Developing a Policy Position on Smart Water Metering

WPI Interactive Qualifying Project

Low rainfall and high water demand threaten Melbourne, Victoria's water supplies. A wide scale implementation of smart water metering throughout Melbourne would cost over $200M but could (1) save water and money for end-users through leak detection, and (2) reduce water consumption up to 18% if water usage data was presented through behavioural cues. These findings form the core of policy recommendations we provided to the Alternative Technology Association of Australia.

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Executive Summary

The Alternative Technology Association (ATA) is Australia's leading not-for-profit organisation that promotes water conservation, renewable energy, and good building design through its advocacy work and magazines. ATA wishes to know more about a relatively new water conservation technology, smart water metering, in hopes of developing a new policy position for a wide-scale implementation of smart water meters. This report provides an analysis of how smart water metering can improve a water distribution system and strengthen ongoing conservation efforts in Melbourne, Australia.

Smart water metering records and wirelessly transmits water consumption data over short time intervals (e.g. second, hour, day). Wireless data transmission makes information more accessible and replaces the current need for manual meter readings. Smart water metering can also aid in the detection of household leaks through interval data analysis. Investigations of smart water metering pilot-scale studies reveal that leaks in households can amount to 10% of total water usage (Thornton & Tanner, 2010). Our analysis shows that smart water metering can salvage water with a retail value of approximately $1,384,446 AUS, which would otherwise be lost annually to household leaks across Melbourne.

Household water consumption can be reduced by up to 18% through using a combination of campaign strategies (e.g. feedback frequency, high goal setting). We evaluated such campaign strategies in order to determine how information can be presented to provoke water conservation. Victoria's current conservation campaigns use effective strategies. They can be improved by incorporating smart water metering information. A combination of

metering information and effective campaign strategies should be displayed through a consumer interface, empowering individuals to change their water use behaviour.

Through our analyses, we have determined how smart water metering can be best implemented to prompt awareness, to instigate behaviour change, and to help ensure Melbourne's future water supply. Our recommendations include:

- The type of smart metering components and communication system that would be best suited for the current water distribution system,
- Conveying smart metering information through an interface so that consumers can better evaluate their water consumptions,
- Alternate solutions to be used in the absence of a wide-scale implementation of smart water metering.

The report lays the groundwork to support a large scale implementation of smart water metering in Victoria, Australia. Our recommendation is supported through an examination of cost, smart water meter functionalities, behaviour models and a comprehensive review of effective campaigning. These sources provide substantial evidence as to why smart water metering is a viable solution to address Victoria's growing water supply problems.

1. Introduction

Melbourne's water situation can be viewed as a struggle of supply and demand. The city is already drought stricken and climate change is further diminishing water supplies while demand is increasing due to a quickly growing population. As Melbourne's municipal reservoirs are only at 38% capacity (Victorian Government, 2010), this pattern is increasing concern for Melbourne's remaining water supply.

To ensure future water supply, each consumer should monitor their consumption and efficiently use water. However, Victoria's gardening culture has resulted in high inefficient water use (A. Nelson, personal communication, 26 February, 2010). The government has imposed restrictions and funded campaigns to promote water conservation but reservoir levels are still dropping (Melbourne Water, 2010b). The government is currently looking for new ways to further control water demand.

Smart water metering (SWM) is one implement that can monitor demand. This new technology can track water flow in time intervals and transmit data using two-way communication (C. Memery, personal communication, 20 January, 2010). SWM could potentially allow people to easily monitor their water usage and therefore help them understand how to save water. Thus far, most research on SWM has focused on the costs and benefits for water distributers, but has neglected to study how SWM information can alter water demand through changing consumer behaviour.

In order to determine how information can lead to conservation, we examined several design principles through behaviour models and conservation campaigns. These factors allowed us to determine how information provided by SWM can provoke behaviour change. Water conservation occurs when a consumer changes their daily water expenditures. A consumer interface, which displays personalised water usage information, could encourage water consumption through proper implementation of design principles. In order for SWM to contribute to conservation efforts, a communications infrastructure is needed to transmit data from the meter to the consumer.

Infrastructure was examined through interviews with water retailers, smart meter producers, and communications experts. We inquired about the current water infrastructure, SWM integration, and SWM data transmission. We found that SWM can initiate substantial water conservation through an effective consumer interface, especially in a wide-scale implementation. Establishing a wide-scale implementation of SWM would be advantageous; if more people are informed of their water usage, more behaviour change could occur, and therefore, more water could be conserved.

2. The Current System

2.1. Domestic Water Usage in Australia

It is essential to examine water consumption to evaluate how it can be reduced. Nationally, only 11% of Australia's total water consumption is used by households (Australia Post, 2007); see figure 1. In contrast to national water consumption patterns, the majority of water consumed in cities is by households. Households account for 60% of Melbourne's water usage; see figure 2 (Australia Post, 2007). Likewise, 54% of Sydney's water (NSW Government, 2003) and 62% of Perth's water is used by households (Loh and Coghlan, 2003).

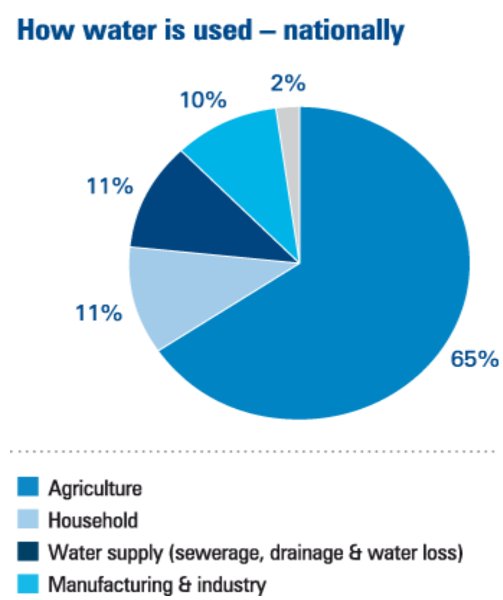

Figure 1: Australia's water usage (Australia Post, 2007)

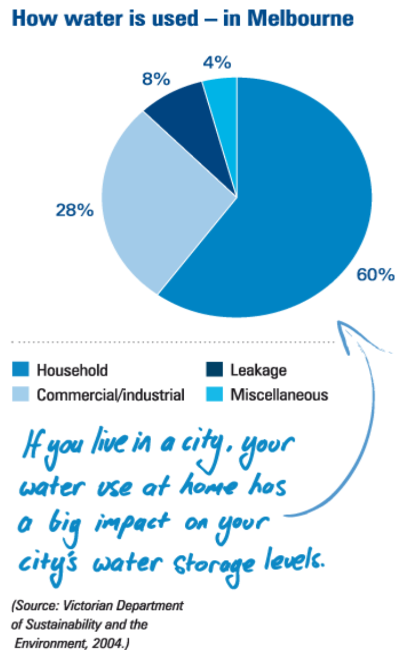

Figure 2: Melbourne's water usage (Australia Post, 2007)

As climate change diminishes freshwater supplies, and as the demand for water continues to grow, it is necessary to minimise the current water use in urban developments. Targeting householders to change their water usage behaviours can enable a considerable decrease in water consumptions as urban development represents a majority of Australia's population.

2.2. Current Water Infrastructure

Melbourne's mains water is supplied by Melbourne Water, a government owned supplier, and is distributed through three main water retail companies, City West Water Ltd., South East Water Ltd., and Yarra Valley Water. Melbourne Water supplies roughly 500 gigalitres of water to approximately 1.7 million customers annually (Melbourne Water, 2010). Each retailer works independently, but communicates with the other retailers to ensure conformity in distribution and customer service (A. Geary, personal communication, 5 February, 2010).

2.2.1. Standard Water Metering in Melbourne

A water retailer's objective is to obtain potable water from a supplier, distribute that water to its customers, track customer water usages appropriately, and accurately bill customers for their consumptions. A contractor is hired by the water retailer to manually read each customer's water meter. This process entails travelling to each end-use property, every three months for residences and every month for high-water users, such as industries (A. Geary, personal communication, 5 February, 2010). Standard water meters are accumulation meters[1], which require usage to be calculated by subtracting a meter's current reading by the last recorded meter reading; see figure 3.

Account Details

Water Usage from 24/08/2009 to 23/11/2009.

Meter Number	Current Reading	Last Reading	Usage
MAF003000	1,014kL	- 1,004kL	= 10kL

In 91 days you used 10.000 kilolitres, equalling 110 litres per day.
One kilolitre (kL) equals 1,000 litres.

	Usage *	Price $/kL	Amount
BLOCK 1	10.000kL	x 1.2532	= $12.53

* Rising block tariffs are adjusted according to the days in your meter reading period, and applied on a daily basis.

Sewage Disposal from 24/08/2009 to 23/11/2009.
For the disposal and treatment of sewage from your property. It is based on your water usage and adjusted for seasonal variations.

Usage	Seasonal Factor	Seasonal Volume	Discharge Factor	Sewage Volume
10.000kL	x 0.9440	= 9.440	x 0.900	= 8.496kL

Sewage Volume	Price $/kL	Amount
8.496	x 1.5126	= $12.85

Service Charges from 01 Oct 09 to 31 Dec 09.
These are fixed charges per property based on a daily rate comprising:

Water Service	$22.53
Sewerage Service	$57.19
Total Service Charges	**$79.72**

Waterways and Drainage Charge from 01/10/2009 to 31/12/2009.
This charge, based on a daily rate, is collected on behalf of Melbourne Water and used to manage and improve waterways, drainage and flood protection. Your *NAV is at a sufficiently low level to attract the current quarterly minimum charge of $16.91.

