Proactive Leakage Management using District Metered Areas (DMA) and Pressure Management – Is it applicable in North America?

R. Sturm*, J. Thornton**

* Water Systems Optimization (WSO), 1111 Brickell Avenue, 11th Floor, 33131 Miami, USA; e-mail: reinhard.sturm@wso.us

** Thornton International Ltd, Rua Arueira 370, Condominium Sausalito, Mairipora SP 076000-00 Brazil; e-mail: thornton@water-audit.com

Keywords: Proactive Leakage Management Technologies; DMA Design Criteria for North America; Advanced Pressure Management

Introduction

The American Water Works Association Research Foundation has awarded a research project to WSO in cooperation with Malcolm Pirnie with the goal to assess how international best leakage management practices can be transferred to North America. The team is augmented by participation from nine North American utilities.

Background

In recent years, water and energy conservation has become increasingly important for water utilities in North America (NA). Policy makers as well as utility managers realize that the reduction of water system leakage and unwanted demand is important from environmental, political and commercial points of view. Similar developments took place in Europe some 15 years ago.

Leakage management practice in North America has been generally limited to passive leakage control (i.e., responding to visible leaks reported by the public, auditing for water loss, etc.) North American utilities are under little or no regulatory pressure to control water leakage and therefore the stance has been that of “reactive” leakage management. Utilities with contracted operations, which are becoming increasingly common in the U.S, often require the contractor to make reductions in leakage. Political pressure to reduce water leakage is also increasing as a result of drought and increasing competition over limited water resources. Water rights issues could eventually lead governing bodies to mandate leakage targets and “proactive” leakage management as opposed to suggesting it, as has been the case in earlier conservation programs. Many states are moving to adopt water resource allocation policies and programs many of which will include a mandated efficiency component. Thus, there is increased demand for effective and appropriate leakage management technologies in North America.

Project Objectives

The overall goal of this project is to provide North American utilities with tools and guidelines to proactively manage and reduce water loss due to leaks in the distribution system. The project is structured into 5 tasks:


- The second step is a detailed analysis of those methodologies that are applicable and transferable to the North American reality, and the development of a new model
to include necessary changes required for safe and sustainable leakage management tailored to North America.

- The third step reviews the applicability of using UK and International methods to determine the economic level of leakage (ELL).
- Step four involves hands-on testing of promising methodologies within the participating utilities water distribution systems.
- Step five is the development of the final water leakage management tools and guidelines.

Assessment of Current Leakage Management Practices in North America

One of the key sources of information for this part of the project has been the AWWA Water Stats distribution survey database (WATER:STATS Survey) recently updated to include information on water loss management. Detailed information on current leakage practices of the participating utilities has been collected and reviewed by the research team. Utility partners are divided into two categories, Level 1 utilities and Level 2 utilities. Three Level 1 utilities participate in only the review process. Six Level 2 utilities are involved in both the review process and in detailed pilot testing.

**Level 1 Utilities:**
- Arizona American Water Company (AZ); Community Water Company of Green Valley (Green Valley, AZ); Metropolitan Domestic Water Improvement District (Tucson, AZ)

**Level 2 Utilities:**
- Birmingham Water Works and Sewer Board (Birmingham, AL); Dallas Water Utility (Dallas, TX); El Dorado Irrigation District (Placerville, CA); Halifax Regional Water Commission (Halifax, Nova Scotia, Canada); Philadelphia Water Department (Philadelphia, PA); Seattle Public Utilities (Seattle, WA)

**Utility Information**

Throughout this paper information is only provided for Level 2 utilities as only those are participating in the practical part of the study. (See table 1.1 for general information)
Table 1.1 Key Level 2 Utility information and Water Stats Average

