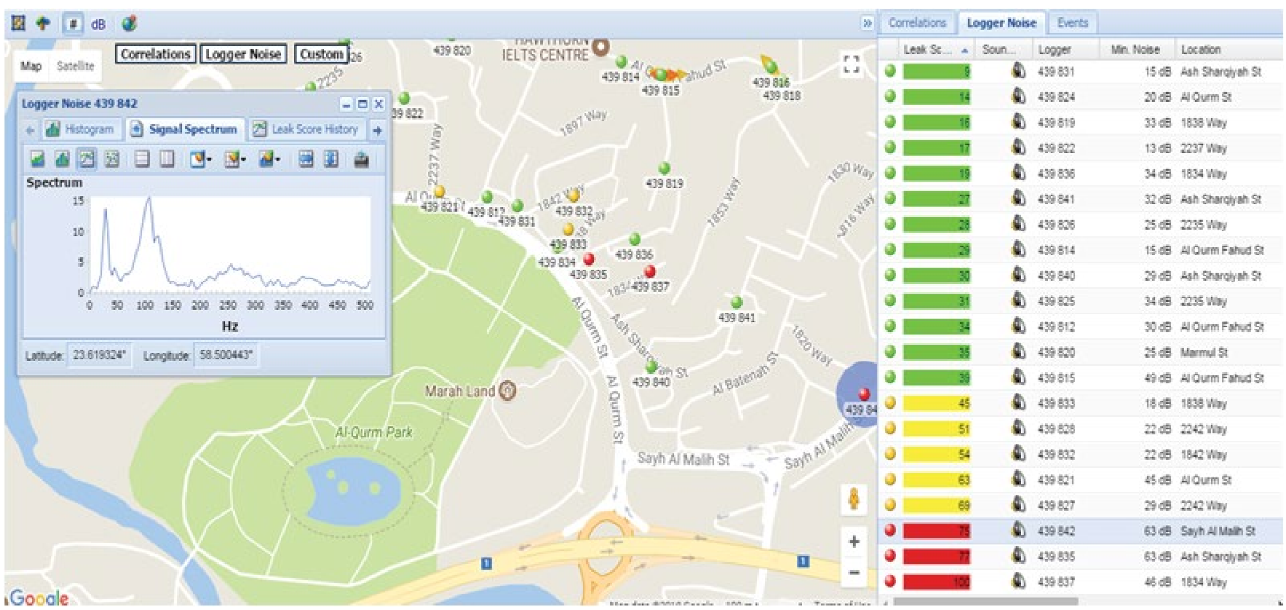
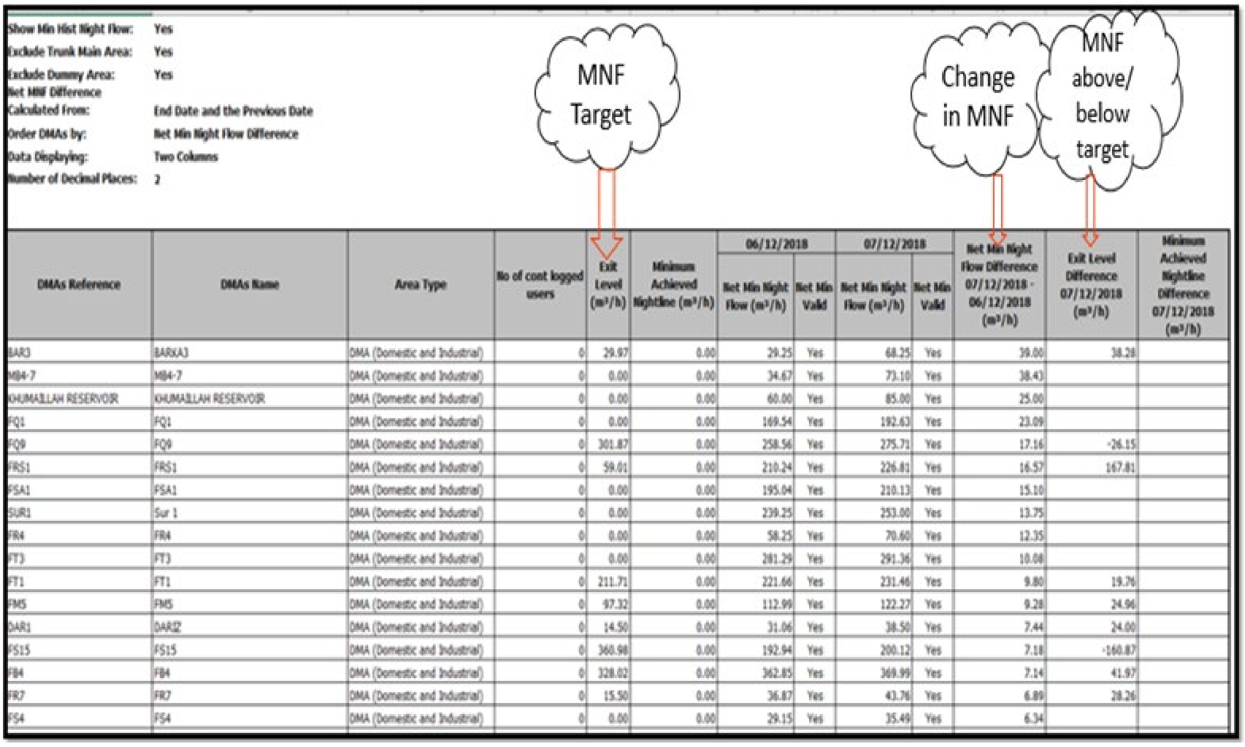


