Baseline Characteristics of Mandated Rainwater Tank Users in South East Queensland (Phase 1)

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August 2011

Urban Water Security Research Alliance
Technical Report No. 48

Queensland Government
National Research FLAGSHIPS Water for a Healthy Country
CSIRO
Griffith University
The University of Queensland Australia

Urban Water Security Research Alliance Technical Report ISSN 1836-5566 (Online)
Urban Water Security Research Alliance Technical Report ISSN 1836-5558 (Print)

The Urban Water Security Research Alliance (UWSRA) is a $50 million partnership over five years between the Queensland Government, CSIRO's Water for a Healthy Country Flagship, Griffith University and The University of Queensland. The Alliance has been formed to address South East Queensland's emerging urban water issues with a focus on water security and recycling. The program will bring new research capacity to South East Queensland tailored to tackling existing and anticipated future issues to inform the implementation of the Water Strategy.

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Chong, M.N., Mankad, A., Gardner, T. and Sharma, A. (2011). *Baseline Characteristics of Mandated Rainwater Tank Users in South East Queensland (Phase 1)* Urban Water Security Research Alliance Technical Report No. 48.

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ACKNOWLEDGEMENTS

This research was undertaken as part of the South East Queensland Urban Water Security Research Alliance, a scientific collaboration between the Queensland Government, CSIRO, The University of Queensland and Griffith University.

Foremost thanks must go to the Queensland Water Commission for their financial contribution to the operating costs of this project. Special thanks are dedicated to Mark Askins, Genavee Telford and Justin Claridge, from the Queensland Water Commission, for their wonderful help on attaining the householders' database during the initiation of this work. Particular thanks go to the members of the Decentralised Systems Project Reference Group for their valuable inputs, advice and assistance to this baseline survey work.

Similar gratitude also goes to Kaye Gardiner, Kelly Fielding, Linda Chalmers and Elizabeth Kellet for their support for this research. TNS market research is also acknowledged for conducting the phone survey and providing necessary data for the report.

Special thanks to Don Begbie, Brian McIntosh and Sharon Biermann from the Alliance for their critical review and valuable suggestions in documenting this report.

Sincere thanks to all the 1,134 participants who willingly contributed considerable amount of their time in participating in this baseline study.

FOREWORD

Water is fundamental to our quality of life, to economic growth and to the environment. With its booming economy and growing population, Australia's South East Queensland (SEQ) region faces increasing pressure on its water resources. These pressures are compounded by the impact of climate variability and accelerating climate change.

The Urban Water Security Research Alliance, through targeted, multidisciplinary research initiatives, has been formed to address the region's emerging urban water issues.

As the largest regionally focused urban water research program in Australia, the Alliance is focused on water security and recycling, but will align research where appropriate with other water research programs such as those of other SEQ water agencies, CSIRO's Water for a Healthy Country National Research Flagship, Water Quality Research Australia, eWater CRC and the Water Services Association of Australia (WSAA).

The Alliance is a partnership between the Queensland Government, CSIRO's Water for a Healthy Country National Research Flagship, The University of Queensland and Griffith University. It brings new research capacity to SEQ, tailored to tackling existing and anticipated future risks, assumptions and uncertainties facing water supply strategy. It is a $50 million partnership over five years.

Alliance research is examining fundamental issues necessary to deliver the region's water needs, including:

- ensuring the reliability and safety of recycled water systems.
- advising on infrastructure and technology for the recycling of wastewater and stormwater.
- building scientific knowledge into the management of health and safety risks in the water supply system.
- increasing community confidence in the future of water supply.

This report is part of a series summarising the output from the Urban Water Security Research Alliance. All reports and additional information about the Alliance can be found at http://www.urbanwateralliance.org.au/about.html.

Chris Davis
Chair, Urban Water Security Research Alliance

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EXECUTIVE SUMMARY

This report outlines the results of a telephone survey of mandated rainwater tank users in South East Queensland (SEQ) undertaken to establish baseline physical, demographic and behavioural factors influencing the implementation of mandated rainwater tanks in detached dwellings, as per the Queensland Development Code MP 4.2–Water savings targets (QDC MP4.2). Under this development code, all detached dwellings in SEQ are required to save 70 kilolitres/household/year (kL/hh/yr) of mains water through the use of supplementary water sources. Installing a rainwater tank internally plumbed to the washing machine cold water tap, toilets and at least one outdoor tap is the typical compliance method chosen. Other acceptable alternatives include communal rainwater tanks, greywater treatment plants, dual reticulation of recycled water and stormwater reuse, or a combination of these sources.

This report on the baseline characteristics constitutes Phase 1 of a wider research project investigating the physical (set-up) and socio-demographic factors influencing the use of rainwater tank water by individual households with mandated rainwater tanks in SEQ. In the broader research project, the actual use of rainwater tank water is estimated using water billing records from known internally plumbed tank (IPT) homes. Tank design and governance and management issues in achieving and maintaining optimal mains water savings through rainwater use are also being considered.

Previously, a desktop statistical study on mains water saving across four local council areas (i.e. Caboolture, Pine Rivers, Redland and Gold Coast) was conducted, comparing 2008 water billing records from mandated tank households to non-tank households (Beal *et al.*, 2011). Water billing data were obtained directly from the four councils. In total, over 6,000 records of mandated tank owners were obtained which were complemented by 91,000 records of households without raintanks. Statistical tests were performed to establish statistically significant differences between homes with mandated rainwater tanks and those without tanks. Results from this preliminary research showed that, in 2008, water savings from mains supplies based on mean water consumption averaged 50 kL/hh/yr across the SEQ region, with the savings varying markedly across councils, ranging from 20 to 95 kL/hh/yr.

Statistical analysis results were cross-checked with two other approaches used to estimate mains water savings from IPT. Water consumption from the IPT-sourced toilet and cold water laundry tap were calculated using measured water end use data from recent SEQ residential end use research (Beal *et al.*, 2010) and rainwater TANK modelling.

Beal *et al.* (2011) highlighted the fact that the variation in savings found from the desktop statistical analysis may be partially attributable to different external water restrictions across the councils, variation in household occupancy (and thus demand), presence of water efficient household appliances and fixtures (e.g. front-loading washing machines) and householders' water use behaviour. Another source of variation may be explained by some ambiguities identified in using the water billing data alone without additional knowledge of individual household occupancy for the new dwellings and number of occupants at that time.

In order to address Beal and colleagues' hypotheses for the variation in estimated mains water savings, telephone surveys were conducted in this first phase of the project, via the Computer Assisted Telephone Interviewing (CATI) approach. Three major areas of interest were examined: (1) basic compliance of new dwellings with mandated rainwater tanks to the QDC MP4.2 requirements; (2) physical and demographic characteristics at the household level and their comparison to the existing ABS 2006 census district data; and (3) householders' attitudes, behaviours, and risk and threat perceptions towards water usage and savings.

In total, 1,134 participants were interviewed in this study, all of whom were owners of new, single detached dwellings from across the four Local Government Areas (LGAs) of interest: Caboolture, Pine Rivers, Redland and Gold Coast. Further, these new homes were built after June 2007 and thus, were presumably compliant with the QDC MP4.2. The physical and demographic characteristics of the sample were also comparable to the ABS 2006 census district data. Questions included in the survey asked residents whether they had a rainwater tank, their tank set-up, uses of their rainwater, rainwater supply satisfaction and general knowledge of water issues in SEQ (e.g. threat perception, water restrictions).

Results indicated that most participants lived in Class 1, single-story dwellings with four bedrooms and two bathrooms. Of the 1,134 respondents, the volume of rainwater tanks at their premises varied considerably and 78% of them reported having a rainwater tank with a volume of 5,000 litres or more and 8% reported having a smaller tank. A total of 14% of householders reported having no knowledge of the volume of their rainwater tanks. The majority of residents (79%) reported having at least 25% of their roof area connected to their rainwater tank. Results also showed that the majority of participants perceived themselves as being medium to low water users, particularly those living in Caboolture and Gold Coast. While all participants owned a rainwater tank, approximately 90% of participants responded that they did not own a greywater treatment plant. However, of those that did have a greywater treatment plant, most resided in the Redland City Council area.

In terms of rainwater tank use, the majority of participants used their rainwater for toilet flushing and laundry applications, with a further 77% of participants also using rainwater for garden irrigation. Only half of respondents reported using rainwater to wash their cars. Overwhelmingly, 96% of participants reported never using their rainwater for drinking or cooking purposes, however, this finding is to be expected, given that the Queensland Government does not recommend that people use their rainwater for drinking without treatment where a potable water supply is available. Interestingly, this finding is in contrast with that of Gardiner (2009) who found that 22% of mandated tank owners mainly in Redland, Sunshine Coast, Ipswich and other areas, used their rainwater for drinking or cooking often. Of those participants who did report using their rainwater for drinking water applications either sometimes or always, only 40% treated the water before use, with filtration being the most popular method.

In addition to rainwater use behaviours, participants were asked to provide qualitative data regarding their beliefs surrounding water shortages in SEQ. Most participants reported that the primary reasons for current water shortages in SEQ were 'people' (i.e. current water use behaviours of SEQ residents were seen to be unsustainable) and 'population growth' (i.e. increasing population in SEQ, but not enough water to keep up with the demand). Similarly, participants believed that population growth and water use habits would be the biggest reasons for future water shortages in SEQ, as well as low rainfall and falling dams levels in SEQ. Conversely, of those who believed that SEQ was not at risk of water shortages, now or in the future, increasing rainfall and rising dam levels were cited as the primary factors alleviating the risks of water shortages in SEQ.

The outcomes from this Phase 1 baseline study enable us to gain an insight into the factors that might impact the use of rainwater. This Phase 1 research will form the basis of subsequent research, which will engage more deeply with the behavioural factors in achieving QDC MP4.2 water savings targets. A large, statistically representative number of households has been recruited from the telephone survey to give permission to access their past and future water billing records so that the magnitude of mains water savings achieved from known IPT homes can be related to physical and social attributes determined through the household surveys as part of the wider research.

A more comprehensive postal survey of mandated tank owners in SEQ ($n \geq 6,000$) in the later phase of the Decentralised Systems project will return more detailed information on rainwater systems, water use appliances, water use behaviour and household demographics. This postal survey will provide deeper social insight into the attitudes and behaviours of householders with mandated rainwater tanks, as well as the role of the community in managing rainwater tanks. Approximately 200 households were also recruited through the telephone survey to give permission for an on-site site audit of their rainwater tank system to validate physical set-up characteristics.

1. INTRODUCTION

Alternative water resources are becoming increasingly important in South East Queensland (SEQ) due to factors such as climate change and population growth contributing significantly to urban water stress. Accordingly, the SEQ Water Strategy calls for the use of decentralised water systems such as rainwater tanks, greywater treatment plants, and groundwater bores. Decentralised wastewater systems allow households to collect, treat and reuse localised wastewater in areas where high quality water is not required. The key benefit of these systems is reducing householders' reliance on town or mains water and providing water on a fit-for-purpose basis (Tjandraatmadja *et al.*, 2009).

To facilitate greater integration of decentralised water systems into urban environments within SEQ, the Queensland Development Code MP4.2 (QDC MP4.2) was modified to include a section which mandated that all detached Class 1 residential dwellings built in SEQ after 1 January 2007 (including properties applying for extension permits) must achieve mains water savings of 70 kilolitres/household/year (kL/hh/yr). The simplest and most efficient way for households to achieve this target is by installing a rainwater tank, with a minimum volume of 5,000 litres (L) (Queensland Development Code MP4.2; DIP, 2010). The tank is required to be plumbed into toilet cisterns, cold tap(s) of washing machines and external garden irrigation tap(s) of detached, single residential households. Further, it was mandated that all tanks have suitable measures to prevent mosquitoes breeding (e.g. mosquito-proof screens) and prevent contaminants from entering the tank (e.g. first flush mechanism for the first 20 L of collected water). Finally, internal fixtures supplied from the tank must also have a continuous supply of water and, therefore, a back-up supply from mains water using either a trickle top-up or an automatic switching device was stipulated (DIP, 2010).

Since the mandate has been in place, approximately 59,173 homes in SEQ have been built with a rainwater tank (ABS, 2010). Gardiner (2009) described the different circumstances under which residential rainwater tanks have been installed in SEQ (e,g. environmentally committed, for gardening, for extra water during drought), highlighting the fact that there are over 300,000 tanks in SEQ. However, follow-up research as to whether households are actually using and setting-up their rainwater tanks appropriately, whether they are achieving the stipulated mains water savings, and whether they are correctly maintaining their rainwater tanks is far from conclusive.

The purpose of this preliminary study is to provide a basic demographic and physical understanding of households with mandated rainwater tanks in SEQ. This research is an important step in achieving a more integrated understanding of decentralised systems use in SEQ. The following section describes some of the research already conducted in this area.

1.1. Past Research on Rainwater Tank Yields

Research on rainwater tank yields has found mixed results. Coombes and Kuczera (2003) predicted that rainwater tanks could yield annual reductions in mains water use ranging from 31 to 144 kL/hh/yr in Brisbane, depending on the tank size and household occupancy. However, in this instance the modelling was based on pre-drought rainfall data and assumed that rainwater was used for hot water systems, which are not mandated in SEQ. In comparison, Marsden Jacob Associates (NWC, 2007) presented a number of modelled scenarios for Australian urban environments where it was found that rainwater tanks could reduce mains water consumptions by 42 kL/hh/yr if the tank was externally plumbed. If the tank was plumbed to both internal and external fixtures, then that figure went up to 71 kL/hh/ yr. Importantly, both of these figures depended on the connected roof area feeding into the rainwater tank. Therefore, it is clear that residential use of rainwater is strongly influenced by connected roof area, household occupancy, rainfall and tank size. It is also important to note that these predictions relating to potential water savings are limited to the climatic or local condition inputs into the various models, such as pre-drought water use.

Other research outside Queensland has also found important considerations for calculating accurate mains water consumption and savings. Turner and colleagues (2005) conducted a study which looked at the differences in water use between households in Sydney with retrofitted efficient fixtures and with existing inefficient water fixtures. A total of 24,000 single residential homes that engaged in the retrofit program were randomly selected and paired with non-retrofitters, using a 2-year period of preintervention water consumption data. The researchers found that each retrofitted house used approximately 21 kL/hh/yr less water than the control households. In New South Wales, the Department of Planning responded to drought conditions and water shortages by implementing water demand management strategies and household level installations to minimise centralised water use. The Building Sustainability Index (BASIX) was used as an online mechanism to implement minimum sustainability performance for all new dwellings in New South Wales. The BASIX program used a water use benchmark of approximately 324 kL/hh/yr and this was based on the average household water consumption in New South Wales. To determine whether the BASIX program had been successful, Sydney Water linked BASIX data to quarterly water consumption data of participating households. Results showed that the BASIX target of 40% reductions was achieved with an average water consumption level of 192 kL/hh/yr, representing a 40.5% reduction on the BASIX benchmark, during 2007-2008 (NSW Department of Planning, 2008). The BASIX research was used as a basis for the present research, as the context for Sydney Water's work was comparable to the situation in SEQ, with respect to mandating rainwater tanks in new homes.

1.1.1. Research Leading to the Present Study

Beal and colleagues (2011) compared water use in new homes to the existing homes in SEQ. Their study used a paired statistical approach involving a large database (>28,000 dwellings) of mandated rainwater tank households across four SEQ Local Government Areas (LGAs): Caboolture, Pine Rivers, Redland and Gold Coast. The purpose of their study was to conduct a desktop assessment of the potential mains water reductions from internally plumbed rainwater tanks in new developments in SEQ. To achieve this aim, the researchers used existing council billing data to estimate mains water reductions from households with internally plumbed rainwater tanks. Beal and colleagues hypothesised that mains water consumption in homes with internally plumbed rainwater tanks would be significantly less than homes without rainwater tanks. Houses approved and constructed after 1 January 2007 were considered for this analysis as they were assumed to have an internally plumbed rainwater tank. Houses constructed prior to this date that had not received a tank rebate were used as the control group (i.e. no tank). Results indicated that an average reduction in mains water use across the three LGAs was 50 kL/hh/yr. Caboolture data are excluded from the final analysis due to quality issues. This research indicated a need for further investigation into the assumptions made, methodology used and contributing factors, resulting in the current study.

