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Analysis and management of unaccounted-for water in the Ahvaz urban water distribution network (A case study of the Mahdis region) using an integrated conceptual model

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A considerable amount of water is wasted by leakage from distribution systems, resulting in major economic losses. According to assessments, on average, 28 to 50% of the water produced in Iran is not accounted. The loss of water can be identified as an apparent or a real loss. With that said, the present case study of the Mahdis region focused on developing an integrated conceptual model for analyzing and managing the Unaccounted-For Water (UFW) in the Ahvaz urban water distribution network. Drawing on the capabilities of the WaterGems hydraulic analysis model, a network of 23 nodes, 27 pipes, and a reservoir was formed with the network characteristics taken into account comprehensively. Then, assuming no leakage, the network was analyzed, and the node pressures were obtained. The results revealed eleven suspected points of leakage in the interval. According to reports from the Ahvaz Water Organization, the nodes within this interval exhibit more leakage at night -when consumption is low and hydrostatic pressure is high- due to their greater altitude difference from the reservoir relative to the other nodes. The results are suggestive of the merits of the proposed method for predicting where leaks take place in water distribution systems. Furthermore, this study investigated the impact of pressure management on the minimum night flow, the results of the investigation are suggestive that the minimum night flow decreases by reducing the upstream network pressure. Reducing the upstream network pressure curtailed the night flow by 20-50% in the network. The inflow to the network was reduced by up to 25% by adjusting the network pressure. Considering the fact that the inflow to the network is a measure of daily consumption and leakage from the network, one can conclude that not only network pressure management reduces the leakage, but also it can limit the surplus consumption. This is particularly significant as regards water demand management. Ultimately, it is safe to say that this study demonstrates the great potential for reducing the leakage and consumption in water distribution networks.

Keywords: Unaccounted-For Water (UFW), Water Distribution Network, Pressure, Leakage, WaterGems

INTRODUCTION

No water distribution system delivers the produced water entirely to the consumers for a portion of the inflow will eventually exit the system somehow. The volume of water that undesirably leaves the distribution system from cutoff valves, fittings, pumping stations, measurement apparatuses, and transmission and distribution facilities by any means is referred to as the Unaccounted-For Water (UFW) and demonstrates a flaw in the distribution network and the management system in general. The real UFW includes: Unknown leakage from the distribution network (for example from pipes or the fittings often due to being worn out), the inaccuracy of water meters, unauthorized consumption, underestimation (in cases where consumption is not measured), water meters selected with incorrect types or sizes, reading errors, and financial errors. Hence, the portion of the treated water that is not delivered to the consumers or is not paid for is regarded to as the UFW. Proper consumption management in urban water distribution networks and expanding it to the whole country is a solution to water losses and prevents this national wealth from being wasted. The UFW can be addressed from environmental, social, cultural, and economic standpoints. In this regard, given the fact that the loss of water is always a problem in urban water distribution systems, identifying its causes and contributing factors is essential so solutions can be proposed to reduce or prevent it. Supplying clean drinking water to the public, as well as the operation and maintenance of the water supply facilities and networks to meet the water demands at minimum cost, are the responsibilities of the water and wastewater handlers. Note that in any water supply system, the produced water will not be used entirely as some degree of loss is inevitable. Water and wastewater handlers are required to make their best effort to control and reduce the losses, to find leaks, and to repair them immediately and effectively. Leaks can take place anywhere in the water supply and distribution system (Tabesh et al, 2002; Araujo et al, 2003). Meanwhile, the pipelines and the distribution network are often accountable for the largest contributions to the loss of water. In some cases where preventive measures were insufficient, a total loss of 28 to 50% of the produced water was observed. Even in the best case scenarios, a 10-15% loss seems to be inevitable, and preventive actions must be in place to keep it at an economically-justifiable level (Management and Planning Organization of Iran, Issue 241). With the growing population and migration to large cities, the water supply system needs to be developed consistently, which means new sources of water must be allocated (Vela et al, 1991; Lambert, 1997).

Gemanopoulos (1985) proposed a model considering the relationship between pressure and leakage in the network. Assuming a uniform distribution of leaks along the pipes, he expressed the leakage in every pipe as follows:

(1) $_{\chi}(P_{ij}^{av})^{1.18}\ Q_{Lrij}=C_{\chi}\ L_{ij}$

Where *QLij* is the outflow of water by leakage from each pipe, and *C* is a constant dependent on the network specifications with a direct relationship with the type and durability of the pipe. *Lij* is the length of the pipe, and *Pij* represents the average pressure along the pipe.

