In Association with

Third Party Evaluation of

Wide Bay Water Corporation Smart Metering

For: DEWHA

FEBRUARY 05, 2010

Please cite this report as: Turner A., Retamal M., White S., Palfreeman L. and Panikkar A., (2010) *Third Party Evaluation of Wide Bay Water Smart Metering and Sustainable Water Pricing Initiative Project*. Report prepared by the Snowy Mountains Engineering Corporation in association with the Institute for Sustainable Futures, UTS, for the Department of the Environment, Water, Heritage and the Arts, Canberra.

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ACKNOWLEDGEMENTS

The authors of this report would like to thank the AMR smart metering team at Wide Bay Water Corporation for their time and assistance in providing the information necessary to conduct this evaluation.

ABBREVIATIONS & GLOSSARY

AD	Average Day
AMR	Automatic Meter Reading
ARC	Australian Research Council
CEO	Chief Executive Officer
DEWHA	Department of Environment, Heritage, Water and the Arts
DMA	District Meter Area
FCRC	Fraser Coast Regional Council
GIS	Geographic Information System
ISF	Institute for Sustainable Futures
IT	Information Technology
LCD	Litres per capita per day
MD	Maximum day
MDMM	Mean day maximum month
MNF	Minimum night flows MNFs in urban areas typically occur between 1 and 4 am, although this varies depending on the characteristics of the zone being investigated. During MNFs, authorised consumption is normally at a minimum and therefore real losses are at their maximum percentage of the total flow.
NRW	Non revenue water NRW is the difference between a system input volume such as bulk water production for city and the billed authorized consumption. This volume of water comprises of unbilled authorised consumption (e.g. unbilled metered and unbilled unmetered consumption), apparent losses (e.g. unauthorized consumption and customer metering inaccuracies) and real losses associated with various types of leakage.
NWC	National Water Commission
PIFU	Planning Information and Forecasting Unit
PRV	Pressure Reducing Valve
SMEC	Snowy Mountains Engineering Corporation
SQL	Structured Query Language
WBWC	Wide Bay Water Corporation
WSAA	Water Services Association of Australia

EXECUTIVE SUMMARY

This report provides the findings of a third party evaluation of a major smart metering project conducted by Wide Bay Water Corporation (WBWC). The Evaluation has been undertaken by the Snowy Mountains Engineering Corporation (SMEC) and the Institute for Sustainable Futures (ISF), at the University of Technology, Sydney, on behalf of the Department of the Environment, Water, Heritage and the Arts (DEWHA).

WBWC has installed the first residential automatic water meter reading (AMR) system in Australia on a city-wide scale and are the first utility internationally to require an advanced level of data storage, issue reporting and data manipulation functionality at this scale[1]. The AMR Project "*Wide Bay Water Smart Metering and Sustainable Water Pricing Initiative Project*" has been funded in part by the Australian Government's Water Smart Australia Program. It has involved the installation of over 20,000 residential AMR water meters in phases since 2006 and the set-up of the associated data capture, billing and management systems.

This AMR Project represents an extremely important step forward in understanding how this rapidly emerging technology can be used effectively in water planning and management. The experience of WBWC can be used to provide insight into how the implementation process has and could be undertaken but also to assist in setting direction for future AMR systems taken up in Australia.

To date WBWC has made significant advances in utilising the data being generated by the AMR system (one hour resolution) to provide local (Hervey Bay region), state, national and international advances in water management and planning. Highlights include:

- **billing** - the ability to provide a far higher level of customer service when customers enquire about their bills (thereby reducing queries and disputes significantly) and where necessary to provide evidence of water restrictions infringement to enable prosecution for restrictions violation;

- **operations** - the ability to understand at a detailed level the effects of pressure reduction on various components of water demand, the opportunity to optimise the system and improve international non revenue water modelling assumptions;

- **research** - discovery for the first time of the level of household water leakage (predominantly associated with leaking toilets), the ability to characterise different types of household leaks and investigate the effectiveness of restrictions;

- **planning** – the ability to determine diurnal patterns for individual areas and therefore refine hydraulic network modelling input parameters which together with demand management activities have the potential to enable deferment of major capital expenditure; and

- **management** – ability to cost an AMR project from the perspective of a pioneer such as WBWC or as a routine utility installing such a system in the future ($290 and $190 per connection respectively based on 2006 figures), develop a business case for AMR systems that highlight the significant and far reaching benefits and need for a research plan to assist in focusing investigations to gain the most out of such a system.

[1] Whilst AMR technology and systems have been used by a number of water utilities in the US in recent years these utilities have not used the full capabilities of such AMR systems.

As can be seen WBWC has made a number of major findings in terms of discovering what AMR systems can provide the water industry. However, there are many additional significant opportunities still to be explored that could revolutionise the water industry within the next 5 to 10 years. These include for example:

- real time downloading of AMR data to a water service providers management systems for an entire region to enable immediate analysis and response to leaks and water restrictions violations;

- greater interaction between AMR data and water planning and demand forecasting tools such as the Water Service Association of Australia's integrated supply demand planning (iSDP) model, to streamline future water management planning and analysis;

- the use of climate correction modelling (which normally relies on bulk water production data) on detailed AMR data to assist in providing a far greater understanding of seasonal outdoor demand in various sectors and customer groups as well as responses to a variety of restrictions regimes; and

- automatic monitoring and evaluation of demand management initiatives (that normally need several quarters of customer metered data for analysis) immediately after the intervention to rapidly determine the effectiveness of individual initiatives.

Since 2006 when WBWC committed to the AMR system it is using, many advances have been made to this emerging technology and thus some of the pitfalls observed by WBWC may not affect other newer AMR systems. However, care needs to be taken by any utility embarking on installing an AMR system to vision what they want to do with the system and as far as possible "future proof" their investment, learning from some of the insights documented in this report.

The Water Smart Australia Program funding deed for the Project included two main objectives and a number of additional specific objectives. The main objectives are listed below and the specific objectives listed in Table 1 together with a summary of WBWCs achievements against those objectives at the time of this Evaluation.

The main objectives of the project include:

1. Implementing Australia's first AMR system - this has been successfully achieved; and

2. Researching a model and developing an implementation program for pricing reform such as "time of use" water pricing - this is an ongoing process as detailed in section 4.4.2 of this report.

This Evaluation represents a snap shot in time. Whilst WBWC may not have achieved some of the identified objectives yet, it is envisaged that over the coming year WBWC is likely to make many additional significant advances both locally and for the water industry at a national and international level. It is likely to have achieved these, where feasible, by the end of the Project evaluation period in 2011.

There is significant opportunity for WBWC to make further advances in how they use the AMR system, which will benefit the water industry at a local, state, national and international level. Where appropriate, WBWC could collaborate with other interested parties in the water industry to pool resources. This would enable applied research in this area to advance where there are broader benefits to the water industry and set-up a network of practitioners interested in advancing AMR.

Table 1 – Summary of specific project objectives and outcomes

Specific objective	Achieved outcome at the time of evaluation
'*reduce customers' residential water leakage (by an estimated 182 ML/a) through the implementation of AMR meters and improved billing information that identifies the presence of a water leak in customer's residences*'	Savings in Port Vernon for a pilot group of 47 households identified with leaks (out of approximately 2,360) saved over 26 kL/day (potentially over 9 ML/a if leaks were assumed to be on going). This was after a pilot household leakage demand management program was implemented from October to December 2007 (Britton et al 2008). Whilst this was only a pilot study and does not achieve the aim of saving 182 ML/a, it does demonstrate the significant savings available if WBWC roll out such a program across the city and that such savings could potentially be achieved.
'*reduce customers' residential water consumption (particularly water usage in residential gardens) by an estimated 914 ML/a through implementation of AMR meters and a new water pricing model that encourages irrigation at night and general water efficiency practices*'	Demand on a per person and per household basis in the residential sector has been declining in Hervey Bay since 2001/02. A large number of factors are responsible for this decline including (but currently to a limited extent) the AMR system. New water pricing has not come into effect therefore this has had no effect on water demand. From inspection of recent water demand (refer to Figure 2-4) the residential sector used approximately 3,837 ML/a in the Project base year of 2004/05. Typical household usage in 2004/05 was approximately 240 kL/household/a (refer to Figure 2-5). 2007/08 shows a significant fall in overall residential demand (3,050 ML/a) and household demand (170 kL/household/a). This significant drop in demand is likely to be mainly attributable to above average rainfall in 2007/08 reducing residential outdoor water usage. From the research carried out by WBWC there is significant scope to reduce customer residential demand in indoor and outdoor water usage and (as above) household leakage. However, it is unlikely that WBWC would be able to reduce residential water usage by 20 to 25% as suggested by the original estimates (914 ML/a which includes the 182 ML/a associated with residential leakage) in "average" weather conditions without a significant level of investment in a demand management program to complement the AMR system. Considering the AMR system is now operational in both the residential and commercial/non residential sectors in the Hervey Bay region it is suggested that the 2011 Evaluation considers the savings in the residential, commercial/non residential and non revenue water sectors achieved by the AMR system and associated demand management programs. This will enable WBWC to implement the most cost effective options to achieve the broader savings of '*20 to 25%*' specified in the funding deed.
'*defer capital construction costs regarding trunk pipe infrastructure by reducing peak daily use (with the aim of deferment of $5 M in capital investment by the end of the evaluation period)*' – 2011	Whilst WBWC has not yet explicitly deferred capital expenditure due to the new AMR system to date, the combination of: - more refined and accurate hydraulic modelling; - the revision of the Capital Works Plan by the end of 2009; - understanding in much more detail where peak demand constraints are and why; and

Specific objective	Achieved outcome at the time of evaluation
	- having an AMR system that enables WBWC to measure the effectiveness of demand management measures targeting constrained areas; will provide WBWC with a major opportunity to defer capital costs associated with their water and wastewater systems (i.e. trunk main infrastructure by reducing peak daily use). With the foundation being set by WBWC there is every indication that the aspiration of saving $5M of capital expenditure will be achieved.
'*demonstrate to other urban water authorities the use of AMR meters and the benefits of the Project*'	WBWC has been very active in keeping the industry informed of the progress of the Project through: - accompanied site visits for a diverse range of water industry practitioners; - production of a DVD; - provision of information on the WBWC website (http://www.widebaywater.qld.gov.au/); and - coverage of the latest research in technical magazines, journal papers and conferences at a state, national and international level.
'*improve water planning and other demand management initiatives*'	WBWC are making significant improvements in both water planning and demand management initiatives through advancement in: - non revenue water modelling; - the assumptions associated with hydraulic network modelling; - revision of their 10 Year Capital Works Plan using the new AMR data; and - demand management programs and pilots associated with household leakage, pressure reduction and restrictions enforcement. However, from evidence of the research carried out by WBWC there is further scope to tap into significant additional water savings (conservation potential) associated with both indoor and outdoor residential water usage and household leakage in Hervey Bay. There is also significant scope to reduce demand in the non residential sector and still some opportunity in the non revenue water sector. WBWC has set the foundation for improvements in water planning and demand management initiatives, which they can build on over the coming years.

1 INTRODUCTION

1.1 BACKGROUND

In January 2009 the Department of the Environment, Water Heritage and the Arts (DEWHA) commissioned the Snowy Mountains Engineering Corporation (SMEC) and the Institute for Sustainable Futures (ISF) at the University of Technology, Sydney, to undertake a third party evaluation (the Evaluation) of a major smart metering project. The findings of the Evaluation are summarised in this report.

The smart metering project, undertaken by Wide Bay Water Corporation (WBWC) is titled the "*Wide Bay Water Smart Metering and Sustainable Water Pricing Initiative Project*" (the Project). The Project has involved the installation of over 20,000 residential automatic meter reading (AMR) water meters in phases since 2006 and set-up of the associated data capture, billing and management systems.

The WBWC AMR Project is the first large scale implementation of smart metering technology in Australia and thus represents an extremely important step forward in understanding how smart metering can be used in water planning and management. The lessons learnt by WBWC will be of significant interest to numerous water service providers across the country interested in taking up this type of emerging technology. This report is a way to provide the water industry with a summary of the first full scale AMR system implemented in Australia, lessons learnt and opportunities for the future.

1.2 THE WBWC AMR PROJECT

1.2.1 Project funding and administration

WBWC provides water and wastewater services to more than 60,000 people (over 20,000 residential connections) in the Hervey Bay region. In 2005/06 WBWC submitted a proposal to the National Water Commission (NWC) under the Water Smart Australia Program to install approximately 20,000 AMR water meters in households within Hervey Bay. In April 2006 the project commenced following approval by the Australian Government. In December 2007 DEWHA took over responsibility of administration of the Project including evaluation requirements.

The Project was originally estimated to cost approximately $5.4M, with $2.6M committed by the Australian Government, an additional $0.9M provided by the Queensland Government[2] and the remainder provided by WBWC.

1.2.2 Objectives

The main objectives of the WBWC AMR Project (as stated in the funding deed) are to:

'*reduce customers' overall water consumption significantly (currently estimated at a potential 20 to 25%) through:*

- *implementing Australia's first AMR system; and*
- *researching a model and developing an implementation program for pricing reform such as a "time of use" water pricing system whereby water used at night is cheaper than water used during the day.*

[2] http://www.widebaywater.qld.gov.au/# [accessed 16/03/09]

The specific objectives of the Project are to:

- *reduce customers' residential water leakage (by an estimated 182 ML/a) through the implementation of AMR meters and improved billing information that identifies the presence of a water leak in customers' residences;*
- *reduce customers' residential water consumption (particularly water usage in residential gardens) by an estimated 914 ML/a*[3] *through implementation of AMR meters and a new water pricing model that encourages irrigation at night and general water efficiency practices;*
- *defer capital construction costs regarding trunk pipe infrastructure by reducing peak daily use (with the aim of realising the deferment of $5M in capital investment by the end of the evaluation period*[4]*);*
- *demonstrate to other urban water authorities the use of AMR meters and the benefits of the Project; and*
- *improve water planning and other demand management initiatives.*'

1.3 THIS EVALUATION

1.3.1 Objectives

The objectives of this Evaluation are to provide an independent review of the WBWC AMR Project focusing on:

- evaluation of the techniques developed during the Project, the processes and methods used and lessons learnt;
- the extent to which the Project objectives have been met; and
- the benefits resulting from the Project.

1.3.2 Approach

This Evaluation has been conducted by SMEC and ISF with the co-operation of WBWC staff. It has been conducted through a combination of review of:

- available written documentation (WBWC Project milestone reports and research papers);
- interviews by SMEC/ISF with WBWC staff;
- workshops with DEWHA, SMEC, ISF and WBWC staff; and
- follow-up discussions between SMEC/ISF and WBWC staff including provision of additional WBWC information not available in current documentation.

This review approach has assisted to draw out lessons learnt and ideas on how the system, processes and techniques developed could be improved.

[3] The 182 ML/a is included within the estimated 914 ML/a savings.
[4] In 2011

SMEC and ISF staff used a combination of auditing and water planning and management techniques to review the various aspects of the AMR system. This included determining what has been done to date and what potential such a system holds in terms of improving water planning and management in the future.

Two key approaches used were:

- a systems approach, as illustrated in Figure 1-1, which helps to clarify both the technical and people based components of the system; and
- an integrated resource planning (IRP) approach, as illustrated in Figure 1-2, which helps to clarify how information from such a system can be used effectively within best practice water planning and management.

Figure 1-1 The system

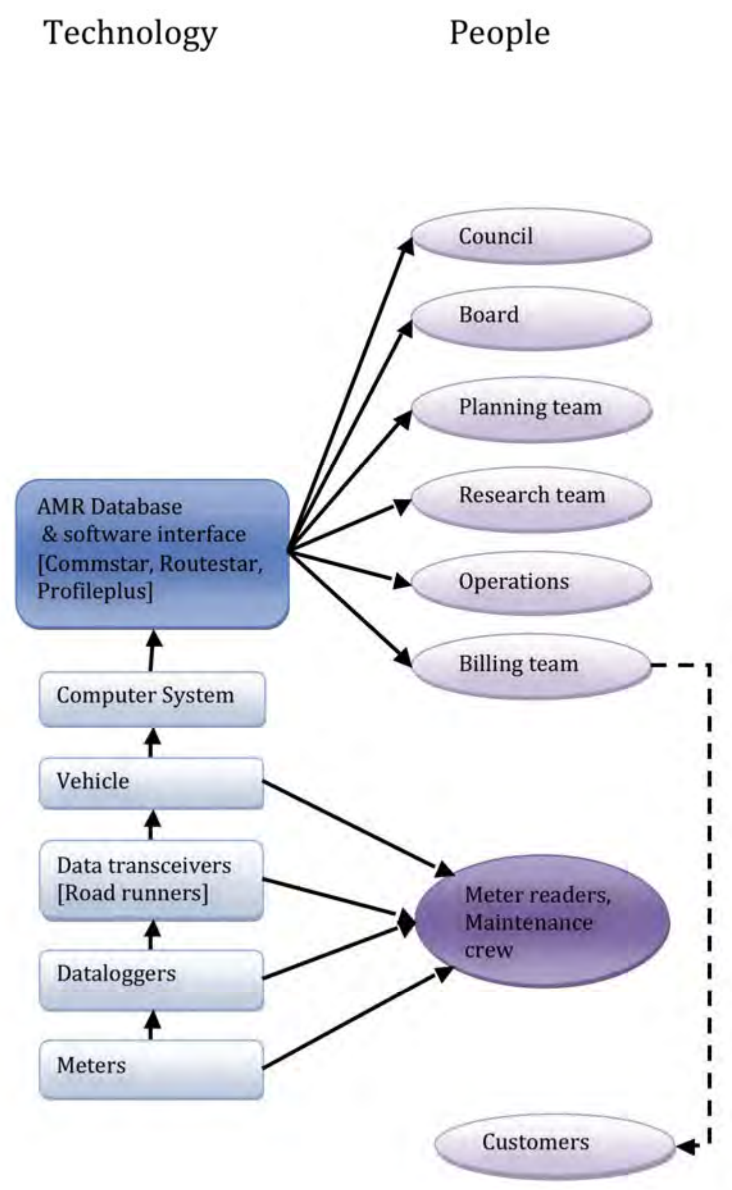
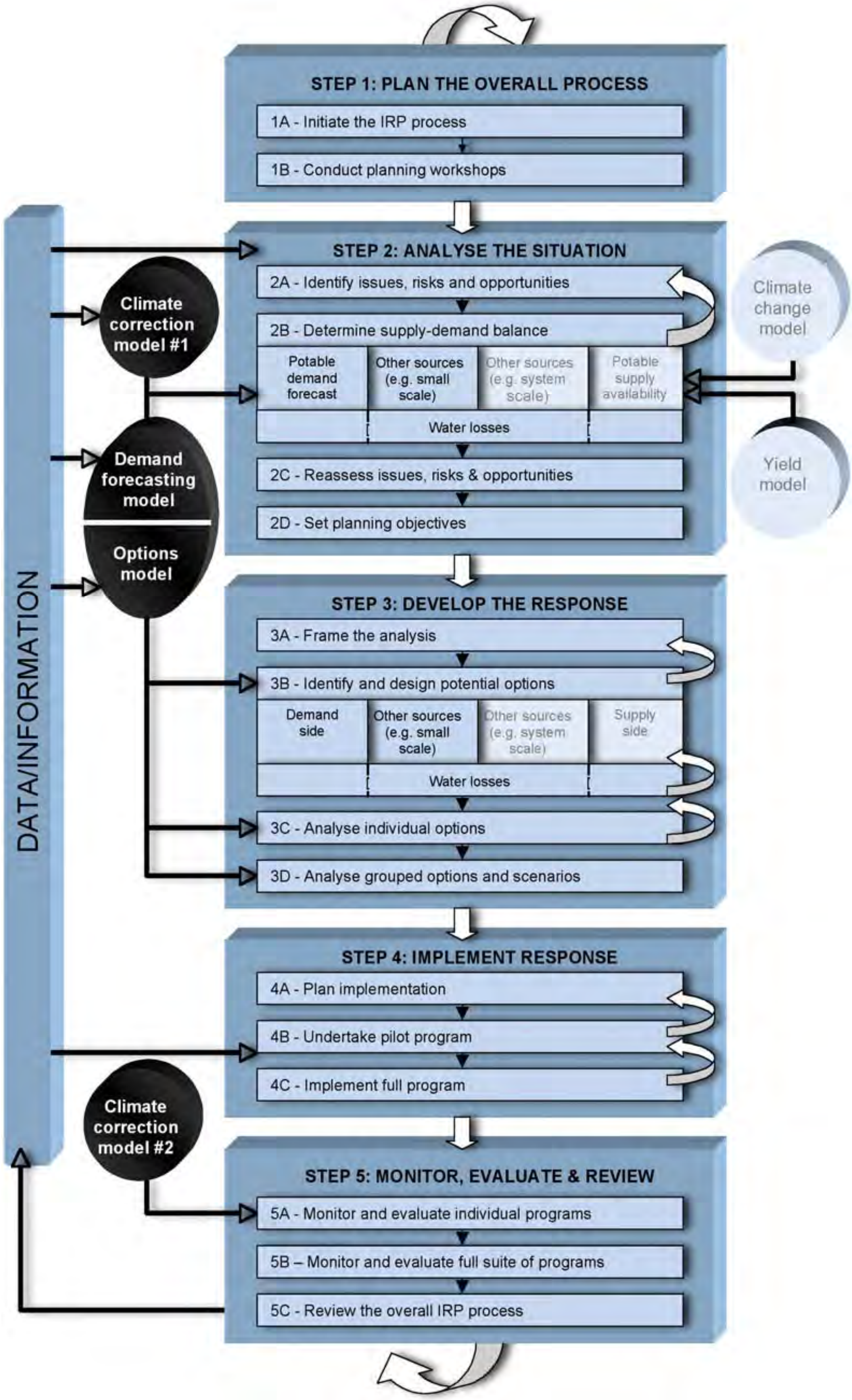