Fig. 9. Leak detection system for noise loggers.



Show Min Hist Night Flow:	Yes
Exclude Trunk Main Area:	Yes
Exclude Dummy Area:	Yes
Net MNF Difference Calculated From:	End Date and the Previous Date
Order DMAs by:	Net Min Night Flow Difference
Data Displaying:	Two Columns
Number of Decimal Places:	2

DMAs Reference	DMAs Name	Area Type	No of cont logged users	Exit Level (m³/h)	Minimum Achieved Nightline (m³/h)	06/12/2018		07/12/2018		Net Min Night Flow Difference 07/12/2018 - 06/12/2018 (m³/h)	Exit Level Difference 07/12/2018 (m³/h)	Minimum Achieved Nightline Difference 07/12/2018 (m³/h)
						Net Min Night Flow (m³/h)	Net Min Valid	Net Min Night Flow (m³/h)	Net Min Valid			
BAR3	BARKA3	DMA (Domestic and Industrial)	0	29.97	0.00	29.25	Yes	68.25	Yes	39.00	38.28	
MB4-7	MB4-7	DMA (Domestic and Industrial)	0	0.00	0.00	34.67	Yes	73.10	Yes	38.43		
KHUMAILLAH RESERVOIR	KHUMAILLAH RESERVOIR	DMA (Domestic and Industrial)	0	0.00	0.00	60.00	Yes	85.00	Yes	25.00		
FQ1	FQ1	DMA (Domestic and Industrial)	0	0.00	0.00	169.54	Yes	192.63	Yes	23.09		
FQ9	FQ9	DMA (Domestic and Industrial)	0	301.87	0.00	258.56	Yes	275.71	Yes	17.16	-26.15	
FRS1	FRS1	DMA (Domestic and Industrial)	0	59.01	0.00	210.24	Yes	226.81	Yes	16.57	167.81	
FSA1	FSA1	DMA (Domestic and Industrial)	0	0.00	0.00	195.04	Yes	210.13	Yes	15.10		
SUR1	Sur 1	DMA (Domestic and Industrial)	0	0.00	0.00	239.25	Yes	253.00	Yes	13.75		
FR4	FR4	DMA (Domestic and Industrial)	0	0.00	0.00	58.25	Yes	70.60	Yes	12.35		
FT3	FT3	DMA (Domestic and Industrial)	0	0.00	0.00	281.29	Yes	291.36	Yes	10.08		
FT1	FT1	DMA (Domestic and Industrial)	0	211.71	0.00	221.66	Yes	231.46	Yes	9.80	19.76	
FM5	FM5	DMA (Domestic and Industrial)	0	97.32	0.00	112.99	Yes	122.27	Yes	9.28	24.96	
DAR1	DARIZ	DMA (Domestic and Industrial)	0	14.50	0.00	31.06	Yes	38.50	Yes	7.44	24.00	
FS15	FS15	DMA (Domestic and Industrial)	0	360.98	0.00	192.94	Yes	200.12	Yes	7.18	-160.87	
FB4	FB4	DMA (Domestic and Industrial)	0	328.02	0.00	362.85	Yes	369.99	Yes	7.14	41.97	
FR7	FR7	DMA (Domestic and Industrial)	0	15.50	0.00	36.87	Yes	43.76	Yes	6.89	28.26	
FS4	FS4	DMA (Domestic and Industrial)	0	0.00	0.00	29.15	Yes	35.49	Yes	6.34		

