WATER SERVICES ASSOCIATION
of Australia

Urban Water Demand Forecasting and Demand Management:

Research Needs Review and Recommendations

Occasional Paper No. 9 - November 2003

Prepared by Institute for Sustainable Futures
University of Technology Sydney

for

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Research Needs Review and Recommendations

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Summary and Recommendations

Summary

This study undertook a preliminary investigation of current research into urban water demand. The objective was to conduct a preliminary review of this field, to provide the beginnings of a comprehensive database of industry knowledge in this area and to identify research gaps. It is anticipated that this will lead to a more considered approach to research funding by the Australian water industry and maximise the potential for transparency and collaboration.

This review concludes that a significant amount of research is being undertaken in relation to factors influencing water demand and demand management initiatives. However, it is the view of the study team that there is an opportunity to improve coordination of research to create consistency, transparency, comprehensiveness and widespread use of best-practice methodology.

Research in Australia in relation to demand management (DM) is currently fragmented. This is in contrast to the situation in North America, for example, where research is being coordinated by the American Water Works Association (AWWA), facilitating significant advancements in research and knowledge. In Australia, other water-related areas are being well coordinated, including for example, research on water quality issues. The Water Services Association of Australia (WSAA) can play a key role in creating a coordinated and efficient approach to research around water demand. This project is the first stage in the development of a research strategy aimed at achieving this coordinated approach.

The key findings of this project include:

- There is significant potential value for cooperation between utilities to advance Australian research in demand management. Benefits for utilities in relation to the research task include:
  - increased efficiency;
  - increased cost-effectiveness;
  - reduced duplication;
  - improved quality; and
  - positioning Australian utilities at the forefront of international demand management research.
- Availability and sharing of key knowledge sources is important if the potential for cooperation is to be achieved.
- There is limited research on the evaluation of demand management programs, despite its importance as a critical step to determine their effectiveness and how they can be improved. Results can feed into future models and forecasts for increased accuracy.
- The applicability of water demand-related data to different locations is limited and there is still a need for local studies (owing to variations in local context such as climate, avoided costs for average and peak demands and tourism).
- Actual data from existing studies may often not be transferable to other areas, due to differences including bio-geography, climate, socio-demographics, political circumstances. However, the methodologies, models or principles behind those studies may be relevant and transferable.
- Many demand forecasting studies have relied on projections of historical metered data without considering end uses.
- Many climate correction model studies have now been undertaken across Australia and there is a clear need for transparency of methodology.

This review has recommended that certain areas be the focus of more detailed analysis. This analysis can take the form of further research programs, as well as a proposed series of research forums, that can potentially provide quicker, more cost-effective results in relation to sharing methodologies and results. The results of this study, in the form of the research project templates and electronic copies of reports, could be made available on a regularly updated CD.

The priority areas that have been determined, including the analysis of the research needs and knowledge gaps, are listed below. These have been prioritised and grouped in Figure 7.

- Climate Correction
- Leakage and Pressure Reduction
- Demand Forecasting
- Water Sensitive Urban Design (WSUD), also termed Integrated Water Management (IWM)
- End Use Analysis,
- Outdoor Water Use
- Non-residential Water Use
- Evaluation of Raintank Programs
- Community Preferences
- Education and Communication
- Evaluation of Demand Management Programs

Recommendations

1. Continue detailed research on priority areas

Further research on priority areas identified from the gap analysis could involve:

- Literature reviews;
- International best-practice comparisons and
- Structured interviews with key experts.

Following the breadth of this first stage, this would enable depth of research to be achieved to screen for the priority research areas. This research could be undertaken in collaboration with various WSAA members. Such studies could include:

- Development of residential stock studies to collect data on water using equipment, water usage practices, residential lot sizes;
- Collection of data on trends in multi-residential household water demand including influencing factors such as water using equipment;
- Collection of data on trends in non-residential water demand in different industry sectors, including key influencing variables (water using equipment, water using practices, employment levels, economic activity);
- Further investigation of issues and options for individual unit metering on multi-residential dwellings;
- Evaluation of non-residential programs that have been implemented by various water utilities and publication of results from such evaluations for sharing amongst water utilities.
- Determining the influence of rainwater tanks on water use behaviour and total water demand. Understanding the perceptions of the community about rainwater tanks and the motivating factors behind their willingness to pay for rainwater tanks will provide valuable information to water utilities, enabling more informed prioritising of DM programs. This could also provide water utilities with an insight into the community's willingness to pay, which could in turn be used to improve the participation rate of demand management programs that are more cost effective than rainwater tanks.
- A collaborative research project focusing on sustainable solutions for the three types of development (greenfield, backlog areas and infill) on a range of scales, will prove valuable as it will help with the development of a consistent approach to water management in new developments across all utilities. It will also provide an impetus to the development of a consistent set of regulations and standards for decentralised systems, which are often part of the sustainable solution for such developments.

2. Research Forum Series

The Research Forum series would complement the detailed research on priority areas. The purpose of the Forum series is to provide an efficient, cost-effective, immediate means of substantially advancing knowledge and research in priority areas related to water demand in Australia. A Forum could combine several related priority areas. It is recommended that a Forum be held each quarter (on average), hosted at various locations (or 'on-line'). The outputs of such Forums could be:

- Research issues papers (developed prior to workshop, to determine what are the key research questions related to the Forum topic and who should attend);
- Publication of all papers presented;
- Focused recommendations made to the WSAA Water Health Environment and Sustainability Committee;
- Consistent and transparent approach to water demand knowledge and research across all WSAA members.

Recommended research priority areas which could warrant such a Forum include:

- Climate Correction
- Leakage and Pressure Reduction
- Demand Forecasting
- Water Sensitive Urban Design (WSUD), also termed Integrated Water Management (IWM)
- End Use Analysis,
- Outdoor Water Use
- Non-residential Water Use
- Evaluation of Raintank Programs
- Community Preferences
- Education and Communication
- Evaluation of Demand Management Programs

A suggested priority timeline is provided in Figure 7 on page 47.

Recommendations

Continued

3. Ongoing collaboration between WSAA and WSAA members

It is recommended that WSAA coordinate the ongoing collaboration of research on water demand. It is recommended that a framework or process be developed to ensure such collaboration continues. This may work within the existing structure of the WSAA Water Health Environment and Sustainability Committee. For example, overseeing the recommendations emerging from the Research Forums (described in 3 above) and updating the proposed CD (or website) as new research becomes available.

4. Continuation of WSAA CD/database of Demand Management Studies

The studies presented in the report provide a partial picture of Australian studies on factors influencing water demand. It is therefore recommended that further collation of relevant and significant studies be undertaken to present a more complete picture. It is recommended that both WSAA and non-WSAA members be contacted for further information. This database could be modelled on the North American waterwiser.org, a web-based, interactive, searchable database. The database provides information on demand management programs that are planned, implemented and evaluated across various water utilities in the U.S. and Canada. The database allows the water utility to directly enter and update information about a DM program by logging in to the database. This database could also update the studies discussed in the Water Wise Manual, incorporating results from evaluation studies that have since been undertaken for various DM programs. In addition, details of participation rates and costs of implementation of the programs could be included.

1 Introduction

1.1 Project Background

Substantial social changes in Australia over the past twenty years have had an impact on the demand for urban water. These include, changes in demographics, land use, types of water-using appliances and trends toward lower occupancy households and apartment living, particularly in inner city areas. At the same time, pressure on urban water supplies has increased, owing to declining yield of systems and increasing demands for water allocations to the environment. Therefore, the importance of and interest in demand management strategies has increased.

This project is designed to investigate research into factors that influence demand and demand management programs that have been undertaken by the Australian water industry, particularly Water Services Association of Australia (WSAA) members.

1.2 Objectives and Scope

The objectives of this study are to provide support to WSAA in developing a research program that will enable water service providers to better understand their customers, their demand for water and how that is changing. This will provide valuable information to use in planning and will enable improved forecasting. It will provide valuable input to the design of demand management programs.

In terms of scope, the study comprises two related projects:

Project 1: Analysis of factors influencing current demand for water and growth of demand in Australia.

This project involves the collation and documentation of the most valuable current knowledge and research on the major factors influencing water demand and provides information on recent changes where possible. Gaps in the data and further research or initiatives that can best be undertaken at a national level by WSAA have been identified.

Project 2: Review of demand management initiatives in Australia including information on their effectiveness.

This project has involved the collation, preliminary review and assessment of demand management and water sensitive urban design initiatives. Where available, information on the effectiveness of these programs has been provided.

Project 1 addresses the significant changes occurring in demographic, social, community attitude, economic and technological factors that have the potential to affect growth in water demand and consequently the reliability of water supplies. It is important that WSAA members are alert to the significance of these changes and their potential to influence demand for water in Australia's major cities. Fundamental to this is a database of available reports to evaluate the effects of these changes and their potential effects on water demand.

An overall objective of this report has been qualitative assessment, conducted where possible by the study team, of the extant reports in relation to overall validity, accuracy and transferability of the results of studies of water use, as well as associated studies linking water use to the numerous factors influencing water demand. These measurements and studies are essential to identifying emerging trends in the growth of water demand, forecasting demand and in preparing management initiatives. Most of the existing current[1] robust, comparable and consistent studies on the factors influencing trends in water demand have been reviewed.

Project 2 will focus on demand management and water sensitive urban designs, including effectiveness where possible, by highlighting significant programs of this kind that have been undertaken in Australia. This information is presented as an annotated bibliography on many of the significant demand management and water sensitive urban design initiatives.

1.3 Outputs

The outputs of this project are:

1. This report, including:
    a. Historical context of urban demand management both internationally and within Australia.
    b. Overview of significant research into factors influencing water demand and demand management initiatives.
    c. Best practice characteristics, data gaps and recommendations.
2. Collation of templates from key WSAA members and other significant contributors to research on demand management in Australia.
3. Contacts and links to relevant key individuals/websites/publications.
4. Bibliography of all significant reports, projects, programs related to demand management.
5. Hyperlinked CD containing same content as report in a user-friendly and searchable format.
6. Workshop presentation to WSAA Water Health Environment and Sustainability Committee to launch and explain outputs 1–5.

[1] This refers to studies undertaken within the last ten years plus any other prior significant studies.

2 Urban Water Demand: History and Context

2.1 History of Urban Water Demand Forecasting and Demand Management

Demand forecasting became necessary as urban populations dependent on public water supplies grew rapidly. New demands for water could not always be met. In some cases, water infrastructure required long lead times to construct, requiring long planning horizons. In other cases, multiple options for water supply existed and the optimal choice depended on understanding likely future requirements. In either case demand forecasting was a means to optimise expansion of the water supply system.

Demand management developed in the United States, where it was termed "water conservation" in the mid to late 1970s as a response to environmental concerns at the time. It was consistent with the actions taken to reduce energy use after the OPEC-induced supply reduction of oil and price increases. However, managing demand for water was not seen as particularly valuable, as water was perceived to be inexpensive. As well, reducing demand was perceived to interfere with people's right to consume any amount they wished and could pay for.

Awareness gradually developed that reducing demand for water was less expensive than adding water supply, often significantly so. Some of the milestones in this process can be represented in a timeline. The largest body of early work was completed in the late 1970s and early 1980s by Duane Bauman and PMCL for the U.S. Army Corps of Engineers. Bill Maddaus of Brown and Caldwell led a study done for the Housing and Urban Development Administration in the1980s, which pioneered the attempt to ascertain quantities of water used by household fixtures and appliances. This work was followed up in the 1990s by the American Water Works Research Foundation studies, including one on Residential End Uses of Water, conducted by Bill Maddaus, PMCL and John O. Nelson.

Least Cost Planning, which is associated in Australia with the water industry, was developed for the electricity industry in the U.S. in the 1980s (Mieir et al, 1983) to compare energy conservation programs with increased generation as sources of supply. The principles of LCP have been transferred to planning other large infrastructure systems including water (Beecher, 1996; Dziegielewski et al, 1993) wastewater (Howe and White, 1999) and gas (Greenberg and Harshbarger, 1993) and even to transport (Victoria Transport Policy Institute, 2003)). See *Box 1* for the principles of LCP.

Early work on demand management in Australia included an Australian Water Resources Council Project (AWRC 72/41) proposed by Peter Dunk of the then State Rivers and Water Supply Commission in 1971. It was called "efficiency in domestic, municipal and industrial water use". In 1972, Monash University worked on the "quantity" aspects of water supply and researchers at the University of Wollongong looked at water "demand elasticity".

Practical implementation of demand management strategies in Australia started with the introduction of charges based on water usage by the (then) Water Authority of Western Australia and Hunter Water (NSW) in the early 1980s.

Dual flush toilets to conserve water were made compulsory in Victoria in the mid 1980s and other States followed.

Box 1: Least Cost Planning (LCP) / Integrated Resource Planning (IRP)

Least Cost Planning (Beecher, 1995) is a process that involves several steps, including:

1. end-use analysis,
2. demand forecasting,
3. the design and modelling of demand management programs,
4. estimating water savings achievable from programs,
5. evaluating costs of achieving water savings,
6. estimating conventional supply costs,
7. developing and costing alternative supply options if applicable,
8. cost benefit analysis of all options,
9. consideration of environmental externalities,
10. sensitivity analysis and
11. reporting.

Detailed end-use modelling of how a supplied resource (energy or water) is used by customers provides a more rigorous basis for demand forecasting and allows for both the development and evaluation of demand management programs, in particular, end-use efficiency. More rigorous demand forecasts also provide better estimates of the future costs of conventional supply augmentation. Results are often expressed in present value terms to take account of both capital and operating costs, and in terms of cost per unit supplied (or conserved) to allow direct comparison of demand management measures relative to increased supply.

LCP and 'Integrated Resource Planning' are often seen as synonymous. However, although both involve consideration of demand management for meeting future service needs, IRP provides a broader framework into which LCP fits. Over time, an IRP process should see the iterative re-application of LCP as part of a cycle of evaluating and assessing options, investing in selected options, assessing conservation results and demand forecasts and re-evaluating options.

Urban Water Demand: History and Context

Continued

Educational programs such as "Don't be a Wally with Water" commenced in the 1980s.The first Perth water use study was carried out in the in the late 1980s and it was a milestone of research at the time.

Since the 1980s, a growing number of urban water utilities in Australia have invested significant funds in demand management programs throughout the country. The drivers for implementing programs have included: the high costs of water supply and distribution; rapid population growth (including tourism); licence conditions required by government; the benefits of deferring capital works and the benefits of downsizing sewage treatment plant upgrades (White, 2001). The measures associated with demand management programs vary as shown in *Box 2*, while some evaluation approaches are outlined in *Box 3*. Although it has been true for a long time in many countries that reducing demand for water is less expensive than adding supply, it is in Australia that some of the more serious efforts are now being made to treat demand management as the principal supply option. This has come about in part through recent applications of Least Cost Planning techniques in the Australian water industry. Better methods for cost comparisons, including the use of "levelised cost". (See *Box 4*) have been a further refinement of LCP methods.

Box 2: Demand Management Terms

Demand management options are a combination of a ***measure*** and an ***instrument***.

Measures increase water efficiency (e.g. AAA rated showerheads), source substitution (e.g. rainwater tank installation) or combine the two in alternative system configurations (e.g. greywater reuse system), and can include influencing behaviour such as watering times.

Instruments are used to assist in achieving the adoption of a measure. They can be categorised as **regulatory, economic** or **communicative**. For example, a residential retrofit option could include the measures of AAA rated showerheads, tap aerators and leak reduction with the **economic** incentive of a rebate or a discounted visit by a plumber arranged by the water utility. The same water efficiency measures could be combined with a **regulatory instrument** in the form of building regulations mandating the installation of water efficient fixtures or minimum appliance efficiency standards at point of sale. They could also be combined with a **communicative** measure in the form of a brochure advising on saving water in the home or a demonstration water efficient garden. The three options differ in their savings and costs. They should be compared under a least cost planning (LCP) framework so that investment in the options with the least total cost to the community can be made.