Vela et al., (1991) formulated a more complex leakage equation:

(2) $_{\chi}\ D_{ij}^{d}\ _{\chi}\ e^{ar}(P_{ij}^{av})^{1.18}\ Q_{Lrij}=CL_{ij}$

Where the power *d* is 1 for small diameters (up to 125 mm) and -1 for larger ones, *a* is the temporary failure deformation adjustment parameter, *Dij* is the pipe diameter, and *r* is the age of the pipe. Relying on the geyser function of the EPANET hydraulic analysis package, Burrows et al. (2003) proposed the following relation:

(3) $QL_{r}MNF=Cu[\sum_{i=1}^{NJ} Nci.P_{i}^{N}]$

QLMNF represents the leakage at minimum night flow, Cu is the rate of leakage in every 1 m pressurized node, Nci is the number of bifurcations entering the node i, and N denotes the pressure power. in this method, Cu is obtained through trial and error.

Considering that the bifurcation entering the nodes are not equal in length, incorporating a factor representing the number of bifurcations is regarded as a flaw of this method. Furthermore, leakage is assigned exclusively to the nodes in this method, and a pressure-independent discharge was not used. Although this component is a small part of the total system discharge at minimum night flow, it can affect the pressure and leakage from the network. This method addresses leakage from nodes only and does not offer any relations as regards leakage from pipes. Two flaws can be recounted for the said models. First, these models do not calculate all leakage components and can only determine leakage from the network. Second, the models do not distinguish the flow into pressure-dependent and pressure-independent components (Lambert and McKenzie, 2002; Burrows et al, 2003; Tabesh and Delavar, 2003).

Araujo et al. (2003) proposed the following relations to model leakage from networks using an analytical hydraulic model:

(4)

$$QLrMNF=\sum_{i=1}^{NJ} qLMNFri=\sum_{i=1}^{NJ}\left(Pi^{1.18}\times C\times\sum_{j=i}^{NK}0.5\times L_{ji}\right)$$

The constant *C* is determined by genetic algorithm optimization, *NK* represents the total umber of bifurcations from the node, *QLrMNF* is leakage at Node *i*, at the time *NJ*, *MNF* is the total number of nodes in the network, *Lji* represents the lengths of the tubes connecting Node *j* to Node *Pi*, *i* is the minimum night flow, and *QLMNF* is the leakage discharge at minimum night flow (Germanopoulos, 1985; Tabesh, 1998; Tanyimboh et al., 2001).

In this method, a fraction of the total system discharge at the minimum night flow is assumed to leak out of the system, which is not a realistic representation. This method also, ignoring the pipes, calculates leakage exclusively from the nodes. Moreover, the impact of discharge was not taken into account independent from pressure. By integrating hydraulic analysis with GIS models, Tabesh and Delavar (2003) introduced a method of calculating leakage. Drawing on the relationship between leakage pressure and MNF calculations, they calculated the constant C for each node using ArcView. The leakage from pipes was then determined by calculating node pressures using the hydraulic analysis software package.

The relationship between pressure and the British Water Research Center (WRC) leakage index is illustrated in Fig. 1. The vertical axis represents the night flow (instead of leakage) whereas the horizontal axis shows the Average Zone Night Pressure (AZNP). Therefore, the vertical axis expresses an index of leakage (Tabesh, 1998; Thornton, 2002; Farley and Trow, 2003).

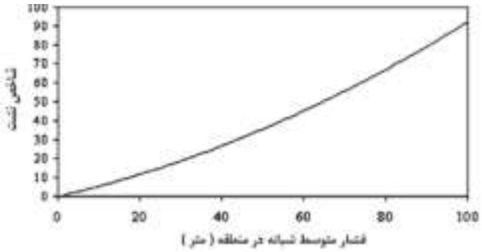

Figure 1; Pressure against the WRC leakage index.