Figure 1-2 Integrated resource planning (Turner et al 2008)



1.4 THIS DOCUMENT

This document has been set out as follows:

- Introduction - brief background on the WBWC Project, the objectives of this Evaluation and approach used.
- WBWC and Hervey Bay - brief overview of WBWC, the Hervey Bay region and how water is used, to provide context for the Evaluation.
- The WBWC AMR system - details of how the AMR system was chosen, what the system actually is and some of the lessons learnt by WBWC in choosing and installing the system.
- Existing processes and techniques - overview of some of the key processes and techniques developed by WBWC so far, following the installation of the AMR system.
- Progress against objectives - assessment of the extent to which the specific objectives of the Project have been met such as achieving water savings, deferring capital investment and informing the broader water industry about the AMR system.
- Opportunities for potential additional processes and techniques - consideration of a spectrum of additional processes and techniques that could be explored using the AMR system that could have significant local, state, national and international benefits.

Further information is available from the DEWHA website. In addition, details of the research undertaken by WBWC can be obtained from the WBWC website.

2 WBWC AND HERVEY BAY

This section provides a brief overview of WBWC, the Hervey Bay region and how water is used. This is to give some context before providing details about the installed technology and the processes that have been developed. These details will assist in understanding how the AMR system has been and could be used to save water and defer capital expenditure, two key aims of installing the technology.

2.1 WBWC

WBWC is a government owned corporation, providing water and wastewater services to over 60,000 people in Hervey Bay and the townships of Burrum Heads, Howard, Toogoom and River Heads. The corporation is wholly owned by Fraser Coast Regional Council (FCRC) and governed by an independent Board of Directors.

WBWC owns and operates three dams on the Burrum river, two water treatment plants, six sewage treatment plants, five wastewater reuse storage reservoirs, 682 km of water mains and 346 km of wastewater mains. WBWC is committed to recycle most of its wastewater (90% by 2008) through a variety of irrigated crops, sugar cane, pasture, tea tree plantations, golf courses, sports fields and a turf farm. Currently only a small proportion of the recycled water offsets potable water. This is mainly in the industrial park being developed.

2.2 HERVEY BAY DEMOGRAPHICS

Hervey Bay has been in the top ten fastest growing regions in Australia for the last decade. The current population is 60,746 (2007/08 - figures provided by WBWC). This is projected to rise to 96,296 by 2026 (PIFU), with an annual growth of around 4% per annum. In addition, Hervey Bay has a significant seasonal influx of tourists during the whale watching season (August to October) and the summer holidays (December to February).

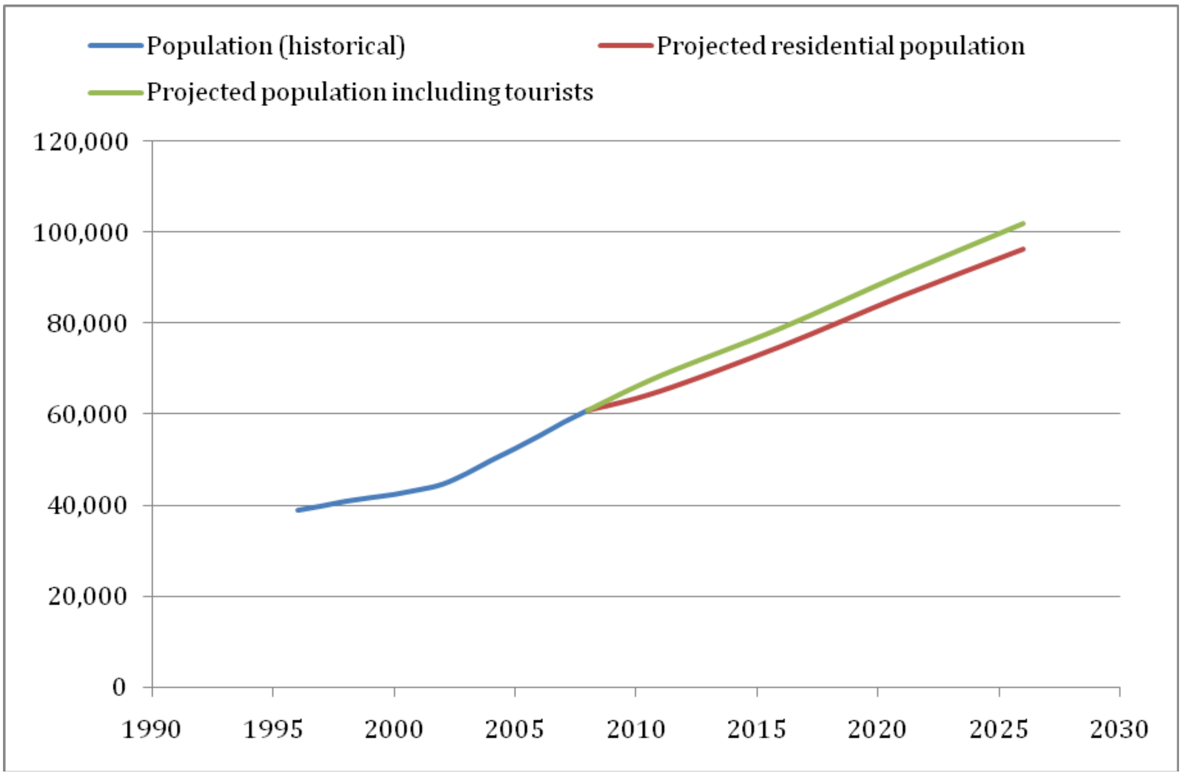
Table 2-1 and Figure 2-1 show the historical and projected population for Hervey Bay including equivalent tourist population projections.

Table 2-1 Historical and projected population including tourism

Year	Population (historical)	Projected residential population (PIFU)	Projected population including tourists (Adjusted PIFU)
1996	38,809		
1997	39,775		
1998	40,810		
1999	41,580		
2000	42,294		
2001	43,298		
2002	44,545		
2003	46,929		
2004	49,746		
2005	52,375		
2006	55,157		
2007	58,116		
2008	60,746		
2011		65,000	68,374
2016		74,900	78,907
2021		86,000	90,759
2026		96,296	101,948

(Source – WBWC)

Figure 2-1 Historical and projected population in Hervey Bay



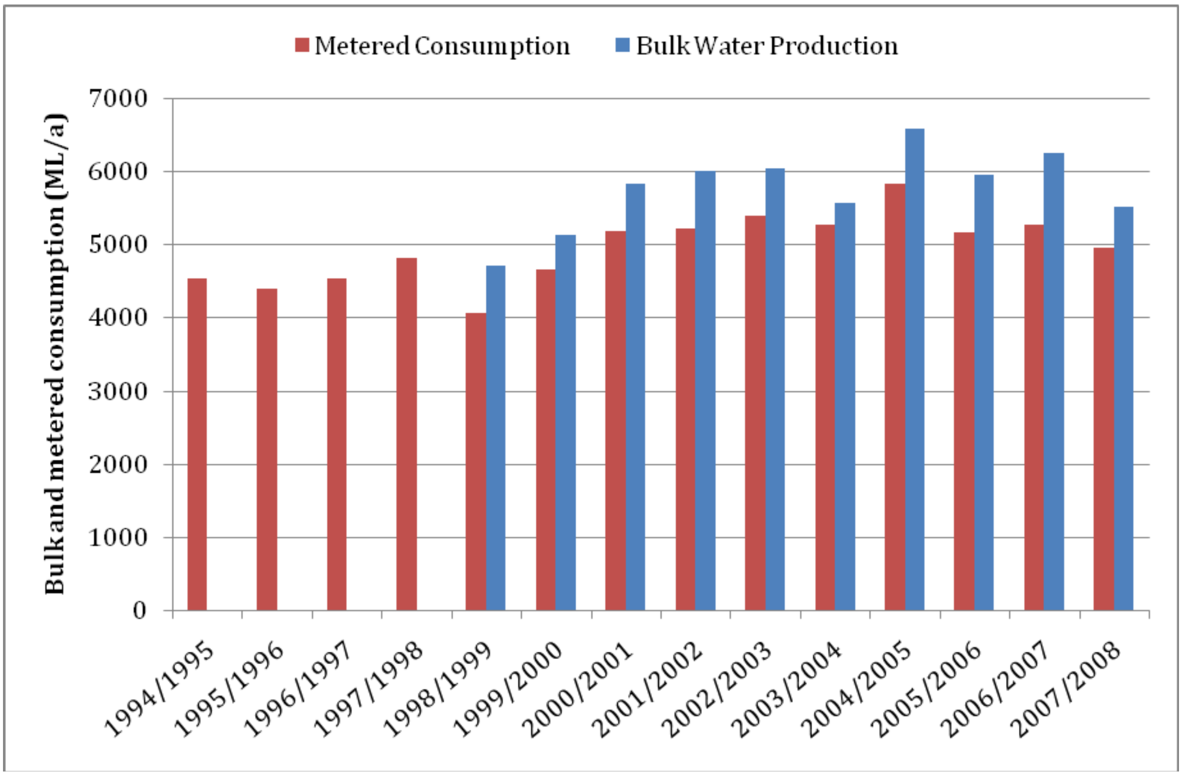
(Source – WBWC data)

2.3 WATER DEMAND

This significant increase in population including tourism is likely to have a major impact on average and peak season demands, the two main drivers that will affect water and wastewater infrastructure requirements.

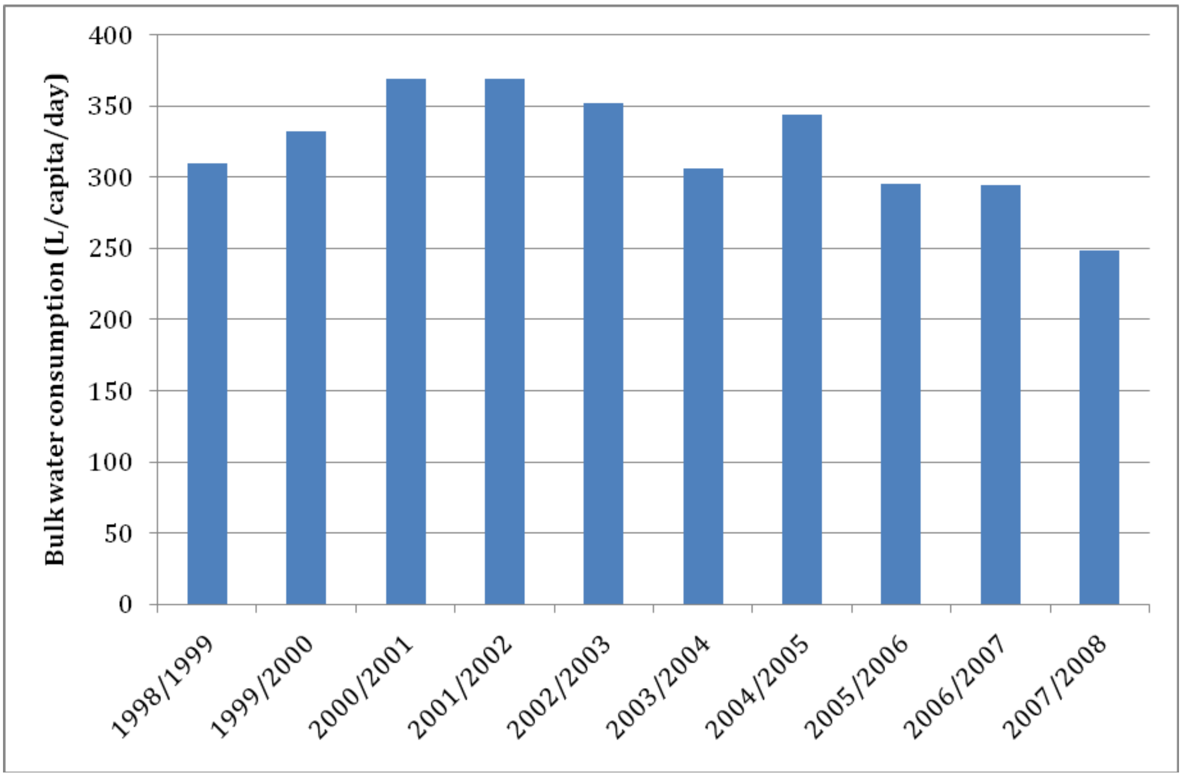
However, to date, despite the population rise, average water demand in the region has not increased significantly and according to per capita demand it has been decreasing since 2001/02. Figure 2-2 shows overall historical bulk water production together with customer metered demand. Figure 2-3 shows the overall historical bulk water production adjusted for population in terms of litres per person per day.

Figure 2-2 Historical bulk water production and customer metered demand



(Source – WBWC data)

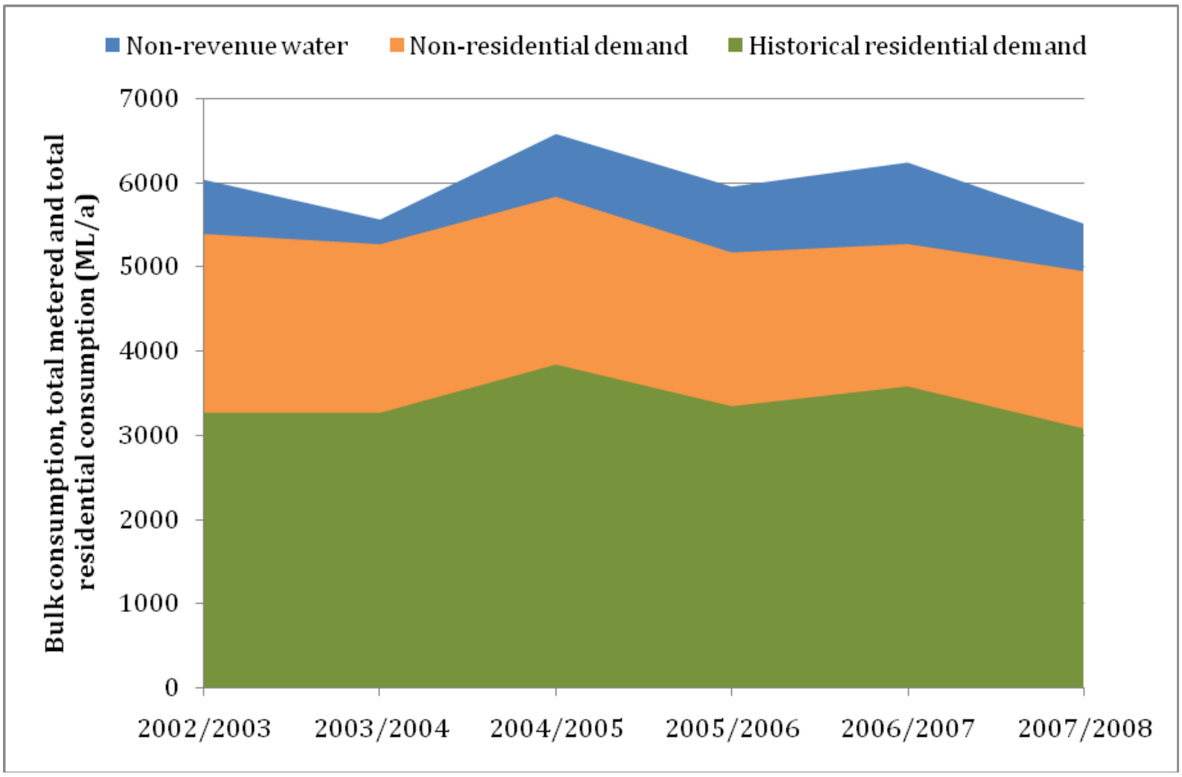
Figure 2-3 Bulk water production per person (LCD)



(Source – WBWC data)

Figure 2-4 shows the disaggregation of residential, non residential and non revenue water (NRW) for Hervey Bay. As in most urban centres in Australia residential demand represents over 50% of bulk water production.

