SEQ residential end use study

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Abstract

Determining the end uses of water in residential (and other sector) properties can facilitate a more proactive approach to water demand management. The analysis of end use data can reveal the predictors of water demand for different end uses (for example, household demographics, washing machine efficiency), thus enabling the government and water businesses to implement targeted communication strategies and rebate programs. This paper represents the first research outputs of the South East Queensland Residential End Use Study (SEQREUS), including a winter 2010 end use breakdown, assessment of the influence of different demographic and appliance/fixture efficiency categories, and winter average day diurnal patterns of end uses.

End Use Analysis Approach

Smart metering has enhanced the capture, transfer, storage and analysis of high-resolution water consumption data (Stewart *et al*. 2010). However, an accurate end use study goes beyond smart metering, requiring the triangulation of data from diverse data sets (Willis *et al*. 2009a). Information on the descriptive, social and behavioural aspects of metered properties, stock inventory audit of water appliances/fixtures, and water use diaries are essential for accurate flow trace analysis (Athuraliya *et al*. 2008; White *et al*. 2004). Software such as Trace Wizard® has provided a key link between measured data and end use disaggregation (DeOreo *et al*. 1999). The SEQREUS has endeavoured to gain all of these data sources to ensure an accurate breakdown of household end use events within the sampling period.

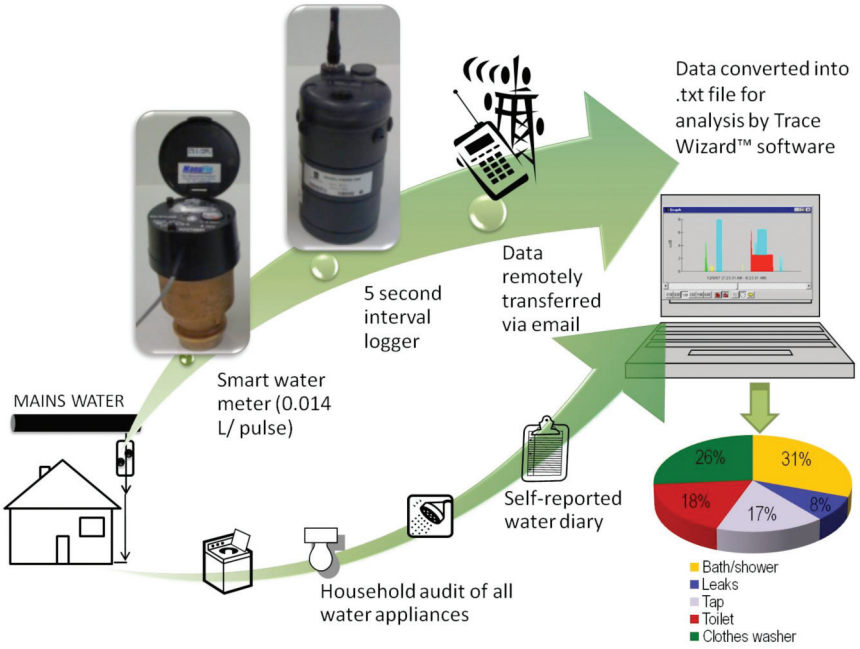


Figure 2: Schematic flow of process for acquisition, capture, transfer and analysis of water flow data.

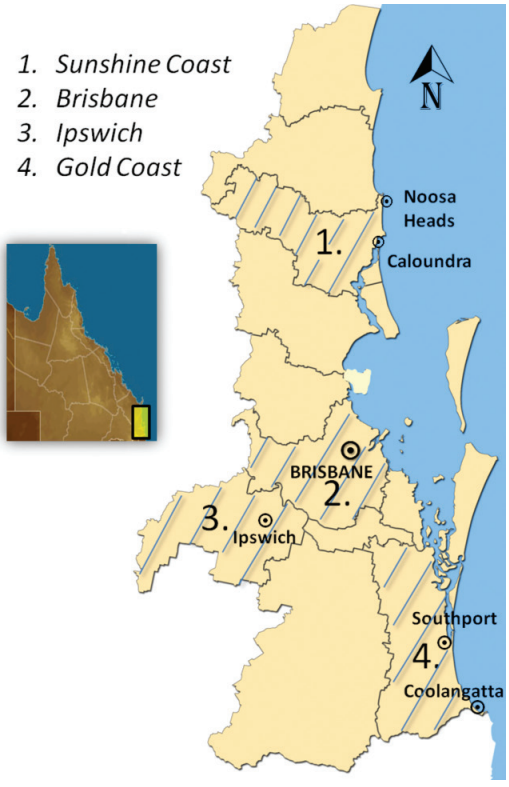


Figure 1: Regions examined in SEQREUS. Inset: Location of SEQ.

