PRESSURE MANAGEMENT TO REDUCE WATER DEMAND & LEAKAGE

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SUMMARY

This paper describes three case studies of the application of pressure management to reduce water demand, improve reliability and save costs – a full suite on the triple bottom line scorecard.

A significant problem for water authorities is the amount of water that goes "missing" from leaving the water treatment plant to arriving at the customers' taps. A simple desk top water balance can indicate the level of water losses and application of software packages can distinguish between apparent losses, real losses and the economic level of preventable lost water.

The problem can result from high leakage rates, excess night-time water pressures or both. This paper discusses the theory of pressure management and application of appropriate measures to assist in drought management in Byron Bay and more efficient water distribution practices for Hervey Bay and Gold Coast Water.

Basically, a higher pressure will result in a greater frequency of bursts and more water lost through leaks and burst pipes. Installation of computerised flow sensitive pressure control valves or the retrofitting of electronics on to existing pressure reducing valves (PRVs) can be used to reduce unnecessary high night-time pressures and minimise the problem of fluctuations in pressure which weaken pipe systems and reduces their asset life.

INTRODUCTION – THE BASICS

Pressure management is an affective way to control the amount of water lost in a system. This can be implemented without affecting service levels when activated during low demand periods such as late night and early morning. It can also reduce consumption in networks with no intermediate storage. A small reduction in pressure can mean a significant reduction in real losses through leaks. It is important though, to comprehensively evaluate a service area and gain an understanding of its background losses, before or alongside introducing pressure control. The effect of pressure control on real losses can then be quantified.

SO WHY MANAGE PRESSURES?

Pressure control can:

- Reduce leakage, saving water resource and associated costs
- Reduce pressure related consumption, such as garden watering, again yielding a saving in resources
- Reduce frequency of bursts and consequential damage which are costly to repair. Bursts also create interruptions to customer supplies and hazards to road users
- Provide a more constant service to customers. Large pressure variations may give customers an impression of a poorly managed service. Also, unnecessarily high pressures raise customer expectations and perceptions of what is adequate
- Lower pressures may enable a company to standardise on pipes and fittings which have a lower pressure rating and are therefore cheaper.
- Drought management

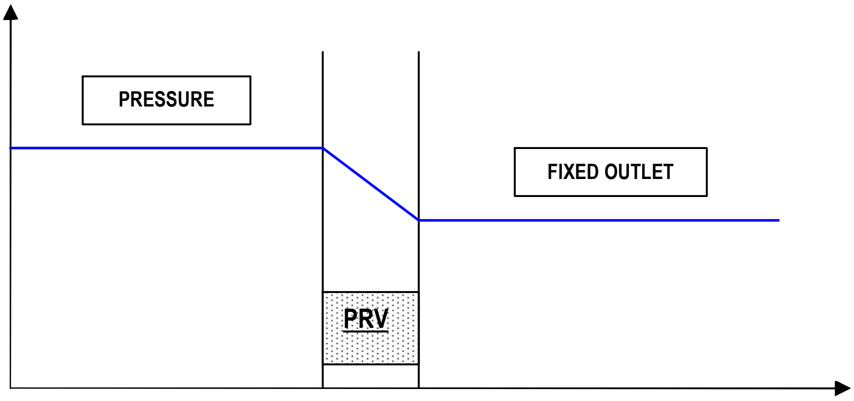
MANAGING SYSTEM PRESSURE

Pressure in water network systems can be controlled in three ways using PRV's and Smart Controllers

Pressure Reducing Valve (Fixed Outlet)

The traditional method of control is via a hydraulically operated control valve. This is effective for areas with low-pressure head losses, demand that does not greatly vary due to seasons and areas that have uniform supply characteristics. Fixed Outlet PRV's are widely available commercially. The valve reduces the pressure of the incoming water to a pre-determined outlet value as shown in Figure 1. Therefore, as the upstream pressure on the valve fluctuates due to different needs (varying levels within reservoirs and pump switching etc.) the downstream pressure remains constant.

