The South East Queensland Residential End Use Study Stage 2

Final report and summary of SEQ water consumption trends from 2010 to 2014

November 2014
ACKNOWLEDGEMENTS
This research was funded by Unitywater and Queensland Urban Utilities. The authors gratefully acknowledge the support for this project provided by Luisa Magalhaes and the metering team at Unitywater and Matthew Bower (formerly at QUU) and his team at Queensland Urban Utilities. Thanks also go to Mark Askins (Seqwater), Lisa Stewart (Griffith University). Griffith University’s eResearch Services group developed the Smart Meter Information Portal that was integral in the gathering, management and visualisation of the remote smart meter data used in this research.

CITATION

COPYRIGHT
© 2014 GU. To the extent permitted by law, all rights are reserved and no part of this publication covered by copyright may be reproduced or copied in any form or by any means except with the written permission of GU.
## CONTENTS

1. INTRODUCTION ........................................................................................................... 1

2. RESEARCH METHOD .................................................................................................. 3
   2.1. Sample Selection Process ...................................................................................... 3
   2.2. End-use Measurement Approach .......................................................................... 3
      2.2.1. Instrumentation for data capture ................................................................. 4
      2.2.2. Data analysis ................................................................................................. 4
      2.2.3. Household stock audits and water diaries ................................................... 5
      2.2.4. Smart Meter Information Portal ................................................................. 5

3. SITUATIONAL CONTEXT .............................................................................................. 7
   3.1. Sample size and characteristics .......................................................................... 7
   3.2. Climatic conditions during analysis periods ...................................................... 7

4. TOTAL WATER CONSUMPTION TRENDS: 2010 - 2013 ........................................ 11
   4.1. Total water consumption – combined SEQ region ............................................. 11
   4.2. Total water consumption – Individual SEQ regions ........................................... 14
      4.2.1. Brisbane and Ipswich Monthly Trends ......................................................... 14
      4.2.2. Sunshine Coast Monthly Trends ................................................................. 16
      4.2.3. Other SEQ Region Monthly Trends ......................................................... 18

5. WATER USE REBOUND TRENDS IN SEQ ............................................................. 21
   5.1. Investigating the post-drought and post-flood water use rebound ..................... 21
   5.2. Environmental drivers of water demand ......................................................... 21
   5.3. Outdoor versus indoor uses ............................................................................. 24
   5.4. Mandatory versus voluntary demand management ........................................ 25

6. WATER END-USE CONSUMPTION – DEC to JAN 2011/12 .................................. 27
   6.1. Combined Regions ............................................................................................ 27
   6.2. Individual Regions .......................................................................................... 28
      6.2.1. Summary .................................................................................................. 28
      6.2.2. Brisbane ................................................................................................... 29
      6.2.3. Ipswich ...................................................................................................... 30
      6.2.4. Sunshine Coast ....................................................................................... 30

7. WATER END-USE CONSUMPTION – MARCH 2012 ........................................... 31
   7.1. Combined Regions ............................................................................................ 31
   7.2. Individual Regions .......................................................................................... 32
      7.2.1. Summary .................................................................................................. 32
      7.2.2. Brisbane ................................................................................................... 33
      7.2.3. Ipswich ...................................................................................................... 33
      7.2.4. Sunshine Coast ....................................................................................... 34

8. WATER END-USE CONSUMPTION – SEPTEMBER 2012 .................................. 35
   8.1. Combined Regions ............................................................................................ 35
   8.2. Individual Regions .......................................................................................... 36
      8.2.1. Summary .................................................................................................. 36
      8.2.2. Brisbane and Ipswich ............................................................................... 36
      8.2.3. Sunshine Coast ....................................................................................... 38
      8.2.4. Other SEQ regions .................................................................................. 38

9. WATER END-USE CONSUMPTION – NOV - DEC 2012 .................................... 39
   9.1. Combined Regions ............................................................................................ 39
   9.2. Individual regions ........................................................................................... 40
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Schematic flow of processes in the mixed method approach.</td>
<td>3</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Measurement and data storage equipment.</td>
<td>4</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Household stock audit and weekly water use diary examples.</td>
<td>5</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Regions examined. Inset: location of SEQ.</td>
<td>7</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Rainfall and temperature daily trend throughout SEQREUS Stage 2.</td>
<td>9</td>
</tr>
<tr>
<td>Figure 6</td>
<td>Relationship between 30 day moving average daily climate data.</td>
<td>11</td>
</tr>
<tr>
<td>Figure 7</td>
<td>Combined average water consumption.</td>
<td>12</td>
</tr>
<tr>
<td>Figure 8</td>
<td>Yearly breakdown of av. monthly consumption</td>
<td>13</td>
</tr>
<tr>
<td>Figure 9</td>
<td>Brisbane and Ipswich average monthly water use.</td>
<td>14</td>
</tr>
<tr>
<td>Figure 10</td>
<td>Brisbane and Ipswich yearly breakdown of average monthly water use.</td>
<td>15</td>
</tr>
<tr>
<td>Figure 11</td>
<td>Sunshine Coast average monthly water use.</td>
<td>16</td>
</tr>
<tr>
<td>Figure 12</td>
<td>Sunshine Coast yearly breakdown of average monthly water use.</td>
<td>17</td>
</tr>
<tr>
<td>Figure 13</td>
<td>Other SEQ region average monthly water use.</td>
<td>18</td>
</tr>
<tr>
<td>Figure 14</td>
<td>Other SEQ region yearly breakdown of average monthly water use.</td>
<td>19</td>
</tr>
<tr>
<td>Figure 15</td>
<td>Two week moving average data for SEQ regions.</td>
<td>22</td>
</tr>
<tr>
<td>Figure 16</td>
<td>Trend weekly water consumption.</td>
<td>23</td>
</tr>
<tr>
<td>Figure 17</td>
<td>Trend comparison for outdoor water use proportions over time.</td>
<td>25</td>
</tr>
<tr>
<td>Figure 18</td>
<td>Bulk water demand trend pre, during and post-drought water restrictions.</td>
<td>26</td>
</tr>
<tr>
<td>Figure 19</td>
<td>Average daily water end-use summer 2011 breakdown for all SEQ regions.</td>
<td>27</td>
</tr>
<tr>
<td>Figure 20</td>
<td>Average daily water end-use summer 2011 breakdown by household.</td>
<td>28</td>
</tr>
<tr>
<td>Figure 21</td>
<td>Breakdown of average summer 2011 end-uses by region.</td>
<td>28</td>
</tr>
<tr>
<td>Figure 22</td>
<td>Average percentage of total summer 2011 water consumption.</td>
<td>29</td>
</tr>
<tr>
<td>Figure 23</td>
<td>Break down of average summer 2011 end-uses for Brisbane.</td>
<td>29</td>
</tr>
<tr>
<td>Figure 24</td>
<td>Break down of average summer 2011 end-uses for Ipswich.</td>
<td>30</td>
</tr>
<tr>
<td>Figure 25</td>
<td>Break down of average summer 2011 end-uses for the Sunshine Coast.</td>
<td>30</td>
</tr>
<tr>
<td>Figure 26</td>
<td>Average daily water end-use autumn 2012 breakdown for all SEQ regions.</td>
<td>31</td>
</tr>
<tr>
<td>Figure 27</td>
<td>Average daily water end-use March 2012 breakdown by household.</td>
<td>32</td>
</tr>
<tr>
<td>Figure 28</td>
<td>Breakdown of average March 2012 end-uses for each region.</td>
<td>32</td>
</tr>
<tr>
<td>Figure 29</td>
<td>Average percentage of total March 2012 water consumption.</td>
<td>33</td>
</tr>
<tr>
<td>Figure 30</td>
<td>Break down of average a March 2012 end-uses for Brisbane.</td>
<td>33</td>
</tr>
<tr>
<td>Figure 31</td>
<td>Break down of average March 2012 end-uses for Ipswich.</td>
<td>34</td>
</tr>
<tr>
<td>Figure 32</td>
<td>Break down of March 2012 end-uses for the Sunshine Coast.</td>
<td>34</td>
</tr>
<tr>
<td>Figure 33</td>
<td>Average per household daily water end-use breakdown all SEQ regions.</td>
<td>35</td>
</tr>
<tr>
<td>Figure 34</td>
<td>Average per capita daily water end-use breakdown all SEQ regions.</td>
<td>35</td>
</tr>
<tr>
<td>Figure 35</td>
<td>Breakdown of average end-uses by region.</td>
<td>36</td>
</tr>
<tr>
<td>Figure 36</td>
<td>Break down of average end-uses for Brisbane.</td>
<td>37</td>
</tr>
<tr>
<td>Figure 37</td>
<td>Break down of average end-uses for Ipswich.</td>
<td>37</td>
</tr>
<tr>
<td>Figure 38</td>
<td>Break down of average end-uses for combined Brisbane and Ipswich.</td>
<td>37</td>
</tr>
<tr>
<td>Figure 39</td>
<td>Break down of average end-uses for the Sunshine Coast.</td>
<td>38</td>
</tr>
<tr>
<td>Figure 40</td>
<td>Break down of average end-uses for other SEQ region households.</td>
<td>38</td>
</tr>
<tr>
<td>Figure 41</td>
<td>Average per household daily water end-use breakdown all SEQ regions.</td>
<td>39</td>
</tr>
<tr>
<td>Figure 42</td>
<td>Average per capita daily water end-use breakdown all SEQ regions.</td>
<td>39</td>
</tr>
<tr>
<td>Figure 43</td>
<td>Breakdown of average end-uses by region.</td>
<td>40</td>
</tr>
<tr>
<td>Figure 44</td>
<td>Break down of average end-uses for combined Brisbane and Ipswich.</td>
<td>40</td>
</tr>
<tr>
<td>Figure 45</td>
<td>Break down of average end-uses for Brisbane households.</td>
<td>41</td>
</tr>
<tr>
<td>Figure 46</td>
<td>Break down of average end-uses for Ipswich households.</td>
<td>41</td>
</tr>
<tr>
<td>Figure 47</td>
<td>Break down of average end-uses for the Sunshine Coast.</td>
<td>42</td>
</tr>
<tr>
<td>Figure 48</td>
<td>Break down of average end-uses for other SEQ region households.</td>
<td>42</td>
</tr>
<tr>
<td>Figure 49</td>
<td>Average per household daily water end-use breakdown all SEQ regions.</td>
<td>43</td>
</tr>
<tr>
<td>Figure 50</td>
<td>Average per capita daily water end-use breakdown all SEQ regions.</td>
<td>43</td>
</tr>
<tr>
<td>Figure 51</td>
<td>Breakdown of average end-uses by region.</td>
<td>44</td>
</tr>
</tbody>
</table>
LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>General characteristics of monitored households for all periods of analyses</td>
<td>8</td>
</tr>
<tr>
<td>Table 2</td>
<td>Climate data during the period of flow trace analyses</td>
<td>9</td>
</tr>
<tr>
<td>Table 3</td>
<td>Data from four climate conditions for the SEQREUS</td>
<td>24</td>
</tr>
<tr>
<td>Table 4</td>
<td>Parameters used for estimating diurnal water savings from behavioural</td>
<td>73</td>
</tr>
<tr>
<td>Table 5</td>
<td>Interventions</td>
<td></td>
</tr>
<tr>
<td>Table 6</td>
<td>Scenarios for encouraging water use behavioural shifts away from peak times</td>
<td>74</td>
</tr>
<tr>
<td>Table 7</td>
<td>Summary of estimated peak hour demand savings from baseline demand scenarios</td>
<td>81</td>
</tr>
</tbody>
</table>
1. INTRODUCTION

This report represents the final deliverable for the Stage 2 South East Queensland Residential End-use Study (SEQREUS). It also presents in summary some of the associated work that has arisen from over four years of water use monitoring in SEQ residential properties.

Three previous reports for the SEQREUS Stage 2 have been completed as deliverables to the industry partners (Unitywater and QUU) who have funded the second stage of the SEQREUS. The methods for sample selection, metering and data analysis are provided in previous reports so will only be presented briefly here. For a detailed explanation of the methodology please refer to Beal and Stewart (2011): http://www.urbanwateralliance.org.au/publications/UWSRA-tr47.pdf.

The project aims to remotely collect and analyse detached residential end-use data for a sample of households located within local government areas in South East Queensland (SEQ). The study aims to gather water consumption end-use results that can influence government and water business demand management policy and practice, with respect to water demand modelling, future infrastructure planning, leak management, householders’ response to changed water policy (i.e. restrictions or pricing), and more. Currently, there is little long term, measured data available, particularly at an end-use level (e.g. data on the proportion of water used for various household activities). Moreover, seasonal data and post-drought/post restrictions data is particularly important to track any rebound consumption activity and identify the end-uses, socio-demographic clusters and regions that are contributing to this rebound.

The objective of this final report is to present a complete summary of the results across the life of the SEQREUS project, with emphasis on the last two years of monitoring outcomes (Stage 2). The SEQREUS project has been activated since January 2010 and has come to close at the end of January, 2014. Borne on the tail of SEQ most severe drought in decades, the original aim of the project (Stage 1) was driven chiefly by water demand management through the understanding and subsequent targeting of specific end-uses to reduce water consumption and promote water conservation. However, 5 years hence, there is a different political landscape and the security of supply in SEQ is now much more resilient with climate-independent sources having been constructed (if not utilised as yet), such as the Tugun desalination plant and a world class advanced wastewater treatment network for indirect potable reuse into the major SEQ water supply (Wivenhoe Dam).

Together with two substantial flood events, and full water supply dams across the region, urban SEQ water conservation and efficiency programs have all but disappeared from the local and state government agendas. Indeed, residents have been encouraged in some cases to increase their water consumption, particularly outdoor use, to assist in cost-recovery (through revenue) of securing SEQ water supply. It is noteworthy to mention that a large portion of regional and rural Queensland continues to remain drought-affected, with some areas officially drought declared for many months.