*NAV = Net Annual Value of your property which is capped at 1990 levels.

Figure 3: A customer water bill from Yarra Valley Water (Yarra Valley Water, personal communication, 2010)

[1] Accumulation meters display lifetime volumetric measurements of mains water flow on either an analogue or digital display.

2.3. Leak Loss and Detection in Melbourne

Water retailers cannot automatically detect leaks within a private residence. Household leaks can only be detected if the consumer consciously discontinues water usage and manually notes any changes to their meter. Household leaks are relatively unnoticed unless the leak is blatant or the consumer tests for it.

Water retailers are responsible for water leaks within their system. Melbourne Water and its retailers are very concerned with leaks because lost water is lost revenue. Melbourne water networks lose around 6-8%, or 40 gigalitres, of distributed water to leaks each year (A. Geary, personal communication, 5 February, 2010). Distributed water leak detection currently occurs through utilisation of sonar technology to pinpoint underground leaks (City West Water, 2008). However, such strategies are only employed periodically. In fact, retailers become aware of most leaks by receiving a phone call from an observer (A. Geary, personal communication, 5 February, 2010).

3. Smart Water Metering

A smart [water, electric, gas] meter, by definition, must be capable of measuring and storing flow in time intervals, and have the ability for two way communication with a remote location (C. Memery, personal communication, 20 January, 2010). These capabilities can be accomplished by upgrading an accumulation meter or through replacing the meter entirely.

A smart water meter replaces the accumulation meter thus providing more accurate water readings through efficient methods of water flow detection[2]; see figure 3. SWM can occur without the use of an actual smart water meter. The components that make up a smart water meter include flow detection hardware, a transmitter and memory to store data.

Figure 4: Smart water meter (Enviro Friendly Products, 2010)

[2] A more detailed description of the different types of water flow measurement can be found in Appendix A: Explanation of Water Flow Measurement Methods

3.1. Transmitters

A transmitter is the most basic component of SWM. A transmitter can be attached to an accumulation meter to enable wireless data transmission. Transmitters are devices that transmit water meter readings to a remote location in the form of radio waves (Enmalta, *n.d.*). For smart metering applications, the typical range of a transmitter using wireless radio is about 1 kilometre (J. Rouse, personal communication, 10 February, 2010). Transmitting data over a large distance requires the use of a GSM[3] transmitter. Most applications of smart metering use radio transmitters because they are about three times cheaper than the GSM alternative (Meter Mate, 2010).

3.2. Data Loggers

Transmitters can be improved through the addition of data storage capabilities. This device is called a data logger which can both store and send interval data. As with the transmitter, a data logger is attached to an accumulation meter: see figure 5.

[3] GSM - Global system for mobile communication (GSM World, 2010).

Figure 5: Data logger (Coronis, *n.d.*)

Data loggers are able to log data on adjustable time scales, which can range from one recording per second to one recording per month (Enviro Friendly Products, 2010). One immediate advantage of interval data logging is that it simplifies leak detection. Leaks are identified by noticing sustained constant water flow over durations of time. Software analysis can calculate the precise amount of water lost in an interval of time; see figure 6.

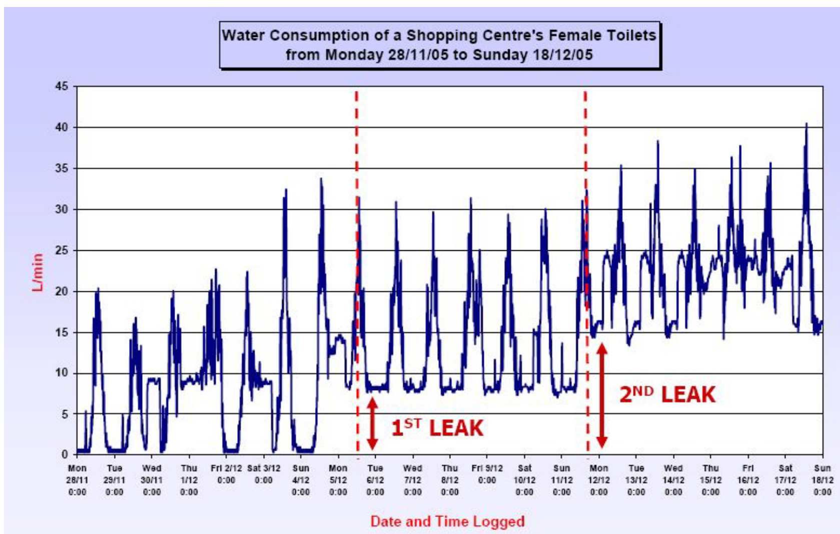

Figure 6: Interval data logging chart showing leaks (Idris, 2006)

3.3. Gateways

A gateway is a device that receives signals from one or more data transmitting devices and relays the information to a distant location (J. Rouse, personal communication, 10 February, 2010). Smart water meters and data loggers typically use radio transmitters to send information to a gateway, which then relays all end-use data via GSM networking (Coronis, *n.d.*); see figure 7.

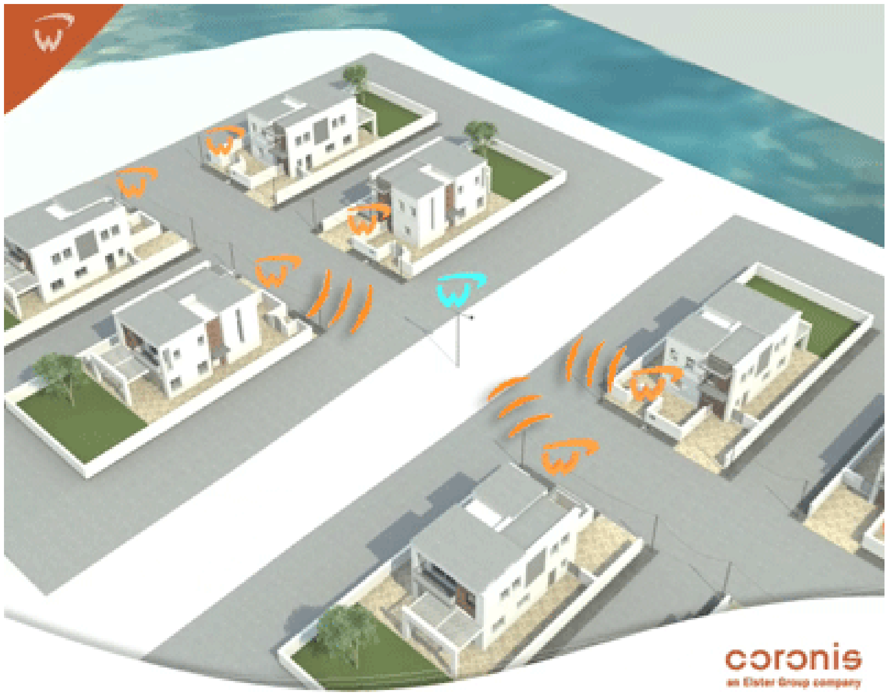

Figure 7: A pictorial representation of a communications network utilising a gateway (Coronis*, n.d.*)

By acting as a large data logger, the gateway can store multiple data points and transmit them in packets to the retailer. This process of data storage and transmission decreases the need to incessantly relay data over large distances

3.4. Consumer Interfaces

A consumer interface is an implement that allows a person to interact with a piece of technology (Linfo, 2005). An in-home display, a water bill, and an online web portal are all examples of consumer interfaces that could be made available for a homeowner to view their water consumption data. In Section 7.1 entitled 'Campaign Design: Factors that Lead to Conservation', it will be discussed how a consumer interface can present information in a way that can compel users to change their water consumption behaviours.

4. Findings: Components and Implications of Smart Water Metering

In order to establish whether or not smart water metering would be an effective technology for water conservation, we had to determine:

- How to enhance the current infrastructure to incorporate smart water metering,
- The costs and benefits of integrating smart water metering into the current water grid.

We analysed cases that tested smart water and/or electric metering in realistic situations to determine the difference between theoretical and practical application.

4.1. Maltese National Power and Water Utilities

The Maltese national power and water utilities, Enemalta and Water Service Corporation, are currently making their country "the first in the world to build a nationwide smart grid and fully integrated electricity and water system" (John, 2009). The nation-wide rollout will include smart electric meters and radio frequency transmitters (for the water meter) to be installed in all homes, businesses and industries (Enemalta*, n.d.*). This system will allow the utilities to better identify water leaks and electricity losses in the grid. Figure 8 gives a visual representation of how Malta uses the smart electric meter grid to transmit water meter data to the utilities.

Figure 8: Communications process for integrating water meters with smart electric meters

The project began in late 2008 and all installations are expected to be complete in 2012 (John, 2009). Once all devices are installed, the new smart meters will allow the utilities to introduce several new services and options to their customers. The two main services that can be offered to domestic households are:

- Prepayment billing where the consumer can top up the meter with smaller, more manageable amounts similar to prepayment of mobile phones;
- Contracts featuring a tariff structure that may reflect better lifestyles and consumption habits, to reduce the electricity bill (Enemalta, *n.d.*).

This approach signifies that the utilities are not only improving their infrastructure, but also aim to change the behaviours of their customers.

