DEMAND MANAGEMENT: A SIMPLIFIED OPERATIONAL METHOD FOR TARGETING RESOURCES TO WATER LOSS.

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ABSTRACT

Demand Management and Leakage Detection are in vogue due to the extreme pressures on our water resources from drought, population growth and ageing infrastructure. The majority of water suppliers have implemented Demand Management strategies including water restrictions, pressure management and active leakage detection.

This paper discusses a simplified operational method for monitoring water loss and targeting resources effectively. How much water am I really losing from my infrastructure and where am I losing it? When I start actively looking for leakage? Is my leakage costing me more than the cost of finding and repairing it?

INTRODUCTION

Water loss has in the past been measured on a system wide basis, and historically water service providers will quote their water loss statistics as a percentage of total input. There is still a necessity to provide system wide statistics for reporting purposes, but how can we look beneath these figures and get a better idea of what we are actually losing and where it is going? Once this data is collected, how can it be best used to prioritise resources and manage system water loss?

DISCUSSION

District Metered Area Design

By dividing our water reticulation system up into manageable areas we are able to do further calculations on consumption and get a better picture of water loss. District Metered Areas (DMA) by definition are districts within the water system that are supplied by a bulk water meter (or meters). It is recommended that these areas contain between 500 and 3000 connections. By establishing District Metered Areas and monitoring flows, better data can be gathered to identify areas of leakage and target resources.

It is important that DMA's are designed well, although there is often more than one way in which a system can be divided. There are a few points to remember when designing your district metered areas:

- All inlets to the area must be metered;
- All outlets from the area must be measured;
- Water towers can be included but the inlet and outlet must be measured;
- Single inlet systems are most effective, but fire flows must be maintained;
- Hydraulic modeling can be used, but is not always necessary;
- Use existing geographical boundaries wherever possible.

What Is The Minimum Night Flow?

The key performance indicator for water loss should be minimum night flow (MNF) and the aim of this paper is to define (MNF) and discuss the way this can be collected and monitored to ensure that leakage is minimized and resources are used effectively.

Data collection for leakage calculation should be carried out during the daily period of lowest consumption and hence we have the minimum night flow calculation. This is an hourly average flow at the lowest consumption period, which, for most water systems, will be between the hours of midnight and 4 am. Historically this was done by reading a bulk flow meter for several hours during the lowest period of usage. This was a technique that would be carried out periodically to provide leakage figures. With modern technology it is possible to log flows continuously and therefore gather data more easily and for less expense (capital expenditure on loggers can be a lot less than the resource cost of sending staff out at night).

When measuring Minimum Night Flow the initial calculation method must be considered. Published equations for calculating how much of the minimum night flow is likely to be consumption and background leakage are based upon an hourly average night flow rate. With modern technology we could get a minimum flow rate, based upon a lower recording rate, which can “see” between usage events, especially in areas with a low number of connections.

For example in an area, with only a couple of hundred connections, if we sample every minute, it is possible that we may collect data at a time when no household is consuming water. This would show us the actual leakage rate (including unavoidable background leakage), but when compared with a larger area, where it would be almost impossible to see between usage events, the calculations would not be comparable. To ensure that this doesn’t happen, Minimum Night Flow data should be collected as an hourly average.

Cutting edge logger software such as the Radwin software supplied with Radcom loggers can calculate this automatically. If data is collected on a continuous basis, minimum night flow figures can be tracked and used to identify leakage issues within a water reticulation system. Data collected periodically can also be used to identify issues but not on a real-time basis.

Estimating A Target Minimum Night Flow

As mentioned previously, the recommended measure for calculating water loss within a reticulation system is the Minimum Night Flow measured in cubic metres per hour. This data should be the lowest hourly average between midnight and 4 am, except where evidence shows that another time period consistently produces a lower average, (this could be caused by local demographic behaviour).

Work previously carried out by the International Water Association has shown that the best approach to estimating avoidable water loss in a DMA is to breakdown the minimum night flow into various components in order to identify the water being lost. These components include:

- Customer Night Usage (mainly toilet flushing)
- Unavoidable Background Leakage (small leaks in water reticulation)
- Exceptional Customer Night Usage (Household and Non-Household)
- Bursts and Leaks