Thus the objectives of the Stage 2 SEQREUS were less focused on water consumption for the purposes of demand management but rather to track the changes to water end-use demand over the long term to assist in forecasting, optimizing future water network infrastructure, leak management, peak usage patterns and examining the rebounding effects of outdoor water consumption. The Stage 2 outcomes have been presented in three previous reports:

1. Technical report No. 1 – December (Summer) 2011 and March (Autumn) 2012
2. Technical report No. 2 – September (Spring) 2012
3. Technical report No. 3 – December (Summer) 2012 and May (Autumn) 2013

This final report will present:

1. A timeline summary of the latest total water use trends to date, including Summer 2013-2014
2. Overall trends for SEQ water consumption from 2010 to 2014
3. Outdoor consumption and water use rebound trend analysis
4. Breakdown of all water end-use analyses for the Stage 2 project (i.e. Summer 2011 to Spring 2013).
5. Flow clustering of end-use reads to help ascertain the proportion of non-registered flow occurring in the SEQ sample of households.
6. Diurnal demand patterns and peak flows
7. Predictions on potential savings to water demand from technical and behavioural ‘interventions’ or otherwise known as social marketing strategies.
8. Appendices containing the table of contents of the three previous technical reports and list of all publications to arise from the SEQREUS.
2. RESEARCH METHOD

2.1. Sample Selection Process

A sub-sample for the SEQREUS project was generated from the larger Systematic Social Analysis (SSA) demand management study, which involved the completion of a questionnaire by over 1,500 homes across SEQ (Fielding et al. 2012). From this pool, a smaller sub-sample of homes in each study region consented to the SEQREUS project. A desktop filtering and quality control process was applied to each of the households that consented to be a part of the SEQREUS. The study sought to target owner-occupied, single, detached dwellings (one water meter present only) with no internally plumbed rainwater tanks, which make up the majority of residential stock in the region at present. Knowledge on household occupancy and family characteristics was extracted from the SSA household survey response database. Further details of the sampling selection process are provided in Beal and Stewart (2011).

2.2. End-use Measurement Approach

The relationship between smart metering equipment, household stock inventory surveys and flow trace analysis is shown in Figure 1. A detailed description of the methods is provided in Beal and Stewart (2011). Essentially, a mixed method approach was used to obtain and analyse water use data:

- Physical measurement of water use via smart meters with subsequent remote transfer of high resolution data; and
- Documentation of water use behaviours and compilation of water appliance stock via individual household audits and self-reported water use diaries.

Note: Household survey conducted by CSIRO/UQ Systematic Social Analysis (SSA) project.

Figure 1. Schematic flow of processes in the mixed method approach.
2.2.1. **Instrumentation for data capture**

Standard council residential water meters were replaced with Actaris CTS-5 water meters. These ‘smart’ meters measure flow to a resolution of 72 pulses/L or a pulse every 0.014 L. The smart meters were connected to Aegis DataCell series Rtx (Figure 2a) and R-CZ21002 (Figure 2b). For the second half of the project, a newer model R-series DataCell was released and was found to be much more robust in terms of water resistance and secure wiring configuration (Figure 2a).

![Figure 2](image)

(a) Aegis Datacell Rtx and inline Actaris water meter  
(b) Installed Aegis Datacell R-series and manifold Actaris meter

**Figure 2.** Measurement and data storage equipment.

2.2.2. **Data analysis**

As the loggers were wireless, data was transferred remotely to a central computer at Griffith University through a GPRS network via email. Removable SIM cards were affixed into each logger and tested prior to installation in the field. The frequency of transfer was weekly, which amounted to approximately 120,000 data records. End-use data in .txt file format was analysed by flow trace software (Nyugen et al. 2014, Aquacraft, 2010). Initially, a template was created for each home which involved extracting relevant information from the household stock efficiency and water audit. The water use diaries were also used to characterise a water use by the known occurrence of that use (e.g. half toilet flush at 3.23 pm). Once a template was created for each household, data for the two-week period of interest was analysed. Flow trace software was used in conjunction with water audits and water diaries to analyse and disaggregate consumption into toilets, taps, leaks, irrigation, shower, clothes washer, bathtub and dishwasher. A range of values is characterised and assigned for the peak and mode flow rate, volume and duration of each end-use category, which is utilised by the software to reveal all other flow trace patterns with those
characteristics. An MS Excel™ spreadsheet was generated as a final output for a more detailed statistical trend analysis and the production of charts.

2.2.3. Household stock audits and water diaries

Concomitantly with meter and logger installation, a water fixture/appliance stock survey was conducted at each participating home in order to investigate how householders interact with such stock (Figure 3a). By completing the stock survey, the householder provided information on typical flow rates of taps and showers, the number and degree of water-efficient appliances and the typical water consumption behaviours of the householders. In addition to the stock survey, each household was asked to complete a water diary (Figure 3b) where as many internal and external water use events as possible were recorded over a seven-day period. This facilitated the disaggregation of trace flows from each home and also provided a valuable snapshot of the daily water consumption habits within each home.

![Example of household stock audit questions](image1.png)

![Example of annotated water use diary](image2.png)

Figure 3. Household stock audit and weekly water use diary examples.

2.2.4. Smart Meter Information Portal

The Smart Meter Information Portal or SMIP, is a tool that was developed by eResearch Services at Griffith University. The SMIP enables total water use to be extracted and interrogated from all homes being metered for the study. This total water use information was invaluable for generating daily and monthly consumption patterns at regional and local resolutions (see Section...
4). Note, SMIP was not used for the 7 discrete end-use analyses as they were based on a continuous, two-week snapshot using the above described flow trace disaggregation methods.
3. SITUATIONAL CONTEXT

3.1. Sample size and characteristics

The four study areas are located in the south-east corner of Queensland (Figure 4). A sample of properties was taken from the Sunshine Coast Regional Council, Brisbane City Council, Ipswich City Council (herein referred to the Sunshine Coast, Brisbane and Ipswich, respectively). The water distribution retailers for these regions are Unitywater (Sunshine Coast and Noosa) and Queensland Urban Utilities (Brisbane and Ipswich). Following on from the Stage 1 SEQREUS, the Gold Coast region was not officially included as there was no funding available to process any available Gold Coast data. However, some of the Gold Coast end-use and total water use data has been included in the combined SEQ regional database, and in some cases, presented here as ‘another SEQ region’ for comparison with end-use data from the other regions.

Household characteristics for each end-use read are presented in Table 1. The sample size indicates the declining number of operable data logging units as time progressed. This was unfortunate but unavoidable due to age and natural attrition of logger components. As many as possible were replaced throughout the first year of the Stage 2 project, subject to available funding. Of note from Table 1 is the trend toward older and smaller household compositions for the Sunshine Coast (e.g. higher % retirees and two person households compared with Brisbane/Ipswich). This has been a consistent observation throughout the Stage 1 and 2 SEQREUS and does reflect the slightly older demographic that occurs on the Sunshine Coast. Conversely, there is a tendency toward younger and larger family make-up in the sample homes for Brisbane and Ipswich. The low sample size for the last few reads will have some degree of influence on the percentages of households with children and without retirees/pensioners.

3.2. Climatic conditions during analysis periods

Data presented in Table 2 and graphically illustrated in Figure 5, summarises the average temperature and rainfall conditions for each of the 7 water end-use reads. The averages are taken from two meteorological stations for each region, thus the average rainfall and temperature data in Figure 5 is based on six datasets for each parameter.

The number of wet days is also provided and this shows that the weather tended toward a drier period during the last half of the study. The driest periods occurred in September, when the temperature also started to increase. This combination gave rise to an increase in average water consumption in the sample households as discussed in later sections of the report.

Figure 4. Regions examined. Inset: location of SEQ.
### Table 1: General characteristics of monitored households for all periods of analyses 2011 - 2013

<table>
<thead>
<tr>
<th>Household Demographics</th>
<th>BRISBANE and IPSWICH</th>
<th>SUNSHINE COAST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st - 14th Dec 2011</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>1st - 14th March 2012</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>1st - 14th Sept 2012</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>22nd Nov - 5th Dec 2012</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>26th Apr - 9th May 2013</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>14-28th June 2013</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>1st - 14th Sept 2013</td>
<td>18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Analysis period</th>
<th>1st - 14th Dec 2011</th>
<th>1st - 14th March 2012</th>
<th>1st - 14th Sept 2012</th>
<th>22nd Nov - 5th Dec 2012</th>
<th>26th Apr - 9th May 2013</th>
<th>14-28th June 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of households⁴</td>
<td>34</td>
<td>22</td>
<td>31</td>
<td>29</td>
<td>24</td>
<td>21</td>
</tr>
<tr>
<td>No. of people⁵</td>
<td>89</td>
<td>68</td>
<td>92</td>
<td>87</td>
<td>81</td>
<td>63</td>
</tr>
<tr>
<td>Av. Household occupancy</td>
<td>2.9</td>
<td>3.15</td>
<td>3.0</td>
<td>3.0</td>
<td>3.4</td>
<td>3.0</td>
</tr>
<tr>
<td>% Households with ≤ 2 people</td>
<td>46.5</td>
<td>27</td>
<td>14</td>
<td>24.1</td>
<td>16.7</td>
<td>38</td>
</tr>
<tr>
<td>% Households pensioners/retired</td>
<td>13.25</td>
<td>11</td>
<td>10</td>
<td>6.9</td>
<td>4.2</td>
<td>9</td>
</tr>
<tr>
<td>% Households with children (aged ≤ 17)</td>
<td>32.5</td>
<td>53</td>
<td>17</td>
<td>51.7</td>
<td>20.8</td>
<td>47</td>
</tr>
<tr>
<td>Average age of children (years)</td>
<td>5.25</td>
<td>4.7</td>
<td>3.4</td>
<td>6.4</td>
<td>6.5</td>
<td>4.9</td>
</tr>
</tbody>
</table>

Notes: ¹ data presented are averages, ² Does not include “other SEQ region”; ³ this is based on known household occupancies at the time of the initial household water audit and also includes any updates to occupancies which were collated in March 2012. This does not include any visitors or absent residents.
Table 2. Climate data during the period of flow trace analyses\(^1\)

Notes: \(^1\) Data taken from Bureau of Meteorology (BOM) http://www.bom.gov.au/climate/data/index.shtml; \(^2\) (±x) indicates standard deviation from mean for the period of analysis; \(^3\) Number of days where rainfall ≥1mm

<table>
<thead>
<tr>
<th>Household Demographics</th>
<th><strong>BRISBANE and IPSWICH</strong></th>
<th><strong>SUNSHINE COAST</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Analysis period</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st - 14th Dec 2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st - 14th March 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st - 14th Sept 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22nd Nov - 5th Dec 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26th Apr - 9th May 2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st - 14th Sept 2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st - 14th Dec 2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st - 14th March 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st - 14th Sept 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22nd Nov - 5th Dec 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26th Apr - 9th May 2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st - 14th Sept 2013</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average Max. (°C)  
- BRISBANE and IPSWICH: 29.6, 21.6, 24.3, 31, 26, 21.6, 26.6  
- SUNSHINE COAST: 28.5, 21.8, 26, 29.7, 26.8, 22.1, 25.1

Total 2 week rainfall (mm)  
- BRISBANE and IPSWICH: 134, 53, 0, 136, 43, 60, 0.6  
- SUNSHINE COAST: 158, 203, 1, 11.2, 2.8, 240, 4.4

No. of wet days\(^3\)  
- BRISBANE and IPSWICH: 8, 5, 0, 2, 1, 4, 0  
- SUNSHINE COAST: 8, 6, 0, 2, 1, 5, 1

Figure 5. Rainfall and temperature daily trend throughout SEQREUS Stage 2 project (end-use read periods indicated).
4 TOTAL WATER CONSUMPTION TRENDS: 2010 - 2013

From the SMIP database, total water consumption for each region, and for the SEQ combined regions were able to be extracted. This section presents a summary of the total residential water use trends from all available households over the lifetime of the SEQREUS projects (Stages 1 and 2). This information can help to forecast trends in usage patterns over time (seasonal influences for example).

4.1 Total water consumption – combined SEQ region

Total water consumption for the combined SEQ region on both a litres per household per day (L/hh/d) and litres per person per day (L/p/d) are provided in Figure 6, along with the corresponding average rainfall and temperature patterns. Water consumption is shown to be gradually increasing from an average of 147 L/p/d for the year 2010 to an average 163 L/p/d for the year 2013. Water use tended to notably increase during periods of low rainfall, such as evidenced in the period Sept – Nov 2012 (Figure 6). On the whole, consumption fluctuated more markedly in the last two years (e.g. 2012 onwards) compared to the first two years of measurement. This may be related to the permanent water conservation measures (PWCM) that were current for the post drought period up to the end of 2012, resulting in a situation where people’s outdoor water usage was less likely to be influenced by the weather conditions and more likely to be influenced by the recent drought and severe water restrictions, and a subsequent continued reluctance for high water use outdoors (Fielding et al. 2013).

Data in Figure 7a and 7b show the overall monthly average consumption for the study on a per household and per person level, respectively. There is a typical reduction in consumption in the cooler months between April and July and then a gradual incline in use as the months become drier and warmer (September to January).

![Figure 6: Relationship between 30 day moving average daily climate data and water consumption – SEQ combined region.](image-url)
Figure 7: Combined average water consumption for 2010 (Jan) to 2014 (March) for (a) per household and (b) per person use

The individual monthly breakdowns for the SEQ region are shown in Figure 8. Note as the sample size reduces, the 90% confidence intervals are widening over time, indicating that they are becoming less representative than the previous sample periods. Nevertheless there appears a continued trend for an increase in monthly water consumption for each year, particularly the spring and summer months. Some explanations for this observation include i) the high rainfall (flooding events) in the 2010/11 period may have resulted in less climate-driven water use (no need to water outdoors) and ii) the impact of the drought and water restrictions is fading over time leading to more willingness to water outdoors, and iii) drawing from point ii) above, has prompted water use behaviours to be more dictated by the drier weather conditions in 2012/13, whereas during restrictions and shortly after there was no correlation between climate and high water use (Beal et al. 2014a).
The months that exhibited the highest increases in water consumption were February (from 341 to 451 L/hh/d and from 134 to 176 L/p/d), March (from 345 to 484 L/hh/d and from 144 to 172 L/p/d), and October (from 345 to 484 L/hh/d and from 144 to 172 L/p/d), shown in Figures 8a and (Figure 8b), respectively. These volumetric increases represented an average percentage water consumption rise of between 27 and 36%. The months of May, June and July appeared the most static in terms of water use fluctuations over the four years, with 2012 being the year which exhibited the most change (increase) in use. This was a fairly dry year, especially toward the end (September /October), which resulted in significantly higher outdoor water use compared to all previous years.

![Figure 8: Yearly breakdown of av. monthly consumption for (a) per household and (b) per capita.](image-url)
4.2 Total water consumption – Individual SEQ regions

This section reports on the individual region’s average water use data for households in Brisbane and Ipswich, the Sunshine Coast, and one other SEQ region.

4.2.1 Brisbane and Ipswich Monthly Trends

Brisbane and Ipswich average monthly water use was similar to the combined SEQ trends with household use (Figure 9a) and per capita use (Figure 9b), although they showed less of a dip in use in the autumn months. Monthly consumption ranged from 359 to 408 L/hh/d and 134 L/pp/d to 151 L/p/d, on a household and individual level, respectively.