1.1.2. Limitations of Past Research

While the research conducted by Beal and colleagues (2011) was informative with respect to the current water savings of mandated rainwater tanks, there are some concerns that these estimates were skewed by water restrictions during the 2008 data period, which restricted external water use, as well as possible differences in the demographics between paired populations (i.e. mandated tank owners and non-tank owner households). Other possible reasons postulated for the bias in the desktop statistical analysis are: (1) the possible use of other water resources (e.g. greywater treatment plants and alternative water substitution measures) to achieve the QDC MP4.2 target; (2) different attitudes, behaviours and perceptions toward the use of rainwater (e.g. illegal garden watering during water restrictions, very frugal water use, limited acceptance of rainwater); and (3) non-compliant installation of mandated rainwater tanks at individual residential dwellings (e.g. inappropriate tank size and connected roof area, the tanks are not internally plumbed, etc.) (Beal *et al.*, 2011).

Due to the desktop nature of the analysis, quantifying the water savings or mains water reductions from the installation of internally plumbed rainwater tanks was difficult. Firstly, separating the billing data into two groups (tanks and no tanks) could only be done using assumptions and proxy data, hence there was no certainty that the data truly represented each cohort. Secondly, details on critical physical factors that influence residential water consumption (garden size, water efficient fixtures, etc.) could not be fully accounted for and, thirdly, socio-demographic factors (e.g. household occupancy, family characteristics, income) were also unable to be controlled for in the analysis. Consequently, several uncertainties in current household consumption of rainwater and mains water savings remained unresolved. These uncertainties arising from the desktop research conducted by Beal and colleagues (2011) provided the primary drivers for the present study in SEQ.

1.2. Purpose of Present Study

The purpose of this exploratory study is to help resolve the uncertainties relating specifically to current household occupancy rates for new and existing dwellings in SEQ and also to characterise household socio-demographical factors. The larger aim of this study is to provide some contextual understanding of Beal and colleagues' (2011) finding in achieving mains water savings through mandated rainwater tanks.

A socio-demographic and physical survey of households with mandated internally plumbed rainwater tanks has been conducted; designed to identify key household characteristics influencing water use including household occupancy, garden and property size, as well as the use of water appliances and fixtures. The target areas for this analysis are four Local Government Areas (LGAs) within SEQ: Caboolture, Pine Rivers, Redland and the Gold Coast, to mirror the sample used in Beal and colleagues' (2011) study. As part of this exploratory study, researchers also attempted to gain a preliminary understanding of the physical elements specific to these homes and to assess the degree to which rainwater tanks are set up according to the correct standards outlined in the QDC MP4.2. This information is likely to be key in determining whether mains water consumption is being reduced due to the correct installation of decentralised rainwater tank systems, or whether socio-demographic factors may also explain these changes. The present study will attempt to provide some validation for these claims and provide a foundation for the next phases of research to better understand the factors influencing water savings from mandated rainwater tanks. This includes an on-site physical audit of the rainwater tank system and a postal survey to examine in more depth the psycho-social and behavioural factors influencing rainwater use among households with a mandated rainwater tank.

2. METHODOLOGY

2.1. Study Setting and Time Period

The study setting comprised four LGAs in the SEQ region: Caboolture, Pine Rivers, Redland and Gold Coast. The 2006 Australian Census described these four LGAs as containing over 40% of SEQ's urban population (DIP, 2009). Beal and colleagues (2011) targeted these four LGAs in their previous investigation of rainwater tank savings. Therefore, the same areas were sampled in the present study to investigate the assumptions and uncertainties arising from the previous research. The phone survey for this study was conducted between July and August 2010.

2.2. Telephone Survey Process

2.2.1. Recruitment of Participants

Participants were recruited from Caboolture, Pine Rivers, Redland and Gold Coast. The Queensland Water Commission (QWC) provided a database of approximately 15,615 new water meter accounts from June/July 2007 to June 2010. The rationale for selecting this sample was the assumption that most of the filtered addresses would be for newly constructed homes with a mandated rainwater tank.

A market research company, TNS Global Research, Australia, was contracted to match the database of addresses with their correct telephone numbers (landlines and mobile phones) and to conduct a phone survey developed by the project team with input from the QWC. Telephone number matching was achieved through a specialised external telecommunications sub-contractor. Only 29% of addresses were matched to valid telephone numbers. However, this was believed to be characteristic of new dwellings due to inherent complications with obtaining reliable information for newly constructed properties. Just over 5,000 households were contacted and asked to participate in the telephone survey.

2.2.2. Screening of Respondents

Out of the 5,055 matched householders from the selected four LGAs, only 1,134 householders completed the full survey that was conducted via the Computer Assisted Telephone Interview (CATI) approach. Thus, in this report, all the percentages are shown as a fraction of the total number of respondent householders if not otherwise stated.

This reduced number of participants was due to an initial filtering process, through which individuals first went through stringent screening questions to ensure only the most relevant individuals were included, so as not to compromise validity. Those without rainwater tanks, tenants, owners or tenants of apartments/units, and those living in areas where recycled water was connected to the house for non-potable uses were not included in the sample, to minimise bias in the data.

The distribution of participants from the four LGAs was relatively uniform, with 240 participants from Caboolture, 264 from Redland, 295 from Gold Coast and 335 from Pine Rivers. The mean number of respondents per LGA was approximately 284 ($SD = 41$). Figure 1 shows the percentage distribution of the total survey respondents across the four LGAs.

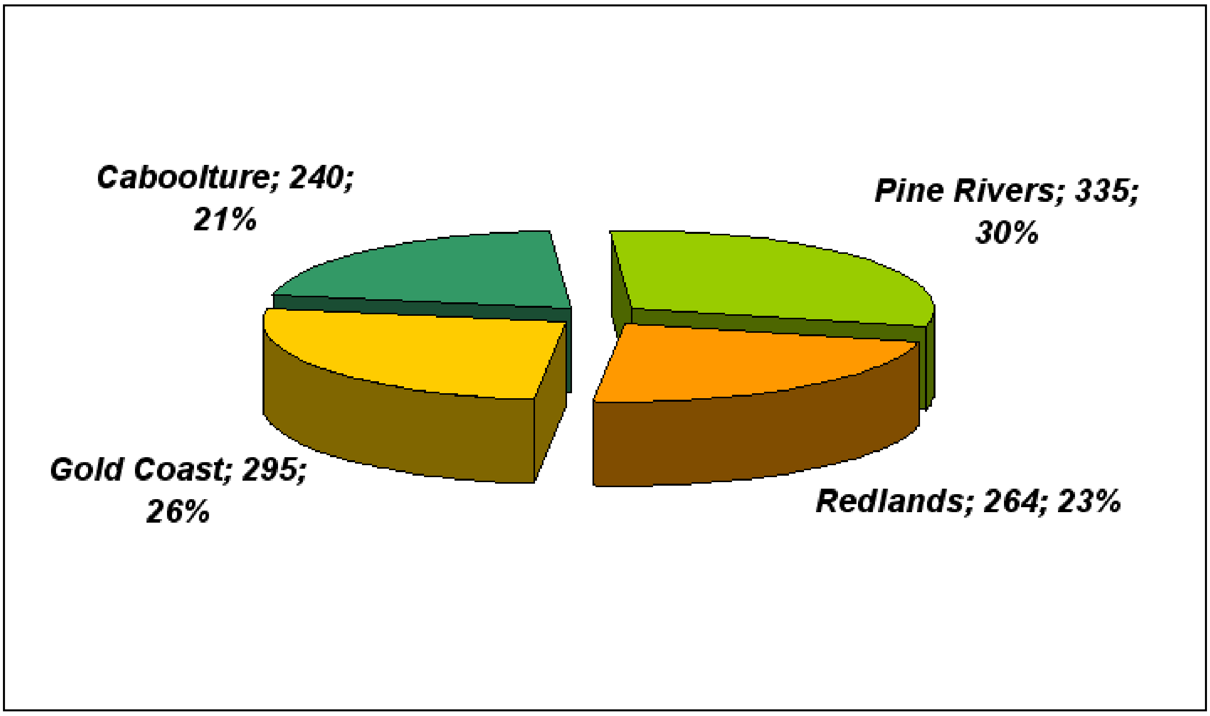

Figure 1: Percentage distribution of the total survey respondents across the four LGAs.

2.2.3. Ethical Clearance

Ethical clearance for the study and the survey questionnaire was obtained from the CSIRO Human Research Ethics Committee.

2.3. Survey Questionnaire

The telephone survey was developed to measure: key household demographic characteristics, including household occupancy (number of adults and children); and physical property characteristics, including Class 1 dwelling structure (i.e. single or double storey), property and house size, and the number of bedrooms and bathrooms. Several other physical items were also included to provide a measure of the types of water appliances and fixtures in the house, size of rainwater tanks, roof connections to the tank (e.g. area connected, number of downpipes), water treatment, number of greywater treatment plants (if any), and whether the tank was connected to a pump.

Social and behavioural items were included in the survey to provide an initial perspective of water use beyond demographic and physical factors. These items included water use habits in the home (e.g. for what purpose is rainwater used), satisfaction with the quality (e.g. taste, odour) of one's rainwater supply, knowledge of water restrictions, gardening behaviour and householders' perceived level of water usage. Participants were also asked to cite their main concerns regarding water supplies in SEQ, as well as their opinions on the risk of permanent water shortages in SEQ, now or in the future. These questions were included to provide an understanding of whether perceptual factors such as threat vulnerability and severity derived from protection motivation theory (Rogers, 1975; 1983) and influenced attitudes toward rainwater use.

The final telephone survey questionnaire is attached in Appendix 1.

2.4. Survey Method

The survey was conducted using the Computer Assisted Telephone Interviewing (CATI) method by a market research company. CATI is a telephone surveying technique in which the interviewer dials the telephone number to be called via a computer. When contact is made with a participant, the interviewer follows an introductory script and then reads questions posed on the computer screen, as per the survey content. Respondents' answers are recorded directly into the computer.

Participants whose home address matched a valid telephone number were contacted during July and August 2010 and were asked to provide formal consent to being interviewed over the phone, as per ethics requirements. After the initial screening questions, interviewers administered the survey, which took approximately 10 minutes to complete. At the end of the survey, participants were asked whether they would be willing to take part in further research. Additional information was collected if their answer was in the affirmative. Data was collected in a locked SPSS file and provided to the research team via a secure email for further analysis.

2.5. Sample Size and Data Analysis

The number of participants ultimately recruited for this survey (1,134 households) was based on a proportional stratified random sampling with a maximum error rate of +/- 6.8% at the 95% confidence level. This gives an indication of the probability that a margin of error around the reported scores would include the "true" score. Along with the confidence level (i.e. the tolerable amount of uncertainty, which in this case is 5%), the sample design for a survey, in particular its sample size, determines the magnitude of the margin of error. A larger sample size produces a smaller margin of error, all else remaining equal; thus the large sample size used in the present study is desirable.

Data were analysed using descriptive methodology where appropriate as well as thematic analysis for open-ended qualitative questions. Means, standard deviations and sample proportions were calculated for the whole sample, as well as for each region.

3. DATA ANALYSIS AND RESULTS

3.1. Basic QDC MP 4.2 Compliance Criteria

Under the QDC MP4.2, it is proposed that an acceptable solution for achieving 70 kL/hh/yr mains water savings is the combination of: a rainwater tank with a minimum volume of 5 kilolitres (kL), plumbed internally for toilet flushing, washing machine cold tap(s) and external garden irrigation tap(s); and at least half of the available roof catchment area or 100m^2 (whichever is the lesser). In this baseline study, most of the survey questions were designed to assess whether homes met the basic criteria in QDC MP4.2 before a comprehensive statistical analysis of billing records was carried out as a subsequent phase of the research to validate whether the proposed mains water savings target of 70 kL/hh/yr is being achieved.

3.1.1. Tank Volumes

Results showed that the volume of rainwater tanks varied modestly from the standard minimum 5,000 litre tank requirement. Figure 2 shows that, of the 1,134 respondent householders, 78% have a rainwater tank with a volume of 5,000 litres or more, while others have a volume ranging from 2,500-4,999 litres (5%) and 1-1,499 litres (3%). A total of 14% of householders reported having no idea of the volume of their rainwater tanks. Detailed analysis over the four LGAs showed that householders from both Caboolture and Pine Rivers have a higher compliance rate (72%) to the minimum 5 kL tank volume requirement than both Redlands and Gold Coast (66%), as depicted in Figure 3. This information is important as it can be used in the subsequent statistical analysis to correctively adjust the compliance rate in dwellings with mandated rainwater tanks, or if the water savings targets are being skewed by the percentages of non-compliance.

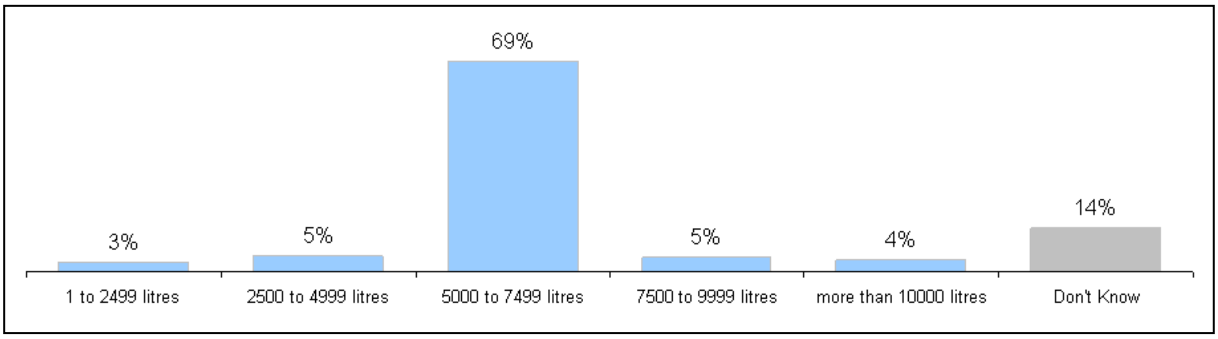

Figure 2: General trend on tank volumes across LGAs. Based on total survey sample (responses), n=1,134.

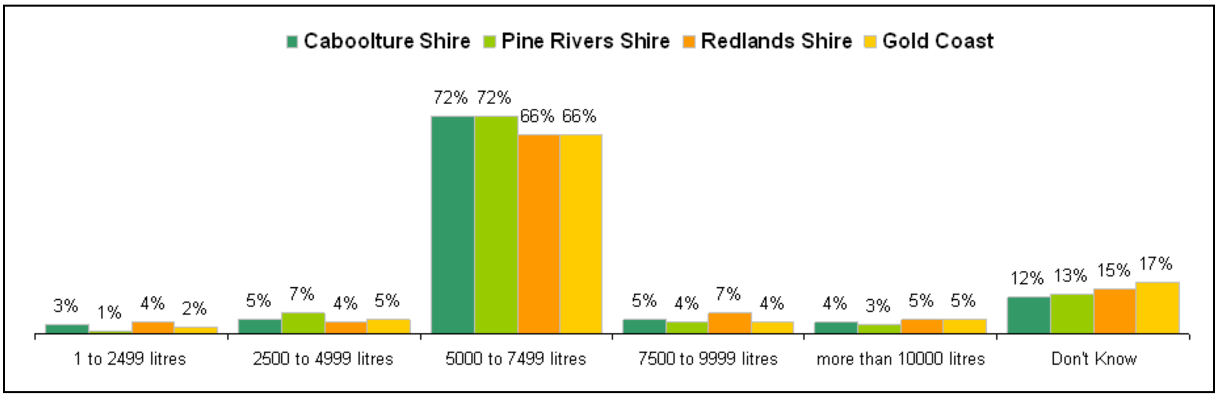

Figure 3: Detailed analysis by LGA on the tank volume distribution. Based on total survey sample, n=1,134.

3.1.2. Roof Area Connected

Other relevant information, such as the number of connected downpipes and estimated proportion of connected roof catchment area, was also gathered in this baseline study. It was assumed that most householders would have little idea of their actual roof catchment area. We adopted an "inferred" approach where the householder's judgement on the number of connected downpipes and estimated proportion of connected roof catchment area to their tank was used as the compliance indicator for QDC MP4.2.