Fig. 10. Netbase system for data analysis.

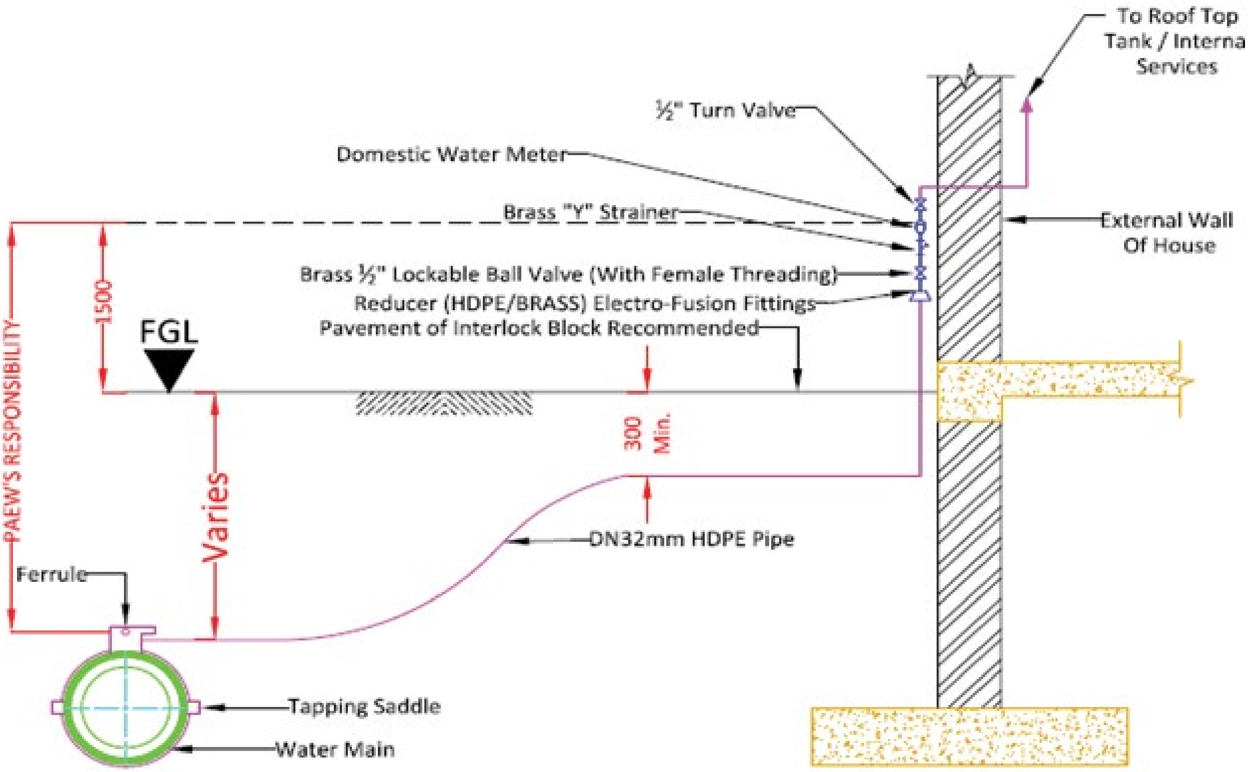


Fig. 11. Old house connection standard in PAW/DIAM in Oman.