Figure 9: Brisbane and Ipswich average monthly (a) per household and (b) per capita daily water use.
Individual monthly trends also followed the same trend as the combined SEQ region, with household (Figure 10a) and per capita (Figure 10b) consumption gradually increasing over the years, particularly for the months between September and March. The most recent data in 2014 is indicating that use has substantially risen in the summer months, with a percentage increase of between 25% to nearly 50% (although the small sample size for the latter value must be taken into consideration).

Figure 10: Brisbane and Ipswich yearly breakdown of average monthly (a) per household and (b) per capita water use.
4.2.2 Sunshine Coast Monthly Trends

The Sunshine Coast average total monthly water use exhibited greater fluctuations than the other regions, with clear reduction in household (Figure 10a) and per capita (Figure 10b) water consumption in March and April. However, the overall quantum of monthly consumption was consistently higher than for the other regions with household and per capita use ranging from 321 to 491 L/hh/d and 140 to 206 L/p/d, respectively. As an example, average daily water consumption measured in Sunshine Coast residential properties was particularly high for the hotter months of the year where average use was at 458 L/hh/d and 198 L/p/d between November and January. This is notably greater than the average across SEQ for the same months, representing a 45 L/hh/d (10%) and 35 L/p/d (17%) increase.

The higher consumption of water in residential homes in the Sunshine Coast, also indicated in the individual monthly trends (Figure 12), has been a consistent observation during the SEQREUS projects, and is reflected in the Queensland Government estimates of per capita use also. An explanation for this higher water use being that since the Sunshine Coast was not subjected to the same stringent outdoor watering restrictions as the other three regions, there is a generally more relaxed attitude to outdoor water use.

Figure 11: Sunshine Coast average monthly (a) per household and (b) per capita daily water use.
Additionally, the higher number of ‘stay at home’ occupants (pensioners/retirees) in the Sunshine Coast sample (Table 1) would also influence higher irrigation/outdoor watering activities during the day. Dual income working couples and families that are more prevalent in the other regions would have limited time for indoor (e.g. clothes washer, tap and toilet) activities and outdoor gardening endeavours.

Figure 12: Sunshine Coast yearly breakdown of average monthly (a) per household and (b) per capita water use.
4.2.3 Other SEQ Region Monthly Trends

For the other SEQ region, average monthly water use was relatively homogenous at around 380-400 L/hh/d and 145-150 L/p/d, respectively for household and individual use (Figure 13). The exceptions were August and September in particular, where consumption was substantially higher in these dry months, and temperatures are typically starting to increase from the mid-winter months of June and July. This trend is also seen in the individual average monthly breakdowns (Figure 14), with again September 2012 featuring as a substantially higher month for both household and individual consumption.

Figure 13: Other SEQ region average monthly (a) per household and (b) per capita daily water use.
Figure 14: Other SEQ region yearly breakdown of average monthly (a) per household and (b) per capita water use.
5 WATER USE REBOUND TRENDS IN SEQ

5.1 Investigating the post-drought and post-flood water use rebound

The term ‘rebound’ has been used in the context of water and energy to describe an economic phenomenon when a sector becomes more efficient and prices drop, resulting in an increase in demand and thus offsetting the efficiency gain – often termed Jevon’s Paradox (Mayor et al. 2011). This is not the definition that will be used herein, rather the term rebound in this paper relates to the increase in water consumption following sustained lower use during a period of scarcer water supply. For example, in SEQ water consumption prior to the drought in 2005/6 was around 300 L/p/d. A figure which decreased significantly following the effective SEQ demand management campaign. While it is not expected that per capita consumption would return to pre-drought level, due partly to smaller lot developments, in-built water efficient fixtures and changes to tariff structures throughout SEQ (Beal et al 2012, Walton and Hume 2011), there is the expectation that the low demand observed mid and post drought of between 120-140 L/p/d cannot be sustained. In this context, total demand data from Qld government sources (Figure 15) and SEQREUS data (Figure 16) clearly shows a bounce back in consumption. From the SEQREUS data it was observed that yearly averages increased from around 156 L/p/d in 2010 to 178 L/p/d in 2012. The breakdown of indoor and outdoor end-uses shown in Figure 16 also indicates the concomitant increase in outdoor demand as total demand increases.

Data from the SEQREUS is presented for eight end-use analysis periods (Figure 16). Comparisons with previous end-use analyses demonstrate that consumption peaked in Sept 2012 after a prolonged period of no or low rainfall, and subsequently appeared to return to the levels that were previously observed prior to Sept 2012 (Figure 16). Despite the lower sample size for May 2013, there is still a notably lower consumption volume. Some likely factors that are responsible for this observed downturn in consumption could be the environmental conditions at the time, where reduced temperatures and regular rainfall prior to the end-use reads may have resulted in less need for outdoor water activities.

While the percentage of outdoor use is still greater than observed in the earlier reads (Figure 16 inset), the volume is much lower. Shower use also is lower than the previous two reads, but well aligned with the March (Autumn 2012) values. The most recent 2013/14 total water use data presented in Chapter 4 is suggesting that consumption has perhaps started to level out again at around 150-160 L/p/d and this might represent the new average in post-drought and post-flood SEQ. However, more longitudinal data (i.e. an average rainfall summer) will be required to fully capture the absence or presence of a rebound in consumption and what that might look like in terms of a per capita average.

5.2 Environmental drivers of water demand

The trend shown in the total bulk water demand pattern (Figure 15) demonstrated that once restrictions were eased, temperature and water consumption were generally positively correlated with an increase in temperature, usually corresponding to an increase in water consumption and vice versa. Similarly, rainfall and water demand were generally correlated with periods of low or no rainfall typically resulting in bulk water demand spikes (Figure 15).
**Drivers of Regional Production for the SEQ Councils subject to restrictions**

*Note that the Gold Coast City Council have been on and off of restrictions but is still included in the production figures*

- Only Central SEQ plus Gold Coast included prior to the introduction of Permanent Water Conservation Measures
- All of SEQ included as from the introduction of Permanent Water Conservation Measures on 1 Dec 2009

---

**Daily Production (ML/day)**

- Level 5 restrictions implemented
- High Volume Water User letters distributed
- High level restrictions implemented
- Medium level restrictions implemented
- Permanent conservation measures implemented
- Wet week following dust storms
- Target 140 TV campaign launched
- Level 6 restrictions implemented
- Implementation of the revised PWCM
- Major Flood Event
- Major Flood Event
- Only Central SEQ plus Gold Coast included prior to the introduction of Permanent Water Conservation Measures
- All of SEQ included as from the introduction of Permanent Water Conservation Measures on 1 Dec 2009

---

**Figure 15:** Two week moving average data for SEQ regions (source Seqwater, Askins 2013)
Figure 16: Trend weekly water consumption (L/p/d) and climate data with inset of indoor versus outdoor end-use breakdown.
In terms of measured residential end-uses the story is not quite so straightforward, in that it is not just the presence or absence of rainfall or hot conditions, but the duration and combination of climatic factors that may play an influencing role in consumption. Data in Table 3 indicates four different clusters of climate combinations: i) dry and cool, ii) dry and hot, iii) wet and cool, and iv) wet and hot. The differences in average total consumption is indicated for each climate condition, with some combinations resulting in greater than average consumption, and others lower than average. For example, in condition 1, when rain occurred in the cooler months, the mean daily household use of 451 L/hh/d was significantly less (p<0.05) than the average consumption of 500 L/hh/d (Table 3). These conditions are typical of late winter - early spring, when the most prolonged periods of dry weather typically occur in sub-tropical SEQ. Referring back to the total water use patterns for the SEQREUS sample (Figure 6), it is this period (Aug – Nov) that exhibited consistently higher peak days. Data in Figure 17 demonstrates that during this time there was also an observed greater proportion of outdoor water use.

The conclusion here may be that the number of consecutive days of low or no rainfall is at least as important an indicator or determinant of higher outdoor use than the presence or absence of rainfall itself. Further, the combination of climate factors appears to be more influential on water use, as opposed to any single climate factor.

<table>
<thead>
<tr>
<th>Climate condition</th>
<th>1 Low Temp + Rain</th>
<th>2 Low Temp + Dry (≥1 d without rain)</th>
<th>3 High Temp + Rain</th>
<th>4 High Temp Dry (≥1 d without rain)</th>
<th>Overall Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total consumption (L/hh/d)</td>
<td>451</td>
<td>565</td>
<td>429</td>
<td>542</td>
<td>501</td>
</tr>
<tr>
<td>Diff in means compared to average</td>
<td>-49.8</td>
<td>65.0</td>
<td>-61.3</td>
<td>41.2</td>
<td>0</td>
</tr>
<tr>
<td>Significance (one-way ANOVA, 95%)</td>
<td>p&lt;0.02</td>
<td>p&gt;0.13</td>
<td>p&lt;0.01</td>
<td>p&gt;0.23</td>
<td>/</td>
</tr>
<tr>
<td>n</td>
<td>18</td>
<td>34</td>
<td>39</td>
<td>28</td>
<td>141</td>
</tr>
</tbody>
</table>

5.3 Outdoor versus indoor uses

The trend comparison of percentage of homes actively using outdoor water and the average consumption of outdoor water use activities is shown in Figure 17. Of the homes that recorded outdoor water use, the average ranged between 14 to 56.8 L/p/d with a notable increase in average use over time (Figure 17). This data also demonstrates that the number of homes engaging in outdoor water use (indicated by “percent homes” on chart) also increased over time, as well as the actual volumetric use of outdoor water. This provides some evidence to suggest that attitudes and behaviours regarding outdoor water use and irrigation may be shifting, post-drought, towards to a more relaxed attitude and greater preparedness for people to turn on the taps outside. Furthermore, this relaxation on outdoor use coincides with generally prolonged wet
weather conditions which, historically, would typically see a decline in peak outdoor water demand.

Water consumption has trended downward since the “dry” spell in August and September 2012, although remains higher than 2010-2011 averages, with the number of homes engaging in water use activities outdoors continuing to exceed 80% of the sample population.

5.4 Mandatory versus voluntary demand management

Both in Australia and internationally, research suggests that due to greater social awareness and increasingly widespread exposure to drought conditions people are beginning to genuinely value water as a precious resource (Jones et al. 2011, Jorgensen et al. 2009). Changing behaviour and attitudes towards water use can be achieved through voluntary or mandatory measures. Both the short term and long term effectiveness of these two approaches is difficult to determine as success is often dictated by interacting variables (Russell and Fielding 2010, Moss and Edmonds, 2005, van Vugt 2001). Data in Figure 18 clearly demonstrates the statistically significant impact of water restrictions on demand. However, unpacking this further, a number of very successful social-based community marketing campaigns were strongly promoted through television, radio and print media. These aimed to promote voluntary water conserving behaviours (e.g. government rebate schemes, Target 140 campaigns and widespread postal distribution of water-efficient devices (shower timers)). Specifically, the majority of the SBCM promotion occurred in the first half of Level 5 restrictions (Figure 18), a period that achieved the greatest percentage reduction in water demand when statistically compared (p<0.001) to all other levels, including Level 6 (most severe) – notwithstanding the initial introduction of restrictions in early 2005. It is worth noting too that environmental cues (rainfall and temperature) were not markedly different throughout mandatory restrictions.
Although a preliminary assessment only, there appears to be evidence to further investigate the role that voluntary social drivers play in the sustained effectiveness of water conservation strategies, especially on rebounding water use in times when environmental or water scarcity cues are absent (Fielding et al. 2013, van Vugt 2001).

Figure 18: Bulk water demand trend pre, during and post-drought water restriction regime (95% confidence intervals are indicated by error bars)
6 WATER END-USE CONSUMPTION – DEC TO JAN 2011/12

6.1 Combined Regions

An average total water consumption of 355 litres per household per day (L/hh/d) was recorded during the summer 2011 period of analysis. This represented a per capita average of 137.4 litres per person per day (L/p/d) (Figure 19) for the 69 homes measured. The main contributors to this total were shower 38 L/p/d (27.7%), toilet use 28 L/p/d (20.4%) and clothes washer 27.3 L/p/d (19.8%).

Figure 19: Average daily water end-use summer 2011 breakdown for all SEQ regions.

The household per capita water consumption activity break down is shown in Figure 20. There is a notable increase in irrigation with this end-use comprising 15% of total household consumption compared to the average for the previously reported figures of 4.4% (Beal and Stewart 2011). In addition to the increase in water volume being used, there were also more incidences of irrigation compared with the previous readings. For example, 73% (or 49) of homes engaged in this water use activity compared with an average 49% for the previous winter and summer periods (Beal and Stewart 2011). Typically, the homes that used the most water had a disproportionately high contribution from irrigation (Figure 20). The elevated irrigation consumption observed during the summer 2011 read may have been driven more by temperature than rainfall as climate data presented in Table 2 demonstrates the generally high rainfall activity during the summer 2011 (and autumn 2012) read. For example, wet days (rainfall ≥ 1mm) occurred on at least 40% of days during the 14 day period of measurement. Others have also noted a strong correlation between temperature and increased water consumption (typically external) (Cole and Stewart 2012, Water Corporation 2011, Zhou et al. 2000).
6.2 Individual Regions

6.2.1 Summary

In terms of water consumption comparisons between regions, Figure 21a shows that homes located in the Sunshine Coast consumed the most water per capita (147.2 L/p/d) but only marginally. On a per household basis Ipswich consumed the highest volume of water at 357.6 L/hh/d, chiefly driven by shower, toilet and clothes washing (Figure 21b).

Figure 20: Average daily water end-use summer 2011 breakdown by household.

Figure 21: Breakdown of average summer 2011 end-uses by region.
The end-uses which varied markedly between regions were clothes washers and irrigation, as shown in Figure 22. Showers and leaks had a relatively stable contribution of around 28 to 30%, and 0.7 to 1% of total household consumption, respectively (Figure 22b).

### 6.2.2 Brisbane

Average household consumption in Brisbane was 350.5 L/hh/d, resulting in a per capita consumption average of 129.7 L/p/d (Figure 23). The average irrigation consumption of 14.2 L/p/d was skewed by one household that was believed to have been filling a pool. Nevertheless, irrigation usage was lower in Brisbane compared to the regional average (Figure 23). Shower use was slightly higher than the regional average, although all other end-uses were similar.

![Figure 22: Average percentage of total summer 2011 water consumption.](image)

![Figure 23: Break down of average summer 2011 end-uses for Brisbane.](image)
6.2.3 Ipswich

Average household consumption for the Ipswich area was 357.6 L/hh/day. This resulted in a per capita figure of 130.7 L/p/d (Figure 24a). Due to the low sample size (n=9 homes), the authors are reluctant to draw too many conclusions from the data. Not that there was a focussed effort on increasing the number of viable loggers and meters in Ipswich, following the severe flooding that affected this area in 2011.