Methods

The four study areas were located in the south-east corner of Queensland (Figure 1). A sample of properties was taken from the Sunshine Coast Regional Council, Brisbane City Council, Ipswich City Council and Gold Coast City Council (herein referred to as Sunshine Coast, Brisbane, Ipswich and Gold Coast respectively). A sub-sample for the SEQREUS project was generated from a larger study which involved the completion of a questionnaire of over 1,500 homes across SEQ.

The study sample included only traditional mains-only supplied detached dwellings, which make up the majority of residential stock at present. Existing standard water meters were replaced with high-resolution meters capable of providing 0.014L/pulse outputs in five-second intervals to wireless data loggers. A representative sample of received data was extracted from the database and disaggregated into all end use events associated with the sampled residential households using the Trace Wizard® Version 4.1 software (Aquacraft 2010). A water fixture/appliance stock survey on the study sample was conducted in order to qualify how householders interact with such stock. In addition to the stock survey, each household was asked to complete a water diary where internal and external water use events were recorded over a seven-day period. The relationship between smart metering equipment, household stock inventory surveys and flow trace analysis is shown in Figure 2. A detailed discussion on the research methods is provided in Beal *et al.* (2010).

Results and Discussion

Overall water consumption trends

An average total water consumption of 37L per household per day (L/hh/d) was recorded during the period of analysis.

This represented a per capita average of 145.3L per person per day (L/p/d) (Figure 3). The water use averages fell well below the Permanent Water Conservation Measures (PWCM) target of 200L/p/d as recommended by the Queensland State Government. Furthermore, the average water consumption for the regions monitored were roughly equivalent to the water use achieved during previous enforced high- and medium-level water restrictions. This is an encouraging indication that there is some long-term behavioural shift by residential water consumers, even though SEQ dams are recording close to full capacity and there has been a prolonged relaxation on external water usage.

End use breakdown on a per capita basis indicated that, on average, showers (42.7L/p/d: 29%), taps (27.5L/p/d: 19%) and clothes washers (31L/p/d: 21%) comprised the bulk of the water consumption (Figure 3). Almost 70% (approximately 100L/p/d) of total consumption was attributed to these three activities. The water consumption activity breakdown is shown in Figure 4. Water end use breakdowns varied substantially across (and within) the regions examined. This variation is a reflection of several factors including family size and composition, socio-demographic factors and climate. In all the homes measured, there was water use from the toilet, clothes washer, taps and showers. The remaining end uses analysed (leaks, dishwasher, irrigation and bath tub) were reported in some, but not all, of the homes.

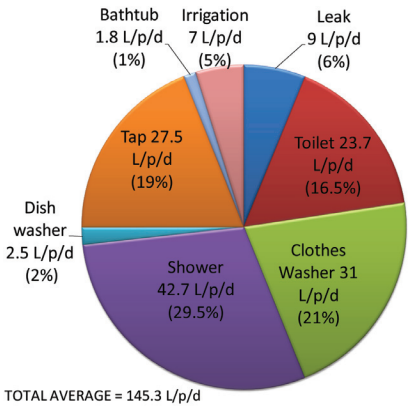


Figure 3: Average daily per capita water end use breakdown for combined SEQ regions.