Options combine an instrument and a measure.

Programs consist of a selected group of options**.**

Box 3: Evaluation of DM programs

Evaluation of DM programs after implementation allows their effectiveness to be assessed and helps in the design of programs. This can be done in a number of ways but it is important that as far as possible, the methodology allows for changes in demand to be attributed to particular actions. This requires researchers to take into account other factors which impact on demand, such as climate.

One way this is commonly achieved is through the use of participant and control groups. By analysing groups that are as similar as possible, except for the participation of one group in the DM Program, it is possible to evaluate what savings resulted from that program. The difference in water use between the two groups will indicate the savings due to the program, irrespective of other factors that may influence water use.

Most importantly, evaluation should be planned during program design and particularly before implementation. There may be steps that need to be taken during the program (for example meter identification) to make the evaluation possible.

Box 4: Cost comparisons, levelised cost

Levelised cost is a means of describing the unit cost of a demand management option. The present value of stream of investment, which may vary in time and includes the costs to both the utility and customers, is divided by the present value of the stream of demand that is met by the option (in the case of a supply option) or the demand that is reduced in the case of a demand management option. This allows for the fact that this quantity also is often varying in time.

(Fane *et al*, 2002). This measure of unit cost can be used to compare quite different options (e.g new sources, reuse, leakage reduction, equipment retrofitting) on an equal basis, and if the benefits are included, can be used to compare the net unit cost of options.

3 Study Methodology

3.1 Introduction

This research has drawn on the following sources of information and knowledge:

- Information provided by selected WSAA members (see *Figure 1*) in relation to two selected projects (1. Factors Influencing Water Demand and 2. Demand Management Initiatives). The information was gathered by requesting WSAA members to complete one page information reporting templates to provide profiles for each study they undertook relevant to either of these two projects. Two template types were provided, *Template A* and *Template B*, referring to Project 1 and Project 2 respectively. See *Appendix F* for Template A and Template B.
- Templates (A and B) were also completed by selected non-WSAA members who have contributed significantly to demand management research in Australia.
- Existing knowledge, research results and data from the research team.
- Interviews undertaken with key international and national players in the demand management field.

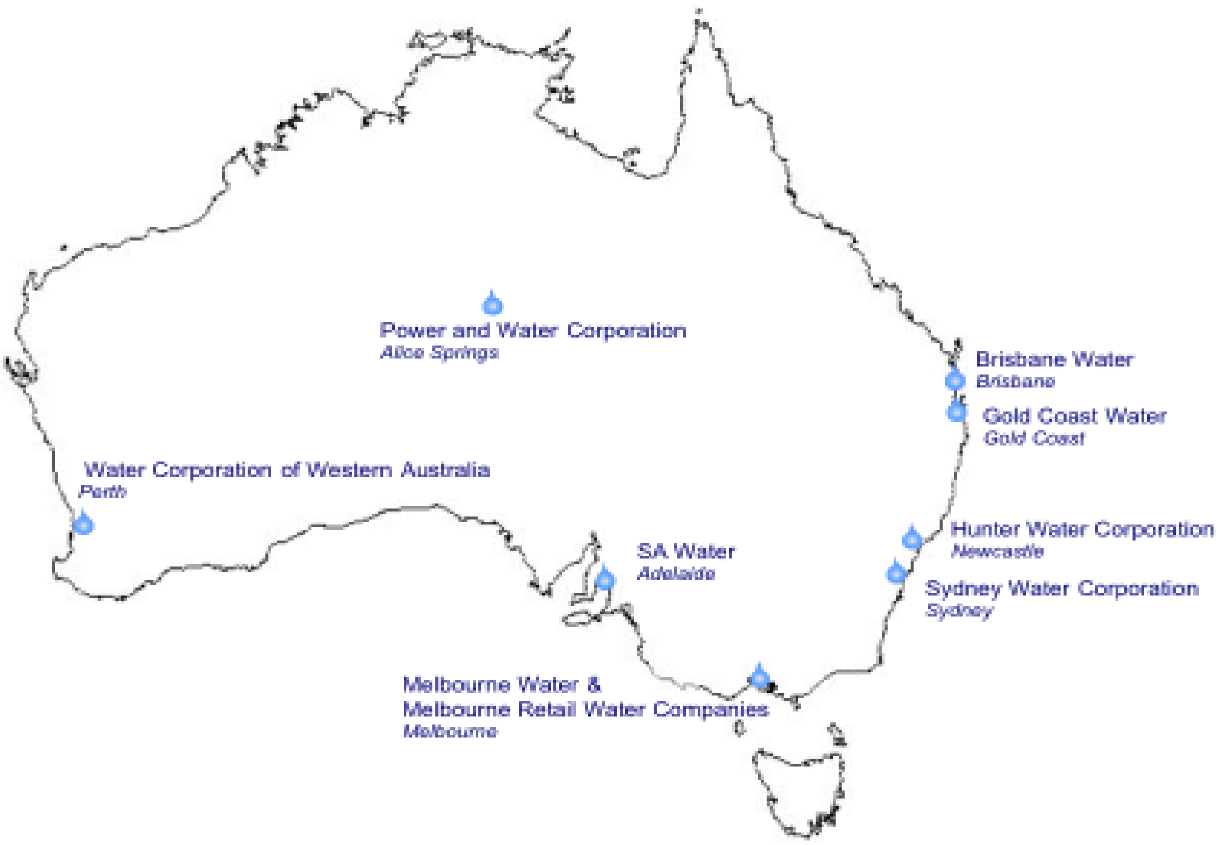


Figure 1: WSAA-members and non-WSAA members participating in this study.

Study Methodology
Continued

The output of this study is a research report and accompanying searchable CD. The following diagram in *Figure 2* depicts the structure of the report. The numbers correspond to chapter sections, the letters to key appendices. The shaded area shows the overlap with the CD content. Details of the report and CD include:

- ***Section 1: Introduction*** provides background, scope and need for this research. The study focuses on two aspects of demand management: factors affecting demand and demand management (DM) initiatives;
- ***Section 2: Urban Water Demand: History and Context*** provides information that is fundamental to understanding the context and need for such a study;
- ***Section 3: Study Methodology*** details the approach taken for this research and the structure of the outputs;
- ***Section 4: Demand Forecasting and Demand Management*** describes the factors influencing water demand in the context of demand forecasting and demand management. Development of a demand 'diagram' which depicts direct and indirect influences on water demand. Note this is just one way of portraying water demand that is appropriate for the purpose of this study. *Section 4* also provides an overview of the current research, literature and knowledge of water demand factors and demand management initiatives;
- ***Section 5: Significant Studies*** provides a more detailed review of selected studies considered significant based on three criteria: relevance, uniqueness and quality;
- ***Section 6: Findings and Conclusions*** provides a discussion on:
  - general and specific findings, research and knowledge gaps;
  - best practice characteristics for undertaking studies related to factors influencing water demand and for undertaking demand management initiatives and evaluations;
  - transferability of these Australian studies to other utility areas;
  - priority research areas; and
  - recommendations for future research on priority areas that are collaborative and cost-effective.
- The **Appendices** provide:
  - Study Profiles predominantly derived from the templates completed by WSAA members participating in this study, and other relevant studies identified by the study team;
  - Glossary of terms related to demand management; and
  - An extensive bibliography of the studies included in the Study Profiles and additional references identified by the research team.

Study Methodology

Continued

3.2 Templates

Key WSAA members were asked to complete templates designed by the study team to collect information on all the key relevant studies on A. *Factors Influencing Water Demand* and B. *Demand Management Initiatives*.

3.2.1 Template A: Factors Influencing Water Demand

Typical research projects include:

1) Specifically designed research projects typically involving measurement of components of water consumption and the variables likely to influence demand for water;
2) Studies using operational data including water flows and routine meter readings taken for billing purposes together with information taken from other sources, such as the Australian Bureau of Statistics (ABS);
3) Studies using data from previous studies to prepare models for forecasting water demands.

3.2.2 Template B:

These research projects emphasise community scale projects rather than individual, single-household experiments. A comprehensive list of examples will be collated which includes a range of water demand management and water sensitive urban design initiatives.

3.3 Selection Criteria for Short-listed Studies

For both Project 1 and Project 2, the top fifteen studies (Top 15) were selected for more detailed assessment and review. This was in addition to the templates and references provided by WSAA members and specific non-WSAA members invited to contribute.

The 'Top 15' in each project was selected based on significance. For the purpose of this project, '**significant**' means '**unique**', '**quality**' and '**relevant**'. That is, for a study to be included in the Top 15, it must provide something new or different to research on water demand management in Australia, have robust and sound methodology and be of relevance and use to other WSAA members.

3.4 Hyperlinked CD

The output of this project is presented as a CD of hyperlinked PDF documents. There are a number of benefits to this format:

1. Ease of search-ability. The viewer can search the interactive database much like one searches a website. This enables viewers to use the database in several different ways, depending on the purpose of their search. For example, to browse for studies under a particular topic, to search for a particular reference, to search for a summary and data gaps under a particular topic or search directly for overall data gaps and recommendations.

2. Ease of update-ability. This hyperlinked format also enables the database to be updated and new documents added.

3. Cross-linkage. This format enables documents to be cross-linked. A single report would be linear in nature and not allow for ease of cross-referencing.

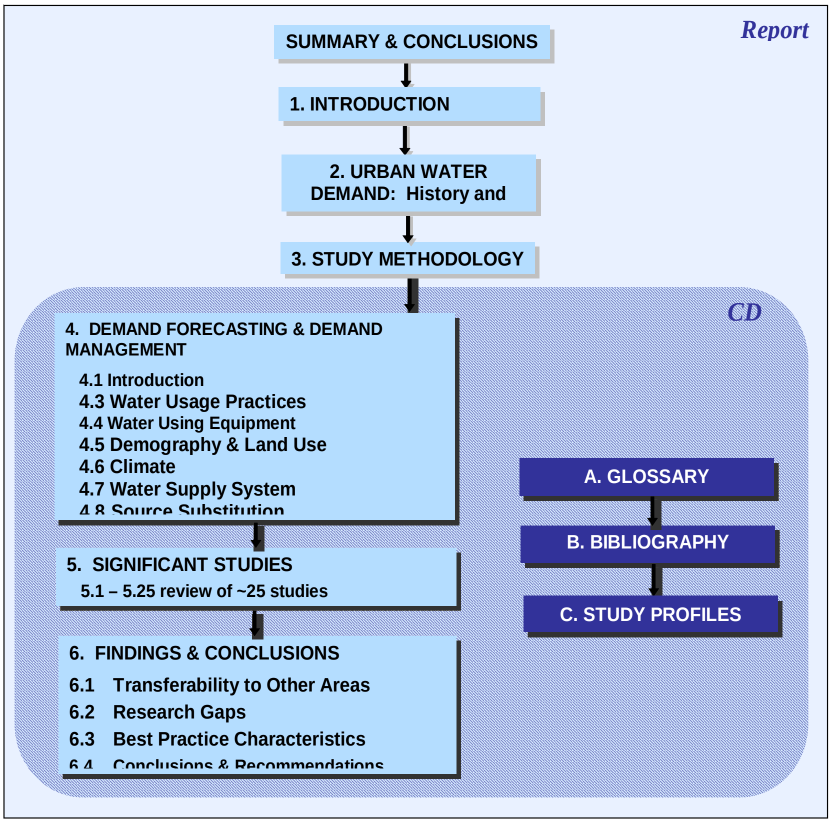


Figure 2: Report structure indicating overlap with CD content.

4. Water Demand & Demand Management Initiatives

4.1 Introduction

Section 4.1 describes factors influencing water demand in the context of demand forecasting and demand management. The following *Sections 4.2 – 4.7* each provide an overview of the research, literature and current knowledge on factors which influence water demand. The information draws on the Study Profiles (completed templates) collated from specific WSAA members, additional profiles of studies identified by the research team and the expert knowledge of the research team. The knowledge gaps identified by this review could be used by WSAA and WSAA members to focus their research in a collaborative and efficient way.

4.1.1 Factors influencing water demand

Numerous factors can directly or indirectly influence water demand. For the purpose of this study, they have been categorised as depicted in *Figure 3*.

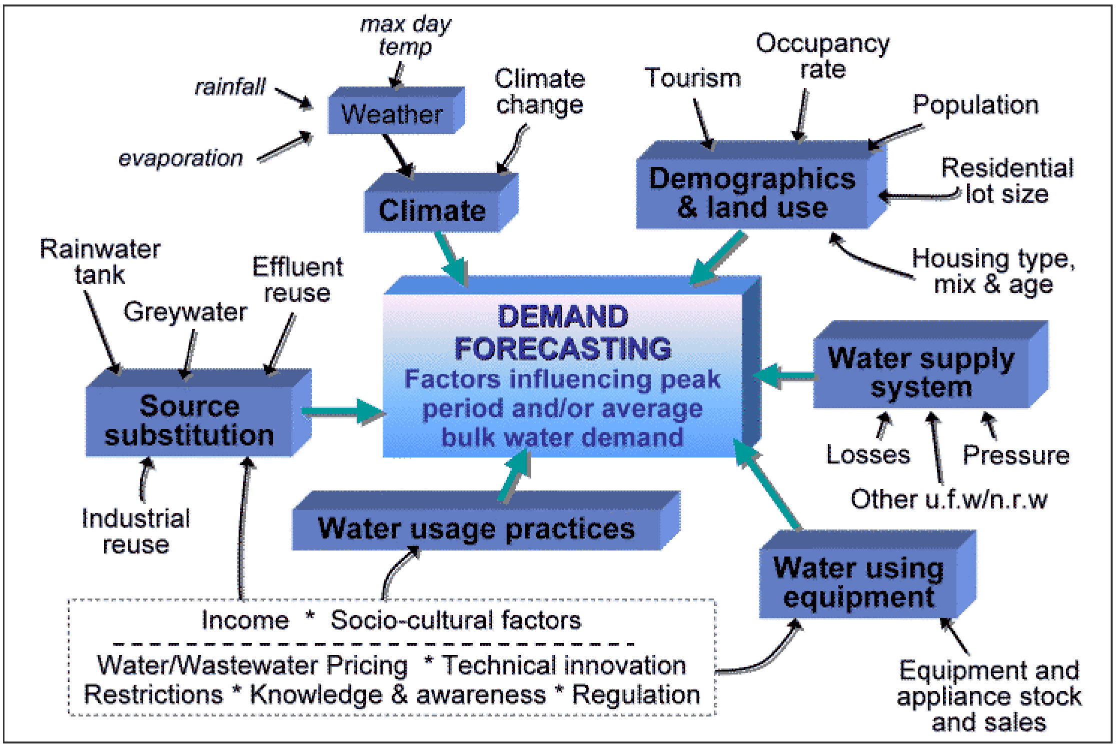


Figure 3: Direct and indirect factors influencing water demand.

Water Demand and Demand Management Initiatives

Continued

Some of these factors are direct and perhaps more significant than others. Both the current level of influence of these factors on water demand and the specific trends in these factors are of great interest in forecasting demand and developing a demand management program. The factors discussed in detail later in this Section include:

- water usage practices (including pricing, regulation restrictions, income levels, socio-cultural factors, knowledge and awareness, technical innovation and presence of water service companies);
- water using equipment;
- demographics and land use;
- climate;
- water supply system; and
- source substitution.

4.1.2 Demand management

Demand management is a term that describes the methods used to modify the level and/or timing of demand for a particular resource. Demand management programs are designed to promote conservation either through changes in consumer behaviour or changes to the stock of resource-using equipment (Greenburg and Harshbarger, 1993). Behaviour change by urban water consumers can be promoted via communication strategies, through economic instruments such as pricing and financial incentives or through regulatory instruments such as water use conditions or restrictions. In the urban water industry, demand can also be reduced through the use of source substitution, such as rainwater storage tanks or wastewater reuse. Increasing resource use efficiency remains the key strategy for water conservation and can involve either replacing water using equipment with more efficient types or finding and repairing leaks in the distribution system (Beecher, 1996). Replacing or regulating water using equipment and appliances as a demand management strategy is based on the notion that demand for a resource such as water is not in fact a demand for that resource itself but rather for the services that the resource provides, often called the end use. Consumers are therefore seen to generate a demand for services such as clothes washing and hot showers rather than a demand for kilolitres. In the first instance, it is assumed that providing the same services with fewer resources can be achieved with no loss of amenity.