**Figure 24:** Break down of average summer 2011 end-uses for Ipswich.

---

6.2.4 Sunshine Coast

At n=35, the number of households was the highest of all regions for the summer 2011 sampling period (Table 1). The Sunshine Coast residents consumed the highest volume of water per capita for all regions during the summer of 2011 at 147.2 L/p/d (Figure 25). However the region had a comparatively low per household water consumption of 331.2 L/hh/d (Figure 25b). Irrigation is notably elevated for the Sunshine Coast compared to the other regions. One reason for this may be the higher proportion of elderly and retired participants in this sample, compared to the other regions (Table 1). Increased daytime occupancy has been shown to be associated with higher average water use, especially outdoor watering events, by this older demographic group (Willis et al. 2011, Russell and Fielding 2010).

**Figure 25:** Break down of average summer 2011 end-uses for the Sunshine Coast.
7 WATER END-USE CONSUMPTION – MARCH 2012

7.1 Combined Regions

An average total water consumption of 333.2 litres per household per day (L/hh/d) was recorded during the March 2012 period of analysis. This represented a per capita average of 133.8 L/p/d (Figure 26). The main contributors to this total were shower 37.1 L/p/d (27.7%), clothes washer 27 L/p/d (20.2%), and toilet use 25.7 L/p/d (19.2%). In comparison to the previous summer 2011 read, there is a marked increase in leakage from 1.3 L/p/d (1%) to 5.6 L/p/d (4.2%). The reasons for this are not immediately apparent, but may be confounded by the small (n=60) sample size.

Figure 26: Average daily water end-use autumn 2012 breakdown for all SEQ regions.

The household per capita water consumption activity breakdown is shown in Figure 27. Again, as for the previous summer 2011 measurement period, there is a notable increase in irrigation with this end-use comprising 13% of average total household consumption. In comparison, the average for the previous three SEQREUS Stage 1 readings in 2010 and 2011 was 4.4%. Like the summer 2011 read, there was also an increase in the number of homes irrigating compared with the first three Stage 1 readings. For example, 70% of homes (or 42) engaged in this water use activity compared with 49%, 41%, 48% for winter 2010, summer 2010-11, and winter 2011, respectively (Beal and Stewart 2011). This increase in irrigation activity may be an indicator of some sort of rebound occurring, although the lower sample size may be confounding or misrepresenting the actual irrigation usage in SEQ homes. Future analysis of data from an increased logger fleet will allow a more detailed examination of this.
In terms of water consumption comparisons between regions, Figure 28a shows that homes located in Brisbane consumed the most water per capita (143.6 L/p/d). On a per household basis, Brisbane also consumed the highest volume of water at 390 L/hh/d (Figure 28b). The end-uses which varied markedly between regions were showers, clothes washers and irrigation, as shown in Figure 29. Surprisingly, the Sunshine Coast recorded the lowest per household consumption, which is in contrast to earlier SEQREUS measurements. This may be influenced by the lower average household occupancy for the Sunshine Coast sample at 2.4 people per house, compared with the other regions of 3.1 (Brisbane) and 2.7 (Ipswich) people per household, respectively (Table 1). In comparison to homes with a large number of occupants, a lower household occupancy will translate into overall lower household consumption.
7.2.2 Brisbane

Average household consumption in Brisbane was 390 L/hh/d, resulting in a per capita consumption average of 143.6 L/p/d (Figure 30). Shower use was a significant component of total average use, comprising over 31% or 44.7 L/p/d of consumption. Irrigation occurred in 60% of homes, at an average of 28.8 L/p/d for these particular homes. Overall, average irrigation consumption in all homes was 17.7 L/p/d (12.3%).

7.2.3 Ipswich

The period of analysis in the Ipswich region showed an average household consumption of 366.7 L/hh/day. This resulted in a per capita figure of 127.8 L/p/d (Figure 31a). Again, the very low sample size (n=6 homes), limits any important observations to be made from the data.
7.2.4 Sunshine Coast

As for the summer 2011 read, the number of households (n=38) was the highest of all regions for the autumn 2012 sampling period (Table 1). Sunshine Coast residents exhibited a low per household water consumption of 304.4 L/hh/d (Figure 32a). As suggested earlier, this may likely be a result of the lower household occupancy and hence lower overall household total consumption for the Sunshine Coast sample.

Again, irrigation is quite elevated for the Sunshine Coast compared to the other regions, and other sampling periods. Irrigation occurred in 70% of the homes, at an average of 25.7 L/p/d in those homes (Figure 32b). This is an interesting result as rainfall events during the period of analysis were considerable with the Sunshine Coast receiving over 100% of their monthly average rainfall during this two week period (Table 2).
8. WATER END-USE CONSUMPTION – SEPTEMBER 2012

8.1. Combined Regions

An average total water consumption of 477.8 L/hh/d was recorded during the September 2012 period of analysis (Figure 33a). This represented a per capita average of 201 litres per person per day (L/p/d) (Figure 34a) for the 80 homes measured. The main contributors to this total were outdoor 53.3 (26.5%), shower 48.1 L/p/d (23.9%), toilet use 31.3 L/p/d (15.6%), clothes washer 29 L/p/d (14.4%), and tap 20.6 L/p/d (10.3%) contributed the majority of the remaining average consumption.Leaks were elevated, representing almost 7% of total household consumption.

Figure 33: Average per household daily water end-use breakdown all SEQ regions.

Figure 34: Average per capita daily water end-use breakdown all SEQ regions.

The per household and per capita water consumption activity break down is shown in Figures 33b and 34b, respectively. There is a significant increase (p<0.05) in outdoor water use compared with all previous reads (based on the commencement of the SEQREUS Stage 1), with this end-use comprising over a quarter of total consumption at a per household and per capita level. This outdoor water use is likely to be comprised largely of irrigation, either hand held or automated watering systems, and also general tap use for cleaning, washing down cars, driveways, and pool top-ups. In addition to the increase in water volume being used, there was also a huge jump in the percentage of homes that engaged in outdoor water use. For example,
94% (or 75) of homes engaged in this water use activity compared with an average 49% for the previous winter and summer periods (Beal and Stewart 2011). Typically, the homes that used the most water had a disproportionately high contribution from outdoor use (Figures 33b and 34b).

8.2. Individual Regions

8.2.1. Summary

In terms of water consumption comparisons between regions, Figure 35 shows that homes located in the Sunshine Coast continued to consume the most water per household (603 L/hh/d) and per capita (223 L/p/d). Water use was elevated in all homes for each region, with outdoor, and to a lesser but notable extent, shower use, being the prime driver for these increases. Leaks also appear to comprise a larger proportion of consumption compared to the previous reads.

Figure 35: Breakdown of average end-uses by region.

8.2.2. Brisbane and Ipswich

Average household consumption in Brisbane was 459 L/hh/d (Figure 36a), resulting in a per capita consumption average of 176.3 L/p/d (Figure 36b). Shower and clothes washer comprised over 45% of total use on both a per household and per capita basis (Figure 36). Ipswich homes also followed the trend of elevated outdoor and shower end-uses with outdoor contributing 23% of the total per capita consumption (Figure 37b). The sample size for Ipswich (n=10) was low, therefore a combined Brisbane and Ipswich sample has also been presented (Figure 38). Again, it was observed that outdoor, shower and clothes washer were all substantial end-uses for this combined sample on both a per household and per capita basis (Figure 38). Leaks are also quite high for Brisbane in particular, which can be sourced to four homes in particular which resulted in per capita leaks ranging from about 60 to 130 L/p/d.
Figure 36: Break down of average end-uses for Brisbane.

Figure 37: Break down of average end-uses for Ipswich.

Figure 38: Break down of average end-uses for combined Brisbane and Ipswich households.
8.2.3. Sunshine Coast

The Sunshine Coast residents consumed the highest volume of water per household and per capita (Figure 39). Outdoor use was particularly high in this region comprising a third of total household water use, which is consistent with previous reads where outdoor – specifically irrigation – has trended comparatively higher than in the other regions (Beal and Stewart 2011).

Figure 39: Break down of average end-uses for the Sunshine Coast.

8.2.4. Other SEQ regions

The other SEQ region average water consumption is shown in Figure 40.

Figure 40: Break down of average end-uses for other SEQ region households.
9. WATER END-USE CONSUMPTION – NOV - DEC 2012

9.1. Combined Regions

This section reports on the combined average water end-use data which consists of household datasets from Brisbane and Ipswich, the Sunshine Coast and other SEQ regions during the 7th read of the SEQREUS between 22 November and 5 December.

An average total water consumption of 414 L/hh/d was recorded during the November – December 2012 period of analysis (Figure 41a). This represented a per capita average of 181.6 L/p/d (Figure 42a) for the 75 homes measured. Outdoor and shower use were the two major activities, comprising 54% of the total household (228 L/hh/d) and per capita (98 L/p/d) use. Individual distributions indicate that a small number of homes were responsible for large outdoor usage. This is typical of residential water consumption distribution curves.

![Figure 41: Average per household daily water end-use breakdown all SEQ regions.](image)

![Figure 42: Average per capita daily water end-use breakdown all SEQ regions.](image)
9.2. Individual Regions

9.2.1. Summary

Data in Figure 43 shows that homes located in the Sunshine Coast again consumed the most water per household, and the Brisbane and Ipswich sample consumed the least (Figure 43). Overall, the volume of consumption is lower than the previous read in September 2012. One reason for this may be the increase in rainfall activity that was observed, which would prompt a reduction in outdoor water use, although outdoor water use again remained quite elevated compared to earlier reads.

### Figure 43: Breakdown of average end-uses by region.

#### 9.2.2. Brisbane and Ipswich

Average household consumption in the combined Brisbane (n=22) and Ipswich (n=7) sample was 354 L/hh/d (Figure 44a), resulting in an average per capita consumption average of 130 L/p/d (Figure 44b). Shower use contributed substantially to the total use. Outdoor use was notably lower than for the other regions, which may be an effect of the Ipswich sample, which, historically, has used markedly less water for outdoor uses compared with regions.

### Figure 44: Break down of average end-uses for combined Brisbane and Ipswich households.
End-use breakdowns for Brisbane are shown in Figure 45 and Ipswich in Figure 46. Due to the very low sample sizes, especially in Ipswich, caution is recommended if extrapolating the results beyond what is presented here. For example leak and shower use in particular are clearly skewed by individual homes in Ipswich that recorded 113 L/p/d and 194 L/p/d, respectively.

![Figure 45](image)

(a) Per household end-use break down (L/hh/d)  
(b) Per capita end-use break down (L/p/d)

**Figure 45:** Break down of average end-uses for Brisbane households.

![Figure 46](image)

(a) Per household end-use break down (L/hh/d)  
(b) Per capita end-use break down (L/p/d)

**Figure 46:** Break down of average end-uses for Ipswich households.

### 9.2.3. Sunshine Coast

At an average of 461 L/hh/d, Sunshine Coast residents consumed the highest volume of water per household and also per capita (202 L/p/d) (Figure 47). Consistent with previous reads, daily outdoor use was particularly high in this region, at around 160 L/hh on average, equating to a per person use of over 70 L/day.
9.2.4. Other SEQ regions

Other SEQ regional data shows the continued trend in outdoor use and showers contributing significantly to the total household demand (Figure 48).

Figure 47: Break down of average end-uses for the Sunshine Coast.

Figure 48: Break down of average end-uses for other SEQ region households.
10. WATER END-USE CONSUMPTION – MAY 2013

10.1. Combined Regions

This section reports on the combined average water end-use data which consists of household datasets from Brisbane and Ipswich, the Sunshine Coast and other SEQ regions between 26 April and 9 May, 2013. An average total water consumption of around 360 L/hh/d was recorded (Figure 49a), representing a per capita average of about 137 L/p/d (Figure 50) for the 69 homes measured. These totals are a substantial reduction compared to the previous two reads, and are more comparable to the early SEQREUS reads in 2010/2011. While the lower values could be confounded by the smaller sample size (n=69), this may also be an indication that, in the absence of environmental cues, such as prolonged dry weather, the SEQ sample population remain generally conscious of their water use.

Figure 49: Average per household daily water end-use breakdown all SEQ regions.

Figure 50: Average per capita daily water end-use breakdown all SEQ regions.
10.2. Individual Regions

10.2.1. Summary

In terms of water consumption comparisons between regions, data in Figure 51 shows a more even consumption across the three regions, particularly on a per household basis. While the Sunshine Coast continues to consume slightly more than the southern regions, the trend for decreased outdoor use since the September 2012 data is observed across all regions.

Figure 51: Breakdown of average end-uses by region.

10.2.2. Brisbane and Ipswich

Average household consumption in the combined Brisbane (n=13) and Ipswich (n=11) sample was 356 L/hh/d (Figure 52a), resulting in an average per capita consumption average of 111 L/p/d (Figure 52b). The low sample size for both these regions may be reflecting the slightly lower than previously observed consumption pattern.

Figure 52: Breakdown of average end-uses for combined Brisbane and Ipswich households.
End-use breakdowns for Brisbane are shown in Figure 53 and Ipswich in Figure 54. As for the December 2012 read, caution is recommended in any interpretation of the results due to the low sample sizes.

10.2.3. Sunshine Coast

Outdoor and shower use comprised a high proportion of the daily total use of 370 L/hh (155 L/p) (Figure 55). Leaks appear to have reduced compared with the previous two reads, and this may be a result of the leak notifications which were issued to those participant homes which had recorded consistently high (>15% of total household use) leak end usage. Overall, the consumption figures for the Sunshine Coast are markedly lower than previous reads.
10.2.4. Other SEQ regions

Other SEQ regional data also supports the observation of continued downward trend in total water consumption after the very high use in September 2012 (Figure 56).
11. WATER END-USE CONSUMPTION – JUNE 2013

11.1. Combined Regions

This section reports on the combined average water end-use data which consists of household datasets from Brisbane and Ipswich, the Sunshine Coast and other SEQ regions during the 9th read of the SEQREUS between 14th – 28th June 2013.

An average total water consumption of 393 L/hh/d was recorded during the June 2013 period of analysis (Figure 57a). This represented a per capita average of 142 L/p/d (Figure 58a) for the 60 homes measured. Shower, toilet and clothes washer were the major activities, comprising over 70% of the total household use. Individual distributions indicate that a small number of homes were responsible for large outdoor and shower usage.