Some researchers relied on hydraulic models to determine leakage in water distribution networks (Tabesh and Hoomehr, 1385). For example, by integrating the WaterGEMS hydraulic model with a Geographic Information System (GIS), a model was presented to estimate the leakage in the network and a scheme was proposed to minimize it. Furthermore, researchers investigated the location and the extent of leakage from the network by using optimization methods and by calibrating the hydraulic models of pressure nodes and inflow to the urban water distribution system using WaterGems (Barzegar, 1373; Idi and Jalili Ghazizaheh, 1388: Valipour and Maghrebi, 1388). In another study, the leakage from the water distribution networks was investigated using the genetic algorithm. Given the costs associated with measures to control leakage and losses, water handlers in large cities around the globe seek methods of attaining an optimal level of leakage that balances the water saved by the leakage control operations with its the costs. Overall, balancing costs with benefits is typical of all fields of engineering, and operation economics is a minuscule matter in some industries. Leakage economics have been addressed for decades, attempting to propose explicit definitions and practical methods in that regard (Pezzinga and Creaco, 2015). In “Materials and Methods”, a conceptual model is presented using mathematical equations and simulation in *Flow-3D* software package to estimate the UFW. Given the fact that the UFW is the sum of leakage from the pipelines and other system components, it can be determined under different conditions by specifying the relationship between leakage and pressure.

MATERIALS AND METHODS

Study Location

Ahvaz, The Capital of Khuzestan Province, is a major city in Iran. The city houses a population of 1,302,000 according to an official 2016 census, making it the seventh most-populated city in the country. Located at 91°29’ N / 66°69’ E coordinates, 16 m above sea level, Ahvaz, one of the largest cities in Iran, stretches across 16449 hectares of the Khuzestan plain. This is a case study of water loss in the Mahdis region of the Ahvaz metropolitan area (Fig. 2).

WaterGems Software Package

After *Loop*, *EPANET*, and *WaterCad*, *WaterGEMS* was introduced as the most advanced and powerful water supply network design software package. This package is, in fact, an improved version of *WaterCad*, developed jointly by *Haestade* and *Bently*. The said software packages all require the designer to apply some manually-calculated input data to the maps of the study region, referring them to a water supply network processing software by collecting the necessary geographic data from analog maps. Not only the preliminaries are time-consuming and tedious, but they also give room to calculation errors that cast doubt on the accuracy of the results.

Figure 2; The location of the Mahdis region in Ahvaz.

With that in mind, *WaterGEMS* was developed to eliminate the need for geographic calculations. Supporting *ArcGIS* data, this software package is capable of transferring and incorporating the results of geographic calculations. *WaterGEMS* features all functions of *WaterCad*, as well as the technology for calculating and reporting the operational and energy consumption costs. The product has other features including supporting the *HAMMER* software package, a powerful tool for water hammer analysis and calculation. In addition to hydraulic modeling, the software features qualitative modeling capabilities and the related analyses. Calculating the *water age* and chlorine concentration tracing along a path can be listed as other capabilities of the software.

Study Method

To form the network, first, the region was prepared in the GIS. Then it was recalled by *WaterGEMS*. The following is a map of the overall Ahvaz water network.

Information on the pipes lengths and diameters

The study area has 4900m of subsystems and GIS main line with different lengths of 110, 160, 200, 250, 300, 400 and 450 mm.

The relationship between pressure and leakage in urban water distribution networks.

Pressure can be divided into static and dynamic types at any point in the urban water distribution network. The pressure measured at any point can simply represent the pressure in a limited area around it. Meanwhile, in most methods of UFW analysis rely on an overall representation of pressure throughout the network. There are different methods to obtain this overall representation according to the objectives, one common method in this regard is to measure the Average Zone Night Pressure (AZNP) AZNP is the average flow measured experimentally in a zone with an isolated network at night time when consumer demand is at its minimum. The power relationship between the average night pressure and the leakage is presented in Eq. 5.

(5) $Q=aP+bP^2$

Where *a* and *b* are equation constants. For example, the coefficients *a* and *b* were calculated in an experiment, and the leakage was plotted against pressure.

Conceptual modeling is currently employed as a suitable, low-cost means of simulating water distribution networks.