<table>
<thead>
<tr>
<th>Utility Name</th>
<th>Total Number of Connections</th>
<th>Population Served</th>
<th>Avg. Annual Water Volume Delivered to Customers (Mm3/yr)</th>
<th>Average Static System Pressure (meters)</th>
<th>Cost to Produce or Purchase a m3 of water (US$/m3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birmingham Water Works and Sewer Board (BWWSB)</td>
<td>233,000</td>
<td>675,000</td>
<td>140 (36,955MG/yr)</td>
<td>49 (70PSI)</td>
<td>0.63 (2,400$/MG)</td>
</tr>
<tr>
<td>Dallas Water Utilities (DWU)</td>
<td>316,875</td>
<td>2,200,000</td>
<td>584 (154,200MG/yr)</td>
<td>47 (67PSI)</td>
<td>0.54 (2,050$/MG)</td>
</tr>
<tr>
<td>El Dorado Irrigation District (EID)</td>
<td>34,863</td>
<td>100,690</td>
<td>38 (10,108MG/yr)</td>
<td>87 (124PSI)</td>
<td>0.24 (9191$/MG)</td>
</tr>
<tr>
<td>Halifax Regional Water Commission (HRWC - Canada)</td>
<td>73,650</td>
<td>300,000</td>
<td>43 (11,474MG/yr)</td>
<td>52 (74PSI)</td>
<td>0.04 (146$/MG)</td>
</tr>
<tr>
<td>Philadelphia Water Department (PWD)</td>
<td>475,273</td>
<td>1,517,000</td>
<td>374 (98,623MG/yr)</td>
<td>39 (55PSI)</td>
<td>0.03 (127$/MG)</td>
</tr>
<tr>
<td>Seattle Public Utilities (SPU)</td>
<td>187,585</td>
<td>1,300,000</td>
<td>190 (50,000MG/yr)</td>
<td>63 (89PSI)</td>
<td>0.44 (1,683$/MG)</td>
</tr>
<tr>
<td>Water Stats Average</td>
<td>43,721</td>
<td>178,053</td>
<td>41 (10,692MG/yr)</td>
<td>50 (71PSI)</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Utility Leakage Management

The utility questionnaire sent out to all participating utilities included a comprehensive section on current leakage management activities including leak repair statistics and leak repair expenditures. The total amount spent on leak repair varies with the size of the utility. However in order to make a comparison of expenditure for leak repair the total cost was divided by the total number of service connections in each utility. The last row of Table 1.2 shows the results of this comparison.
Table 1.2 Leakage Management in Level 2 Utilities

<table>
<thead>
<tr>
<th></th>
<th>BWWSB</th>
<th>DWU</th>
<th>EID</th>
<th>HRWC</th>
<th>PWD</th>
<th>SPU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regularly Compile an Audit</td>
<td>yes</td>
<td>yes</td>
<td>Yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Audit Format</td>
<td>custom</td>
<td>custom</td>
<td>AWWA M36</td>
<td>IWA</td>
<td>IWA</td>
<td>N/A</td>
</tr>
<tr>
<td>Audit Frequency</td>
<td>monthly</td>
<td>monthly</td>
<td>annually</td>
<td>quarterly</td>
<td>annually</td>
<td>N/A</td>
</tr>
<tr>
<td>Periodic Supply constraints</td>
<td>yes</td>
<td>no</td>
<td>Yes</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Most Critical Constraint</td>
<td>drought</td>
<td>N/A</td>
<td>drought</td>
<td>N/A</td>
<td>N/A</td>
<td>withdrawal restrictions</td>
</tr>
<tr>
<td>Agency Requirements to Address water losses</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Leak Detection Passive Only</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Total Annual expenditure for leak repair expressed in $/utility service connection</td>
<td>27.04$</td>
<td>4.73$</td>
<td>3.77$</td>
<td>10.55$</td>
<td>9.68$</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Summary

Although nearly all level 2 utilities undertake a water audit, no common water audit format is used. Only HRWC and PWD use the AWWA recommended standardized IWA water audit format. Despite the fact that some utilities experience periodic supply constraints active leak detection is only applied in PWD and HRWC. This can be explained to some extent by the fact that most utilities are not required to address their level of water losses by Regulatory Agencies. Therefore it can be said that active leakage control and a proactive approach towards leakage management still depends very much on the utilities initiatives and foresighted stance.

