End Use Modelling & Water Efficiency Programs for Arid Zones

The Alice Springs Experience

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Abstract

This paper describes the methods used to gather data and information to build a water end-use model for Alice Springs, a remote town within an arid zone of Australia, and the subsequent application of that data and information to models used in developing a demand management program.

In arid climates outdoor water demand often represents a large proportion of total demand and is difficult to characterize, thus causing difficulties when building an end use model. In the investigations undertaken to build the end use model and demand management program for Alice Springs, a wide variety of low cost data and information sources have been used. These have included: bulk production and customer metered demand; review of previous local studies on water issues; assessment of database information (e.g. swimming pool registration); design and implementation of a resident indoor/outdoor water usage survey (subsequently linked to customer metered demand); interviews with supplier/maintenance specialists (e.g. pools, air conditioners and garden irrigation) and the use of air conditioning experiments.

The results presented in this paper will be useful to practitioners dealing with water efficiency issues in arid zones and will provide details on the cost effective methods that have been employed, on the results of climate correction modeling undertaken and the identification of preliminary water efficiency options evaluated using the principles of least cost planning.

Keywords: end use models, water efficiency/demand management programs, data gathering methods, arid, Australia

1 Background

Alice Springs is a remote town within an arid zone of Australia. The town has relied on a deep aquifer for its primary source of potable water for over 35 years. As the population has increased, the water level of the aquifer has dropped at a rate of approximately 1.5 m per annum, resulting in water currently being extracted from more than 145 m below ground level (SKM, 2000). Also due to population growth, the volume of wastewater produced by the town has increased, resulting in overflows from the wastewater treatment plant passing to an adjacent swamp. This has caused mosquito breeding and health issues as well as alteration of the swamp's natural ecosystem.

Two key bodies within the Northern Territory Government, Power and Water Corporation (PW) and the Department of Infrastructure Planning and Environment (DIPE), have recognised the need to develop a co-ordinated approach to achieve the primary goals of reducing demand on the aquifer and minimising the overflows passing to the swamp. They have therefore set up the Alice Springs Urban Water Management Strategy (ASUWMS) to develop a range of programs to achieve these goals by considering options such as water efficiency/demand management, the use of alternative water sources and re-use of treated effluent. The

Alice Springs Water Efficiency Study, the subject of this paper, covers one aspect of the ASUWMS. The main aim of the Study has been to develop a suite of options (that form a demand management program) to reduce annual and peak potable water demand but also wastewater production.

To achieve this an end use model has been developed in order to provide a baseline projection of future water demand and wastewater production. End use analysis uses the disaggregation of demand into individual sectors (e.g. residential and non residential) and into individual end uses (e.g. toilets, showers and washing machines). This projection, the base case or reference case, has then been used to test how individual options focused on specific sectors and end uses can reduce water demand and wastewater production. These individual options are then costed and the most appropriate suite of options combined using the principles of least cost planning (LCP)[1] to build a demand management program in order to achieve the required goal.

This paper does not provide details of the options and costs being developed under the Study, as these are being finalised at the point this paper was submitted. The paper focuses instead on the cost effective data methods used to build the end use model (e.g. surveys, interviews, experiments). By using these methods the reliability of assumptions used has been increased by enabling assumptions to be cross checked using various sources. The paper also highlights the way in which the various methods have been expanded to assist in the development of the options.

2 Data Sources

In order to build the end use model and develop demand management options specifically for Alice Springs a variety of data sources have been used. These are summarised in Table 1.

Table 1 Data/Information Sources

Data/Information Sources
• Alice Springs bulk water supply and customer metered demand readings.
• Various existing reports on Alice Springs concerning issues such as the aquifer borefield, non-potable supply system, sewage management, community consultation and audits.
• Information from existing Alice Springs databases such as swimming pool registration and building applications.
• Correspondence from PW and DIPE files on previous and planned demand management initiatives.
• Correspondence/discussions with key PW/DIPE staff on system management.
• Australian Bureau of Statistics (ABS) data on demographics and appliance ownership.
• Bureau of meteorology data on climate variables.
• A residential survey carried out at the Alice Springs Show investigating indoor and outdoor water use.
• Experiments in Alice Springs to investigate evaporative air conditioner water usage.
• Face to face and telephone interviews with key customer types and specialist on specific end uses.
• Use of general literature on end uses, stock, water use and demand management programs.

Data logging of appliance usage was not available to input to the model therefore the wide variety of other data sources, identified in Table 1, were used to develop robust cross checked assumptions from independent sources. The large variety of data sources and the design of the survey, interviews and experiments undertaken as part of the Study were all designed to not only provide input to the end use model but to also provide detailed

[1] LCP is an approach in which water supply, water efficiency and other options are compared on the basis of the least cost to society (White & Howe, 1998).

information to develop the demand management options that consider the complexity of implementation issues such as public perception, water quality issues and barriers specific to Alice Springs.

