Large scale pressure management implementation in the City of Cape Town

N Meyer *, M Engelbrecht **, D Wright ***

* WRP Engineers, PO Box 1522, Brooklyn Square, South Africa, 0075, e-mail: nielm@wrp.co.za
** City of Cape Town, Goodwood Municipal Office, c/o Voortrekker Rd and Molteno Rd, Goodwood, South Africa, e-mail: Melvin.engelbrecht@capetown.gov.za
*** City of Cape Town, Goodwood Municipal Office, c/o Voortrekker Rd and Molteno Rd, Goodwood, South Africa, e-mail: donnavinmichael.wright@capetown.gov.za

Keywords: Pressure management, Water savings, Lessons learned.

Abstract

Water supply to the City of Cape Town has been a problem for many years and several large and expensive water transfer schemes have been commissioned to keep pace with the ever-increasing demands. In order to ensure that water will be used effectively and efficiently the City of Cape Town has developed a water demand management strategy which focuses on a range of initiatives including public awareness campaigns on water conservation, replacement of old infrastructure, treatment and re-use of sewerage effluent and pressure management. This paper highlights the pressure management component of the WDM strategy of Cape Town and specifically on the savings achieved to date, the problems experienced and the lessons learned.

The City of Cape Town was the first city in South Africa and one of the first major cities in the world to successfully commission a large scale pressure management project specifically to reduce leakage during off-peak periods. The Khayelitsha installation was the first of such installations to be commissioned in South Africa and was completed in 2001 amid great publicity and press coverage. Since then, the City of Cape Town has implemented pressure management in a number of other areas such as Guguletho, Atlantis, Mfuleni, Delft, and Mitchells Plain and new projects are currently underway in Belhar, Langa and Eersterivier. The results for some of the completed projects are summarised below.

Area	Water Savings (million m^3/year)	Implementation Cost (R)	Cost Savings @R6.20/ m^3 (R/ year)
Khayelitsha	9 million m^3/yr	2.7 mill (2001)	R 55 million/yr
Mfuleni	0.4 million m^3/yr	1.5 mill (2007)	R 2.5 million/yr
Gugulethu	1.6 million m^3/yr	1.5 mill (2008)	R 10 million/yr
Mitchells Plain	2.4 million m^3/yr	7.7 mill (2009)	R 15 million/yr
Total	**13.4 million m^3/year**	**13.4 million**	**R83 million/yr**

Note:
- The cost of R6.20/ m^3 was provided by the City of Cape Town as the current cost (02/09) to produce water.
- The implementation costs are actual costs for the years in which the installations were constructed.

Based on the results it is clear that pressure management has been a highly effective tool to reduce water leakage in Cape Town. The total savings for the projects listed above are approximately 13.4 million m^3/yr which represents approximately R80 million/yr @ R6.20 per m^3 (Approximately US$ 8 million/yr).

This paper clearly highlights the importance of pressure management as a tool to reduce water loss. When correctly implemented, in areas that are suited, pressure management can yield excellent results far exceeding the impact of other types of WDM interventions. The paper also provides guidelines for water utilities on the lessons learned with the implementation of pressure management projects in Cape Town.

Introduction

Water supply to the City of Cape Town has been a problem for many years and several large and expensive water transfer schemes have been commissioned to keep pace with the ever-increasing demands. In order to ensure that water will be used effectively and efficiently the City of Cape Town has developed a water demand management (WDM) strategy which focuses on a range of initiatives including public awareness campaigns on water conservation, replacement of old infrastructure, treatment and re-use of sewerage effluent and pressure management. This paper highlights the pressure management component of the WDM strategy of Cape Town and specifically on the savings achieved to date, the problems experienced and the lessons learned.

The basic concept behind pressure management is that leakage is driven by pressure. If the pressure can be reduced in any way (even if only during off-peak periods) and /or the pressure fluctuations in the system can be lowered in any way, the leakage will be reduced. In addition, the lowering of pressures will result in longer lasting of household plumbing fittings and fewer pipe burst which in turn result in cut-offs when the pipes are being repaired.

It should be noted that pressure management cannot be used in every area and therefore it is essential to carry out careful planning to determine the financial feasibility of a proposed project and to ensure that the network will be able to accommodate pressure reduction.

Pressure Management Planning for the City of Cape Town

General criteria to select potential pressure management areas

The City of Cape Town receives most of its water via the Blackheath Water Purification Plant which stores the water in a large reservoir at an elevation of approximately 110m above sea level. From there water is transferred under gravity to the various parts of the city. Any areas at or near sea level are therefore likely to experience water pressures in the order of 100m unless some form of pressure control is used to lower the pressure to a more appropriate level.