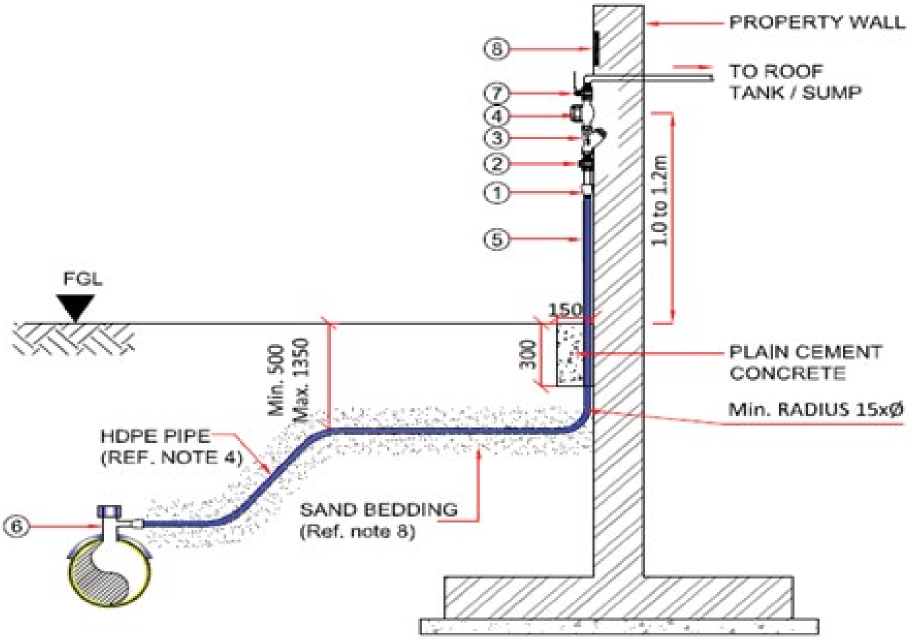


Fig. 12. New house connection standard in PAW/DIAM in Oman.