Figure 2-4 Historical residential, non residential and non revenue water demand

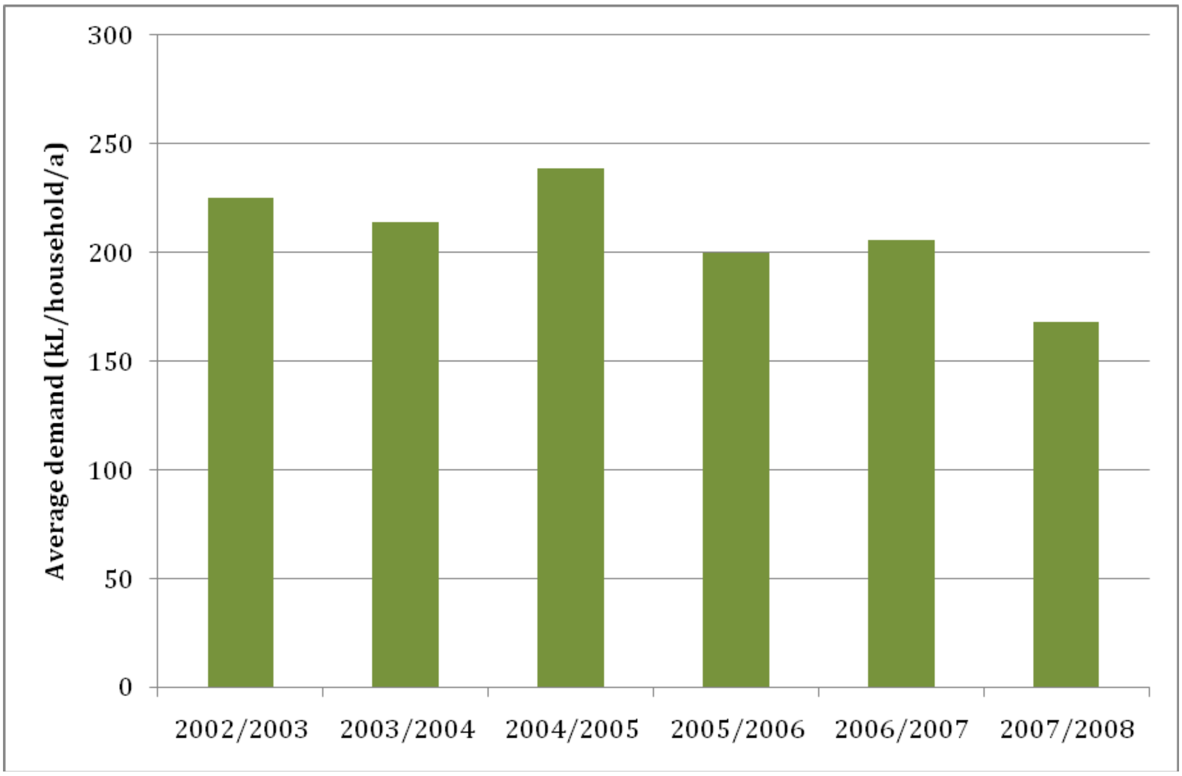


(Source – WBWC data)

Figure 2-5 and

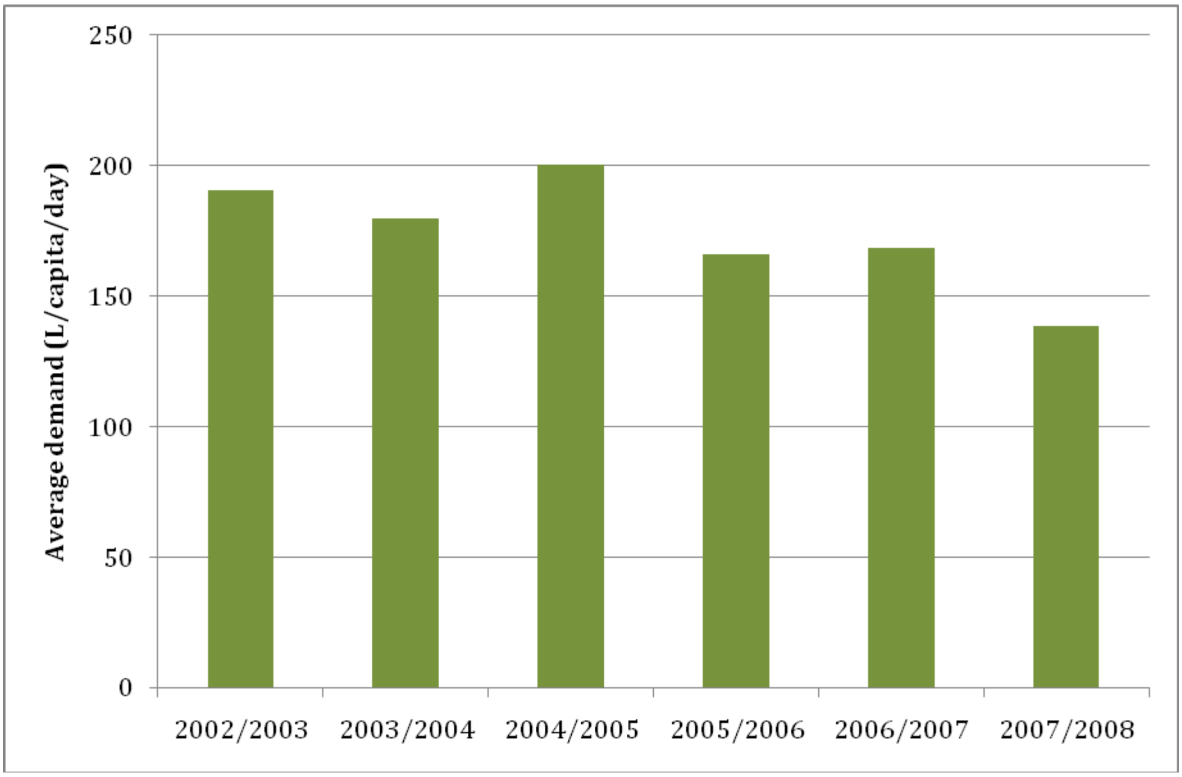
Figure 2-6 show the demand per household (kL/household/a) and per person per day (L/capita/day) illustrating an overall decline in both per household and per person residential demand over recent years.

Figure 2-5 Average residential demand per household (kL/household/a)



(Source – WBWC data)

Figure 2-6 Average residential demand in litres per capita per day (LCD)



(Source – WBWC data)

These demand figures provide an overview of historical water usage in the Hervey Bay region and indicate a decline in overall bulk water production, customer demand and per person and per household water demand. The potential reasons for this decline are explored further in Section 5.2.2, by asking the question ‘can the reduction in demand be attributed to the AMR system?’ This demand reduction is a key objective of the AMR Project.

If this decline is affecting both average and peak demand this will affect infrastructure requirements especially in constrained areas and have the potential to allow the deferral of capital expenditure on both water and wastewater infrastructure. This is also a key objective of the AMR Project and is further explored in Section 5.2.3.

The AMR system has the potential to provide a far greater depth of understanding of how water is being used on an hourly, daily, weekly, monthly and annual basis for the residential sector. This will also be feasible for the non residential sector now that WBWC has installed the AMR system on their non residential customers (approximately 2,350 commercial water meters). Having such detailed information provides WBWC with significant capacity to understand how water is being used (such as high seasonal outdoor water usage) and how it could be saved (for example through household leak detection). The AMR system also allows potential savings to be tracked over time.

Conventional metering configurations and meter reading methods can and have provided extremely useful information for understanding water usage by different sectors, the potential to save water and the tracking of those savings. However, AMR systems provide a far superior level of detail and if used effectively can provide water service providers such as WBWC with an extremely powerful water management and planning tool.

Based on this initial overview of the Hervey Bay context and customer demand, the following sections explore the AMR system adopted by WBWC, the way it has used this tool so far and how this could be expanded.

3 THE WBWC AMR SYSTEM

This section provides details of how the AMR system was chosen, details of the system and some of the lessons learnt by WBWC in choosing and installing the system.

3.1 HOW THE SYSTEM WAS CHOSEN

During a visit to the US in 2005, WBWC CEO Tim Waldron was invited to Plano in Texas to see an AMR system in action. This system was able to store 70 days of hourly reads (customer profile data) at the meter therefore having a rudimentary capability for time-of-use charging.

Shortly after this visit, the WBWC Board of Directors gave approval for an AMR system in Hervey Bay. Expressions of interest were invited from suitable AMR and meter manufacturers for the supply of system components to meet basic criteria. These criteria included being able to provide customer profile data down to a minimum one hour resolution and storing data at the meter for a period of no less than 70 days.

Several submissions were received with only two given serious consideration because the remainder did not meet the stated basic criteria. After deliberating on and researching the merits of the two competing technologies (one being drive-by and the other wide area network) it was decided to award the contract to supply the AMR system to Datamatic (the drive-by AMR technology) and Elster Meters (the water meters). The main factors affecting the decision were price and the reliability of the drive-by system compared to contemporary wide area network systems, which were considered at risk of outages caused by lightning strikes etc. at that time.

WBWC simultaneously submitted an application for funding to the National Water Initiative's Water Grants Fund. WBWC was granted $2.6M towards the AMR Project in March 2006. A later submission to the State Government resulted in a further $0.93M funding, contributing a total $3.53M of the projected total $5.4M AMR Project cost.

A contract was finalised with Datamatic and expressions of interest called for on the installation of 20,000 new water meters. Skilltech, a Melbourne based company, was awarded the meter installation contract which was completed in early September 2007.

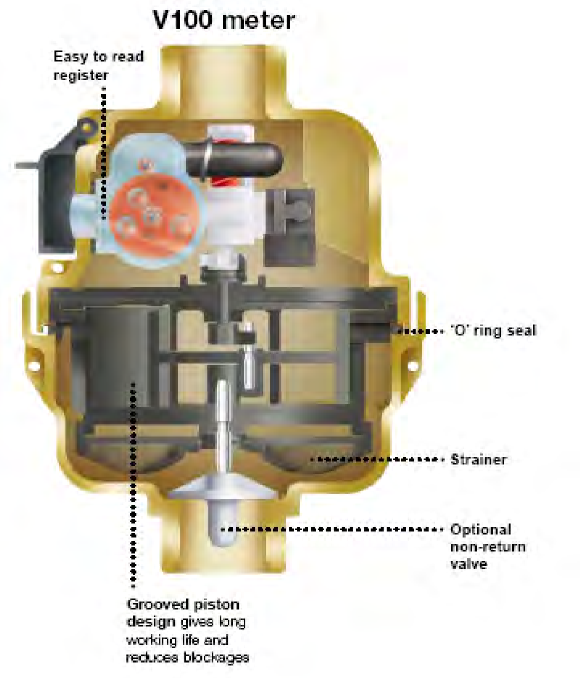
3.2 DETAILS OF THE WBWC AMR SYSTEM

The AMR system comprises of the following key components:

- Elster water meters;
- Datamatic data loggers (Firefly); and
- Datamatic transceiver (Roadrunner).

The Elster water meter V100 is a standard volumetric water meter that can be used for water metering through manual reading but can also be connected with a data logger to provide more real time information. The V100 uses a rotary piston, which rotates the water counter as a set volume of water is displaced through the meter. The counter then displays the cumulative volume of water that has passed through the meter. A cross section is shown in Figure 3-1.

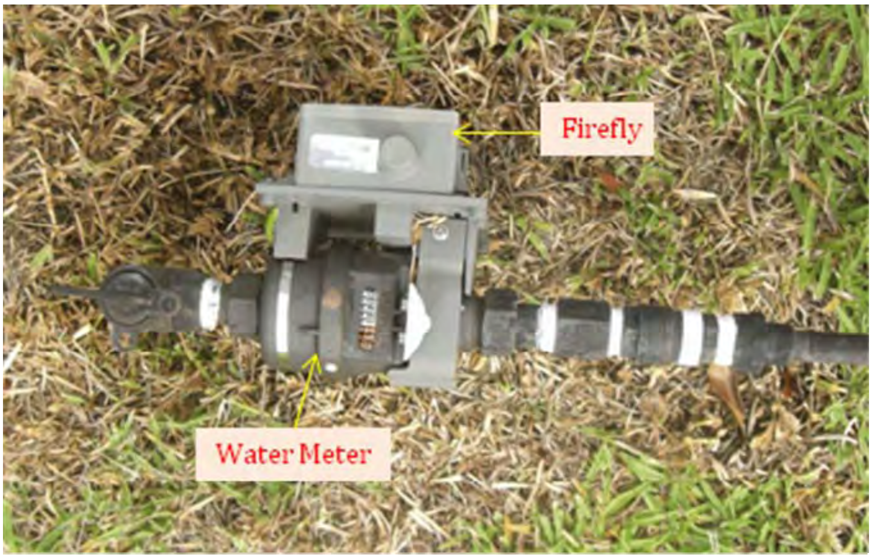
Figure 3-1 Cross section of the Elster V100 water meter



(Source – Elster Meters)

The 20mm V100 meter is manufactured with a magnetic pulse capability, which emits a pulse for every 5 litres of recorded consumption. A pulse output lead can be connected between the water meter and a data logger to allow logging of water usage according to the number of pulses received. The number of pulses is aggregated by the data logger according to programmable timed intervals (hourly in this case) so that a water usage profile is built according to the number of pulses received per interval. The WBWC AMR system uses a Datamatic Firefly as the data logger. Figure 3-2 shows the coupling of the Elster water meter and Datamatic Firefly on a residential water connection.

Figure 3-2 The Elster V100 water meter coupled with the Datamatic Firefly data logger



The Datamatic Firefly records water consumption every hour and has the capacity to store up to 330 days of hourly data. This data is then collected through the use of a data transceiver, which downloads the data remotely. In the WBWC AMR system a Datamatic Roadrunner is used, which is effectively a field computer. The Roadrunner transceiver can either be hand-held by the meter reader as they walk past each property or fitted to a vehicle to enable a drive-by reading. This can be in the form of one off meter reads or the full hourly profiles.

The Roadrunner sends a “handshake” signal to the Firefly to request data download and the logger responds by transmitting the requested data. The Roadrunner is pre-programmed with all the meters in the reading route and the number of days data to be collected which enables any downloading issues to be identified immediately. The Firefly will also transmit a “trickle alert” if it has recorded consumption for every hour of the 24 hours prior to reading. Thus the total number of houses with potential leaks are identified and later verified by reference to the usage profile.

The download time for the full hourly profile is relatively quick but dependent on the amount of information being transmitted. To download 30 days worth of data takes approximately 10 seconds. 90 to 120 days could take between 30 and 60 seconds.

Figure 3-3 Illustration of the AMR system components

An illustration of the AMR measuring, recording, receiving, storage and interpretation system is illustrated in Figure 3-3, from the water meter and data logger at the top, through to the computer interpretation of the water usage profiles and customer water use bill.

In the case of the WBWC system after the data has been collected in the field through the handheld or mobile Roadrunner, data storage, processing and interpretation is undertaken using various specialised database and software packages.

These new systems are linked to the Council *PROCLAIM* customer data information system which provides specific Council customer details relevant to water billing.

The Datamatic *Commstar* data collection system is the main data storage system, which enables other systems or applications to access the data (i.e. via SQL).

As part of the WBWC AMR system up to ten standard queries have been generated by Datamatic for WBWC including:

- *a leak property report* that highlights those households where no (or a specified restricted number of) zero readings in any one hour are observed during the meter cycle period recorded; and

- *a water restrictions offender report* that highlights households which have water usage patterns in accordance with set parameters that indicate they are likely to be violating restrictions.

The *Routestar* system enables day-to-day manipulation and querying of the last 4 to 5 stored meter readings for each customer, using *ProfilePLUS*. These usage profiles are useful for general analysis and for customer billing queries and/or complaints.

3.3 KEY LESSONS LEARNT

WBWC is the first water utility to install an AMR system in Australia on this scale. From an international perspective WBWC is the first utility to require an advanced level of data storage, issue reporting and data manipulation functionality (i.e. whilst this kind of technology and system have been used in the US in the past other utilities have not used the full capabilities of the system). Hence WBWC has experienced a number of unforeseen technological, manufacturer-related and system setbacks. This is to be expected with any new and emerging technology. A number of the key lessons learnt from these setbacks are listed in the following sections.

3.3.1 Pilot project

Whilst the original intent of the Project was to pilot a small proportion of the residential meters (approximately 10%, which was 1,850 at that time) it was found during the tender and contract procurement process that this would be difficult. This was due to the level of risk and commitment required by the various companies involved and the need to develop the data transfer, storage and manipulation system whether for 10% or 100% of the AMR meters. Hence, it was decided to contract the full 20,000 AMR system in one tender (pers com. D Wiskar, WBWC).

A number of difficulties arose during the installation of the AMR system such as defective reed switches, issues with the individual meter identity numbering system and the need to synchronise the loggers to provide real time recorded data. In retrospect the tender documents could have been written to allow for piloting to resolve a proportion of the issues encountered. Care in the preparation and management of tender and contract documents is therefore required. However, such documents need to be both tight in specification but also allow flexibility as the full capability of such new and emerging technology is explored.

3.3.2 Contracting

The contract was let in two parts: (1) a contract with Datamatic and Commstar and (2) a contract with Skilltech for the installation of the Elster meters. Liaison with multiple contractors was found to be difficult in terms of interpretation and timing of responses to queries. This was particularly in the context of developing how this emerging technology could be used for maximum benefit now and in the future. WBWC contracted the supply of meters, data loggers, transceiver arrangement and computer systems through Datamatic (excluding the meter installation component). This packaging of the system through one contractor reduced the risk to WBWC of the “system” not working. However, it required Datamatic to liaise with Commstar about the computer system and standard database queries etc. It was found during the course of setting up the system that this liaison route caused significant interpretation issues and time delays. At several points WBWC found it necessary to liaise directly with Commstar to resolve specific queries.

Water utilities need to determine if a single contract or multiple contracts best suit their needs and ongoing liaison requirements. A balance between communication requirements and aversion to risk need to be taken into consideration.

3.3.3 Validation

As part of its data validation and checking process WBWC continued to conduct manual reads of the water meters at the same time as testing the new AMR system. As the system was rolled out it was found that a batch of reed switches were faulty (due to inadequate QA procedures by the manufacturer). This resulted in almost 10% of the installed meters not logging data correctly. After investigations and discussions with the meter supplier/manufacturer the issue was identified and the full cost of replacement was born by the supplier/manufacturer.

Because WBWC has taken the approach of validating the new AMR system by checking against the manual reads, this issue was identified early and the ability to bill customers maintained for the 10% of faulty meters. Although the full benefits of remote downloading have not yet been realised (i.e. it still takes 2 staff members 3 to 4 months to read a complete meter reading cycle) the customer meter reading and billing process still operates as normal. When all the reed switches have been replaced and the system validated this process will be significantly faster with the new AMR system.

3.3.4 System installation

Several additional technology and system setbacks have been noted during this review. These include the need to ensure that the data loggers are synchronised in clock mode so that all the meter readings entering the Routestar system are logged in real time and the fleet of meters installed have a compatible numbering system. In addition, care needs to be taken when specifying the Commstar database query requirements and standard reports. The software bought as part of the AMR system was effectively ‘off the shelf’ and many of the standard reports that it generates are rudimentary requiring considerable modification to obtain a useful query that makes sense for a particular location.

4 EXISTING PROCESSES AND TECHNIQUES

This section provides an overview of some of the key processes and techniques developed by WBWC so far, following the installation of the AMR system.