4.2. Smart Metering HAN in Victoria

The Victorian government has mandated a rollout of smart electric meters (SEM) to approximately 2.2 homes and 300,000 businesses across Victoria (Grubb, 2009). Beginning in 2009 and anticipated to be complete in 2012, all electricity distributors are responsible for installing SEM within all end-use properties. This rollout also entitles the installation of a home area network (HAN) in order to provide a means of communication between SEM, and both electricity distributer and homeowner.

The HAN acts as a consumer interface, allowing both the distributor and consumer to interact with the meter and its data. However, electricity distributors do not want consumers to be able to tamper with usage data and therefore, have created two parts to the HAN (C. Memery, personal communication, 15 January, 2010). One part of the HAN is limited to the distributer's control, where the distributer is able to remotely acquire data and control domestic energy appliances when deemed necessary. The other part allows the consumer to access their electrical usage data and control appliances from wireless components such as a mobile or computer (Victorian Distribution Businesses, 2008).

As seen in figure 9, considerations have already been made to incorporate smart water and gas metering into HAN networks.

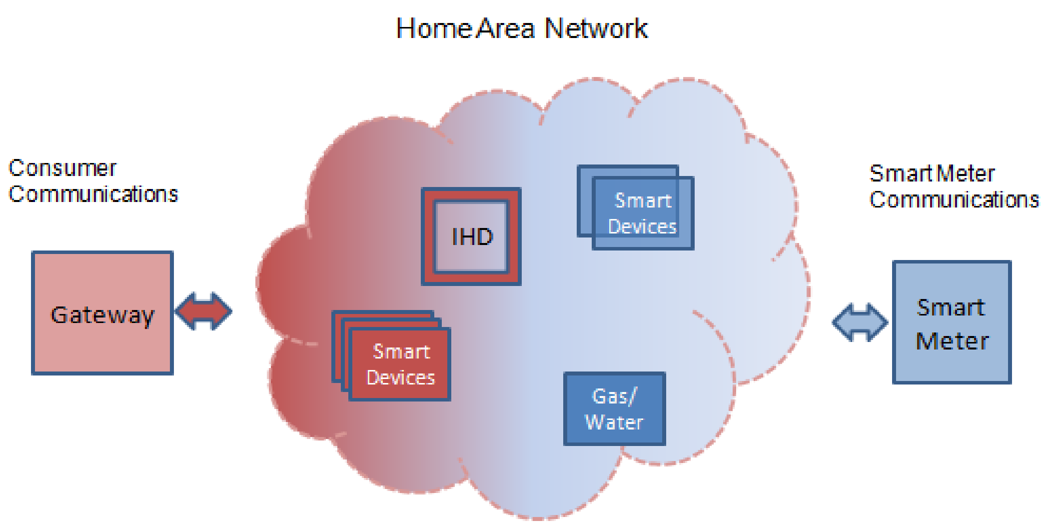

Figure 9: Depiction of a home area network (Gill, 2010)

4.3. Sydney Water Residential Case Study:

Sydney Water is a New South Wales government-owned corporation that supplies potable water to Sydney and neighbouring regions. Sydney Water is currently conducting a pilot-scale study of smart water metering in a Sydney suburb, Westleigh, NSW. It began in January 2009 and is due to end in June 2010[4]. All of the following information was provided by the project manager of this trial, Corinna Doolan (personal communication, 17 February, 2010).

[4] A more qualitative summary of this study can be found in Appendix C: Summary of CORINNA DOOLAN interview

The main objectives of this trial are to: (1) determine how smart water metering can change behaviour in consumers and (2) find the cost and savings of a network incorporating smart water metering. This study's findings will reveal costs and benefits of large scale SWM implementation.

In this trial, 468 homes were equipped with transmitters that send data to 23 gateways. Each gateway is able to collect and receive data from about 20 transmitters. The transmitters use radio frequency to send data to a gateway, which uses GSM to relay that data to Sydney Water. The cost of installation into each home, depending on transmitter and/or user interface type, could vary from $200 to $3000. The prices of these devices vary according to fluctuating market demand and size of purchase. In this trial, the transmitters cost about $200 and the gateways cost approximately $3000.

Transmitters were initially set to track usage and log data every five minutes to track leaks. A few months after initial installation, Sydney Water replaced the majority of the transmitters because the short time intervals limited battery life significantly. The study is currently logging data on hourly intervals to prolong battery life.

In-home displays are installed in 160 of the 468 homes. Sydney Water is observing the effectiveness of these in-home displays. Doolan observed that many people find one particular screen on the interface, which shows hourly consumption data for the household, most useful because it is informative and detailed. Sydney Water is also tracking the water savings of households with an in-home-display in comparison to the households without an interface. They are studying the interest of the participants in the display by monitoring the frequency of interface access and usage. By tracking how often participants use their in-home display, it was found that participants interest in monitoring their water usage dwindled over time.

4.4. Water Leak Case Studies

Wide Bay Water, a Queensland water retailer, placed data loggers in 2,359 homes as part of a case study in 2008 to learn about domestic water consumption (Britton, Cole, Stewart, Wiskar). By monitoring water usage between 1-3 AM, data analysis revealed that 2% of monitored homes had leaks. The combined estimated total of the lost water was 9,566 kilolitres per year. This annual loss equates to about $11,957 AUD.

East Bentleigh Secondary School, located in greater Melbourne, prides itself in practicing sustainable solutions. In 2007, the school connected a data logger to its water meter and discovered a major leak. Fixing the leak prevented about 6,000 kiloliters of water loss per year. The school has a combined three-year revenue savings of approximately $19,000 AUS and 85% water usage reduction since it has installed the data logger (Thomas, 2010).

5. Analysis: Components and Implications of Smart Metering

This section contains a summary of the benefits and drawbacks of a large scale implementation of SWM as well as an analysis of associated costs.

5.1. Smart Water Metering

A comparison of both methods metering shows limited drawbacks of implementing smart water metering.

	Benefits	Drawbacks
Standard water metering	❖ Low cost ❖ Infrastructure already established and functional	❖ Data collection occurs every 3 months ❖ Minimal info ❖ Billing is priority
Smart water metering	❖ Leak detection capability ❖ Real-time data available ❖ Data is personalised	❖ Large cost

Table 1: Comparison of standard and smart water metering

SWM benefits compensate for the drawbacks of standard water metering. SWM allows data to be more available and easily accessed. Standard metering only collects data once every three months whereas SWM allows for close to real-time water monitoring. SWM data transmission benefits water retailers by eliminating the need to contract manual meter readers. Additionally, the ability of frequent data transmission in SWM technology provides conservational benefits as discussed in Chapter 7: Analysis: Behaviour Change.

5.2. Associated Costs

The major drawback of SWM is the large associated cost. Wide implementation of SWM would involve approximately 1.7 million customers throughout Melbourne. Several costs are involved with upgrading every water meter to becoming a smart water meter. The water retailer must purchase the SWM device (e.g. transmitter, data logger) and contract man labour for installation. Figure 10 shows a cost comparison between purchasing a smart water meter and its simpler components juxtaposed to standard water meters for Melbourne. This cost includes both the cost of the device and installation.

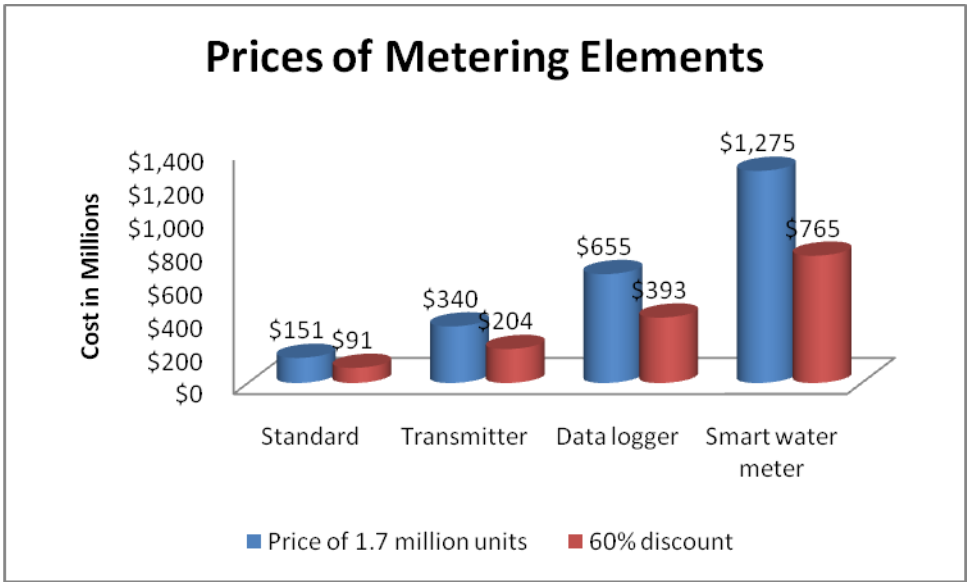

Figure 10: Purchase cost of implements with 60% discount

This figure uses approximate individual unit costs of $36 AUS for a standard meter (A. Geary, personal communication, 5 February, 2010), $200 AUS for a transmitter (C. Doolan, personal communication, 17 February, 2010), $385 AUS for a data logger (Giurco et al., 2008), and $750 AUS for the smart water meter. Note that the costs of the metering components are estimates since cost is dependent upon market demand and the quantity purchased (A. Bodächtel, personal communication, 5 February, 2010).