Using this approach, we found that a high proportion (87%) of the householders had two or more pipes connected to their rainwater tanks. In this instance, connected downpipes of two or more is a reasonably good threshold indicator that dictates that at least a quarter to half the available roof catchment area is used to harvest the rainwater to the tanks. In the standard practice for QDC MP4.2, all rainwater tanks must receive rainfall from at least half of the available roof catchment area or 100 m^2, whichever is less. Figure 4 shows the percentage distribution of number of connected downpipes to the rainwater tanks across the four LGAs of interest. In this instance, the average number of connected downpipes to the rainwater tanks is estimated to be 3.33. For accurate data, physical inspection of households would be required, which will be conducted in the subsequent phase of this broader research project.

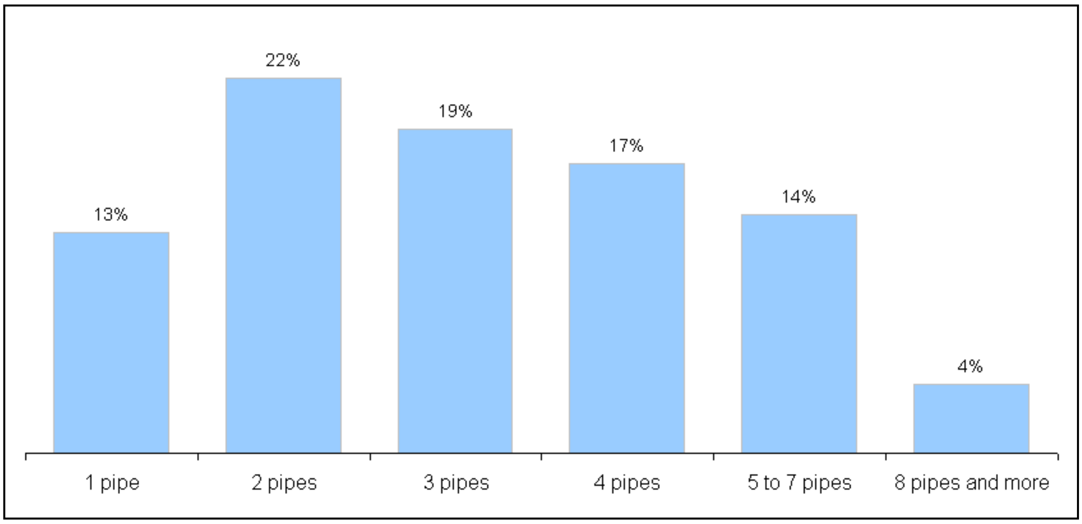

Figure 4: Percentage distribution of estimated number of connected downpipes across the four LGAs. Based on total survey sample, n=1,134.

In addition, 35% of householders estimated they have more than 50% of roof area connected to their rainwater tanks (Figure 5). However, using this approach, we were not able to establish whether the households had 100 m^2 of roof catchment area connected to the tank. Estimated percentage roof area connected to the rainwater tank on a LGA-by-LGA basis (Figure 6) shows uniformity of distribution at the LGA level and strong agreement with the general trend of outcomes depicted in Figure 5.

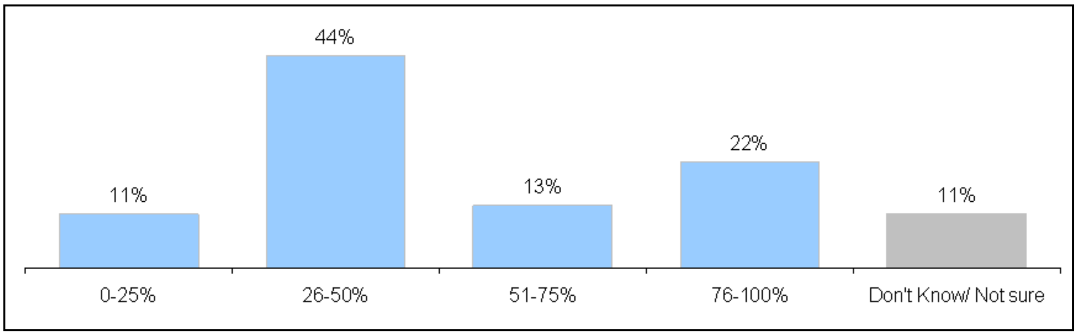

Figure 5: Percentage distribution of estimated proportion of connected roof area across the four LGAs. Based on total survey sample, n=1,134.

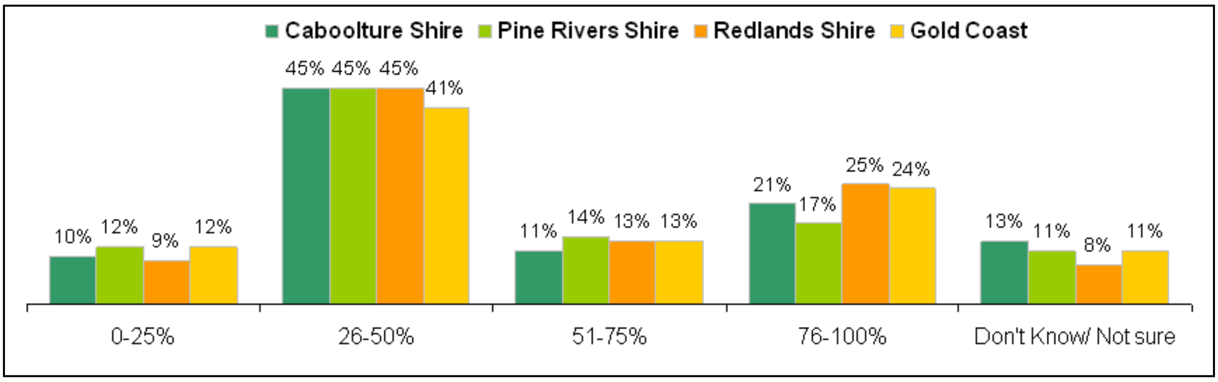

Figure 6: Percentage distribution for estimated proportion of connected roof area at LGA level. Based on total survey sample, n=1,134.

3.1.3. Rainwater End-Uses

Among all the householders, it was generally found that QDC MP4.2 was complied with and that mandated rainwater tanks were installed for both internally plumbed fixtures, such as toilet flushing and cold-tap washing machine, and at least one external tap end-use. From the survey question on rainwater end-use application, it was found that a high proportion of householders used rainwater for toilet flushing (97%) and clothes washing (94%), with garden irrigation (77%), car washing (54%) and swimming pool top-up (26%) being other major end uses (Figure 7). There is a marked difference between the internal and external end-uses of rainwater. The lower percentage of householders using rainwater for garden irrigation might be impacted by householders' attitudes and behaviours toward their water usage pattern, as well as their awareness of water restrictions and risk perceptions of possible permanent water shortage in SEQ. When these data were further analysed according to specific LGAs (Figure 8), a similar pattern of water use was apparent across most LGAs with the exception of Gold Coast where rainwater end-uses for both garden irrigation (82%) and swimming top-up (36%) were considerably higher than the rest of the LGAs.

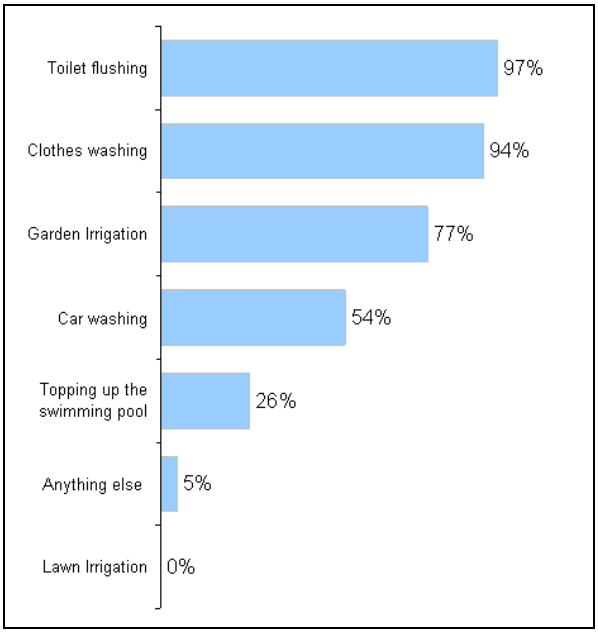

Figure 7: Percentages distribution for common end-uses of rainwater across all the LGAs. Based on total survey sample, n=1,134. Multiple responses permitted.

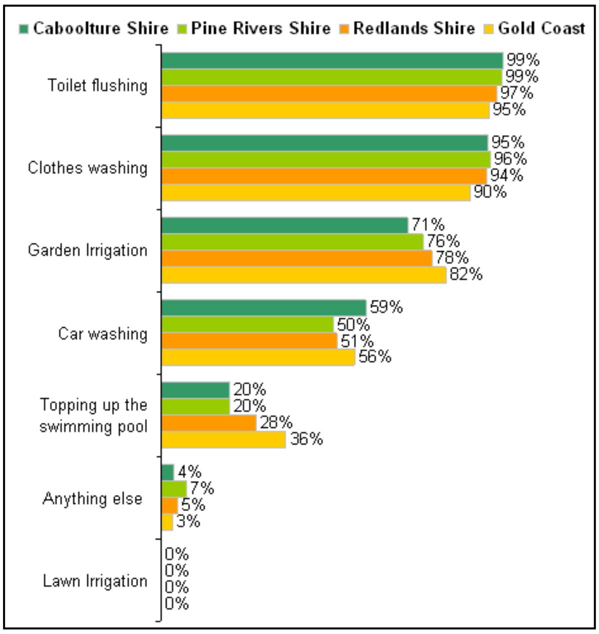

Figure 8: Detailed analysis on the percentages distribution for common end-uses of rainwater at specific LGAs. Based on total survey sample, n=1,134. Multiple responses permitted.

3.1.4. Use of Other Alternative Water Resources

Since all the single detached dwellings within SEQ are required to supply their own 70 kL/hh/yr of alternative water resources under QDC MP4.2, there is a possibility that some households might be using alternative water sources other than rainwater. In this baseline study, we have attempted to determine if any of the surveyed householders with tanks are also using any other alternative water resources such as greywater, wastewater or stormwater. This is essential to investigate before conducting statistical analysis to validate the magnitude of water savings from mandated rainwater tanks. From the survey outcomes (Figure 9), a small proportion (7%) of householders have a greywater treatment plants installed at their premises. However, most other householders (90%) are solely dependent on the supply from rainwater tanks to meet the water savings target. The remaining households (3%) are not sure whether their premises are reticulated with greywater or any other alternative water systems. A detailed LGA-by-LGA analysis as in Figure 10 did not reveal any significant drift of results from the general trend as presented in Figure 9.

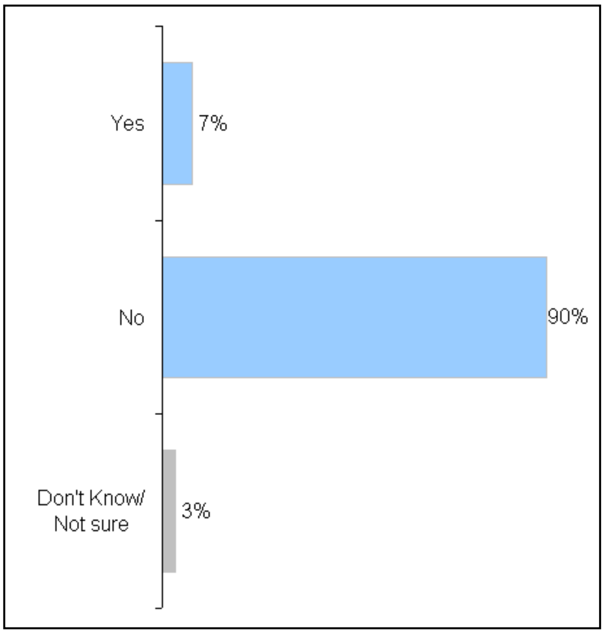

Figure 9: Percentages distribution for dwellings with greywater treatment plant across all LGAs. Based on total survey sample, n=1,134.

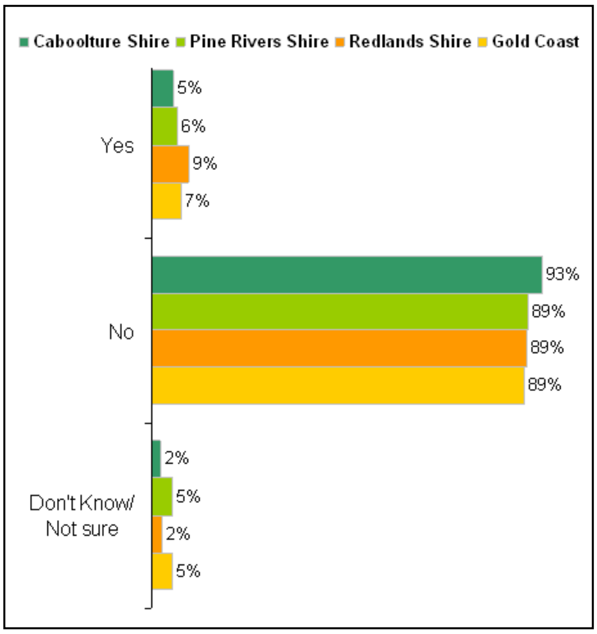

Figure 10: Detailed percentages distribution for dwellings with greywater treatment plant at specific LGAs level. Based on total survey sample, n=1,134.

3.1.5. Use of Water-Efficient Fittings and Appliances

It is also a necessity to understand other synergistic factors that might contribute to the overall water savings from mandated rainwater tanks. In SEQ, the local councils have introduced the WaterWise Rebate Scheme since June 2006 that promotes mains water savings via the installation of domestic water efficient fittings and appliances such as shower roses, taps and washing machines (Gardiner *et al.*, 2008). In this baseline study, we have attempted to identify whether the surveyed householders have taken up such a rebate, which will impact on the magnitude of water savings from mandated rainwater tanks. The survey outcomes (Figure 11) show that most householders have domestic water-efficient fittings or appliances installed at their premises. A high proportion (91%) of households have a low-flow shower rose installed, followed by a water-efficient washing machine (79%), water-efficient dishwasher (74%) and water-efficient irrigation system (25%). A detailed LGA-by-LGA analysis has also been conducted and the results are as shown in Figure 12. Generally, it was found that there is no significant deviation at the specific LGA level for the adoption of these domestic water-efficient appliances.

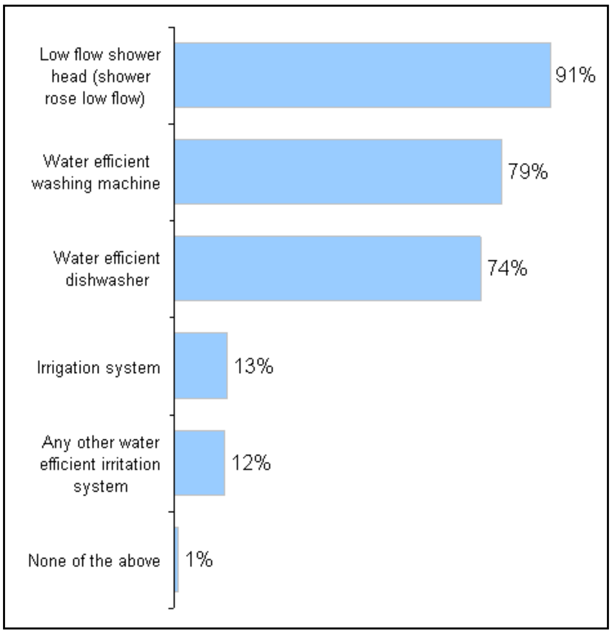

Figure 11: Responses on different types of domestic water-efficient appliances installed. Based on total survey sample, n=1,134. Multiple responses permitted.