Interestingly, water consumption for irrigation and general outdoor purposes was found to be low, at an average of only 7L/p/d, which is less than 5% of total consumption (Figure 3). The distribution for irrigation (Figure 4) indicates that half the homes monitored did not register any irrigation use during the period of analysis. The lack of irrigation could be attributed to the winter season when outdoor watering is usually lower than the hotter summer climate. Rainfall prior to the measurement period may also have reduced the need for watering. Additionally, there may be a tendency for lower external watering to occur due to the change in behaviour as a result of the water restrictions adhered to during the relatively recent drought period. However, of the homes that did irrigate (or use water for external purposes), 20% contributed to over 80% of total irrigation water use at an average of 30L/p/d. This *pareto* effect has been observed in other residential water use studies (Willis *et al*. 2009a; Turner *et al*. 2009) and is a good example of why water restriction policy focuses on outdoor use to reduce residential demand (Barrett & Wallace 2009; Inman & Jeffrey 2006).

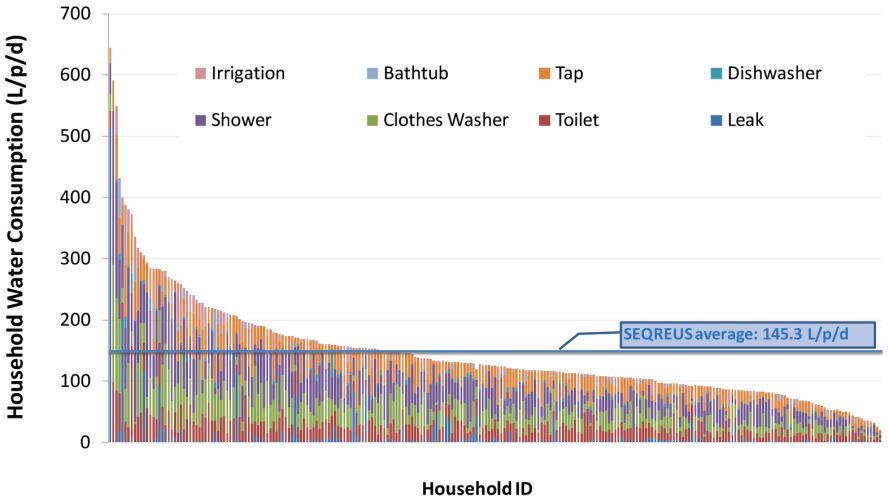
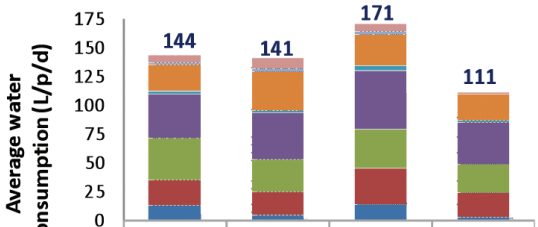


Figure 4: Household per capita consumption (L/p/d) activity breakdown for each participant in the SEQREUS study.



	Brisbane	Gold Coast	Sunshine Coast	Ipswich
Irrigation	7.2	9.4	6.8	1.7
Bathtub	1.8	1.9	2.9	0.0
Tap	22.7	34.2	26.6	23.0
Dish washer	2.3	1.6	4.2	1.4
Shower	38.6	40.9	51.1	36.3
Clothes Washer	35.8	27.9	34.0	24.5
Toilet	22.0	20.6	31.1	21.4
Leak	13.3	4.3	14.1	2.9

Figure 5: Per capita end use breakdown for SEQ regions.

Irrigation has historically been a key contributor to average and peak day demand. However, this study reconfirms other recent findings (Willis *et al*., 2009a) that irrigation may be sustainably reduced into the future and may not return to 30-50% of total residential potable demand (eg, Loh & Coghlan, 2003; Roberts, 2005); summer end use sampling will reinforce this hypothesis.