Our findings on bulk purchases suggest that a 60% reduction on individual unit costs is a reasonable estimate of the bulk purchasing discount that can be expected in a wide-scale rollout in Melbourne. . City West Water pays substantially less than the individual retail price for each meter due to bulk purchase. (A. Geary, personal communication, 5 February, 2010). In addition, “the actual incremental cost of additional functions of smart meter infrastructure often proves to be less than that used for the cost inputs to a typical smart meter rollout cost benefit analysis due to the competitive nature of the supplier tendering process. For some functions or features, this is known to be a factor of ten” (C. Memery, personal communication, 22 January, 2010). In other words, it is difficult to predict the price reduction of a massive purchase.

Maintenance is an additional associated cost. Yearly upkeep is important because the water utility must replace the meter once its battery dies and the functionality of the unit is compromised. A cost table has been created to reflect the costs of replacing such smart water metering components; see table 2.

	60% discounted price	Lifespan (years)	Annualised cost	Annual cost per user
Standard	$90,780,000	15	$ 6,052,000	$3.50
Transmitter	$204,000,000	5	$ 40,800,000	$24.11
Data logger	$392,700,000	10	$ 39,270,000	$22.90
Smart water meter	$765,000,000	10	$ 76,500,000	$45.00

Table 2: The yearly cost of maintaining units

The annualised cost of a unit is calculated by dividing the purchase cost by the expected lifespan of the meter. This is to standardise all of the costs into a per year basis for comparison. Although the transmitter is the cheapest SWM component to purchase, it would actually be more expensive to maintain as opposed to a data logger.

5.2.1. Standard Water Meter Reading Costs

The current method of meter reading costs about sixty cents per reading. This occurs once per three months for households and once per month for industries (A. Geary, personal communication, 5 February, 2010). Therefore, the approximate cost of reading each water meter in Melbourne four times a year is $4,080,000 AUS.

$$\mathbf{60 * 4\ \mathit{readings\ per\ year} * 1.7\ \mathit{million\ users} = \$4,080,000}$$

However, because we do not know how many end users have their meter read more often than four times per year, we will estimate that the total annual cost for manual meter readings in Melbourne is $6,000,000 AUS.

5.2.2. Data Communication Costs

One of the main advantages to a smart water grid is that data automatically uploads to a database, therefore eliminating the costs of manual meter readings. However, this cost is replaced by the cost of maintaining a wireless communications network.

In the Sydney Water Residential study, gateways were used to relay water usage data from households using short range transmitters to the Sydney Water database (C. Doolan, personal communication, 17 February, 2010). The advantage of using a gateway as opposed to extending the range of each transmitter came down to cost. The prices of the gateways and transmitters depended on market demand and size of purchase. The approximate cost of these devices was approximately $200 for each transmitter and $3000 for each gateway at the time of purchase (C. Doolan, personal communication, 17 February, 2010). In order for a single transmitter to relay information as far as a gateway, the price for such a long-range device jumps up to $650 per transmitter (Meter Mate, 2010); see equations below.

$$\mathbf{23}\ \boldsymbol{gateways} * \mathbf{\$3000} + (\mathbf{468}\ \boldsymbol{transmitters} * \$200) = \mathbf{\$162,600}$$

$$\mathbf{468}\ \boldsymbol{transmitters} * \mathbf{\$650} = \mathbf{\$304,200}$$

Using the same setup as Sydney Water's pilot study for a gateway communication infrastructure, where one gateway is able to communicate with up to 20, Melbourne would expect to pay:

$$\mathbf{1.7}\ \boldsymbol{Million\ end\ users} * \frac{\mathbf{1}\ \boldsymbol{gateway}}{\mathbf{20}\ \boldsymbol{end\ users}} = \mathbf{85,000}\ \boldsymbol{gateways\ needed\ for\ Melbourne}$$

$$\mathbf{85,000}\ \boldsymbol{gateways} * \mathbf{3000}\ \boldsymbol{per\ gateway} = \$\mathbf{255}\ \boldsymbol{Million}$$

This cost would be in addition to purchasing and installing a chosen smart water metering unit for Melbourne's end users. Creating a wireless infrastructure is a large cost, but it is a onetime start up cost. However, integrating SWM with the SEM wireless network would be a cheaper solution since it avoids the large start up fee while still providing valuable near real-time water consumption data.

5.2.3. Estimating Savings from Leak Detection in Households

To gain an idea of how much water could be saved through household leak detection through SWM, we estimated expected savings for Melbourne. The Wide Bay Water study found leaks in 2% of the 2,359 domestic water systems in its study (Britton, Cole, Stewart, Wiskar, 2008). Therefore for our analysis, we will assume that 2% of a water grid's customer base has water leaks. To estimate how many end users in Melbourne have leaks, we multiplied this percentage with the total number of end users in Melbourne.

$$.02 * 1.7\ million\ end\ users = 34,000\ end\ users\ with\ leaks$$

When analysing Yarra Valley's Smart Account, as shown in Appendix D, we found that the average daily use for a four person home with a medium sized garden is 760 litres. We then converted this number to analyse how much water such a household can use in a year's time.

$$760\frac{litres}{day} * 365\frac{days}{year} * \frac{1\ kilolitre}{1000\ litres} = 277\frac{kilolitres}{year}$$

According to a study in the United States, 10% of household water is lost to leaks when a leak is present (Thornton & Tanner, 2010). We applied this number to Melbourne households.

$$277\frac{kilolitres}{year} * .10 = 27.7\frac{kilolitres}{year} water\ lost\ to\ leaks$$

$$27.7\frac{kilolitres}{year} * 34,000\ users = 941,800\frac{kilolitres}{year}\ is\ leaked\ water$$

These homes are being charged $1.47 per kiloliter (Yarra Valley Water, 2010). Calculations for household leaks in Melbourne include:

$$27.7\frac{kilolitres}{year} * \$1.47\ per\ kilolitres = \$40.72\ spent\ on\ leaked\ water\ per\frac{user}{year}$$

$$\$40.72\ per\frac{user}{year} * 34,000\ users = \$1,384,446\ annually\ spent\ on\ leak\ water$$

Homes with leaks in Melbourne spend about $40 annually on wasted water, or roughly $1,384,446 spread between 34,000 households. Note that this cost will be twice as expensive within 5 years as the price of water is expected to increase in Melbourne (A. Geary, personal communication, 5 February, 2010). Also note that the actual savings could widely vary depending on the source of the leak. This is a cost that can be reduced if SWM were widely implemented in Melbourne. Wide Bay Water noted that a fraction of the homes with leaks detected had an exceptionally high loss compared to others, suggesting that the quantity of water lost to leaks is not always straightforward to predict.

5.3. Summary of SWM Analyses

We analysed our findings to understand what type of wide-scale smart water metering implementation would be most suitable for Melbourne. We found that smart water meters are expensive in comparison to their simpler components (i.e. transmitter, data logger) and standard water meters. We also found that a device's battery life is a limiting factor in regards to maintenance and annualised costs. Battery power is required to send data wirelessly and can be prolonged for as long as a device can send data infrequently. Transmitters cannot store data and thus, take interval water usage readings and transmit those readings immediately after they have been taken. Data loggers store interval data, which allows less frequent wireless transmission. Therefore, data logger's battery is more reliable than a transmitter's battery.

We also analysed how integration between SWM and SEM could be a cost effective communication solution. If integration is unlikely, using short range wireless in conjunction with gateways becomes the next most effective communication network for SWM. Lastly, leaks in households account for a small fraction of total water usage but could easily be detected and fixed by employing a wide-scale SWM system. Water leak detection could benefit households to potentially conserve water and money.

6. Findings: Behaviour Change

We explored the impact of SWM information on consumer water conservation through investigating conservation campaigns and studies. We examined the studies using two behaviour change models to determine:

1. The impact of current conservation efforts in Melbourne
2. The results of a comprehensive review of conservation campaigns
3. What factors increase the conservational impact of a campaign

6.1. Behavioural Models

The two models in this section focus on different aspects of changing behaviours. The Transtheoretical Model describes the temporal, step-by-step process of behaviour change and the Fogg Behavior Model explains the factors that lead to behaviour change.

6.1.1. Transtheoretical Model

The Transtheoretical Model, proposed by Prochaska and DiClemente (as cited in TravelSmart, *n.d.*), explains the progression of thought from being unaware of a problem to maintaining a behaviour change. Progression through these stages requires communication, support, and guidance; see figure 11.

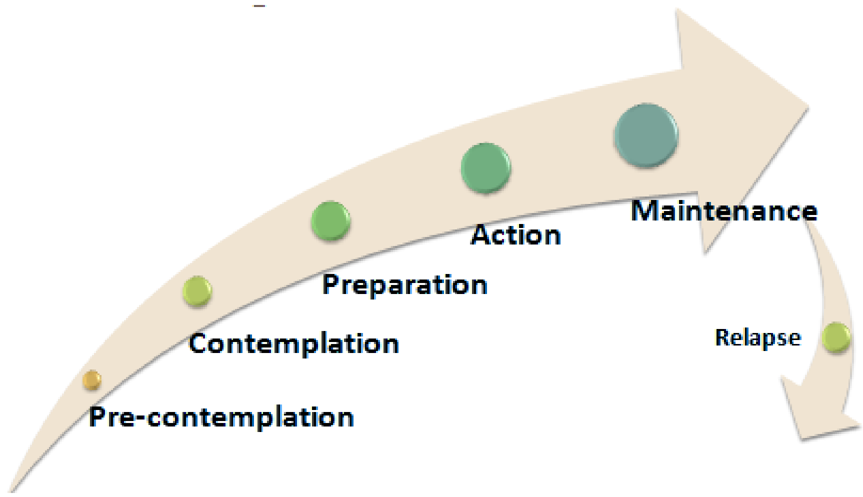

Figure 11: Transtheoretical model - the process of change

There are five stages that explain the process a person goes through to reach and sustain target behaviour. Pre-contemplation is when individuals are unaware of a problem or do not care to implement a solution. The contemplation stage is when the individual is aware of the problem and is deciding whether or not to attempt change. Once the individuals decide to alter behaviour, they reach the preparation stage where they prepare for the change then finally take action. The action stage is when individuals are performing the target action. The maintenance stage is when the individuals perform the new routine (TravelSmart, *n.d.*).