3 The Demand for Water

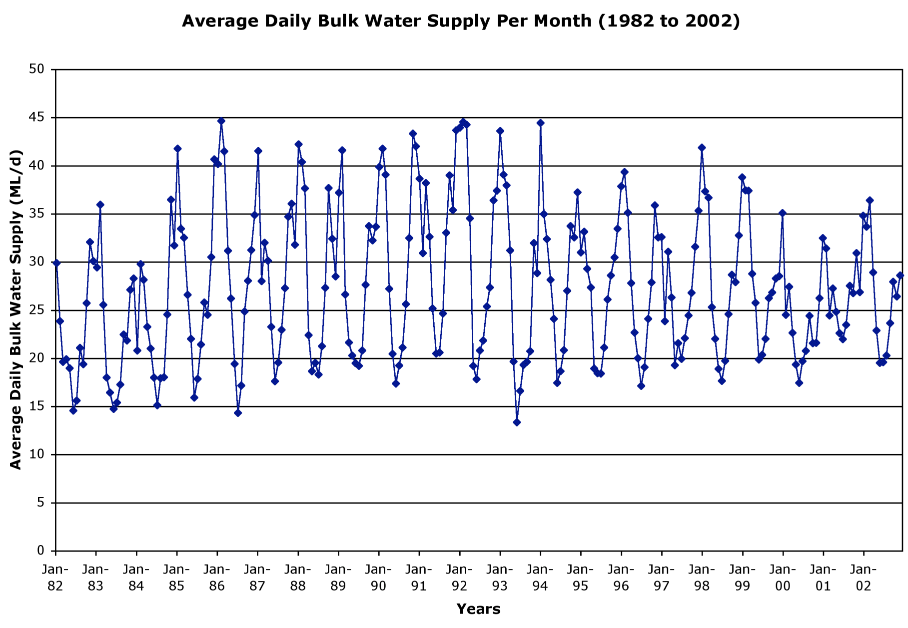
The historical demand for water has been used to understand total and individual sector water demand trends. These have been used to calibrate the reference case projection and to understand seasonal variation, which can assist in determining the relationship between indoor and outdoor demand. Historical demand has been determined using 20 years of bulk water supply records and 10 years of customer metered demand data.

3.1 Bulk Water Supply

In Alice Springs the average bulk water supply over the last 20 years has been approximately 10,000 ML/a. The average daily bulk water supply per month, shown in Figure 1, illustrates the significant variation in peak and minimum monthly demand. As indicated the lowest water demand generally occurs in June and July (southern hemisphere winter) and the peaks most commonly occur in January (southern hemisphere summer). The significant difference between the peak summer and low winter demand months is typical of arid climates (White, 1994) where the outdoor component of water demand is high and influenced by climate variables such as rainfall, evaporation and temperature.

As individual elements within a water supply system are often designed on peak day demand it is generally advantageous to reduce peaks. By reducing peak day demand, system augmentation can often be deferred, providing both capital and operating cost reductions for the water service provider.

Figure 1 Average Daily Bulk Water Supply Per Month



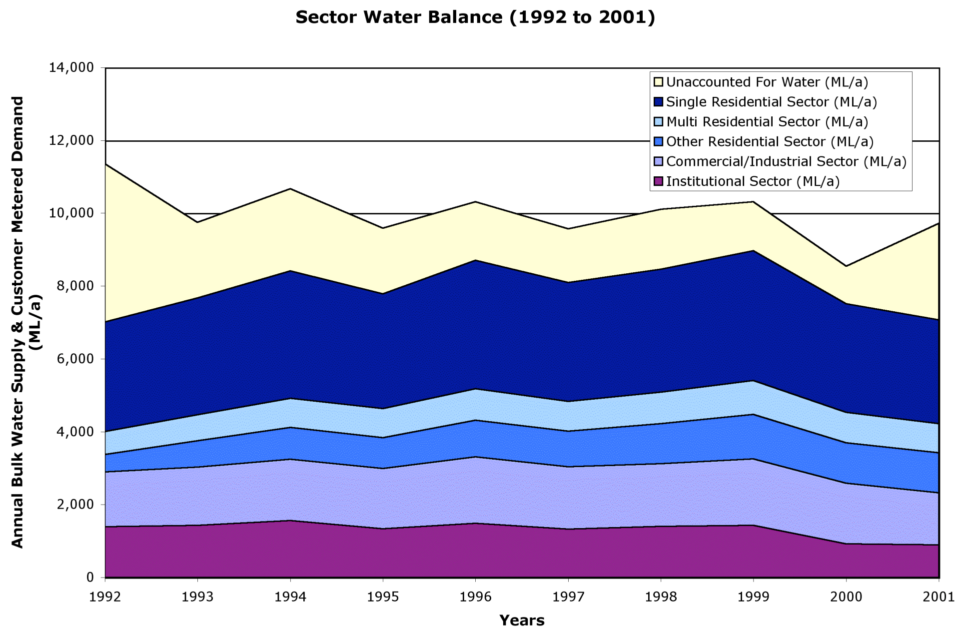
3.2 Water Balance

The difference between bulk water supply and customer metered demand provides details of the water balance within the system and highlights the unaccounted for water (UFW), which is the volume of water lost from the system between the source and the customer meters. This water can be lost through issues such as slow running/faulty meters, leaks, system maintenance and unmetered demand or theft.