The City of Cape Town identified all potential pressure management areas, in the low laying parts of Cape Town, using the following rating criteria:

- High minimum night flows – a high minimum night flow is one of the clearest indicators of high leakage.
- The topography of the area - one of the key characteristics of the topography in the City of Cape Town is that there are large relatively flat areas at or near sea-level. These large flat areas can in many cases be pressure managed from one or two pressure reducing installations, which may not be possible in an area with a steep gradient.
- The size of the area – larger areas will normally yield larger savings than smaller areas;
- Number of supply points – fewer supply points for an area are considered more ideal because fewer pressure management installations would be required to control the pressure.

Pressure Management Feasibility Studies

The potential for pressure management areas were investigated in detail in separate feasibility studies. The focus of each study was to determine the expected water savings and the suitability of the network for pressure reduction. The feasibility studies typically included the following aspects:

- Logging of actual pressures and flows (or verification of logging results if it were already available).
- Analysis of logging data to determine the expected savings from pressure management implementation.
- Cost benefit analysis to compare the expected water savings to the estimated implementation costs.
- Analysis of logged pressures to determine if the implementation of pressure management will not negatively affect the operation of the system;
- Basic planning to indicate where pressure reducing valves should be located, what the settings of the valves and/ or pressure controllers should be;

Based on the results obtained through the feasibility studies certain areas where prioritised for the implementation of pressure management.

Pressure Management Implementation

The City of Cape Town was the first city in South Africa and one of the first major cities in the world to successfully commission a large scale pressure management project specifically to reduce leakage during off-peak periods. The Khayelitsha installation was the first of such installations to be commissioned in South Africa and was completed in 2001 amid great publicity and press coverage. Since then, the City of Cape Town has implemented pressure management in a number of other areas including Guguletho, Atlantis, Mfuleni, Delft, and Mitchells Plain and new projects are currently underway in Belhar, Langa and Eersterivier.

Mitchells Plain Pressure Management Project

The most recent large scale pressure management project for Cape Town was the Mitchells Plain project. The Mitchells Plain area supports a population of 500 000 and were previously experiencing water pressures ranging from 60m to 90m. The initial combined minimum night flow for two inlets to Mitchells Plain was 900kl/hr of which 430kl/hr was calculated as excess night flow. This indicated high leakage levels in an area experiencing high pressures and as a result, the Mitchells Plain pressure management project was initiated in 2008. The project entailed the construction of one large chamber on a 1220mm diameter pipeline in the Mandalay suburb of Mitchells Plain and another smaller chamber on a 300mm diameter pipeline in the Strandfontein suburb.

The large chamber consisted of four 300mm diameter parallel lines each equipped with two isolating valves, strainer, meter and PRV. The four smaller PRV's were chosen above the option of one large PRV due to the cost implications and the maintenance difficulty of very large valves. Provision was also made in the chamber for a fifth parallel line that can be added in future if the flows should increase. The City of Cape Town also requested a by-pass valve for the installation that can be opened in case of an emergency or maintenance activities. A schematic drawing and a photo of the pipework of the large PRV installation and the by-pas chamber is shown in **Figure 1 and Figure 2.**

