# Assessment of the Physical Characteristics of Individual Household Rainwater Tank Systems in South East Queensland

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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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# 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.

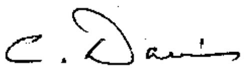
As the largest regionally focused urban water research program in Australia, the Alliance is focused on water security and recycling, but will align research where appropriate with other water research programs such as those of other SEQ water agencies, CSIRO's Water for a Healthy Country National Research 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 has summarised the results of a physical on-site assessment of mandated rainwater tanks in 223 Class 1 (detached domestic) dwellings. The assessment was carried out in four Local Government Areas (LGAs) in South East Queensland (SEQ): Pine Rivers and Caboolture (now both part of the Moreton Bay Regional Council), Gold Coast City Council (Gold Coast) and Redland City Council (Redland). The on-site assessment had the purpose of determining compliance with the Queensland Development Code (QDC) Mandatory Part 4.2 (MP 4.2) – Water Savings Targets (2007). This was considered important to assess as non-compliance would adversely impact on achieving the 70 kilolitres/household/year (kL/hh/yr) target for reduced mains water use.

The three main requirements of MP 4.2 for achieving the water savings target relate to: rainwater tank storage capacity, connected roof catchment area and connection to various end uses.

The on-site assessment audit established that:

- installed rainwater tank storage capacity was mostly above the required 5,000 L, although 16% of the dwellings inspected had storage volumes below 5,000 L;
- connected roof catchment area did not meet requirements in 40% of dwellings, because less than 100 m² or 50% of total roof area was connected to the tank; and
- rainwater systems were connected to toilet, washing machine cold water tap and external tap(s), meeting requirements in most cases.

In addition, the study found that, in estimating rainwater tank volumes, the volumes claimed by the manufacturers should be reduced by about 10% to account for the dead volume below the outlet level, and by about 20% if the larger dead volume below the pump cut-off level, used to activate mains water back-up supply, is factored in. In the absence of manufacturers' volumes, storage volumes can be calculated using physical tank dimensions, reduced by about 12% to account for irregularities in tank shapes from rounded-off edges and/or tank cross-sections not perfectly square or round.

Other studies in SEQ (Chong *et al.*, 2012; Umapathi *et al.*, 2012) have found that maximising connected roof area was more important for maximising the yield from rainwater systems, than increasing tank volume. Therefore, the finding that connected roof area was not compliant with QDC requirements in up to 40% of dwellings has implications for management interventions to ensure the policy to maximise mains water reductions is achieved in practice.

A secondary outcome of this study was quantitative information on the installation of rainwater quality protection measures (e.g., first flush devices) and the provision of back-up mains water supply for those internal end uses connected to the rainwater tank (e.g., toilet). The results indicated a high level of compliance for mandated rainwater tanks for both these criteria.

# 1. INTRODUCTION

## 1.1. Background

Under the amended Queensland Development Code (QDC) Mandatory Part (MP) 4.2 (2007), all new residential dwellings are required to reduce their reliance on mains water supply. For detached dwellings, the target set for mains water reduction was 70 kilolitres/household/year (kL/hh/yr). This target can be achieved through a variety of approaches, including recycled water, stormwater harvesting, greywater systems, and rainwater harvesting at the individual household or cluster scale. The combination of a 5 kL household rainwater tank connected to at least 100 m² of roof area has been deemed to comply with achieving the 70 kL/hh/yr water saving target. According to the QDC, the tank must also be internally plumbed for toilet flushing, a cold water tap for the washing machine in the laundry and an external tap(s) for outside water use including garden watering.

Research to validate the efficacy of individual household rainwater tanks in augmenting the mainstream water supply, and delivering the mains water saving as per QDC MP 4.2, is important as components of the SEQ Water Strategy (2010) are based on this supply assumption. Research data can also help guide the development of policy and regulations addressing issues such as inspection and maintenance protocols.

Desktop studies of mains water savings by Beal *et al.* (2011) and Chong *et al.* (2011), using statistical analysis of water billing data, revealed that a combination of 5 kL tanks and 100 m² connected roof area may not achieve the expected mains water saving target. The Beal *et al.* (2011) study, using 2008 household billing data, concluded a mean mains water saving of 50.5 kL/hh/yr across the three local government areas (LGAs) of Pine Rivers, Redland and Gold Coast. The Chong *et al.* (2011) study, using 2009 and 2010 water billing data, reported an average saving of around 58 kL/hh/yr across all four LGAs. In both studies, Caboolture and Pine Rivers yielded the lowest levels of mains water savings. Similar mains water savings levels were found in a study which monitored water and energy use in 20 homes in SEQ (Umapathi *et al.*, 2012).

There was some concern that the Beal *et al.* (2011) estimates were skewed by water restrictions over 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) (Chong *et al.*, 2011). Other reasons for the possible bias in the desktop statistical analyses were: (1) the use of other (extra) water resources (eg., recycled water or stormwater systems) to achieve MP 4.2 targets; (2) different householder attitudes, behaviours and perceptions toward the utilisation of rainwater (eg., garden watering during severe water restriction or very frugal water use, limited acceptance of rainwater); and (3) non-compliant installation of mandated rainwater tanks at individual residential dwellings (eg., undersized tanks and connected roof area, tanks not being internally plumbed, etc). The focus of this report was the third point, which was to quantify the levels of compliance with installation requirements for individual dwellings.