Although PW have used volume based charging for many years only 10 years of customer meter readings were available for analysis. Figure 2 shows the water balance for Alice Springs and indicates that UFW reduced from 21% in 1993 to 12% in 2000. From discussion with PW it was found that the high proportion of UFW in 1992 was due to incomplete customer meter readings and the high proportion of UFW (27%) experienced in 2001 was mainly due to a number of faulty customer meters and an undetected system leak. The large proportion of UFW experienced throughout most of 2001 illustrates the need for water service providers to ensure the bulk and customer meter reading databases have systems in place which ensure that high water demand variance associated with faulty meters and leaks can be detected and rectified quickly.

Having found such a large increase in UFW in 2001, PW have carried out a number of leak detection and customer meter replacement initiatives throughout 2002 in order to reduce UFW in the future.

Figure 2 Water Balance



3.3 Customer Metered Demand

Having obtained the water balance, customer metered demand was then used to disaggregate demand into individual sectors in order to input to the end use model and to develop specific sector options. In Alice Springs general coding systems are used for residential, commercial/industrial and institutional customers although other more detailed customers types can be observed due to additional code entries (e.g. schools, airport, hospital). Figure 2 shows the disaggregated residential and non residential sectors together with the UFW. The sectors have been disaggregated into single residential, multi residential (duplex, terraced/town houses, flats, units), other residential (hostels, indigenous communities, unclassified residential), commercial/industrial and institutional. As expected the single residential sector dominates water demand.

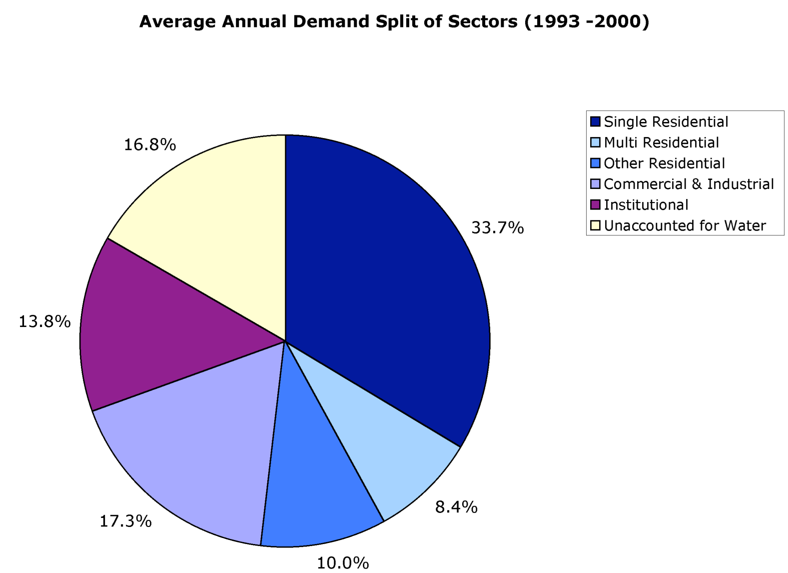
As in many Australian towns and cities, PW generally use one meter for a single, duplex (semi-detached) or multi residential building, making it very difficult to obtain a reading for an individual unit of occupancy. Hence electricity meter readings and toilet pedestal records (used for sewage charges) were used to assist in identifying whether a property was single or multi residential and if multi residential, how many units of occupancy are associated with that property. In addition, discussions with managers responsible for a large number of properties (e.g. public housing and government defence housing) assisted in clarification of units of occupancy associated with individual properties.

The disaggregation of customer meter readings for input to an end use model can be very difficult and most water service provider databases have not been set up for this purpose. However, there is opportunity to modify most databases so that they can include universally accepted codes[2] for sectors and customer types and include the units of occupancy associated with multi residential properties. This modification would mean that databases could still be used for their primary purpose of customer billing but could also assist in clearly disaggregating customer types into sectors and enable the identification of high water use properties/units of occupancy. There is also the opportunity for water service providers to install single meters on all new individual units of occupancy to ensure that water pricing and volume based charging can be used most effectively to influence water demand.

3.4 Sector Demand

The average water demand of individual sectors are shown in Figure 3. The end use model reference case has been built by projecting future demand for each of the sectors identified and by considering various customer types within these sectors.

Figure 3 Breakdown of demand by sector



4 End Uses

Having obtained a picture of the types of customers within Alice Springs and their relative and historical demand, the end uses and associated stock/usage/technology were considered.

4.1 Indoor and Outdoor Water Demand

As expected in an arid climate all sectors had higher water demand during the summer months. In particular, single residential properties were found to have an equivalent average annual demand of 520 kL/household/annum (kl/hh/a) in winter but 870 kL/hh/a demand in summer, resulting in an average annual demand of approximately 708 kL/hh/a. As to be expected, multi residential household demand was considerably less than single residential demand at 280 and 440 kL/hh/a in winter and summer respectively, resulting in an average annual demand of 372 kL/hh/a. This lower average annual demand can mainly be attributed to factors such as lower occupancy and smaller gardens associated with this sector. These average annual demand figures are very high compared to single and multi residential households in other cities situated in non arid areas of

[2] Several water utilities in Australia are currently investigating the use of Standard Industry Classification (SIC) codes for use in customer meter databases.