Figure 3; Specifying the study region in ArcMap

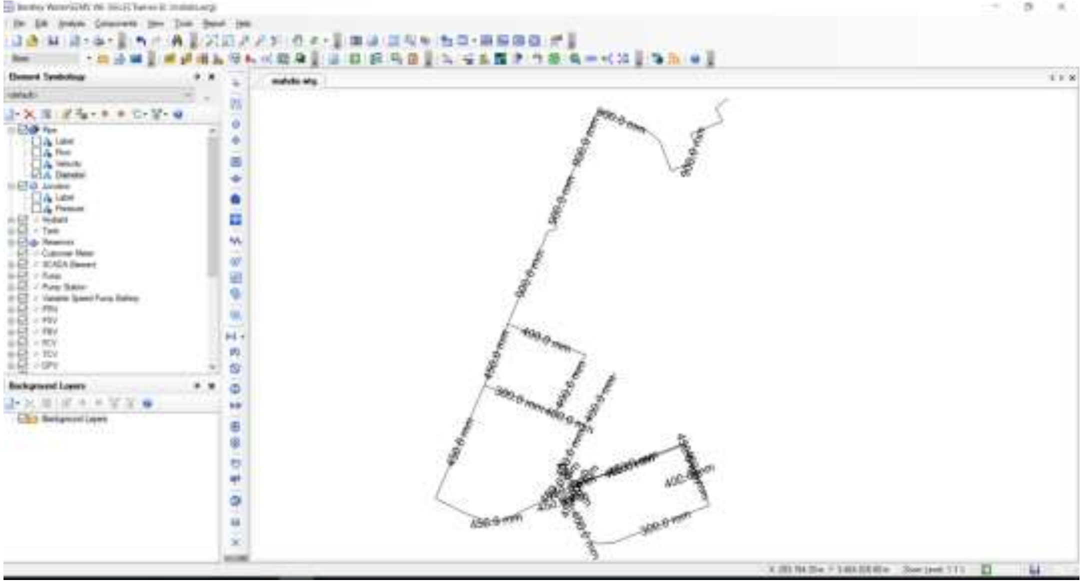

Figure 4; Plotting the transmission and distribution lines in *WaterGEMS.*

Accordingly, this study was based on the idea of calculating node pressure differences between the cases with and without leakage from the network nodes by assuming a base node leakage. In this regard, the studied network and all of its characteristics were first modeled using WaterGEMS. Then, the network was analyzed assuming no leakage, and node pressures were specified. Ultimately, the node pressures were obtained by assuming leakage at one of the network nodes and analyzing node pressures. In this study, Eq. 6 was used to analyze the network sensitivity to the location of the leak.

$$LI(i) = \frac{\left(H_{nol}^{i} - H_{l}^{i}\right)}{\left(H_{nol}^{j} - H_{l}^{j}\right)_{max}} x100 \quad (6)$$

Where H^{i}_{nol} is the pressure head in the case with no leakage at Node i, H^{i}_{l} is the head in the case with leakage at Node i, H^{j}_{nol} is head in the case with no leakage at Node j, H^{j}_{l} is head in the case with leakage at Node j, and *LI(i)* represents the pressure difference (%) between the two cases at Node i and is referred to as the Leakage Index. Using the relation above, the leak can be graphically located on the network. In the said method, the node pressures are required to be obtained at every point throughout the network with leakage. Then, isobar contour lines must be plotted using Eq. 6 to locate the leak. Here, to evaluate the efficiency of the method, it was tried to generalize Eq. 6 and add several calculation steps to locate the leak using the minimum number of pressure measurements at network nodes. To this end, first, the Leakage Index (LI) is obtained for all nodes in the network by applying a base leak at each node and analyzing the network in each case. Ultimately, the LI matrix can be formed by knowing the parameter for leaks at every node. Then, using a minimum of two nodes, the pressure is measured at the selected nodes with real leakage. Given the fact that the LI cannot be determined by only two pressure measurements, the following dimensionless index was used:

$$\mathrm{LI}(m/n)=\frac{\mathrm{LI}(m)}{\mathrm{LI}(n)}=\frac{\dfrac{\left(H^{m}_{nol}-H^{m}_{l}\right)}{\left(H^{j}_{nol}-H^{j}_{l}\right)_{max}}\times 100}{\dfrac{\left(H^{n}_{nol}-H^{n}_{l}\right)}{\left(H^{j}_{nol}-H^{j}_{l}\right)_{max}}\times 100}=\frac{\left(H^{m}_{nol}-H^{m}_{l}\right)}{\left(H^{n}_{nol}-H^{n}_{l}\right)} \qquad (7)$$

Where *m* and *n* are the nodes selected for pressure measurement, and *LI(m/n)* is the relative leakage index. Starting off, the *LI(m/n)* was calculated for the Nodes *m* and *n* for the base leak using the leakage index matrix ($\mathrm{LI(m/n)}_{\text{base leak}}$). Then, by measuring the pressure at Nodes *m* and *n* of the network with real leakage, *LI(m/n)* was obtained for real leakage ($\mathrm{LI(m/n)}_{\text{real leak}}$). In the following, the leak is identified by defining the suspected leakage interval. After correction, the network includes 23 nodes, 27 pipes, and a reservoir. Figure 4 illustrates the diameter of the pipes and the number of nodes and pipes. The results corresponding to the suspected points of leakage obtained from the conceptual Eq. 7 model are presented in “Results”.