Figure 4 shows examples of demand management measures and where they fit on a spectrum from changing behaviour to technology.

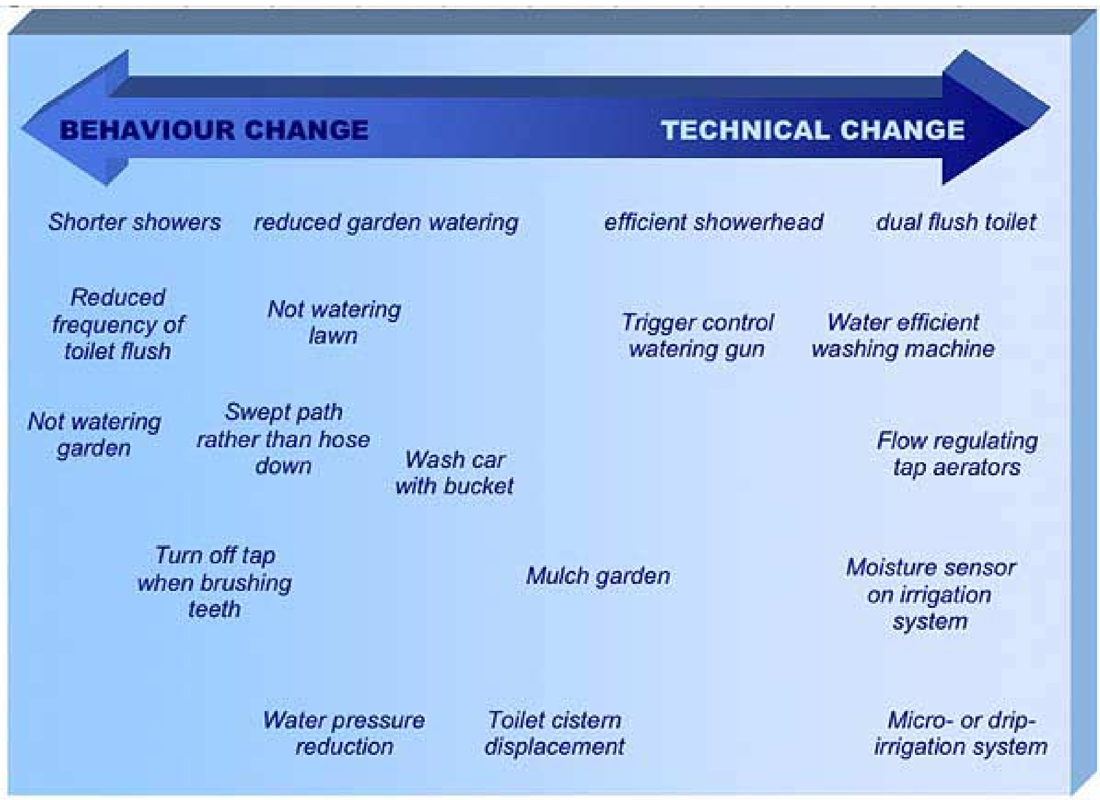


Figure 4: A range of water efficiency measures by which residential customers can reduce their demand for water, illustrating the difference between behaviour change-driven measures and technical change measures.

Water Demand and Demand Management Initiatives
Continued

Demand management measures and source substitution can each be applied to existing urban developments (via retrofits) or to new developments. *Figure 5* depicts how these can be applied and the relationship between demand management and source substitution in terms of potential water savings and unit cost. In general, it makes sense to 'pick the low hanging fruit' that is, actions that are easy to do now, are low cost, that do not require major changes to the existing urban water system and that will result in a reduction in water demand and sewage discharge in both the short and long term. These kinds of actions are aimed at making the most of the system as it stands and particularly include a focus on water efficiency. The first priority is to reduce the volume of water necessary to fulfil a particular service or meet a demand. The second priority is to match the quality of water required to fulfil a service with the quality of water supplied for that service. This concept is also known as source substitution or implementing the water quality cascade. Taken separately or together, both these actions provide additional benefits in terms of the resources (energy, materials and cost) necessary to deliver a particular water service (Mitchell, 2003).

	EXISTING DEVELOPMENTS	NEW DEVELOPMENTS
DEMAND MANAGEMENT	Potential water savings: **medium** Unit cost: **low** Examples: • Mandatory labelling • Mandatory performance standards • Showerhead retrofit • Improved irrigation practices • Fixing leaks	Potential water savings: **medium** Unit cost: **low/zero** Examples: • Water efficient fixtures • Low water using landscape • Efficient irrigation systems
SOURCE SUBSTITUTION	Potential water savings: **high** Unit cost: **high** Examples: • Raintank retrofit • Greywater reuse • Dual reticulation	Potential water savings: **high** Unit cost: **potentially low/zero (net)** Examples: • Greywater reuse • Raintanks and stormwater reuse • Dual reticulation • Reduced reticulation, pressure or vacuum sewers • Different scales or clusters of supply or treatment

Figure 5: Demand Management and Source Substitution initatives for existing and new developments.

Water Demand and Demand Management Initiatives

Continued

4.1.3 Demand forecasting

This section addresses demand forecasting: why accurate demand forecasting in important, what influences demand and best practice characteristics for modelling and forecasting demand.

4.1.3.1 Demand projection

Traditionally, demand forecasting was undertaken by either extrapolating historic trends of per capita consumption or using multiple regression techniques incorporating a range of variables such as population, income, price of water and periods of restrictions. Such models are useful for assessing historical demand and for providing a baseline to compare demand after implementation of a demand management program. However, what was important in the past may not be as important in the future, because of changes in behaviour or technology and both these approaches often result in oversupply. They are limited in their ability to project demand into the future due to the aggregated nature of the variables.

Approaches based on historical trends have an important role but should not be the sole way of forecasting demand. If we do not know how much water consumers use for different purposes and which uses we might be able to influence, it is very hard to design relevant and effective demand management and efficiency programs. End use analysis allows us to focus on what is important.

4.1.3.2 End use analysis

End use analysis (EUA) provides a mechanism for understanding how and where water is used, for choosing the most effective demand management measures and estimating the water savings they will yield. End use analysis focuses on the factors and technologies that affect water use, including emerging trends, relying less on historic trends.

End use analysis involves disaggregating demand into the 'services' for which people use water. This perspective is consistent with the principle of a utility providing a service (e.g. clean clothes) rather than a commodity (water) and it assumes that providing the same service with less water provides the same amenity to the consumer. For example, end uses for the residential sector can be broadly broken down into indoor and outdoor and further sub-divided into specific uses such as toilets, showers, clothes washers, garden watering and so on. EUA keeps the focus on what consumers need.

Ideally, the consumption attributable to these end uses should be modelled on the ownership, technical and usage characteristics, utilising a stock modelling approach. This is most readily applicable to the residential sector because of the similarity of end uses in houses, whereas in the non-residential sector the diversity of activities can make it more difficult to apply. End use modelling allows for likely future trends in technical efficiency improvements and household characteristics to be taken into account.

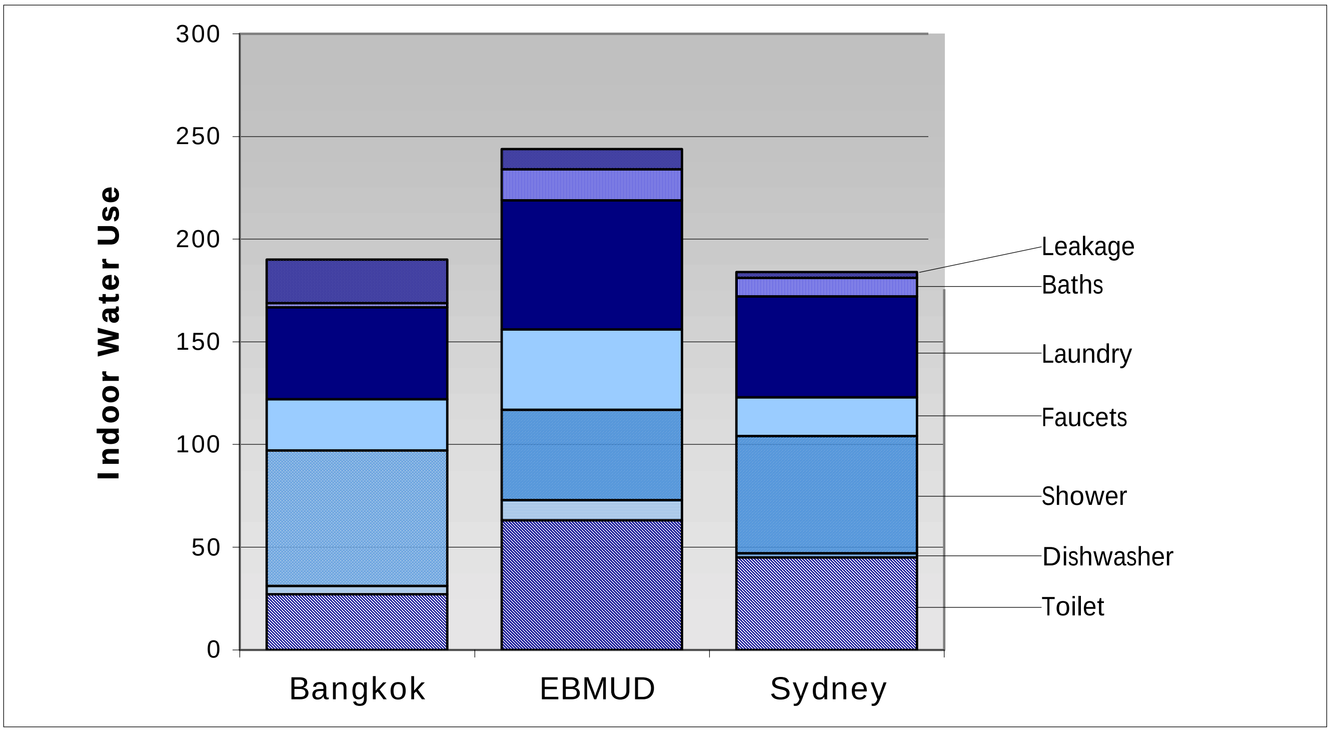
Stock X Usage X Technology = Water use

Demand for each end use is calculated based on the ownership of appliances, usage patterns and technologies.

The total demand is the aggregate of the demands for the specific end uses. It is important that where possible, modelled figures are calibrated or tested against measured results.

The following diagram, (*Figure 6*) shows residential indoor water use disaggregated by end use, for three cities: Bangkok, Sydney and East Bay of San Francisco (EBMUD). The differences in end use water demand between the regions illustrates the importance of collecting and analysing region-specific end use data. It is not always appropriate to transpose data from one region to a different study region (that is, to use 'secondary' data). The collection of primary end use data is considered more accurate than the use of secondary data, however, this is only true if it has been collected using a sound study design and appropriate data collection technique (Cordell and Robinson, 2003).

Figure 6: Results of end use analysis for residential indoor water use for three cities including Bangkok, East Bay area of San Francisco (EBMUD) and Sydney. *(Derived from Darmody, Maddaus and Beatty (1998) and ISF, 1998, cited in White* et al*, 2003).*



End use analysis provides an understanding of current influences, practices and trends in water demand. More importantly, such analysis informs demand management, allowing region-specific programs to be developed that address the 'lowest hanging fruit'. Whilst the priority of demand management options may vary from region to region, mandatory labelling and performance standards of efficient water using appliances is typically the most cost effective option (see *Figure 3*). Such an option is typically low (or zero) cost and achieves medium water savings. End use analysis provides a strong technical underpinning for modelling the demand management option of such mandatory schemes.

4.2 Water Using Practices

Customer water usage practices will directly influence water demand. There are many ways in which customer water usage practices can be influenced:

- pricing
- regulation
- restrictions
- income levels
- socio-cultural factors
- knowledge and awareness
- technical innovation

existence of water service companies

Different factors motivate different consumers to change their water usage practices. Some people will be motivated primarily by financial considerations, some by information provision and some by social factors. An effective demand management program will integrate a comprehensive range of strategies.

It should also be noted that these factors might indirectly influence both water using equipment and source substitution, which, in turn, influence water demand.

Water Demand and Demand Management Initiatives

Continued

4.2.1 Pricing

Changes in the pricing structure of water can affect water consumption. A sound pricing policy should be cost-reflective to allocate resources efficiently, while at the same time generating sufficient revenue. In Australia, policies on water pricing vary from State to State and from utility to utility. Historically, prices charged by water utilities have rarely been cost-reflective but reforms initiated as part of the Council of Australian Governments process have changed this practice.

Several studies of the effects of pricing on water demand have been undertaken in Australia (see for example Dandy, 1997). Some indicate that whilst outdoor water use exhibits a degree of price elasticity, the elasticity of indoor use is typically low or non-existent. Techniques used to measure impact of price have varied from the contingent valuation technique, to the use of quantitative monitoring and evaluation of metered data using climate correction to remove impacts of the climate variables. See for instance, Study 1: Water Pricing Impacts Study (Montgomery Watson, 1997) (*Section 5*).

4.2.2 Regulation

For the purpose of this study, regulation and regulatory measures include the use of building controls and appliance performance standards. Other measures include mandatory water efficiency labelling of appliances, which could provide a basis for regulation of the performance of these appliances. A voluntary version of this is currently in place and investigations of a mandatory scheme are underway. Some local councils, such as Marrickville Council in Sydney, have introduced development control plans requiring AAA-rated showers and taps in new dwellings and major renovations. Few studies in Australia[2] have directly measured the impact of such regulation on water usage patterns and water using equipment, however some relationships are evident from studies that look at stocks of water efficient appliances in areas in which have regulated the use of such appliances. Most notable is the adoption rate of dual flush toilets following the regulation of their use in many parts of Australia in the early 1990s. Dual flush toilets now represent over 50 per cent of the stock in most cities.

4.2.3 Restrictions

Water restrictions include the use of voluntary or mandatory regulation of water-using practices by customers. This includes short-term water use restrictions, such as those used during drought periods. Most water utilities have imposed water restrictions as a drought response at some time. Mandatory restrictions tend to yield more reliable water savings, although they can be time consuming and costly to enforce (White et al, 2000). Drought restrictions usually have a greater influence on outdoor water use than indoor. Other drought response planning strategies can include:

- ***Rationing***. Includes short-term water allocations based on local area, per capita or across the board.
- ***Pricing***. Includes inclining block tariffs, scarcity pricing, seasonal rates and fines.
- ***Education and Communication***. Includes workshops, media advertising, establishing a drought information centre and telephone hotline. This strategy is often considered more acceptable to customers and is consistent with other demand management programs. However, it may not effectively target all customer groups and predicting water savings can be uncertain, which in turn can make planning problematic in terms of justifying costs.
- ***Mitigation***. Implementing a demand management strategy in advance of a drought will reduce the severity of water shortages. Like education and communication, this approach often has a high level of customer acceptability and supports other objectives for implementing demand management programs.
- ***Operational improvements***. Includes improvements to the water supply infrastructure, such as reducing mains pressure or implementing a more rapid response to reported leaks.
- ***Supply-side options***. The use of alternative water supply sources during shortage periods, such as groundwater, alternative storage dams or desalination.

4.2.4 Income levels

Household income may influence ownership levels of appliances and fixtures and therefore affect water usage patterns. For example, during the 1960s the increase in ownership of automatic top loading washing machines correlated significantly with rising levels of disposable household income, increasing water demand for this end use as these machines replaced less water intensive washing methods such as handwashing, twin tubs and wringer machines. A current example is the rise in the number of automatic reticulated sprinkler systems in some areas.