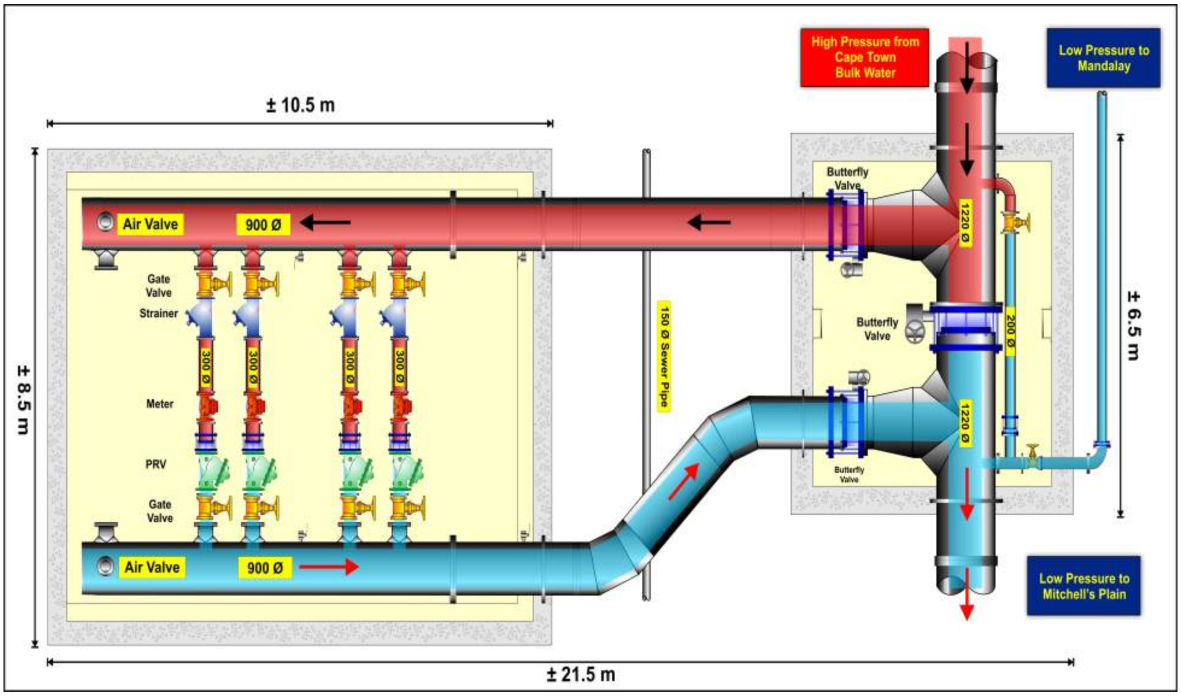

Figure 1: Schematic layout for the large pressure management chamber in Mitchells Plain on the 1220mm diameter supply line.

Figure 2: Installed pipework in recently completed Mitchells Plain Pressure Management Chamber on the 1220mm diameter pipe.

The smaller Mitchells Plain chamber consisted of one 200mm PRV, meter, strainer and isolating valves. A schematic drawing and a photo of the pipework of the small installation is shown in **Figure 3 and Figure 4**.

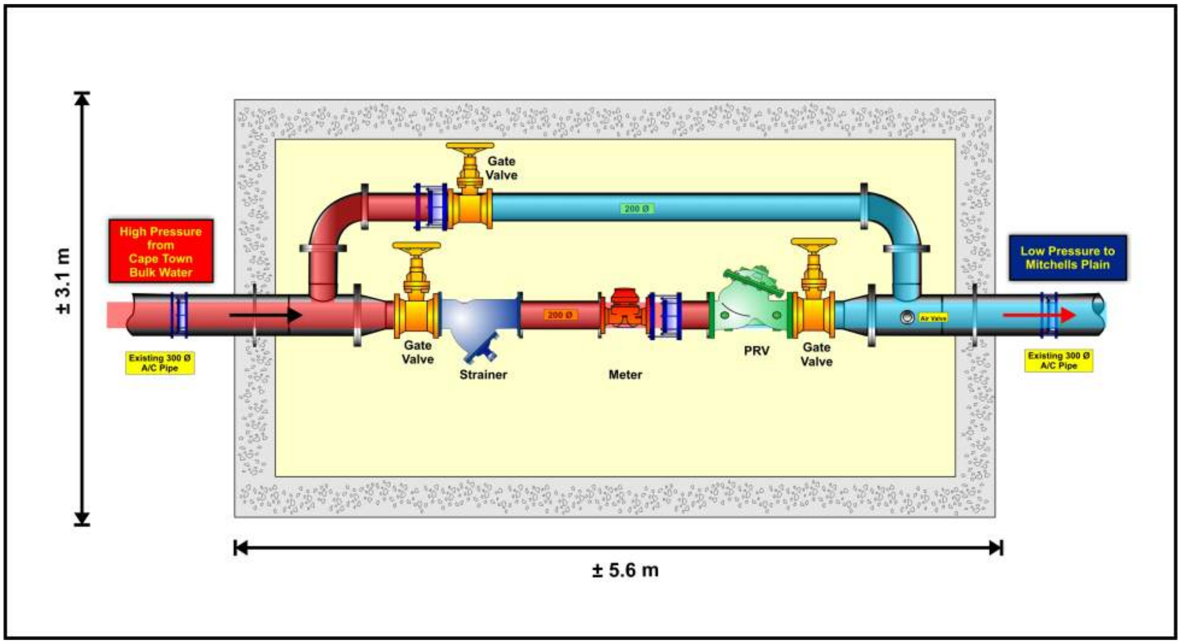

Figure 3: Schematic layout for the large pressure management chamber in Mitchells Plain on the 300mm diameter supply line.