Relapse is when individuals fall back into old habits. This can happen during any of the stages. When relapse occurs, the reason must be evaluated and the individuals must be encouraged to continue with the change (TravelSmart, *n.d.*).

6.1.2. The Fogg Behavior Model

The Fogg Behavior Model explains the factors that lead to behaviour change. According to Fogg, individuals must have "sufficient motivation, sufficient ability, and an effective trigger" at the same time in order for a behaviour change to occur (2009a, p.1); see figure12.

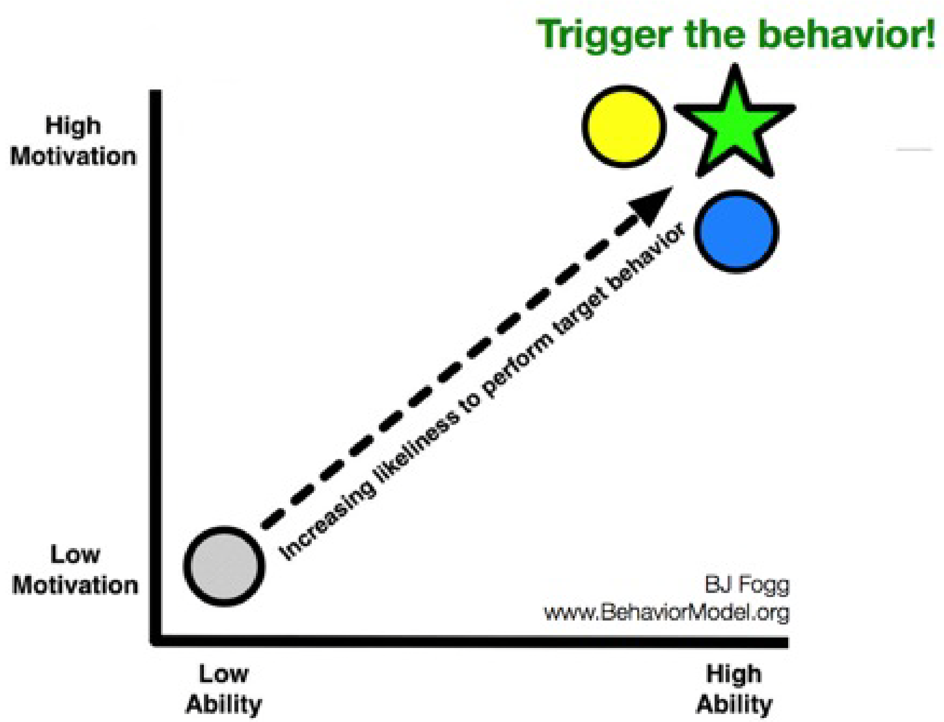

Figure 12: Fogg Behavior Model (Fogg, 2009b)

The Fogg Behavior Model defines motivation in terms of three core motivators: pleasure/pain, hope/fear, and social acceptance/rejection (Fogg, 2009a, p.4). The ability to change is characterised through simplicity factors. There are six main elements of ability: time, money, physical effort, cognitive effort, social deviance, and routine deviance. The greatest of these six factors is what limits the individual's ability to perform a target behaviour. If a person is able and sufficiently motivated, a behaviour trigger can prompt an individual to perform a desired action (Fogg, 2009a, p.5-6).

There are three behavioural triggers identified by the Fogg Behavior Model: signals, sparks, and facilitators. A trigger is a “final straw” event that causes the person to take action. A signal trigger simply reminds or informs the individual of the correct action. A spark is a motivational trigger. A spark immediately increases the individual’s motivation to perform the targeted behaviour. A facilitator is an event that enables behaviour to be completed more easily by heightening ability (Fogg, 2009, p.6).

SWM can only show information; they cannot force a person to take action in conserving water. We examined the models to find out how information leads to conservation. The Transtheoretical Model shows that changing behaviour in people is a multi-step process. The Fogg Model shows that motivation, simplicity and a trigger is needed to cause behaviour change. Both models imply that information must be presented in a compelling way. We took these models and used them as analysis tools to study conservation campaigns and case studies.

6.2. Campaign Success and Failure

We reviewed a comprehensive study on the conservational effects of several campaigns to determine how information should be presented in order to better encourage conservation. Table 2 shows a summary of the findings.

	Effect during program	Long-Term Effect	Additional Notes
Feedback:			
General	0% to 10.5%	some savings	Low consumers may increase consumption
Continuous Feedback	12.0%	none	Gas, also used goal and info
Monthly Feedback	7.4%	none	Gas, also used goal and info
Usage Comparison	12.5%	n/a	Gas and electricity
Cost Impact	12.7%	n/a	Gas and electricity
Environmental Impact	3.4%	n/a	Gas and electricity
Goal Setting:			
High goal	15.1%	n/a	Goal: 20% reduction, also has information
Low goal	5.7%	n/a	Goal: 2% reduction, also has information
Other Strategies:			
Information	-2% to 10%	n/a	Tailored information
Commitment	some savings	some savings	Public commitment increased conservation
Combination Strategies:			
Info, Feedback, Goal	18.0%	n/a	Water use, 48 respondents
Info, Feedback, Reward	12.0%	n/a	High reward
Info, Individual & Comparison Feedback	2.8%	6.70%	Water use, 8 month duration of program, long-term measured after 2 years

Table 2: The effects of design on campaign success as defined by percentage saved

(Becker (1978), Bittle et al.(1979), Brandon & Lewis(1999), Hayes and Cone (1981), Katzev and Johnson (1983), McClelland & Cook (1979-1980), McMakin et al. (2002), Pallak & Cummings (1976), Seligman & Darley (1977), Staats et al. (2004), Van Houwelingen & Van Raaij (1989), Vollink & Meertens (1999), Winett et al. (1978)) **[As cited in Abrahamse *et al*. (2005)]**

This table picks out key information from a study by Abrahamse *et al*. on the conservational impact of campaign design factors (2005). The campaigns that were chosen for this table had over 100 participants, examined impact, and used or tested a single variable unless stated otherwise in the additional notes column. The effects (i.e. percentage savings) were adjusted according to control groups.

It is important to note that gas, electric, and water consumption were affected differently in studies that targeted all three resources. Unless indicated otherwise, the campaigns involved electricity usage. Gas usage typically declined more while electricity and water usage experienced similar reductions (usually within 2% difference).

Few studies observed the long-term impact of the intervention and therefore, not much data is available. In a few cases, qualitative assessment of the long-term impact was mentioned. Figure 13 illustrates the relative success of certain design factors, as discussed in Table 2.

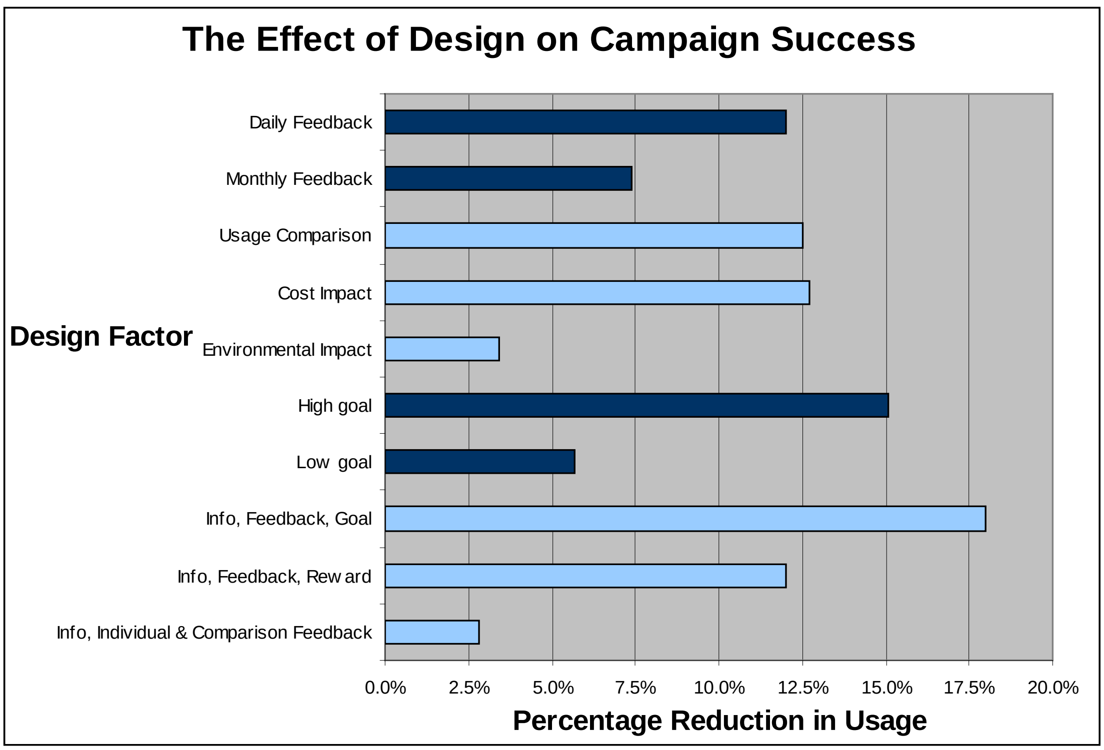

Figure 13: The effects of design on campaign success as defined by percentage saved

This figure shows that:

- Continuous feedback is more effective than monthly feedback
- Feedback on usage comparisons and cost impacts are more effective than environmental impact
- A high goal results in greater conservation than a low goal

- Greatest conservation arises from a combination of strategies

6.3. Conservation Efforts in Melbourne

We looked at Victoria's Target 155 and Yarra Valley's Smart Account in order to assess the conservational contributions of these programs and the design strategies that they use.