[2] There are estimates of these savings in the U.S., in relation to the Federal Energy Act (1994), which regulated the efficiency of a range of water using appliances (see Maddaus and Dickinson, 2002). Estimates of the savings from shower head regulation in Australia have been provided by Day and White (2002).

However, there is no automatic link between increasing income (longitudinal) and rising water use. Spending on newer, more efficient appliances may in fact result in a reduction in water use as they replace older units. Income is usually not considered specifically in end use modelling, as it is implicit in the forecast change in the stock of appliances and the efficiency of those appliances. However, in relation to cross-sectional studies addressing income and water use, the Perth DWUS (Loh & Coghlan, 2003) does indicate a strong relationship between income level and outdoor water use. This result is derived from a cross-sectional study and cannot be translated into a conclusion that increasing affluence in the community is necessarily linked to increasing water use over time.

4.2.5 Socio-cultural factors

Socio-cultural factors can influence water usage practices, including the willingness to adopt water efficient equipment as well as general water using behaviour. An example of these kinds of studies is provided by work from the Australian Research Centre for Water in Society (ARCWIS) based at CSIRO Land and Water and customer research undertaken by Sydney Water Corporation. Another recent set of studies aiming to assess customer perceptions was the Customer Value Study (Qualitative and Quantitative) and the Customer Preferences on Water Resource Issues. These studies are described in more detail in *Section 5.3* Study 2: Customer Value Studies and Customer Preferences on Water Resource Issues (Chong, 2001a; Chong, 2001b).

4.2.6 Knowledge and awareness

Education and communication strategies are often designed to influence water demand patterns. These can take various forms such as educational materials distributed by water providers or the use of water efficiency labelling. It can be difficult to determine the effectiveness of an education and awareness strategy because it is often part of a larger program implemented to reduce water demand, such as new pricing structures, a rebate program or drought restrictions. Few, if any, studies have been undertaken in Australia to quantify the effectiveness of such programs.

4.2.7 Technical innovation

This includes innovation by industry to reduce or eliminate water use in appliances, fixtures, irrigation and other water-using equipment. Examples are AAA-showerheads, dual flush toilets, waterless urinals, cooling tower controllers and greywater systems. The availability, awareness and perceived acceptability of such technologies will influence customer uptake and water usage practices, which will in turn affect water demand. See Study 3: Perth Pilot Toilet and Shower Water Use Study (ISF, 2002).

4.2.8 Development of a water service framework

Demand management provides water utility planners and managers with the opportunity to take a water service approach to the business of selling water. This considers management of the demand for water as an issue of 'how to provide the service for which the water is needed' rather than 'how much water must be provided'. This approach may result in business opportunities for selling water to meet the water service needs of residential and non-residential customers that can be met with less water or water of a quality lower, equal to or higher than potable mains quality water. In the past decade, with corporatisation of water utilities, the water service approach is beginning to be more widely adopted. However, to develop strategies for meeting the market's various water service needs, market research is essential. The size of the market for water service needs will vary from place to place. However, water utilities could benefit from collaborative research on the characteristics of the water service needs that tend to be common within residential and non-residential sectors.

Water Demand and Demand Management Initiatives
Continued

Box 5: Outdoor Water Use

Outdoor water use is typically a significant and highly variable component of water use. It can be over 50% of water use in some towns and cities and as little as 25% in others.

Outdoor water use is easily influenced by a number of options, including regulatory options such as restrictions and education programs, as well as economic instruments including pricing and incentives. There have been a number of research studies that quantify the demand for water in domestic lawns and gardens, including the Perth DWUS (Loh and Coghlan, 2003). However, the transferability of these results is limited.

Research on influences on outdoor water demand including lot size has been undertaken and customer surveys in relation to outdoor water use behaviour are reported on (see Study 20: Customer Research Unit Program, and Study 21: ARCWIS Research).

A research project entitled "Water Use in Domestic Gardens: A Review and Analysis of Recent, Current and Planned Activity" has been commissioned by Nursery & Garden Industry Australia on behalf of both NGIA and WSAA. It is funded as a Horticulture Australia Ltd research and development project, via voluntary contribution and matching Federal Government funding. The report will be freely available to the industry, WSAA and other interested parties (Anne Currey, personal communication).

4.3 Water Using Equipment

There have been several substantial studies in Australia to date which look at residential water using equipment and the stock and sales of appliances. These have been undertaken in Melbourne, Perth and Sydney. See Study 4: Melbourne End Use and Water Consumption Influences Study (ISF and CSRIO Urban Water, 2002) and Study 5: Domestic Water Use Study (Water Corporation of W.A., 2003). A national stock study undertaken on energy using equipment, *Greening Whitegoods* (Energy Efficient Strategies, 2001) has detailed and reliable stock data on washing machines and dishwashers in each State.

4.4 Demographics and Land Use

There are numerous demographic and land use factors that can influence water use:
population;

- occupancy rate of dwellings;
- lot size (including ratio of garden/lawn size to entire lot); and
- age of the building stock;
- industry growth (in terms of land area);
- landscape area, ownership type (public, commercial/industrial, institutional) or function (lawn, garden, field/oval, golf course, etc).

Both the current level of influence on water demand of these factors and the specific trends are of interest in forecasting demand and developing an end use model. Research undertaken by ARCWIS (see Syme, 1990) collected and analysed the relationship between lot size and household water demand. Two recent studies which address residential demographic factors and non-residential land-use trends are Study 6: Average Residential Consumption Variability (Hunter Water Corporation, 2002) and Study 5: Domestic Water Use Study (Water Corporation of W.A., 2003).

4.5 Climate

Climatic or weather factors can significantly influence urban water demand and should be taken into consideration when developing a demand forecasting model. Climatic factors can be separated into short-term and long-term factors. Short-term factors include weather factors, such as maximum day temperature, *perceived* rainfall and *perceived* evaporation. It is important to note that it is 'perceived' rainfall and evaporation rates that are significant, as customers will change their outdoor watering behaviour based on their perception of these two factors. Recent innovation has seen the development of controllers for automatic sprinkler systems, which directly link actual rainfall and evapotranspiration to outdoor water use (see for example Hunt et al, 2001). Longer term climate change is likely to increase annual average temperature, rainfall and evapotranspiration, although this is regionally determined.

Several researchers have developed demand models using multiple regression techniques, which attempt to determine the impact of weather-related variables on water demand for short-term demand prediction or longer term analysis of trends. For example, Viswanathan (1991) modelled water demand as a function of climate variables for Hunter Water to determine the impact of restrictions. Other work has included the development of a model for Sydney Water Corporation (SMEC/MW, 1995) and for Gold Coast Water (Montgomery Watson, 1998) and for Alice Springs (ISF, in progress).

However, there is very little published on the methods used in Australia and there is little discussion and comparison of methodologies by the water industry. See Study 7: Water Demand Management Strategy for Alice Springs (ISF, in progress).

4.6 Water Supply System

The physical state of the urban water supply system can influence bulk water demand because of leakage from pipes. Leakage typically represents more than 50 per cent of unaccounted for water.

The extent of leakage will vary from area to area depending on the state of the infrastructure and system design. However, the experience within existing programs, such as the Sydney Water Demand Management Program, is that leakage control and pressure reduction can be one of the most cost-effective and immediately available methods of demand management. There are a number of leakage control measures that can be used, such as pressure control, routine sounding and district metering (Wide Bay Water, 1999).

Significant work on the affects of leakage and leakage management has been undertaken in the international arena. The International Water Association (IWA) has developed a methodology for leakage management and supported an international conference on the issue[3]. The Infrastructure Leakage Index (see Lambert and McKenzie, 2002) has been proposed as a standard method of defining and benchmarking leakage levels. A number of Australian utilities such as Wide Bay Water, South East Water and Hunter Water Corporation have addressed the impact of pressure reduction on leakage and overall water demand. However, there is little publicly available literature that provides a summary of cost estimates for implementing leakage management programs in Australia and the actual water savings achievable.

4.7 Source Substitution

Source substitution is the use of other sources of water to replace or supplement bulk water supply. This includes measures such as rainwater harvesting or effluent reuse where there is an opportunity for substituting sources of water for end uses such as irrigation, car washing, toilet flushing and laundry use or with appropriate treatment for other end uses where a higher quality is required. It can include options that substitute water with non-water solutions, such as dry toilets, waterless urinals or air for industrial cleaning processes (Grant, 2002). Many utilities have considered the use of rainwater tanks as a substitute to bulk water supply. However, few have undertaken quantitative analyses of the actual influence rainwater tanks can have on bulk supply and specifically, *peak* supply. One study that endeavours to do so is Study 8: Integration of Rain Tanks: Impact on Water Supply Headworks (ISF, 2003).

[3] See the proceedings of the conference "Leakage Management: A Practical Approach ' held November 2002, at http: //www.leakage2002.com

5. Significant Studies

This section provides a review of selected studies that the study team considers significant. These were chosen from a larger group of studies identified through the information reporting templates sent to selected WSAA-members and the study team's existing knowledge. The studies reviewed in this section were chosen on three criteria: relevance, uniqueness and quality.

5.1 Study 1: Water Pricing Impacts Study

Themes: water usage patterns – pricing

This study was undertaken by Montgomery Watson for Gold Coast Water in 1997 with the objective of developing a model to forecast the impact of different water prices on future water demand. This study aimed to enable Gold Coast Water to establish a water pricing structure with greater confidence.

The study provided a review of pay-for-use pricing in fourteen NSW and Victorian cities and towns, developed a pricing impact model for Gold Coast Water and incorporated this model into the previously prepared demand monitoring and forecasting database. The model was developed to assess the impact of pricing on different water customers (including residential single family, residential strata/flats, commercial, industrial, public and other). Price elasticities were estimated for internal and external water demand for each of the customer categories.

The review of impacts of price changes in other cities and towns indicated that there are generally other factors influencing a downturn in water demand, thus making it difficult to determine the quantitative influence of pricing alone, that is, the price elasticity. Whilst the study undertook an analysis of quantifiable non-price factors, such as income, housing type and population to eliminate their influence on downturn in water demand, some variables were difficult to quantify and thus could not be eliminated. Such difficult factors were:

- the level of community education associated with the price change;
- the existence of drought management strategies; and
- the extent of other demand management initiatives.

This study concluded that when developing an impact model for water demand it must be assumed that in addition to price changes, a combination of the above three factors may also influence the change in water demand. This means that there can be significant uncertainty in predicting the quantitative influence of introducing pay-for-use pricing on water demand. Because of this uncertainty, the study recommended that sensitivity analysis be undertaken when forecasting future demand.

Further, the study concluded that the influence on water demand of introducing pay-for-use pricing may be less in the Gold Coast compared to other areas of Australia because of the relatively low level of per capita demand in the Gold Coast and the downturn in demand during the 1990s.

5.2 Study 2: Customer Value Studies and Customer Preferences on Water Resource Issues

Themes: water using practices – socio-cultural factors

This set of three studies was commissioned by Melbourne Water for the Water Resources Strategy Committee for the Melbourne Area in 2001, to determine customer values in relation to drought management, water restriction issues and preferences towards water management options being considered by the Victorian Government. Such water management options include:

- reducing water demand;
- develop new water sources;
- substitute drinking water; and
- squeezing more from the existing water supply.

The initial phase was an exploratory qualitative study using focus groups in three target audiences (metropolitan households, control groups in areas of restrictions and business/organisations). The general attitude of the participants suggested a willingness to conserve water and accept restrictions. However, there was uncertainty in the community on how to go about this on an individual basis and how to know whether one is having an effect. The study indicated a diversity of views in relation to the merits of increasing supply versus reducing demand or a mixture of the two strategies.

The second phase included a quantitative survey of a representative sample (n=601) of the community (by age, gender, ethnicity and geographical location) via telephone. It revealed a high degree of willingness to consider using greywater, highly treated sewage water (for external ap-

Significant Studies

Continued

plications and toilet flushing) and rainwater tanks. However, barriers (such as cost, space, odour, health issues, security of supply and local government restrictions) could reduce this preparedness. Attitudes towards conserving water appeared to be positive, though respondents wanted to be convinced of both the costs and benefits of their efforts (i.e. water savings and costs). There was a strong preference for achieving water conservation through education programs rather than pricing increases. Middle-aged groups tended to be amenable to innovative solutions. In general, of the four management options (as listed above), the option to reduce water demand was most favoured.

The third phase explored customer values through a survey of 1,411 residents in Melbourne and Geelong. As Geelong has recently experienced water restrictions as a result of drought, an aim of the study was to assess any difference in values and attitudes between the Geelong and Melbourne respondents. The key differences found were in actual behaviours, not attitudes. The overall results suggest that in general there is strong willingness to consider conserving water, especially for external uses. There was also a certain degree of understanding or acceptance of more frequent and less severe restrictions, rather than less frequent and more severe. A possible self-selection bias may have occurred in this survey, as those who were initially recruited but did not end up completing the full survey tended to be younger, renting property, be non-Australian in origin and living alone.

These studies provide details of current perceptions and attitudes of the community in relation to water use, conservation and restrictions in the Melbourne area. The outputs of this study may be relevant to other parts of Australia with similar socio-demographic and geographic characteristics. Certainly, the study methodology could be applicable throughout Australia. It is important, however, to ensure that using results from such a study for a purpose different from which it was intended, may result in less reliable results. For example, the quantitative survey asked participants to estimate their current shower duration and what, if asked to cut their duration they would reduce it to. This information is useful for understanding the community's attitudes and perceptions. However, these attitudes may not be reflected in their behaviour. That is, shower durations are likely to be higher than respondents claim.

5.3 Study 3: Perth Pilot Toilet and Shower Water Use Study

Themes: water using equipment and water usage practices

The Pilot Toilet and Shower Water Use Study was conducted in 2002 by the Institute for Sustainable Futures, UTS, for the Water Corporation of Western Australia, as an extension of the Domestic Water Use Study DWUS (see *Section 5.5*). The principal objective was to determine the most likely cause(s) for higher than expected average flush volumes for 6/3 L dual flush toilets. This is important, as high flush volumes would suggest much lower than expected water savings from retrofit programs for older toilets or because of the normal replacement rate. A secondary objective of this study was to develop techniques for obtaining high quality data on appliance and fixture stocks and associated water use, at minimal cost and while working in cooperation with customers.

The available number of potential households for this pilot study was limited and other households could not be substituted. Thus, it was necessary to develop a strategy that maximised the participation rate of the few available households. Participation was maximised by:

- Sending a letter to all desired participant households to introduce the study, explain what participation would involve and provide a consent form as an attachment;
- Following up the letter with a telephone call to further explain the purpose of the study, make appointments with those households agreeing to participate and to survey a person who was willing to commit the household to participate.
- Undertaking the household visit, which involved a male and female pair of researchers[4]. One researcher undertook a technical inspection of the water using appliances, while the other conducted a face-to-face survey on water usage behaviour with a member of the household. The purpose of the face-to-face survey was three-fold: to understand people's toilet usage practices to help clarify data previously gathered using a different data collection technique, to understand people's patterns of use of their dual flush toilet and to determine how satisfied households were with the operation of their dual flush toilet. This was to find out the most likely cause(s) for higher than expected average flush volumes for 6/3 litre dual flush toilets. The technical inspection aimed to identify the stock of various water using appliances and determine actual shower flow rates.

[4] Research suggests participants of an in-house survey may be least threatened and willing to participate when a male-and-female combination conduct the household visits (compared to two males, two females, a single male or a single female).

Significant Studies

Continued

- Providing rewards to show participants the value that the Water Corporation placed on the household's contribution to the study.
- Sending evaluation forms to all participants to help the study team look for opportunities to improve the way the household visits were conducted and to affirm positive aspects.

The telephone survey questions were identical to those asked in the face-to-face survey. The purpose of asking these questions over the telephone was to collect data from more than one member of the household, to account for variation in individual responses among household members.