RESULTS

The proposed method requires pressure measurement at a minimum of two points. However, if more than one point falls in the suspected leakage interval, the pressure must be measured also at another node. In this case, there are three suspected leakage intervals. It is obvious that the leak takes place at the node shared by all three intervals. This study investigates the network demonstrated in Fig. 4. The initial discharges were received from the Water Organization and incorporated into the model. In the network above, a base leak of 10 lit/s was applied to each node. The network was then analyzed and the LI matrix was formed using Eq. 6. The results are presented in Fig. 5.

Next, a real 10 lit/s leak was assumed at Node 18, and the network was analyzed by WaterGEMS, calculating the node pressures presented in Table 1.

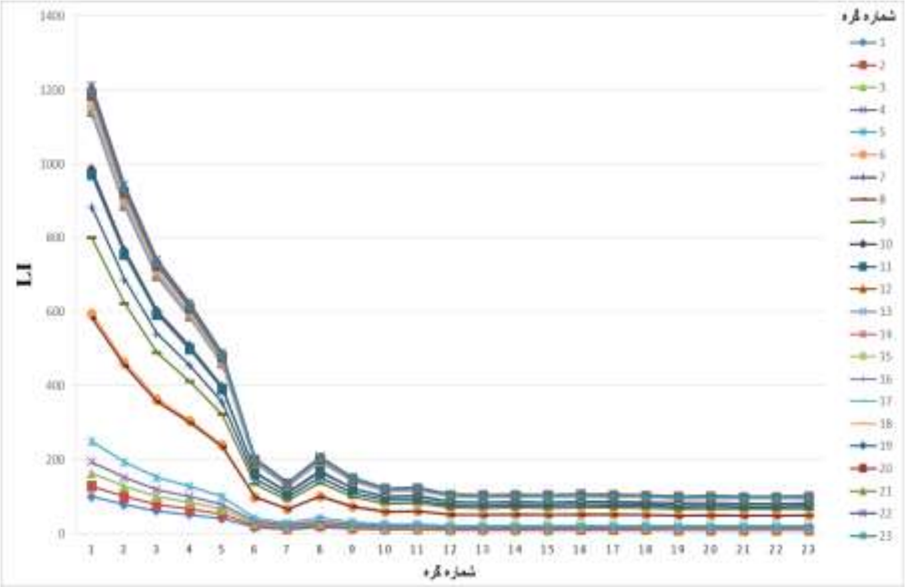

Figure 5; Leakage Index for the studied network for a base leak of 10 lit/s.

Table 1; Node pressures in the case of a real 10 lit/s leakage at Node 20.

Node	No Leakage	With Leakage	Node	No Leakage	With Leakage
1	37.61	37.56	13	28.66	27.84
2	39.22	39.15	14	29.74	28.92
3	39.73	39.64	15	28.65	27.83
4	38.31	38.21	16	29.98	29.18
5	38.57	38.43	17	28.75	27.93
6	33.6	33.25	18	28.34	27.4
7	30.22	29.64	19	26.94	26.12
8	34.68	34.34	20	27.13	26.29
9	32.21	31.72	21	28.83	28.01
10	31.51	30.88	22	29.78	28.96
11	31.24	30.61	23	27.6	26.73
12	28.86	28.05			

At this stage, the LI was calculated between Node 11 and the other nodes and presented in Table 2. For example, the LI between Nodes 11 and 18 is:

=0.75 LI(11/18)real leak= (31.24-30.61)/(28.34-27.4)

Nodes 11 and 18 were selected at this point for pressure measurement. Then, by selecting the suspected leakage interval, the diagram (Fig. 6) was plotted, and the suspected point(s) of leakage was (were) identified.

Based on the results presented in Fig. 6, it is safe to say that Nodes 12 through 17, and 19 through 23 are located in the suspected leakage interval and are, therefore, the leaking network nodes. At this point, given the fact that one of the pressure measurement nodes matched the leaking node, it was placed in the said interval. However, in case none of the nodes matched the leaking one, or the assumed base leakage is not equal to the real leak, a larger number of points may fall in the interval, in which case the pressure must be measured at another point. The next example addresses this scenario.

In another example, a base leak of 10 lit/s was assumed, the LI matrix of which is illustrated in Fig. 5. A real leakage of 50 lit/s was also assumed at Node 16, with the corresponding software analysis results presented in Table 3

At this stage, the LI was calculated between different nodes and the results were presented in Table 4. Ultimately, the suspected leakage interval was determined for different cases using the results and demonstrated in Fig. 7.