4.1 OVERVIEW OF EXISTING TECHNIQUES AND PROCESSES

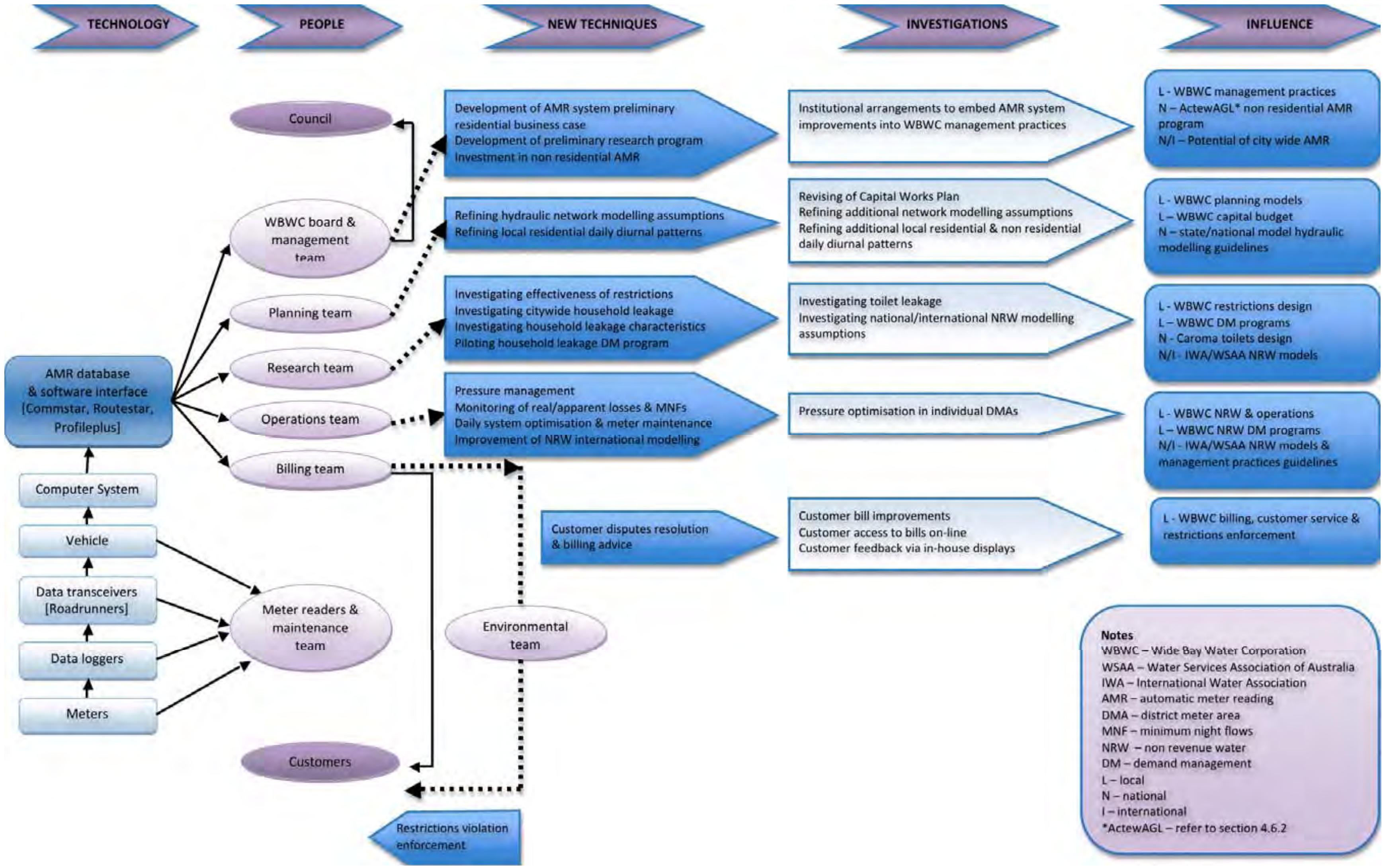
WBWC sees the AMR system as a new technology and thus as an organisation it is still developing many processes and techniques. WBWC staff recognises that these processes and techniques are yet to be fully explored and embedded into the management practices of the organisation. Until WBWC embed these processes and techniques into their standard water management and planning practices the full benefits of the system will not be realised.

Figure 1-1 in Section 1 shows the main system considered as part of this Evaluation including the key elements (the technology and people). Figure 4-1 summarises some of the main processes and techniques developed by WBWC since the installation of the system at the end of 2007. It also indicates some of the current investigations and the level of influence these new processes and techniques are having at a local, state, national and international level (knowledge transfer to the water industry being a key aim of the AMR Project).

As can be seen in Figure 4-1 and in the details presented in this section, WBWC has made many significant discoveries since installing the system that will have a far reaching influence on the water industry. These discoveries also have the potential to enable WBWC to monitor the water use in their system to the extent that they can take water management and planning actions to optimise the system. This could potentially defer millions of dollars of capital and operating expenditure over the coming years (another key aim of this Project).

This section provides brief details of some of the processes and techniques developed so far and the findings of the research that is currently being undertaken. The potential for deferral of capital and operating expenditure is discussed in Section 5.2.3.

Figure 4-1 Expanded system diagram to show the new techniques, additional investigations and influence of the new AMR system



4.2 BILLING

4.2.1 Overview

The AMR system has revolutionised the potential for innovation within the billing section of WBWC. As described in Section 3.3 the system is not yet completely automated and not all residential customer profiles are currently being collected, stored and downloaded to the Datamatic Commstar computer system, due to the issues with the faulty reed switches in the meters. However, the vast majority of households do have hourly profile data stored within the Commstar computer system that can be retrieved and interrogated on an hourly, daily, weekly and monthly basis using the ProfilePLUS system. The AMR system enables WBWC to provide a very high level of customer service to its residents and also where necessary enable a level of evidence based compliance-monitoring of water restrictions. These are demonstrated in the case studies below.

4.2.2 Customer advice

Figure 4-2 illustrates a case study of a customer telephoning the billing section of WBWC to enquire why their latest bill appeared to be unusually high. Normally the billing section under a standard 3, 4 or 6 monthly billing cycle would check the billing records and potentially offer to re-check the meter read in case of error. Using the AMR system the billing section was able to interrogate the customer profile immediately. They advised the customer of a potential leak that appeared to have commenced in early February and subsequently increased during the billing cycle. Once informed, the customer confirmed the presence of a leak by checking the meter and took action to repair the leak.

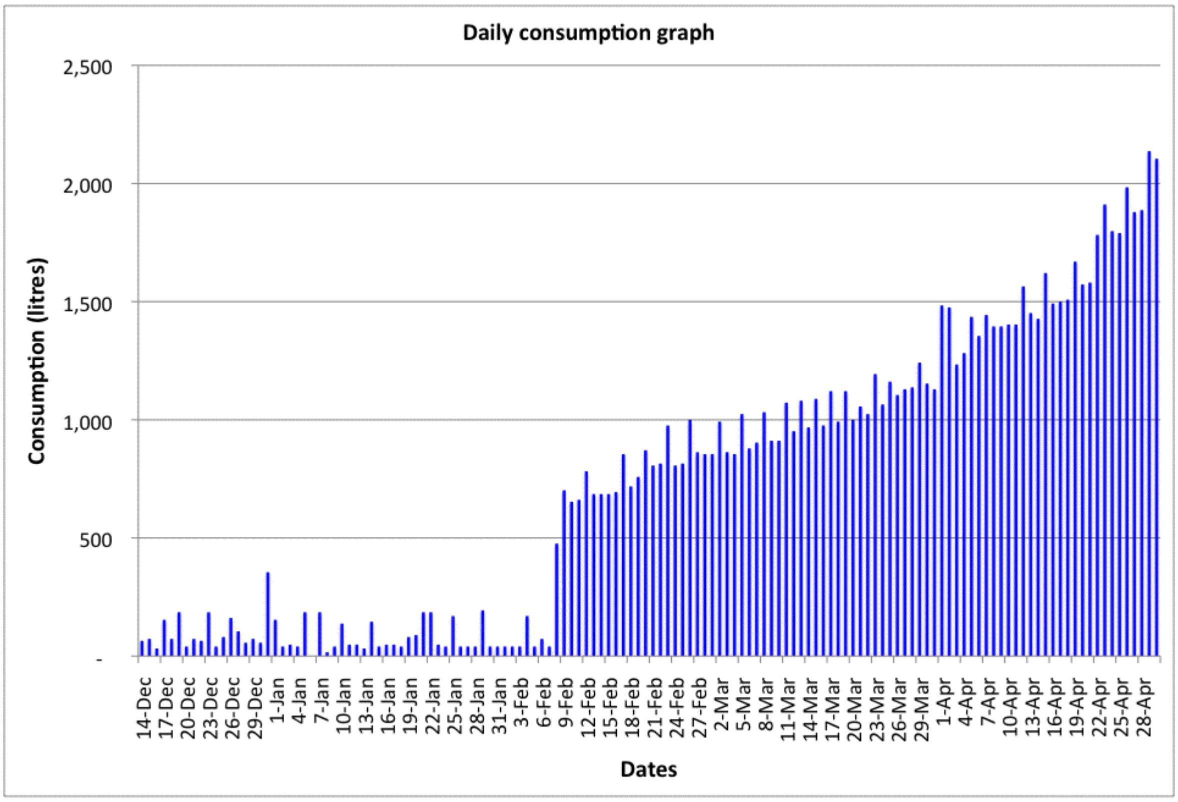
This example illustrates the potential for the AMR system to be used to resolve customer disputes, characterise leaks, assist in saving water and provide an advanced level of customer service. Customers are often very impressed that WBWC can provide this level of service when they call (pers com. B Yarrow, WBWC). Since installing the AMR system phone calls to the billing department at WBWC has reduced significantly from over 100 to between 15 and 20 per meter reading cycle (pers com. B Yarrow, WBWC).

4.2.3 Restrictions violation

Another case study provides an example of how the AMR system can assist in identifying individuals breaching the requirements of water restrictions. The daily usage profile of a particular customer observed showed unusually high water demand. The profile obtained from the AMR system showed average daily usage of approximately 500 L/day over the summer/autumn period. However, once or twice a week the usage during this period jumped to over 3,000 L/day (typical of a sprinkler system - banned at the time of the meter reading). Further investigation using the AMR system indicated that the time of the water usage was generally late in the evening when it would not be obvious. Other similar examples of restrictions violations have been seen between 1 am and 4 am (impacting on the minimum night flows).

Historically WBWC would need to rely on its regular restrictions patrols or a neighbour reporting the violation. Even when a customer was suspected of violating restrictions in the past, it was often found to be difficult to prosecute because the Water Act requires irrefutable evidence. However, with the AMR system the current customer meter readings can be interrogated using a standard query to highlight this form of restrictions violation and individuals can then be approached by WBWC, warned or prosecuted as deemed appropriate.

Figure 4-2 Example of a customer's bill information which led to an enquiry



(Source data – WBWC)

At WBWC if restrictions violations are found then the details of the offending customer are passed to the Environmental Team who approach customers using the following escalation process:

- first non compliance – letter of compliance including AMR information;
- second non compliance - face to face meeting with a letter threatening a fine presented to the customer together with AMR information; and
- third non compliance – customer fined using AMR information as evidence.

WBWC experience to date indicates that the public are well aware of the strong evidence provided by the AMR system and that they are unlikely to re-offend (WBWC 2009).

The AMR system enables the billing section to analyse individual households by overall city, district meter area (DMA), meter reading route, sewer catchment or other defined group by hour, day, week, month or billing cycle. Hence, this provides significant potential for understanding how water is being used, compared to the previous 4 monthly meter reading cycles. It also provides significant potential to give residents a high level of customer service when they query their water bills and for WBWC to be proactive in terms of restrictions management.

4.2.4 Investigations in progress

The data collection and analysis of the meter readings and profiles now being obtained is not fully operational. It will take time to systematise the data validation and verification processes. WBWC is in the process of working on this in terms of setting up standard flagging/exception reports and queries at various stages from data collection to billing.

In addition, WBWC is investigating how to use the AMR system to:

- Make the profile data available to customers via a secure log-in over the internet to enable each customer to see in detail their historical water use and then via the same website look-up actions that can help them save water. WBWC is currently working with Datamatic on logistics and customer privacy issues. The service is expected to be available to customers by the end of 2009.
- Improve customer bills by incorporating minimum daily demand (i.e. indicates leakage), average and maximum daily demand and a comparison with previous meter reading cycles. WBWC has liaised with the WBWC community focus group about these changes and received positive feedback. The service is expected to be available in 2009.
- Provide immediate feedback on water usage through the use of in-house displays, which could potentially eventually incorporate time of use charging. WBWC is currently trialling 10 prototype in-house devices (designed by Datamatic) that are initialised by the FIREFLY on each specific water meter. These devices, which are still relatively expensive, provide information on the date, time, temperature, daily usage, last hour of usage and bill estimation. It is anticipated that once the technology is refined WBWC will sell these products to customers as part of a behavioural demand management program (WBWC 2009).

4.3 OPERATIONS

4.3.1 Overview

Individuals within WBWC have been extremely active in the International Water Association's Water Loss Task Force[5] since its conception. WBWC has introduced many of the IWA best practice management approaches associated with water loss management and understanding of the components of non revenue water (NRW) to Hervey Bay. WBWC has also assisted other water service providers in best practice water loss management both nationally and internationally.

Due to the importance of water loss management to WBWC, the organisation has approximately 14 staff in the water operations team actively involved in managing pressure and leakage on a day-to-day basis. The new AMR system has not required additional staff or a reduction in staff but has required a greater level of IT skills to reap the benefits of the new AMR system.

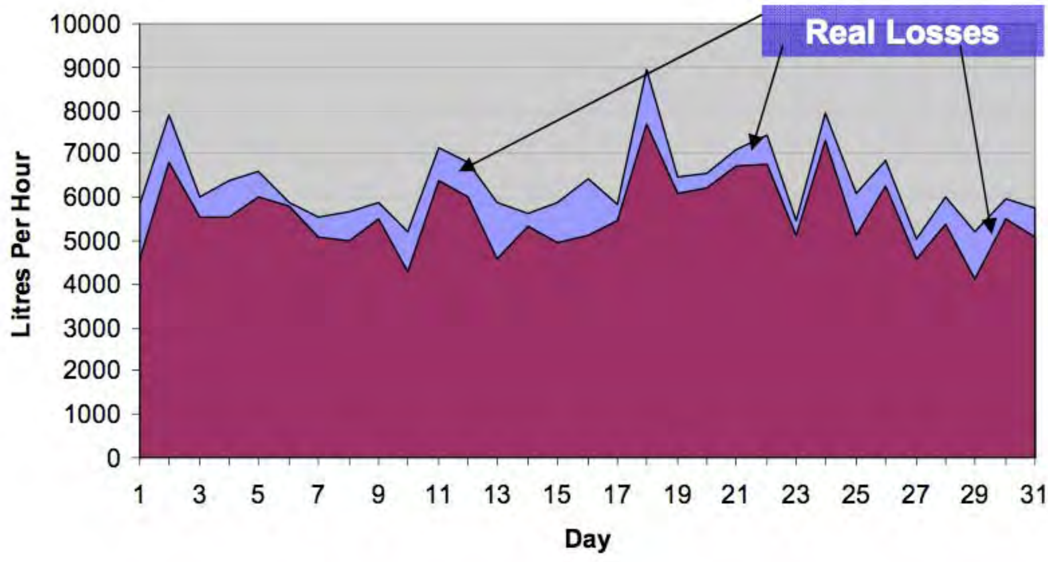
Several ways in which the AMR system is currently being used are described below.

4.3.2 Understanding and monitoring real losses

A large proportion of the resources of the team are associated with investigating and repairing leaks to minimise water losses. The AMR system can provide an aggregated hourly consumption figure for all customers within a DMA. This figure can then be compared with the DMA bulk meter hourly data to identify *real* losses within the system, as distinct from *apparent* losses. This can be done for any hour of the day and specifically for the minimum night flows (MNF) period normally associated with the hours of 1 am to 4 am. This is not possible with conventional meters on a standard 3, 4 or 6 monthly reading cycle. Figure 4-3 illustrates real losses in the system estimated by comparing the MNF period (typically 1 am to 4 am) for the DMA data (the top water profile on the graph) with the AMR data (the lower usage profile shown in burgundy on the graph). The blue wedge of water (the difference) clearly indicates the real losses.

[5] Refer to International Water Association webs site (http://www.iwaom.org/index.php?name=task-description&tp=3) for details.

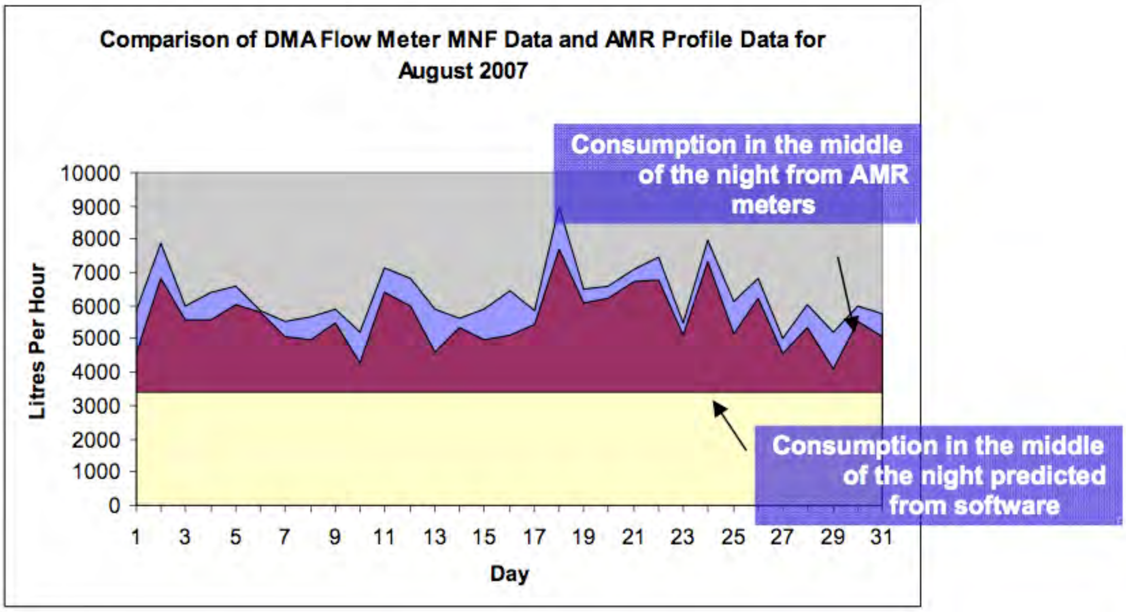
Figure 4-3 Example of the comparison of DMA flow meter MNF data with AMR profile data for a pilot study in August 2007 (WBWC 2009).



This level of detail enables the operations team to calculate the actual volume of network leakage within each DMA. It also provides an invaluable planning tool for decisions on interventions such as deploying a team to undertake a proactive leak detection survey for a specific area.

Figure 4-4 compares current software predictions of the consumption component (the bottom yellow section) of MNF with the actual consumption component as measured by the AMR system (the yellow and burgundy sections combined). This illustrates that the MNFs in Australia may actually be higher than predicted by current international models. According to this software prediction, the burgundy and blue areas would have been incorrectly interpreted as leakage. This more in depth knowledge of MNFs enables better utilisation of WBWC resources and the operations team.