The high participation rate and general satisfaction of participants in the Perth Pilot Study affirmed the importance of incorporating a good communication strategy in the data collection to ensure participants were treated with respect, to maximise their participation and cooperation and to establish or further build customer relationships with the organisation.

The technique used is highly applicable to other water utilities in Australia. That is, the process of collecting high-quality household water-usage data is transferable. Whilst the pilot study did not have a statistically significant sample size, some of the data resulting from the survey may also be relevant to other water utilities, such as data suggesting that actual shower flow rates may be much lower than the capacity flow rate. It is also important to note that the actual flow rate appears to vary substantially as a percentage of capacity flow rate, depending on the "A" (or efficiency) rating of the showerhead. The actual flow rate was found to be a much lower percentage of capacity flow rates for high water-using showerheads but a much higher percentage for water efficient showerheads. This type of data is important for predicting water savings achievable from a retrofit of water efficient technologies and fixtures.

Another important finding from this study is the value of collecting specific water usage data using an appropriate data collection technique. For example, identifying stocks[5] of the various dual flush toilet types in Australia may not be as simple as a superficial check of the toilet during a household technical visit. An even less accurate method is asking the householder what type of dual flush toilet they own. This is because there are currently three types of dual flush toilets: 11/6 L, 9/4.5 L or 6/3 L and there are no consistent, obvious markings on these toilets to enable easy identification. These difficulties may be overcome by taking measurements of the volume of water inside the cistern. Whilst this technique may not be quick and straightforward, it may provide results that are reliable. Another option yet to be trialled in Australia is the use of the *T5 Flushmeter*[6] to obtain instantaneous data on actual toilet flush volumes (claimed to be accurate to the nearest 0.1 L).

5.4 Study 4: Melbourne End Use and Water Consumption Influences Study

Themes: water using equipment

This data collection study was undertaken by CSIRO Urban Water and the Institute for Sustainable Futures, UTS, on behalf of the Water Resource Strategy Committee for the Melbourne Area in 2002. The main objectives were to understand how and when water is used within the community and the factors influencing water consumption. The intention was to provide a summary of best current knowledge of end uses of water within Melbourne and collate existing knowledge about the major influences on end uses of water, including penetration levels of water efficient fixtures and appliances. Data were sought that could provide inputs to an appropriate water end-use model for Melbourne.

It involved collating primary demographic data and secondary end use data on water efficient technologies. A qualitative assessment of the relevance, reliability and sensitivity of available data for modelling Melbourne's water consumption was undertaken. This allowed identification of:

- data which is appropriate for a Melbourne end use model;
- gaps in appropriate data and knowledge, (such as ownership of various dual flush toilets types); and
- recommendations for further data collection.

This objective influenced the type and extent of data collected: for example, data were collected on *actual* water use of the different water efficient shower and toilet types, rather than *theoretical* or 'design' water use data. Further, the study focused on collecting reliable data for end uses that are significant to an end-use study, such as showers and toilets (which can each make up 30 per cent of in-

[5] For the purpose of this paper, 'stocks' refer to the quantity or percentage of specific water efficient fixtures.

[6] See http: //www.t5flushmeter.com/ for further details on T5 Flushmeter.

Significant Studies

Continued

door water consumption), compared to dishwashers (which make up approximately 1 per cent of indoor water use).

The residential end use data collected in this study is relevant to other Australian water utilities to the extent that they have similar relevant characteristics to Melbourne. Relevant characteristics may include climate, socio-demographics and other factors. Regardless of the actual data, the framework for collecting and assessing secondary data is applicable to all water utilities.

A unique aspect of this study is perhaps its use of existing data from one region for use in a water end-use study in another region, prior to any further primary data collection. A popular belief in the U.S. (and Australian) water conservation community is that primary data should always be collected specifically for the study region. It is thought that transposing data from one region to another will result in inaccurate outcomes because of the distinctive characteristics of different cities and regions. While collecting primary data can be preferable, it is often more expensive than collating existing data. The Melbourne End Use and Water Consumption Influences Study collated existing end use data from Australia (and a limited amount from overseas) and assessed each data set's integrity and relevance to a Melbourne water end use model. Recommendations for further primary data collection were based on existing data sets assigned as low relevance and/or low data quality. This raises the question, does the collection of existing data (where appropriate) reduce the cost of collecting all primary data? If so, to what extent? It is likely that regardless of the quality of existing data, stock studies (of water using appliances and fixtures) would still need be undertaken as this is a site-specific parameter and will differ from area to area.

This study also concluded that while the collection of further specific residential data is needed to contribute to an end use model for Melbourne, non-residential data gaps are best addressed through methods other than developing an end use model. Such methods could include surveying an industry sample to determine interest in site-by-site audits or determine best practice water use in each industry category.

5.5 Study 5: Domestic Water Use Study

Themes: water using equipment

The Domestic Water Use Study (DWUS), undertaken by Water Corporation of Western Australia in Perth 1998–2001, has become perhaps the largest residential end use data collection in Australia. The DWUS collected data on household water usage and identified patterns and trends in water use. It provided a snapshot of how water is used in the average Perth household and flow data on selected households. It is anticipated that a demand forecasting model and a water use efficiency program might be developed from this.

Using data loggers attached to water meters, data has been gathered on water use in about 125 single-family residences, stratified by income, over eighteen months. The study also involved an analysis of trends in water use over the past fifteen years and determination of savings for various water efficient devices.

Although this end use database is the largest in Australia, trying to use it for purposes for which it was not originally intended is difficult.

The DWUS was designed to identify patterns and trends in water use behaviour,, and data was collected using a survey with only two categories of water using appliances: 'efficient' and 'standard' (for showers). This is sufficient for understanding general trends, however, if water and cost savings for the different appliances are to be analysed, further information is required about them. The reason for this is that the word "efficient" is unclear in a technical sense. In Australia at that time, efficient showerheads could be A-rated (12–15L/min), AA-rated (9–12L/min) or AAA-rated (<9L/min). Categorising the showers as 'efficient' or 'standard' may be straightforward and useful for trend development but may not provide all the information needed to calculate savings. Knowing the end goal of the data collection is important.

The same issue applies for dual flush toilets. Currently in Australia, these can be 11/6L, 9/4.5L or 6/3L. In the future, 4/3L and other efficient toilets may become available. If quantitative data is required on savings achieved by replacing all higher water using toilets with 6/3L toilets, the level of detail of toilet type and actual flush volumes is required.

In the DWUS study, data to identify dual flush toilet stocks were initially collected via a face-to-face survey but no physical inspection of the toilets was made. Towards the end of the study, the data was cross-checked via an examination of the flow trace data emerging from the data

Significant Studies

Continued

loggers and by an in-house technical survey. The in-house technical survey involved researchers entering the house and examining the toilets to increase the level of accuracy in identification (this was undertaken as part of the Perth Pilot Toilet and Shower Water Use Study, see *Section 4.3.8* for further detail). The toilet identifications from the in-house survey technique and review of data logger outputs were reasonably consistent, while they differed considerably from those initially estimated by participants during the DWUS telephone survey. However, because toilet flush volumes can be different from those obtained in a laboratory setting, collection of data using in-house surveys can produce better identification than the use of data loggers alone. Based on this Perth pilot study, identification techniques have been further improved.

Key findings of this study included:

- Average total household water use was 369 L/person/day. The components were: bath and shower (14%), washing machine (11%), toilet (9%), tap 7%, other (1%) and outdoor (58%);
- Water use in toilets has decreased substantially since 1981–82 because of increasing ownership of dual flush toilets, however, this has been offset by increased water use by the washing machines component (due to increase ownership in automatic washing machines);
- Increased ownership of automatic reticulated irrigation systems has resulted in increased outdoor water use;
- · Higher income households tended to have higher outdoor water use (note this is a cross-sectional study and cannot be translated into a conclusion that increasing affluence in the community is necessarily linked to increasing water use over time); and
- No significant relationship between lawn area and outdoor usage exists.

The indoor water use data is generally applicable to other water utilities in Australia. The outdoor data may be less applicable to other areas owing to climatic and demographic factors. However, the data is only applicable to other studies to the extent to which the original study was initially undertaken. For example, accurate data on water savings may not be applicable to another study, as this was not the original intention of the DWUS and the available data may not be appropriate for the specific need.

5.6 Study 6: Average Residential Consumption Variability

Themes: demographics and land use

This study was undertaken by Hunter Water Corporation in 2001–02 partly to review average residential consumption and to determine the variability of consumption by socio-demographics such as affluence, property age, topography and size. Peak demands are designed based on average demand by applying peaking factors. The investigation analysed the annual metered consumption of all residential properties within the Hunter Water Corporation area of supply (180,000 properties) at a collector's district level. A review of Hunter Water's customer database indicated newer houses have a substantially higher average water consumption compared with older houses. However, this has not appeared to offset the overall average, owing to the decreasing annual water consumption by older houses.

In addition to property age, other factors which appeared to affect average consumption included: geographical area, topography, property size, customer affluence and housing type.

The principal conclusion was that there is considerable variability in annual consumption (also maximum consumption) for different collector's districts. The analysis highlighted a variation in average consumption from 150kL/year to 410kL/year for varying sites. In addition, the analysis identified that younger properties (<15 years old) had a higher consumption than older properties (40–50%), which could indicate a culture change in consumption.

Following this study, it was recommended that residential diurnal patterns, peaking factors, extreme day (and week) demand and average annual consumption for multi-residential houses be revised for the Hunter Water customer area because of changes in consumption identified.

Significant Studies

Continued

5.7 Study 7: Water Demand Management Strategy for Alice Springs

Themes: water using equipment, water usage practices, climate, demographics and land use.

The Institute for Sustainable Futures, UTS, developed a climate correction model as part of a demand analysis and demand management study in Alice Springs. The arid climate in Alice Springs presented significant challenges for the client, the Northern Territory Power and Water Corporation, in reducing demand in summer periods, where the peaking factor (peak day demand to average day demand) has consistently averaged approximately 1.6. The climate correction model was used in this project specifically to look for historical instances in which local activities may have had an impact on water demand, i.e. changes in demand that were not the result of climate. In future, the model will be able to be used to measure the impact of the Alice Springs Urban Water Management Strategy.

The following data from the period July 1981 to June 1981 was obtained:

- climatic: rainfall, pan evaporation and maximum daily temperature;
- demand: daily reservoir-corrected bulk water demand; and
- demographics: population (interpolated to provide daily values).

Manipulation converted the daily data to monthly data, including:

- degree days: the monthly sum of the daily maximum temperatures;
- ·evaporation: using a crop factor to convert pan evaporation;
- soil moisture deficit: combining daily rainfall and evaporation data in a daily model, summed monthly to represent the fluctuations in soil moisture due to its finite capacity to hold water; and
- monthly average demand per capita.

A multiple regression analysis was used to define the demand equation. Interestingly in this case, the moisture deficit was found to have a far greater influence on demand than temperature. The model was calibrated on a 24-month period and tested and verified for significance at the 95 per cent confidence level.

Importantly the model is useful now to monitor the impact of future programs. The researchers have taken on the responsibility to address this and hand the model over in a form and with sufficient information to ensure that the utility is able to use the model 'in house'. This ability to broadly understand the anticipated response of demand to climate will allow utilities to better measure the impact of their programs and to evaluate their successes.

5.8 Study 8: Integration of Rain Tanks: Impact on Water Supply Headworks

Themes: source substitution

In 2003, Rous Water, a bulk water supplier on the north coast of NSW, commissioned the Institute for Sustainable Futures, UTS,, to undertake a study of the potential for integration of rainwater tanks thereby reducing the need for water supply headworks. The aim of the study was to analyse and evaluate the potential for a major installation of rainwater tanks, acting as a reliable water supply source supplementing the supply storages that service the Rous region. This study built on a previous study of rainwater tanks undertaken as part of the Rous Demand Management Strategy (White, 1997), which investigated the potential for rainwater tanks to be a supplementary supply source and as a sole supply for new buildings.

Using the least cost approach and using the 'unit capacity cost' (expressed as $ per ML/a water saved or yield provided) as the basis, other DM options, source substitution and supply-side options were compared with rainwater tank options. Three rainwater tank options were developed from various demand scenarios obtained by connecting the rainwater tank to toilet flushing only, outdoor use only and to toilet flushing, outdoor and to laundry use. Secure yield provided by each option was also used as a criterion in evaluating and comparing the options.

In addition, the study estimated a rainwater tank rebate scheme that the utility could offer to customers for the three rainwater tank options. The rebates for each of the three options were estimated based on a planned capital investment of supply augmentation, which will be deferred (by the option) in proportion to the secure yield it will provide.

In the cost-benefit analysis of the rainwater tank options, an attempt has been made to quantify the benefits that are accrued by avoided stormwater infrastructure costs as well as to internalise the externality of greenhouse gas emission.

Significant Studies

Continued

The investigation of the relationship between rainwater tanks and the behaviour of supply headworks shows that the widespread use of the largest modelled capacity rainwater tanks (10,000 litres) have the potential to increase the security of supply by up to 24 per cent. This provides a new way of accounting for the benefits of rainwater tanks as an alternative supply and highlighting the need for implementing and promoting any rainwater tank program on a scale larger than household level to derive maximum benefit on the supply-side as well as on the stormwater-side.

5.9 Study 9: Wise Water Management: A Demand Management Manual for Water Utilities

Themes: water using equipment, water usage practices, water supply system and source substitution

This demand management manual (White 1998) was published in November 1998 by the Water Services Association of Australia and NSW Department of Land and Water Conservation. The Manual has three parts. Part A provides an overview of demand management. It also includes an introduction to planning for demand management. This section includes the economic evaluation processes that can be used for comparing various demand management options in the planning process. Part B discusses demand management measures related primarily to actions that are designed to be implemented by the water utility, such as pricing reform, metering, non-revenue water (including leakage reduction and repair), utility water use and reuse of water. Part C discusses demand management measures at the customer end. One chapter also discusses the importance of community-based strategies in the context of demand management and outlines the elements of a successful communication strategy.

The Manual is a reference for information about water-using technology and the potential for improved efficiency. Various incentives and retrofitting programs are listed in the Manual with examples of implementation.

The Manual describes a number of demand management programs. However, it does not provide significant details on the evaluation methodologies of the demand management programs that are highlighted as case studies or of climate correction methods, end use analysis or forecasting techniques. Other manuals and guidelines produced since this one was published provide details on a number of aspects covered in this manual. For example, Vickers (2000) provides a comprehensive coverage of the field of water efficiency in North America and PMCL (2001) provides details of methods for assessing the cost effectiveness of demand management measures.

5.10 Study 10: Residential and Non-residential Water Pricing Communications

Themes: water usage practices – knowledge & awareness and pricing.

The study titled “Water Pricing Communication Plan” was conducted by Gold Coast Water (GCW) in June 2002 as part of short-term communication strategies developed with the specific aim of communicating the new pricing structure that was announced as a drought response measure.

The study has costed communication strategies targeted at specific categories of water customers including senior citizens, concerned residents, ratepayers and pool owners. The strategies aim to create awareness in the community regarding the two-part pricing structure introduced by GCW and to encourage customers to locate and read their water meters and to increase awareness of water issues. The strategies employed were wide ranging and used different media outlets, including information brochures for general distribution, a campaign involving a ‘meet your water meter’ competition, held in collaboration with a local radio station, presentation kits and displays targeted for specific customers, local newspapers and local television and periodical council rate notices.

Strategies and their respective costs targeting non-residential water customers are also described and proposed in the document.

Significant Studies

Continued

5.11 Study 11: Water Conservation Partnership Program (WCPP)

Themes: water usage practices

This study is essentially a literature review compiled for the Water Conservation Partnership Program by the Urban Water Resources Centre, University of South Australia in January 2001. The review focuses on studies of water conservation and water substitution technologies and practices for domestic users and local government. The review discusses issues specific to sustainable water management namely:

- water conservation practices and technology;
- roof runoff storage and use;
- greywater and reclaimed water; and
- aquifer storage recovery.