Figure 1.1 Comparison of Real Losses in litres/service connection/day at current system pressure and 50 meters pressure

Figure 1.1 shows the current real loss levels of Level 2 utilities in comparison to the Water: \Stats results. When adjusting the real losses from current pressure levels to a
standard pressure of 50 meters (71PSI) it can be seen that in EID the level of real losses would be about 50% lower than with the current high average system pressure. In PWD the opposite picture emerges. The real losses would be significantly higher if PWD would increase their average system to 50 meters (71PSI).

### Review of International Leakage Management Practices

#### Introduction

It is the goal of the AwwaRF 2928 project to assess well established and new proactive leakage management methods and techniques which are internationally implemented. The UK water industry for example, has developed a range of sophisticated processes (e.g., standardized system auditing, BABE and FAVAD analysis and reporting, DMA, improved leak detection technologies and improved leak repair technologies) for proactive leakage control and rapid identification, location and repair of previously unreported leaks. As leakage targets are set on an economic basis it was possible for the UK water industry to achieve and sustain substantial reductions in water losses in an efficient and economic manner. However it is not only in the UK that proactive leakage control is successfully applied as Germany, Japan, South Africa and Australia also have reported proactive programs.

#### Findings

Key water loss reduction strategies identified by the review of international best leakage management practices were:

- Improvement of Data Quality (system input volumes, residential and non residential consumption figures, etc.)
- Standardized System Auditing
- Calculation of Economic Level of Leakage
- Establishment of DMA
- Reduction of Awareness-Location-and Repair times
- Pressure Management
- Improved Management of Customer Side Leakage
- Improved Leak Detection Effort
- Asset management

Whilst the AwwaRF 2928 project details all of the above leakage management tools and how they can be transferred to North America, this paper only addresses the establishment of DMA and the implementation of pressure management in North America.
How can the identified International Leakage Management Practices be transferred to North America?

Introduction

Permanently monitored DMA are the most effective way of reducing the duration of previously unreported leakage, because continuous monitoring of night flows facilitates the rapid identification of unreported breaks, and provides the data required to make the most cost effective use of leak localization and pinpointing resources. The concept of district meter areas was introduced to the UK water industry in the early 1980's. In order to transfer this technology to North America it has to be adapted to local requirements and circumstances. It is common that pressure management is applied along with the DMA.

The objectives of pressure management are two-fold: to reduce the frequency of new breaks within a water distribution system, and to reduce the flow rates of those breaks and background leakage that cannot be avoided. Pressure management is the only real loss management strategy that can reduce background losses, except for infrastructure replacement.

Creating DMA in North America: What are the general DMA principles and what are the main differences to DMA in the UK

Currently the authors of this paper are aware of only two utilities which have permanent DMA meters installed in NA. These utilities are Halifax Regional Water Commission and the Pennsylvania American Water Company Wilkes-Barre/Scranton. Even though several utilities in North America have conducted DMA measurements, no permanent DMA meter installations from other utilities could be found.

Basically there are two aims for the design of DMA (UK WIR: A DMA Manual, 1994):

1. To divide the distribution network into a number of zones or DMA, each with a defined and permanent boundary, so that night flows into each district can be regularly monitored, enabling the identification and location of unreported breaks and leakage.

2. To manage pressure in each district or group of districts so that the network can be operated at the optimum level of pressure.

The general DMA principles depending on the characteristics of the network are:

- Supplied via a single or multiple metered feeds
- Hydraulically discrete area with no unmonitored in or outflow
- Area which cascade into an adjacent DMA

The goals for the design of a DMA in North America are basically the same as for DMA in the UK. However, there are fundamental differences between the designs of distribution systems in North America and the UK which need to be taken into account for the design of DMA in NA.