Australia[3]. From the analysis of the single and multi residential sector, which make up over 42% of total bulk water supply, it was concluded that outdoor demand end uses associated with changes in temperature, rainfall and evaporation were extremely important and needed to be modelled individually.

Indoor and outdoor demand have been modelled separately in the Study to enable the sewage model to be developed from the indoor component of water demand.

4.2 Residential Sector

Considerable information is available on end use data for the indoor components of residential demand from various literature sources and studies carried out in Australia and internationally. However, little specific information is known about outdoor water demand or arid climates.

It was therefore considered essential under the Study to collect specific information concerning indoor and outdoor end uses, stock, usage, technology and behaviour for Alice Springs in order to fill this knowledge gap. A combination of detailed information from the ABS and various other statistical data sources were used, together with information from other cities and countries. These more general data sources were ground truthed using a local survey, interviews carried out in the area and an experiment to confirm their applicability to the Alice Springs situation.

The main residential end uses that have been investigated are shown in Table 2.

Table 2 Residential End Uses

Indoor End Uses	Outdoor End Uses
Toilets	Evaporative Air Conditioners (a/c)
Showers	Swimming Pools
Washing Machines	Garden & Miscellaneous Outdoor
Miscellaneous (including baths, taps, and toilet leakage)	

Note - Although evaporative a/c are used indoors they have been considered as outdoor end uses due to the limited effluent that passes to the wastewater system from this end use.

In the following sections details are provided of some of the more innovative/unusual methods and locally specific end uses investigated under the Study.

The Alice Springs Show Survey

A residential survey was carried out at the annual Alice Springs Show, in July 2002, to obtain information on:

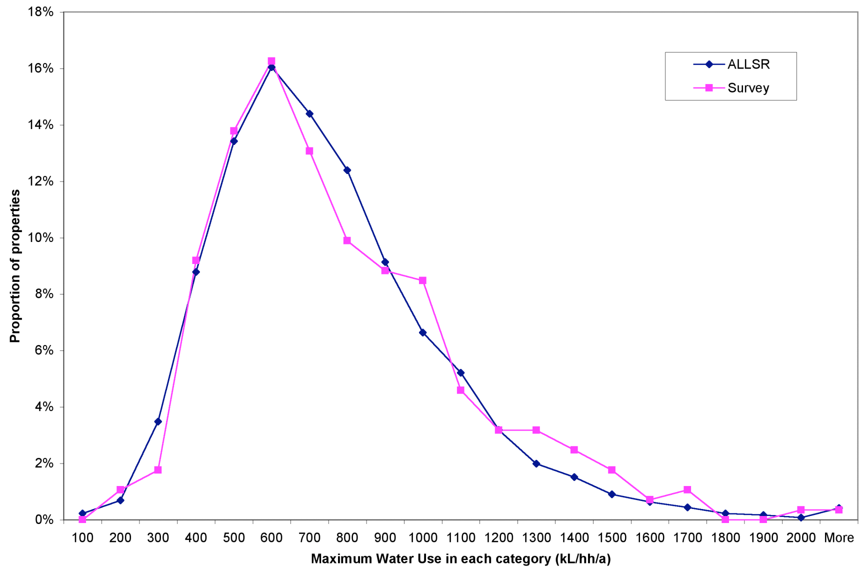
- the proportion of dual flush toilets and efficient showers;
- types of washing machines and number of loads normally used each week;
- number of evaporative air conditioners and their discharge point (e.g. sewer, storm pipeline, garden);
- types and size of gardens;
- types, timing and duration of garden watering; and
- number of swimming pools and pool cover ownership.

To attract people to participate in the survey a water efficient front loading washing machine was offered as a prize. Over 530 surveys were collected from the 8,200 single and multi residential households within Alice Springs (6.5% of single and multi residential households). With the permission of the participants these surveys were linked to customer meter readings. To ensure a representative sample was used for analysis, stratification

[3] A study (ISF, 2002) carried out for Sydney Water Corporation identified a representative sample of single and multi residential households for the Sydney region. Average annual demand was found to be 287 kl/hh/a and 136 kl/hh/a for single and multi residential households respectively.

of the survey meter readings was carried out by splitting the data into single and multi residential properties and then checking these against the consumption figures for the entire single and multi residential data sets. A total of 258 single residential properties from the survey were ultimately used to assist in understanding indoor and outdoor water use as there was a high correlation between the water consumption characteristics of the single residential survey data and the main single residential data set, as indicated in Figure 4. The survey data was therefore used to verify the ABS data on several appliances including the number of dual flush toilets, efficient showerheads and front loading washing machines before input to the end use model.

Figure 4 Single Residential Water Demand



Swimming Pools

Details on the number of pools within Alice Springs were obtained from records of an aerial survey undertaken by the Town Council in the mid 1990s. The Alice Springs Show Survey was also used to identify the number of pools and use of pool covers. Further details on the number of pools, typical size, trends in ownership, issues associated with water use and possible solutions (e.g. pool covers to limit evaporation losses) were discussed with local pool specialists to verify assumptions in the model.