Figure 1



Modulated Pressure Reduction Valve (Multi Point control)

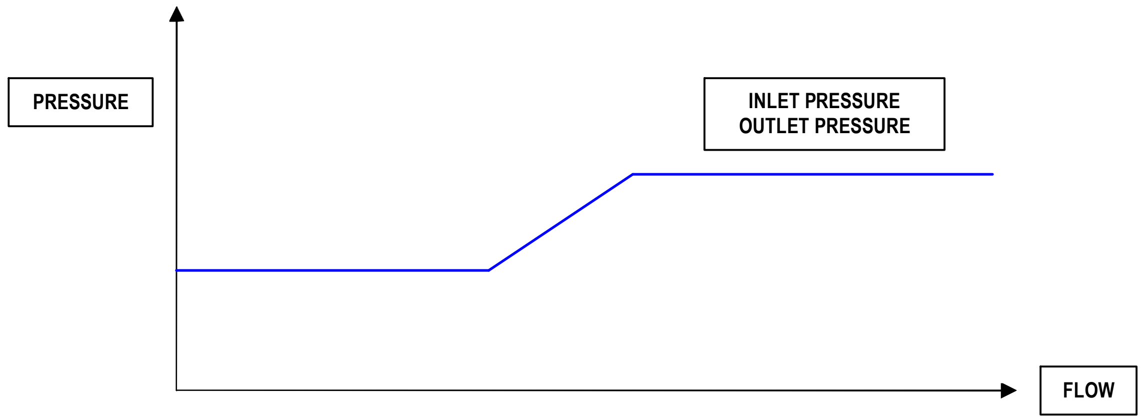
Time based modulation is the simplest form of Advanced Pressure Control and uses a controller with an internal timer. Pressure is controlled in time bands according to demand profiles. The method is suitable for areas with stable demand profiles and head losses and is usually used where cost is an issue but advanced pressure management is desired.

Flow Modulating Pressure Reduction Valves (Flow based Dynamic Modulation)

This control method involves a more complex controller (the flow modulated controller) which provides greater flexibility and control than that offered by the simpler time modulated controller.

Flow modulating pressure is the best type of control for areas with changing conditions, variable head loss, and high fire flow requirements. Flow modulating pressure reduction provides advanced control of outlet pressure related to demand. The valve controller reads flow from a meter and uses this input to control the position of the valve, the greater the flow, the more the valve opens and thus the higher the pressure. The controller is normally supplied with a local data logger and optional remote communications. Water pressure can be controlled with a preset profile related to the changing relationship of demand and head loss in a zone. The concepts of the flow modulated controller are shown in Figure 2.

Figure 2



Pressure control can enable substantial savings in water in an area. Pressure reduction is best carried out in small District Metered Areas (DMAs), supplied by mains that can be reduced to accept a PRV not in excess of 200 mm in diameter. PRVs and flow modulating PRVs become disproportionately expensive above that size. Pressure reducing valve installation demands careful attention. For electrically operated PRVs consideration should be made of its natural state i.e. normally fully open or normally fully closed when there is a power failure.

CASE STUDIES INCORPORATING PRESSURE MANAGEMENT

The case studies below describe how implementation of pressure management and control influenced the unique problems of the respective networks.

CASE STUDY 1 - MULLUMBIMBY – DROUGHT RELIEF

In 2003, residents of Byron Bay were facing severe Level 5 water restrictions. In Mullumbimby, one of the shire townships, two fixed outlet pressure reduction valves were installed. The aim was to extend the raw water supply in Laverty Gap Weir, reduce water consumption and leakage and to achieve these results quickly at the lowest cost. Pressure reduction was undertaken in Mullumbimby to reduce consumption and leakage (burst frequency and background leakage). The purpose was to maintain supply for a longer period through this current drought. This summary details the consumption and leakage rates prior to pressure reduction and indicates the water savings and financial benefits which were delivered by implementation of a pressure reduction scheme.

To reduce consumption and leakage, two 100mm pressure reducing valves were installed on by-passes as shown in figures 1 and 2 below; these were located on the 200mm main along Jubilee Avenue and on the 300mm main along Eugenia Avenue.

Flow Rates – Pre-commission

The flow rates were monitored and recorded to ascertain consumption and leakage rates at night time prior to pressure reduction. The average daily consumption was estimated to be 768 m^3/day or 0.77 ML/day. The average minimum night flow was estimated at 2.37 litres/second or 8.5 m^3/hour.