6.3.1. Target 155

Target 155 uses a combination strategy of goal setting, information, rewards (rebates) and feedback through weekly usage averages. Since the program started in late 2008, water usage per person per day has dropped by 9.1% from 164 litres to 149 litres (Victorian Government, 2010).

6.3.2. Yarra Valley Smart Account

Yarra Valley Water has initiated conservation efforts through information printed on its water bill. This water bill, termed the "Smart Account[5][6]", uses a combination strategy of information and comparison feedback. Key features of the Smart Account include an organised and simple layout, easily visible billing information, historic usage comparison, water saving tips based on time of year, and comparison to average and water efficient households that match garden size and occupant number(Yarra Valley Water, *n.d.*).

[5] Can be viewed in Appendix D: Yarra Valley Smart Account

[6] Note: The conservation effect of the Smart Account bill has not been assessed by Yarra Valley.

7. Analysis: Behaviour Change

By studying campaigns and behaviour models, we have found that many factors contribute to behaviour change. This section contains a summary of the most important factors that should be considered in implementing effective conservation campaigns. These factors were applied to Melbourne's Target 155 and Yarra Valley's Smart Account to determine the specific strengths and weaknesses of these campaigns.

7.1. Campaign Design: Factors that Lead to Conservation

Our findings show that the conservational success of campaigns varies greatly based on how the campaign is designed. Depending on strategy, a campaign can influence water usage greatly. The campaigns that were successful in contributing up to 18% conservation implemented three types of strategies. When a campaign utilised the better of two strategies, about 12% resource savings was seen (Abrahamse *et al.*, 2005).

This conservation review revealed several design factors that raise the success in campaign efforts. Campaigns were more successful if they did the following; see figure 14:

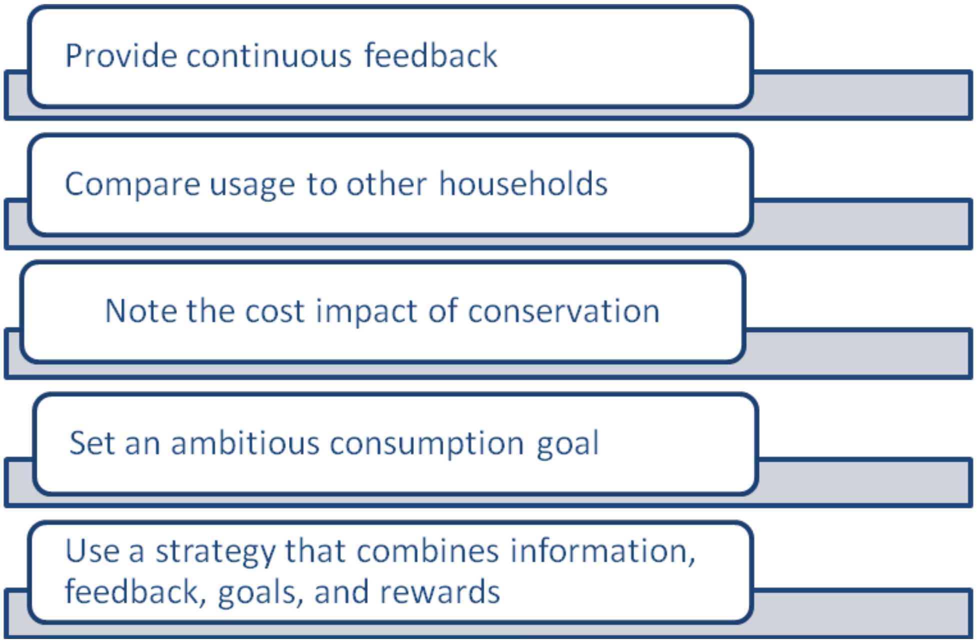

Figure 14: Summary of factors which contribute to campaign success

The Transtheoretical and Fogg models suggest several design considerations in addition to the ones examined in the case studies. The relapse stage of the Transtheoretical model suggests that campaigns should anticipate reasons for relapse and pre-emptively develop coping strategies to increase long-term impact. The simplicity factors in the Fogg model suggest that a campaign would be more successful if it made information easily accessible. Fogg's signal trigger suggests that campaigns may be able to improve long-term impact by providing simple signals and reminders in everyday life.

7.2. Conservation Efforts in Melbourne

Through the design considerations found in the comprehensive study review and the behaviour models, we analysed the strengths and weaknesses in current campaigns applied in Victoria.

7.2.1. Target 155

Target 155 is a campaign that uses a combination of design considerations such as continuous feedback, usage comparison, goal setting, simplicity and signalling. Water usage has since dropped in Melbourne by 9%, exceeding the target value of 155 litres per person per day (Victorian Government, 2010). One significant flaw of this well-advertised campaign is that the goal is not ambitious enough. The target of 155 litres was only a 5.5% reduction in water usage. In examining high and low goal setting, Abrahamse revealed that setting a high goal caused more significant conservation. Victoria would likely have benefitted more from a Target 130. This would be a target reduction of 20%.

7.2.2. Yarra Valley Smart Account

The Yarra Valley Water Smart Account incorporates many of the identified design principles such as goal setting, comparison, cost impact, and simplicity. One of the campaign's biggest strengths is its use of simplicity. The information appears as a foldout from the quarterly water bill and therefore does not require any effort to acquire. The bill has a simple visual organisation to reduce the difficulty of reading and understanding the content. The bill's weakness is that it incorporates most design principles but in a poor way. The water usage comparison table sets a personalised goal but the reader must choose number of occupants, garden size, and the efficiency of the household they wish to be compared against which increases the difficulty of obtaining information. The bill provides cost feedback through simple billing information but there is no historical cost comparison which weakens the value of the information. To address these issues, the Smart Account should use a clear goal consumption and provide a historical cost graph.

8. Conclusions

In this project, we examined the effects of smart water metering (SWM) on the water distribution infrastructure and on conservation behaviour of individual consumers. In order to help ATA create a policy position on a wide-scale implementation of SWM, we had to assess:

1. The costs and benefits of integrating SWM into the current water distribution infrastructure,
2. The design factors that underlie effective conservation campaigns,
3. The successes and failures of current conservation efforts in Victoria,
4. The ways in which the information provided by SWM can be used to induce consumers to behave in ways that use less water.

We investigated basic costs associated with integrating SWM into current water distribution infrastructures through examining Melbourne's infrastructure and pilot studies that practically applied SWM. We concluded from infrastructure analyses that:

- ❖ Water distribution infrastructures could be improved by a SWM rollout but at a high cost,
- ❖ In the long-term, a data logger is more cost effective than a transmitter due to annual upkeep costs,
- ❖ SWM can integrate with Victoria's current SEM HAN as a cheap solution for wireless communication,
- ❖ SWM interval data can lead to reducing water consumption through leak detection.

We developed a list of design principles for implementing effective water conservation campaigns by reviewing a comprehensive evaluation of conservation campaigns and studying behaviour models. Successful conservation campaigns incorporate one or more of the following design principles; see figure 15:

-

Figure 15: Design principles derived from successful conservation campaigns

We examined the conservational success of current water saving campaigns in Melbourne through these design principles to critically assess the strengths and weaknesses of these programs. Combining our findings on the functionality of SWM, the behavioural design principles just listed, and the assessment of Melbourne's water saving campaigns, we concluded that:

- SWM will do little to reduce water consumption without the addition of a consumer interface to aid conservation behaviour,
- Conservation campaigns can be modified immediately to incorporate some of the behavioural design principles using only the current quarterly metering information,

- Conservation campaigns and SWM information can be coupled through a variety of user interfaces to more effectively promote conservation.

8.1. Integrated Infrastructure

Our findings show that a wide-scale implementation of SWM would have many informational benefits but few financial benefits. Contractors would no longer be needed to manually read meters and data would be readily available for water retailers and householders through a wireless communication network. However, SWM systems would cost millions of dollars to update, install, and maintain.

A data logger would be more cost efficient than a transmitter in the long term based on annualised costs. The Sydney Water Residential Study found that transmitter life was limited by battery life due to constant transmissions. This is because the transmitter cannot store data but must immediately communicate each reading. Data loggers can store several readings and send multiple data points in one transmission. Infrequent transmissions prolong a data logger's battery life and therefore, are less costly to maintain.

Integrating SWM into the SEM communication network reduces the cost of SWM communication infrastructure. A SEM HAN is already in place within parts of Victoria and the compatibility to integrate SWM and other wireless components was implemented when it was built. This means that the communications start up fee costs for SWM is relatively small as long as the SEM HAN is widespread.