Figure 4: Installed pipework in recently completed Mitchells Plain Pressure Management Chamber on the 300mm diameter pipe.

The Mitchells Plain Pressure Management Project was successfully completed in early 2009. The project will be saving approximately 2.4 million m^3/year.

Community involvement with pressure management projects

In an effort to involve the community and at the same time highlight the importance of water conservation the City of Cape Town has made use of colourful messages on the walls of the large pressure reducing valve installations. A local artist was appointed to create graffiti messages that are both entertaining to look at and informative from a water conservation point of view. (see **Figure 5 and Figure 6**).

The graffiti messages included the toll free telephone number in Cape Town where general water problems and leakage can be reported. Positive feedback has been received from the community and as a result the City of Cape Town plans to utilise similar graffiti messages in other areas.

Figure 5: Graffiti with a water conservation theme used on the outside of the Mitchells Plain chamber.

Figure 6: Graffiti with a water conservation theme used on the outside of the Kayelitsha chamber.

Problems experienced and lessons learned

Through the implementation of a number of large scale pressure management projects the City of Cape Town has learned a number of valuable lessons which are summarised below:

- When correctly implemented, pressure management can yield excellent results with very rapid payback periods. These benefits include the following:

  - The burst frequency for pipes and connections will be significantly reduced,
  - The background leakage (small leaks on connections) will be reduced;
  - The internal plumbing leakage (inside buildings) will be reduced;
  - Daily consumption deemed to be wasteful can be reduced;
  - The water reticulation system as well as the internal plumbing fixtures will have an extended useful lifespan.

- Pressure Management cannot be used in every area and therefore it is essential to analyse the data for a selected area before implementing pressure management. Different software programmes are available to assist the water utility to analyse the logging results and to determine the expected savings from pressure management prior to implementation.
- A high percentage of the total obtainable savings will often be achieved through the use of a normal pressure reducing valve. The remaining (smaller) percentage of the savings can then be achieved through the use of smart pressure controllers.
- Once installed, it is important to monitor the operation of pressure reducing valves and controllers on a regular basis to ensure that all the equipment is operating satisfactorily.
- Operational staff at the water utility should be trained on the maintenance of pressure reducing valves and on the setting of pressure controllers.
- At design stage different pressure reducing valve and pipework configurations should be considered. For installations with high flows on large diameter pipelines it might be cost effective to rather use multiple smaller pressure reducing valves rather than one large valve.
- It is essential to perform a zero pressure test prior to the date of installation. The test involves the temporary isolation of the installation point, while the pressure is monitored. If the pressure drops to zero during the test it means that the isolating valves work properly and that there are no unknown connections that might be feeding in reverse into that section of pipe. Problems were experienced with some of the installations in Cape Town were zero pressure tests were not performed prior to the actual installation, and where it became known that the isolating valves malfunctioned only on the day of cut-in.
- The complete pipework assembly should be pressure tested prior to actual installation. If problems are experienced with leaking fittings during the pressure test these fittings must be replaced or repaired prior to the installation.
- The pressure reducing valves should be correctly sized and selected for the specific minimum and maximum flow rates. Incorrect valve sizing may lead to cavitation or erratic behaviour of the valves. Other publications are available on the correct sizing and selection of pressure reducing valves.
- It is always useful for a water utility to determine the impact of a pressure management project after commissioning. This can normally be done by comparing the logged flow data before and after implementation.

It is normal practice to house pressure reducing valves and associated fittings in a brick or concrete chamber depending. The following issues should be considered when designing the chamber:

- Working space should be allowed underneath the pipework to allow for easy maintenance of fittings (i.e. remove bolts etc). If mechanical meters are used the working space should also be sufficient to easily remove the sieve of the strainer. For Y-type strainers this will require lowering the sieve from the strainer body in which case sufficient ground clearance is required to remove the sieve. Details of the required clearance can be obtained from the strainer manufacturers.
- The overall inside height of the chamber should ideally be sufficient for an average person to stand up while performing maintenance work. A guideline for the inside height is 1.8 m to 2.2 m with an inside width of between 1.4 m to 1.6m.
- The chamber should ideally be designed as a water-tight structure in areas where natural groundwater levels are above the floor level of the chamber.
- The pipework should be anchored in the walls/floor of the chamber. This is especially important for installations on high pressure lines.
- The pipework should be supported with brick or concrete plinths.
- Provision should be made for a sump in the floor of the chamber, below one of the manhole covers, to allow for collection of water when pumping water out of the chamber with a submersible pump.
- If security is of concern a lockable manhole cover should be provided to prevent unauthorized access to the chamber. A range of different lockable manhole covers are available.