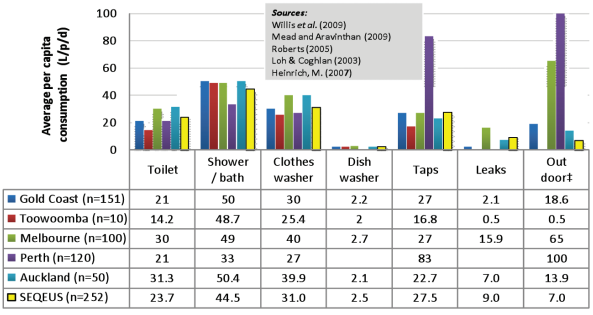
Regional water consumption

In terms of water consumption between regions, there were some clear variations between total water use and some end uses on both a per capita and household basis (Figure 5). Properties located in the Sunshine Coast consumed the most water per capita (171L/p/d) and per home (472L/hh/d). Householders included in the Ipswich sample were clearly the most conservative water consumers, using an average of 111L/p/d (305L/hh/d). In general, there was less variation in total household use in Ipswich than in the other regions. For example, the standard deviation was 46L/p/d for Ipswich, which is low when compared with the average standard deviation for the other regions of 90L/p/d (data not shown). This is unexpected given the smaller sample size for Ipswich, and may suggest that water conservation and water use awareness is more uniform across all family types and socio-demographic groups in this region. This may also partly explain the low overall water use compared to the other regions. (Further examination of water use patterns and

socio-demographics in future reports will explore this more). Brisbane and Gold Coast had similar average per capita and household total water usage at 144 and 141L/p/d and 331 and 348 L/hh/d, respectively. The end uses that varied markedly between regions were showers, leaks and irrigation, as shown in Figure 5. All regional averages were well below the PWCM 200L/p/d water use target.

End use comparisons with similar studies

Volumetric consumption for all end uses fell within the range reported in other studies, with the exception of irrigation (Figure 6). At an average of 7L/p/d, irrigation was noticeably lower for this study compared to the combined average 40L/p/d reported in other studies. On a percentage basis (data not shown), there was good agreement between this study and other end use studies, although again with the noticeable exception of irrigation (5% for SEQREUS versus a combined average of 20% for other studies).



	Toilet	Shower / bath	Clothes washer	Dish washer	Taps	Leaks	Out door‡
Gold Coast (n=151)	21	50	30	2.2	27	2.1	18.6
Toowoomba (n=10)	14.2	48.7	25.4	2	16.8	0.5	0.5
Melbourne (n=100)	30	49	40	2.7	27	15.9	65
Perth (n=120)	21	33	27		83		100
Auckland (n=50)	31.3	50.4	39.9	2.1	22.7	7.0	13.9
SEQEUS (n=252)	23.7	44.5	31.0	2.5	27.5	9.0	7.0

Figure 6 Comparison of average end use consumption between SEQREUS data and other end use studies. Notes: ‡ = Gold Coast study – outdoor mains water use subject to government water restrictions. Toowoomba study – outdoor mains water use prohibited. Yarra Valley Water study – outdoor end use reported for summer only.

Essentially, several factors are likely to be influencing the low irrigation volumes observed in this study. A lingering reluctance to use mains water outdoors as a result of the recent drought and an associated strong awareness of water conservation is one underlying factor. Another is related to seasonal factors, including the relatively frequent rainfall (days > 1mm of rain) in SEQ in the month leading up to the winter 2010 readings, and a much reduced need to irrigate during winter months to sustain grass and plant life.

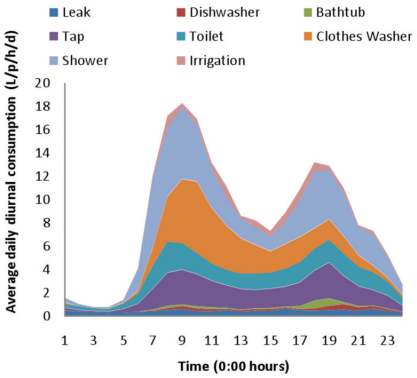


Figure 7: Average day diurnal pattern analysis – SEQ sample (all regions).

As for previous studies, shower usage comprised the bulk of household water use for all regions, with a minimum of one-quarter of all household water demand associated with this practice. This is not unusual and has been reported in other end use studies (Willis *et al*. 2009a, Mead & Aravinthan 2009) Roberts 2005).

Diurnal patterns of water end use consumption

Diurnal pattern data of water end uses provide a representation of the average day and hour flow rates (on a per capita basis) for the residential detached households in the sample. The combined average day diurnal patterns for the four SEQ regions are shown in Figure 7. A value of 18L per person per hour per day (L/p/h/d) peak flow was recorded between 8am–9am in this SEQ average day diurnal pattern for winter 2010. The major contributors to the peak water use periods of 7am–10am were showers, toilets and clothes washers. Similarly, the major contributor to the evening period of 5pm–8 pm were shower, toilet and tap use. All of the regions demonstrated a concentration of washing machine use in the 9am–12 pm period (Figure 7).