A rough estimate shows that approximately 941,800 kilolitres of water is wasted annually in Melbourne's households. Through SWM, leak detection software can salvage leaked water and reduce overall water use within Melbourne's water grid. The software detects leak patterns in water usage and alerts water retailers and homeowners of a leak's presence. However, the benefits of SWM extend beyond an improved water grid for retailers or detecting household leaks. Behaviour change efforts can be more effective through coupling SWM and a consumer interface.

8.2. Household Water Consumption Behaviour

We found that the conservational effect of information depends on the presentation of information. If SWM data was displayed through a consumer interface that incorporated effective design principles, this would facilitate the frequency and accessibility of obtaining SWM information. Interval logging and data transmission allows continuous personalised feedback through 'real-time' data. A consumer interface would also help maintain sustainable behaviour through timely signal reminders if and when water usage rises.

By strategically presenting information using effective design principles, conservation campaigns have reduced water consumption by up to 18%. SWM information can be coupled with conservation campaigns to better encourage efficient water use. If and when SWM data is portrayed in a consumer interface, this would allow householders to easily access their personal consumption data, which would also allow campaigns to better provoke behaviour change in households by promoting personalised water conservation methods. A campaign can be created around SWM information by tailoring goals, feedback, and signals to a household's water usage. Goal setting would be particularly more effective when based off of SWM data.

However, Victoria does not need to wait for SWM to improve the effectiveness of conservation campaigns. The design principles for figure 15 can be used to assess and improve current conservation campaigns. We have identified several design principles that can be used more effectively in Target 155 and the Smart Account. Target 155 could benefit from setting a more ambitious goal for water consumption, and Smart Account could be improved by simplifying information on the bill, providing a clear consumption goal, and emphasising the cost and environmental impact of the consumer's increase or decrease in usage.

9. Recommendations

We strongly recommend the use of an interface (e.g. in-home display, web interface, mobile SMS and/or a Smart Account type of bill) to relay SWM key consumption information to the consumer. Victoria's water demand could be greatly reduced by using SWM to present information in an effective way. Behaviour change through SWM can only occur if information is presented to the consumer through a consumer interface. In order for the interface to be most effective, we recommend that it incorporates all of the design principles shown in figure 15. We also encourage using the interface as a medium for Victoria's informational campaigns. This coupling will allow all of the design principles of figure 15 to be used to the best effect.

According to the design principles, we recommend the use of in-home displays. This facilitates both continuous feedback and easy access compared to Smart Account and a web portal. However, Sydney Water's study suggested that in-home displays had a diminishing effect over time. Therefore, we recommend that each type of interface (e.g. in-home display, web interface, mobile SMS and/or smart billing) should be tested on both short and long-term conservation.

There should also be a study to examine the following issues specifically for SWM to determine how to best use design principles to maximise savings:

- How often should consumption information be displayed
- In what interval should data be displayed (daily, weekly, ect.)
- What kind of comparison should be used (e.g. historical vs. neighbourhood)
- Is there any advantage to particular combinations of the above

Since our cost-benefit analysis was an overview of major costs, we recommend that further research be conducted regarding several components of a SWM component rollout. We recommend research into the price reductions associated with a bulk purchase along with both short and long-term cost implications. We suggest that the problems associated with integrating SWM with SEM should be examined for political issues such as the need for the government to moderate an agreement between the electric and water utilities and how the politics would change if the utilities become privately owned. The costs of data storage and processing should be examined including server costs, labour costs, and data analysis software costs.

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Appendix A: Explanation of Water Flow Measurement Methods

Accumulation (Pulse) Meter

In a pulse meter, a reed switch within the meter is connected to a magnet. The reed switch can either be in an open or closed position. A pulse is sent to a counter when the reed switch is closed. The pulse counter is typically the display, showing either a digital readout or an analogue representation of kilolitres. An accumulation meter justly earns the name as the readout keeps track of the total kilolitres of water that have ever passed through it. The meter is designed to track every few litres (e.g. one, five, ten, one hundred) that pass through the meter before a pulse is sent. Pulse meters are sensitive to the flow of water that passes through them; too small of a meter results in possible damage, whereas too large a meter results in poor accuracy ("SmartMeter N2.5").

Fluidic Oscillation

Fluidic oscillation is an example of water flow detection used only by smart water meters. Water flows into the meter before being redirected. Oscillation refers to the usage of two alternating pathways within the meter ("SmartMeter N2.5"). Magnets inside the meter detect how often water is going around each pathway before a fraction is recycled to the intake. The flow rate of water is proportional to the frequency of oscillations; the higher the rate of oscillation, the higher the flow rate. This method is very accurate and can be used for a large range of flow rates, as opposed to the pulse meter which is specifically chosen for the expected flow.

Ultrasonic Flow

Another example of water flow detection that can be found in a smart water meter is called ultrasonic flow metering. One end of the meter emits a sound wave and the other receives it ("Ultrasonic flow sensor," 2009). The time it takes the sound wave to travel the length of the meter is proportional to the level of water within the chamber. Ultrasonic smart water meters are very sensitive and therefore can detect even the smallest fluctuations in water flow rate.

Appendix B: Summary of Andrew Geary Interview

Interview with Andrew Geary, Metering Services Coordinator at City West Water

On Friday, 5 February 2010, we interviewed Andrew Geary from City West Water in Melbourne. Geary is a metering services coordinator and therefore is involved with installation and replacement of water meters in both domestic and industrial settings.

Melbourne Water supplies water to City West Water as well as two other distributers. City West Water distributes water to approximately 330,000 properties and connects 600-800 new properties to the water network per month. An Elster water meter is installed in every property, upon connection to the network.

Elster supplies City West Water with all of their domestic meters at a cost of $35 per meter. The meters are installed into households at a cost of around $25 per meter. Meters at these properties are manually read every three months or every month for high volume users. Reading the meters manually costs City West Water around $0.10 per meter. Many properties have their water use estimated because the meter cannot be found by the reader. If the householder wishes to lock in the yard, he or she may purchase a remote device which sends a signal a short distance to be picked up by handheld devices. Few people purchase this option. Replacement of the meters occurs around every 15 years according to a formula which takes into account age and total volume flow through the meter. Replacement costs City West Water around $61. Geary also states that the company would likely opt to replace a meter rather than a battery because of difficulty with the battery's seal.

City West Water charges properties for the water they consume and Melbourne Water charges City West Water for the water that it distributes. City West Water is highly concerned with leaks as lost water is lost revenue. City West Water relies primarily on calls concerning main breaks. They also have leak detection programs using sounding devices. Around 6-8% of water is lost due to leaks. Geary estimates that the price of water will double in the next five years as a result of the new desalination plants.

Appendix C: Summary of CORINNA DOOLAN Interview

Interview with Corinna Doolan, Project Manager of Water & Energy Futures Science & Technology, Sustainability Division Sydney Water

On Wednesday, 17 February 2010, we interviewed Corinna Doolan of Sydney Water over the phone. Mrs. Doolan is the project manager of two pilot studies that Sydney Water is currently conducting; the Sydney Water Residential Case Study and a Smart Energy and Water case study with the collaboration of Energy Australia.

Sydney Water Residential Case Study:

The main objectives of this trial were: (1) to determine how smart water metering can change behaviour in consumers, and (2) find the cost and savings of a network incorporating smart water metering. Findings of this trial will lead to determine if the cost and benefits of smart metering will favour a roll out across Sydney or designated areas.

Westleigh is a suburban town of Sydney where the trial is being conducted. Westleigh incorporates mostly white Anglo-Saxons, middle aged and middle class people. The reason why Westleigh was the site for this trial is because it is solely residential and it is a district (DMA) metered area. This means water flow can be monitored from the head of the mains water system. This makes leak detection easier. Currently there are only about 10-15 DMA in Sydney ranging in size from 90 properties to over 2000.

The trial began in October 2008, when recruitment was initiated to find residents in the town of Westleigh willing to participate in this study. It took about 6 months to recruit all the participants. Participants were initially informed by post and further recruitment was carried out using flyers, attending community meetings and by providing details on the web. They were incentivized for their participation by being offered vouchers.

In total, there are 600 participants (homes) in this trial. Of them, 468 have the transmitters attached to their analogue water meter. Of these 468 homes, 160 had in-home displays. The control group consisted of those who had completed household profile surveys but were not receiving the technology. There are 23 spider loggers (gateways) that received the data from the 468 transmitters. The transmitters use RF signal (433, free signal) to send data while spider loggers used GPRS to relay that information back to the Sydney Water database server. The cost of installation into each home, depending on the type of transmitter and user interface used, could cost from $200 to $3000. At first, transmitters logged every 5 minutes but this exhausted the life of the battery too quickly. The interval loggings were then set to send every 15 minutes, and are currently read every half hour. Regardless of which time increment the transmitter sends data to the spider loggers, spiders send the data to the provider’s server on a daily basis.

Initially, high resolution interval logging was done for the purpose of leak detection and as a result a majority of the transmitters have had to be replaced. Current half hourly reads ensure that the battery life of transmitters will be longer and last the duration of the project. The limiting factor of the current smart metering technology is the battery life.

The 160 in-home displays were first installed in May/June 2009 in the homes that were willing to participate. Each display had four separate digital touch screens. The first screen provided a summary of the household’s daily average over 7 days compared to that of a water efficient household of a similar size. This provided a target for the household to which they could benchmark themselves against. The second screen showed hourly consumption data of the household on a daily basis. The third screen does bi-weekly water usage while the fourth screen showed 28 day history of water consumption throughout the household. Each display had the functionality to track how many times a consumer interacted with the display. Mrs. Doolan said that many people found the second screen to be very informative and that participants liked the detailed data that was incorporated into that display. However, Mrs. Doolan found that interest started to decline over the time. Many participants reported that it had raised their level of awareness and that their behaviours were changed as a result.