![Figure 57: Average per household daily water end-use breakdown all SEQ regions – June 2013.](image1)

![Figure 58: Average per capita daily water end-use breakdown all SEQ regions – June 2013](image2)

11.2. Individual Regions

11.2.1. Summary

End-use breakdowns for each region are shown for June 2013 on a per household (Fig 59a) and per capita (Fig 59b) basis. The low sample sizes make it challenging to make too many generalisations, although the breakdowns for Brisbane and Ipswich (n=21) and the Sunshine Coast (n=33) are generally consistent with previous data, where indoor use is dominated by shower, clothes washer and toilet. Outdoor use was observed to be lower for most households.
compared with recent previous reads. This may be due to the cooler winter months of June, requiring less watering of gardens and typically reduced outdoor water use activities in general.

Figure 59: Breakdown of average end-uses by region – June 2013.

11.2.2. Brisbane and Ipswich

Average household consumption in the combined Brisbane (n=12) and Ipswich (n=9) sample was 455 L/hh/d (Figure 60a), resulting in an average per capita consumption average of 149 L/p/d (Figure 60b). Shower use contributed substantially to the total use. At 20.2 L/p/d, outdoor use was notably higher than that of the previous two reads (a potential effect of low sample size).

Figure 60: Breakdown of average end-uses for Brisbane and Ipswich households - June 2013.

11.2.3. Sunshine Coast

Sunshine Coast residents from a sample of 33 homes consumed an average of 349 L/hh/d, equating to a per capita average of (135 L/p/d) (Figure 61). Shower, toilet and clothes washer all contributed to this, with outdoor use markedly lower than previous reads.
11.2.4. Other SEQ regions

Other SEQ regional data (n=6) suggests a trend for shower and clothes washer to dominate total household use has continued, with slightly lower outdoor use than previous reads (Figure 62).

Figure 61: Break down of average end-uses for the Sunshine Coast - June 2013.

Figure 62: Break down of average end-uses for other SEQ region households.
12. WATER END-USE CONSUMPTION – SEPTEMBER 2013

12.1. Combined Regions

This section reports on the combined average water end-use data which consists of household datasets from Brisbane and Ipswich, the Sunshine Coast and other SEQ regions during the 10th and final read of the SEQREUS Stage 2 between 1st – 14th September 2013. By this time, the sample size, at n=53, was substantially lower than the original 252 households participating at the start of the project in January 2010, due to a combination of two major and destructive flood events, aging data logging equipment and some householders opting out after 4 years of participation. However, based on the state government reported data, the figures remain generally representative (e.g. within 10%) of the SEQ average estimated by Seqwater.

An average total water consumption of around 400 L/hh/d was recorded (Figure 63a), representing a per capita average of about 151 L/p/d (Figure 64a) for the 53 homes measured. These totals are a small increase compared to the previous two reads in early May and late June, 2013. As previously discussed in Section 8, there was also a rise in September 2012 consumption patterns, following a prolonged dry period (detailed analysis in Technical Report 2). There appears to be a trend of higher water use, including elevated outdoor use, in the months following winter where there has been a period of dry weather, typical for SEQ, combined with a rise in springtime temperatures. This may be prompting an increased level of outdoor water use activity.

![Diagram 1](image1.png)

(a) Per household end-use break down (L/hh/d)  
(b) Per household individual end-use distribution (L/hh/d)

Figure 63: Average per household daily water end-use breakdown all SEQ regions.

![Diagram 2](image2.png)

(a) Per capita end-use break down (L/p/d)  
(b) Per capita individual end-use distribution (L/p/d)

Figure 64: Average per capita daily water end-use breakdown all SEQ regions.
12.2. Individual regions

12.2.1. Summary

Water consumption comparisons between regions for the September 2013 period of analyses is presented in Figure 65 and shows the familiar picture of Sunshine Coast sample homes having the highest per capita water use, largely due to the lower household occupancy for this sample. The other SEQ region has a very low sample size and should not be taken as representative, although it is included here for consistency.

(a) Per household end-use break down (L/hh/d) (b) Per capita end-use break down (L/p/d)

Figure 65: Breakdown of average end-uses by region.

12.2.2. Brisbane and Ipswich

Average household consumption in the combined Brisbane (n=13) and Ipswich (n=11) sample was 411 L/hh/d (Figure 11a), resulting in an average per capita consumption average of 127 L/p/d (Figure 11b). The low sample for both these regions are likely to reflect a slightly lower than expected per capita consumption pattern. The households that had operating meter equipment had a higher than average household occupancy (3.3 persons), thus a lower per capita water use.

(a) Per household end-use break down (L/hh/d) (b) Per capita end-use break down (L/p/d)

Figure 66: Break down of average end-uses for combined Brisbane and Ipswich households.
12.2.3. Sunshine Coast

Outdoor, shower and toilet use comprised a high proportion of the daily total use of 387 L/hh/d, equivalent to 165 L/p/d (Figure 67).

Figure 67: Break down of average end-uses for the Sunshine Coast.

12.2.4. Other SEQ regions

Due to the very small sample size available for the other SEQ regional dataset, there are no water end-use breakdowns reported here. Total household water use for the three homes was averaged at 481 L/hh/d with an equivalent per person average of 134 L/p/d (Figure 65).
13. END-USE CONSUMPTION TRENDS OVER TIME: 2010-2014

13.1. Comparison of water use trends with Qld Government data

Data presented in Figure 68 shows the Stage Government (formerly the Queensland Water Commission [QWC] and now Seqwater) estimations of per capita water consumption against the average per capita from the SEQREUS end-use datasets. In general, they are well aligned, with only a maximum margin of around 5-10 % difference for some reads. The disparity between SEQREUS data and Seqwater data was expected due to the different approaches used by Seqwater in obtaining their data. For example, the residential per capita water usage for SEQ is calculated based on Seqwater bulk water use records over a weekly period and as such there is an inherent assumption that a certain percentage of businesses and leakage volumes are included within this bulk water measurement. Residential water consumption (based on average household occupancy) is the remaining quantum after these assumed volumes have been considered. Additionally, there will be some differences in sample characteristics; and biases encountered when recruiting consenting households to a research study (e.g. very high water consumers unlikely to consent). Notwithstanding the above, the fluctuations of water consumption in the SEQREUS households generally continue to behave in much the same way as the overall SEQ regional fluctuations (Figure 68).

![Figure 68: Comparison of average per capita end-use consumption over time (2010 to 2013)](image)

13.2. Combined Regions

Comparisons with previous end-use data analysis demonstrate that consumption has generally returned to the levels that were observed prior to the September Read 7 (Figures 69 and 70). Despite the lower sample sizes for the latter end-use read periods, there is still a much lower consumption volume. Some likely factors that are responsible for this observed downturn in consumption could be the environmental conditions at the time, where reduced temperatures and regular rainfall prior to the end-use reads may have resulted in less need for outdoor water activities. While the percentage of outdoor use is still greater than observed in the earlier reads (say pre-March 2012) (Figure 71), the volume is much lower than observed in the latter half of 2012 and early 2013.
Figure 69: Comparison of average per capita end-use consumption over time (2010 to 2013)

<table>
<thead>
<tr>
<th>Month</th>
<th>Outdoor</th>
<th>Bathtub</th>
<th>Tap</th>
<th>Dish washer</th>
<th>Clothes Washer</th>
<th>Shower</th>
<th>Shower</th>
<th>Showers</th>
<th>Clothes Washer</th>
<th>Toilet</th>
<th>Leak</th>
</tr>
</thead>
<tbody>
<tr>
<td>June, Winter 2010 (n=252)</td>
<td>15.8</td>
<td>5.9</td>
<td>68.7</td>
<td>6.6</td>
<td>115.0</td>
<td>115.0</td>
<td>27.4</td>
<td>2.5</td>
<td>82.7</td>
<td>58.9</td>
<td>17.8</td>
</tr>
<tr>
<td>Dec - Feb, Summer 2010-11 (n=219)</td>
<td>10.4</td>
<td>4.8</td>
<td>67.2</td>
<td>5.0</td>
<td>94.3</td>
<td>94.3</td>
<td>27.4</td>
<td>1.9</td>
<td>65.2</td>
<td>56.3</td>
<td>8.8</td>
</tr>
<tr>
<td>June, Winter 2011 (n=110)</td>
<td>17.0</td>
<td>5.0</td>
<td>70.3</td>
<td>6.2</td>
<td>150.5</td>
<td>150.5</td>
<td>25.1</td>
<td>2.2</td>
<td>89.6</td>
<td>70.6</td>
<td>9.0</td>
</tr>
<tr>
<td>Dec, Summer 2011 (n=93)</td>
<td>49.0</td>
<td>3.5</td>
<td>47.9</td>
<td>4.6</td>
<td>108.8</td>
<td>108.8</td>
<td>24.0</td>
<td>1.9</td>
<td>67.9</td>
<td>70.2</td>
<td>3.0</td>
</tr>
<tr>
<td>March, Autumn 2012 (n=85)</td>
<td>35.0</td>
<td>4.6</td>
<td>45.0</td>
<td>3.8</td>
<td>102.0</td>
<td>102.0</td>
<td>21.2</td>
<td>1.6</td>
<td>64.6</td>
<td>63.1</td>
<td>15.1</td>
</tr>
<tr>
<td>Sept, Spring 2012 (n=80)</td>
<td>123.0</td>
<td>9.6</td>
<td>45.6</td>
<td>6.0</td>
<td>126.0</td>
<td>126.0</td>
<td>18.2</td>
<td>2.1</td>
<td>71.1</td>
<td>70.0</td>
<td>26.5</td>
</tr>
<tr>
<td>May, Autumn 2013 (n=69)</td>
<td>106.5</td>
<td>5.6</td>
<td>41.6</td>
<td>5.0</td>
<td>116.8</td>
<td>116.8</td>
<td>20.6</td>
<td>1.8</td>
<td>60.1</td>
<td>62.9</td>
<td>15.6</td>
</tr>
<tr>
<td>June, Winter 2013 (n=61)</td>
<td>52.4</td>
<td>8.8</td>
<td>46.4</td>
<td>5.0</td>
<td>101.1</td>
<td>101.1</td>
<td>18.3</td>
<td>1.8</td>
<td>70.4</td>
<td>65.3</td>
<td>10.4</td>
</tr>
<tr>
<td>Sept, Spring 2013 (n=53)</td>
<td>37.2</td>
<td>6.8</td>
<td>46.4</td>
<td>4.7</td>
<td>111.1</td>
<td>111.1</td>
<td>18.0</td>
<td>1.6</td>
<td>74.0</td>
<td>72.4</td>
<td>9.1</td>
</tr>
<tr>
<td></td>
<td>72.9</td>
<td>10.4</td>
<td>51.5</td>
<td>4.7</td>
<td>111.1</td>
<td>111.1</td>
<td>19.7</td>
<td>1.8</td>
<td>58.1</td>
<td>71.2</td>
<td>15.3</td>
</tr>
</tbody>
</table>

Figure 70: Comparison of average per capita end-use consumption over time (2010 to 2013)
Figure 71: Comparison of percentage total water consumption over time (2010 to 2013).

13.3. Individual Regions

The end-use breakdowns for each region for all periods of analyses are shown in Figures 72 to 74. Both the volumetric and percent of total water consumption is indicated. Overall, there is little significant fluctuation in the indoor water use (also includes leaks), with the exception of tap, which tends to be reduced with a concomitant increase in outdoor use.

Leaks have also varied with a decline observed following the intervention study from the CSIRO project (Fielding et al 2013), and a rise in leaks coinciding with elevated outdoor use. This latter observation may be a result of old and poorly functioning outdoor tap fixtures being used for the first time after a prolonged period of minimal use.

Brisbane and Ipswich data indicate an increase in bath end-use which is likely to be a reflection of the high percentage of families with younger children comprising the last few read samples (Table 1). The homogeneity of indoor uses is generally well illustrated for the Brisbane and Ipswich data in Figure 72.
For the Sunshine Coast end-use consumption over the last four years, the percentage of total water consumption for each end-use is less homogenous and more varied for outdoor use, reflecting the increase in outdoor water use consistently observed for this region. This increase in outdoor use gives rise to a subsequent decrease in proportions of other end-uses. Toilet use and dishwasher use remains very homogenous both volumetrically and percentage-wise, reflecting the generally standardised water demand volumes from these appliances (i.e. automated water use compared with discretionary water use from showers, taps and outdoor). The amount of water consumed for clothes washers does vary to some extent, and although this is also an automated appliance, the frequency and variation in machine models, mains tap connections and load options will impact on the demand compared with toilets.

The other SEQ region (Figure 74) also showed more variance between end-uses over time, but this can be attributed to the very small sample size more than actual variation in end-use behaviours.
Figure 74: Average per capita and percentage total end-use consumption for other SEQ region

(a) Per capita end-use break down (L/p/d)

(b) Percentage of total water consumption
14. FLOW CLUSTERING OF WATER CONSUMPTION

14.1. Introduction

Leak detection is considered an important demand management strategy, especially during periods of drought and dwindling water supply. Leak detection is also used to reduce non-registered water losses and identify ageing infrastructure – although the latter is typically related to the larger distribution networks rather than the post-meter supply lines. The occurrence of network leaks as part of the production and distribution process are resource and labour intensive. Much has been written about leakage from mains and service pipes, however literature regarding water losses located within residential household boundaries has been given less attention (Britton et al., 2008, 2009). Residential, or post-meter, leakage can occur in any number of different plumbing fixtures or piping within a property.

During the SEQREUS (Stages 1 and 2), it has been observed that tap and toilet “leaks” are the most common, in terms of characterising very low flow events immediately after a toilet flush or tap use. Strictly, these are not leaks, but more mechanical or human-caused low flow events whereby the taps haven’t been turned off properly or the toilet cistern takes very long time to fill or is faulty (e.g. stuck ball valve). Typically, ‘true’ post-meter leaks have a very clear pattern of flow and are usually attributed to cracks in pipes or similar. From analysis of SEQREUS flow category data (Figures 75-77) there appears a trend toward four main ‘clusters’ of flow rate categories:

- **Flow rate range category Cluster 1** – this cluster denotes the first 11 categories (0 to ≤ 100 L/hr) and usually contributes around 10% of the total consumption. The end uses associated with such low flows were mainly leaks, internal tap use, dishwasher, and some low flow toilet, shower and clothes washing events. Analysis has shown that household leaks are typically in the lowest four categories (i.e. flow rates ≤ 30 L/hr)

- **Flow rate range category Cluster 2** – this cluster represents the middle nine categories (100 ≤ 1,000 L/hr) and typically contributes about 80% of the total consumption. In particular, the categories between 300 ≤ 700 L/hr comprise 57% (or 148.8 L/hh/d) of the cluster, or 45% of the overall total consumption. The end uses associated with these flow rates were typically shower, clothes washing, full flush toilet use, external tap use, and irrigation.

- **Flow rate range category Cluster 3** – this cluster denotes the next 8 categories (1,000 - 1800 L/hr) and generally contributes to almost 10% of the total consumption. The end uses associated with high flow rates included shower, clothes washing, external tap use, and irrigation.