Pressure Reduction

The pressure reducing valves were commissioned on the 22nd January, 2003, with an initial average reduction of 19m at Jubilee Avenue PRV and an average of 10m at the Eugenia Avenue PRV.

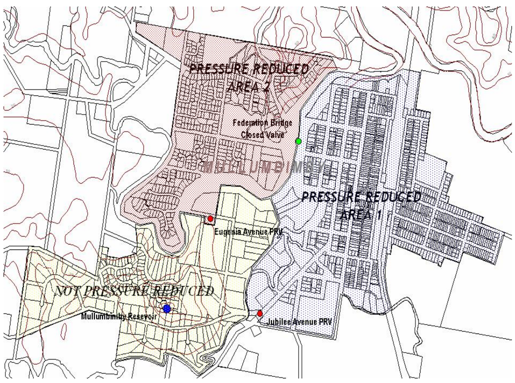
Flow Rates – After commissioning

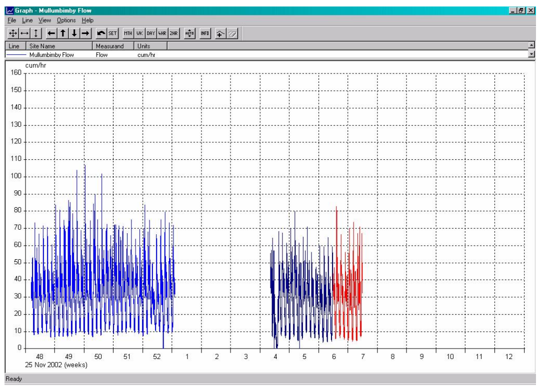
The average daily consumption was reduced to 652 m^3/day. This resulted in a reduction in consumption of 116.5 cum/day or 42.5 ML/year.

The average minimum night flow was reduced to 1.59 litres/second, a saving of 67 m^3/day. The reductions in the minimum night flow represent true water loss savings, which comprises a reduction in background leakage and burst leakage flow rates

In financial terms the savings amount to $8,123 per year based on the marginal cost of water production from the Mullumbimby treatment plant of $0.33/KL (figures from initial evaluation)

Further reductions in pressure were carried out on the 6th February 2003; an average reduction of 5m was implemented for both pressure-reduced areas. The reduction had little impact on the daily average volumes, actually increasing consumption on average by 13 m^3/day for that particular week. However, a long term average would be expected to confirm a reduction in consumption. Fine tuning has resulted in a further real loss saving of 5.3 m^3/day, giving total true loss water saving of 72.7 m^3/day amounting to $8,760 per year.





Conclusion

With the implementation of pressure reduction in Mullumbimby, there was a significant reduction in water consumption. In addition, there was a reduction in real water losses as indicated by the reduction in the minimum night flows. The impact of pressure reduction avoided the need to bring in further restrictions.

However, if the drought situation got worse further reduction in pressure was still possible.

Further to these savings the implementation and application of demand and leakage control through pressure management yielded the following benefits:

- reduction in background losses
- reduction in consumption
- reduction in burst frequency
- improved system performance
- extended asset life

CASE STUDY 2 - HERVEY BAY – TORQUAY DMA FLOW MODULATION

Currently the Hervey Bay district metering areas are served by fixed outlet pressure reducing valves. Wide Bay Water Corporation installed a flow modulation controller in one of its district-metered areas.