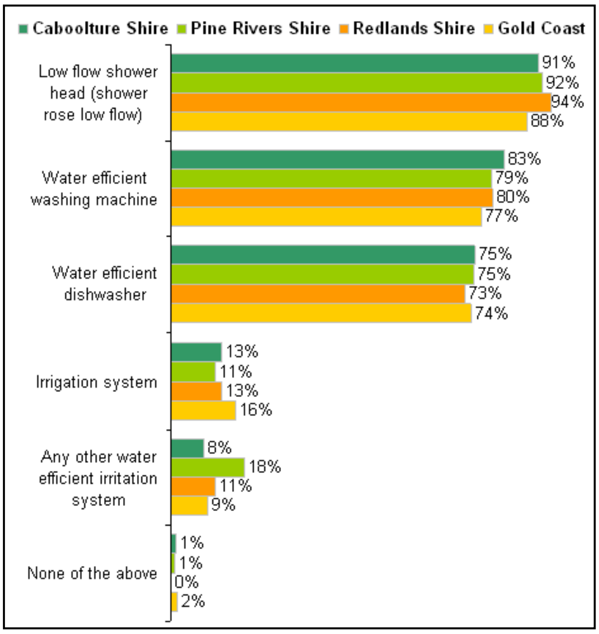

Figure 12: Detailed percentages distribution at specific LGAs level for dwellings with water-efficient appliances. Based on total survey sample, n=1,134. Multiple responses permitted.

3.2. Physical House and Householders' Characteristics

In this baseline study, we have studied the various physical house and householders' characteristics that might affect the water use pattern at the individual household level. These characteristics are some of the important parameters that might affect water savings targets from mandated rainwater tanks. Thus, a thorough understanding of these characteristics will enable a better justification for how we estimate and analyse the water savings target of 70 kL/hh/yr in subsequent research.

3.2.1. Housing Type

The physical house and householders' characteristics of interest include the type of house, number of bedrooms and bathrooms within the house, as well as the specific occupancy rate within each household (i.e. number of adults, adolescents and children). We found that most householders (73%) lived in a single storey dwelling, followed by 26% in double storey dwellings with the remaining 1% not specifying their housing type (Figure 13). When these groupings were analysed for their distributions at the specific LGA level, a large variability within each group across the four LGAs of interests was noticed (in Figure 14). Caboolture has the highest proportion of single storey houses (93%) among the LGAs, followed by Pine Rivers (78%), Gold Coast (63%) and Redland (59%). Conversely, the highest proportion of double storey houses was noted at Redland (39%), followed by Gold Coast (35%), Pine Rivers (21%) and Caboolture (8%).

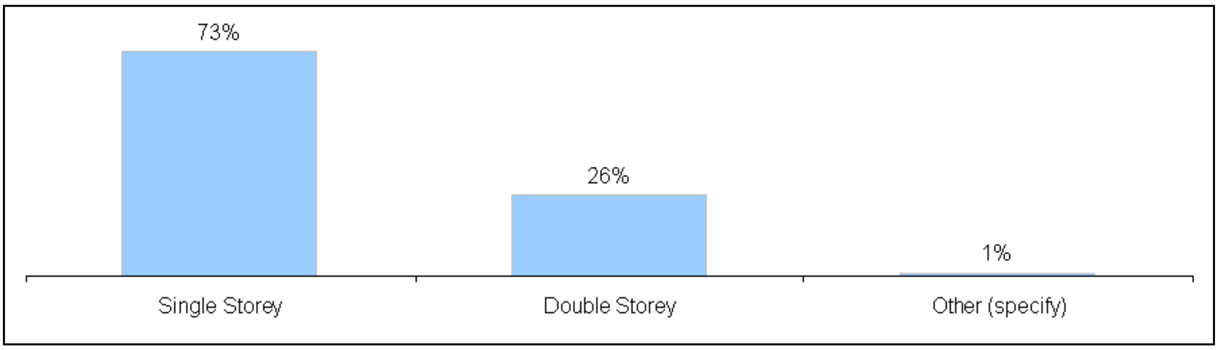

Figure 13: Types of house reported back from the surveyed householders. Based on total survey sample, n=1,134.

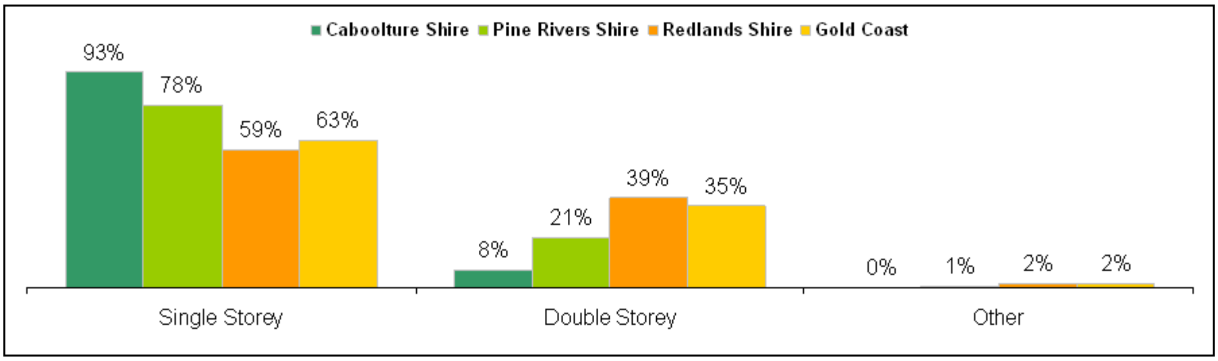

Figure 14: Detailed LGA-by-LGA analysis on the variability of house types at each specific LGAs. Based on total survey sample, n=1,134. Multiple responses permitted.

3.2.2. Number of Rooms

We also attempted to correlate the physical characteristics which might affect the water use pattern at individual household level; the number of bedrooms and bathrooms within the household. In this instance, the number of bedrooms is actually used to infer the approximate size of the house (and thus the size of roof catchment area), while the number of bathrooms dictates the number of toilets that were supposed to be internally plumbed from the rainwater tank. From Figure 15, it can be seen that most of the households in the targeted LGAs are homes with four bedrooms (56%) and two bathrooms (81%). When these trends were examined at the specific LGA level, it was found that there was slight variability in distribution relative to the general trend. Figure 16 details the number of bedrooms and bathrooms at the individual LGA level.

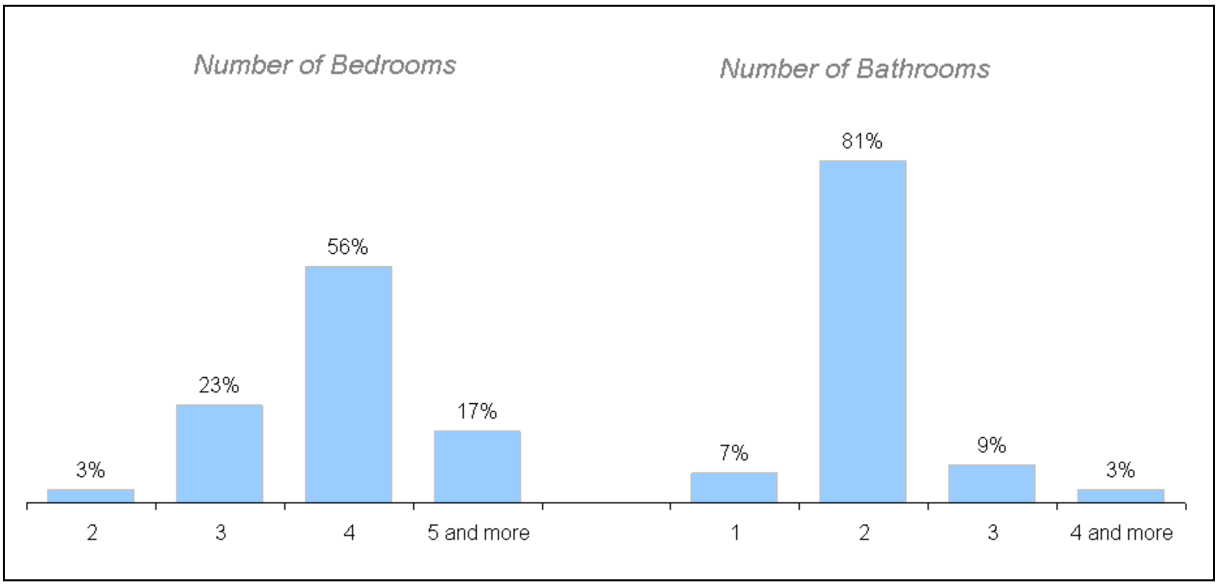

Figure 15: Household characteristics on the number of bedrooms and bathrooms across all LGAs. Based on survey sample, n=297. Multiple responses permitted.

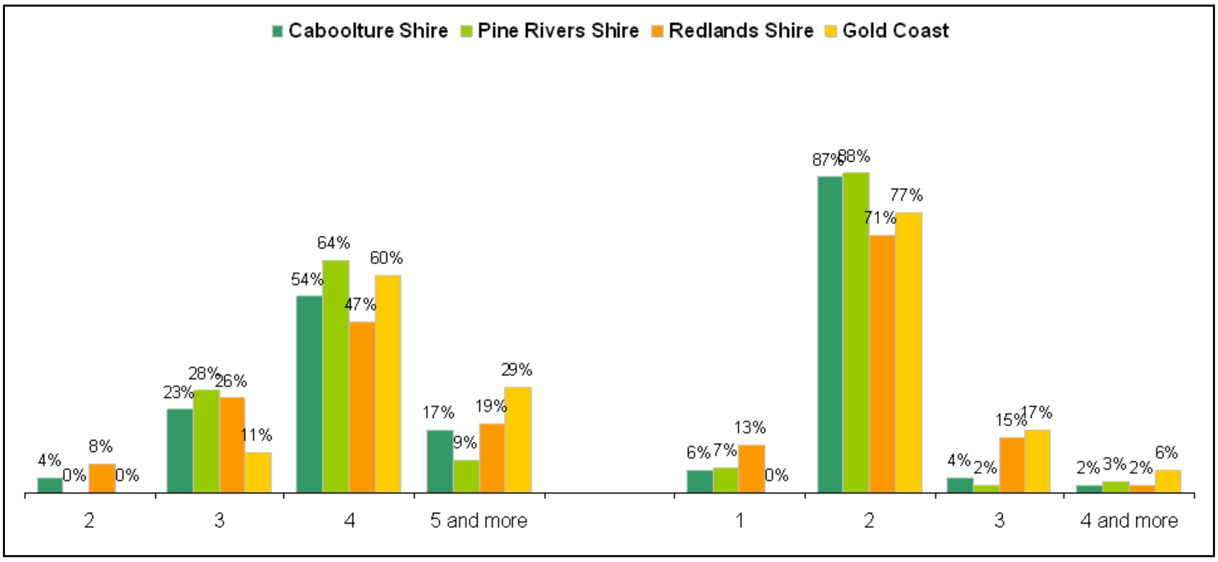

Figure 16: Detailed analysis on the variability in number of bedrooms and bathrooms at each specific LGAs level. Based on survey sample, n=297. Multiple responses permitted.

3.2.3. Household Occupancy Rates

The most important factor that might affect the water use pattern as discussed by Beal *et al.* (2011) is household occupancy rate. From this baseline study, we found that most households are comprised of two people (34.7%), followed by four people (28.1%), three people (17.1%) and five people (11.5%) (Figure 17). A detailed household occupancy rate at each specific LGA level showed that there is not much variation across the LGAs, with the exception being two people per household where the rates were seen to vary from 29% (Gold Coast) to 43% (Caboolture). The detailed household occupancy rates at each specific LGA are shown in Figure 18. These household occupancy rates will be used to match the corresponding mains water billing records in the subsequent stage of research to obtain the mains water use per capita as well as the relative savings from using plumbed rainwater tanks.

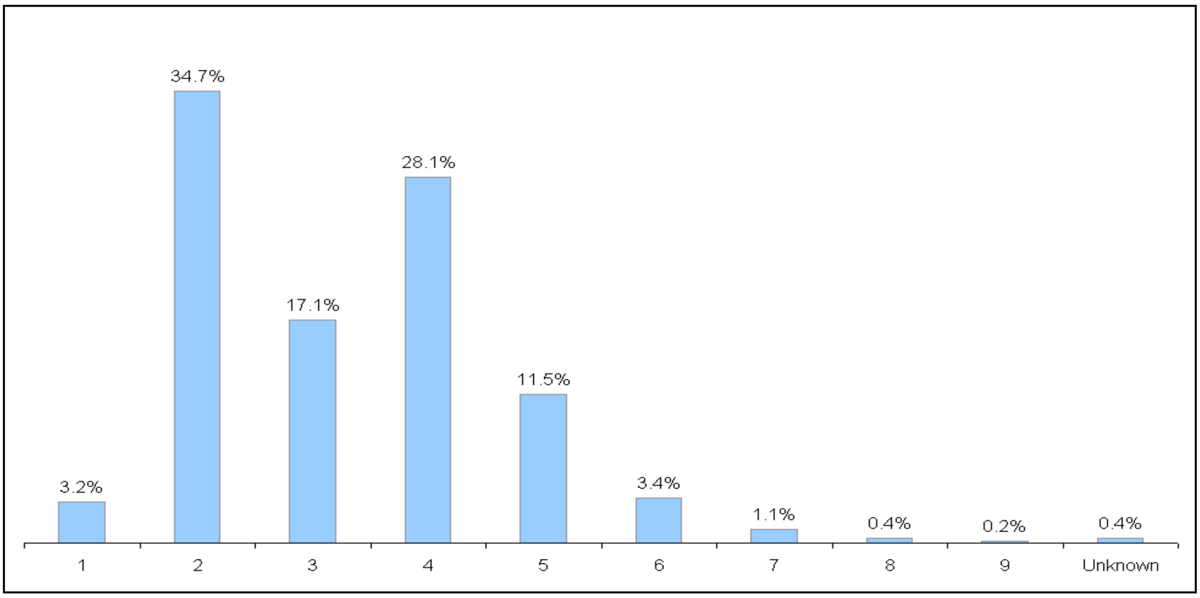

Figure 17: Household occupancy rates across all LGAs. Based on total survey sample, n=1,134.

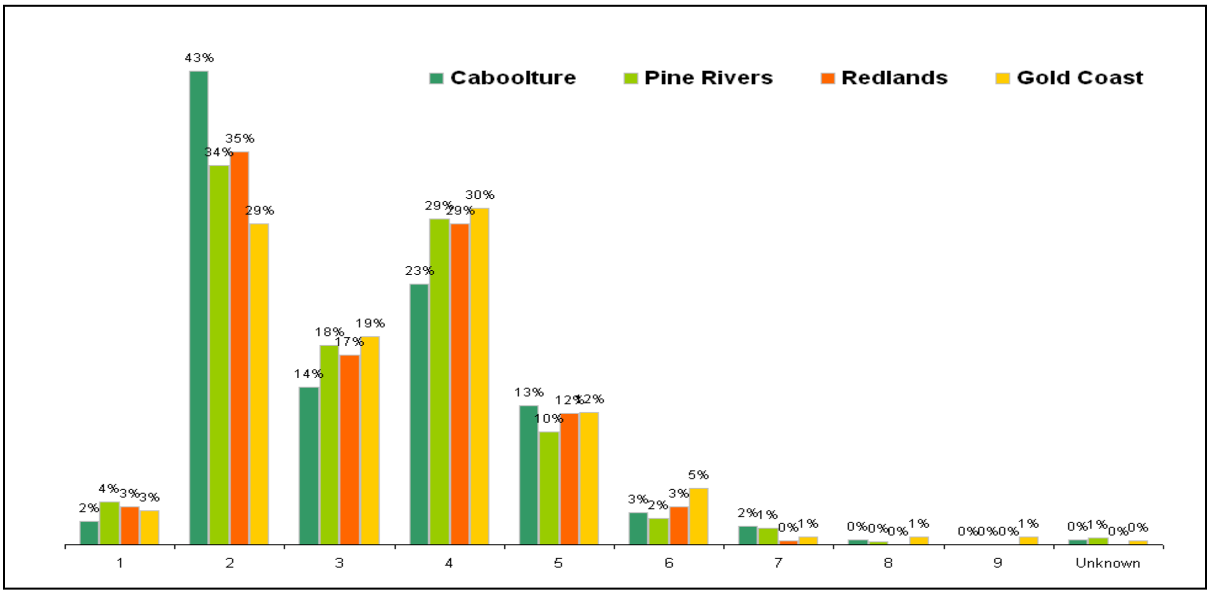

Figure 18: Detailed household occupancy rates at each specific LGAs level. Based on total survey sample, n=1,134.