It was found that due to the very low rainfall and high evaporation losses associated with arid climates that evaporation losses alone can be responsible for nearly 3 m^3 per annum of water loss for each 1 m^2 of pool surface area exposed or an average of more than 300 L of water per day from an average pool. It therefore appears that significant water savings can be made by using a pool cover or permanent shading. However, these savings are dependent on the months and timing of the use of the pool covers/shading.

Due to the large number of pools in Alice Springs one option being considered is an incentive program where PW financially support the cost of installation of permanent shading over pools thus reducing evaporation losses. This form of program may attract co-funding from anti-cancer organisations. Alternatively a lower cost option would be to provide a pool cover but this may not be as effective at reducing evaporation losses due to lower usage rates during the peak summer months.

Evaporative Air Conditioners

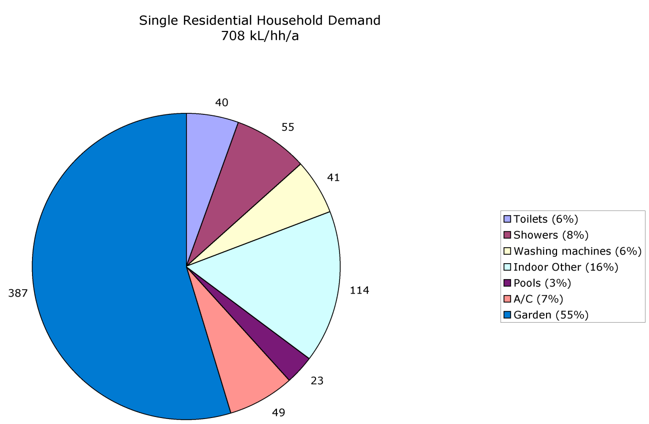
The Alice Springs Show Survey identified that nearly 90% of respondents had evaporative air conditioners (a/c), which are effective in hot dry climates. This very high proportion of evaporative a/c was verified by interviews with local a/c service personnel, who also advised that these a/c are generally used for approximately 10 hours per day for 8 months of the year.

Little reliable data was available on the volume of water used by evaporative a/c. Therefore during the Study, the Arid Land and Environment Council (ALEC) carried out an experiment on seven evaporative a/c units in Alice Springs to measure the water used in both evaporation and bleed off (required to reduce salt build up). The experiment found that for the evaporative a/c units considered that the average evaporation rate per unit ranged from 17 to 30 L/hr and the bleed off rate ranged from 1 to 11 L/hr for units with a pad area ranging from 0.9 to 3.1 m^2 (pers comm. G Marshall, co-ordinator, ALEC, 21/2/03). Discussions with the Alice Springs public housing maintenance staff identified that they set bleed off at 25 L/hr for a typical a/c unit with a pad area of approximately 2.5 m^2 and from discussions with the a/c specialists it was found that manufacturer recommended bleed off rates ranged from 7 to 30 L/hr although bleed off on actual units was often set at less. This range in evaporation and bleed off rates illustrates the need to understand water demand associated with this end use in more detail and that there is considerable scope to save water. It also identifies that a demand management option considering this end use is essential in Alice Springs.

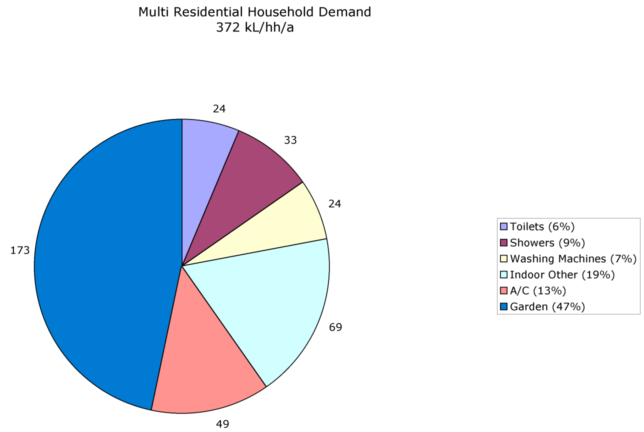
Single & Multi Residential End Uses

The proportional demand estimated for each end use for typical single and multi residential households are shown in Figure 5. It should be noted however that, as indicated in Figure 4 for the single residential sector, the demand for water in both single and multi residential households varies significantly. This indicates that there is considerable scope to obtain water efficiency savings in both single and multi residential households, which have a high annual demand compared with the local average. Targeting some aspects of the demand management program at these higher water use customers has been found to be effective[4].

Figure 5 Typical Single & Multi Residential Demand



[4] Sydney Water Corporation included two targeted options in their demand management program, which has a financial commitment of more than $10 million (AUD) per annum (SWC, 2002).



4.3 Non Residential Sector

Very little is known about end uses within properties in the non residential sector, due to their widely varying characteristics (e.g. schools, hospitals, bakeries, laundries). Hence for the non residential component of end use models the average water demand per property and per head of population for a sector or a customer type is often used instead of detailing the specific end uses. This approach was used in the Alice Springs end use model.

Total annual and seasonal demand for Alice Springs was obtained by disaggregating the non residential sector into commercial/industrial (general commercial and hotels) and institutional (the hospital, schools, Town Council and other institutional properties).

From an audit (DPWS, 1998) on the hospital and several of the schools an understanding of the water demand was obtained as well as the proportion of water used for specific end uses and the efficiency of those end uses. This data was not used to input to the end use model but to calculate the potential savings available and the costs of demand management options for individual customer types.