The suspected leaking nodes were determined based on the results presented in Fig. 7. Nodes 12 through 23 were shared by both pressure measurements, which reveals them to be the leaking nodes. According to reports from the Ahvaz Water Organization, the nodes within this interval exhibit more leakage at night -when consumption is low and hydrostatic pressure is high- due to their greater altitude difference from the reservoir relative to the other nodes. The results are suggestive of the great capacity of the proposed method for predicting where leaks take place in water distribution systems.

The Effect of Relief Valves in Reducing the Leakage

After isolating the zone, to apply pressure variation schemes, a pressure controller with logger was installed on the relief valve at the inlet. Furthermore, an ultrasonic flow meter was used to measure the inflow at the inlet. The flow meter logs the rate of the inflow to the isolated zone at 10-minute intervals during the studies. After completing and preparing the isolated zone and installing the equipment, the study of the inflow discharge rate and consumption readings at different pressures started. Each stage of measurement took one week to complete. In each stage, the relief valve was adjusted to the required pressure and the inflow discharge rate was logged at 10-minute intervals. The measurements took one week for each stage of outflow pressure adjustment. It must be also noted that the relief valve was adjusted at both fixed and variable outlet pressures, with the variable pressure assumed as a pressure distribution pattern for consumption at the critical point. Considering the fact that a direct measurement of the leakage from the network is difficult, the variations of the minimum night flow was investigated to estimate the leakage. The minimum night flow is the total of leakage from the network and the nightly consumption. Given the fact that the minimum consumption can be estimated, the minimum night flow is a reliable measure for estimating the leakage from the network. The minimum night flow often occurs around the midnight and between 12 AM and 5 AM. Table 5 presents the results of measuring the minimum night flow during different weeks. The table also demonstrates the outlet pressure of the relief valve and also the minimum night discharge during the week.

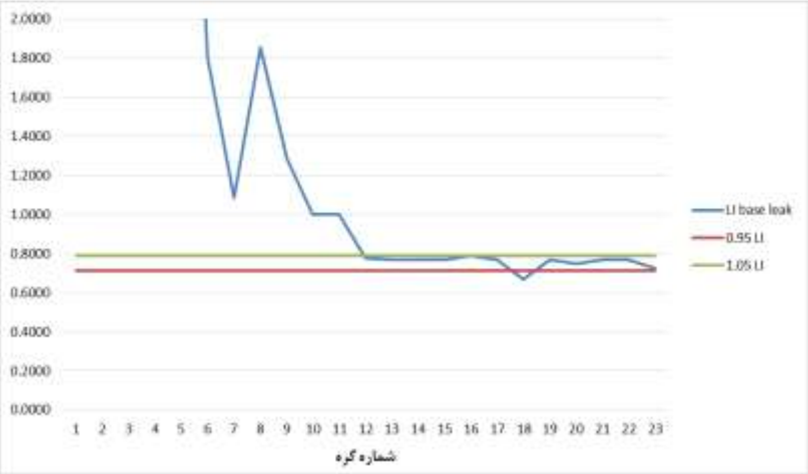

Figure 6;The suspected leakage interval in the studied network.

Table 2. Leakage indices obtained between Node 11 and other nodes.

Node	Leakage Index		Node	Leakage Index
1	0.0595		**13**	0.9762
2	0.0833		**14**	0.9762
3	0.1071		**15**	0.9762
4	0.1190		**16**	0.9524
5	0.1667		**17**	0.9762
6	0.4167		**18**	1.1190
7	0.6905		**19**	0.9762
8	0.4048		**20**	1.0000
9	0.5833		**21**	0.9762
10	0.7500		**22**	0.9762
11	0.7500		**23**	1.0357
12	0.9643			

Table 3; Node pressures in the case of a real 50 lit/s leakage at Node 16.

Node	No Leakage	With Leakage		Node	No Leakage	With Leakage
1	37.61	37.4		**13**	28.66	25.34
2	39.22	38.94		**14**	29.74	26.42
3	39.73	39.38		**15**	28.65	25.32
4	38.31	37.88		**16**	29.98	26.63
5	38.57	38.01		**17**	28.75	25.43
6	33.6	32.14		**18**	28.34	25.01
7	30.22	27.82		**19**	26.94	23.62
8	34.68	33.28		**20**	27.13	23.82
9	32.21	30.19		**21**	28.83	25.51
10	31.51	28.93		**22**	29.78	26.46
11	31.24	28.66		**23**	27.6	24.29
12	28.86	25.55				

Table 4; Leakage indices obtained for a 50 lit/s leakage at Node 16.