3.2.4. Household Age Structure

In this baseline study, we have also determined the number of adults, adolescents and children within each household. In this study, adult refers to people aged greater than 18 years, while adolescent refers to the age group between 13 and 17 years and children were classified as the age group of 12 years or less. The dominant features were that 75% of respondent households comprised two adults, 81% had no adolescents and 57% had no children. Figure 19 shows the overall picture of household age structure across our surveyed LGAs. Further analysis by LGAs showed little variation in the number of adults, adolescents and children as shown in Figure 20.

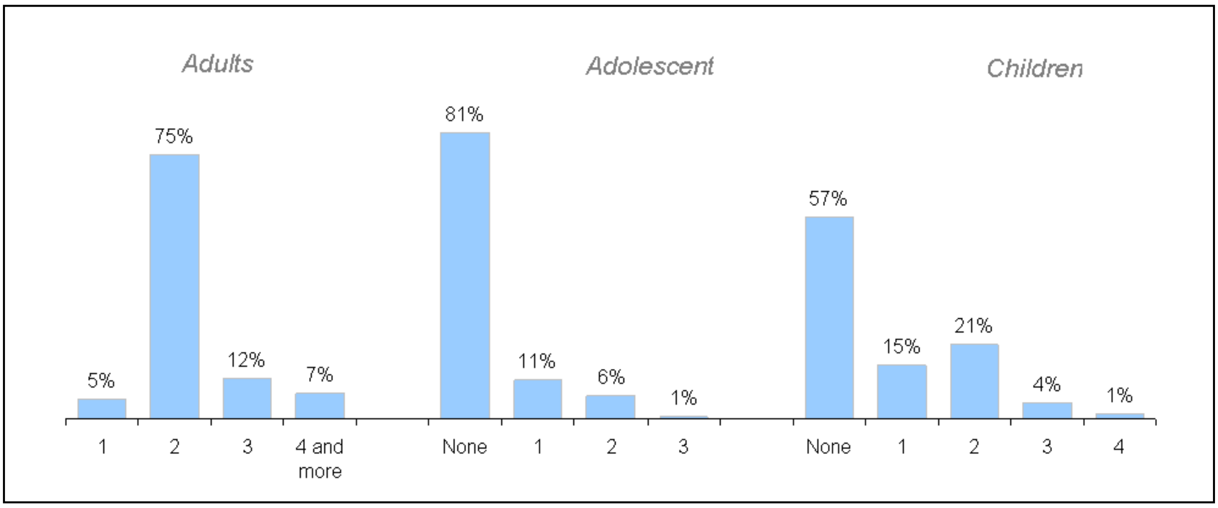

Figure 19: Common household age structure from the selected LGAs. Based on total survey sample, n=1,134. Multiple responses permitted.

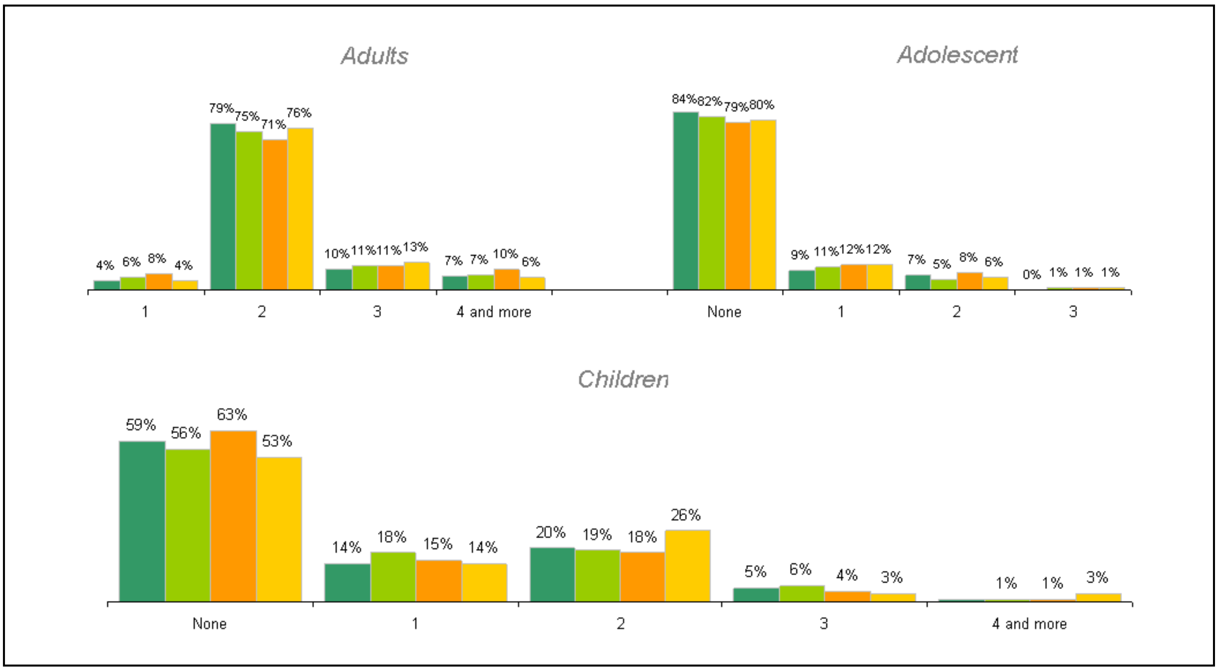

Figure 20: Detailed household age structure at each specific LGAs level. Based on total survey sample, n=1,134. Multiple responses permitted.

3.2.5. Family Characteristics

In addition to both of the household occupancy rates and age structure, we have also analysed the family characteristics for this baseline study. The data obtained from the telephone survey were grouped into the relevant family characteristics categories to allow a direct comparison with the relevant 2006 ABS census district data. Figure 21 shows the analysis outcomes for the family characteristics at each specific LGA level. It was observed that most of the households fall into the category of either couple families with children or couple families without children, with some variations across the studied LGAs. The percentage of couple families with children varied from 41.7% (Caboolture) to 51.2% (Pine Rivers); while the percentage of couple families without children varied from 37% (Pine Rivers) to 47.8% (Caboolture). This was followed by the one parent families category (7.5% - 8.3%), and other families (2.2% - 5.6%).

When these family characteristics were compared to the ABS census district data (2006) presented in Figure 22, it was found that most of the characteristics are relatively comparable and similar, with the possible exception of couple families without children in Caboolture (47.8% in this baseline study compared to 39.5% from the 2006 ABS data). There were large discrepancies in the family characteristics between this study and 2006 ABS census district data for the groupings of one parent families and also other families. The family characteristics obtained from the baseline survey and the matching ABS 2006 census data can be seen by comparing Figures 21 and 22 respectively.

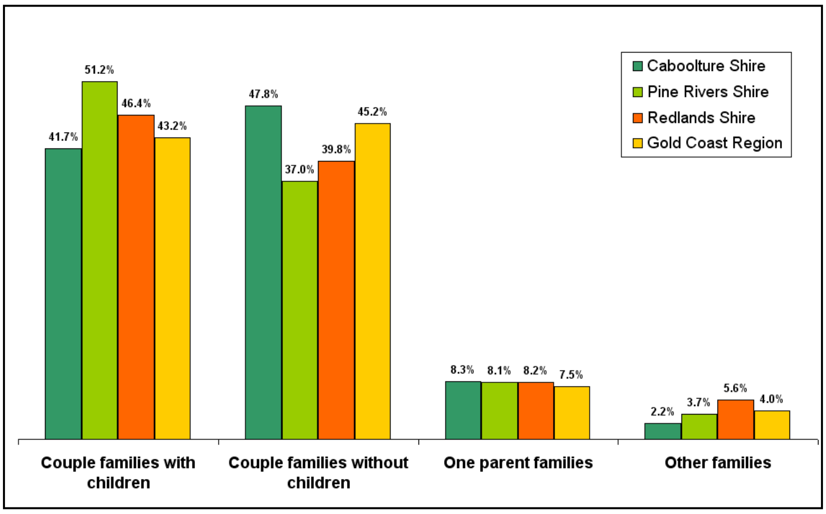

Figure 21: Summary of family characteristics at each specific LGAs level. Based on total survey sample, n=1,134. Multiple responses permitted.

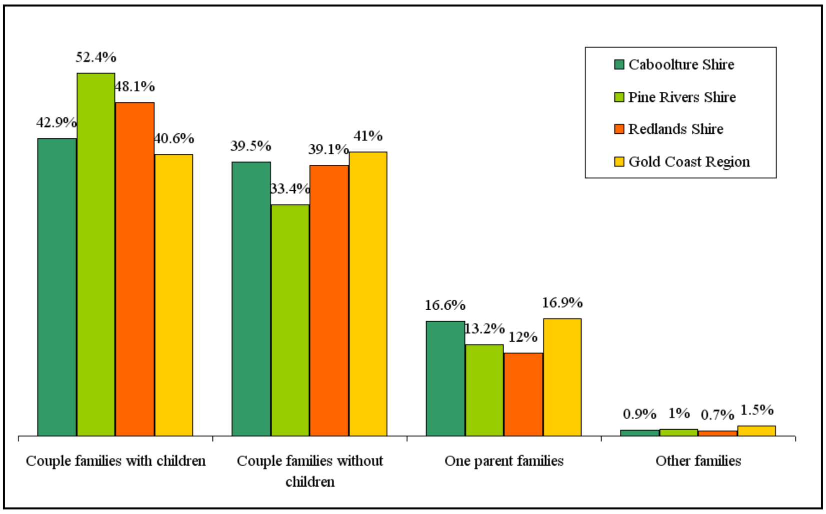

Figure 22: Summary of family characteristics from the 2006 ABS census district data (ABS, 2006).

3.3. Householder Attitudes, Behaviours, and Risks and Threats Perception towards Water Usage and Savings

3.3.1. Self-Rating of Water Use Pattern

Apart from identifying the key physical descriptors that might impact on the magnitude of water savings from mandated rainwater tanks, we are also interested in understanding householders' attitudes, behaviours, and risks and threats perception towards water usage and savings at the individual household level. These included householders' attitudes, behaviours and perceptions toward their own water use pattern, awareness of any forms of water restrictions and other possible threats to the reliability of rainwater supply. In this baseline study, householders were asked how they considered or rated their own water usage level. Most householders rated themselves as medium (53%) or low water users (33%) rather than high water users (10%). The remaining 4% of householders did not rate their own water usage level. The survey outcomes are shown in Figure 23. A detailed percentage distribution analysis based on specific LGAs (Figure 24) revealed that there are some variations across the four LGAs, where medium water users span from 48% (Redland) to 58% (Caboolture) and low water users range from 28% (Gold Coast) to 38% (Redland).

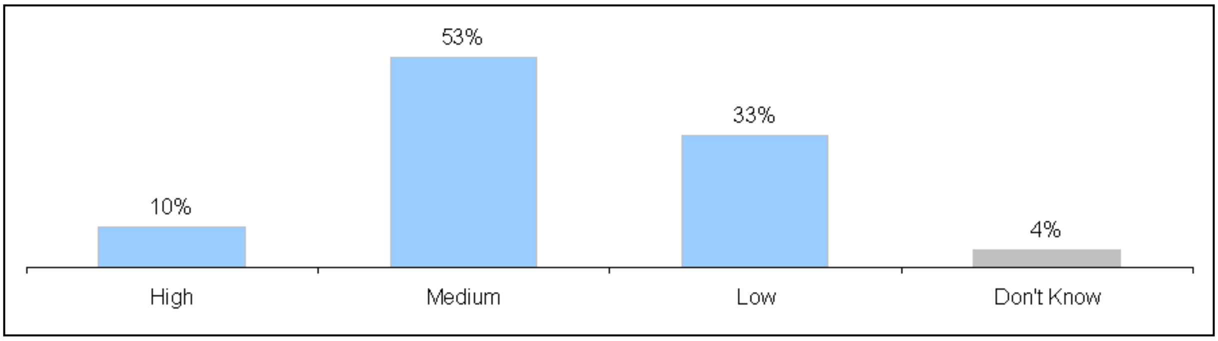

Figure 23: Householders' ratings of their own water usage pattern. Based on total survey sample, n=1,134. Multiple responses permitted.

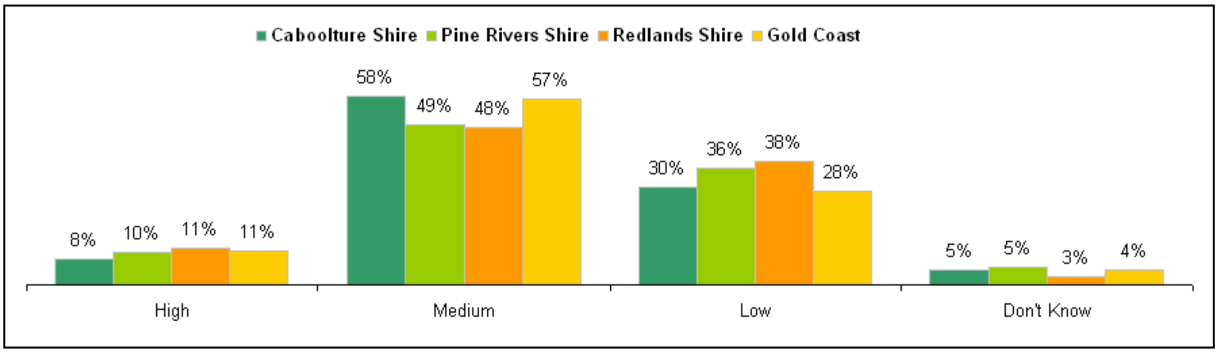

Figure 24: Detailed percentages distribution analysis of householders' ratings of their own water usage pattern at specific LGAs level. Based on total survey sample, n=1,134. Multiple responses permitted.

3.3.2. Self-Rating and External Water Use

We also examined the interrelationship between reductions in external rainwater use and the householders' self-rating of their own water use pattern. From the baseline survey, we found that there is a high proportion of householders who do not use tank water for garden irrigation (n = 259), car washing (n = 527) or topping up a swimming pool (n = 841). Figure 25 shows the detailed analysis of this interrelationship and we found that most of the householders who choose not to irrigate their garden, top up a swimming pool and wash cars rated themselves in the medium water users group (50-52%), followed by low water users group (32-36%) and high water users group (9%).

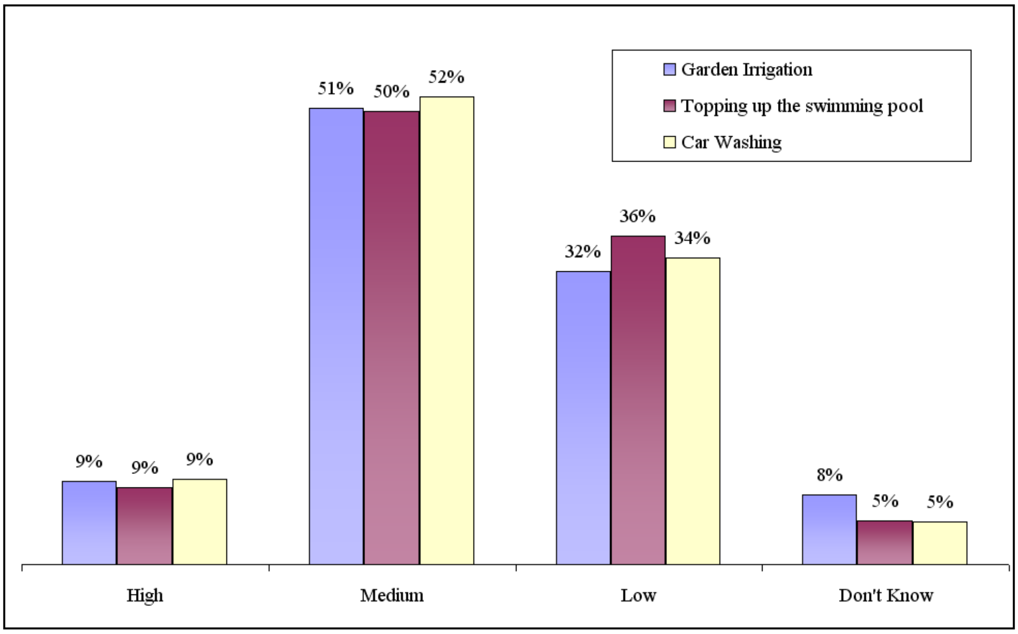

Figure 25: Interrelationship analysis between householders' self-rating water use pattern and their rejection (%) of various external end-uses. Based on survey sample, n=1,134. Multiple responses permitted.