- **Flow rate range category Cluster 4** – this cluster denotes the final category (< 1,800 L/hr) and usually contributes to less than 1% of the total consumption. The end uses are likely to be associated with excessive irrigation and uncommon water usage (e.g. service break leaks).

14.2. Total flow rate categories – combined SEQ dataset

From the SEQREUS datasets three periods of end-use analysis have been selected for closer examination in terms of flow rate categorisation: June 2010 (read 1), September 2012 (read 6) and September 2013 (read 10). These three periods were chosen as they: 1) cover the early, middle and final end-use reads, 2) include the period where outdoor use was notably higher (read 3, Table 1), and 3) allow a comparison between increased water use behaviour and average
water use patterns post-drought (2010) and post flood (2013). Flow rate category clusters are presented for Brisbane and Ipswich combined and for the Sunshine Coast for the years 2010 (Figure 75), 2012 (Figure 76) and 2013 (Figure 77). Each of the four flow rate categories discussed above are shown for each period. The pie chart for daily average household use is also indicated in the figures to provide some context of where the flows might be attributed to within the home. The following observations can be made from examination of flow rate clusters:

- flow rates between 100 and 1,000 L/hr are the most common for all years of analysis and they seem to be associated with shower, tap and clothes washer;
- as the proportion of outdoor water use increases, so does the frequency of flow rate clusters 3 and 4 (e.g. >1,000 and >1,800 L/hr), particularly for the September 2012 period;
- the proportion of leaks don’t appear to be strongly correlated with high flow rates, but do show some correlation with the low flow cluster (0-100 L/hr), suggesting that for the sample of homes under observation, the ‘leak’ component was more likely to be attributable to small, discretionary leaks (discussed below);
- it is likely (and typical) that a small proportion of homes have contributed to the high flow cluster shown in Figure 76.

Figure 75: Average and cumulative water consumption (L/hh/d) for combined SEQ region in June 2010.
Figure 76: Average and cumulative water consumption for combined SEQ region September 2012.

Figure 77: Average and cumulative water consumption for combined SEQ region September 2013.
14.3. Total flow rate categories – individual regions

Individual region flow rate clusters were also analysed and presented as flow averages for each cluster, for each of the three selected years for Brisbane and Ipswich combined (Figure 79) and the Sunshine Coast (Figure 80). The Sunshine Coast exhibited a greater proportion of larger flow volumes, which appeared to be correlated with outdoor use, although this is not confirmed. Where leaks were higher, the lower flow component was also slightly higher, which is consistent with the assumption that many of the leak end-use activities were likely to be small rather than larger flow service break type leaks.

Figure 78: Average flow volumes (L/hh/d) for Brisbane and Ipswich region for (a) June 2010, (b) September 2012, and (c) September 2013.

Figure 79: Average flow volumes (L/hh/d) for the Sunshine Coast region for (a) June 2010, (b) September 2012, and (c) September 2013.
14.4. Trends in daily leak end-use rates: 2010 to 2013

The trend in post-meter leakage across the SEQREUS households over the last 4 years can be seen in Figures 69 to 71 where leaks, as a volumetric average and as percentage of total household demand, fluctuated over time with current data suggesting they are returning to pre-intervention levels, after a substantial drop between 2010 and 2011. The notable decrease of leak volumes was a result of feedback to participants following the 2010 baseline study and as part of an aligned intervention study by Fielding et al. (2013), homes with high leakage rates were alerted to such, with resultant leakage rates reduction following maintenance.

To explore a little further into the typology of leaks for the SEQREUS data, a frequency histogram of daily flow leak events (L/hr/d) taken as a combination of the 10 end-use read periods is presented in Figure 80. A majority of leaks identified in the end-use reads were less than 0.5 L/hr/d (or 12 L/p/d) where it was observed that what may be termed false or minor leaks that can be typically associated with discretionary behaviours such as not fully turning off tap. Conversely, the ‘true’ leaks, which are associated with larger leak events such as pipe breaks, did not occur very frequently and were attributable to around 20% of the sample.

![Histogram of average daily leak flow rate (L/hr/d) for combined SEQ sample.](image)

The breakdown of leak end-use volumes for Brisbane, Ipswich and the Sunshine Coast is shown in Figure 81 where again, the low flow leaks are more prevalent, especially for the Sunshine Coast. Some explanations for the higher leak occurrences in Sunshine Coast homes may be due to the higher outdoor water use that can lead to dripping or not properly shutting off taps, the age of the homes e.g. the sample consists of a high representation of retirees that have occupied their homes for some time, and the higher number of toilet events that have also been observed in Sunshine Coast households. On this latter point, Beal and Stewart (2011) identified a strong association between the diurnal occurrence of leaks and toilet events, suggesting that although many toilets are now dual flush, it may be prudent address the maintenance and inspection processes for toilets.
A number of potential factors that may correlate with leak flow rates were examined and presented in Figure 82. There were significant correlations (p<0.05) between larger leak end-use volumes and number of toilets, household income and older properties (Figure 82). There were significantly fewer occurrences of high leak end-use volumes for homes ≤ 10 years of age, compared to those homes that were >10 years of age. Homes with more than 2 toilets were also associated with a higher volume of leak end-use, as were homes with occupancy of 3 or more people. Aligned with these trends were the higher leak end-use volumes associated with households of >$60,000 per year. From this data, it could be hypothesised that leaks of a potentially more serious nature in terms of daily volume, may be more likely to occur in family homes with at least two toilets (therefore larger homes) that are at least 10 years of age.
A critical part of any leak detection programme is informing customers of how to check for leaks, how to fix or maintain leaking fixtures and appliances, and how to detect leaks in the first place. The reader is referred to recent work by Britton et al. (2008, 2013) to learn more about the effectiveness of communication and feedback information on reducing post meter residential leakage. Management of leaks is obviously greatly facilitated by advanced metering technology where regular and accurate detection can occur on a house by house basis, as demonstrated in this study and others (Britton et al, 2013, Willis et al. 2011, Roberts et al. 2011). The onus then may be placed on water utilities to inform customers, who, in turn, may be liable for making repairs in a reasonable time period. Further discussion and research needs to be conducted to develop a suitable leak detection strategy that is equitable in terms of reducing customer charges on “un-used” water while ensuring water utilities do not bear the sole responsibility for identifying and informing customers of poorly maintained fixtures and appliances.

A further consideration is the benefit perceived by the customer in fixing the leak compared to the cost of not repairing the leak, of which the latter may often be cheaper, and making it less desirable to fix the leak, even after being alerted by the utility. This has been observed in utilities that have deployed smart metering programs which offer automatic leak alerts to the customer, but the customer does not necessarily act on this information (Beal and Flynn 2014). Despite this, a majority of respondents indicated they would like to have a leak alert system offered by their utility in a recent survey of 270 SEQ residents (Beal 2014).
15. AVERAGE DIURNAL DEMAND PATTERNS

15.1. Introduction

Diurnal water end usage patterns can be generated from high resolution micro-component data. Diurnal usage patterns have been used to identify trends and peaks in water (e.g. Beal and Stewart 2014, Willis et al. 2011) and energy (e.g. Firth et al. 2008) consumption over time.

A software tool, specifically developed to enable the high resolution flow trace data to be created into diurnal patterns, was used to generate the data that is presented in this section of the report (Figure 83). The software facilitates the creation of diurnal patterns at various time intervals. An MS Excel™ spreadsheet is then used to obtain an average day and peak hour consumption.

![Software graphic user interface for diurnal pattern development.](image)

**Figure 83:** Software graphic user interface for diurnal pattern development.

15.2. Average Day Diurnal Patterns

The average day (AD) diurnal patterns for combined SEQ households 2010-2013 is shown in Figure 84. Typically, there are two main peaks between 7 to 9 am and 5.30 to 7 pm, although during the summer months the afternoon peaks tend to start later and finish later. Previous technical reports have discussed the AD diurnal pattern trend at length and this will not be repeated here. In summary, the end-uses contributing the most to these peak times are shower, clothes washing and outdoor use. The AD patterns for outdoor use fluctuated the most notably throughout the SEQREUS project. As discussed throughout this report, fluctuations are driven by weather and behavioural factors predominantly, and were at their most prominent in the September 2012 period where a prolonged dry period, together with warming Spring temperatures prompted an increase in outdoor water use in households (Figure 84c). Clothes washing occurred mostly in the morning hours, with more events on the weekends than the weekdays typically (data not shown). Shower events were the most influential end-use on indoor diurnal patterns contributing to at least 30-50% of the indoor morning and afternoon peaks. Toilet use was consistent throughout day, particularly for those homes that had a high proportion of all day occupancy (e.g. household with retirees, pensioners and young families).
Figure 84: Average day diurnal patterns for combined SEQ households for a) June 2010; b) June 2011; c) September 2012; and d) May 2013.
15.3. Peak Day Diurnal Patterns

15.3.1. Introduction

From the AD diurnal patterns, peak hourly demand can be identified and quantified. Peak hour demand from AD diurnal data has been divided into morning and afternoon events. This type of peak demand analysis can provide valuable information to water utilities to address issues such as supply-side operational efficiencies, planning, asset management and hydraulic engineering based problems.

15.3.2. Combined SEQ peak trends

The peak hourly demand for SEQ is averaged over end-use reads between Jan 2010 and April 2013, and includes water restrictions (Permanent Water Conservation Measures) and post drought water consumption behaviours (typically low levels of outdoor watering) (Figure 85). Indoor water consumption for SEQ has been demonstrated as relatively homogenous across seasons and households (Beal and Stewart 2011, Willis et al 2011). Therefore, the peak hourly demand is expected to be more representative of the current indoor water consumption patterns, compared to the outdoor consumption patterns for SEQ.

However, to provide some insight into the peak demand patterns of recent outdoor use in SEQ, peak hour demand data from the first two weeks in September 2012 is presented in Figure 86. This time period was retrospectively selected for end-use analysis as this was identified as the peak month of the entire 4 year study and occurred at the end of a period (approx. 6 weeks) of low or no rainfall. The resulting total daily household demand was the highest of all the previous months measured (Figure 86). Outdoor peak hourly demand from this September 2012 dataset is much higher at 27% of total peak hourly demand (Figure 86b), compared to 14.5% for the SEQ average (Figure 85b).

Shower, and to a lesser extent clothes washer, peak hourly demand are consistently high during morning and afternoon periods for both averaged SEQ (Figure 24) and peak month (September 2012) (Figure 25) diurnal patterns.

![Volumetric peak hour flows (L/p/h/d)](image-a)

<table>
<thead>
<tr>
<th></th>
<th>AM</th>
<th>PM</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor</td>
<td>1.54</td>
<td>1.99</td>
<td>3.5</td>
</tr>
<tr>
<td>Bathtub</td>
<td>0.07</td>
<td>0.65</td>
<td>0.7</td>
</tr>
<tr>
<td>Tap</td>
<td>1.63</td>
<td>1.63</td>
<td>3.3</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>0.15</td>
<td>0.19</td>
<td>0.3</td>
</tr>
<tr>
<td>Shower</td>
<td>4.54</td>
<td>3.38</td>
<td>7.9</td>
</tr>
<tr>
<td>Clotheswasher</td>
<td>3.18</td>
<td>1.52</td>
<td>4.7</td>
</tr>
<tr>
<td>Toilet</td>
<td>1.97</td>
<td>1.27</td>
<td>3.2</td>
</tr>
<tr>
<td>Leak</td>
<td>0.28</td>
<td>0.29</td>
<td>0.6</td>
</tr>
</tbody>
</table>

![Percentage of total peak day flows (%)](image-b)

<table>
<thead>
<tr>
<th></th>
<th>% AM Total</th>
<th>% PM total</th>
<th>% Daily Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor</td>
<td>11.5</td>
<td>18.2</td>
<td>14.5</td>
</tr>
<tr>
<td>Bathtub</td>
<td>0.5</td>
<td>6.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Tap</td>
<td>12.2</td>
<td>14.9</td>
<td>13.4</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>1.1</td>
<td>1.7</td>
<td>1.4</td>
</tr>
<tr>
<td>Shower</td>
<td>34.0</td>
<td>31.0</td>
<td>32.6</td>
</tr>
<tr>
<td>Clotheswasher</td>
<td>23.8</td>
<td>13.9</td>
<td>19.3</td>
</tr>
<tr>
<td>Toilet</td>
<td>14.8</td>
<td>11.6</td>
<td>13.4</td>
</tr>
<tr>
<td>Leak</td>
<td>2.1</td>
<td>2.7</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Figure 85: End-use breakdown of average day peak hour flow for south-east Queensland.
15.3.3. Distribution of peak end-uses

The distribution of peak demand for individual end-uses was also examined to provide a comparative analysis of not only the volume of end-use peaks, but the time of day of such peaks. This is a critical point when assessing areas for optimising water supply pump operating costs during times of peak water demand. Data in Figure 87 presents the average combined SEQ diurnal distribution (timing) for each end-use for mornings and afternoons. The morning peak demand pattern is influenced by shower (4.5 L/p/h/d or 34% of total morning peak flow) and clothes washer (24%) primarily, with toilet (15%), tap (12%) and outdoor use (11.5%) also contributing (Figure 87). While there are only two significant peak hours in the morning (total of 13 L/p/h/d), they are greater in volume than the four main peak demand hours occurring in the afternoon (total of 10 L/p/h/d). The major end-uses driving the afternoon peaks is again shower activity (3.4 L/p/h or 31 % of afternoon total), with contributions from outdoor (18%), tap (15%), toilet (11.6 %), and bath (6%). The afternoon peak for clothes washer occurs just between 12 to 1 pm (13.9%), which would allow for the remainder of the afternoon for drying clothes.
16. IMPACT OF BEHAVIOURAL INTERVENTIONS ON WATER USE

16.1. Introduction

The main aim of this section was to determine estimated savings from implementation of social marketing (behavioural) water-efficiency strategies. The full report is provided in Beal et al. (2014b) and selected sections have been reproduced here to illustrate how technical and behavioural ‘interventions’ can reduce and/or shift peak water demand.

Water demand varies during the day, with demand generally lowest during the night and highest in the morning and early evening hours, resulting in double peaks concentrated over these two periods; the higher of which is termed a daily peak demand. This variation in water demand is also referred to as a diurnal demand curve. Over an annual analysis period, water utilities define certain peak demands to assist in infrastructure design. Peak hour (PH) demand exists in a peak day (PD), which is the maximum day demand over a 12-month period, and is utilised mainly in the design of pipe infrastructure. Additionally, in Queensland, the average of the highest moving average 30-day water demand, the mean day at maximum month (MDMM), is utilised to reflect demand persistence in response to climatic conditions (DERM, 2010). This average is used mainly in the sizing of pumps and reservoirs. Peaking factors are thus derived relative to average day (AD) demand; that is, average consumption over a 12-month period, to assist water utilities in designing water infrastructure. Following from this, diurnal patterns were developed for each of the three water demand parameters used in design and forecasting: AD, PD and MDMM (Gurung et al. 2014).