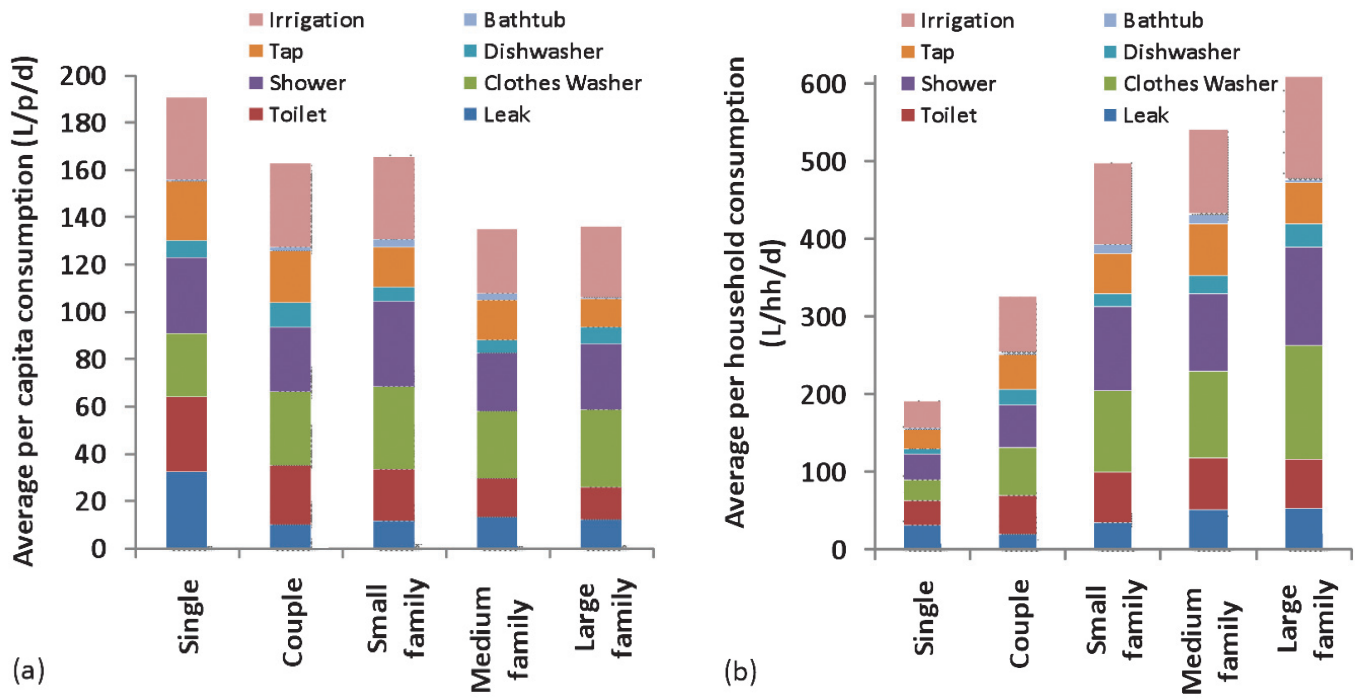
In general, the restrictions on daytime irrigation appear to be adhered to, with the peak times occurring outside these hours, although some irrigation was occurring throughout the day in all regions (Figure 7). As the data in Figure 7 is for the average day for the winter 2010 period, there is likely to be a slight shift during the summer months and if daylight saving was to occur. Peak water use data can be used to compare weekdays to weekends, compare seasonal differences (where irrigation is typically greater in the summer), and also to determine peak hourly and daily consumption for specific occasions where water demand is extreme. Peak and average day diurnal data is critical for many design parameters underpinning pump and pipe infrastructure modelling, future network distribution planning and targeted demand management policy. Smart metering enables diurnal patterns to be established from 'real' field data, thereby enhancing the accuracy of present network modelling parameters founding water distribution infrastructure planning and detailed design.