3.3.3. Awareness of Water Restrictions

We also raised the question of whether householders are aware of any forms of water restrictions that may apply in the past, present and future. Surprisingly, there is a mixed outcome, with most householders (61%) not aware of any form of water restrictions applying at all, about 32% of the householders not aware of water restrictions applying in the past and only 20% stating that they were aware of current water restrictions (Figure 26).

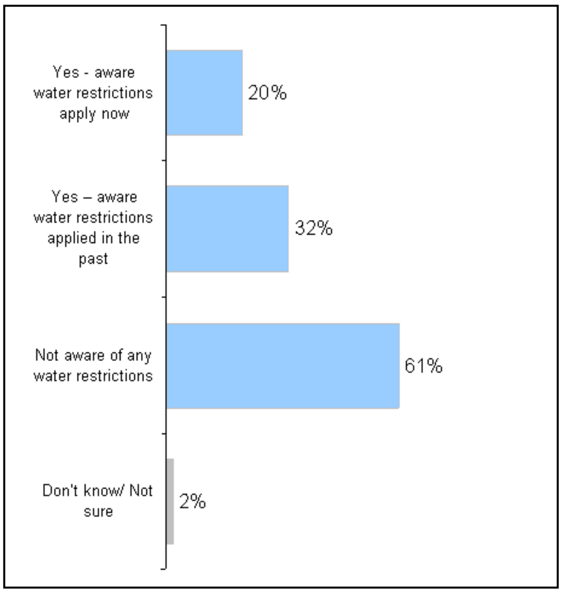

Figure 26: Householders' awareness of water restrictions. Based on total survey sample, n=1,134. Multiple responses permitted.

When a detailed analysis of each specific LGA was examined (Figure 27), a mixed result at this finer scale was also observed where 55% (Pine Rivers) to 66% (Redland) of households were unaware of any form of water restrictions. Similar small variations across the different LGAs were also observed for the proportion of householders who were aware of water restrictions both in the past and present.

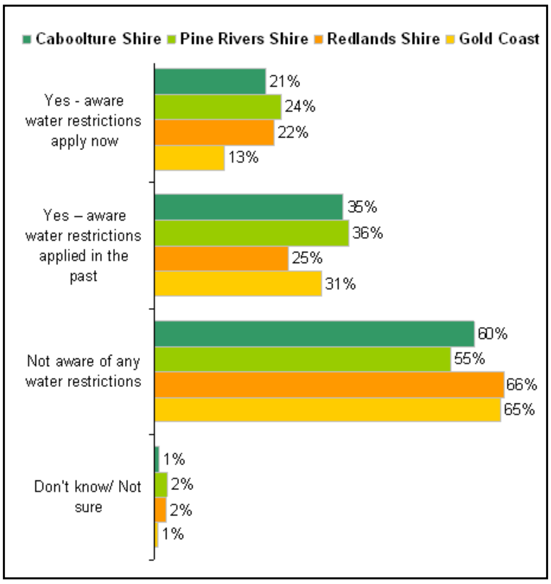

Figure 27: Detailed analysis of householders' awareness of water restrictions at specific LGAs level. Based on the total survey sample, n=1,134. Multiple responses permitted.

3.3.4. Awareness of Restrictions and External Water Use

We have analysed the relationship between householders' awareness of water restrictions and external rainwater uses. Figure 28 shows the results of relationship analysis between householders' use of rainwater for external purposes (i.e. garden irrigation, topping up a swimming pool and car washing) and their awareness of water restrictions. It was found that the greater the awareness of households of current or past water restrictions, the lower their external rainwater uses (Figure 28).

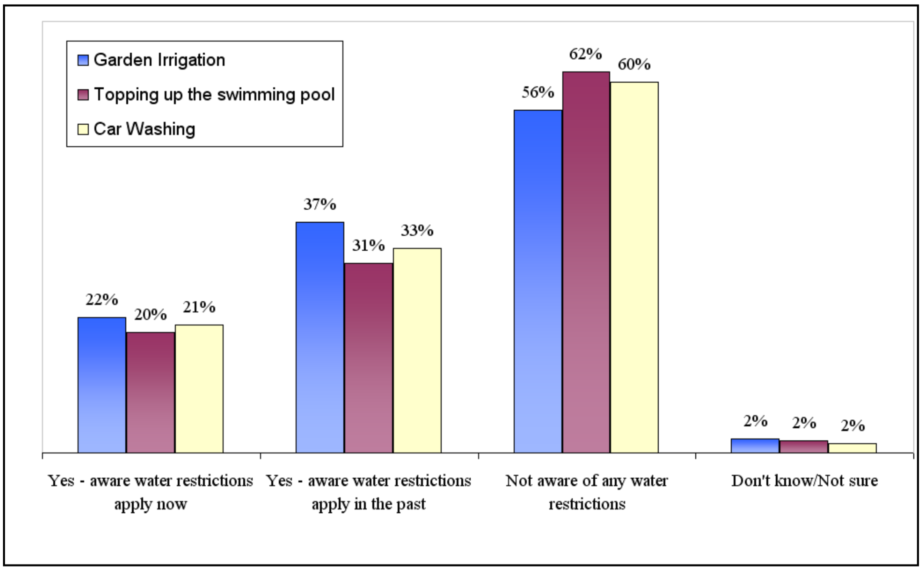

Figure 28: Relationship between the householders' awareness of water restrictions and the use of rainwater for various external end-uses. Based on the total survey sample, n=1,134. Multiple responses permitted.

From Figure 28, it was evident that "topping up a swimming pool" (20% + 31%) is most reduced by the combined awareness of water restrictions in the past and present, followed by car washing (21% + 33%) and garden irrigation (22% + 37%). For those householders that are not aware of any form of water restrictions, the least impacted end-use is topping up a swimming pool (62%). It should be noted that not every household has a pool and this might slightly affect the survey outcomes. However, the percentages estimated in Figure 28 are normalised independently of the number of householders that have not used rainwater for the indicated external end-uses.

3.3.5. Drinking Water End-Use

From the survey, we acquired information on the actual proportion of householders who use rainwater for potable end-uses such as drinking or cooking, apart from the mandated purposes. In addition, we also surveyed householders' risks perception towards their rainwater quality, the treatment technology that they used to purify the rainwater (if any), as well as their perception on reliability of supply from the mandated rainwater tanks.

Most householders (96%) responded that they had never used rainwater for drinking or cooking purposes with the remaining 4% (n= 40) having used their rainwater for drinking water purposes to a varying extent (Figure 29). Such a low rainwater utilisation rate for drinking or cooking purposes might be owing to the QDC MP4.2 mandate which stipulates that the rainwater is only for toilet flushing, cold water washing machine use and garden irrigation. Another possible reason could be the householders' perception of the public health risks associated with the quality of untreated rainwater. Of the 40 respondents who have used their rainwater for drinking water purposes, a fair proportion (40%, n = 16) has some form of rainwater treatment system installed at their premises (Figure 30). Most of these households (88%) adopted a filtration type of water purification system while a small proportion (6%) has an advanced UV treatment system installed. Although the UV system is currently being recognised as having a higher viability in disinfecting almost all pathogenic microorganism in rainwater, the low level of adoption for the system might be owing to its associated high operating costs in terms of on-going energy consumption and UV lamp replacements. A further 6% of the households do not know if any rainwater treatment systems have been installed at their premises.

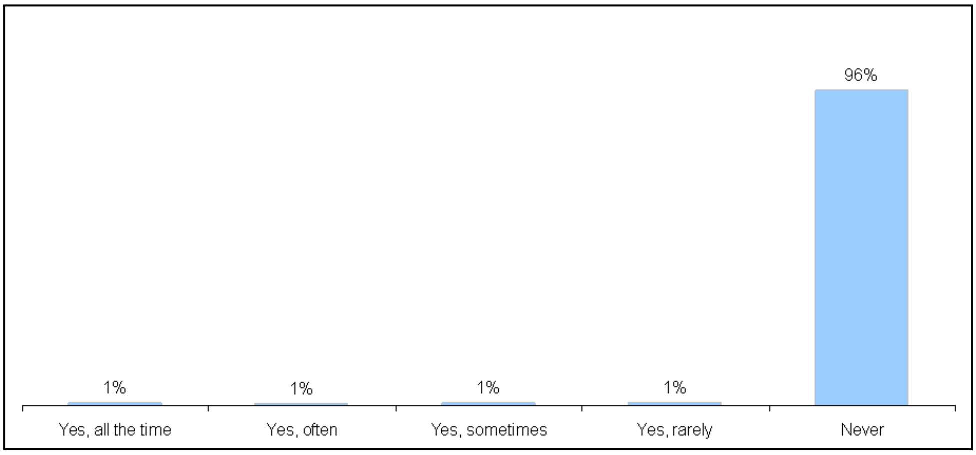

Figure 29: Frequency of use of rainwater for cooking or drinking purposes. Based on the total survey sample, n=1,134.

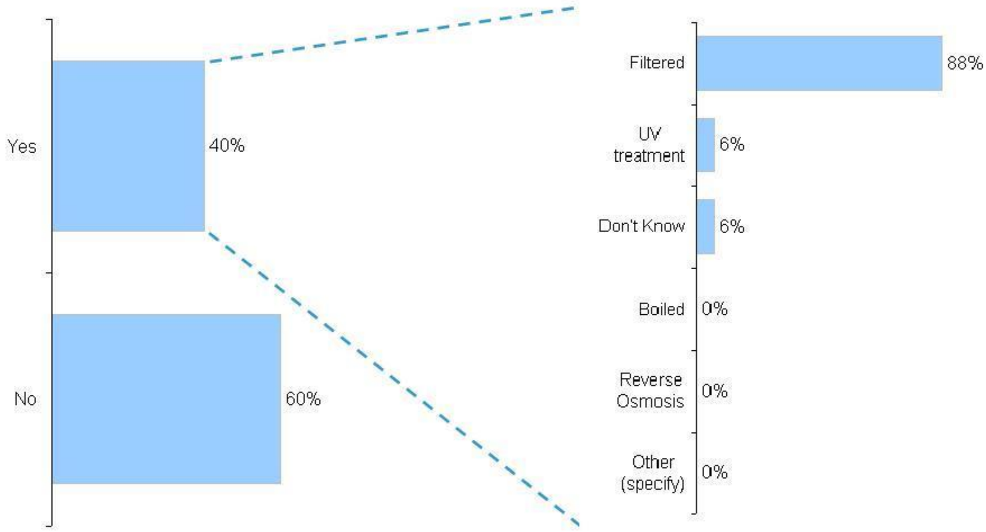

Figure 30: Percentage distribution of householders who have a rainwater treatment system installed and the treatment processes used. Based on the total survey sample, n=40.

3.3.6. Satisfaction with Rainwater Quality

Most householders are very happy or satisfied with the quality of rainwater, and have a low risk perception of rainwater for non-drinking uses (Figure 31). Approximately 86% of the total householders scored at 4 or 5 point on a score chart of 1 (very unhappy), 2 (unhappy), 3 (satisfied), 4 (happy) and 5 (very happy). The mean score for the householders' satisfactions toward the water quality from their rainwater tanks was calculated to be 4.4. This showed that generally householders are happy with the quality of water from their tanks. Of all householders, only 2% are unhappy with the water quality sourced from their rainwater tanks. A detailed analysis by LGAs (Figure 32) validated that householders are happy with the water quality sourced from their rainwater tanks, with the percentage of "satisfied householders" ranging from 83% (Caboolture) to 88% (Pine Rivers).

The householders who are unhappy with the water quality from their rainwater tanks ranged from 1-4%, with the highest dissatisfaction rate being noted from Redland. A total of 26 households out of 1,134 surveyed stated that their concerns over the water quality from their rainwater tanks were due to the colour (58%) of the rainwater. This is followed by other unidentified reasons (27%), taste (15%) and odour (15%). The remaining 4% did not state a valid reason for their unhappiness with the rainwater quality. The survey outcomes are summarised in Figure 33.

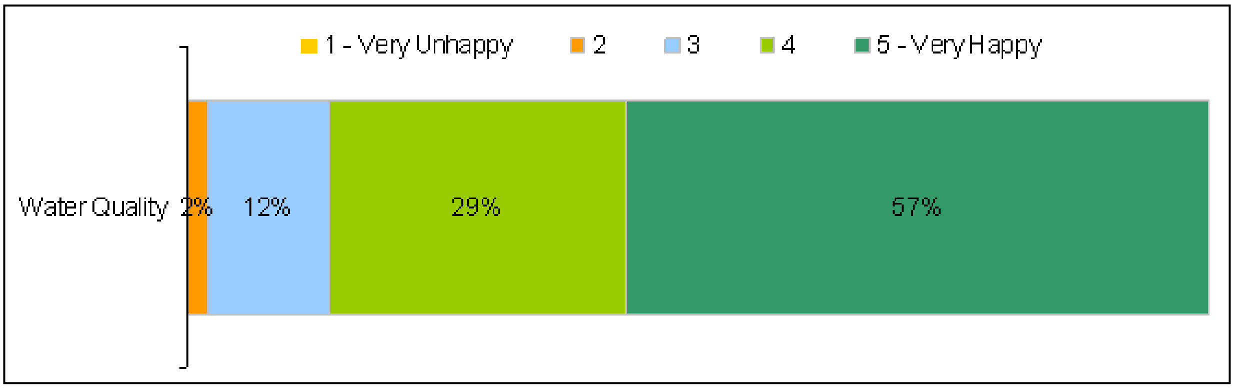

Figure 31: Householders' satisfaction with the quality of rainwater. Based on total survey sample, n=1,134.

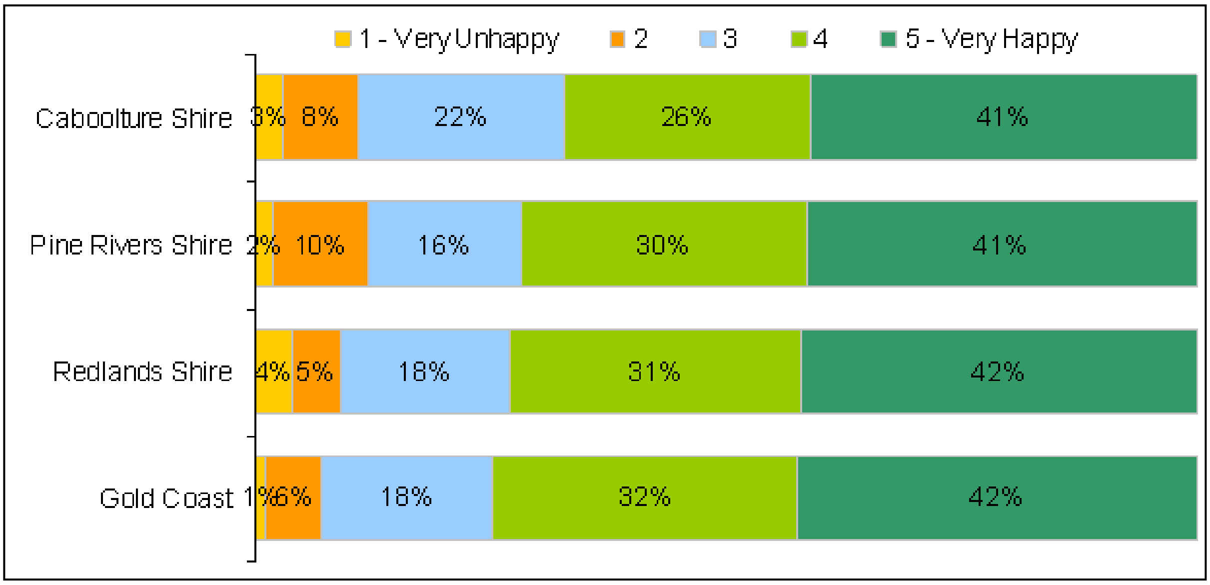

Figure 32: Detailed analysis by LGAs on householders' satisfaction with the quality of rainwater. Based on total survey sample, n=1,134.