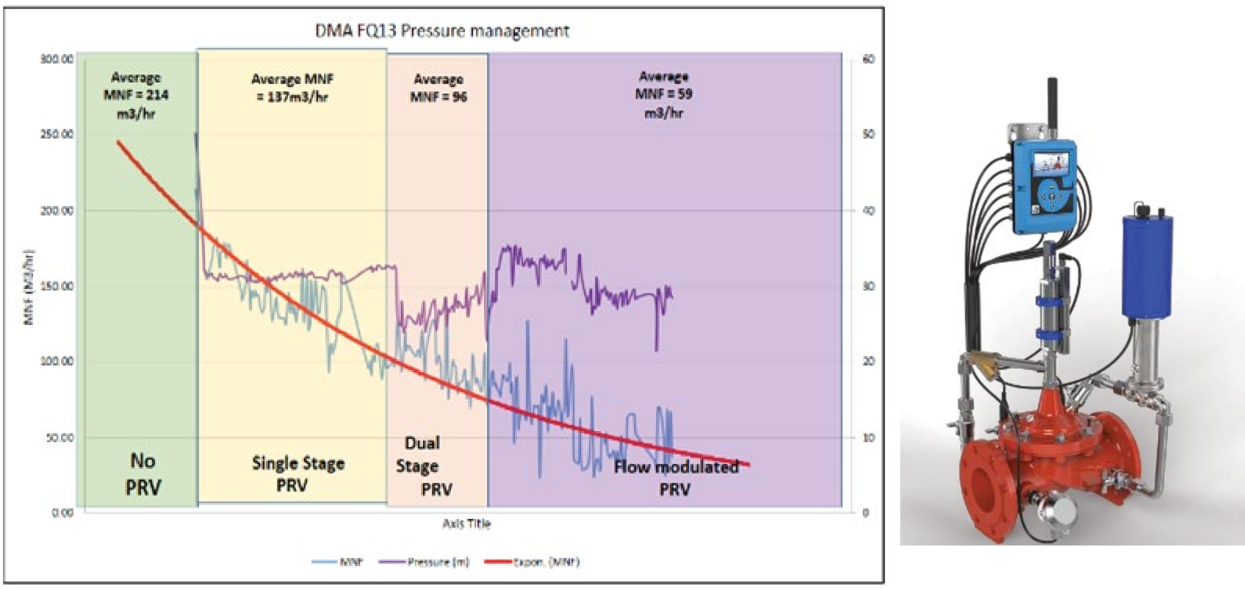


Fig. 13. Reduction in water losses by pressure management.

- Pressure management
- Pipes rehabilitation
- Improve PPM and CM
- Activate leak detections
- Improve QMS, reporting and documentations
- Improve monitoring and controlling
- Improve analyzing methods
- Introduce key performance indicators
- Using of new technologies
- Increasing the technical skills
- Improve water quality
- Create research department

3. Conclusion and recommendations

The saved amount of water in 2017 by using the shown methods and techniques to reduce the technical losses was 10,223,913 m^3/year, which caused a great achievement and reduction in NRW/UFW from 35.86% to 24.34%. PAW is continuing the initiatives and activities to reduce NRW and

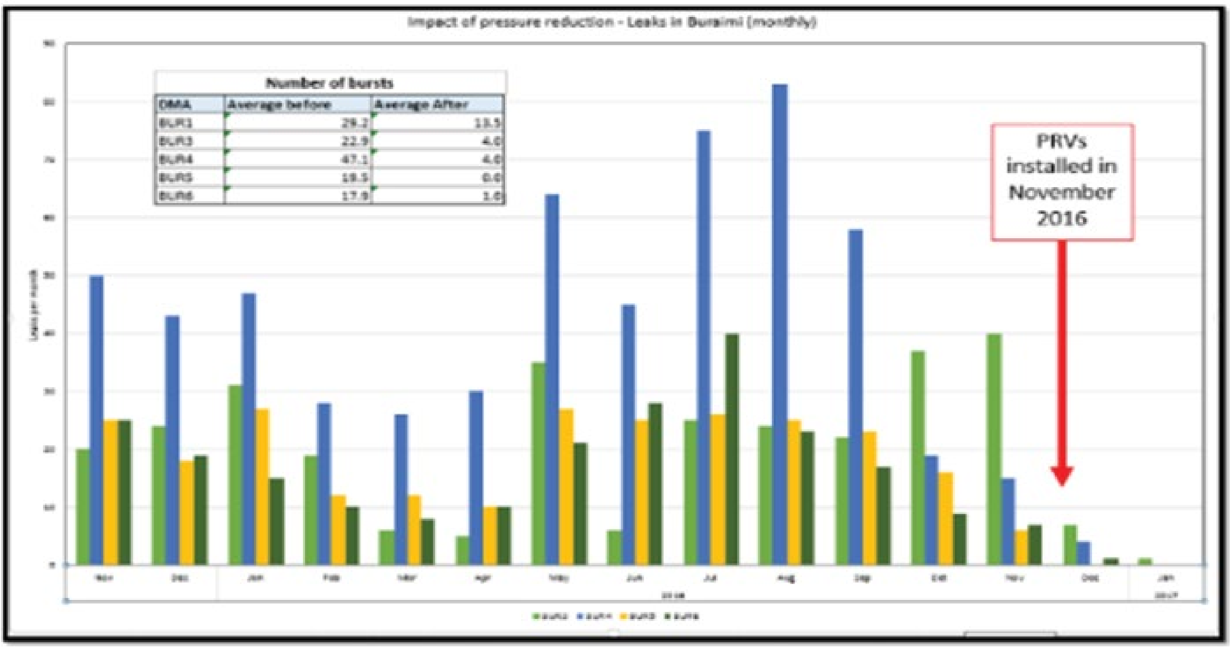


Fig. 14. Reduction in number of leaks by pressure management.