- In North America mains are sized to meet high fire flow requirements, whereas in the UK mains are designed to meet customer demands. This results in larger mains diameters in North America and therefore lower velocities particularly during the minimum night flow period.

- When designing DMA in North America it is important to consider the large size of mains causing low flow velocities during the minimum night consumption period. As such low flow velocities can cause problems for accurate flow measurements the
DMA size needs to be sufficient to provide enough flow velocities during the hours of minimum consumption in order to accurately measure these flows.

- UK networks tend to be dendritic, or tree like, in design, whereas North American networks tend to be grid systems. This difference in network geometry may mean that the design of DMA boundaries is more complex in NA.

The characteristics of DMA in North America will be very similar to the DMA characteristics in the UK. However it is likely that the many DMA will cascade into adjacent DMA due to the grid network design and that it might be necessary to have multiple metered in and outflows for the DMA.

One of the main differences between the UK and North America influencing the DMA design considerations is that in the UK approximately 70% of residential customers are not metered. Which means, that utilities in the UK are highly interested in reducing leakage on the customer section of the service pipes, which affects the optimum size of DMA. The smaller the size of a DMA, the easier it is to pick up small size leaks through permanent flow monitoring.

In North America it will be necessary that every utility takes into consideration the location of their residential customer meters. If the residential meters are located next to the curb stop near the property boundary it might be the case that the DMA size should be designed larger than recommended in the UK. The reason is that although losses from service lines are still important, the utility will be primarily concerned with losses up to the meter over a shorter distance of service line. However in utilities where meters are inside the property DMA sizes similar to the UK may be appropriate.

**DMA Design Criteria and DMA planning in North America**

These are the general design and planning criteria identified for DMA in North America:

- Assess the economic level of Leakage
- Optimum size of DMA (based on ELL, and location of customer meter,)
- Variation in ground level
- Assess existing pressure zones and closed valves related to pressure zones. Make use of existing pressure zones where possible
- Closed PRV’s and check valves can be used as boundary valves in order to provide fire flow when required.
- Water quality considerations: Boundary valves should be on smaller mains to minimize the effect of dead ends. Try to include large customers near boundaries or dead ends in order to avoid water stagnation and water quality problems.
- Minimum flow and pressure requirements for fire flow and insurance obligations are of utmost importance for the design of DMA in NA. Assess minimum and maximum pressure at the critical zone point. Knowledge of system operating pressures and hydraulic gradients under various demand conditions (diurnal and seasonal) is important for anticipating the effects of reduced main capacity on fire-fighting capability and normal service in areas of higher elevation prior to final implementation of the DMA. Most state regulatory agencies require purveyors to maintain a minimum of 14 meters (20 psi) at street level above the main under all conditions of flow. If the initial assessments show that the DMA can not provide required fire flows or minimum pressure for fire sprinkler systems when supplied through one feed then it is necessary to revise the DMA planning and provide two or if necessary 3 feeds into the DMA. If this is the case, a solution may be sought were...
only one feed is equipped with a meter and the other feed or feeds are equipped with PRV’s which open up only for a fire flow event or if demand is too high for only one feed.

- Looping and redundancy requirements.
- Consider system changes required for DMA installation, like the number of new valves required, installation of meter point and chamber, etc.
- Correct DMA meter installation and sizing.
- The configuration of the distribution network pump system and location of pumping stations needs to be carefully assessed and included in the planning stage.
- The HRWC case demonstrated that in DMA where multiple feeds are required, which is more often than not, it is possible to supply the DMA through multiple metered feeds on a daily bases and when data is required for analysis, on a temporary basis, the flow can be supplied only through a single meter.
- The depth of main, main material, age and condition needs to be assessed for the potential meter location.
- For future meter locations accessibility, traffic conditions, need for special permits to undertake construction work, potential conflict with other utilities e.g. electricity, cable etc. needs to be assessed.

**Pressure Management in North America**

Advanced pressure management may result in more complex designs in North America due to fire flow requirements and insurance requirements. Whether pressure management is applicable or not will in most cases depend on the business case, which should be assessed individually for every utility prior to applying pressure management.