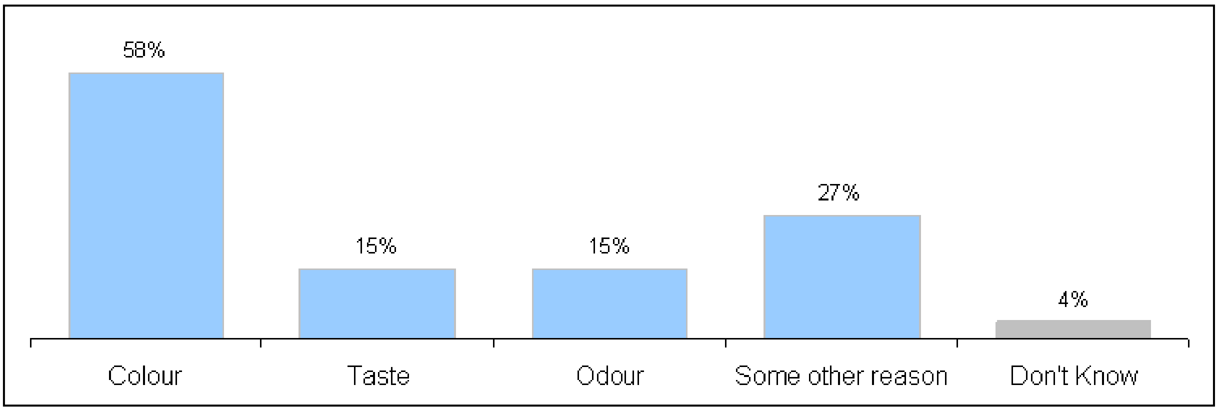

Figure 33: Reasons why the householders are unhappy with the quality of rainwater. Based on total survey sample, n=26. Multiple responses permitted.

3.3.7. Threats Perception of Reliability of Supply

In this baseline study, we also addressed householders' perception of the threats to the reliability of supply from mandated rainwater tanks. If householders' view is that there is a threat of discontinuity in water supply owing to the irregularity of rainfall or for other valid reasons, this might discourage them from connecting and maintaining their rainwater tank as part of the QDC MP4.2 requirement. Results in Figure 34 show that, in general, most householders are happy (72%) with the reliability of water supply from rainwater tanks, with 18% being neutral and 10% of them being unhappy. In this instance, the average score (on a 1 – 5 score chart) is 4.01. When these results were analysed on a LGA-by-LGA basis (Figure 35), it was found that there is not much of a deviation from the general householders' perceptions of the reliability of supply from their rainwater tanks.

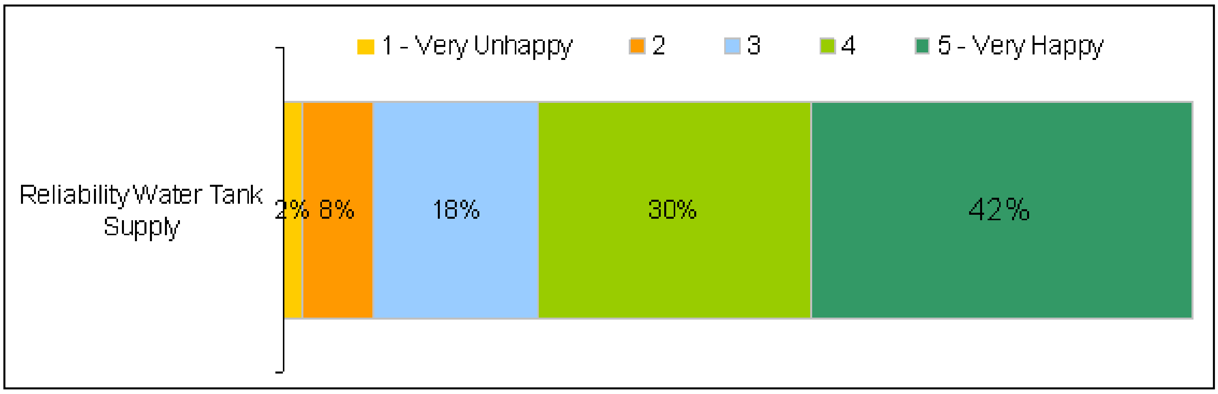

Figure 34: Householders' views of the reliability of supply from rainwater tanks. Based on total survey sample, n=1,134.

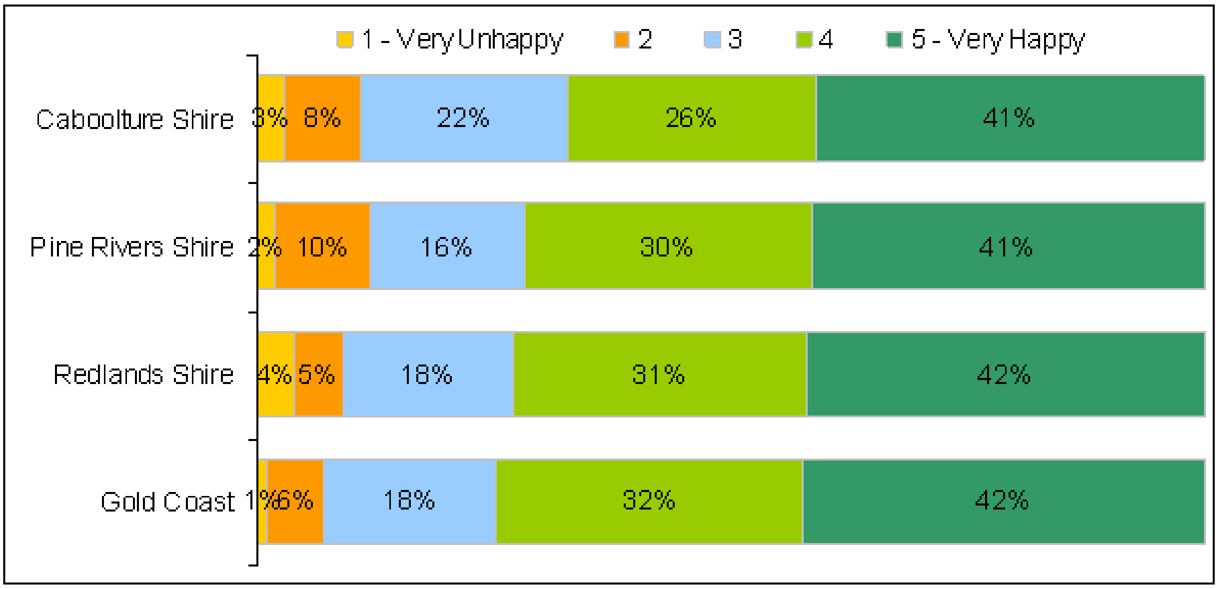

Figure 35: Detailed LGA-by-LGA analysis of householders' views of the reliability of supply from rainwater tanks. Based on total survey sample, n=1,134.

We also examined householders' perceived risks regarding permanent water shortages in SEQ because, if this exists, they might be more consciously organised towards better management of their rainwater tanks. We found that most of the householders perceived that there is a risk of permanent water shortages now (22%) and in the future (65%), as shown in Figure 36. Surprisingly, almost one third (27%) of the surveyed sample do not believe that there is a risk of permanent water shortages at all, while 5% of the total householders did not give their view on this issue. Figure 37 shows the detailed analysis at specific LGA level, and the results show that there is not much variability at this finer scale as opposed to the general reported trend.

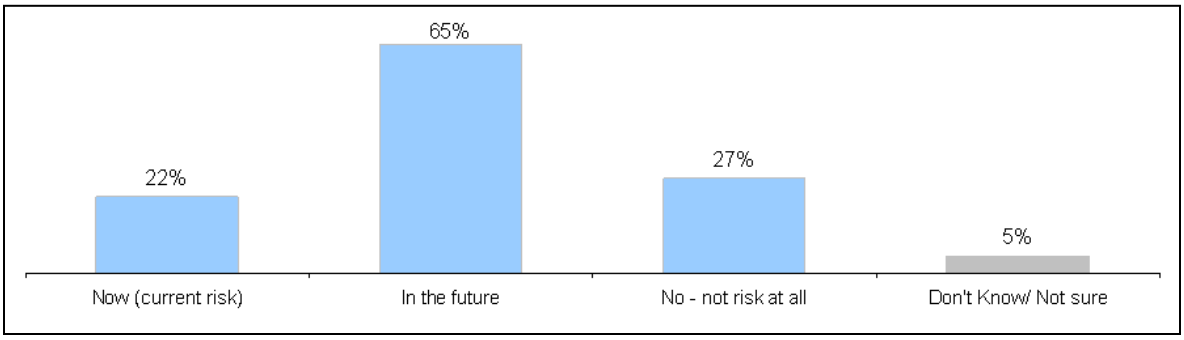

Figure 36: Householders' perception of the risk of water shortages in South East Queensland. Based on total survey sample, n=1,134. Multiple responses permitted.

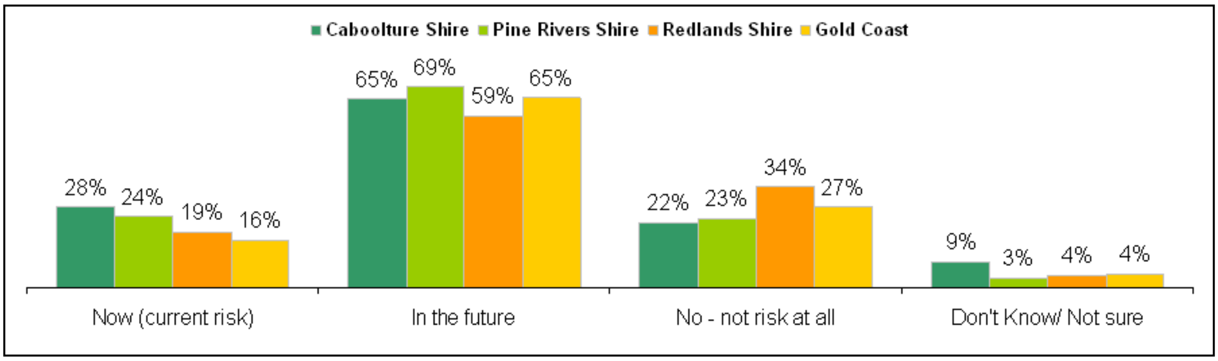

Figure 37: Detailed analysis by LGA of householders' perception of the risk of water shortages in South East Queensland. Based on total survey sample, n=1,134. Multiple responses permitted.

3.3.8. Risk Perception and End-Use

We also correlated householders' risk perception with external end-uses of rainwater (Figure 38). Results indicate that householders who do not use their rainwater for external end-uses are strongly correlated with their risk perceptions that there will be either a current or future risk of water shortage. This forms an interesting physically-based social behavioural relationship which confirms that people actually perceived there are possible risks for current and future water shortages, and thus restrictions on their external rainwater uses.

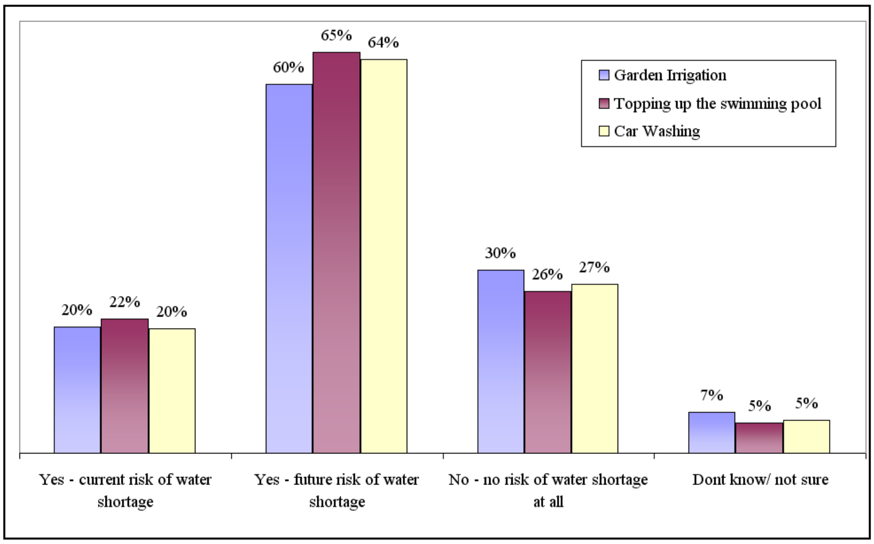

Figure 38: Relationship between householders' perception of risk of water shortages and their rejection (%) of various external rainwater uses. Based on total survey sample, n=1,134. Multiple responses permitted.

4. DISCUSSION AND CONCLUSION

Traditionally, urban Australians have enjoyed centralised water supply services which are considered to be reliable and cost effective. Homeowners are not involved in any way in the operation and maintenance of these systems. Due to factors like climate change, population growth, increasing urbanisation and industrialisation, the reliability and availability of water supply from traditional sources is being questioned. During the 2004-2007 drought, SEQ residents realised that their centralised water supply sources were fallible and changes would need to be made to SEQ's future water strategy. As a result, demand management polices were initiated and implemented to encourage existing home owners to use less water and incentives were offered to install rainwater tanks and water saving appliances on their properties. Since January 2007, new homes are required to have decentralised supply installed. This has been mandated under the QDC MP4.2, which stipulates that all residents must install and supply alternative water sources that can augment the savings on mains water by up to 70 kL/hh/yr. The major aim of this baseline study was to understand the key physical compliance, demographic and attitudinal and behavioural factors which might impact on the achievement of the water saving target through mandated rainwater tanks. Further, this study sought to follow on from the research of Beal and colleagues (2011), which attempted to examine whether the installation of rainwater tanks contributed to a reduction in mains water consumption, particularly internally plumbed tanks, which substitute mains water in the laundry and toilets, irrespective of outdoor watering restrictions.

The study showed that most post-2007 dwellings included in the survey had the required volume (min. 5,000 litres) for their mandated rainwater tanks, to meet the QDC MP4.2 requirements. Only 7% of the total 1,127 householders have rainwater tanks of less than 5,000 litres. The validation of the other basic compliance requirement also revealed that most detached dwellings within the four LGAs (i.e. Caboolture, Pine Rivers, Redland and Gold Coast) had the appropriate roof catchment area and an appropriate number of downpipes connected to the rainwater tanks, were internally plumbed (for toilet flushing and washing machine cold water tap), and had at least one external rainwater tap. It was established that these detached dwellings did not have any other alternative water systems that could potentially impact on water savings from mandated rainwater tanks. It is, however, interesting to note that a high proportion of householders have domestic water-efficient appliances installed at their premises. This will indirectly present a significant challenge in the Stage 2 of our research, where we intend to understand the extent to which the mandated rainwater tanks alone can provide mains water savings. With the findings from this study, however, it allows us to devise various "controlled" groups in order to single out the net impact of dwellings having water-efficient appliances installed.

Regarding householders' characteristics, participants in the study were demographically comparable to ABS census district data (2006). However, a slight variability was found between survey participants and ABS population data on both the family characteristics and household composition, particularly for Pine Rivers and the Gold Coast. Both LGAs show highly variable characteristics in terms of the couple families with children (Pine Rivers) and family household (Gold Coast). In this instance, two different scenarios can be evaluated when the subsequent statistical analysis is carried out using (1) average ABS occupancy rate and (2) the occupancy rate found from this baseline survey.

From householders' self-ratings of attitudes and behaviours regarding water use patterns, it is interesting to note that most householders regarded themselves as either medium or low water users. However, it was found that such a self-rating does not necessarily mean that they are either water conserving or prolific water users. Further correlation with self-reported water use and awareness of water restrictions could provide an alternative explanation for such a high frequency of self-rating as low and medium water users. It may be that these responses could be explained by the social desirability effect of responding via the CATI process, where participants are interacting with another person on the telephone, rather than the anonymous activity of responding to a paper survey. Further, participants may also be fearful that their individual information will be used to reprimand high water users, despite being assured of confidentiality.