Figure 4-4 Comparison of software predicted and measured MNF real losses (WBWC 2009)

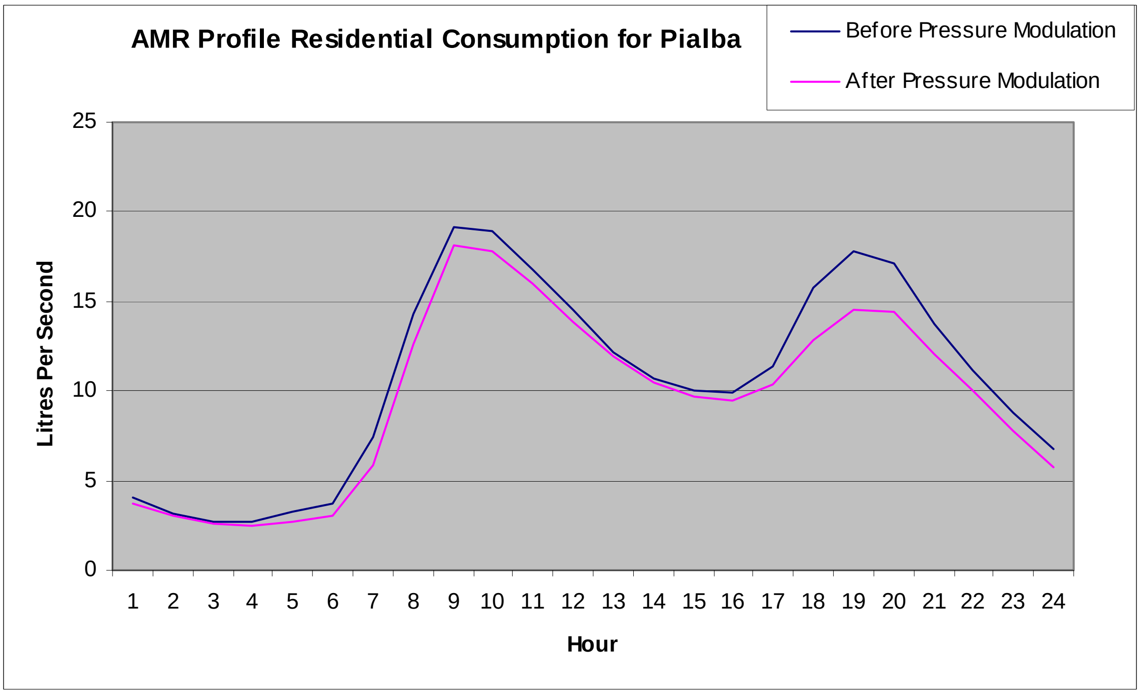


(Source – WBWC)

4.3.3 Pressure management

Pressure modulation testing was conducted in the suburb of Pialba to achieve a reduction in consumption and leakage while still satisfying levels of service requirements. Figure 4-5 illustrates how the AMR system can be used to identify the savings for residential customers on the customer side of the meter from adjustment of the pressure within the system. In this case the original 40 metres head of pressure was reduced to a modulated range of 33 to 39 metres head of pressure. This resulted in a saving of 91,000 L/day in residential demand in the Pialba DMA during the comparison period (WBWC unpublished).

Figure 4-5 The effect of pressure modulation on customer demand in the Pialba DMA



(Source - WBWC)

In late 2008 the DMA of Torquay (comprising 2,602 water meters) was used as a pilot to investigate the detailed effects of a pressure reduction program. The AMR system was used to inform the analysis.

The DMA is split into high and low pressure zones. The high level pressure zone wasn't changed (the inlet pressure remaining at 55.5 m and outlet at 30.9 to 31.7 m). The low level pressure zone outlet was reduced from 51.7 m to 39.7 m resulting in a reduction in pressure of between 11 and 12 m.

A pressure reduction program would normally be expected to save water associated with a reduction in real losses (including unavoidable real losses[6]), post meter leakage, customer consumption and pipe bursts. The pilot study investigated where savings were being achieved compared to theoretical savings currently used in international models. Due to the AMR system it was possible to examine the water savings on the customer side of the meter. It was found that significant reductions (13.7%) were observed in the average household MNFs for the low level pressure zone after pressure reduction. The high level pressure zone that shouldn't have been affected also reduced but by only 3.7%.

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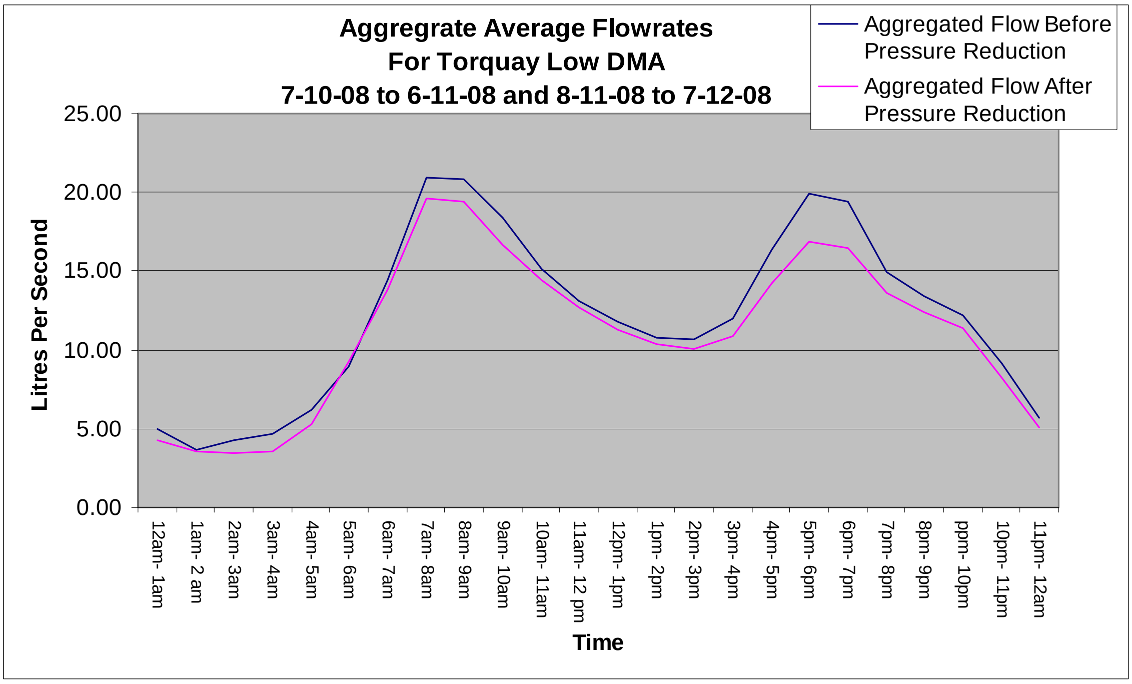
[6] UARL, measured in litres/service connection/day, are the losses associated with the characteristics of the system and recognize the separate influences of real losses from length of mains, number of service connections and average pressure.

This reduction in the high pressure zone is believed to be associated with a rainfall event after the intervention that caused a reduction in demand (Waldron et al, 2009).

Overall 12% and 6.8% reductions in average water consumption per household were observed for the low and high level pressure zones respectively. The 6.8% reduction in the high zone is again likely to be attributable to the post intervention rainfall event. Not all of the 5.2% reduction in the low level pressure zone (assuming 12% minus 6.8% equals 5.2%) could be attributable to the pressure management intervention. However, it is likely to be a significant proportion (refer to Figure 4-6). This result of 5.2% is significantly more than what current international models predict (i.e. only 0.9%); hence further investigation is currently underway (Waldron et al 2009).

Figure 4-6 Residential customer flow rates for the low level pressure zone before and after pressure reduction

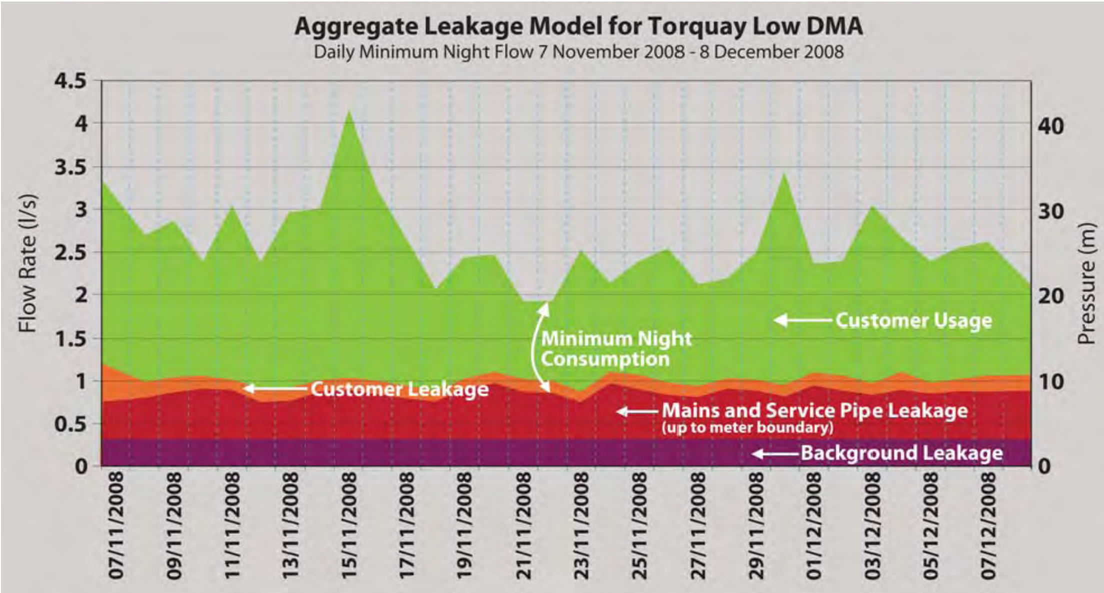


(Source – WBWC)

4.3.4 Improving modelling of non revenue water

By being able to measure the real losses within the system (on the WBWC side of the customer meter), the customer demand and losses on the customer side of the meter (refer to Section 4.4.3) it has been possible to begin to review assumptions in international models used to estimate non revenue water (NRW). Figure 4-7 illustrates the way in which the WBWC AMR system has been used to assist in modelling the various components of MNF leakage in the pilot DMA of Torquay.

Figure 4-7 Leakage model for pilot DMA in Hervey Bay (Waldron et al 2009)

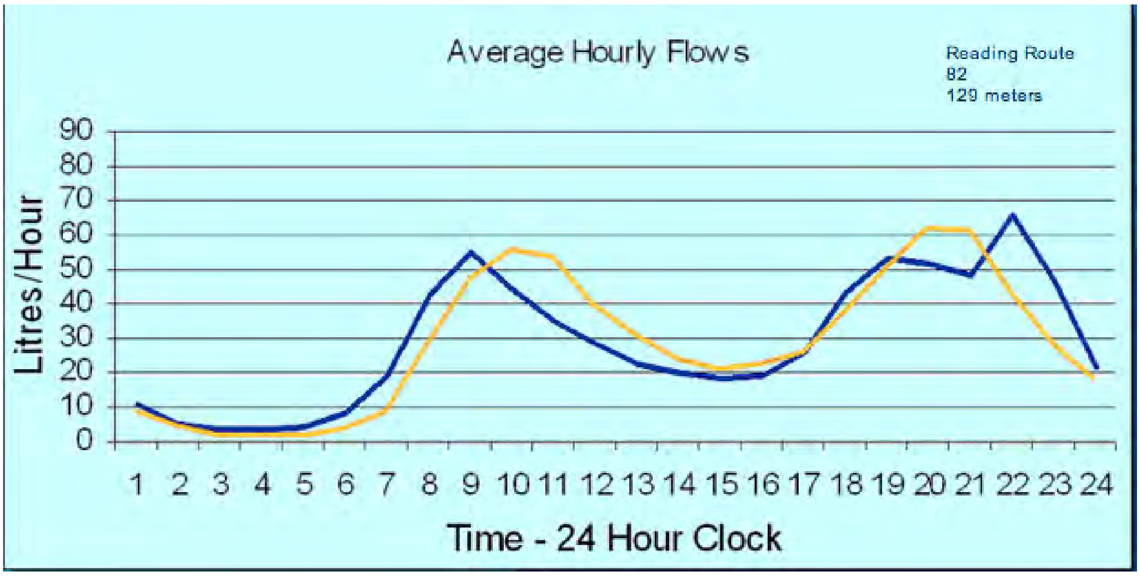


4.4 RESEARCH

4.4.1 Effectiveness of restrictions

Not only can the AMR system assist in monitoring compliance with restrictions as indicated in Section 4.2.3 but it can also be used to determine the effectiveness of restrictions and how restrictions affect the diurnal profile of water demand. Figure 4-8 illustrates the diurnal variation of a sample of 129 residential households with a restrictions sprinkler ban shifting from 8 am to 4 pm (yellow line) to 6 am to 8 pm (blue line). The yellow profile indicates a typical diurnal variation with a peak in the morning and evening. The blue profile shows how the modified restrictions have brought the peak forward slightly in the morning and pushed the second peak of the day further into the evening actually increasing the intensity of the peak slightly. The data also illustrates that the area under the graph is not substantially different (i.e. the modified restrictions timing may not actually be saving any additional water).

Figure 4-8 Effect of restrictions on the diurnal profile of a sample of 129 households



(Source – WBWC)

Hence the AMR system provides an ideal tool to:

- measure the total volume of water saved due to restrictions;
- measure the effectiveness of existing restrictions on *specific* sectors; and
- test how different regimes and levels of restrictions can assist in achieving the objective of saving water during various levels of drought.

4.4.2 Pricing reform

As part of the Project, WBWC is expected to research a model and develop an implementation program for pricing reform (e.g. time of use). WBWC has determined that to evaluate pricing options as part of the reform process at least 2 years of AMR system data is needed. In addition, liaison with the WBWC Board, Fraser Coast Regional Council (FCRC) and the community will be necessary. WBWC has commenced this process by beginning to collate data and holding workshops with WBWC Board and the FCRC to obtain their input on pricing options, political processes required to implement pricing reform and the community engagement process necessary. It has developed a program to enable the preferred pricing reform options to be considered in the Council 2010 budget process (WBWC 2009).

4.4.3 Household leakage

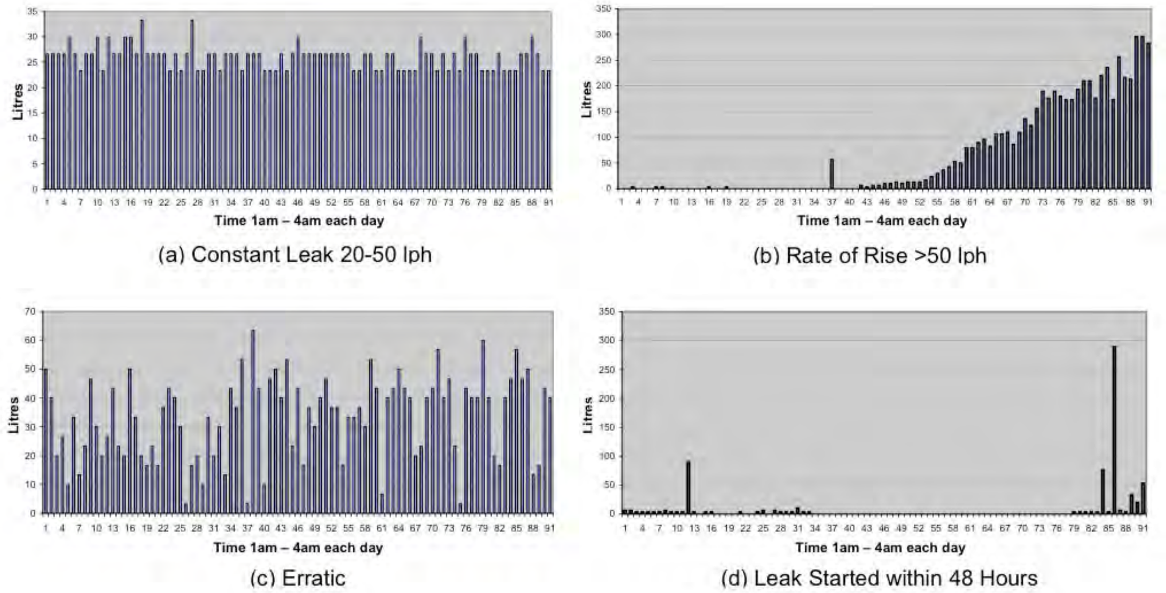
For the first time in Australia the WBWC AMR system has enabled a water service provider to investigate leakage on the household-side of the meter at a city scale using a typical water meter reading cycle. The research will ultimately assist in the development of new policies to manage this particular loss within the spectrum of demand management options available.

From the residential meter reading cycle of over 20,000 households in 2008 an initial and final number of properties with leaks was identified (633 and 235 respectively). Of the 210 detached dwellings assessed within the 235 final set, over 55% had constant leak rates of between 5 to 15 litres per hour (equivalent to more than 2.57 ML over the 3 months considered) typically associated with leaking taps and toilets. Overall the 210 detached dwellings lost nearly 10 ML over the 3 month period assessed. Figure 4-9 illustrates the kinds of leaks observed and what these look like graphically using the WBW AMR system (Britton et al 2009).

Figure 4-9 Household leaks analysis using WBW AMR system (Britton et al 2009)

Category	No of Meters	Total Water Loss* Mega litres	Av loss per hour Litres	Av Loss Per Day Litres
Constant Leak 5 - <20 lph	86	2.57	13.66	327.91
Constant Leak 20 - 50 lph	25	1.72	31.42	754.18
Constant Leak > 50 lph	6	0.76	57.68	1384.47
Leaks with Rate of Rise < 50 lph	51	1.84	16.55	397.27
Leaks with Rate of Rise > 50 lph	6	1.87	66.6	1598.39
Erratic not conforming to above criteria	19	0.84	21.37	512.85
Leak started with 48hrs	17	0.32	8.49	203.64
	210	9.92	30.82	739.82

*Total water loss = average hourly loss per meter per day x 91



(a) Constant Leak 20-50 lph

(b) Rate of Rise >50 lph

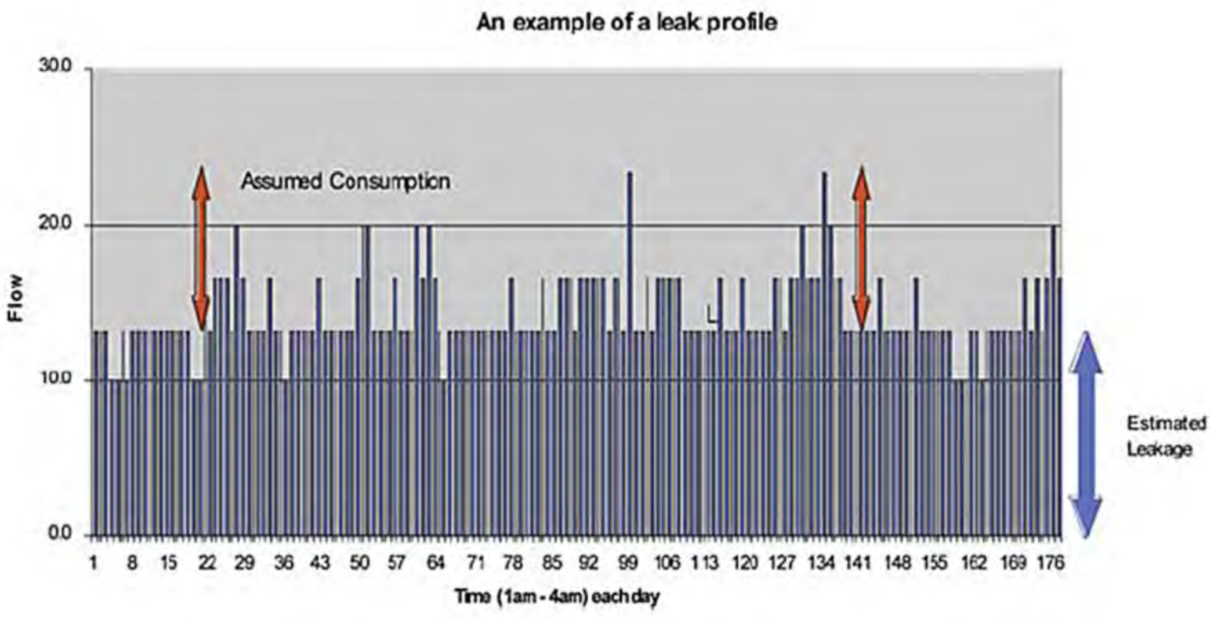
(c) Erratic

(d) Leak Started within 48 Hours

More detailed research using a pilot study was conducted from October to December 2007. The objective of the pilot study was to test the effectiveness of using the AMR system to identify household leakage in a selected area. The DMA of Port Vernon was chosen. This was subsequently followed by the implementation of a household leakage repair program. Leakage detection using the AMR system can be undertaken in two ways (1) a "trickle alert" flag during the meter reading process that detects no "0" readings are recorded in the 48 hours preceding the meter reading and (2) by analysing the full set of customer meter records following download from the meter loggers.