The key factors that were reviewed for each of the issues included technological, public health and economic factors, as they influence the applicability and feasibility of the adoption of such technologies. The review also includes references that discuss and provide evidence of various kinds of benefits associated with above-mentioned aspects of sustainable water management.

Regulations in South Australia also have been reviewed with a view to identify the barriers and opportunities that exist for rainwater tanks, aquifer storage and recharge, greywater and reclaimed water reuse.

The study provides ample references for water efficiency and rainwater tanks. The review of the regulatory environment is pertinent for S.A.

5.12 Study 12: Kalgoorlie–Boulder Water Use Efficiency Study and Evaluation

Themes: water using equipment

The objective of this study was to investigate the potential to reduce water demand by increasing water use efficiency and, to implement actions based on the study. An emphasis was placed on cost effective, permanent and simple options.

Water use restrictions had been in place over the previous two summers and surveys had shown that the community in general supports them as a means of conserving water. However, it is clear that restrictions do not permanently reduce the demand for water and restrictions on watering times often merely shift the peak of water use, rather than reducing the overall demand.

The project process involved extensive community, stakeholder and trade-ally consultation, the development of a demand model including climate correction, a 200 household residential and selected commercial customer survey, identification and analysis of efficiency options, cost benefit analysis and program design. The study was completed in December 1994 by Preferred Options (Asia-Pacific) Pty Ltd and in February 1995, the W.A. Minister for Water Resources announced a major retrofitting, incentive, auditing and communications program resulting from the study. The $3.5m, one year program had a number of components: free retrofits of water using equipment within residential premises (including toilets), free audits and advice on outdoor water use including vouchers for purchasing mulch and drought resistant plants, free water audits to commercial and industrial customers and an extensive education campaign. The second study, undertaken by the Institute for Sustainable Futures, UTS,, for the Water Corporation of W.A. in 2001, involved evaluating the savings and cost effectiveness of the program using both statistical comparison of participant and comparison groups and climate correction of demand. This study showed that the indoor residential retrofit program saved water in accordance with the estimates, while the outdoor efficiency program was less effective. This was attributed to the limited follow-up and compliance monitoring. The climate correction model developed as part of this study indicated that demand for water was reduced following the program by approximately 1–2 ML/day, from a base of approximately 30ML/day.

5.13 Study 13: Sydney Water Least Cost Planning Study

Themes: water using equipment, water usage practices, climate, demographics & land use

This study was undertaken by the Institute for Sustainable Futures, UTS,, for Sydney Water Corporation (SWC). The work was completed in several phases and involved the development of a detailed end use model for the Sydney water supply region.

The main objective of the study was to develop and design demand management programs that would enable SWC to achieve the demand reduction targets set in its operating licence. The study involved development of an end use model for the residential sector and the develop-

Significant Studies

Continued

ment of a Least Cost Planning (LCP) model to evaluate and compare a range of demand management programs.

In the Phase One Study, the water savings from the demand management programs for the residential sector have been estimated based on existing knowledge for this sector, using ABS data, the Perth 1985 Domestic Water Use Study and other minor studies. Subsequent revisions of the least cost planning model (Phases Two and Three) benefited from evaluative research that had been undertaken in the intervening period, which monitored and assessed savings from implementation of programs, including the retrofit program.

In the case of the non-residential sector, the breakdown of water consumption was limited to its disaggregation into industrial, commercial and institutional sectors. Because of a gap in the knowledge in terms of end-use breakdown of non-residential water use and savings from demand management programs designed for the non-residential sector, water savings were based on assumptions of percentage reduction in water consumption made for each sector.

The non-residential sector forms a significant proportion (approximately 25 per cent) of the total water consumption for SWC. In general, DM programs for the non-residential sector have the potential to provide more savings per customer. However, a number of unknowns remain:

- end-use break-down within different sub-categories of non-residential water consumption;
- water savings that can be expected from demand management programs for a variety of industry types
- typical costs of implementing demand management programs in the non-residential sector
- methods of ensuring effective implementation of demand management measures in the non-residential sector

These gaps mean there is less confidence in the potential savings to be achieved through investment in demand management programs targeting the non-residential sector, despite the significant opportunities that exist in this sector.

5.14 Study 14: Demand Management, Water Efficiency and Reuse in the Hunter Water

Themes: water using equipment, water usage practices, source substitution

The *Integrated Water Resources Plan* published by Hunter Water in 2002, provides details of the demand management and water conservation initiatives taken by Hunter Water Corporation and outcomes to date. It also provides an outline of the programs that Hunter Water has developed as part of its integrated water resource plan. The demand management and supply development options have been compared on an equal basis consistent with least cost planning principles.

The key components of the demand management programs include:

- residential retrofit schemes targeted at the low income group customers residing in the DOH properties and the pensioners;
- integration of the showerhead program with a media based community awareness campaign;
- community awareness strategy focusing on demand management and its integration with broader government, environmental and water conservation initiatives;
- pilot programs targeting outdoor water use;
- water audits for non-residential customers;
- indoor-outdoor consumption monitoring to measure the impact of demand management at local and regional level;
- amending planning legislation to implement water efficiency in new developments;
- leakage management options;
- development of an aggressive water recycling marketing strategy;
- further research into water use patterns, rainwater tanks and water efficient devices; and
- maintenance of a strong water conservation pricing signal.

On the supply side, the plan proposes that no new water sources will be developed within the next ten years. The only investment to be made on the supply side is aimed at improving the efficiency of current storages. It involves construction of a new low-level spillway to more effectively manage stormwater run-off during floods and providing additional storage in the dam.

Significant Studies

Continued

5.15 Study 15: Edmondson Park

Themes: source substitution, water-using equipment

Two reports, *Greenfield Manual–Version 1: New Approaches to Water Services* and *Edmondson Park Feasibility Report* were prepared in July 2002 for Sydney Water Corporation by researchers from CSIRO Urban Water and the Institute for Sustainable Futures, UTS. The main objective was to develop a generic methodology that could identify and evaluate alternative approaches to servicing Greenfield sites, in keeping with the principles of sustainable water management. The study used a real-life case study of a Greenfield site at Edmondson Park, a new urban release area in Sydney's southwest.

A generic methodology is documented in the Greenfield Manual and the specifics of the methodology are covered in the Feasibility Report. The methodology in the Manual and the Edmondson Park solutions were developed following a series of discussions and consultations with key decision makers in the SWC representing potential Manual users, in a series of workshops conducted and facilitated by the team of researchers. External workshops were conducted with key stakeholders including the Environmental Protection Authority, Department of Land and Water Conservation, Landcom (the developer of the site) and the Department of Defence.

The studies focus on the technical options and solutions needed to service the water, wastewater and stormwater management needs of the development site and identify potential barriers and constraints likely to occur during the development process.

Five major categories of option were identified and evaluated for the case study site at Edmondson Park, based on the level and scale of infrastructure options considered for water, wastewater and stormwater services. The options considered for evaluation were: Option 1: Base Case – Business as Usual, Option 2: Regional Level Options, Option 3: Regional/Estate Level Options, Option 4: Estate/Neighbourhood Level Options: and Option 5: Allotment Level Options. In all, the full range of options was considered, from fully centralised (involving water supply pipeline for water, sewer pipe for sewage and stormwater pits and pipes), to fully decentralised options (involving composting toilets for reducing water demand and sewage volume, rainwater tanks for self-supply of water and stormwater collection and using landscapes and pervious surfaces for minimizing stormwater flows and increasing groundwater recharge).

The options were evaluated and ranked using four assessment components: sustainability rating, water balance, costing calculations and barriers and incentives.

The sustainability rating was based on the capacity or extent to which the options achieved the following objectives:

- minimising of resource use
- minimising waste and by-products and maximising resource potential
- maintaining ecological function
- fostering awareness of and engagement with the water cycle
- contributing to amenity
- satisfying utility
- minimising whole of life cost to the community

The water balance and costing calculations quantified the scheme water demand, the volume of sewage and stormwater flow that ended in the infrastructure or disposal points external to the site. Annualised costs were estimated to quantify the costs of the options.

The incentives and barriers associated with each option provided an indication of the feasibility of each and opportunities they provided to create synergies with the power and resources of the stakeholder agencies in a manner that would facilitate provision of sustainable water services to Greenfield development sites.

The methodology and framework developed in these studies are applicable to any urban water utility on the verge of planning water and wastewater services for a Greenfield development site.

The costing calculations used in the study pertain to the cost of the infrastructure associated with each option. The cost calculations do not account for operation and maintenance costs of the options. Externalities associated with each option have also not been accounted for in the calculations.

Significant Studies

Continued

5.16 Study 16: Pimpama–Coomera Integrated Water Master Plan

Themes: source substitution, water using equipment

This study was conducted in November 2002 for Gold Coast Water by GHD Pty Ltd. The objectives of the study were to quantify the need for water cycle infrastructure, to develop opportunities and strategies for an integrated urban water management approach and to prepare a preliminary economic analysis for the strategy options.

The strategic options were assessed against a set of evaluation criteria defined to take into account triple bottom line elements. The approach determined a weighting for each major criterion and scored the options against each of the evaluation criteria. A 'value for money' score was determined by dividing the weighted score by the life-cycle cost.

The options for reducing scheme water demand included: mandatory use of water efficient devices, dual reticulation to use recycled effluent for outdoor use, rainwater tanks to supply laundry, toilet and hot water service, tighter asset creation controls and better system.

The water and wastewater reduction estimates from the options related to water efficiency and efficient wastewater systems were made based on assumptions relating to percentage reduction from the options.

The costing of the options was undertaken from the perspective of the water utility. The benefits associated with the options were not quantified. In addition, the externalities associated with the options were not accounted for.

However further major work is continuing on this project to address issues identified in the November 2002 report, including a recent papers addressing externalities and risk assessment.

5.17 Study 17: Recommendations for Developing a Framework for Assessing Sustainability of Urban Water Systems

Themes: source substitution, water using equipment

Recommendations for Developing a Framework for Assessing Sustainability of Urban Water Systems was published in May 2002 by researchers in CSIRO Urban Water, for Sydney Water Corporation.

The study is a review of methods that can be used to assess the sustainability of urban water systems. Multi-criteria analysis was used as the basis for design and development of a framework for assessing sustainability within the context of Sydney Water Corporation. The study identifies a set of indicators suitable for sustainability assessment. The monitoring strategies corresponding to each of the indicators were recommended.

The framework recommended in this report could be useful as a reporting tool. However, implementation of a sustainable urban water system would require a different kind of framework. The *Greenfield Manual* and *Edmondson Park Feasibility Study* are an attempt to develop such a framework for urban water systems designed and implemented within a specific type of urban development.

Significant Studies

Continued

5.18 Study 18: Sustainable Urban Water Futures

Themes: source substitution

The study was conducted in November 2001, for South East Water Ltd by the Institute for Sustainable Futures, UTS. The objectives of the study were:

- to study the water balance of three distinct types of urban development, namely backlog, Greenfield and infill, within the South East Water Ltd service area;
- to identify various sustainable water management scenarios applicable to each of the three types of urban developments, backlog, Greenfield and infill;
- to undertake a cost-benefit analysis of the scenarios for each development type and to rank them in the order of their present value cost; and
- to identify any barriers (in the form of inconsistencies or gaps in current regulatory frameworks) to implementing these sustainable water management systems.

Options for water and wastewater systems were developed for each of the three types of urban development. The options were developed in keeping with the principles of sustainable water management systems. The study did not include options for stormwater systems within the development.

The cost-benefit analysis included the cost of the infrastructure to the utility, developer and the residents and the benefits to the utility, which were quantified from the savings accrued from the avoided costs of servicing lower volumes of water and wastewater and from any deferral of investment in future supply-augmentation works.

The study is useful in terms of determining various water and wastewater system options for each of the three types of development common to all urban regions. It also provides an indication of relative ranking of options for each type of development. However, as the study is focused on options at the allotment level, the costs and evaluation of the options may not be applicable on a larger scale such as regional scale or estate scale.

The review of regulatory barriers in the study used a framework developed by a Victorian utility. However, the barriers identified are applicable in States that do not yet have regulations that address the decentralised and on-site reuse systems.

5.19 Study 19: Infrastructure Charges Project

Themes: demographics & land use

This report details the structure, inputs and outputs of an Infrastructure Demand Model (IDM) developed for Gold Coast Water. The IDM is an interactive user-friendly program designed to convert planning information into infrastructure demands. This in turn allows planning and designing for water and sewerage infrastructure specifically for the next ten years.

Various scenarios can be run through the model. The input data required includes:

- development type (within each of residential, business, industrial, community purpose, open space, other, special/introduced). Units are in dwellings/ha or ET/ha;
- yield factor 1: percentage of developable land within a specific lot. This is used to account for future roads, floodplain areas etc;
- yield factor 2: percentage of likely development over maximum development;
- historical information;
- existing information;
- projected override values (option to override standard growth projection);
- water billing consumption data (per lot) in kL/annum; and
- projected growth in households and commercial industrial (in ET/hhlds or ET/employees).

The limitations of such a model include the reliability and consistency of the input data. For example, the data sourced for 'Tourist Residential Development Type' includes both residential and non-residential, without differentiating between the two.

There are very few such planning tools in the public domain that project water demand for the non-residential sector. This model is broadly applicable to other Australian urban areas where similar input data sets are available. The report recommends that future users take into consideration several issues, such as inclusion and maintenance of all data sources and associated assumptions, that meter readings per individual lots are not always feasible and might distort results if this not accounted for. Other issues and recommendations are discussed in the report.

Significant Studies

Continued

5.20 Study20: Customer Research Unit Program

Themes: water usage practices – socio-cultural factors, restrictions, regulation, income

"In a Nutshell", was prepared in 2002 by Sydney Water Corporation and summarises "key discoveries 'nutted out' in the ten-year history of Sydney Water's Customer Research Unit". 'Nutshells' are documents prepared by the Customer Research Unit that distil the key community views on all aspects of water. For the purpose of this study, *Section 5.20* will refer predominantly to nutshells related to water demand.

The views of customers presented in "In a Nutshell," are broadly relevant to other WSAA members that are urban water utilities of significant size. The information in the documents from which this report is collated, were collected via regular customer surveys over a period of ten years. This comprehensive report covers community views in relation to pricing changes, drought restrictions and water conservation at large.

"Water Conservation: Synthesis of Sydney Water's customer research 1995–2003" is another significant report by Sydney Water's Customer Research Unit that distils key findings from eleven community research projects related to water conservation. The information gathered for these studies was collected predominantly via telephone surveys of randomly selected customers, with some deliberative polls and focus groups. This synthesis provides a comprehensive summary of community views on water use behaviour, water saving devices, rainwater tanks, recycled water, water restrictions and regulations, provision of sustainable services and communication and information. The document intends to aid water utilities in understanding such views on water conservation and identifying gaps in sufficient knowledge about community views.

5.21 Study 21: ARCWIS research

Themes: demographics and land use, water using equipment, water usage practices – socio-cultural factors, restrictions, regulation, income

Over the past few decades, the social research branch of CSIRO, Australian Research Centre for Water in Society (ARCWIS), has undertaken extensive social research related to customers' water use. This work has primarily been led by Dr Geoff Syme and Blair Nancarrow. More specifically, Syme and Nancarrow has produced publications on:

- review and evaluation of educational residential water conservation campaigns;
- assessing customer attitudes and preferences in relation to level of service, water restriction policies and alternative sources;
- priorities for social change in achieving urban water conservation; and
- relationship between residential lot size and water use.

According to this literature, there is a current lack of quality evaluations on the effectiveness of information campaigns related to water conservation. Those that do exist are predominantly focused on short-term measures, such as drought restrictions. The literature also indicates that perceived outcomes depend heavily on the methodology of the evaluation.

This research is in general applicable to all urban water utilities. It provides an understanding of how communication and education programs can and have influenced customers' knowledge, awareness, attitudes and behaviours and recognises the differences between these four attributes.

6 Findings and Conclusions

6.1 Introduction

Following the investigation of current Australian (and selected international) research on demand management, priority research areas have been identified and recommendations made.