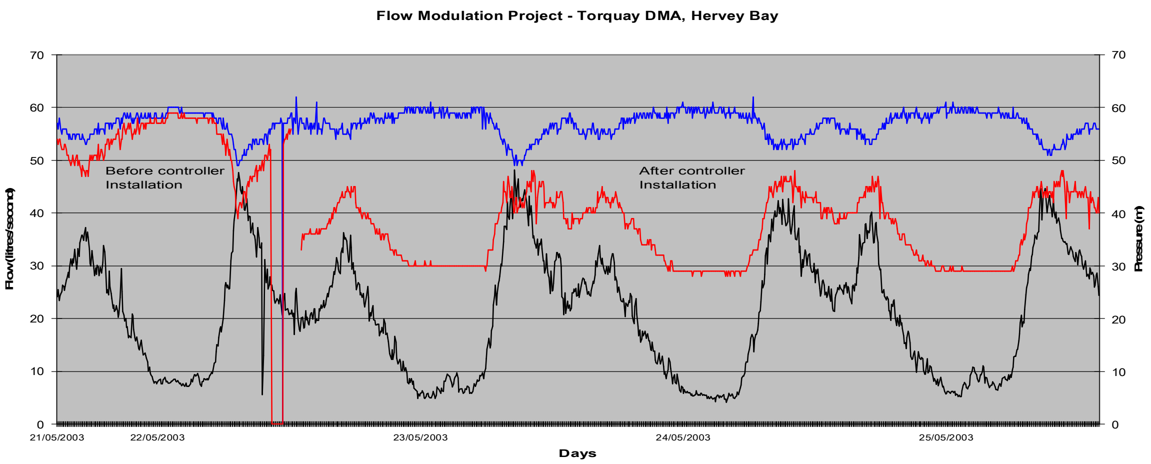
The objective of this trial was to reduce leakage through pressure reduction (especially night time) and maintain levels of service during peak demand periods.

As Hervey Bay has seasonal variations in demand due to holidaymakers during the summer months, the fixed outlet PRV's are unable to change settings automatically when increased demand is experienced, unless carried out manually.

The trial controller was installed in the Torquay district metered area serving 1757 connections. Once the controller was activated, immediate savings were recorded. The average leakage figure was reduced from 6.21 litres per second to 4.55 litres per second, an average saving of 1.66 litres per second.

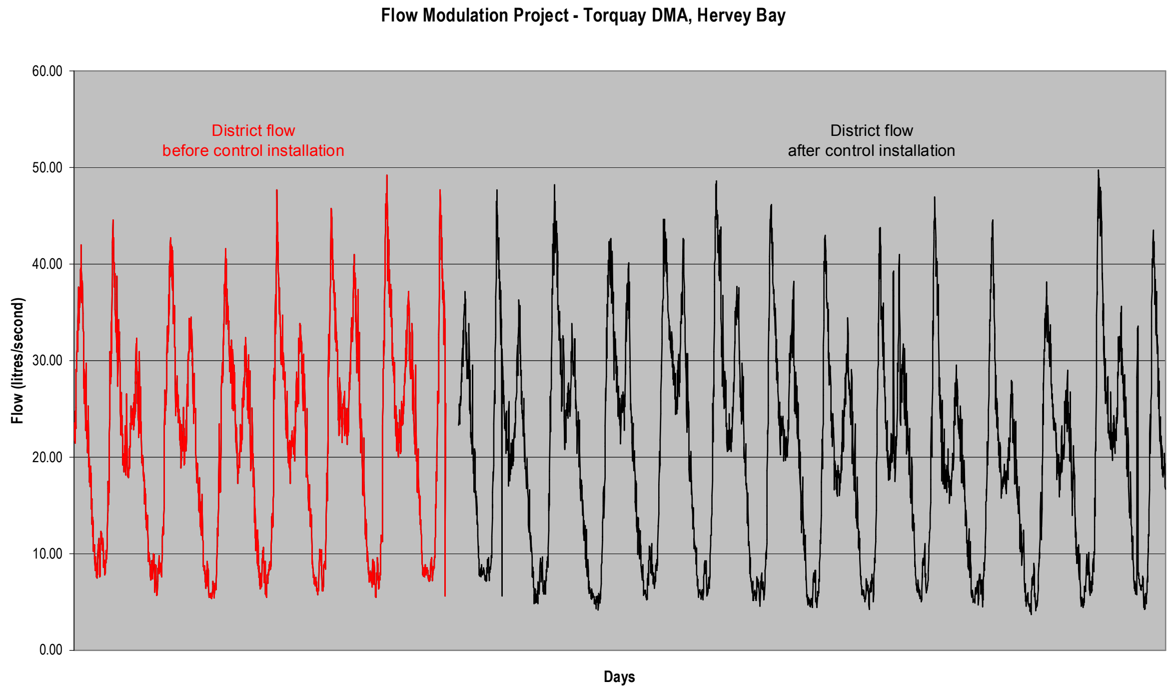
Tests were also carried out at night time to check the response of the controller to a simulated fire emergency. These tests are ongoing so that the response of the controller can be set to an optimum in the event of these types of emergencies.