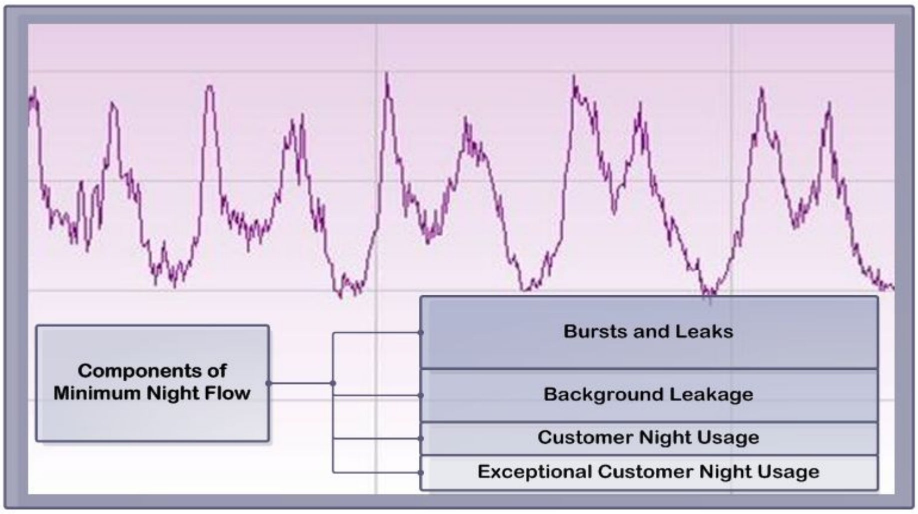

Figure 1: Basic Components of Minimum Night Flow

Estimating Customer Night Usage

Historical work into night usage has led to an equation that can be used in the majority of cases and will give a standardised approach to estimation within any system. This equation takes into account toilet flushing (at a rate of 6% of residents per hour) and usage by non residential properties at a default rate. Research in your area may lead to more accurate default values, but for a quick start the defaults may give you an idea of how much you should be targeting.

$$\text{Domestic Usage} = DP \times R \times 0.06 \times CS$$

$$\text{Non-Domestic Usage} = NDP \times 8$$

Where

DP = Number of Domestic Properties
R = Average Number of Residents Per Property
CS = Average Toilet Cistern Size

NDP = Number of Non-Domestic Properties

Figure 2 : Equation for estimating customer night usage

Unavoidable Background Leakage

Unavoidable background leakage (UBL) is the expected small leaks that are found in all reticulation systems. Again, work by the IWA has come up with a standard equation to estimate this figure for the majority of systems (See Figure 3). As the pipe leakage is affected by pressure the calculation includes an adjustment for the average night pressure found in the area. Average night pressure is the pressure at the average pressure within the DMA during the minimum night flow period. Methods of pressure management can have an effect on the data, but for this simplified methodology, this figure will suffice.

$$\text{UBL (litres/hour)} = (20 \times Lm + 1.25 \times Nc + 0.0333 \times Ls) \times (P/50)^{1.5}$$

Lm = Length of mains in kilometres
Nc = Number of connections
Ls = Avg. length of service pipe from meter to property in metres
P = Average Night Pressure in metres

Figure 3 : Equation for estimating unavoidable background leakage

Exceptional Customer Night Usage

This is a figure that should be included where there is a large user with known consumption, or there has been work done to estimate exceptional night usage such as irrigation. Exceptional night usage is normally defined as individual usage of more than 250 litres per hour.

Using The Target Minimum Night Flow

Once Minimum Night Flow data has been collected the estimated target minimum night flow can be used to assess current performance of the system and target resources to the identified poorest performers. By subtracting the estimated customer night usage, unavoidable background leakage and exceptional night usage from the measured MNF, an estimate of DMA leakage can be calculated.

Using the target figure as a guide, a trigger or alarm level of leakage can be determined. This then becomes the point at which intervention should be made and an active leakage detection survey carried out in that particular location.

Using a DMA based monitoring system where pressure data is collected in addition to flow data has a number of benefits. Pressure and flow monitoring, as well as identifying water loss, can also point out undesirable system changes such as valves left closed after repair or closed valves that have been opened by operators.

Calculating The Trigger Value For Intervention

On a purely financial basis the trigger level for intervention should be set according to the calculated value of water loss against the cost of the leakage detection and repair work.

There has been a lot of discussion amongst water loss professionals on the calculation of the Economic Level of leakage, or the amount of leakage that should be accepted before it is economical to carry out active leak detection or pressure management. The issue is that depending upon the availability of water resources, the value of lost water will change. For example, as water levels in dams drop the value of water loss increases to a point where economic levels of loss are no longer a consideration and water must be saved at any cost!

Trigger value can be calculated using the following equation in Figure 4.

Trigger MNF = (Lm x LDC /720 / WV) - CTMNF

Lm = Length of mains in kilometres
LDC = Cost of active leakage detection in $ per kilometre
WV = Accepted value of water loss in $ per cubic metre
CTMNF = Calculated target minimum night flow

Figure 4: Equation for calculating a trigger minimum night flow for intervention

Continuous Monitoring And Targeting Resources

By using a continuous monitoring system such as telemetry or data logging, Minimum Night Flow Data can be assessed on an ongoing basis and alarms set to identify leakage issues as they occur.