End use and water appliance efficiencies

The stock surveys undertaken for each home revealed a variety of water-star-rating washing machines, with a clear trend for higher star-rating machines that use less water (Table 1). Estimated annual savings from water-efficient washing machines (front loaders in particular) ranged from 2.5 to 4 kilolitres per person per annum (kL/p/a) or around 7 to 11 kilolitres per household per annum (kL/hh/a). Results demonstrate that the installation of high water-efficiency washing machines could save around 7% of total household consumption.

Table 1: Clothes-washer and shower-head efficiency comparisons.

Description	Clothes-washer efficiency clusters				Shower-head efficiency clusters		
	Efficiency rating		Loading type				
Efficiency feature	≤3 star	≥4 star	Top	Front	Low (A)	Medium (AA)	High (AAA)
Daily use (L/p/d)	35.1	28.3	33.8	22.5	49.7	37.7	35.8
Daily use (L/hh/d)	94.7	76.4	91.2	60.7	139.9	106.7	104.1
Annual use (kL/p/a)	12.8	10.3	12.3	8.2	18.1	14.1	13.1
Annual use (kL/hh/a)	34.6	27.9	33.3	22.2	51.1	39.0	38.0



(a) Per capita end use consumption

(b) Per household end use consumption

Figure 8: Average end use consumption for different household types.

Table 1 shows that replacing low-efficient with high-efficient shower-heads could provide household savings of at least 13kL/hh/a (or over 25%), lower than reported by Willis *et al*. (2009b); however, the percentage of householders that were reported to have high-efficient/low-flow showerheads in this study was over 70%. Additionally, shower consumption for this study was lower than several of the previous studies, including Willis *et al*. (2009b), suggesting that the margin for savings will be less as the technology has already been widely adopted in the SEQREUS sample.

End use patterns and socio-demographics

End use comparisons were made between different household types. Households were grouped into single (1 person), adult household (2 people), small family (eg, 2 adults and 1 child), medium family (eg, 2 adults and 2 children) and large family (5 or more people). The water consumption pattern for a single household shows a relatively even consumption across all end uses, with a growing trend for higher clothes-washer, shower and tap use as the households become larger (Figure 8). Bathtub use is also apparent mainly in the households with families.

On a per capita basis (Figure 8a), larger families are typically more water efficient than smaller households, whereas the opposite is typically found on a per household basis (Figure 8b). Analysis also showed a trend for higher-income families to have larger households but use relatively less water than lower-income, smaller families (data not shown). There was a noticeable tendency for older householders to use more water. Although neither relationship was statistically significant, this may reflect the likelihood of the occupants of a higher income household to be away from home for greater periods, when compared to low income groups such as single parent families and pensioners. Willis *et al*. (2009b) found no significant differences between water consumption across four different socio-economic groups, although the higher-income group used the least volume of water during the period of analysis.

Conclusions

The water end use consumption reported for this study confirms the anecdotal and government reporting of a shift towards lower residential water consumption post-drought in SEQ. The attitudes and water use behaviours of people have generally moved toward a more conservative approach to water use. This increased awareness, together with ongoing water conservation measures for much of SEQ, was likely to maintain a generally low consumption rate of water during the winter of 2010. A summer 2010/11 end use sample will enable better understanding of seasonal influences on water end uses, particularly irrigation.

Water demand management key points for stakeholders in this project include:

- Non-compliant irrigation between 10am and 4pm, particularly for homes in the Sunshine and Gold Coasts;
- Water-efficient fittings for showers and taps continue to provide a least-cost water demand management option for conserving water;
- Changing to water-efficient washing machines significantly reduces household consumption; and
- A trend for higher per capita water consumption for older, lower income, smaller-sized households.

Future Reporting

End use analysis will also be completed for other seasons (for example, summer 2010/11) where more detailed analysis and discussion will cover:

- Comparative assessments between clustered samples based on demographics, households with different fixture/appliance star ratings;
- Water end use diurnal patterns;
- Analysis of leakage volumes and leak typology patterns; and

- Comparisons of end uses before and after a range of interventions instigated through an associated research project.

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