16.2. Methods

An overview of the methods used to determine the estimated savings from various water-efficient strategies is presented in Figure 88. Baseline water end-use consumption has been used which represents the average water end-use consumption from four years of monitoring data taken from residential properties in SEQ (Beal and Stewart 2011).

Each of these diurnal demand curves have been normalised to reflect the current utility-assigned AD consumption of 220 L/p/d (SEQ Code 2013). Although this per capita usage is above that reported by Beal et al. (2014b) and the weekly updates from Seqwater (range between 165 and 178 L/p/d over last two months- see http://www.seqwater.com.au/latest-updates/news/), it is a prudent approach for water supply planning and takes into uncertainty levels, population growth and behavioural change to name a few. Once the datasets were normalised, a water-use reduction factor was then applied to the baseline data for each of the AD, PD and MDMM patterns. The factors and justifications are presented in Section 2.2. For detailed explanations and method descriptions on obtaining the SEQREUS data and creating diurnal patterns please see the Beal and Stewart (2011) and Gurung et al. (2014).
16.2.1. Determining daily water demand reductions from social marketing

Work by Fielding et al (2012, 2013) provided a basis for determining the potential savings that can be achieved from using behavioural intervention strategies for reducing water consumption (Table 5). In that study, various interventions were applied to sub-groups of the participating SEQREUS household, to evaluate different behavioural approaches to achieve the reduction of household water demand.

Table 4: Parameters used for estimating diurnal water savings from behavioural interventions (L/hh/d)

<table>
<thead>
<tr>
<th></th>
<th>Before Intervention</th>
<th>After Intervention</th>
<th>Reduction factor</th>
<th>Volume reduction (L/hh/d)</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dishwasher</td>
<td>6.5</td>
<td>4.3</td>
<td>0.67</td>
<td>2.1</td>
<td>33%</td>
</tr>
<tr>
<td>Bathtub</td>
<td>7.7</td>
<td>4.9</td>
<td>0.63</td>
<td>2.9</td>
<td>37%</td>
</tr>
<tr>
<td>Tap</td>
<td>66.4</td>
<td>61.1</td>
<td>0.92</td>
<td>5.2</td>
<td>8%</td>
</tr>
<tr>
<td>Toilet</td>
<td>58.7</td>
<td>55.5</td>
<td>0.95</td>
<td>3.2</td>
<td>5%</td>
</tr>
<tr>
<td>Clothes Washer</td>
<td>86.3</td>
<td>65.3</td>
<td>0.76</td>
<td>21.0</td>
<td>24%</td>
</tr>
<tr>
<td>Shower</td>
<td>110.1</td>
<td>85.8</td>
<td>0.78</td>
<td>24.3</td>
<td>22%</td>
</tr>
<tr>
<td>Irrigation</td>
<td>14.9</td>
<td>8.6</td>
<td>0.57</td>
<td>6.3</td>
<td>43%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>350.5</td>
<td>285.6</td>
<td></td>
<td>64.9</td>
<td></td>
</tr>
</tbody>
</table>
16.2.2. Determining peak hour demand reductions from social marketing

For water utilities where average water demand management is not required but peak demand is putting strain on associated energy and economic costs (e.g. peak water use = peak energy tariffs for pumping to supply reservoirs etc.), a shift in peak water use activities is desired. This may be achieved by encouraging behaviour change in peak water use activities such as irrigation and other outdoor water use. Encouraging behaviour change can be a cheaper, and potentially more long-term solution than upgrading existing infrastructure. However, unlike water-efficiency and behavioural solutions, water demand reductions arising from shifting peak behaviour is not well documented and hence the reduction ‘factors’ were arbitrarily chosen for baseline and adjusted demand curve comparisons.

A number of scenarios targeting a shift in the peak water use behaviours of householders is presented in Table 6, along with some justification and assumptions. Peak energy tariffs in Qld are typically between 16:00 and 20:00 hours, thus this is the target time that the modelling has focussed on (e.g. to shift key end-use peak water use to late evening or early in the morning).

Table 5: Scenarios for encouraging water use behavioural shifts away from peak times

<table>
<thead>
<tr>
<th>Behaviour change in water use activity</th>
<th>Peak time to target shift / reduce</th>
<th>Shift to new time</th>
<th>Low uptake rate (%)</th>
<th>High uptake rate (%)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set clothes washer in early morning</td>
<td>07:00 – 11:00 AM 16:00 – 20:00 PM</td>
<td>0:00 - 06:00 AM</td>
<td>10</td>
<td>20</td>
<td>This would require the clothes washing machines to be set automatically to operate at hours between 0 and 6 am</td>
</tr>
<tr>
<td>Shower later in evening</td>
<td>16:00 – 20:00 PM</td>
<td>20:00 – 22:00 PM</td>
<td>5</td>
<td>10</td>
<td>To prolong people’s shower use until after 8 pm. Difficult to control discretionary behaviour that also incorporates quality of life aspects.</td>
</tr>
<tr>
<td>Set dishwasher in early morning</td>
<td>18:00 – 22:00 PM</td>
<td>0:00 – 6:00 AM</td>
<td>10</td>
<td>20</td>
<td>This would require the dishwasher to be set automatically to operate at hours between 0 and 6 am</td>
</tr>
<tr>
<td>Reduce kitchen tap use</td>
<td>16:00 – 20:00 PM</td>
<td>20:00 – 22:00 PM</td>
<td>2.5</td>
<td>5</td>
<td>Aims to encourage people to minimise their tap use during 4-8 pm where possible.</td>
</tr>
<tr>
<td>Outdoor watering</td>
<td>07:00 – 09:00 AM 16:00 – 20:00 PM</td>
<td>0:00 - 06:00 AM</td>
<td>15</td>
<td>30</td>
<td>This will have the most impact on peak day diurnal pattern as much of the peak is typically attributed to outdoor use</td>
</tr>
</tbody>
</table>

Not a lot of research has been done on encouraging a behavioural shift in how people interact with their water use activities. It is most likely quite difficult to encourage a behavioural shift in water use activities that are strongly associated with routine and quality of life (e.g. showers and tap use) (Russell and Fielding 2010). In comparison, it may be easier to encourage clothes washing and outdoor watering to occur out of peak times as these things can be automated and may be undertaken at any time of the day. There are a number of factors that would contribute to the success of encouraging shifts in behaviour including: season (hot weather = irrigation), family size (difficult to change shower routine with high demand for shower) and composition (young children need baths before bed), water use attitudes (environmentally aware households may be more likely to readily adopt shifts in peak water use) and employment factors (shift
workers. For this reason, there are two uptake rates that have been assumed in the modelling: a low uptake where fewer households engage in the water use shifts, and a high uptake, where it is assumed that twice as many targeted households engage in the behaviour. The uptake rates also represent the percentage of reduction that would be expected from the baseline end-use value for each scenario (e.g. 10% rate applied to shifting clothes washing to early morning = 10% of targeted population would engage in this strategy resulting in a 10% change to baseline clothes washing use).

16.3. Results and Discussion

16.3.1. Baseline water demand patterns

Average total (i.e. indoor and outdoor) end-use baseline demand pattern for average day (Figure 89) and peak day (Figure 90) diurnal demand patterns show consumption trends for end-uses over the combined SEQREUS stage 1 and 2 period. Both sets of diurnal patterns provide the baseline for determining the estimated savings from applying the behavioural intervention strategies, and will be referred back to throughout this chapter.

Figure 89: Total end-use baseline demand pattern for average day diurnal demand patterns

Figure 90: Total end-use baseline demand pattern for peak day diurnal demand patterns
16.3.2. Impact of social marketing strategies on daily demand

This section explores the potential reduction in water demand arising from the implementation of behavioural strategies for residential water use. This section is not focussed on shifting peak demand to other parts of the diurnal demand curve, but overall reduction of water consumption across the curve. The basis for this is from the work that was aligned with the SEQRUS and undertaken by Fielding et al. (2012, 2013) from CSIRO and University of Queensland. As previously outlined in the methods section, water use reduction factors were applied to each end-use (except leaks as they are not considered a human element of water use) to determine the estimated reduction after implementation of behavioural strategies. (Note the next Section 15.3.4 focusses solely on shifting peak demand but not actually reducing the total water consumption).

As for the previous section, results are presented as baseline and adjusted end-use diurnal demand curves for AD (Figure 91a) and PD (Figure 91b). Savings estimates from these demand curves are also presented for AD (Figure 92a) and PD (Figure 92b). It is worth noting that Fielding et al (2013) compared three social marketing (or also termed behavioural intervention) strategies to a control condition (no information at all) and found that all three voluntary strategies were effective in reducing household water use, even in the context of low pre-existing levels of household water use and high levels of rainfall during the intervention period. Behavioural cues for discretionary uses such as outdoor, tap use and to a certain extent shower use, can be effective as shown in the results here and reported elsewhere (Fielding et al. 2012).

In terms of achieving reductions in peak demand, outdoor water use activities are a key discretionary end-use that is strongly behaviourally driven; with frequency, duration, timing, and nature of outdoor use (e.g. trigger hose vs soaker hose) all important factors. Climatic cues such as duration of low or no rainfall, temperature and humidity are also influencing factors. Wider macro cues such as water restrictions, political ‘encouragement’ via media messaging (e.g. “it’s OK to water your garden again, the dams are full” or “it is socially unacceptable to be seen to waste water in the garden during the drought”) will also moderate the behaviour of individuals in how their use their water, particularly outside their house (Russell and Fielding 2011).
Baseline and adjusted AD demand curves indicate that good savings can be made across all end-uses and peak AD demand is not preferential to either morning or afternoon (Figure 91a). Estimated savings from AD peak hours are 22% and 11% in the morning and afternoon, respectively (Figure 92a). This translates to between 5.5 and 6.5 ML/h/d reduction in peak demand on an average water consumption demand day across SEQ. Overall, total water that can be potentially saved from behavioural strategies is predicted to be around 53 kL/hh/year, representing a 24% reduction from AD demand for business as usual.

PD demand curves show a clear reduction in outdoor usage as result of behavioural prompts to residents to conserve water (Figure 91b). The reduction in peak hour PD demand is estimated at 28% (11 ML/h/d) and 35% (20 ML/h/d) for the morning and afternoon, respectively (Figure 92b). Overall, a reduction in daily PD diurnal demand is predicted to be around 127 kL/hh/year, which is 30% less than the baseline demand (Figure 92b).
16.3.3. **Impact of social marketing strategies on peak hour demand**

Unlike the above Section (16.3.2), this component specifically concentrates on how peak demand can be shifted to other times of the day (non-peak times). *There is no assumption of reduced water consumption in this modelling.* As explained in the methods, encouraging behaviour change in order to shift peak water use activities, and ultimately the goal of reducing peak energy consumption at the water supply point, may be a cheaper option than upgrading infrastructure. Table 6 presented the scenarios and water demand reduction factors and the following section graphically presents the comparisons between baseline and adjusted demand curves for both low and high uptake rates assumed for householders participating in the peak shift behaviours. The predicted adjusted curves from behavioural shift interventions are indicated (baseline, low and high uptake rates), along with an indicative range of volumetric savings from the morning and afternoon peak hours. Baseline indoor total patterns are shown as a dashed line on the Figures for comparison.

The AD diurnal curves at low uptake from householders (Figure 93a) and high uptake from householders (Figure 93b) demonstrate a shift (reduction) from peak hour use to the early hours of the morning and later in the evening (say after 9.00pm). Data in Figure 93 presents the predicted shifts to peak demand away from the 8 am and 6 pm peak hours to early in the morning between midnight and 6 am, and later in the evening from 9.00pm to 11 pm. The afternoon peak shift away from 6.00pm is driven primarily by lower outdoor use, shower and tap. A reduction in the average peak hours for morning and afternoon are 5 % (low uptake) and 10% (high uptake) and 8% (low uptake) and 17% (high uptake), respectively (data not shown).
The PD diurnal curves at low uptake (Figure 94a) and high uptake (Figure 94b) demonstrate a clear shift away from afternoon peak for outdoor use. The shift to early morning, tends to flatten the curve out somewhat, particularly for high uptake rates. As the outdoor use is known to strongly influence the quantum of the PD diurnal curve, and most specifically the peak hour

Note: dashed line represents baseline indoor total for comparison

**Figure 93:** Adjusted Average Day end-use demand for homes receiving social marketing material to shift peak hour demand for (a) low uptake by residents and (b) high uptake by residents
demand, even a small shift in outdoor use can have a notable impact on flattening the afternoon peak demand. A reduction in the PD peak hours for morning and afternoon are substantial at 8\% (low uptake) and 15\% (high uptake) and 12\% (low uptake) and 23\% (high uptake), respectively (data not shown—see Beal et al. 2014b). The curve is also notably altered to the typical curve with early morning activity up to nearly 12 litres per person per hour per day (L/p/h/d), at 2:00am, compared to the baseline for the same time of around 1.6 L/p/h/d (data not shown).

### Figure 94: Adjusted Peak Day end-use demand for homes receiving social marketing material to shift peak hour demand for (a) low uptake by residents and (b) high uptake by residents (baseline total also shown for comparison)
16.4. Summary of estimated savings

A summary of the results in terms of estimated percent reductions from baseline water demand curves are presented in Table 7. Total water savings, along with morning and afternoon peak hour demand reductions are also indicated for AD, PD and MDMM. There is no total estimated water demand savings for the Section 5 results as this was not the goal of the modelling exercise.