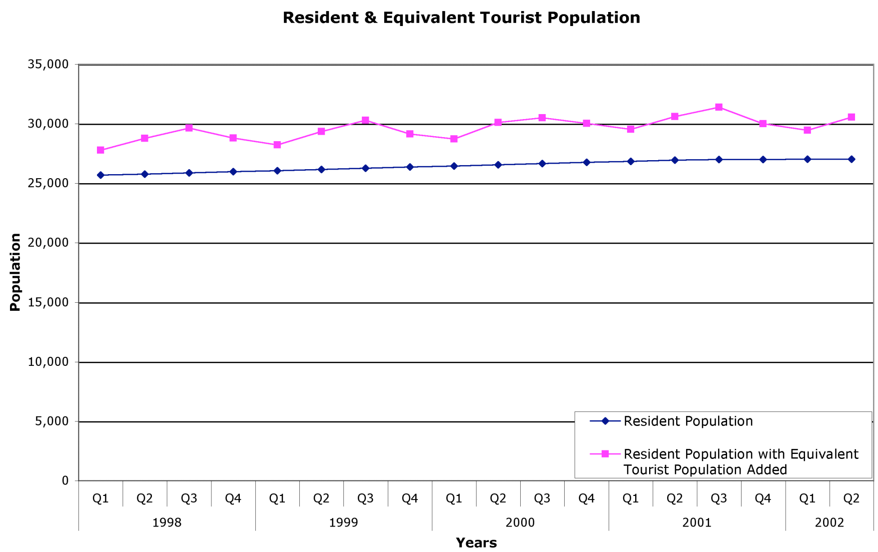
Tourist Accommodation

Due to the importance of tourism in Alice Springs, tourist accommodation (which represents nearly 7% of total bulk water supply) was considered in more detail. Both the trend in visitor numbers and any effect by tourism on the seasonal peaks in water demand and wastewater effluent were considered. ABS data on the number of hotels, motels, backpacker hostels and caravan parks was collected together with the number of bed nights available and guest nights occupied per quarter over the five year period available. The number of establishments identified by ABS was checked against the customer metered data to ensure these customers were extracted from the data set. In addition discussions with PW staff, with local knowledge of the town, ensured that all the large establishments were captured.

From analysis of this data it was found that the peak tourist season was in the cooler winter months yet the peak water demand was in the summer months when the number of tourists were at their lowest. This indicates that tourist accommodation establishments are likely to have high outdoor water demand in summer due to outdoor maintenance of their gardens and pools etc. even though tourists are at their minimum. In addition it indicates that because the number of tourists increases in winter (when evaporation is low) this exacerbates the overflow problems associated with the wastewater treatment plant as it relies on evaporation to minimise overflow.

By understanding these issues and appreciating the proportion and seasonal variation in tourist numbers in relation to the resident population, as indicated in Figure 6, it was evident that both an outdoor and indoor program would be necessary for the tourist establishments and that the ABS bed nights available and guest nights occupied could assist in understanding the savings that could be obtained.