The flow modulation retro-fit kit was installed onto the 150mml pressure reducing valve situated at the junction of Boundary Road and Robert Street, with one part of the controller installed in the chamber (see left) and the other installed above ground (see above) where the display can be read and adjustments made to the controller. The graphs below show the pressure, flow profiles and volumetric savings before and after the controller was commissioned.

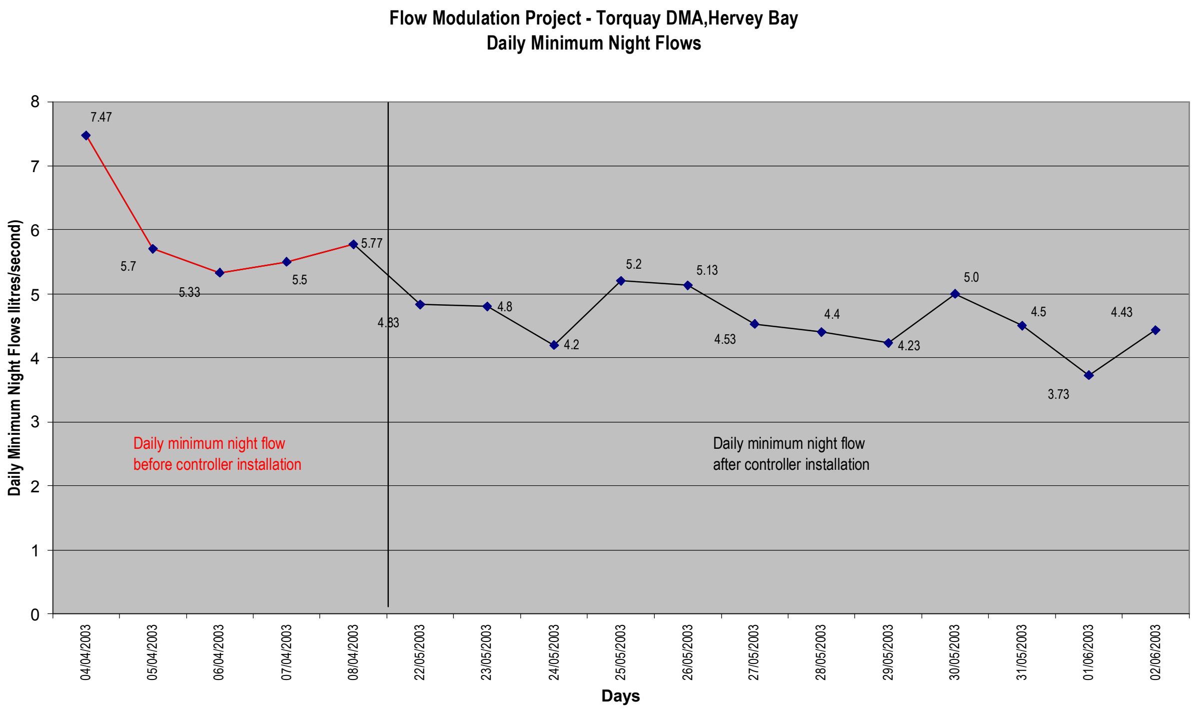


Blue line – incoming pressure, Red line – downstream pressure, Black line – flow

The chart above shows how the downstream pressure follows the flow rate into the district meter area. The controller eliminates the excessive high pressures that would be experienced with no control



The above graph shows the changes in flow profile before (in red) and after the commissioning of the controller. The reduction in the minimum night flows as well as a reduction in overall consumption is evident. The reduction in the minimum night flow is seen to be a gradual decrease as the district metered area adjusts to the new pressure regime



The above graph shows the reduction in the daily minimum night flows before (in red) and after the commissioning of the controller, average reduction is 1.66 l/sec. However the absolute minimum recorded flow is 3.73 l/sec suggesting that further reduction can be achieved with fine tuning.

FINANCIAL SAVINGS

The financial savings from the reduction in the average real loss component of 1.66 l/sec are calculated below, based on the marginal cost of water at $0.15 cents/kilolitre (chemicals, power and pumping costs).