Table 6: Summary of estimated peak hour demand savings from baseline demand scenarios for SEQ

<table>
<thead>
<tr>
<th>Demand Management Scenario</th>
<th>Demand curve type</th>
<th>Morning peak hour</th>
<th>Afternoon peak hour</th>
<th>Total daily (24 hour) estimated water demand savings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ML/hour/day savings</td>
<td></td>
<td>GL/year</td>
</tr>
<tr>
<td>Social marketing strategies aimed at reducing daily diurnal consumption (see Table 2)</td>
<td>AD</td>
<td>5.4 (22%)</td>
<td>6.4 (27%)</td>
<td>253 (24%)</td>
</tr>
<tr>
<td></td>
<td>PD</td>
<td>11.5 (28%)</td>
<td>20.2 (35%)</td>
<td>604 (30%)</td>
</tr>
<tr>
<td></td>
<td>MDMM</td>
<td>8.9 (26%)</td>
<td>12.9 (33%)</td>
<td>451 (29%)</td>
</tr>
<tr>
<td>Social marketing strategies aimed at encouraging shift in peak day consumption – Low uptake assumed (see Table 3)</td>
<td>AD</td>
<td>1.2 (5%)</td>
<td>1.9 (8%)</td>
<td>41 (29%)</td>
</tr>
<tr>
<td></td>
<td>PD</td>
<td>3.2 (8%)</td>
<td>6.7 (12%)</td>
<td>135 (25%)</td>
</tr>
<tr>
<td></td>
<td>MDMM</td>
<td>2.3 (7%)</td>
<td>4.2 (11%)</td>
<td>45 (29%)</td>
</tr>
<tr>
<td>Social marketing strategies aimed at encouraging shift in peak day consumption – High uptake assumed (see Table 3)</td>
<td>AD</td>
<td>2.4 (10%)</td>
<td>3.9 (17%)</td>
<td>87 (21%)</td>
</tr>
<tr>
<td></td>
<td>PD</td>
<td>6.3 (15%)</td>
<td>13.5 (23%)</td>
<td>280 (25%)</td>
</tr>
<tr>
<td></td>
<td>MDMM</td>
<td>4.6 (14%)</td>
<td>8.4 (21%)</td>
<td>188 (20%)</td>
</tr>
</tbody>
</table>

Notes: data in parentheses denotes a percentage reduction from the baseline peak hour or total daily

It should be stressed that the modelling exercise in Section 16.3.3 represents a separate set of social marketing objectives and strategies to the work presented in Section 16.3.2. The Section 16.3.3 results focused solely on peak periods rather than daily diurnal demand. Thus, the social marketing strategy objectives would be to maintain the same amount of water which is sold to customers, which may be an objective for some local and state governments, but for this consumption to occur outside peaks hours as much as possible to reduce infrastructure costs. However, for this marketing strategy to be successful, there would have to be some incentives from the customer’s perspective to engage in different water use behaviour activities, especially if they are discretionary and/or involve a degree of lifestyle change (e.g. showering at a later time, setting clothes washer on in the early hours of the morning, using an irrigation timer). Based on current water demand trends in SEQ for example, where there are no restrictions, regular rainfall and perceived security of water supply, these marketing strategies would potentially be a ‘hard sell’ to customers. While there is genuine savings to be made off the peak hour demand, this may be unlikely to be realised without, for example, time-of-use tariffs (TOUTS), determined through smart metering, which can then incentivise customers to reduce water use (e.g. showering and irrigation) during peak periods of the day.
17. OVERALL STUDY CONCLUSIONS

A range of total and end-use water consumption trends and analyses have been presented in this report, which is a culmination of over four years of ongoing smart metering of a sub-sample of South East Queensland homes. The starting sample size of 250 households has fluctuated over time due to two floods, mechanical issues and natural attrition. Despite the changes to sample size, there is considerable evidence from comparisons with other SEQ residential water use datasets (e.g. Seqwater) that the data presented in the numerous publications (see Appendix 2) is generally representative of the water consumption volumes and patterns experienced in SEQ over the post drought period to date.

17.1. Water Consumption Rebounds in SEQ

End-use analysis and total water use trends for the sample of residential homes in SEQ have indicated a potential rebound in water consumption – particularly outdoor use. On the whole, consumption fluctuated more markedly in the last two years (e.g. 2012 onwards) compared to the first two years of measurement. This may be related to the permanent water conservation measures (PWCM) that were current for the post drought period up to the end of 2012, resulting in a situation where people’s outdoor water usage was less likely to be influenced by the weather conditions and more likely to be influenced by the recent drought and severe water restrictions, and a subsequent continued reluctance for high water use outdoor activity. Thus, it is difficult to determine whether the observed increase in average consumption post-drought and post-floods is a result of a rebound to a “new normal” average use with the absence of social and behavioural cues to conserve water, or if it is skewed by natural variation in use prompted by periods of dry, warm weather which have coincided with elevated outdoor use. Further water consumption data will assist in confirming the conclusion here that while water use has rebounded from the mid-drought low of ~130 L/p/d, it is highly unlikely that average water consumption will ever reach the >250 L/p/d that was observed pre-Millennium drought, due largely to permanent shifts in people’s water use behaviour (especially outdoors), the mandated water-efficient fixtures in new developments and the growing number of smaller lot sizes and multi-unit dwellings.

17.2. Demand Management for Long-term Water use Efficiency and Network Optimisation

By understanding the factors that drive upward or downward trends in water consumption, managers can adopt a proactive approach to demand management and potentially circumvent the need for restrictions or other mandatory approaches. The effectiveness of water restrictions, while not always a favoured demand management approach for water utilities, has been shown to be very effective at reducing residential demand. Another non-mandatory approach that was used in combination with enforced restrictions was aimed at behavioural shifts in water consumption prompted by community and government media messaging, Target 140 campaigns and promotion of water-efficient devices. This approach was also effective in significantly reducing demand, and may be a more favoured approach when water scarcity becomes an issue again in the future. As demonstrated in Chapter 16, using behavioural interventions, in combination or as a substitute for the often unpopular water restrictions, may be a useful approach in changing the daily peak demand patterns; thus reducing the pressure on network pumping energy costs during these peak times. In the absence of immediate threats to water supply, the approach of using demand management to optimise water network infrastructure operating costs may well shift more strongly into focus in the near future.
18. REFERENCES


Carragher, BJ., Stewart, RA., Beal, CD.,(2012) Quantifying the influence of residential water appliance efficiency on average day diurnal demand patterns at an end use level: A precursor to optimised water service infrastructure planning. Resour Conserv Recy (2012), 62, 81-90


APPENDIX A: SEQREUS STAGE 2 TECHNICAL REPORTS TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Title</th>
<th>page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical Report No. 2</td>
<td></td>
</tr>
<tr>
<td>Summary progress report No. 3</td>
<td></td>
</tr>
<tr>
<td>July 2013</td>
<td></td>
</tr>
</tbody>
</table>
# TABLE OF CONTENTS: TECHNICAL REPORT 1

1. BACKGROUND AND OBJECTIVES ........................................................................... 1
2. RESEARCH METHOD ................................................................................................. 2
   2.1. Sample Selection Process ............................................................................... 2
   2.2. End-use Measurement Approach ................................................................... 2
       2.2.1. Instrumentation for data capture ............................................................. 3
       2.2.2. Data analysis .......................................................................................... 3
       2.2.3. Household stock audits and water diaries ................................................. 4
3. SITUATIONAL CONTEXT ......................................................................................... 5
   3.1. Sample size and characteristics ....................................................................... 5
   3.2. Climatic conditions during analysis periods ...................................................... 6
4. SUMMER 2011 END-USE RESULTS ........................................................................ 7
   4.1. Overall Water Consumption Trends ................................................................. 7
   4.2. Regional Water Consumption ......................................................................... 8
       4.2.1. Summary ............................................................................................... 8
       4.2.2. Brisbane ............................................................................................... 9
       4.2.3. Ipswich ................................................................................................. 9
       4.2.4. Sunshine Coast .................................................................................... 10
5. AUTUMN 2012 END-USE RESULTS ...................................................................... 11
   5.1. Overall Water Consumption Trends ............................................................... 11
   5.2. Regional Water Consumption ....................................................................... 12
       5.2.1. Summary .............................................................................................. 12
       5.2.2. Brisbane .............................................................................................. 13
       5.2.3. Ipswich ............................................................................................... 13
       5.2.4. Sunshine Coast .................................................................................... 14
6. AVERAGE AND PEAK TOTAL WATER CONSUMPTION ....................................... 15
   6.1. Introduction ...................................................................................................... 15
   6.2. Timeline Breakdown of Consumption Activity ................................................. 15
7. STOCK EFFICIENCY INFLUENCE ON WATER USE ........................................... 17
   7.1. Introduction ...................................................................................................... 17
   7.2. Water-efficient cluster comparisons ............................................................... 17
       7.2.1. Clothes washer ....................................................................................... 17
       7.2.2. Shower ................................................................................................. 18
       7.2.3. Taps ....................................................................................................... 19
8. SOCIO-DEMOGRAPHIC INFLUENCES ON WATER END-USES ...................... 20
   8.1. Introduction ...................................................................................................... 20
   8.2. Household type .............................................................................................. 20
   8.3. Income .......................................................................................................... 21
   8.4. Age ................................................................................................................. 22
9. CONCLUSIONS AND FUTURE ANALYSIS ......................................................... 24
10. REFERENCES ........................................................................................................ 25
# TABLE OF CONTENTS: TECHNICAL REPORT 2

1. **BACKGROUND AND OBJECTIVES** .......................................................... 4

2. **SITUATIONAL CONTEXT** ....................................................................... 5
   2.1. Sample size and characteristics .................................................... 5
   2.2. Climatic conditions during analysis periods ............................... 5

3. **WATER END-USE CONSUMPTION** ...................................................... 7
   3.1. Combined Regions .......................................................................... 7
   3.2. Water end-use consumption – individual regions ....................... 8
       3.2.1. Summary ................................................................................. 8
       3.2.2. Brisbane and Ipswich .......................................................... 8
       3.2.3. Sunshine Coast ..................................................................... 10
       3.2.4. Other SEQ regions .............................................................. 10

4. **DIURNAL WATER USE PATTERNS** .................................................... 11
   4.1. Combined Regions .......................................................................... 11
   4.2. Individual Regions .......................................................................... 13
       4.2.1. Brisbane and Ipswich .......................................................... 13
       4.2.2. Sunshine Coast ..................................................................... 15
       4.2.3. Other SEQ regions .............................................................. 15

5. **END-USE CONSUMPTION TRENDS OVER TIME: 2010-2012** ............ 17
   5.1. Comparison with previous end-use data ....................................... 17
   5.2. Drivers of increased water use: social, environmental or both? ........ 18
   5.3. Climatic influences on total daily consumption ........................... 19

6. **TOTAL WATER CONSUMPTION TRENDS: 2010 - 2013** .................. 24
   5.1. Total water consumption – combined ......................................... 24
       5.1.1. Monthly trends ..................................................................... 24
   5.2. Individual Regions .......................................................................... 25
       5.2.1. Monthly trends ..................................................................... 26

7. **POST-METER LEAKAGE** ................................................................. 32
   6.1. Introduction .................................................................................... 32
   6.2. Flow rate categories and MNF ..................................................... 32
   6.1. Trends in leak rates: 2010 to 2012 .............................................. 34

7. **TOTAL PEAK FLOW AND PEAKING FACTOR PATTERNS** ............. 36
   7.1. Introduction .................................................................................... 36
   7.2. Combined Regions .......................................................................... 36
   7.3. Individual Regions .......................................................................... 37
       7.3.1. Brisbane ............................................................................... 38
       7.3.2. Ipswich ................................................................................. 39
       7.3.3. Sunshine Coast ..................................................................... 41

8. **CONCLUSIONS AND FUTURE ANALYSIS** ...................................... 43

9. **REFERENCES** .................................................................................... 44
# TABLE OF CONTENTS – TECHNICAL REPORT 3

1. INTRODUCTION ........................................................................................................ 1

2. SITUATIONAL CONTEXT ......................................................................................... 2
   2.1. Sample size and characteristics ...................................................................... 2
   2.2. Climatic conditions during analysis periods .................................................. 2

3. WATER END-USE CONSUMPTION – NOV - DEC 2012 ......................................... 3
   3.1. Combined Regions .......................................................................................... 3
   3.2. Water end-use consumption – individual regions ........................................... 4
       3.2.1. Summary .................................................................................................. 4
       3.2.2. Brisbane and Ipswich .............................................................................. 4
       3.2.3. Sunshine Coast .................................................................................... 5
       3.2.4. Other SEQ regions ............................................................................... 6

4. WATER END-USE CONSUMPTION – MAY 2013 .................................................. 7
   4.1. Combined Regions .......................................................................................... 7
   4.2. Water end-use consumption – individual regions ........................................... 8
       4.2.1. Summary .................................................................................................. 8
       4.2.2. Brisbane and Ipswich .............................................................................. 8
       4.2.3. Sunshine Coast .................................................................................... 9
       4.2.4. Other SEQ regions ............................................................................... 10

5. END-USE CONSUMPTION TRENDS OVER TIME: 2010-2013 ....................... 11
   5.1 Combined Regions .......................................................................................... 11
   5.2 Individual Regions .......................................................................................... 12

6. TOTAL WATER CONSUMPTION TRENDS: 2010 - 2013 ................................. 15
   6.1 Comparison of total water consumption with State Government estimates ....... 15
   6.2 Total water consumption – combined SEQ region .......................................... 16

7 IMPACT OF WATER RESTRICTIONS AND MEDIA MESSAGING ON WATER USE ........................................................................................................................... 18

8 OUTDOOR WATER USE TRENDS OVER TIME .................................................. 20

9 CONCLUSIONS ....................................................................................................... 23

10 REFERENCES ........................................................................................................ 23
APPENDIX B: LIST AND LINKS TO ALL AVAILABLE PUBLICATIONS ARISING FROM THE SEQREUS STAGES 1 AND 2

Please contact the authors if requiring a copy of any of these publications that cannot be accessed fully through the link provided.

SEQREUS Stage 1 Final Report

Water use trends post drought and post flood in SEQ
Link: http://www98.griffith.edu.au/dspace/bitstream/handle/10072/38126/68062_1.pdf?sequence=1

Link: http://www.iwaponline.com/ws/01404/ws014040561.htm


Drivers of peak water demand
Link: http://ascelibrary.org/doi/abs/10.1061/(ASCE)WR.1943-5452.0000357

Socio-demographic factors of water consumption
Link: http://www.iwaponline.com/ws/01105/ws011050527.htm

Perceived versus actual water consumption

Water efficiency influence on daily demand
Carragher, BJ., Stewart, RA., Beal, CD.,(2012) Quantifying the influence of residential water appliance efficiency on average day diurnal demand patterns at an end use level: A precursor to optimised water service infrastructure planning. Resour Conserv Recy (2012), 62, 81-90

Predictors of shower consumption

Cont...
**Smart meters and optimised network modelling**
[Link](http://www.sciencedirect.com/science/article/pii/S0921344914001347)

Gurung, R.T, Stewart, R.A., Sharma, A. and Beal, C.D (In press) Smart meter enabled water end-use demand data: platform for the enhanced infrastructure planning of contemporary urban water supply networks. *Journal of Cleaner Production, accepted 19/9/14*
[Link](http://www.sciencedirect.com/science/article/pii/S0959652614009846)

**Looking into the energy benefits of water end use conservation**
[Link](http://www.sciencedirect.com/science/article/pii/S0378778812003908)

**ANN approach to predict water end use**