Of the 2,359 residential meters read in the DMA, 47 flagged a trickle alert. The hourly profiles of the 47 households for the previous 177 days were downloaded and the MNF checked for the period 1 am to 4 am for each household. Figure 4-10 shows an example of the average hourly profile of 1 am to 4 am for one of the households with a leak. Of the total 2,359 residential meters, the 47 meters (2%) with identified leaks consumed nearly 25% of the demand between the hours of 1 am and 4 am (Britton et al 2008).

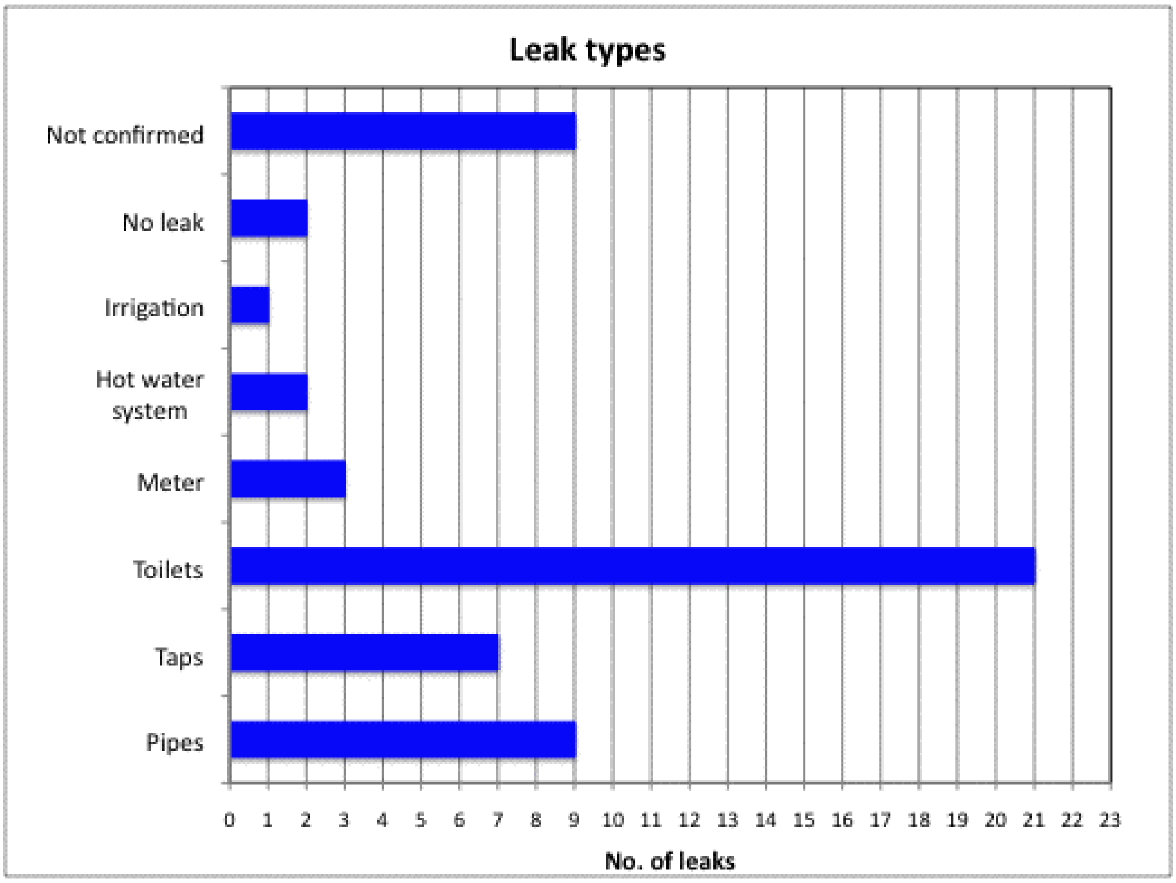
Figure 4-10 An example of a leak profile for one household from 1 am to 4 am each day (Britton et al 2008)



Having analysed the 47 households using the AMR system each was then contacted by letter to participate in a free household audit offering $100 towards repair of the suspected leak. During November 2007, 32 of the households responding to the program were audited with 17 being repaired by WBWC and the others undertaking their own repair. The majority of leaks found were associated with toilets (both single and dual flush) as shown in Figure 4-11.

The program resulted in a dramatic MNF reduction from 1,300 L/hr to 356 L/hr. After a further 3 households were repaired this reduced further to 173 L/hr, a total saving of 1,095 L/hr (26,280 L/day and potentially over 9 ML/a if leaks were assumed to be on going) (Britton et al 2008).

Figure 4-11 Leak types found during the pilot study (Britton et al 2008)



Hence the AMR system has been used to detect household leaks at both a DMA and city-wide scale using the trickle alert system. The additional detailed investigations into the kinds of internal leaks in households and the savings achieved through the pilot program would not have been possible without the AMR system.

4.4.4 In progress

As a result of this research WBWC is in the process of setting up a routine report after each water meter reading cycle that flags all houses with a suspected leak. This will be fully operational when all meter reed switches have been repaired and the whole AMR system is active. A policy matrix associated with household leaks has been developed by WBWC as follows:

1. Letter to customer – a letter with information on water use and advising customer of the cost of the water lost.

2. Rebate repair – an arrangement where the customer is offered a rebate to help them to pay for a plumber to fix the work.

3. Direct intervention – WBWC plumber comes to the house to fix the leak.

4. Enforcement – using powers under the Water Act to enforce the repair.

To date WBWC has decided that only level 1 of the policy matrix is currently required, although, the Drought Management Plan has been updated so that as water becomes more constrained WBWC can use the higher levels.

An interesting outcome of this research has been the ability to identify the high proportion of leaks associated with toilets (both single and dual flush) and to start to clarify some of the reasons for this and whether the leaks are pressure dependent. Most of the toilet leaks found were caused by failure of the “top valve” within the cylindrical control units of each cistern. Research is currently in progress to investigate why so many toilets are failing (Britton et al 2008). WBWC has been in discussion with Caroma to begin to investigate this leakage further and with WSAA (responsible for water efficiency labelling in Australia) in their role associated with working with manufacturers to improve industry standards.

4.5 PLANNING

4.5.1 Refining hydraulic modelling input data

Water reticulation models are used to help predict constraints within a water system and to assist in short term planning of new infrastructure. Due to the high population growth in Hervey Bay, WBWC has investigated how the new AMR data can assist in improving this form of modelling through increased accuracy of input data and assumptions. This increased accuracy may potentially lead to deferral of capital expenditure on new infrastructure, an aim of this Project.

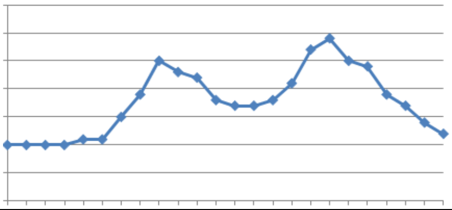
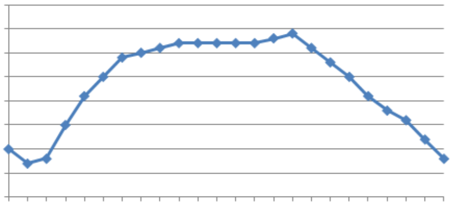
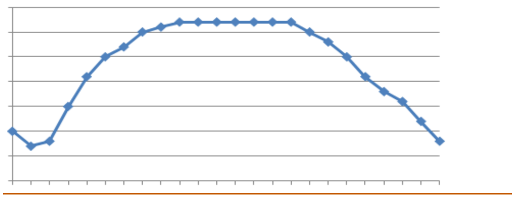
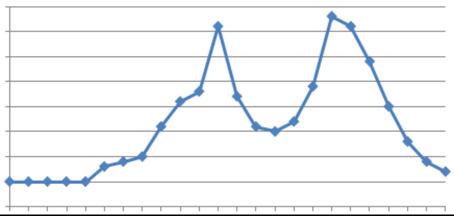
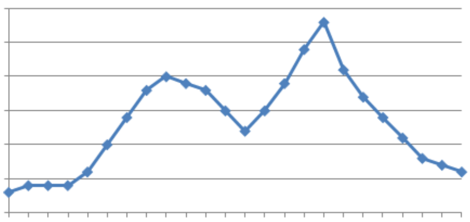
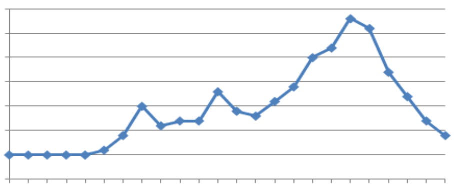
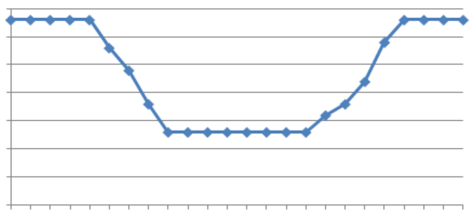
Water network models such as the *Infoworks WS* software package used by WBWC generally use standard assumptions for input variables such as the diurnal water consumption patterns of different customers. Due to a paucity of data for specific customer types in each region these “standard” patterns are commonly used by the modelling community. The diurnal patterns used for different customer types in Hervey Bay, adapted for local conditions where possible, are shown in Figure 4-12. These original diurnal patterns can now be improved due to the more detailed AMR data.

Network modelling assists water planners to analyse average day (AD), maximum day (MD) and mean day maximum month (MDMM) demands within different areas of their network. This helps water planners determine when a specific area may become constrained due to growth and therefore require augmentation. Using the detailed AMR data available WBWC staff decided to select several DMAs in the network to develop specific AD diurnal consumption patterns for residential property types within each DMA. This was then used to test whether this more detailed data could make the models more accurate compared to using standard industry assumptions.

A selection of 6 DMAs with a high concentration of residential properties were chosen from across the city for this experiment. From monthly water treatment plant data the month of November 2007[7] was chosen to represent the “average” water consumption because it most closely represented the average of monthly production in the data period available (July 2007 to April 2008). AMR hourly meter reading data was then extracted from the Commstar database for all available residential meters within the 6 DMAs chosen for the month of November 2007. The meter reading data was checked for missing and/or erroneous results and correct linkage to GIS data that would be used within the Infoworks software package. Where appropriate, data was discarded or corrected.

[7] Due to the significant seasonality in Hervey Bay and other regions in Australia care needs to be taken when repeating this form of analysis to obtain a representative month for high, low and average seasonality to ensure the revised diurnal patterns input to the models are representative of the test being performed (i.e. average versus high demand). In addition care needs to be taken to correct the data for climate and other necessary variables to ensure it is representative.

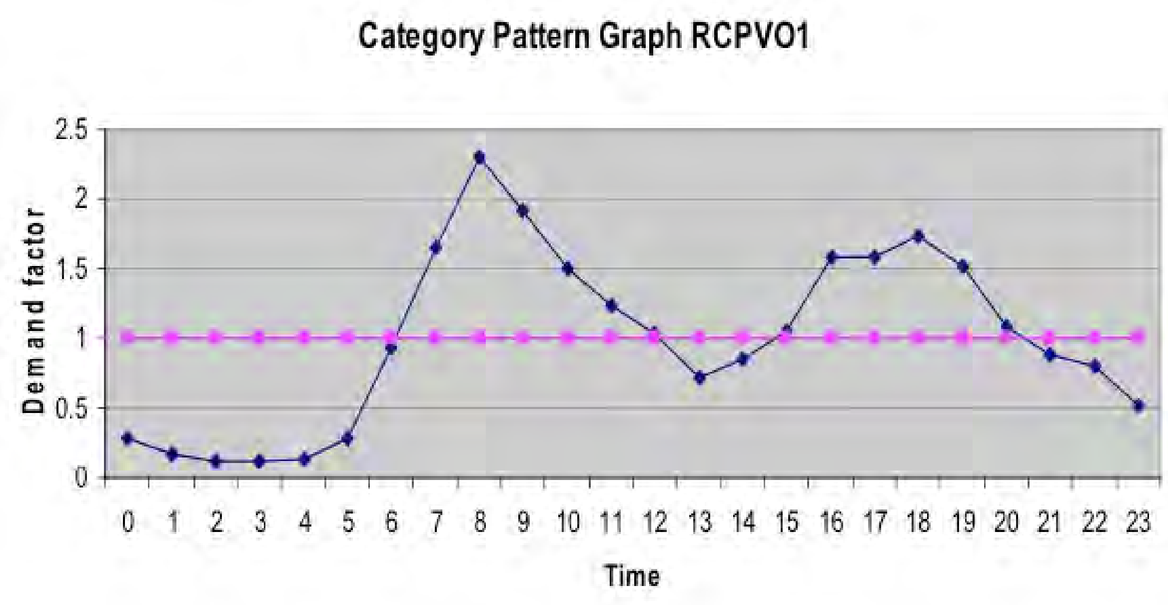
Figure 4-12 Original diurnal patterns

Name	Explanation	Shape	Description	Example from *Infoworks*
RRR	Residences, Residential Accom', Rural Residences		Higher peak consumption in the afternoon than in the morning	Multi-family, medium and high density residential, vacant land, garage, shed
CILU	Communities, Industrial, Light Industrial, Utilities		High consumption during the day between 7AM and 6PM	Shops, veterinary & doctor surgery, service stations, special tourist attractions, industry
SI	Schools and Institutions		Similar to CILU	Schools, offices
CH	Club and Hotel		High Consumption midday and early evening	Amusement centre, hotel. Tavern, licensed club, restaurant
PR	Park Rural		Morning and afternoon peak with greater consumption in afternoon	Park, garden, caravan park
EPF	Estimated Public Facilities		High consumption during the day and peak at 8PM	Sports fields, bbq sites, fairgrounds
EOS	Estimated Public Open Space		High consumption during the night between 6PM and 7AM	Irrigated parks and open space

(Source – Skowron and Chevalier 2008)

The AMR data sets for each DMA were then analysed using various steps and statistical tests to group them into a number of characteristic diurnal patterns, with a normal distribution, for each DMA investigated. Figure 4-13 illustrates a typical diurnal pattern found for a subset of residential customers within one of the DMAs chosen. This diurnal pattern with a high peak in the morning compared to the afternoon was for a sample of 1,780 water meters representing 74% of demand. This diurnal pattern differs significantly from the standard Hervey Bay residential diurnal pattern shown in Figure 4-12.

Figure 4-13 Diurnal pattern found for subgroup of 74% within one DMA tested



(Source WBWC unpublished)

Hydraulic models were built for each of the DMAs in Infoworks using:

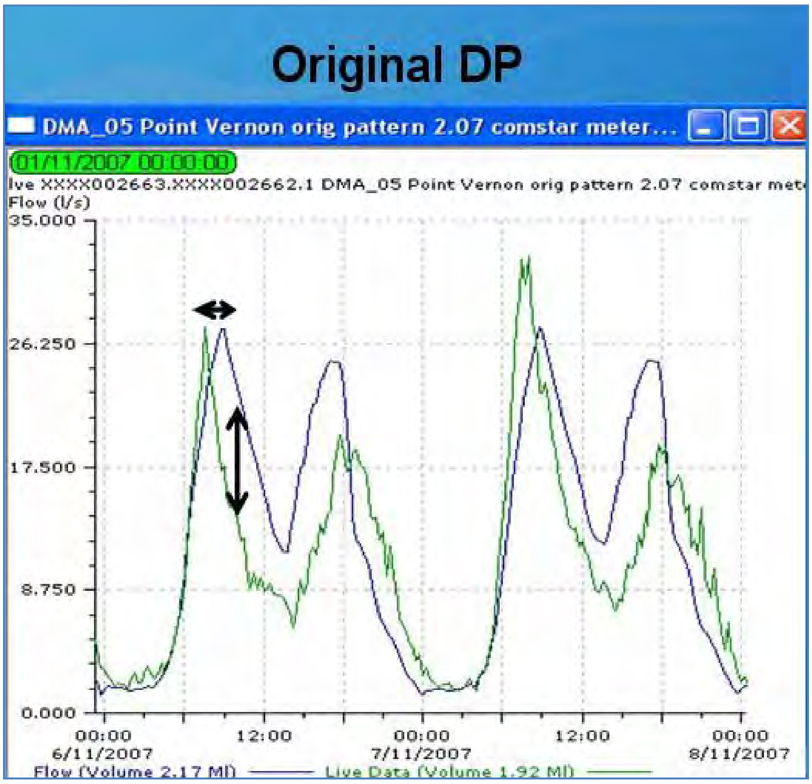
- GIS data relating to infrastructure (mains, valves, hydrants);
- Control data for pressure reduction valves (PRV);
- GIS data for each water meter identifying the customer location and property type;
- Average Day (AD) consumption data from AMR data for November 2007;
- Original standard diurnal patterns;
- New revised diurnal patterns for subgroups within each DMA; and
- DMA bulk meter data for each DMA.

Within each DMA model individual customer points were assigned a consumption (L/household/d) based on the AMR data available for each customer for November 2007. Previously this level of detail would not have been possible with 4 monthly reading cycles. A DMA model was run using the detailed AMR data set followed by a normal meter reading dataset to compare the predicted total consumption of the model run performed. A much stronger correlation was observed with respect to predicted (modelled) versus actual consumption when using the AMR dataset, indicating the potential of a higher level of accuracy in such models when using AMR data.

Each DMA model was also run using the standard diurnal patterns and then the new residential subgroup diurnal patterns. The use of the new detailed diurnal patterns resulted in an increased correlation between predicted (modelled) and measured demands (as much as 40% for Port Vernon). In addition, it was found that the morning and afternoon peaks were more closely correlated with measured demand.

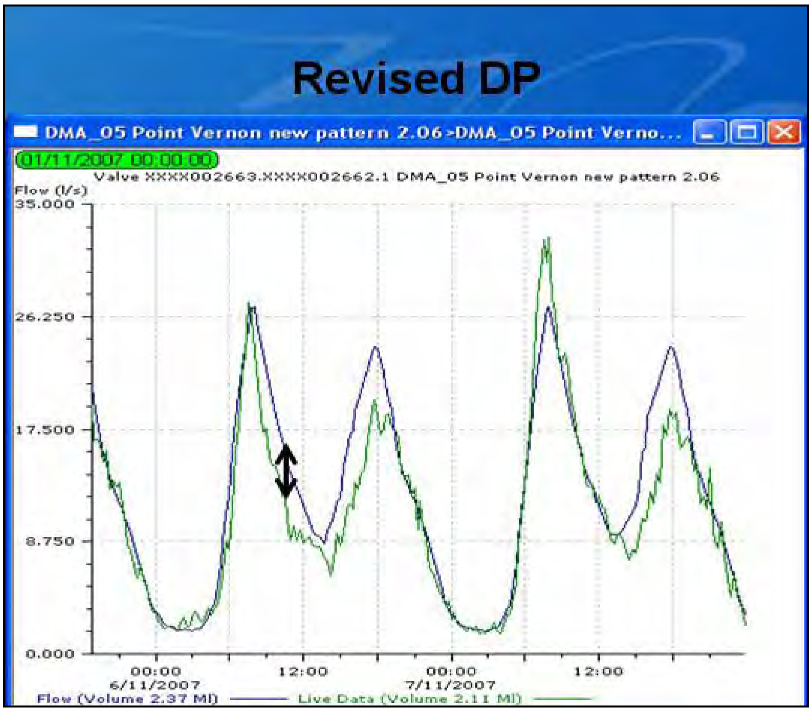
By inputting more accurate and refined data into the hydraulic models the accuracy of the models was found to increase significantly as illustrated in Figure 4-14 and Figure 4-15.