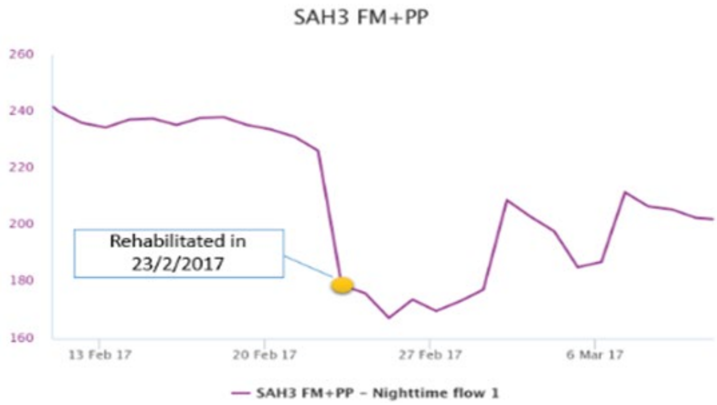


Fig. 15. Reduction in water losses by pipes rehabilitation.

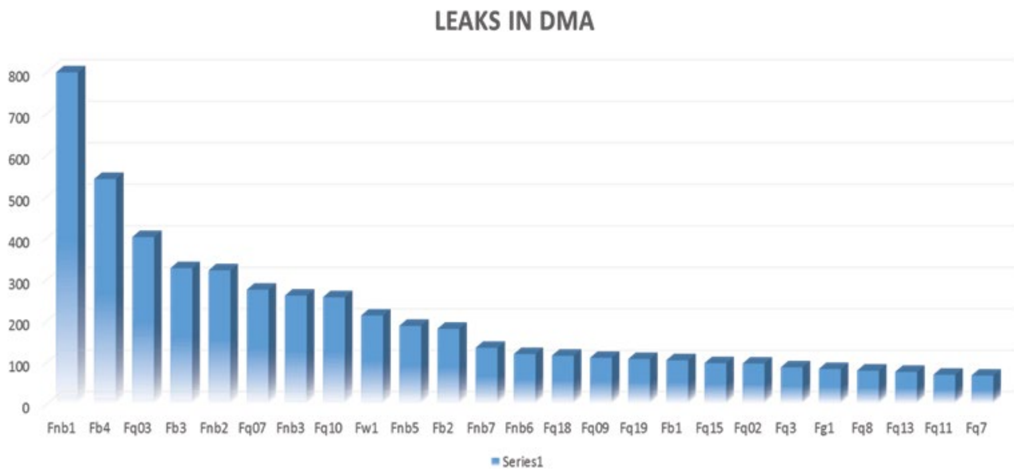


Fig. 16. Number of leaks per district metering area (DMA).

technical losses by utilizing the full capabilities of the existing tools. In parallel there are new technologies that have been implemented in 2018 such as satellite leak detection which can also enhance the work of the teams responsible about leak reduction. The most important part is to create clear action plans for reducing the water losses with detailed data analysis and following up for all areas to ensure the best results.

References

Bill Kingdom, R. L. (2006). The Challenge of Reducing Non-Revenue Water (NRW) in Developing Countries. Washington DC: Energy and Water Department (EWD) of the World Bank.

DIAM. (2017). DIAM Annual Report. Muscat: DIAM.

DIAM. (2018). DIAM NRW Reports. Muscat: DIAM.

LAMBERT, A. (2003). Assessing Non-Revenue Water and its Components: A Practical Approach. IWA Water Loss Task Force, 5.

Malcolm Farley, G. W. (2011). The Manager's Non-Revenue Water Handbook. United States: Ranhill Utilities Berhad and the United States Agency for International Development.

Water Partners Jp Co., L., (2017). Japan's Experiences on Water Supply Development. Tokyo: Japan International Cooperation Agency.

UN Water (2015). Water for a sustainable world. Paris: UN Water.