Average reduction in MNF	Volume/day	Volume/year	Savings/year
1.66 l/sec	144 m3/day	52 ML	$7,852.46

CONCLUSION

From the above results, it can be seen that there were significant benefits made by the installation of the flow modulation controller. There were direct volumetric and financial savings, but also operational benefits because when the system experiences high demands the controller can adjust accordingly

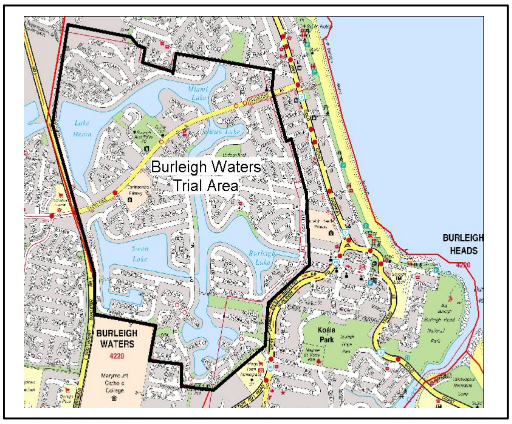
CASE STUDY 3 - GOLD COAST WATER – BURLEIGH WATERS PILOT

In 2002-2003 the Gold Coast experienced its worst drought on record with dam reaching levels as low as 28%. In responding to this situation Gold Coast Water (GCW) implemented a range of drought management strategies including water restrictions, consumer incentive programs and public education initiatives.

Part of this work was to establish a district metered and pressure management pilot area to gauge water loss savings achievable through this method.

PILOT AREA DESCRIPTION

The district metered area is situated in Burleigh Waters which is part of Gold Coast Water's supply area 07. The area supplies 3,310 connections through 46.67km of water mains and is flow is measured by a 200mm Magflow meter. The district metered area is also pressure reduced through a 200mm pressure reducing valve at the same location.



District Meter Area – Flow Monitoring and Leakage Analysis

Using the minimum night flow data and pressure data the potential recoverable leakage was calculated and estimated, using the concepts of Burst and Background Estimates (BABE) methodology. The following results were observed

Average Observed Minimum Night Flow	6.46 litres/second
Estimated Background Flow	3.72 litres/second
Potential Recoverable Excess Leakage	2.75 litres/second or 0.24 ML/day

From the initial analysis, it was determined that potential water savings of 0.24 ML/day could be achieved within this DMA. However, past experience suggests not all of these estimated savings are achievable. It is normally accepted that 60% of the total potential savings are actually saved through leakage control and pressure management.

Leakage Control

To reduce the potential estimated water losses in the pilot area, a series of leakage control methods was implemented to identify burst mains and services these were as follows:

- Leakage detection
- Pressure management

Leakage Detection/Pressure Reduction

Using a combination of noise loggers, leak noise correlators and acoustic listening sticks, five potential leaks were detected and repaired. In conjunction with this leak detection find and fix survey, pressure control was also implemented. A 200mm fixed outlet pressure reducing valve was installed at the supply point (Deodar Drive), downstream of the flow meter and was commissioned on the 16th September 2003.

The pressure reduction was staged over three days and the effects were monitored by the flow and pressure logging. The Table below shows the staged reductions that were implemented.

Date	Average Night Pressure (m) Before	Reduction (m)	Average Night Pressure (After) (m)
16/09/03	69.45	5.01	64.44
17/09/03	64.44	6.8	57.64
18/09/03	57.64	5.77	51.87

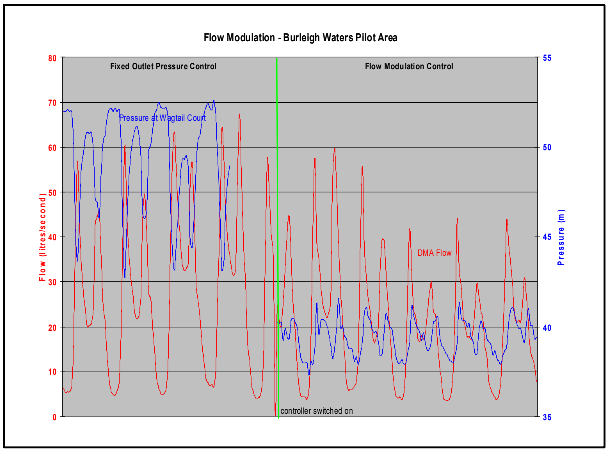
The PRV controller reduces the excessive night pressures experienced in the district meter area without compromising the levels of service at the target or critical points. The graphs below shows the overall reduction flow rates into the pilot area in conjunction with the leak detection and pressure control.