Savings achieved to date with Pressure Management Implementation in Cape Town

Pressure management has been highly successful in achieving water savings in the City of Cape Tow. A summary of the savings at some of the larger installations are summarised below in **Table 1**.

Table 1: Summary of Results for some of the completed pressure management projects in the City of Cape Town.

Area	Water Savings (million m^3/year)	Implementation Cost (R)	Cost Savings @R6.20/ m^3 (R/ year)
Khayelitsha	9 million m^3/yr	2.7 mill (2001)	R 55 million/yr
Mfuleni	0.4 million m^3/yr	1.5 mill (2007)	R 2.5 million/yr
Gugulethu	1.6 million m^3/yr	1.5 mill (2008)	R 10 million/yr
Mitchells Plain	2.4 million m^3/yr	7.7 mill (2009)	R 15 million/yr
Total	**13.4 million m^3/year**	**13.4 million**	**R83 million/yr**

Note:
- The cost of R6.20/ m^3 was provided by the City of Cape Town as the current cost (02/09) to produce water.
- The implementation costs are actual costs for the years in which the installations were constructed.

Based on the results it is clear that pressure management has been a highly effective tool to reduce water leakage in Cape Town. The total savings for the projects listed in **Table 1** are approximately 13.4 million m^3/yr which represents approximately R80 million/yr @ R6.20 per m^3 (Approximately US$ 8 million/yr).

In addition to the water savings, pressure management has also resulted in fewer pipe bursts and a reduction in wastewater volumes which results in additional financial savings to the City of Cape Town through reduced treatment costs and the postponement of additional costly sewage treatment capacity. The reduction in wastewater volumes has been determined for the Kayelitsha installation and is 20Ml/day which results in an annual saving in sewerage treatment cost of R2.5 million/year.

Conclusions

This paper clearly highlights the significance of pressure management as a tool to reduce water loss. When correctly implemented, in areas that are suited, pressure management can yield excellent results far exceeding the potential impact of other types of WDM interventions. The paper also provides guidelines for water utilities on the lessons learned with the implementation of pressure management projects in Cape Town.

References

Heimann, A., Meyer N. & Liemberger, R. (2009) Tailoring the Specifications for Pressure Reducing Valves, *Paper presented at the IWA Water Loss Conference in Cape Town.*

Lambert, A.O., (1997) Pressure Management/Leakage Relationships: Theory, Concepts and Practical Applications. *Conference on Minimising Losses in Water Supply Systems. IQPC Ltd, London.*

May, J. (1994) Pressure Dependent Leakage. *World Water and Environmental Engineering.*

Mckenzie, R.S. (2005) Pressure Management : Overview of Activities in South Africa. *Paper presented at the International Water Association Specialist Workshop, Radisson Resort, Gold Coast, Queensland Australia.*

Mckenzie, R.S. (2005) Best practice in Pressure Management. *Paper presented at the Water Supply Association of Australia, Swiss Grand Hotel, NSW Australia.*

McKenzie, R.S., Mostert, H. & Wegelin, W. (2003) Leakage Reduction through Pressure Management in Khayelitsha, Western Cape: South Africa. *Paper presented at the Australian Water Association Annual Conference, Perth. .*

Mckenzie, R.S., & Wegelin, W. (2002) Leakage Reduction through Pressure Management in South Africa. *Paper presented at the IWA Managing Leakage Conference in Cyprus.*

Mckenzie, R.S., Rohner K. & Wegelin, W. (2000) Leakage Reduction through Pressure Management in Greater Johannesburg area. *American Water Works Association, Conference Proceedings, 1 December 2000.*

Queensland Environmental Protection Agency & Wide Bay Water (2003) Managing and reducing losses from Water Distribution System, *Manual 5, Advanced Pressure Management and PRV Selection (EP, Brisbane).*

Seago, C.J. & McKenzie, R.S. (2006) An assessment of Non Revenue Water in South Africa. *South African Water Research Commission Report Project: K5/1535.*

South African Water Research Commission (1999) Development of a standardised approach to burst and background losses in water distribution systems in South Africa. *South African Water Research Commission, Report No. TT 109/99, ISBN 1 86845 490 8*