Figure 4-14 Original diurnal pattern network modelling for Port Vernon DMA



(Source – WBWC)

Figure 4-15 Revised diurnal pattern network modelling for Port Vernon DMA



(Source – WBWC)

4.5.2 Investigations in progress

WBWC are now in the process of investigating the diurnal patterns of additional DMAs for both residential and non residential customers and finding ways to automate the statistical analysis associated with sub-grouping diurnal patterns. In addition, WBWC are assessing other assumptions typically used in standard modelling and design guidelines to inform future modelling.

Having started the process of improving the input data and assumptions for their hydraulic models WBWC are now running the models for various population growth and urban planning scenarios as part of the review of their 10 year Capital Works Plan.

The current 10 year Capital Works Plan was based on water and wastewater network modelling completed in March 2004. The revised Plan is using the new assumptions and AMR data as input to the hydraulic models. Various AD, MD and MDMM parameters are being modelled for various components of the water and wastewater systems to test for constraints due to growth as part of the AMR revised baseline modelling. In addition, various options to reduce constraints (i.e. new trunk mains, moving pressure reduction valves to maintain levels of service and potential demand management measures for specific locations to relieve peaking issues) are being explored to optimise the system and defer capital expenditure.

4.6 MANAGEMENT

4.6.1 Investigation of the AMR business case

WBWC saw the potential of the AMR system when investigating new metering technologies in 2005. When submitting their funding proposal to the Water Smart Australia Program in 2005/06, the WBWC management team and Board were already committed to implementing this form of technology due to the significant benefits envisaged, independent of whether funding from other parties was secured. Involving the Australian Government provided the potential for a broader distribution of the findings and the use of the learnings from the project for national urban water policy development.

To aid the WBWC management and Board in their decision whether to proceed with the AMR system a Business Case was investigated in 2006. This was undertaken from two perspectives, a “pioneer” such as WBWC and that of another “routine” utility taking up the technology after the WBWC AMR project (White & Herriman, 2006).

From preliminary analysis it was found that the costs of conversion were approximately $290 and $190 per connection for a pioneer and routine utility respectively. The annualised costs were approximately $482,000 versus $385,000 respectively for a pioneer versus routine utility installation with approximately 20,000 residential connections. However, at the time it was recognised that there were a number of major additional benefits both financially and non-financially quantifiable that needed to be considered such as:

- The potential for peak (time of use) pricing to influence water consumption behaviour.
- Increased data availability and ability to use the data in customer engagement, restrictions enforcement, feedback and education programs ultimately resulting in reduced water demand.
- The potential for peak load reduction through pricing and/or education ultimately resulting in deferral of capital expenditure.
- Reduced time and staff costs resulting from more streamlined meter reading.
- Reduction in water losses and operating costs associated with more expedient response to leakage on both the WBWC system-side and household-side of the customer meter.
- Reduction in revenue loss to WBWC associated with customer meter under registration.
- Commission and future potential business for WBWC derived from uptake of the AMR system by other water utilities in the future.

4.6.2 Implementation of the non residential AMR system

In 2006 WBWC decided to install the AMR system on their non residential sector (in excess of 2,350 meters). This project (funded by WBWC) was completed in 2008. During the process WBWC found numerous examples of meters inappropriately sized for their flow rates, incorrectly positioned and/or slow running. Hence many of the flow records for these non residential customers would have been low, resulting in lost revenue to WBWC (increased NRW). These meters are relatively new and the full potential of the data being extracted by WBWC has yet to be realised. However, many of the techniques and processes already described will be used for this new component of the AMR system.

WBWC are in the process of assisting other utilities such as ACTEW AGL in Canberra with the installation, data extraction and monitoring of their non residential sector meters. ACTEW AGL is working with over 60 of their large commercial customers (using approximately 10% of Canberra's water) as part of a large customer leakage audit. After 18 months and with only 2 full time staff, significant water savings are already being achieved. These savings are being achieved from a combination of installation of the AMR system (which includes customer on-line access to data), audits, interpretation of MNFs and customer action taken as recommended by leakage reports.

Due to the smaller number of meters required and the higher potential benefits of savings associated with large customers, WBWC acknowledge that the installation of an AMR system in the non residential sector (before the residential sector) is likely to be the first priority for utilities interested in AMR systems.

4.6.3 Development of a preliminary research outline

Following the installation of the residential AMR system WBWC conducted a workshop in August 2007 with key staff to develop a preliminary research outline and conduct a visioning exercise for the AMR system. The workshop aided the team to validate the importance of the investigations currently being conducted. It also provided a broader vision of how this type of technology could be used in the future and what knowledge gaps might need to be filled to move towards that future vision.

Within this preliminary research outline WBWC has been working in collaboration with Griffith University and the Institute for Sustainable Futures as part of an Australian Research Council (ARC) Grant. Tracy Britton a PhD student funded by the ARC has been working directly with WBWC staff since 2007 on much of the ground breaking in-house leakage research mentioned earlier in this section.

4.7 SUMMARY OF KEY LESSONS LEARNT

WBWC is the first water utility in Australia to implement an AMR system on this scale. It is dealing with the enormous amount of additional data and detail available and systemise processing of that data so that it can be used in the most effective way to improve water management and planning practices at every level within the business.

As indicated in this section WBWC has made some extremely important discoveries due to the AMR system that are important at a local, state, national and international level. These are summarised in Table 4-1.

Table 4-1 Summary of discoveries and investigations in process

Area	Lessons learnt
Billing	WBWC are able to: - provide a high level of customer service, resolve billing disputes quickly and advise customers of potential leaks; and - extract profiles of customers potentially violating restrictions to enable evidence based prosecution as deemed appropriate. WBWC are also in the process of: - providing more detailed and informative customer bills, a web based portal for customers to access their billing history and profiles on line and provide immediate feedback to customers via an in-house display. (*These activities are currently delayed by investigations into technical and privacy issues and changes in Council responsibilities*).
Operations	WBWC are able to: - determine the proportion of MNF associated with system and household leakage to assist in efficient deployment of staff for leak detection; - optimise pressure in each DMA to reduce average and peak demand whilst

Area	Lessons learnt
	maintaining required levels of service; and - disaggregate NRW further than ever before to assist in improving national and international NRW modelling.
Research	WBWC are able to: - measure the effectiveness of restrictions and begin to test alternative strategies that may provide a better water saving outcome; - obtain city wide household leakage reports at the end of each water meter reading cycle that can be used to contact individual customers as part of a household leakage demand management program; and - broadly characterise household leaks to better inform potential demand management actions. WBWC are also in the process of: - further investigation into why toilets are responsible for a high proportion of indoor household leaks (including pressure investigations) and are liaising with Caroma and WSAA on how to improve toilet design; and - researching a model for pricing reform. (*These activities are delayed because WBWC believe that a two year process is required to collate sufficient existing metering data and allow sufficient time to develop new pricing options and liaise with the WBWC Board, FCRC and community*].
Planning	WBWC are now able to: - refine parameter inputs to hydraulic network modelling to improve the accuracy of the models (both individual water meter data for a specified period and new detailed diurnal profiles to replace standard profiles used by the water industry). (*This will allow major improvements in network modelling and standard guidelines for input parameters at a local, state, national and international level*). WBWC are in the process of: - running revised models with new input data to test constraints under different scenarios as part of the review of the WBWC 10 year Capital Works Plan. This is likely to lead to significant deferral of capital expenditure.
Management	WBWC has: - investigated the business case to justify expenditure on the AMR system looking at both costs and benefits (financially and non financially quantifiable); - installed non residential sector water meters with significant learnings on sizing and placement of meters to ensure accuracy of meter reading; - shown that for many utilities installing AMR in the non residential sector first is likely to be more cost effective and produce higher savings; and - created a preliminary research outline which has aided the initial direction across a broad set of issues that can be augmented as the research unfolds.

5 PROGRESS AGAINST OBJECTIVES

This section considers the extent to which the specific objectives of the Project have been met such as achieving water savings, deferring capital investment and informing the broader water industry about the AMR system. Due to the slight delays in the AMR system becoming fully operational, several of these objectives have yet to be fulfilled. There is still significant opportunity to achieve these objectives and WBWC is working through a process to achieve them acknowledging the fact that the new AMR system, processes and techniques will take time to embed into everyday management practices.

5.1 KEY OBJECTIVES OF THE PROJECT

As indicated in Section 1 the main objectives of the WBWC AMR Project (as stated in the funding deed) are to:

'reduce customers' overall water consumption significantly (currently estimated at a potential 20 to 25%) through:

- *implementing Australia's first AMR system; and*
- *researching a model and developing an implementation program for pricing reform such as a "time of use" water pricing system whereby water used at night is cheaper than water used during the day.*

The specific objectives of the Project are to:

- *reduce customers' residential water leakage (by an estimated 182 ML/a) through the implementation of AMR meters and improved billing information that identifies the presence of a water leak in customers' residences;*
- *reduce customers' residential water consumption (particularly water usage in residential gardens) by an estimated 914 ML/a through implementation of AMR meters and a new water pricing model that encourages irrigation at night and general water efficiency practices;*
- *defer capital construction costs regarding trunk pipe infrastructure by reducing peak daily use (with the aim of realising the deferment of $5M in capital investment by the end of the evaluation period[8]);*
- *demonstrate to other urban water authorities the use of AMR meters and the benefits of the Project; and*
- *improve water planning and other demand management initiatives.'*

5.2 PROGRESS AGAINST PROJECT OBJECTIVES

5.2.1 Australia's first AMR system and research into pricing reform

WBWC has implemented the first city scale installation of an AMR system in the residential sector (installation of over 20,000 residential meters and loggers by December 2007). It has now also completed the installation of over 2,350 commercial meters and associated data loggers.

The pricing reform research for the Project has commenced. However, as detailed in Section 4.4.2, WBWC anticipates this will not be completed until late 2010. This is due to the need to collate a minimum of two years of AMR data and liaise closely with the WBWC Board, FCRC and Hervey Bay community.

[8] In 2011

In terms of achieving the estimated 20 to 25% customer water savings through these two measures it is highly unlikely this has been achieved to date as detailed in the following sections. However, there is still significant scope to achieve such savings as the technology is embedded in the WBWC water management planning and practices, pricing reform is enacted and the full potential of demand management explored.

5.2.2 Reducing customers' residential water demand

This is expected to be achieved through:

- *'reduced customers' residential water leakage (by an estimated 182 ML/a) through the implementation of AMR meters and improved billing information that identifies the presence of a water leak in customers' residences; and*
- *reduced customers' residential water consumption (particularly water usage in residential gardens) by an estimated 914 ML/a through implementation of AMR meters and a new water pricing model that encourages irrigation at night and general water efficiency practices.'* (It should be noted that under the Project funding deed the 182 ML/a to be achieved through residential leakage reduction is assumed to be a subset of the overall residential water consumption reduction (914 ML/a). This provides the overall residential water consumption reduction of 20 to 25%[9].

In Section 2 it was observed that there has been a decrease in overall bulk water production and residential per household and per person demand in recent years. A number of factors are likely to have affected water demand in the region over recent years and may continue to affect demand into the future. To determine the extent to which the AMR system is responsible for this decrease in demand, these other factors would need to be accounted for. This requires detailed analysis beyond the scope of this Evaluation.

Some of the key factors likely to have affected demand include:

- The influence of local, state and national media concerning the drought (especially the South East Queensland "Target 140[10]" campaign which although primarily targeted SEQ had a high profile in the media during the period March 2007 to July 2008).
- Changes in plumbing laws at a state level (i.e. the introduction of water efficiency in the Queensland Development Code and Sustainable Housing Code) affecting both new and/or refurbished houses since 2007 and 2008 respectively.
- State level water efficiency rebates on rainwater tanks, washing machines, dual flush toilets, efficient showerheads, greywater systems and swimming pool covers that have been available since 2006.
- WBWC system pressure and leakage demand management programs, which have been active since 2000/01 (pers com. G Cole, WBWC). These include recent trials in DMAs such as Pialba (refer to Section 4.3.3) that have affected both system and residential and non residential customer water usage (i.e. a reduction of over 90,000 L/day was recorded in the residential customers for Pialba alone during the DMA trial in 2007).
- Local water restrictions as indicated in Table 5-1 predominantly affecting outdoor water use.
- Provision of restrictions infringement notices to customers since the installation of the AMR system at the end of 2007 targeting households found to be violating restrictions. Refer to Section 4.2.3.

[9] In 2004/05 residential water demand was 3,837 ML/a. Hence 914/3,837 is approximately a 20 to 25% reduction.

[10] http://www.target140.com.au/About+Target+140 [accessed 01/05/09]

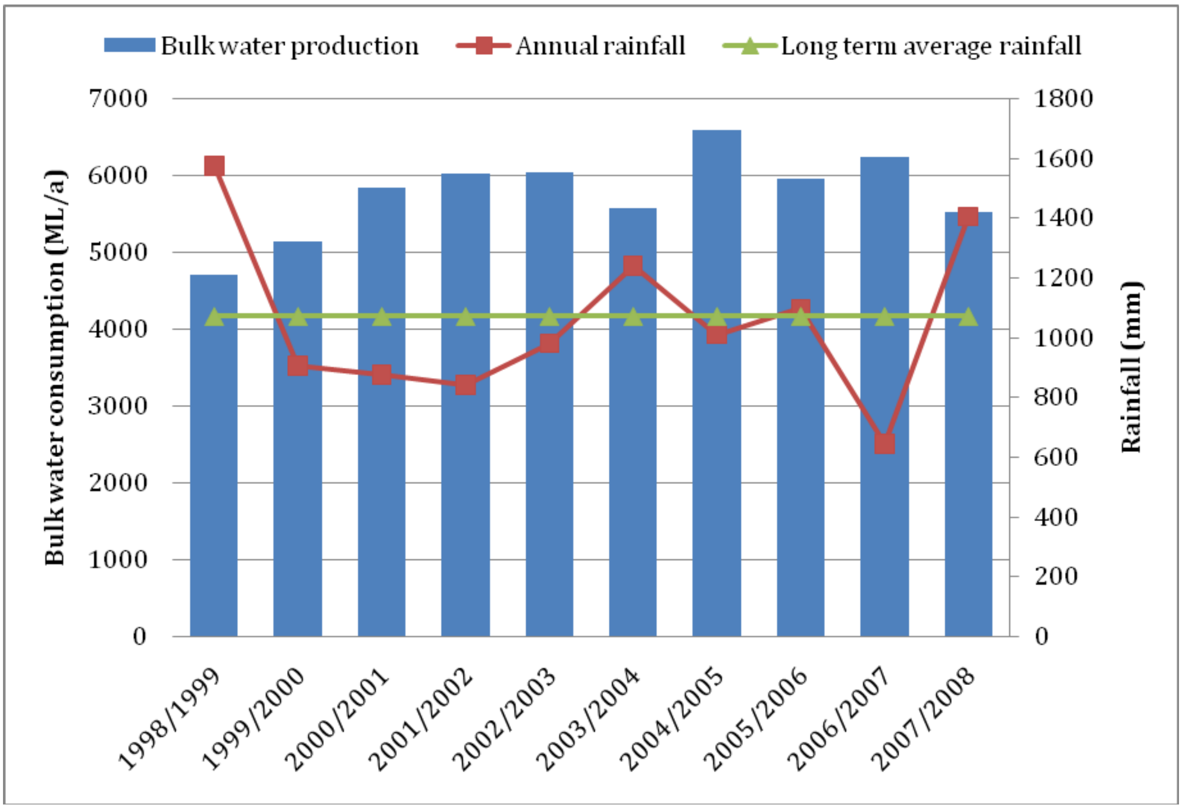
- Recent weather patterns including higher than average rainfall in 2007/08 when overall bulk production and residential demand were significantly lower than previous years (refer to Figure 5-1).
- Gradual change in housing style (i.e. increase in the proportion of multi residential properties with less outdoor watering and lower occupancy ratios) and gradual lowering of occupancy ratios in single detached dwellings, which is common nationally.
- Increase in the proportion of efficient appliances such as dual flush toilets due to the growth in new houses.
- Installation of the AMR system for the residential sector (completed in September 2007) and public education about the system being installed and the associated benefits.
- Demand management programs implemented by WBWC associated with the AMR system. These include the in-house leakage program in Port Vernon from October to December 2007. This program involved 47 households, which were found to have leaks and saved approximately 26 kL/day (potentially over 9 ML/a if the leaks were assumed to be ongoing). Refer to Section 4.4.3.

Table 5-1 Hervey Bay water restrictions 2005 to 2009

Date effective	Level	Description
07 October 2005	2	• Hosing of driveways and paved areas BANNED AT ALL TIMES • Sprinklers and soaker hoses BANNED 5.30am-8.00pm
14 April 2006	1	• No sprinklers and soaker hoses between 10.00am-2.00pm
19 January 2007	2	• Hosing of driveways and paved areas BANNED AT ALL TIMES • All sprinklers, irrigation systems and soaker hoses BANNED 5.30am-8.00pm • All hand held hosing is BANNED 8.00AM-4.00PM except for washing of vehicles and boats with a working trigger nozzle and for the flushing of boat motors. •
30 March 2007	3.1	• All sprinklers, irrigation systems and soaker hoses are banned at all times • Hosing of driveways and paved areas BANNED AT ALL TIMES • All hand held hosing is BANNED 8.00am-4.00pm except for washing of vehicles and boats with a working trigger nozzle and for the flushing of boat motors. •
07 September 2007	1	• All irrigation and soaker hoses BANNED 9am-4pm daily • Hosing of driveways and pavements BANNED AT ALL TIMES* **except where a water efficient high pressure cleaner (i.e. similar to a 'gurney') is used* • Hand held hosing permitted at anytime with a trigger nozzle *Flushing of boat motors by hose is allowed*

(Source – WBWC 2009)

Figure 5-1 Bulk water production compared with rainfall for the last 10 years



(Source – WBWC and BOM data)

Whilst both overall bulk water demand and residential demand in 2007/08 (since the AMR system has been in place) are lower than previous years (refer to Section 2.3) it is evident that many factors are responsible for this reduction in demand. These include a contribution due to specific interventions made possible by the AMR system (i.e. the household leak detection program) and where direct linkage between the AMR system outputs and the customer usage can be made (i.e. where restrictions infringement notices have been issued to customers).

Due to the number of factors potentially affecting demand over the last 10 years and more recently since the AMR system has been in place, it is beyond the scope of this Evaluation to be able to identify a specific volume of water savings that can be attributed to the AMR system in isolation.

Detailed records of water usage (bulk, residential, non residential and NRW), actions undertaken by the WBWC team that might affect demand and other factors not directly under the control of WBWC would need to be collated to assist in full evaluation of savings. In addition a detailed methodology for evaluating water savings and reviewing the longevity of savings would need to be set up now in order to evaluate future water savings.