Section 6 addresses:

- research gaps (general and specific findings and knowledge gaps);
- best practice characteristics for undertaking studies related to factors influencing water demand and for undertaking demand management initiatives and evaluations;
- transferability of Australian studies to other utility areas;
- priority research areas; and
- recommendations for future research on priority areas, that is collaborative and cost-effective.

The outputs of this project are formatted in a user-friendly, interactive way to allow for searching under themes or by studies and have been designed in such a way as to allow for additions and updates to be made. This should facilitate further collaboration between members of the water industry in Australia and further coherent research on understanding water demand than has often been the case.

6.2 Research Gaps

Research gaps can include gaps in data, knowledge and management of research.

This section discusses:

- limitations of this study
- general findings; and
- data and knowledge gaps identified by both WSAA members and the ISF study team.

6.2.1 Limitations

This project aimed to provide a picture of recent research undertaken in Australia on understanding water demand. Whilst much of this research is presented in this document, it should be acknowledged that it is not a complete set of research studies. This is owing to a number of factors, including:

- not all WSAA members were invited to participate in the study. Some of these water utilities may have undertaken studies relevant to this project;
- only a limited number of non-WSAA members participated in this study. Some significant research studies on understanding water demand have been undertaken by non-WSAA members, such as CSIRO. Some of these have been captured but not all.
- some knowledge within water utilities is difficult to access because of its existing format (e.g. assumptions in models, anecdotal information, unpublished ongoing programs). Whilst the templates were designed to capture some of this information, time constraints and the scope of the project itself did not allow all this information to be extracted.

Findings and Conclusions

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6.2.2 General findings

This section summarises key findings in relation to the overall research.

In general, a large amount of research is being undertaken in relation to factors influencing water demand and demand management initiatives. However, there is not enough coordination of the research to allow consistency, transparency, comprehensiveness and best-practice methodology.

The research in relation to demand management is currently highly fragmented. In the U.S., this type of research is being coordinated by AWWA in an effective and efficient manner that has allowed for significant advancements in research and knowledge. In Australia, other water-related areas are being well coordinated, such as water quality. WSAA can play a key role in creating a coordinated and efficient approach to research relating to water demand.

The key findings are:

- There is significant potential value for utility cooperation to advance Australian research in demand management. Benefits for utilities could include:
  - increased efficiency;
  - increased cost-effectiveness;
  - reduced duplication;
  - improved quality; and
  - positioning Australian utilities at the forefront of international demand management research.
- Availability and sharing of key knowledge sources is important if the potential for cooperation is to be achieved.
- Evaluation of programs is a critical step in determining their effectiveness and how they can be improved. Results can feed into future models/forecasts for increased accuracy.
- Applicability of data to different locations is limited and there is still a need for local studies (due to variations in local context such as climate, avoided costs for average and peak demands, tourism).
- Actual data resulting from existing studies may often not be transferable to other areas, because of differences in biogeography, climate, socio-demographics, political climate etc. However, the methodologies, models or certain principles behind those studies may be relevant and transferable.
- Many demand forecasting studies have relied on projections of historical metered data, without considering end uses.
- Many climate correction model studies have now been undertaken and there is a clear need for transparency of methodology.

6.2.3 Data and Knowledge Gaps

This section discusses data gaps related to research on factors influencing trends in water demand in Australia. This information has been compiled from several sources:

- existing studies undertaken by WSAA members (via those completed template received from the WSAA members);
- data gaps identified by some WSAA members in templates and
- the research team's expert knowledge of the state of demand management research in Australia.

[7] This column indicates who identified the knowledge gaps. The Study Team refers to the ISF study team working on this project on behalf of WSAA.

Findings and Conclusions

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Data and Knowledge Gaps

Theme	Data gap	WSAA member/ Study team
General	**The extent of influence of factors influencing water demand is uncertain**. "The extent of influence of a variety of factors is often accounted for by variance in the main variables influencing demand (such as climate and population variables). It is not possible to assess the influences of other affects such as GDP impacts, changes to higher density housing, demographic influences, and others outlined in the introductory letter."	Melbourne Water
	A **database** summarising demand forecasting, Demand Management and water efficiency programs;	Gold Coast Water
	Data collection techniques: The first major studies often used customer reports of stocks in their homes and some evidence suggests these are less reliable than is desirable. Hence, appropriate data collection techniques should be used for stock data, which are also capable of collecting information about household appliances. In the U.S., data loggers are sufficient, but in Australia, this may not be appropriate because of huge variation in different toilet types. Data logger studies are never large enough to be significant (i.e. 100 homes). i.e. so, we need to know average use of each time of toilet over time, and stocks in each city. Understanding water-using equipment is more important where we are contemplating accelerating replacement of equipment from the natural rate.	Study team
	Inconsistent classifications for Residential and Non-Residential sectors. There is a need for consistent **use of ANZSIC codes** (or other industry-wide agreed variant) where possible.	Study team
Demographics and Land Use	Trends in **breakdown of industry categories** and sub-categories.	Study team
	Trends in lot size, especially garden/lawn size for both residential and non-residential. There is a strong correlation between garden/lawn size (which can often be inferred from lot size) and lawn/garden irrigation water use;	Study team
	Water use in **multi-residential dwellings** is often difficult to determine, especially because individual meters are not available on multi-dwelling units.	Study team
	Trends in per capita use of customers in **multi-residential dwellings**.	Study team
	Consistent data on trends in **non-residential planning** and land-use	Study team
Water using equipment	**Appliance ratings** and water demands for individual appliances	Brisbane Water
	Stock of A, AA, AAA and no-rating showers: : note problems with ambiguous classification into 'standard' and 'efficient' in several surveys;	Study team
	Actual dual-flush toilet flush volumes, Stock of 6/3L vs. 9/4.5L vs. others; Leakage over time	Study team
	Trends in ownership of **automatic reticulation sprinkler systems** and use of timers.	Study team
	There is a current lack of understanding of stocks of water using equipment in the **non-residential sector**.	Study team
	Whilst there have been several studies undertaken (or in progress) on **stocks of residential water using equipment**, further research is required to strengthen and complement such studies, in addition to gathering data from areas set in a different climatic, legal or other context.	Study team

Findings and Conclusions

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Data and Knowledge Gaps

Continued

Theme	Data gap	WSAA member/ Study team
Water usage practices	How **shower** usage practices can differ with different technologies	Study team
	Perceptions, fears, attitudes, acceptance of **water efficient toilets**.	Study team
	There is currently little understanding of the impact/effectiveness of **education and communication** on reducing water demand. Many complex social and cultural issues influence attitudes to water conservation, which require investigation. For example, Even though rainwater tanks are not the least cost solution, water utilities and local councils are under pressure from community and environmental groups to promote rainwater tanks as a solution to water scarcity.	Study team
	Usage patterns of **irrigation/outdoor** water (frequency and duration of watering).	Study team
	Water use patterns across the day.	Brisbane Water
	There is a gap in our understanding of the impact of **socio-economic variables** on demand, for example, income and education levels.	Study team
	There is always a lag between **new technology** and information on acceptance, water use, practices and stocks.	Study team
Water Supply System	Understanding the extent to which **pressure** can influence bulk water demand in different areas;	Study team
	Bulk/metered data is often not in consistent and appropriate format both across water utilities and within a single utility itself.	Study team
	Most urban water utilities are at a turning point in time when the **water and wastewater infrastructure** are ageing and are due for replacement. They are also in the process of developing an understanding of the various ways in which new developments and infill developments (which are characterised by ageing infrastructure) can be best serviced in a manner that provides sustainable water management solutions (ISF, 2001c).	Study team
Non residential Outdoor and indoor water use	There is a general lack of data on non-residential water use both in Australia and overseas. This is primarily because Industrial Commercial and Institutional (ICI) customers are fairly complex in their water end-use needs and thus need to be individually considered and audited (Vickers, 2001). In addition, it is difficult to develop category-wide benchmarks of ICI water based on average or annual water use per active account (or customer), within an ICI category due to the differences in size of establishments that comprise the category.	Study team

Findings and Conclusions

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6.3 Best Practice Characteristics

Best practice characteristics are described in this section for different types of studies related to *1. Factors influencing water demand*; and *2. Demand management initiatives*. Best practice characteristics related to 1. and 2. are provided for each of:

- water usage practices
- water using equipment
- demographics and land use
- climate
- source substitution
- water supply system.

6.3.1 Water Usage Practices

Best practice characteristics for studies on factors influencing water usage practices include:

- ***Pricing***: Use climate correction to remove climate related variables and allow price elasticity to be determined;
- ***Knowledge and awareness***:
  - ensure representative and deliberative processes are used for public involvement;
  - exploratory research using informal, open-ended face-to-face interviews, which allows participants to express their needs and concerns in their own words (compared to say choosing from a list of 'answers') may improve the accuracy of the responses;
  - it is important to acknowledge that awareness or even attitudes of the community to water use do not necessarily reflect *behaviour* (Morehead, 1989), that is, translate into action. There may be an increased awareness of water conservation as a result of a campaign, which may emerge from follow up interviews and surveys but this may not result in actual reduction of water use;
  - be clear about the objectives of the education and awareness program and evaluate it against these original objectives. Is the objective related to increasing awareness? Attitude changes? Behavioural change?

Best practice characteristics for undertaking demand management programs that change water usage practices include:

- ***Pricing:*** Two-part inclining block price tariff is one of the most common ways of encouraging water efficiency amongst customers. In response to the recent drought a similar pricing structure is being implemented in the residential sector by some water utilities in Australia.
- Pricing as a demand management measure is found to be more effective in regions where outdoor water use forms a relatively large fraction of total water use, as the demand for outdoor water is more elastic than the demand for indoor water. The elasticity of the demand also depends upon whether the measure is being taken as a short-term or emergency response to drought event or as a long-term demand management strategy.

  Pricing policy should be aimed at:
  - implementing water prices that reflect the cost of producing and supplying water;
  - encouraging water saving practices and behaviour from both residential and non-residential customers; and
  - Any changes in pricing structure should be accompanied by other demand management initiatives. This is particularly important when pricing is being employed as a long-term demand management strategy.
- ***Regulation***. Regulation can play an important role in contributing to water demand management. Regulation could be targeted either at water usage practice or at water using equipment. The objective of such regulation is to promote and encourage water efficient practice or equipment.

  The most effective way of influencing installation of water efficient fixtures and devices in the new developments is to incorporate clauses relating to water efficient fixtures in the development controls of local councils.

  The availability of water efficient fixtures in the market can be influenced by implementing mandatory water efficiency performance standards for water using fixtures and appliances and mandatory water efficiency labelling. Such regulation exists in the U.S.
- ***Restrictions***. Climate correction of demand projection has been used by some water utilities for predicting the water savings that can be expected from drought restrictions. There is opportunity for water utilities to collaborate in relation to their experience and findings from such restrictions to improve the understanding and predictability of water savings from drought restrictions.

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- ***Knowledge and awareness***. An education and communication strategy can influence knowledge and awareness. Such a strategy should be seen as an integral part of any demand management initiative.

6.3.2 Water using equipment

Best practice characteristics for undertaking a stock study on water using equipment and appliances include:

- gather specific stock data and water-use data for each technology using appropriate data collection techniques such as data loggers, technical in-house/ building studies, surveys (e.g. face-to-face, telephone, diaries) and secondary data.
- consider opportunities for value adding to a data collection exercise, as data collection can be tedious and expensive. For example, while gathering data, perform retrofits as well, as much of the cost of a retrofit is getting access to household. The technologies themselves and the additional labour costs for installation once inside the house are often very small.
- obtain time series information where possible.
- use end use analysis, including stock models.

Best practice characteristics for undertaking demand management programs that relate to water using equipment include:

- Least Cost Planning principles;
- use of regulatory requirements for all new and renovated buildings to have water efficient appliances/ fixtures (see Regulation);

6.3.3 Demographics and land use

Best practice characteristics for undertaking a study on how demographic factors influence water demand include:

Collecting data on:

- number of households (or population) by dwelling type (e.g. single- or multi-dwelling);
  - average household occupancy by dwelling type;
  - density of multi-residential dwellings (i.e. units/lot);
  - tenure type within dwelling type;
  - lot size (including proportion of lawn/garden area);
  - (other factors: dwelling age, household income);
  - non-residential land use trends.
- Collect time series for all data sets that vary over time, including future projections where available.

6.3.4 Climate

Best practice characteristics for undertaking a study on how climatic factors influence water demand include:

- the use of daily reservoir corrected demand, expressed in per capita or per connection terms;
- transparent methodology, including description of the demand equations and the tests for significance, as well as the variables tested and rejected.

6.3.5 Source Substitution

Best practice characteristics for undertaking a study on how source substitution can influence water demand include:

- evaluation of the savings and the costs and benefits using transparent methods;
- use of whole-of-society life cycle costs.

6.3.6 Water Supply System

Best practice characteristics for undertaking a study on how factors relating to the water supply system influence water demand include:

- for meter replacement programs, it is recommended that old meters be measured following their replacement to determine the effectiveness and usefulness of meter replacement.
- studies of leakage and other components of unaccounted for water should use the currently agreed international framework and terminology.

6.4 Relevance of studies to other areas

An objective of this overall research is to make informed recommendations with respect to opportunities for collaboration between WSAA members for further research. One way this can occur is through sharing methodologies and results from existing studies. This section addresses the general relevance or transferability of studies to other water utilities.

In general, the methodologies and models used in studies are transferable from one urban area to another. However, it is important to note that only best practice methodologies should be considered for use by other water utilities. Transferability of results and recommendations emerging from studies can range from relatively transferable to not at all. A popular belief in the U.S. (and Australian) water conservation community is that primary data should always be collected specifically for the study region. It is often thought that transposing data from one region to another will result in inaccurate outcomes owing to dissimilar characteristics of different cities and regions. While collecting primary data can be more accurate, it is often more expensive than collating existing data. Some factors to consider when assessing the transferability of data from one area are:

- reliability of the original data (including the study methodology);
- applicability of the data to the water utility of concern (considering study region, study period, socio-demographics and climate); and
- sensitivity to variance of the original data when used by another water utility in a specific study or analysis.

In order for some data types emerging from studies on water usage practices to be applicable to other areas of Australia, other relevant variables would need to be relatively consistent. For example, a study in say, 'Area 1', which determined the elasticity of price changes on a particular community, may only be applicable in 'Area 2' if certain variables or factors in 'Area 2' are relatively consistent with 'Area 1'. Such factors in this case may include:

- owner occupant status;
- single-residential versus multi-residential;
- household occupancy;
- geographical distinction; and
- income levels and other socio-economic variables (such as pensioner status).

Stocks of indoor water using technologies in a particular area are often more transferable compared to those of outdoor technologies. Outdoor water using technologies depend more on local climatic and geographic characteristics. For example, evaporative air conditioners have significantly higher penetration rates in areas where evaporation rates are high, such as Western Australia, Northern Territory and some parts of Victoria. The prevalence of water efficient technologies and equipment in an area may also be affected by regulations or guidelines pertaining to that region.

Information about stocks of water using equipment can only be transferred in situations where other external factors are similar. Some such factors may include climate, regulation, presence of water service companies, socio-economics and demographics.

Demographic, land use and climatic/geographic data are difficult to apply to other areas, although the methodologies are often transferable.

Factors of system losses, pressure, unaccounted for water, are typically relevant to all water utilities, however, the extent will usually vary from utility to utility. The method of determining this extent may be transferable from one utility to another, as leakage management options are, while the quantitative results (costs and water savings) are usually system dependent.

Methods for assessing the extent of influence of source substitution on the bulk water supply are generally applicable to all urban areas in Australia, however, actual input data and resulting data may vary from region to region owing to such factors as rainfall, local regulations, land area, industry type and growth.