**Practical aspects of installation of identified proactive methods and preliminary results**

**Introduction**

After the concept of DMA was introduced and explained to the level 2 utilities, each utility selected potential areas for the implementation of permanent DMA. Together with the project team the most suitable areas were chosen and steps were taken to set up the DMA. This paper only discusses the results from El Dorado Irrigation District, Philadelphia Water Department and Seattle Public Utilities as pilot project progress in these utilities is most advanced at this point in time.

**El Dorado Irrigation District (EID)**

The topography of EID’s supply area is not homogeneous which is why the distribution network is already subdivided in pressure control zones. Therefore it was decided to utilize an existing pressure zone and to make the necessary changes to be able to operate it as a permanent DMA. The selected area is “North Shingle”, which is fed through a single inflow point. The existing PRV station for North Shingle is equipped with an 8” main and a 200mm (8”) Pressure Reducing Valve (PRV) plus a 150mm (6”) bypass with a 150mm (6”) (150PRV).
Calculations have shown that the flow velocities to be expected during the minimum night-time flow period (typically between 1am and 4am) on the 200mm (8") main are low and accurate flow measurement would be problematic. For that reason it was decided to convert the existing 150mm (6") PRV on the bypass into a “Metering PRV”. The accuracy of the metering PRV is quoted by the manufacturer at +/- 3% of span. Various PRV manufacturers offer such kits to convert PRV’s into metering PRV’s. The 200mm (8") main and PRV will only serve for stand by purposes in case of an emergency or an increase in demand that can not be handled by the 150mm (6") bypass.

After the 150mm (6") PRV was converted into a “Metering PRV” enabling monitoring of total inflow to the DMA, initial flow and pressure measurements have been conducted. The initial base line measurements in conjunction with night consumption readings showed that the real losses for the DMA in terms of the IWA level 1 performance indicator are 1,453 l/conn/day (384gall/conn/day).

| Table 1.3 EID – general DMA characteristics and baseline results from 8th of March 2005 |
|---------------------------------------------------------------|-----------------|
| Total Number of Service Connections                          | nr              | 444             |
| Mains Length                                                 | Km              | 27’ (16.8 miles) |
| Connection Density                                           | nr/km           | 18 (26 nr/mile)  |
| Average Zone Pressure                                         | meters          | 78 (109 psi)    |
| Average Pressure at Critical Point                            | meters          | 54 (77 psi)     |
| Consumption                                                  | litres/conn/day | 979 (259gall/conn/day) |
| Real Losses                                                  | litres/conn/day | 1,453 (384gall/conn/day) |

The controller for flow modulated pressure control was installed during the week of April 9th. Due to several concerns from EID (sufficient pressure at critical pressure point and upcoming high demand for the summer season) a conservative profile was applied while observing the results closely. The initial flow modulation profile used was set to reduce the outlet pressure by a maximum of 7 meters (10psi) if the inflow to the DMA was less than 8.8l/sec (140 gpm). If the inflow was higher than 15.8 l/sec (250 gpm) the outlet pressure would increase up to 49 meters (70psi) which was the initial fixed outlet pressure used by EID at this PRV station.

The comparison of the baseline measurements taken before flow modulated pressure control was applied; with the results from flow modulated pressure control revealed that the profile applied is too conservative to see a noticeable reduction in real losses. However, the continuous flow and pressure monitoring has proven that the 150 mm (6") PRV is able to accommodate a significant increase in demand (between April 28th and June 7th the peak demand has doubled due to the hot weather) with no noticeable reduction in average zone pressure or critical zone pressure.

Figure 1.2 depicts the increase in total inflow and how the inlet, outlet and average pressure were affected by this increase. Of particular interest is the inlet pressure fluctuation during high demand. The PRV is able to modulate and maintain a stable outlet pressure at all times. This will undoubtedly reduce the number of new breaks in the DMA.
The performance of the flow modulated pressure control has built confidence in this type of pressure management within EID. Therefore it is planned that after the summer period a more aggressive modulation profile will be applied, where the outlet pressure is reduced further down during minimum demand periods. The project team is confident that clear result in reduction of real losses will then be seen.