Figure 6 Seasonal Variation of Resident and Equivalent Tourist Population



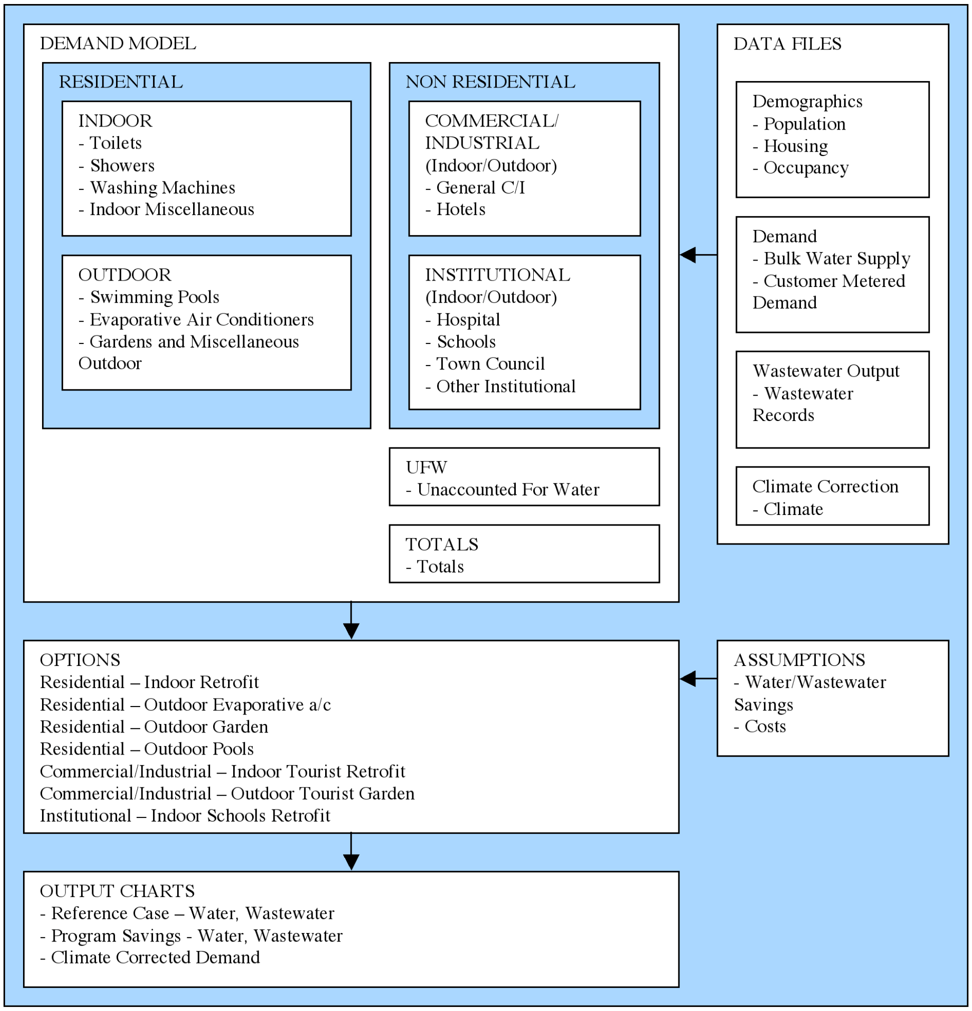
5 The End Use Model

The data gathered and ground truthed for individual end uses and sectors was used to build the end use model. For example, in the outdoor residential sector the number of evaporative air conditioners, how often they are used and their average water consumption together with the current population, housing stock and occupancy ratio were used to identify the proportion of total water used by evaporative air conditioners per capita per day and per household per annum. Then using the projected demographics data the water demand per person and per household for air conditioning was projected to 2021.

The main outputs from the end use model are the water and wastewater reference cases against which the options developed are to be tested. Both the water and wastewater historical reference cases have been calibrated against the bulk water supply, customer metered demand and wastewater output records to further ground truth the accuracy of assumptions and the model developed.

Figure 7 illustrates a simplified version of the various components that make up the model.

Figure 7 End Use Model

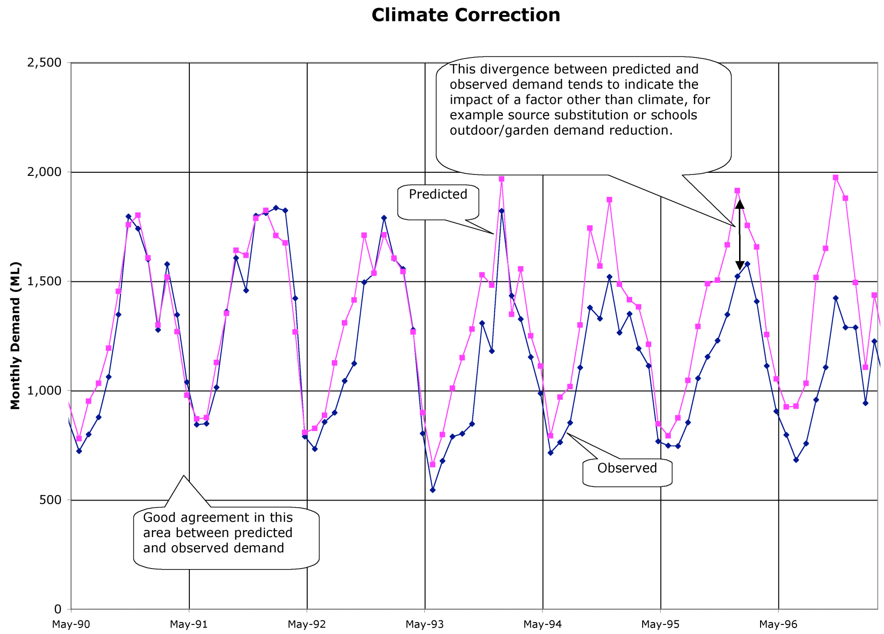


As the seasonal variation in demand for water is so significant in Alice Springs, a climate correction model has also been developed which identifies the impact of climate related variables (e.g. rainfall, evaporation and temperature) on bulk water supply. Using these variables and by correcting for population increase over the 20 year period examined, a predicted bulk water supply demand curve has been developed for Alice Springs. This predicted demand curve, developed through multiple regression analysis, has been plotted against the observed bulk water supply records as shown in Figure 8.

When the two lines follow each other closely this illustrates good agreement between predicted and observed demand. However, where the lines diverge (e.g. observed demand is less than predicted demand) this indicates that some other factor has influenced demand (e.g. a price increase, an alternative water source was brought on line or a leak in the system occurred).

The climate correction model is therefore a useful tool that has enabled assessment of whether previous PW demand management initiatives implemented in the past have had a noticeable impact on water demand. This model will be used in the future to assist in evaluating demand management initiatives implemented as a result of this Study and other PW initiatives.