6.5 Priority research areas

Sections 6.1–6.4 identified research gaps, discussed findings and provided best-practice characteristics for undertaking research in this field. *Section 6.5* draws together the key areas in relation to water demand that require further research. Some of these priority research areas can be undertaken independently (potentially simultaneously), as they typically will involve a discrete group of specialists. While other priority areas may need to be performed consecutively as they may involve similar key personnel.

Priority area needs:

- ***Climate Correction***. It would be useful for utilities to have a consistent and transparent approach to correcting demand forecasting for climate. For example, consistent, historical and regularly updated reservoir-corrected bulk metered data preferably for each supply zone, would assist in forecasting.
- ***Leakage and Pressure Reduction***. In many instances, leakage management is the most cost effective demand management option for water utilities to save the most water from the system. Widely understood knowledge of savings achievable and techniques for leakage management, similar to the IWA framework, would assist utilities.
- ***Demand Forecasting.*** Currently there is a range of models used by water utilities. There are advantages in each water utility developing one demand-forecasting model internally, to ensure consistency within the utility. It is also desirable to ensure all significant factors that influence water demand are included in such a model.
- ***Water Sensitive Urban Design (WSUD)*** (also referred to as Integrated Water Management or Total Water Cycle Management) encourages the integration of water services (such as water, wastewater and stormwater), which are traditionally managed in isolation. Of particular interest is the application of IWM to new infill and Greenfield sites. A significant number

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of recent studies commissioned by WSAA members (including case studies in relation to Edmondson Park in Sydney and Pimpama-Coomera on the Gold-Coast) have demonstrated that for servicing new areas there are potential water resource and economic savings in these strategies. However, there is a need for a more consistent understanding (including assumptions, methods, terminology, costing etc) of the approaches used in these studies.

- ***End Use Analysis.*** Options (both demand and supply-side) can be compared using a least cost planning framework. This will enable the most cost effective option to reduce water demand to be determined. For example, regulating minimum performance standards for water using appliances and equipment is often the most cost-effective demand management option, however, this would only emerge from undertaking end-use analysis to forecast demand.
- ***Outdoor Water Use.*** A significant proportion of urban water demand is outdoor water use. There are a limited number of research studies that assist in characterising outdoor water demand and the impact of programs designed to reduce demand for water in this important group of end uses. However, there is currently a research project being undertaken, commissioned by the Nursery and Garden Industry of Australia (NGIA) on behalf of the NGIA and WSAA (A. Currey, pers. comm.) and the results of this project will be widely available and should be integrated into any future research related to outdoor water used. Further research needs to be undertaken on both characterising outdoor water use and evaluating the effectiveness of demand management programs targeting outdoor water use.
- ***Non-residential Water Use***. The non-residential sector can vary between water utilities. However, it is often a significant proportion (10–40%) of water demand. Significant savings per customer can potentially be achieved in the non-residential sector. Both water use and appropriate implementation of demand management in this sector is poorly characterised.
- ***Rainwater Tank evaluation***. Rainwater tank programs are often raised by the community as a preferred water conservation measure and an increasing amount of utility funds are being invested in rainwater tank programs, especially rebate programs. There is a need to evaluate the impact of such programs and to ensure that they are designed to maximise their effectiveness. Research questions that should be addressed include: what are the actual water savings that are achieved by the program? What end uses are best supplied by rain water (indoor and outdoor)? What is the magnitude of other potential benefits (including those related to stormwater retention)?
- ***Community Preferences.*** There have been numerous studies to date which address community preferences on water use and restrictions (Syme et al, 1983, 1986, 1990, 2000; Roseth, 2003; Newton Wayman Chong & Associates, 2001a, 2001b, 2001c). However, a greater level of engagement of the community, through more deliberative and representative participatory decision-making processes (Carson and Gelber 2001) is required in a range of areas related to the development of demand management strategies, the reliability of water supply, water pricing and the appropriate balance between demand and supply-side options.
- ***Education and Communication***. Education and communication should be an integral part of any demand management initiative. Further research is required to increase understanding of how education, communication and awareness campaigns can influence water demand and which approaches are most effective and acceptable. Evaluations of various types of education and awareness programs can be undertaken to understand their effectiveness and impact on behavioural and attitudinal change.
- ***Evaluation of demand management programs***. There is limited experience in Australia of measuring the effectiveness of demand management programs. Following implementation of a demand management initiative, evaluation (monitoring and assessment) should always be undertaken at an appropriate time.

6.6 Recommendations

This section outlines the recommendations made by the study team that address the research gaps identified in *Section 6.2 Research Gaps*. The recommendations have been developed with the following objectives in mind:

- potential opportunities for collaboration between WSAA members;
- addressing overdue and fast-moving research topics;
- this research is extensive in *breadth*. It enabled a screening of the research to date on factors influencing water demand and demand management initiatives and priorities for next steps to be determined. Thus, the next stage should enable *depth* of research.

The recommendations on further research to address key research gaps identified in this research are a suite of actions summarised as follows:

6.6.1 Continued detailed research on priority areas

Further research on priority areas identified from the gap analysis could involve:

- Literature reviews;
- International best-practice comparisons; and
- Structured interviews with key experts.

This would enable depth of research to be achieved, following the breadth of this first stage to screen for the priority research areas. This research could be undertaken in collaboration with various WSAA members. Such studies could include:

- Development of residential stock studies to collect data on water using equipment, water usage practices, residential lot sizes;
- Collection of information on multi-residential household water demand trends;
- Collection of non-residential trends in industry sectors;
- Further developing programs for individual metering on multi-residential dwellings;
- Evaluation of the non-residential programs that have been implemented by various water utilities and results from such evaluations be published for sharing amongst the water utilities.
- Determining the influence of rainwater tanks on water use behaviour and total water demand; Understanding the perceptions of the community about the role of rainwater tanks as a water conservation measure and the motivating factors behind their willingness to pay for rainwater tanks will provide valuable information to water utilities enabling more informed prioritising of DM programs. This could also provide water utilities with an insight into the community's willingness to pay, which could in turn be used for improving the participation rate of demand management programs that are more cost effective than rainwater tanks .
- A collaborative research project focusing on sustainable solutions for the three types of development (Greenfield, Backlog areas and Infill) on a range of scales will prove valuable, as it will help with the development of a consistent approach to water management across all utilities in different States. It will also provide an impetus to the development of a consistent set of regulations and standards for decentralised systems, which are often part of the sustainable solution for such developments.

Recommendations
Continued

6.6.2 Research Forum Series

The Research Forum series would complement the detailed research on priority areas. The purpose of the Forums is to provide an efficient, cost-effective, immediate means of substantially advancing knowledge and research in priority areas related to water demand in Australia. A Forum could combine several related priority areas. It is recommended that a Forum be held each quarter (on average), hosted at various locations (or 'online'). The outputs of such Forums could be:

- research issues papers (developed prior to workshop, to determine what are the key research questions related to the Forum topic and who should attend);
- publication of all papers presented;
- focused recommendations made to the WSAA Water Health Environment and Sustainability Committee;
- consistent and transparent approach to water demand knowledge and research across all WSAA members.

Recommended research priority areas which could warrant such a Forum include:

- Climate Correction
- Leakage and Pressure Reduction
- Demand Forecasting
- Integrated Water Resource Planning
- End Use Analysis
- Outdoor Water Use
- Non-residential Water Use
- Community Preferences
- Education and Communication
- Evaluation of programs

Suggested priority timeline is provided in *Figure 7*.

6.6.3 Ongoing collaboration between WSAA and WSAA members

It is recommended that WSAA coordinate the ongoing collaboration of research on water demand. It is recommended that a framework or process be developed to ensure the continuation of such collaboration. This may work within the existing structure of the Research Committee. For example, overseeing the recommendations emerging from the Research Forums (described in 3 above) and updating the proposed CD (or website) as new research becomes available.

Recommendations
Continued

6.6.4 Continuation of WSAA CD/ database of Demand Management Studies

The studies presented in the report provide a partial picture of Australian studies on factors influencing water demand. It is therefore recommended that further collation of relevant and significant studies be undertaken to present a more complete picture. It is recommended that both WSAA and non-WSAA members be contacted for further information. This database could be modelled on the North American waterwiser.org, a web-based, interactive, searchable database. The database provides information on demand management programs that are planned, implemented and evaluated across various water utilities in the U.S. and Canada. The database allows the water utility to enter the latest information directly and update information about a DM program by logging in to the database. This database could also update the studies discussed in the Water Wise Manual, by incorporating the results from evaluation studies that have since been undertaken for various DM programs. In addition, details of participation rates and costs of implementation of the programs could be included.

Figure 7 indicates the suggested timeline of research forum areas. This timeline is based on priorities, appropriate groupings of areas and the dependent/independent nature of other areas. Forum A is considered highest priority as it combines techniques and methodologies for determining where resources should be focused (i.e. the 'lowest hanging fruit'). Forum D, Forum E and Forum F may involve some of the same participants and Forum A, hence they should occur after Forum A. Forum B and Forum C are likely to involve different participants.

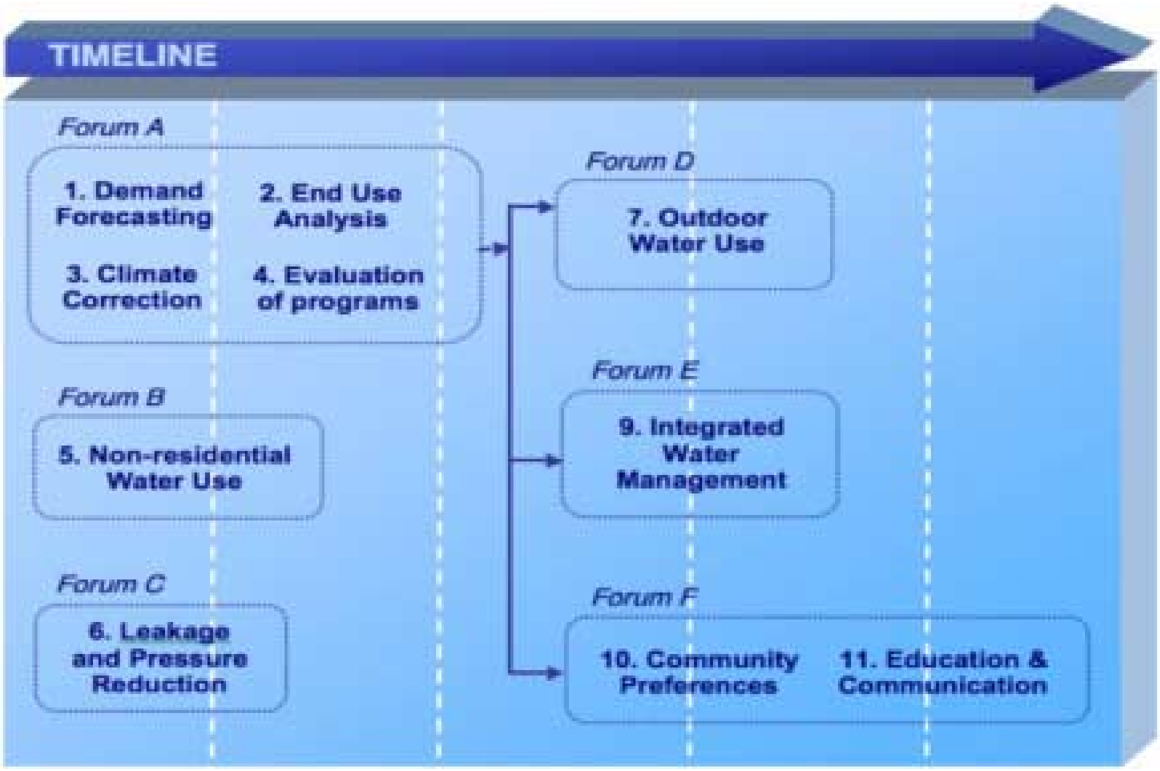

Figure 7: Recommended timeline based on a selected set of priority research areas that would benefit from a forum process.

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Appendix A: Glossary

Attitude	Opinion, perception, not necessarily reflected in behaviour.
Awareness	A consciousness of a particular education/communication program's existence (ie. recognition of a program), however not necessarily an understanding of the program, nor a behaviour or attitude change.
Behaviour	Related to actions and practices, as opposed to thoughts.
Climate Correction	A modelling process to remove impacts of the climate variables from water demand data.
Contingent Valuation Technique	A technique for valuing non-market uses of a natural resource, using surveys to find the willingness to pay for a benefit and/or the compensation required to tolerate a cost. (NSW EPA, 1995)
Demand Forecasting	Predicting future water demand via any means.
Demand Management	The methods used to modify the level and/or timing of demand for a particular resource, in this case potable water. Demand management programs are designed to promote conservation either through changes in consumer behaviour or changes to the stock of resource-using equipment
End Use Analysis	End use analysis involves disaggregating water demand into the 'services' people actually use water to provide (eg. clean clothes).
Instrument	Demand Management Instruments are used to assist in achieving the adoption of a demand management measure. They can be categorised as regulatory, economic or communicative.
Measures	Demand Management Measures increase water efficiency (e.g. AAA rated showerheads), source substitution (e.g. rain water tank installation) or combine the two in alternative system configurations (e.g. grey water reuse system), and can include influencing behaviour such as watering times.
Occupancy rate	The average number of residents per household.
Option	Options combine an instrument and a measure.
Penetration rate	Or Stock, refers to the quantity or percentage of specific types of water efficient fixtures.

Glossary

Continued

Price elasticity The amount by which customers will change their demand for water for a given change in price.

Program Programs consist of a selected group of options.

Regulation For the purpose of this study, regulation refers to longer-term regulatory measures and includes the use of building controls and appliance performance standards. Other measures include mandatory water efficiency labelling of appliances, which could provide a basis for regulation of the performance of these appliances.

Restrictions For the purpose of this study, 'restrictions' refers to short term water use restrictions such as drought restrictions.

Secondary data Secondary data usually adapts existing data from other studies, in some cases extrapolating or interpolating such data. In contrast, primary data collection refers to data collected from a primary or 'original' source, specific to the study area.

Stock See penetration rate.

TWCM Total Water Cycle Management. The TWCM approach recognises water, wastewater and stormwater as three inter-related aspects of one common water cycle8. TWCM recognises the significance and value of adopting an integrated approach to planning of water, wastewater and stormwater systems for a given catchment or sub-catchment or allotment.

WSUD Water Sensitive Urban Design. Traditionally this has referred to sustainable stormwater management, however more recently it has come to refer to the integration of stormwater, water and wastewater services for more efficient and sustainable urban water design.

[8] The water cycle can be represented by a water budget that clearly defines and outlines the source, quality and quantity of water, wastewater and stormwater pertaining within the boundary of a given site. The site may be as small as a household or allotment and can be as large as a sub-catchment, catchment or indeed the entire planet. A water cycle can be defined within the boundary of every catchment, sub-catchment or allotment and household.

Appendix B: Templates A and B

The following is a copy of the headings of the information reporting Templates (A and B) that were provided to participating WSAA-members.

TEMPLATE A-1

1a. Title of the study:
1b. Year of study

2. Objectives of the study:

3. General description of the study, location, climate, sample size etc:

4. Variables measured:

5. Statistical design (controls etc):

6. Description of the analysis:

7. Principal conclusions & recommendations:

8. List of publications relating to the study:

9. Applicability to other areas in Australia? If yes, where? If no, why?

10. Complete Reference:

11. Other Comments:

TEMPLATE B-1

1a. Title of the study:
1b. Year(s) of study

2. The driver(s) for the project/program:

3. The magnitude of the project/program (eg. sample size):

4. Implementation method:

5. Options implemented:

6.Cost of the program:

7. Estimated water and/or cost savings (if available):

8. Methodology of evaluation (hypotheses, variables, controls, replicates):

9. Results of evaluation (including confidence intervals, conclusions if available and major factors considered, such as water/wastewater offsets, integrated planning (cost to utilities and community) and externalities):

10. Complete Reference:

11. Other comments:

Additional Appendices:

Completed templates by participating Member and non-member organisations and other supporting documentation to this paper are available in pdf format. For a copy please email info@wsaa.asn.au.

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