Node	Leakage Index	Node	Leakage Index
1	12.2857	**13**	0.7771
2	9.2143	**14**	0.7771
3	7.3714	**15**	0.7748
4	6.0000	**16**	0.7701
5	4.6071	**17**	0.7771
6	1.7671	**18**	0.7748
7	1.0750	**19**	0.7771
8	1.8429	**20**	0.7795
9	1.2772	**21**	0.7771
10	1.0000	**22**	0.7771
11	1.0000	**23**	0.7795
12	0.7795		

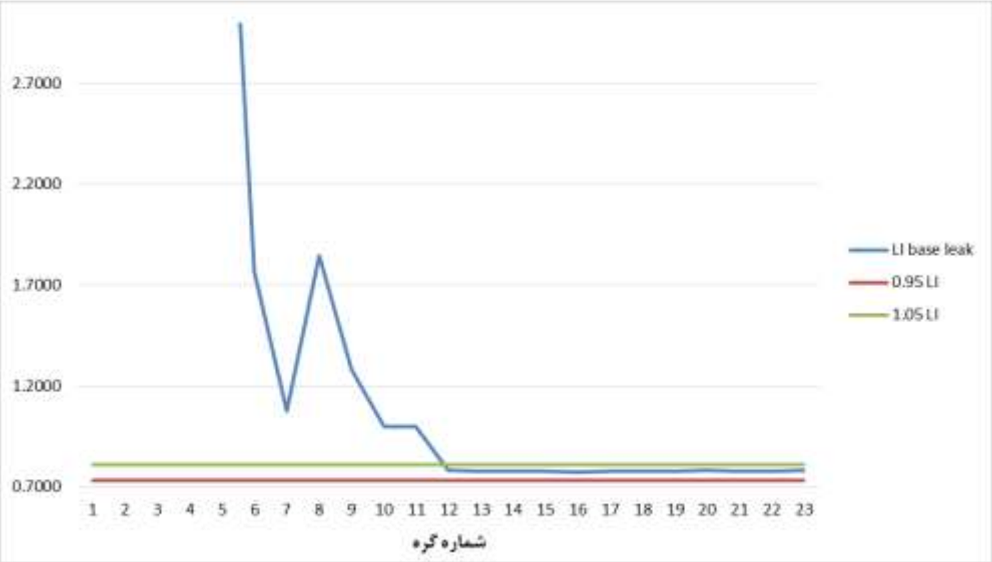

Figure 7;The second suspected leakage interval in the studied network.

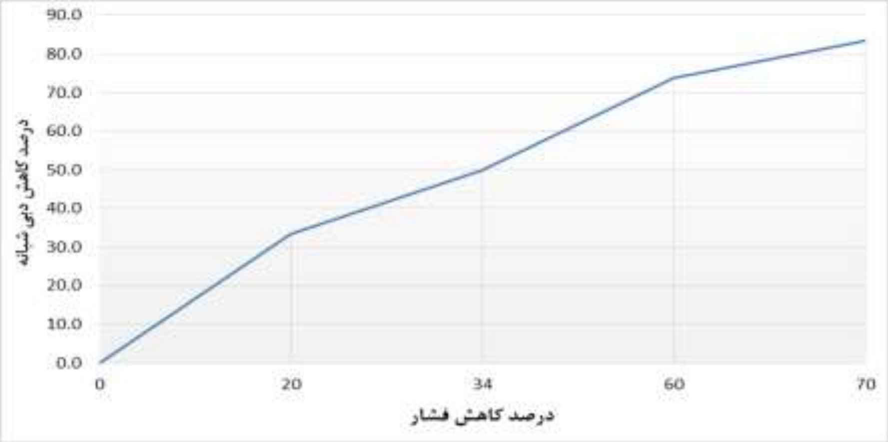

Figure 8; The decrease in the minimum night flow against the reduction of the relief valve outlet pressure.