Figure 8 Climate Corrected Demand



6 Demand Management Options

Having developed the end use model, individual options focusing on specific end uses and customer types are now being developed and tested against the water and wastewater reference cases, to see how they affect total projected demand. The wide variety of data sources and information gathered have assisted in clarifying which options are more likely to succeed. For example, during interviews carried out with plumbers in Alice Springs it became evident that water quality associated with hard water deposits are likely to be of concern. It is therefore likely that hard water deposits may affect water efficient showerheads or tap aerators in a retrofit program and that the use of stainless steel tap seats are more suitable in such areas as they are more robust. Hence a residential program involving retrofitting of showerheads and tap aerators and checking of leaks would need to take this into consideration by building maintenance procedures into the option.

As the options are still being developed details cannot be provided at this stage. However, the kinds of options being considered to reduce water demand and sewage discharge are provided in Table 3.

The ultimate demand management program, which will be taken forward for implementation will be made up of a number of the options similar to those identified in Table 3. It is important to note that each option should be made up of a measure (e.g. water efficiency, source substitution, alternative system configuration) and an instrument (e.g. regulatory, economic or communicative). For example in a residential retrofit option, which includes measures such as the fitting of AAA rated showerheads, tap aerators and fixing household leaks this would be combined with a financial incentive such as a reduced cost visit by an approved PW plumber to carry out the retrofit but would also involve communication material providing water efficiency advice for the customer.

The demand management program being developed will rely on a skilled PW program manager and team to train/co ordinate/liaise with individuals involved. It is likely that the options associated with institutional buildings will be carried out first in order to pilot various aspects of the demand management options developed for other sectors.

Table 3 Demand Management Options

Target Sector/Customer Type	Option
Residential	Indoor tune up/retrofit (subsidised) - for toilets, showers, taps and leaks with ongoing education and maintenance
	Indoor top loading washing machine purchase incentive
	Outdoor efficiency (subsidised) - a/c tune up, garden watering advice on timing/duration/system type with ongoing education and maintenance
	Outdoor cut the lawn & native planting (subsidised) – incentives for reduction of lawn size & use of native arid plants with sign off and inspection required
	Outdoor pool cover purchase incentive
	Indoor/outdoor public housing and government defence housing tune up/retrofit and ongoing maintenance
Non Residential	Hotels (indoor/outdoor) - audit of top 17 of 50 hotels (using 85% of sector water) and subsequent action plan with sign off for subsidies including staff training, appliance retrofit/modification, visitors education material and use of alternative water source
	General commercial/industrial (indoor/outdoor) - audit of top 40 of 700 properties (using 40% of sector water) and subsequent action plan with sign off for subsidies including staff training/education and appliance retrofit/modification.
	Hospital (indoor/outdoor) – audit and action plan including appliance retrofit, staff training/education and use of alternative water source
	Schools (indoor) & water efficiency project – tune up/retrofit for toilets, taps and leaks including ongoing maintenance program and part of school education
	Schools (outdoor) – a/c tune up, garden watering advice on timing/duration/systems and training of staff
	General institutional (indoor/outdoor) – audit of top water using properties (airport, gaol, government department buildings) and subsequent action plan including appliance retrofit/modification, leak detection, staff training/awareness raising, garden watering timing/duration/system modification

7 Costs

The costs of individual options are currently being investigated and thus details cannot be provided at this stage. The interviews with garden, plumbing, a/c and pool specialists are proving invaluable in clarifying costs associated with items such as pool covers, air conditioner maintenance checks and irrigation equipment. This emphasises the need to incorporate costing questions into such interviews.

Once the costs have been finalised for each of the options the associated benefits will also be taken into consideration. This involves the calculation of savings and benefits such as:

- energy reduction for the customer associated with water efficient showerheads;
- reduction of chemical treatment and pumping costs for the water service provider associated with any demand management initiative compared to the reference case: and
- the reduction of sewage effluent pumping costs and reduction in overflows that may be obtained due to reducing indoor demand (e.g. retrofitting standard showerheads and 11 litre single flush toilets in tourist accommodation with water efficient AAA rated showerheads and 6/3 litre dual flush toilets).

8 Conclusions

The development of the end use model and associated options for Alice Springs has highlighted a number of important issues:

- The need to ground truth data/information obtained from other locations/countries to check its applicability in the specific area being considered and to exercise caution when using generic decision support systems that do not allow modification of end use types or water demand associated with specific end uses.
- The importance of using local knowledge to assist in end use model and associated program development and to take advantage of the opportunities that arise from using a variety of low cost methods such as local surveys, interviews and experiments which are specifically designed to provide information for the program being developed.
- The scope to ensure that customer meter databases are made consistent with regard to coding systems used for sectors and customer types and the need to ensure that units of occupancy are included so that these databases can be used for end use analysis as well as for billing purposes.
- The need to fill current knowledge gaps on end uses associated with the non residential sector and outdoor water use in different climates to increase the accuracy of end use models and to enable the considerable water savings associated with these sectors and end uses to be calculated more accurately.

The wide variety of methods used for the Alice Springs Water Efficiency Study have been a very useful and cost effective way in which to develop the end use model and associated options. The methods used have been designed by focusing on the output of the Study, which is a robust demand management program consisting of a suite of options that take into consideration implementation issues. Although the Alice Springs population is relatively small compared to many of the major cities around Australia and the world it is anticipated that the methods used and lessons learnt can be applied to other locations with larger populations.

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Erratum: These graphs replace Figure 5 - Typical Single & Multi Residential Demand.