**Seattle Public Utilities (SPU)**

SPU also proposed several potential areas of which an existing pressure zone (Graham Hill) was selected to be set up as a permanent DMA. Graham Hill is supplied through a 500mm (20") main. As this size of main was deemed too large for the needs of DMA flow measurements and pressure control, initial flow and pressure measurements were conducted in February 2005 to gather the necessary information for the design of a new DMA inflow chamber. These measurements and information about changes in demand between summer and winter plus daily peak factors allowed calculation of the appropriate size of feeder main for the new DMA inflow chamber.

<table>
<thead>
<tr>
<th>Table 1.4 SPU – general DMA characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Service Connections</td>
</tr>
<tr>
<td>Mains Length</td>
</tr>
<tr>
<td>Connection Density</td>
</tr>
<tr>
<td>Average Zone Pressure</td>
</tr>
<tr>
<td>Average Pressure at Critical Point</td>
</tr>
</tbody>
</table>

The initial Minimum Night Flow measurements indicate a significant level of real losses in the Graham Hill DMA. At this point however, no detailed figure of real losses can be provided as minimum night consumption readings are still to be conducted.
As Graham Hill DMA is supplied from one feed the inflow chamber was designed to include a 150mm (6") main equipped with “Metering PRV” to accommodate the daily demand (both summer and winter demands) and a 300mm (12") main equipped with a normal fixed outlet PRV as bypass which should provide a back up in case of fire flow or other emergencies (see Figure 1.3 for design details).

The first visit to install and commission the pressure control station on Juneau Rd was undertaken from June 15th to June 22nd 2005.

The 300mm (12") valve (shown on the right below) was set at an outlet pressure of 85m (120psi) and the 150mm (6") valve at an outlet pressure of 93m (132psi) allowing room for an initial conservative modulation of 7m (10psi).

A metering valve kit and flow modulated controller was fitted to the 150mm (6") valve shown on the left above.

In order to check smooth operation of the 300mm (12") valve during fire flow demands and to ensure that the site could deliver sufficient water to meet any emergency a fire flow test was undertaken with SPU staff. Hydrants were selected around the district and turned on slowly to see when and how the 300mm (12") valve responded. All four hydrants were able to provide the necessary flows individually and the installation was able to supply sufficient flow even when all four hydrants were flowing together. The 150mm (6") valve
was over powered at a flow of around 443 cubic meters per hour (1,950 gpm) and the 300mm (12") valve took over to supply the higher volumes.

Data was logged for the inlet and outlet pressures and the flow in order to check the smooth operation of the 150mm (6") valve during normal operation. There was some "valve swing" identified and further calibration of the hydraulic controls undertaken to slow the valve down. The next phase of this installation will be to switch on a conservative and then a more aggressive flow controlled profile to identify savings from flow modulated pressure reduction.

So far the results of this installation show that pressure management can be undertaken in a DMA within the Seattle network and that a combination of valves can be installed to ensure that minimum flows can be properly recorded and emergency demands can be met hydraulically by proper calibration of a larger sleeper valve.

**Philadelphia Water Department (PWD)**

The area selected by PWD was not an existing pressure zone. Therefore it had to be isolated from the rest of the distribution system. PWD has conducted tests on each boundary valve to make sure they are not leaking by, which is an important exercise to guarantee the integrity of a DMA. The selected DMA (named DMA#5) has two inflows, one 200mm (8") main and a 300mm (12") main. These inflow points are located at the opposite ends of DMA#5.

24 hour flow (using electromagnetic insertion flow meters) and pressure measurements have been conducted at each inflow point with the other inflow main valved off. The results provided valuable information on how the DMA reacts if supplied only through one inflow. The data gathered during the initial measurements plus results from AMR minimum night consumption meter readings served to carry out Minimum Night Flow analysis. The results of this analysis are shown in Table 1.5.