Ongoing data management and field maintenance requires dedicated resources to ensure everything runs smoothly. Even though there were only 468 transmitters, which is not a large number compared to what a wide scale rollout would mandate, some type of occurrence would call for weekly on-site maintenance. Many of the participants were fully engaged in this project which was reflected by the high level of communication received, about 150 events over 18 months. If the technology was to be rolled out on a wider scale the appropriate level of resources would need to be in place to ensure a high level of customer service. A cost and benefit analysis has not yet been conducted for this study.

Sydney Water and Energy Australia Case Study:

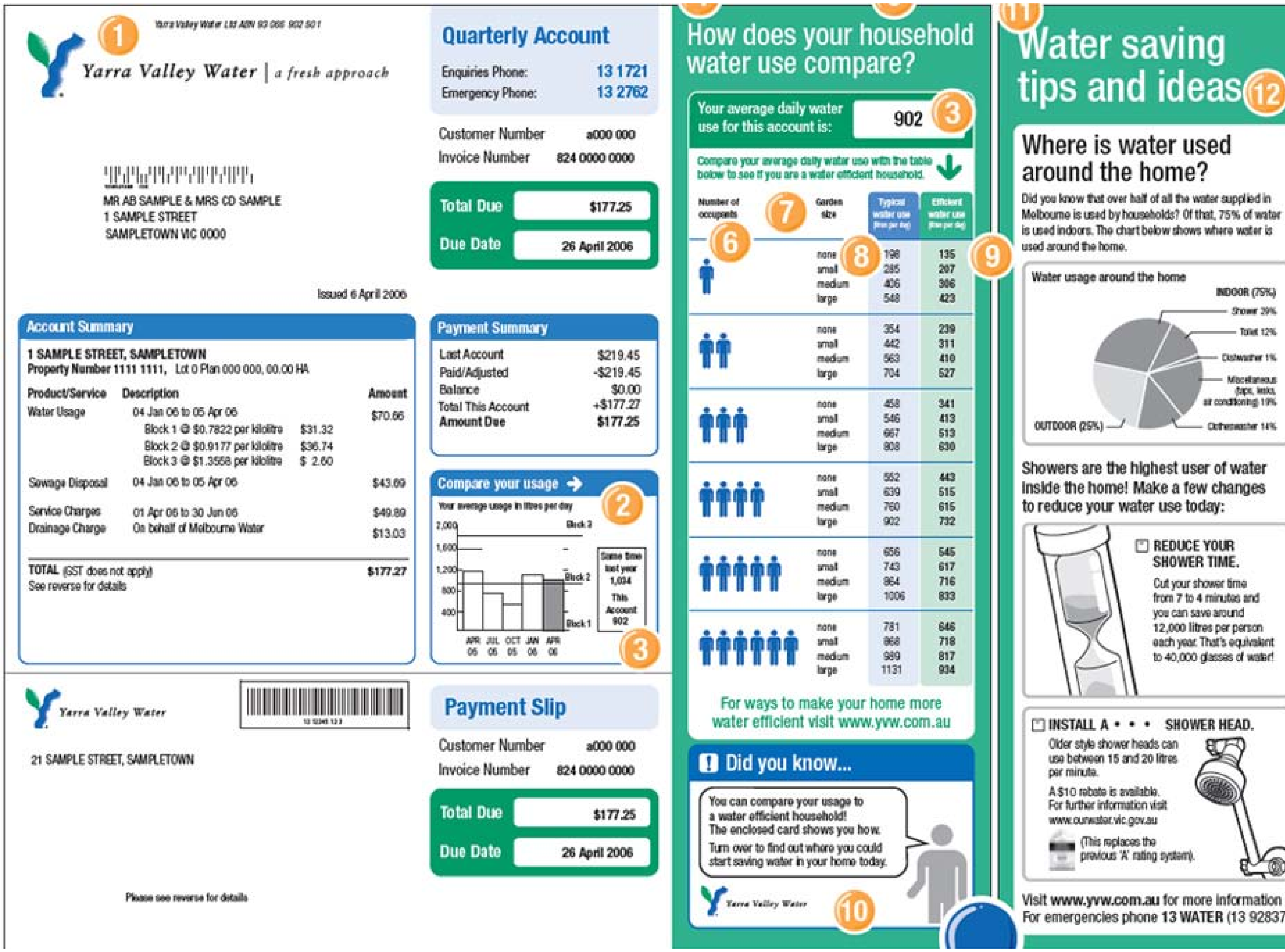
A second trial that Sydney Water is participating in incorporates integrating electricity and water utilities. The study objective is to gauge the relationship of data transmission and utility cooperation. This is a $10 million dollar project. Less than $1 million is funded from

Sydney Water, around $9 million is funded by Energy Australia, and approximately $1 million is funded by the Department of Environment, Climate Change and Water (DECCW).

In this trial, 1,000 homes near Sydney's Olympic Village (that is not district metered), will have one smart water meter and one smart electricity meter installed. In this communication solution, smart meter sends data from the analogue water meter to the smart electric meter via radio frequency. In this case, the smart electricity meter works as a gateway. The smart electricity meter has data storage capabilities to store the water interval data along with the electricity interval data and send it directly to the electricity provider. Once the data has been processed, the water interval data is then sent from the Energy Australia to the Sydney Water database server.

This study is currently in the process of recruiting participants. However, it is predetermined that some homes will have in-home interfaces displaying both water and electricity usages, some will have access to web portals which would also display both usages, and some will have a Home Area Network (HAN) set up where participants will be able to virtually control their appliances from a mobile or computer. In addition to these capabilities, 500 participants of this study will be able to monitor their recycled water use.

Appendix D: Yarra Valley Smart Account



Yarra Valley Water Ltd ABN 93 066 902 501

Yarra Valley Water | a fresh approach

MR AB SAMPLE & MRS CD SAMPLE
1 SAMPLE STREET
SAMPLETOWN VIC 0000

Issued 6 April 2006

Quarterly Account

Enquiries Phone: 13 1721
Emergency Phone: 13 2762

Customer Number a000 000
Invoice Number 824 0000 0000

Total Due $177.25
Due Date 26 April 2006

Account Summary

1 SAMPLE STREET, SAMPLETOWN
Property Number 1111 1111, Lot 0 Plan 000 000, 00.00 HA

Product/Service	Description		Amount
Water Usage	04 Jan 06 to 05 Apr 06		$70.66
	Block 1 @ $0.7822 per kilolitre	$31.32	
	Block 2 @ $0.9177 per kilolitre	$36.74	
	Block 3 @ $1.3558 per kilolitre	$ 2.60	
Sewage Disposal	04 Jan 06 to 05 Apr 06		$43.69
Service Charges	01 Apr 06 to 30 Jun 06		$49.89
Drainage Charge	On behalf of Melbourne Water		$13.03

TOTAL (GST does not apply) **$177.27**
See reverse for details

Payment Summary

Last Account	$219.45
Paid/Adjusted	-$219.45
Balance	$0.00
Total This Account	+$177.27
Amount Due	**$177.25**

Compare your usage

Your average usage in litres per day

Block 3, Block 2, Block 1
APR 05, JUL 05, OCT 05, JAN 06, APR 06
Same time last year 1,034
This Account 902

Yarra Valley Water

21 SAMPLE STREET, SAMPLETOWN

Please see reverse for details

Payment Slip

Customer Number a000 000
Invoice Number 824 0000 0000

Total Due $177.25
Due Date 26 April 2006

How does your household water use compare?

Your average daily water use for this account is: 902

Compare your average daily water use with the table below to see if you are a water efficient household.

Number of occupants	Garden size	Typical water use (litres per day)	Efficient water use (litres per day)
1	none	198	135
	small	285	207
	medium	406	306
	large	548	423
2	none	354	239
	small	442	311
	medium	563	410
	large	704	527
3	none	458	341
	small	546	413
	medium	667	513
	large	808	630
4	none	552	443
	small	639	515
	medium	760	615
	large	902	732
5	none	656	545
	small	743	617
	medium	864	716
	large	1006	833
6	none	781	646
	small	868	718
	medium	989	817
	large	1131	934

For ways to make your home more water efficient visit www.yvw.com.au

Did you know...

You can compare your usage to a water efficient household! The enclosed card shows you how. Turn over to find out where you could start saving water in your home today.

Yarra Valley Water

Water saving tips and ideas

Where is water used around the home?

Did you know that over half of all the water supplied in Melbourne is used by households? Of that, 75% of water is used indoors. The chart below shows where water is used around the home.

Water usage around the home

INDOOR (75%): Shower 29%, Toilet 12%, Dishwasher 1%, Miscellaneous (taps, leaks, air conditioning) 19%, Clotheswasher 14%
OUTDOOR (25%)

Showers are the highest user of water inside the home! Make a few changes to reduce your water use today:

☐ REDUCE YOUR SHOWER TIME.
Cut your shower time from 7 to 4 minutes and you can save around 12,000 litres per person each year. That's equivalent to 40,000 glasses of water!

☐ INSTALL A * * * SHOWER HEAD.
Older style shower heads can use between 15 and 20 litres per minute.
A $10 rebate is available. For further information visit www.ourwater.vic.gov.au
(This replaces the previous 'A' rating system).

Visit www.yvw.com.au for more information
For emergencies phone 13 WATER (13 92837