Interim Results

From the implementation of the water demand management techniques as outlined in this pilot study report, significant water savings were made as follows:

Average Minimum Night Flow before	6.20 litres/second (averaged observed night line adjusted)
Average Minimum Night Flow after	4.13 litres/second
Reduction in Minimum Night Flow	2.07 litres/second

This is a real loss saving of 0.17 ML/day or 62.1 ML/year. The 2.07 litres/second water saving amounts to 75% of the potential recoverable water losses. This is higher than the normal expected savings as experienced in similar situations in other parts of the world.



Flow Modulation

In addition to the savings achieved by ordinary fixed outlet pressure control and find and fix leak detection, a flow modulation controller was installed on to the 200mm Dorot pressure reducing valve.

Results

The flow modulation controller was commissioned on the 01st December 2003 with immediate savings.The controller was initially set to maintain 34m of pressure at the critical point (Grebe Place). These settings were maintained from the 01/12/03 through to the 07/01/04 and the following savings were made.

Average MNF Post-Modulation	***Average MNF Flow modulation Commissioned (01/12/03)***	***Reduction***
4.13 l/sec	3.77 l/sec	0.36 l/sec

Further adjustments were made to the controller profile to reduce the pressure during the night to 28m at the critical point (Grebe Place). The adjustments were made on the 08/01/04 and 28/01/04. The following savings were achieved.

Average MNF Flow modulation Commissioned (01/12/03)	***Average MNF 1st Adjustment***	***Further Reduction***
3.77 l/sec	3.44 l/sec	0.33 l/sec

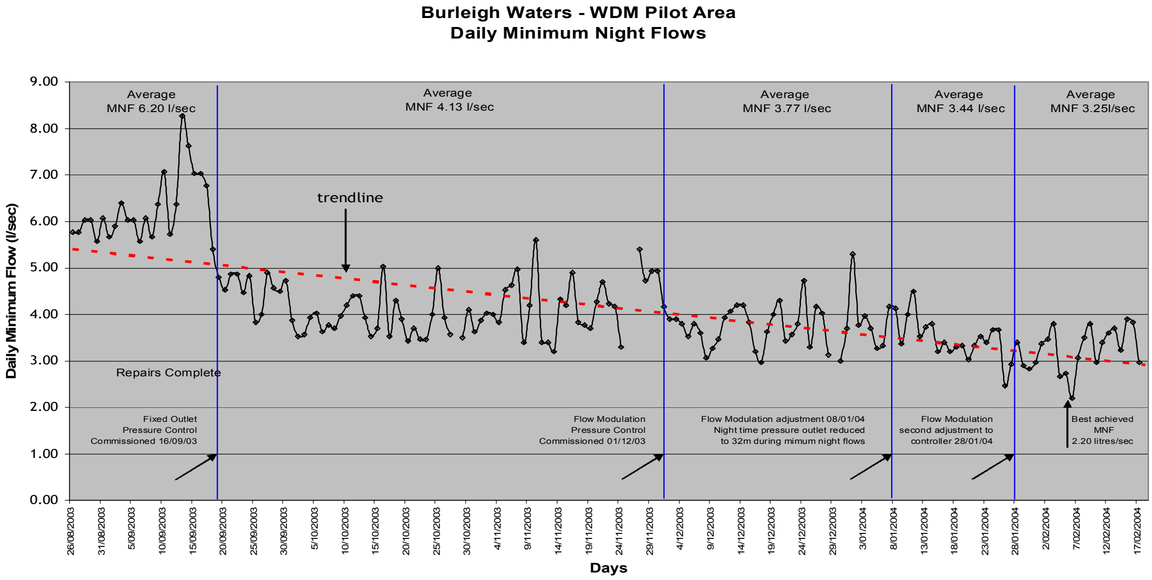
Average MNF 1st Adjustment	***Average MNF 2nd Adjustment***	***Further Reduction***
3.44 l/sec	3.25 l/sec	0.19 l/sec

Summary – Flow Modulation Savings

Date	***Average MNF Pre-Modulation***	***Date***	***Average MNF Post-Modulation***	***Total Reduction***