<table>
<thead>
<tr>
<th>Total Number of Service Connections</th>
<th>nr</th>
<th>2101</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mains Length</td>
<td>Km</td>
<td>25 (16 miles)</td>
</tr>
<tr>
<td>Connection Density</td>
<td>nr/km</td>
<td>84 (136 nr/mile)</td>
</tr>
<tr>
<td>Average Zone Pressure</td>
<td>meters</td>
<td>65 (92 psi)</td>
</tr>
<tr>
<td>Average Pressure at Critical Point</td>
<td>meters</td>
<td>47 (68 psi)</td>
</tr>
<tr>
<td>Consumption</td>
<td>litres/conn/day</td>
<td>1,245 (329gall/conn/day)</td>
</tr>
<tr>
<td>Real Losses</td>
<td>litres/conn/day</td>
<td>2,361 (623gall/conn/day)</td>
</tr>
</tbody>
</table>

Initially it was planned to equip the 300mm (12") inflow point with a full bore-mag meter and a PRV, to be used as the main feed for DMA#5. The 200mm (8") main was intended to be used as a stand by feed, equipped with a PRV which would open up only in case the pressure inside DMA#5 drops below a set level (fire flow or other emergency).

Simulations of emergency cases like fire flow, revealed several problems: There is no statutory minimum pressure within PWD. However PWD has an internal guideline which is 25 meter pressure (35psi) at the curb and fire flow minimum flow availability at any determined hydrant of 63 l/sec (1,000 gpm) at a residual flowing pressure of 14 meter pressure (20psi). During fire flow tests undertaken by PWD with only the 300mm (12") feed open it was identified that under current system conditions the critical point hydrant can only deliver 47 l/sec (750 gpm) at 14 meter pressure (20 PSI). Another problem that occurred during flow tests is that the largest required fire flow (221
l/sec or 3,500 gpm), on a street where several senior citizens retirement homes are located, could not be provided (only 155 l/sec or 2,450 gpm could be provided) with only one feed into the DMA.

PWD together with WSO decided to conduct a thorough leak detection and repair campaign to remove leakage from DMA#5, which currently is at very high levels (nearly twice the daily consumption). Once this has been completed tests will be conducted to verify if there is sufficient flow capability to meet the critical peak and fire flow requirements through only one feed, which represents the worst case if the other inflow point was down for maintenance.

**Conclusion**

At this stage of the project it can be said that DMA are applicable in NA. Due to regulations and the design of the distribution network in NA it appears that in order to design a successful DMA it is necessary to have one main feed plus one or two back up feeds. These can be located in the same DMA chamber or at different inflow points to the DMA. The main feed which will generally be smaller in diameter than the backup feed is to be equipped with an appropriate flow meter and a PRV if pressure management is suitable. The backup feed will be equipped with a PRV and only open up if pressure drops below a set level, allowing for sufficient inflow to the DMA in case of emergency.

It appears that in many cases it will be the easiest solution to use existing pressure control stations and convert one of the bypass PRV’s in a metering PRV and use the PRV on the main line for back up purposes.

The DMA minimum night flow analysis conducted so far during the course of this study have already shown the great benefit of identifying exactly the level of real losses existing in the respective DMA and helping to prioritize leak detection efforts within the water utility.

Pressure management is definitely applicable however, it is necessary to build up confidence within NA utilities for this type of leakage management to be able to apply more aggressive pressure management schemes in order to see clear results in reduction of losses.

**Acknowledgements**

The authors of this paper and WSO would like to thank the participating utilities for their support and patience during this very “hands on” project.

**References**

Walski et al. (2001), Establishing a System Submetering Project, American Water Works Association 2001 Annual Conference Proceedings

UK Water Industry Research Limited “A manual of DMA practice”, 1999 United Kingdom