By looking at this continuously captured data, each month, a reporting system can be set up to identify areas that have exceeded or are approaching their trigger values and decisions on whether to carry out Active Leakage Detection can be made. Logging systems such as the Radcom Multilog are able to produce this monthly minimum night flow automatically. Using a simple Excel Spreadsheet and a traffic light system a leakage report can be easily provided. An example system is shown below (See Figure 5).

DMA Data for operational prioritisation of leakage

Accepted Value of water loss per m^3	$1.00
Cost per Km for Active Leak Detection	$200

DMA No.	DMA Name	No. of connections		Mains Length	Service Length	Average Pressure	Estimated Night Consumption	Unavoidable Background leakage	Exceptional Night Usage	Calculated Target MNF		Lowest recorded MNF		Trigger Level
		Dom.	Non Dom.	Km	m	m	m^3/h	m^3/h	m^3/h	m^3/h	l/conn/h	m^3/h	l/conn/h	m^3/h
1	A-town	660	10	8.4	10.00	70	0.58	2.03	0	2.61	3.89	1.60	2.39	4.94
2	B-town	2032	62	37.1	10.00	40	2.02	2.90	1.9	6.82	3.26	14.28	6.82	17.12
3	C-town	245	0	5.9	2.00	27	0.18	0.17	0	0.36	1.46	1.08	4.41	2.00
4	D-town	510	18	14.9	10.00	32	0.53	0.58	0	1.11	2.10	0.68	1.29	5.25

Monthly Minimum Night Flow (m3/h)

DMA No.	DMA Name	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06
1	A-town	(green) 1.60	(green) 2.80	(green) 2.40	(green) 2.80	(green) 4.00	(green) 4.40	(amber) 4.80
2	B-town	(amber) 15.84	(red) 17.68	(green) 14.88	(green) 14.28	(red) 17.20	(red) 20.68	(red) 22.36
3	C-town	(green) 1.60	(green) 1.60	(green) 1.32	(green) 1.08	(green) 1.24	(green) 1.28	(green) 1.40
4	D-town	(green) 1.92	(green) 1.48	(green) 1.32	(green) 1.71	(green) 1.65	(green) 2.60	(green) 3.87

(red) Greater than trigger Level
(amber) Between 90% and trigger level
(green) Below 90% of trigger level

Figure 5: Example Excel spreadsheet showing traffic light system

The Radcom logging system can also be easily programmed to provide a Minimum Night Flow Alarm at the calculated trigger value. A minimum night flow alarm differs from a conventional level alarm as it is triggered when the night flow doesn't drop below the trigger level.

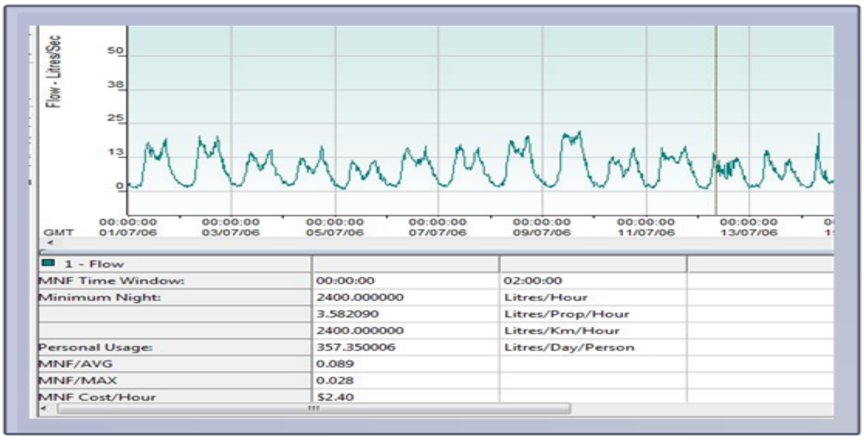

Figure 6: Screen print from Radcom software showing automatic calculation of MNF

Using this simple methodology crews can be targeted to the poorest performing areas, and leakage detection surveys are not carried out when they are not required.

CONCLUSION

When trying to establish a leakage management program it is essential that a target minimum night flow is calculated. This data should be in the form of cubic metres per hour as an average of a predefined period at which flows are lowest in the diurnal pattern. Once actual minimum night flow data has been collected it can be compared with target levels to give an indication of losses.

By ranking each DMA according to the avoidable leakage level and volumetric loss, prioritisation of active leakage detection can be carried out. Once a leak detection survey has been carried out and all detectable leaks found and repaired, the target should be reviewed as necessary.

Economic levels of leakage should be considered and trigger levels decided for future intervention. Where possible these trigger levels should be used to set alarms in the monitoring system. Continuous tracking of nightlines can help ensure that leak detection resources are used when and where needed.

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