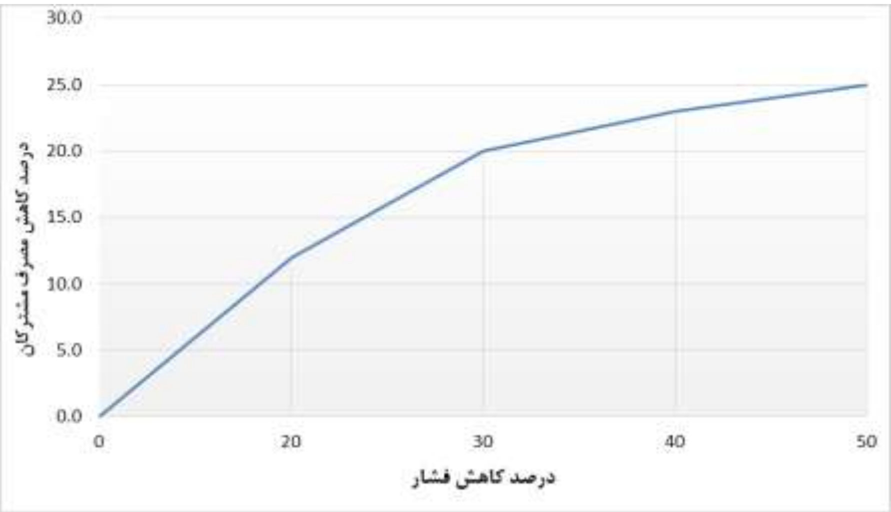

Figure 9; The decrease in the consumption against the reduction of the relief valve outlet pressure.

Table 5; Variations of the minimum night flow with pressure in the studied isolated zone.

Relief Valve Pressure (m)	The Minimum Night Flow (m^3/s)
50	42
40	28
33	21
20	11
15	7

According to Table 5, the minimum night flow decreases with reducing the relief valve outlet pressure. Figure 8 illustrates the decrease in the relief valve outlet pressure in different cases against the decrease in the minimum night flow. The comparison is based on a 50 m relief valve outlet pressure.

It is evident from Fig. 8 that reducing the pressure by 70%, the night discharge decreased by 83.3%.

Figure 9 plots the reduction of the weekly consumption against the decrease in the relief valve outlet pressure. As evident from the figure, consumption was reduced with the decrease in the average relief valve outlet pressure. The results presented in the figure are indicative of an excess of 25% reduction in consumption with no complaints from the consumers as a result of pressure management.

CONCLUSION

Drawing on the capabilities of the WaterGems hydraulic analysis model, a network of 23 nodes, 27 pipes, and a reservoir was developed in this study with the network characteristics taken into account comprehensively. Then, assuming no leakage, the network was analyzed, and the node pressures were obtained. The process was followed by applying a 10 lit/s base leak at each node, analyzing the network, and forming the LI matrix. Next, a real 10 lit/s leak was assumed at Node 18, and the network was analyzed by WaterGEMS, calculating the node pressures. The results revealed eleven suspected points of leakage in the interval. Nodes 12 through 23 were shared by both pressure measurements, thus being identified as the leaking nodes. According to reports from the Ahvaz Water Organization, the nodes within this interval exhibit more leakage at night -when consumption is low and hydrostatic pressure is high- due to their greater altitude difference from the reservoir relative to the other nodes. The results are suggestive of the great capacity of the proposed method for predicting where leaks take place in water distribution systems.

Furthermore, this study investigated the impact of pressure management on the minimum night flow, the results of the investigation are suggestive that the minimum night flow decreases by reducing the upstream network pressure. Reducing the upstream network pressure curtailed the night flow by 20-50% in the network. Given the fact that the night flow is the total of the leakage from the network and nighttime consumption, the results demonstrate that the leakage decreases considerably with reducing the network pressure. The present study also investigated the impact of reducing pressure on the consumption and the inflow to the network. The inflow to the network was reduced by up to 25% by adjusting the network pressure. Considering the fact that the inflow to the network is a measure of daily consumption and leakage from the network, one can conclude that not only network pressure management reduces the leakage, but also it can limit the surplus consumption. This is significant as regards water demand management. Furthermore, applying suitable pressure management schemes reduced the consumption by approximately 25% in the pilot. Moreover, using the model designed in WaterGEMS and ArcGIS, different pressure management options can be tested before being implemented across the real network. Ultimately, it is safe to say that this study demonstrates the great potential for reducing the leakage and consumption in water distribution networks.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

ACKNOWLEGEMENT

Authors wish to express their sincere thanks to all persons who were contributed in the current study.

AUTHOR CONTRIBUTIONS

MK designed and performleed the investigation and also wrote the manuscript. AT, was the supervisor of the study. RR who gave useful consultation during study. All authors read and approved the final version.

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