Interestingly, the detailed analysis showed that most householders who chose not to irrigate their garden, top up a swimming pool, or use rainwater for car washing lay within the medium water users group. Theoretically, it would be expected that householders with this attitude and behaviour towards external irrigation should be in the low water users group. Thus, the existing strong linkage to the medium water users might be attributed to other factors that we will examine in detail in the subsequent stage of social research.

Surprisingly, a majority of respondents (over 60%) reported that they were unaware of any past or current water restrictions, particularly those in Redland and the Gold Coast. This is unusual, since water restriction have been a pervasive part of the SEQ water culture for a number of years and past research, for example Mankad and colleagues (2010), have highlighted that SEQ residents believe themselves to be very knowledgeable of water issues affecting the region. This finding suggests that either survey participants were really unaware of water restrictions, or their responses were potentially biased as an artefact of the survey design (i.e. asking specifically about tank water use as opposed to more general water use issues). This latter idea is further supported by the current finding that 87% of participants believed that there would be a risk of water shortages now or in the future. Having such high threat perceptions of water shortage among the majority of participants does not seem to fit with the parallel finding of poor knowledge of water restrictions among participants. A potential explanation for this could be that participants may feel that if they self-report as being aware of water restrictions yet are seen to be using excessive amounts of water, they incriminate themselves in some way. There is enough evidence to suggest that water restrictions do have a direct impact on householders' attitude and behaviour to irrigating their garden. Therefore, future research may be warranted to assess the level of water restrictions knowledge among SEQ residents.

In terms of "social-hydrology", most of the householders show a high acceptance rate toward the integration of rainwater as part of their daily activities. In this instance, most of the rainwater harvested was being used for toilet flushing, clothes washing and external garden irrigation purposes. However, it was found that almost all householders were averse to the notion of rainwater being used for higher end-uses (i.e, cooking or drinking). This might be owing to the fact that many urban residents have lower acceptance and strong public perceptions toward the public health risks associated with rainwater (e.g. Mankad and Tapsuwan, 2011). A majority of the householders have noted that their primary discerning issues on using rainwater for drinking or cooking are colour, taste and odour. Consequently, a fair proportion of householders using rainwater for drinking or cooking have adopted various types of rainwater treatment systems to reduce the associated public health risks to an acceptable level. The majority of participants who do treat their rainwater in some way used the filtration method to possibly remove some particulate or pathogenic microorganisms in water that might present severe acute risks once consumed. Other more advanced rainwater treatment systems such as UV disinfection were also used to deliver a safer alternative water source for higher end-uses.

In conclusion, it is important to note that householders are happy with the reliability of supply of rainwater and do not view the system as a threat or inconvenience for their daily activities. It is likely that there are other possible social and cultural issues that must be examined to provide a holistic understanding of mandated rainwater tank use and the households that use them. Lifestyle changes associated with a reduced water supply, as well as changing water infrastructure, are also likely to have important and ongoing, enduring consequences for the social environment. Therefore, multidisciplinary research examining social and physical factors is important to understand decentralised water systems implementation in SEQ from a holistic perspective.

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APPENDIX 1

Job Name:	Survey to Investigate and Validate Water Savings from Rainwater tanks
Job Number:	81218
Version:	FINAL
Date:	6 July 2010
Client Name:	Aditi Mankad / Ted Gardner
Researcher(s):	Richard Bishop
Adhoc or Tracking job:	Ad Hoc
Panel Provider:	CATI
Expected Interview Length:	10 minutes
Sample Size:	N=2000 answering main section onwards Caboolture Shire: n=425 Pine Rivers Shire: n=512 Redlands Shire: n=424 Gold Coast: n=638
Expected Pilot Launch Date:	w/c 5th July
Expected Field End Date:	23rd July
Project Notes: (Please note any additional project notes not covered elsewhere below e.g. is there a previously scripted job that should be used as a starting point etc.)	
Please ensure Property ID (from sample database) is recorded as part of the survey data (for all who consent)	

tns™

1. Master Lists and Scales

Satisfaction Scale:

Very Unhappy	1	
Unhappy	2	
Neither Happy nor Unhappy	3	
Happy	4	
Very Happy	5	

2. Questionnaire

2.1 Introduction

Good morning/afternoon, my name is ________________ and I'm calling on behalf of CSIRO. CSIRO is currently conducting research to measure the effectiveness of mandated rainwater tanks with respect to household water savings in South-East Queensland.

Interviewer note: CSIRO is the Commonwealth Scientific and Industrial Research Organisation.

2.2 Screener

Hard Termination: Respondents will be immediately terminated once they screen on any one question

Screener Questions

ASK ALL

S1 How many rainwater tanks does your household have?

Numeric min 0 max 100
Allow Don't Know

If 0 or Don't Know then terminate

ASK ALL WHO HAVE A RAIN WATER TANK AT S1

S1.5 {**IF MORE THAN** ONE And how many of your rainwater tanks are} {**IF ONE** And is your rainwater tank} internally plumbed rainwater tanks? That is, the rainwater tank supplies water to your toilet, laundry and outside tap?

Numeric min 0 max 100.
Answer cannot exceed response given at S1
Allow Don't Know

If 0 or Don't Know terminate

S2 Do you have a moment to take part in this brief 10- minute survey?
(Select one)

Yes	1	
No	2	**ARRANGE CALL BACK / TERMINATE**

Thank you.

At this time we would like to inform you that participation in this phone survey is voluntary and you are free to withdraw at any time. Personal information you share with

CSIRO will be kept confidential, as per CSIRO Ethical guidelines. If you have any concerns, we can provide you with details for the CSIRO Ethics officer.

Researchers directly involved with this study will work with aggregate, anonymous data from around 2000 households in SEQ.

Should you choose to stop the survey, the information you have given us will be discarded. If you have any questions during the survey, we will be happy to answer them.

S5 Do you give consent to begin this survey?
(Select one)

Yes	1	
No	2	**TERMINATE**

ASK ALL

S3 Are you a renter at the dwelling you are currently living in?
(Select one)

Yes – renter	1	**TERMINATE**
No – owner/something else	2	

ASK ALL DEFINED AS OWNER

S4 What best describes your dwelling structure?
(Select one)
READ OUT

Separate house	1	
Semi-detached or town house	2	
Flat, Unit or Apartment	3	**TERMINATE**

ASK ALL DEFINED AS CODE 1 or 2 IN S4

S5 Was your house built before 2007?
(Select one)

Yes	1	TERMINATE

No	2	GO TO S6
Don't know	3	GO TO S6

ASK ALL DEFINED AS CODE 2 or 3 IN S5

OPEN

S6 To the best of your knowledge, in which month and year was this dwelling first occupied?

Month (specify)	1	
Year (specify)	2	
Not sure, I was not the first to live in it	3	

Response list for month

January	1
February	2
March	3
April	4
May	5
June	6
July	7
August	8
September	9
October	10
November	11
December	12

Response list for year should be four digit numeric starting minimum 2007, maximum 2010.

ASK ALL DEFINED AS HOUSE BUILT 2007 ONWARDS (No or Don't know at S5)

S7 Are you in an area where recycled water is connected to your house for toilet flushing, laundry and the outside taps?

(Select one)

Yes	1	TERMINATE
No	2	
Don't know/ Not sure	3	

Main

Section A

ASK ALL

Q1 Are you aware of any water restrictions that may have applied to your usage of rainwater, either now or in the past?

(Read out, Select all that apply)

Yes – aware water restrictions apply now	1	
Yes – aware water restrictions applied in the past	2	
Not aware of any water restrictions	3	**EXCLUSIVE - CAN NOT BE SELECTED WITH CODES 1 OR 2**
Don't know/ Not sure	4	**EXCLUSIVE - CAN NOT BE SELECTED WITH CODES 1 OR 2**

ASK ALL

Q2 Do you have a greywater treatment system that supplies treated water to your toilet or laundry or outside taps?

(Select one)

Yes	1	
No	2	
Don't know/ Not sure	3	

INTERVIWER NOTES

(Greywater system definition: collects wastewater that has been generated from household activities, such as laundry, shower and dishwashing, and redistributes it to the garden. This process may or may not include treatment of the water.)

These next questions are aimed at identifying how rainwater is used at your property, as each household can use their rainwater in different ways. When answering the questions please think about your ***main*****,** ***internally plumbed rainwater tank.***

ASK ALL
OPEN

Q3 What is the approximate volume of your **internally** plumbed water tank, in litres (e.g. 5,000 litres) or kilolitres (e.g. 5 kL)?

Please enter answer for one of litres or kilolitres only

Litres	Numeric	
Don't know/ Not sure	99999	Eg 20,000 litres

Kilolitres	Numeric	
Don't know/ Not sure	99	Eg 20KL

ASK ALL

Q4 Thinking about the last three years or so for which of the following purposes have you regularly used your rainwater in or around the home?
(Select all that apply)
ROTATE RESPONSES
READ OUT

Toilet flushing	1	
Clothes washing	2	
Garden Irrigation	3	
Lawn Irrigation	4	
Topping up the swimming pool	5	
Car washing	6	
Anything else (specify)	9	**Do not rotate, always ask at end of list**

ASK ALL

Q5 Is the rainwater used for drinking or cooking?
(Select One)

Yes, all the time	1	Go to Q6a
Yes, often	2	
Yes, sometimes	3	
Yes, rarely	4	

Never	5	Go to Q7

ASK ALL DEFINED AS 1-4 IN Q5

Q6a Is it treated before consumption?

Yes	1	
No	2	

ASK ALL WHO TREAT (YES AT Q6a)

Q6b How is it treated?

(Select all that apply) Read out if necessary

Boiled	1	
Filtered	2	
Reverse Osmosis	3	
UV treatment	4	
Other (specify)	8	
Don't Know	99	

ASK ALL

Q7 How many downpipes from the roof gutters are connected to your main plumbed rainwater tank (i.e. pipes from the roof)?

IF NOT SURE / DON'T KNOW ASK FOR BEST GUESS BEFORE CODING DON'T KNOW

Number of pipes (numeric)		
Don't know/ Not sure	3	

ASK ALL

Q8 Could you estimate what proportion of your roof is connected to the plumbed rainwater tank?

(Select One)

NUMERIC MIN 1% MAX 100%

IF NOT SURE TRY AND GET BEST GUESS AND CODE TO NEAREST PROPORTION AS PER TABLE BELOW

¼	1	
½	2	

¾	3	
All of my roof is connected	4	
Don't know/ not sure	5	

ASK ALL

OPEN

Q9 To give us an idea of the typical number of people using water in your household, please tell me how many adults (>18 years old), adolescent (13-17 years old) and children (<12 years old) are usually at home?

Allow Don't Know for each category

Adults		Min 1, Max 9
Adolescent		Min 0, Max 9
Children		Min 0, Max 9

ASK ALL

OPEN

Q10 To the best of your knowledge, how large is your house?

READ OUT. PLEASE CODE IN EITHER CODE 1 or CODE 2; whatever respondent is most comfortable with.

IF NOT SURE / DON'T KNOW ASK FOR BEST GUESS BEFORE CODING DON'T KNOW

Square Metres(specify)	1	Go to Q12
Squares (specify)	2	Go to Q12
Don't know/ not sure	3	Go to Q11

ASK ALL DEFINED AS 3 IN Q10

OPEN

Q11 How many bedrooms and bathrooms are included in your house?

No of bedrooms	1	
No of bathrooms	2	

ASK ALL

Q12 Is your house single storey or double story?

(Select One)

Single	1	
Double	2	
Other (specify)	3	

ASK ALL

OPEN

Q13 To the best of your knowledge, how large is your allotment/property?

(Select One)

READ OUT

IF NOT SURE / DON'T KNOW ASK FOR BEST GUESS BEFORE CODING DON'T KNOW

Square Metres(specify)	1	
Perches (specify)	2	
Don't know/ not sure	3	

ASK ALL

Q14 Thinking about water quality in terms of colour, odour and taste, how happy are you with the water quality of your rain tank system? Please use a scale of 1 to 5, where 1 is very unhappy and 5 is very happy

(Select One)

ALLOW ONE RESPONSE FOR SATISFACTION

Response Scale (across the top)

USE MASTER LIST "SATISFACTION SCALE"

ASK IF CODE 1 or 2 at Q14

Q14a Are you unhappy because of the…

READ OUT SELECT ALL THAT APPLY

ROTATE ORDER OF CODES 1-3

Taste	1	
Colour	2	
Odour	3	
Some other reason (specify)	4	
Don't Know	9	

ASK ALL

Q15 And thinking about reliability, for example that that there's always water in the tank for the garden, how happy are you with the reliability of your rainwater tank supply? Please use a scale of 1 to 5, where 1 is very unhappy and 5 is very happy

(Select One)

ALLOW ONE RESPONSE FOR SATISFACTION

Response Scale (across the top)

USE MASTER LIST "SATISFACTION SCALE"

With the next few questions, we are interested in knowing how you describe your own water usage. This information is simply to establish how much households and individuals vary with their use of water and their thoughts related to personal water use.

ASK ALL

Q16 How do you rate your level of water usage, compared to others in your community?

READ OUT

(Select One)

Higher	1	
Medium or average	2	
Lower	3	
Don't know/ not sure	4	

Q17 Which of the following water efficient appliances are installed in your home? Please just think about appliances installed that are water efficient, not just any type of the appliance

(Read out – Select all that apply)

Water efficient washing machine	1	
Water efficient dishwasher	2	
Low flow shower head (shower rose low flow)	3	
Irrigation system	4	
Any other water efficient	5	**Do not rotate, always ask at end of list**

appliances - SPECIFY		
None of the above	6	
Don't know/ not sure	9	

Interviewer note: There are AAA or star ratings on the front of dishwashers and washing machines if they are 'water efficient'.

ASK ALL

Q18 Do you believe there is a risk of permanent water shortages in South East Queensland…?

READ OUT
SELECT ALL THAT APPLY

Now (current risk)	1	
In the future	2	
No – no risk at all	3	DO NOT READ OUT AUTO-CODE IF NOT YES AT CODE 1 AND CODE 2
Don't know/ not sure	9	

ASK ALL
OPEN
IF CODE 1 AND 2 AT Q18

Q19 Why do you think there is a risk of permanent water shortages in South East Queensland in the future?
PROBE FULLY

IF CODE 1 or 2 AT Q18

Q19 Why do you think there is a risk of permanent water shortages in South East Queensland [now / in the future {insert as applicable}]?
PROBE FULLY

IF DO NOT CODE 1 or 2 AT Q18

Q19 Why do you not think there is a risk of permanent water shortages in South East Queensland
PROBE FULLY

Finally, in order to fully understand water use trends among households in SEQ, CSIRO would like permission to access some of your property's water data. This will be obtained from your water service provider or the Queensland Water Commission, and will be analysed with your survey responses. This involves the water provider or Queensland Water Commission giving us numerical data relating to water use patterns for households in our study. Information will not be linked to your name or address in the analysis.

ASK ALL

Q20 Would you consider giving CSIRO permission to access your property's historic water use data, as well as data for the next 2 years and to link this to your responses in the survey? If you agree to do so, we will mail you an information packet with a consent form, which needs to be completed and signed by the home owner, before CSIRO can request this data. As a thankyou for your time and effort in completing the form, we will send you a small gift for your participation, a **$10 Coles/Myer gift voucher,** upon receiving your completed permission statement.

Yes	1	
No	2	

To mail out the permission forms, we will need your name and address. If you do not wish to provide your full name at this stage, we completely understand, just your first name will do. We do this to ensure that the permission forms we mail out actually get to you, and are not discarded as junk mail.

As with your survey responses, your name and address will remain confidential and will not be linked to the information you have provided us today.

Do you understand this confidentiality statement?

Yes	1	**Proceed to collect information**
No	2	**Clarify the misunderstanding**

Name	1	
Address	2	
Contact No	3	
Date of Phone Call	4	

ASK ALL

Q21 Lastly, would you also be interested in participating in a CSIRO monitoring study of your tank water use patterns? The study would involve two things:

1) Installation of state-of-the-art water meters and data loggers on your rainwater tank and outside taps. This will be used to see how the rainwater is used and how often it is topped up by mains water. Again, your personal identification information will remain confidential.

2) A one-off internal and external house assessment on water devices within your home, to be carried out over the next 12 months. This will be arranged at a suitable time for you and will be conducted by a trained, professional

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