01/12/03	4.13 l/sec	08/01/04	3.25 l/sec	0.88 l/sec

The following graph shows the progressive daily reduction in night flows achieved by leakage control and pressure reduction

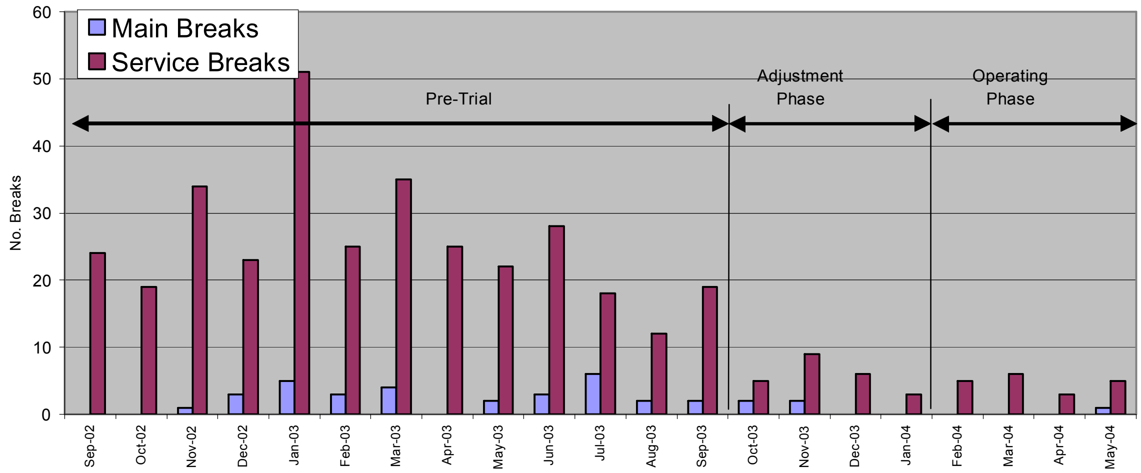


TOTAL SAVINGS

The total average water volume savings after leakage control and pressure/flow modulation is as follows.	Average Minimum Night Flow Pre – *LD & *PR (adjusted)	6.20 l/sec	**Difference**
	Average Minimum Night Flow Post – *LD & *PR	4.13 l/sec	2.07 l/sec
	Average Minimum Night Flow Post – *LD & *PR and FM Modulation	3.25 l/sec	0.88 l/sec
	Average Total Saving		**2.95 l/sec** or 89.15 ML/year

*LD – Leakage Detection *PR – Pressure Reduction

In addition to the reduced water consumption in the trial area, there was a noticeable decrease in water main and water service breaks. The observed decrease in water service breaks was approximately 80%. The observed decrease in water main breaks was approximately 90%. The reduction in water service and main breaks decreases the number of water interruptions and therefore results in an improved level of service to customers. The graph below illustrates the measured changes in water main and water service breaks during the trial period.



Conclusion

There are significant benefits for Gold Coast Water's water supply business units in undertaking pro-active leakage detection and repair in conjunction with a and pressure management program, as demonstrated in the pilot study area

These benefits include:

Short-term financial benefits associated with the costs of buying water from a bulk supplier, water treatment cost savings including the marginal costs of chemicals, power and sludge disposal and water reticulation costs.

Longer-term benefits related to whole-of-life asset costs including a reduction in pipe failures (burst frequency), extended asset life and savings in the costs of repairing burst mains.

Indirect financial benefits also result from more efficient use of existing water supplies. In particular, reduced water losses help ensure that existing water supplies can meet future increases in demand. This can defer construction of new water infrastructure such as dams, treatment plants, reservoirs and water mains.

A degree of drought security is also possible as a lower water demand means that the security of water supply can be maintained for longer periods.

In addition, system verification of pipes and fixtures provides improved knowledge of the distribution system. This enables staff to become more familiar with the system, including the location of mains and valves. This knowledge assists staff to respond more quickly to emergencies such as mains breaks and provides an early indication of any increases in water losses from leaks.

Improved public relations can be expected as Council can inform customers of their efforts to conserve water, save money and improve service delivery by having fewer unplanned water supply failures. Field teams undertaking water audits, leak detection and maintenance work also provide visual evidence that the water system is being well maintained.

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