Evaluation of water savings from specific interventions typically use techniques such as participant and control pair matching and comparison of means (Turner et al 2008) and/or regression analysis (ISF unpublished) taking into consideration weather correction. However, due to the detail available from the AMR system, modified versions of these techniques should be developed to more accurately identify the savings attributable to specific interventions.

The Project funding deed listed an objective for the AMR system to assist in reducing customers' residential water leakage by 182 ML/a and customers' residential general water usage, including garden watering, by 914 ML/a. The funding deed assumes that the 182 ML/a residential leakage saving is a subset of the 914 ML/a overall residential water saving objective.

From inspection of existing water demand (refer to Figure 2-4) the residential sector used approximately 3,837 ML/a in 2004/05, the last complete year of data prior to commencement of the Project (the base year). In 2004/05 household demand was approximately 240 kL/household/a (refer to Figure 2-5). Current available demand figures (2007/08) for residential and household demand are lower than 2004/05 at 3,050 ML/a (even with population rise) and 170 kL/household/a respectively. These figures are the lowest in the last six years of data available and represent a 787 ML/a (20%) overall drop in residential demand or 70 kL/household/a (29%) drop in demand per household. This drop in demand is likely to be attributable to the factors previously highlighted. These include the AMR system, but are likely to be dominated by the higher than average rainfall in 2007/08 (refer to Figure 5-1), which would have significantly reduced outdoor residential demand.

The demand has reduced significantly since 2004/05. However, if fluctuations in climate are taken into consideration these reductions are not as dramatic as would first appear and cannot be solely attributed to the new AMR system. The research carried out by WBWC to-date provides evidence that there is significant scope to reduce both indoor and outdoor water usage as well as residential household leakage. However, it is unlikely that WBWC would be able to reduce overall water usage by 2011 by 20 to 25%[11] or 914 ML/a, as suggested by the original funding deed estimates, without a significant level of investment in a demand management program to complement the AMR system.

WBWC should make every effort to reduce residential water demand in their region (as highlighted in the Project funding deed) through the use of the AMR system and a targeted demand management program. However, it should be noted that it is already focusing considerable effort in the NRW sector and should consider water efficiency in the commercial/non residential sector and determine the cost effectiveness of all available options according to the principles of Integrated Resource Planning[12]. The commercial/non residential sector and NRW sectors represented over 40% of the total bulk water demand in Hervey Bay in 2004/05. There are therefore significant potential available savings in the commercial/non residential sectors including those associated with garden watering and leakage.

The AMR system is now operational throughout the entire residential and commercial (including multi residential flats often used for holiday lets) sectors. It is therefore suggested that the 2011 Evaluation of the Project considers potential savings from the AMR system and any associated demand management programs in all sectors, taking into consideration climate variability between years. This will ensure that the savings from the residential, commercial/non residential and NRW sectors are all considered as part of the contribution to water savings (i.e. the broader objective of achieving water savings of 20 to 25%) and that WBWC are able to concentrate on the most cost effective options for city-wide roll out of water efficiency programs.

5.2.3 Defer capital construction costs

As indicated in Section 4.5.2 WBWC is currently reviewing their 10 year Capital Works Plan which was last updated in March 2004 and will be revised by the end of 2009. The

[11] 914/3837 = 24%

[12] IRP is where a full range of both supply-side and demand-side options are assessed against a common set of planning objectives or criteria (Turner et al 2008).

revised plan is incorporating new analysis and modelling assumptions made possible by the AMR system. In several cases analysis is indicating that standard modelling assumptions overestimate demand, thus potentially leading to unnecessarily early capital expenditure on upgrading of the system. The revised assumptions being developed will assist in correcting for this overestimation.

WBWC has recently committed significant capital expenditure on upgrading the system (i.e. augmenting a dam, water treatment plant and wastewater treatment plants). However, significant additional expenditure is still anticipated over the coming years, due to the high growth rate in the region. An additional water source is not anticipated to be required until around 2020 to 2025. However, due to major growth around the harbour and the extremities of the system, small capacity desalination plants have been proposed to be constructed within the next 10 years. In addition, augmentation of the sewers and wastewater treatment plant in Urangan will be necessary.

Each component of the water and wastewater system is designed according to various water usage design parameters. For example, reservoirs (peak 3 days), trunk mains (peak day), water network (peak day/peak hour) and sewer network and wastewater treatment plants (peak wet weather flow/average dry weather flow). The new AMR data and methods of analysis will enable these parameters to be determined more easily for specific areas and DMAs. This in turn can be used as more accurate input data to system design and modelling conducted for Capital Works Plans.

The AMR system also enables WBWC to have a more detailed understanding of existing peaks within different components of the system. This will enable WBWC to investigate how to reduce the peaks that are causing constraints and potential capital expenditure.

Whilst WBWC has not yet explicitly deferred capital expenditure due to the new AMR system, the combination of:

- more refined and accurate hydraulic modelling;
- the revision of the Capital Works Plan;
- understanding in much more detail where peak constraints are and why; and
- having an AMR system that enables WBWC to target demand management programs in constrained areas and subsequently measure the efficacy;

will provide WBWC with a major opportunity to defer capital construction costs associated with their water and wastewater systems. For example, costs for trunk main infrastructure can be reduced and deferred by reducing peak daily water use. The aspiration in the original Project brief was to save $5M in capital expenditure by 2011 (the end of the Project evaluation period). With the foundation being set by WBWC there is every indication that at least this level of capital expenditure savings will be achieved.

5.2.4 Demonstrate to other urban water authorities

WBWC has been very active in keeping the water industry informed of the progress of the Project. WBWC currently has information on the AMR system on their website[13] and has produced a DVD available to the public. WBWC has also hosted/and continue to host site visits for interested parties to raise awareness about the system and benefits of the Project. Site visits, which have included a briefing/tour of the system, have been conducted for:

- Representatives from Gladstone City Council, Rockhampton City Council and Isaac Shire Council

[13] http://www.widebaywater.qld.gov.au/

- Representatives from the Queensland Water Commission
- Logan Water and South East Water representatives
- Burnett Mary Regional Group (Catchment Management Group)
- Representatives from the Department of Sustainability, Victoria
- Representatives from key Australian consultants and research organisations SMEC, Price Waterhouse Coopers, GHD, Cardno MBK, CSIRO and the Institute for Sustainable Futures
- International visitors - Thailand Municipal Water Authority and Israeli Government

Coverage in technical magazines and conferences has been at a state, national and international level including:

- Water Loss Management Conference, Auckland, February 2008
- AWA Water Efficiency Conference, Gold Coast, February 2008
- IPWEAQ Magazine, Autumn 2008
- IPWEAQ Branch Conference, Rockhampton, June 2008
- Water Reform Workshop Queensland Local Government Association, Mackay, August 2008
- International Water Association World Water Congress, September 2008
- AWA (Water Journal), September 2008
- IPWEAQ Conference Logan, October 2008
- Water Efficiency and Water Loss Conference, Malta, November 2008
- Water Efficiency Conference, France, December 2008
- IWA Water Loss 2009 Conference, South Africa, April 2009
- IWA Efficient2009 Conference, Sydney, October 2009

5.2.5 Improve water planning and demand management initiatives

As indicated in Section 4 WBWC is:

- investigating international NRW modelling assumptions;
- improving standard input parameters used in hydraulic network modelling; and
- revising the local 10 Year Capital Works Plan with improved input data available from the AMR system to assist in revising capital expenditure requirements.

Also as indicated in Section 4 WBWC:

- has implemented a pilot household leakage demand management program;
- provides information to customers if a leak is suspected;
- is in the process of undertaking pressure reduction programs for various DMAs;
- has set-up restrictions violation procedures including enforcement where necessary; and
- set-up a broad water efficiency education program.

Hence WBWC are making significant improvements in both water planning and demand management initiatives. However, as indicated in Section 4, from evidence of the research carried out by WBWC there is scope to tap into additional water savings potential associated with both indoor and outdoor residential water usage and household leakage in Hervey Bay. There is also significant scope to reduce demand in the non residential sector and still some opportunity in the non revenue water sector.

To achieve this, it would be beneficial for WBWC to consider using a detailed demand forecasting and options model such as the Water Services Association of Australia (WSAA) integrated supply demand planning (iSDP) model[14]. Using such a tool would enable WBWC to understand in more detail how water is currently being used by sector and end use (informed by the AMR system and other investigations), how demand is likely to grow in the future and how water can potentially be saved at least cost to the community.

Employing this form of modelling would assist WBWC to improve their water planning (including comparison of supply and demand options) using an internationally recognised best practice approach and ensure they are investigating how they can tap into water efficiency in the region to achieve major water savings (an objective of this Project).

[14] The iSDP model was first developed by ISF for Sydney Water Corporation (SWC) in the late 1990s. It was subsequently modified by SWC and later released in 2003 as the Water Services Association of Australia (WSAA) end use model (EUM). The tool, now known as the iSDP model, has gradually been developed by ISF and CSIRO with various WSAA members to assist water utilities apply the principles of Integrated Resource Planning.

6 OPPORTUNITIES FOR ADDITIONAL PROCESSES AND TECHNIQUES

Whilst WBWC has made significant advances in water planning and management due to the AMR system there are still a range of opportunities to undertake further investigations into additional new processes and techniques. These new processes and techniques could create a paradigm shift in the water industry.

This section aims to provide a spectrum of additional processes and techniques that could be explored by WBWC and others interested in implementing an AMR system. WBWC should undertake many of these as part of their new advanced water planning and management business. However, in some cases, due to the significant advances that could be made for the water industry, it may be viable to set up a research collaboration group with other parties. This would enable all members of the group to explore taking these processes and techniques associated with AMR to the next level. Some of the potential additional processes and techniques to be explored are discussed in the following sections.

6.1 BILLING

6.1.1 More frequent data collection

To date WBWC has decided to maintain the 4 monthly billing cycle. However, once the meter and data logging fleet is fully operational (i.e. all faulty reed switches have been replaced) meter readers could rely on the much faster vehicle based profile and trickle alert downloading system. By obtaining the data on a more regular cycle the downloading speed would be adequate for a slow moving vehicle.

This would enable the entire customer base to be read, for example once a month. By doing this any household leaks and/or restrictions violations could be observed much more frequently (currently only observed once every 4 months as part of a standard meter reading cycle). A standard database report could then be generated for typical leak characteristics and restrictions violations and used where necessary to take action. This more regular checking of meters could potentially save a significant amount of water and ensure savings previously obtained are maintained.

With more advanced technologies now available continuous downloading to a central database could be adopted by water utilities wanting to implement an AMR system. This would enable automated checking of leakage and restrictions violation on a weekly and even daily basis.

6.1.2 Overview and monitoring of city-wide household leakage

By examining the hourly profiles of all households within Hervey Bay on a regular monthly basis an overview of the types of leaks present plus the proportion of leaks that are ongoing and/or intermittent could be obtained. This could be used to inform modelling of water demand forecasts (reference case demand) in Hervey Bay and other locations across Australia that currently do not have access to such in-house leakage data.

WBWC could also set-up a regular monthly demand management program informing households found to have leaks. It could use the AMR system to evaluate the program to determine the water savings of implementing such a program on a city-wide scale. The results of which would be extremely useful for WBWC and the broader water industry.

6.2 OPERATIONS

The benefits of the AMR customer profile data in the operational sphere lie primarily in the ability to monitor and compare the bulk volume of water supplied with the volume of water recorded by customer meters. Because the Hervey Bay region is divided into DMAs, flow and volume data can be compared down to an hourly interval for specific areas. This information can tell the operations team what is happening in each DMA in the reticulation network.

As customer meters are read consumption volume is aggregated by DMA and compared with the volume recorded by the DMA flow meter over the corresponding period. Any trends which show a rise in the calculated difference between the bulk and consumption data is invariably due to an increase in leakage that may be a leaking water main or perhaps a series of smaller leaks. Either way it allows the operations team to identify the broader area where the leakage is occurring and specific leakage control techniques can then be used to narrow the search down until the leaks are identified and repaired.

WBWC currently read the AMR on a 4 monthly cycle. Hence the comparative analysis between the bulk volume of water supplied and the volume of water used by customers is currently conducted retrospectively. However, with more frequent meter reading cycles in future this comparative analysis could be conducted much more frequently. This increased frequency would enable leaks to be identified and resolved much more quickly thereby achieving significant water savings.

6.3 RESEARCH AND DEMAND MANAGEMENT

6.3.1 Expansion of team

To date, the research team at WBWC has been responsible for researching and piloting the household leakage demand management program. As additional data analysis and demand management pilots are explored to meet WBWC's commitment to water efficiency and sustainability and fulfil the objectives of this Project (i.e. saving water in the residential sector) this team will need to be expanded. A dedicated research and demand management team could be established and made responsible for:

- drawing together the investigations conducted by the various teams so far (billing, operations, research and planning);
- developing and co-ordinating the tools, processes and techniques needed for the next five years;
- conducting further data collection, extraction and analysis;
- conducting a detailed economic and sustainability assessment of the demand management initiatives required to meet specified objectives including targeted demand management to defer specific capital expenditure;
- development of a demand management implementation plan;
- establishment of a program of ongoing monitoring and evaluation of the plan and regular reporting to WBWC management and Board; and
- assessment of research gaps for ongoing improvement of the AMR system and WBWC water planning and management.

This demand management team would ensure that further actions associated with the AMR system are advanced using a co-ordinated approach.

To date the team implementing and exploring the AMR system has included the same staff responsible for traditional WBWC management and planning activities, which has put significant strain on existing resources. A dedicated AMR demand management team would ensure that:

- the AMR system, techniques and processes developed are taken to the next level;
- that these techniques and processes are embedded within WBWC water management and planning activities; and
- that specified water savings and capital deferral objectives are achieved.

6.3.2 Climate correction modelling

Much of the analysis undertaken to date has extracted raw data from the AMR system to determine average demand for different customers. For more advanced and robust analysis, consideration of other variables including the effects of weather will be needed.

The AMR system provides a unique opportunity to take climate correction modelling to the next level. By isolating residential demand on an hourly, daily, weekly and monthly time step the effects of weather variables and other factors affecting demand can be observed. From this an “average” demand can be obtained that excludes whether a specific year was hot and dry or cold and wet (often dramatically affecting demand). Climate correction regression models are often used to understand average water demand (by stripping out the effects of weather and other variables). They are also used in evaluating the effects of an intervention such as restrictions and typically rely on the use of daily bulk water production data. This data constraint creates difficulties, including the fact that bulk water data includes demand from the residential, non residential and non revenue water sectors (i.e. the effects of climate on a household with a large garden compared to a café in the non residential sector will be very different).

Using the AMR data will allow climate correction models to be developed for specific sectors. This will enable average (climate adjusted) demand to be used in modelling the effects of restrictions on various sectors and customer types. Ultimately the effects of demand management programs can be measured using participant and control and/or regression model techniques.

6.3.3 More detailed end use investigations and modelling

Investigation into diurnal water patterns for various DMAs across the city are in progress. However, this could be investigated further by observing seasonal water demand to assist in identifying indoor versus outdoor water usage at a household level (and other non residential properties). This would aid in more accurate average and peak demand forecasting in both water and wastewater modelling.

This is being done to an extent through the hydraulic modelling discussed in Section 4.5.1. However, as described in Section 5.2.5, it is not being undertaken from the perspective of an overall demand forecasting and options model such as the WSAA iSDP model. This type of modelling would allow a more detailed end use picture of exactly how water is being used and could be saved and ultimately how much this could cost.

With more advanced metering technology on a selection of households (combined with household interviews) it would be feasible to understand water demand at an end use level (i.e. toilets, showers, washing machines etc.). This would enable:

- development of a detailed end use based demand forecasting model for the city which allows for different scenarios in terms of growth of various sectors and customer types;
- estimation of the water savings potential of each sector in the city for both average and peak water demand as well as wastewater production; and

- development of a suite of options to potentially take forward for implementation as part of a demand management program.

6.3.4 Monitoring and evaluation

The AMR system and the level of detail available can take monitoring and evaluation of demand management programs to a new level. This is in terms of obtaining a detailed understanding of how much water is being saved in a specific house and any decay of those savings over time. There is also an advantage with respect to the speed with which this valuable information can be obtained. In the limited demand management evaluations conducted to date it is typical to wait at least 6 months after the intervention to be able to obtain sufficient customer water meter data to undertake statistical analysis of water savings. This kind of analysis has been typically undertaken using participant versus control and comparison of means techniques (Turner et al 2007) or regression analysis techniques (ISF unpublished).

The AMR data monitoring can be undertaken immediately after the intervention. Having access to this new more detailed data source will require modification of the existing evaluation techniques developed.

In addition monitoring and evaluation of demand management interventions will be possible at multiple levels such as listed below:

- different residential and non residential customers;
- pressure and leakage programs associated with non revenue water and components thereof;
- average and peak water and wastewater (i.e. constraints of particular parts of the system);
- the effects of pressure management on the assumed savings of indoor and outdoor demand management programs; and
- the effects of specific restrictions and pricing policy interventions.

This will refine input parameters to demand forecasting and options models and the ongoing design of demand management programs, restrictions and pricing.

6.3.5 Further research

Considering much of the original research has been undertaken or is in progress it would be an ideal point to revise the research plan and split those tasks that have become "mainstream" from those that are still "research". This will provide focus for the WBWC team and enable opportunities for large scale research projects involving multiple collaborators to be explored for the ultimate benefit of the water industry.

6.4 PLANNING

Extremely valuable research is already being undertaken by WBWC in terms of advancing the water industry's knowledge of residential and non residential diurnal patterns.

By combining:

- the detailed AMR system data on average and peak water and wastewater demand for various sectors and customer types;
- the hydraulic network modelling of software such as *infoworks*; and
- end use demand forecasting and options modelling feasible through models such as the WSAA iSDP model which incorporate economic and sustainability assessment;

a paradigm shift in water planning and management could be possible.

Through this combination, major achievements in system optimisation, demand management and decision making could be achieved.

6.5 MANAGEMENT

6.5.1 Embedding the AMR system

It will be essential to continue to explore the capabilities of the AMR system but to also embed the new data, processes and techniques into everyday water management and planning. To do this WBWC is likely to need to expand the team and/or redeploy resources within the organisation as well as set up a co-ordination team as suggested in Section 6.3.

At the local Hervey Bay level, if such a team was set up they would be expected to take the responsibility of reporting to WBWC management team, the Board and Council in terms of achievement of defined objectives associated with water savings achieved and deferral of capital (and operating) expenditure.

By setting up a reporting system and a line of communication in terms of ultimate evidence based decision making this could open up the opportunity of influencing broader decisions. For example, currently WBWC respond to Council planning and development scenarios. Through the more detailed modelling feasible with the AMR system WBWC will be able to clearly show to Council the implications of different types of development and their location. By running different scenarios this will assist the Council to decide the best locations for new developments and the consequences in terms of headworks charges.

6.6 CONCLUSIONS

This Evaluation represents a snap shot in time. To-date, WBWC has made some major findings in terms of discovering what AMR systems can provide at a local, state, national and international level.

Whilst WBWC has not yet achieved some of the identified Project objectives, it is envisaged that over the coming year WBWC is likely to make many additional significant advances that will aid both WBWC locally and the water industry more broadly. It is therefore likely to achieve the majority of the Project objectives by the end of the Project evaluation period due to be completed in 2011.

As detailed in Section 6 there are many additional significant opportunities available due to AMR that should be explored by WBWC and other water industry practitioners and utilities. By exploring these additional processes and techniques we are likely to find that AMR will revolutionise the water industry within the next 5 to 10 years.

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