## 1.2. Decentralised System Project

This research was part of the Urban Water Security Research Alliance's (UWSRA) Decentralised Systems project that was focussed on addressing knowledge gaps on the implementation of rainwater tanks as a strategy to reduce mains water demand. The project was designed to understand the feasibility of achieving the QDC water savings target of 70 kL/hh/yr, from rainwater tanks. This has been achieved through monitoring, evaluation and modelling of mandated tanks. The project also explored different configurations of rainwater systems, the energy footprint, and the need for appropriate governance and management models for rainwater tanks (Figure 1).

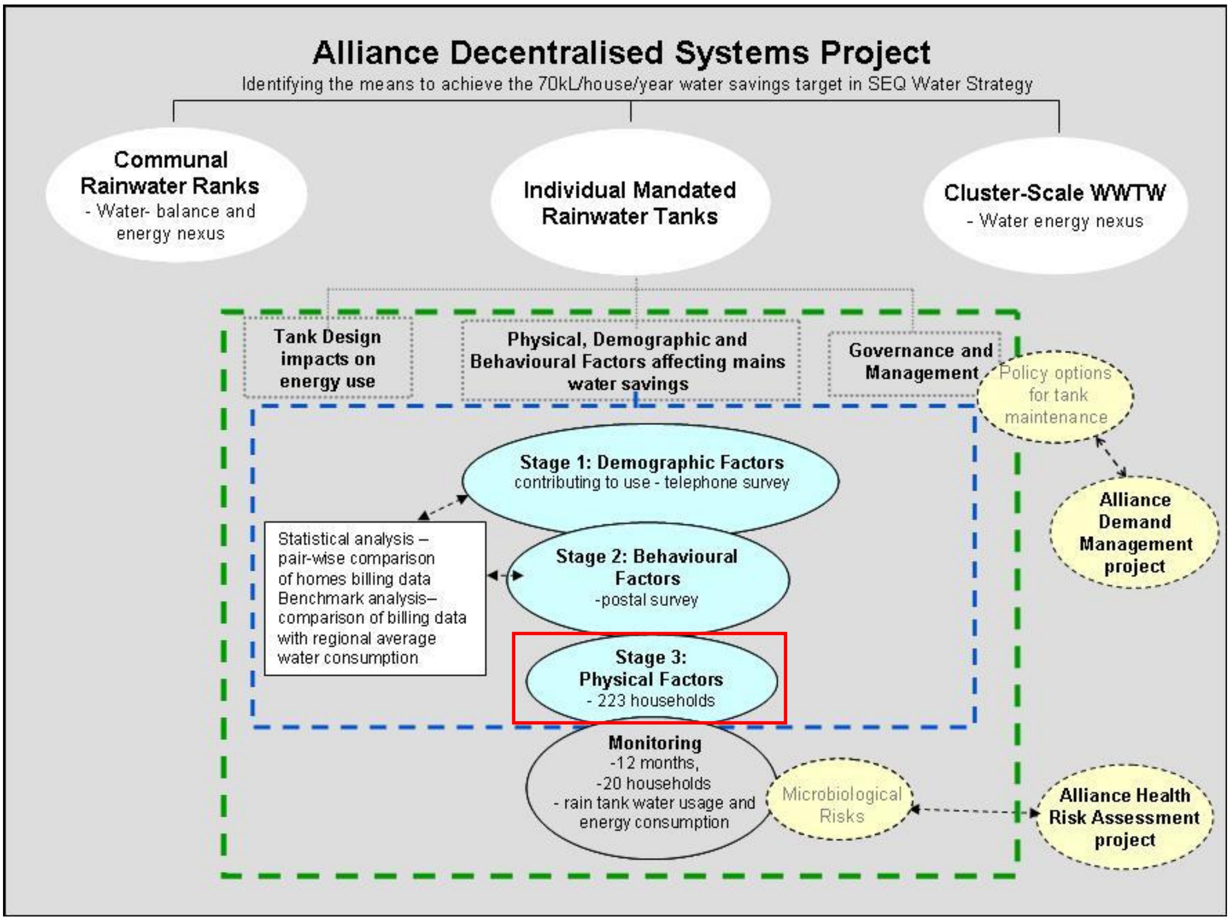


**Figure 1: Components of the UWSRA's Decentralised System project.**

## 1.3. Individual Mandated Rainwater Tank Project Components

The individual mandated rainwater tank component of the Decentralised Systems project comprised three focus areas: investigation into the demographic, behavioural and physical factors influencing usage; governance and management models, and a laboratory study to investigate optimal rainwater tank configurations and energy implications (Figure 1). This current report relates to Stage 3 - the physical factors component (highlighted in red in Figure 1).

Stage 3 comprised a household rainwater system supply assessment of 223 participants recruited in Stages 1 and 2. These households agreed to an on-site inspection of their rainwater systems including storage capacity, roof catchment area, internal connections, pump size, current operational performance and collateral water appliance information. Together with the outputs of Stages 1 and 2 (reported in Chong, Mankad *et al.*, 2011; Chong, Umapathi *et al.*, 2011), this on-site audit is intended to identify the possible physical issues which could impact on the usage and performance of rainwater systems in attaining the 70 kL/hh/yr water savings target.

The Queensland Water Commission (QWC) contributed to the study through financial support to cover the costs of procuring contracting services for undertaking the on-site inspection.

## 1.4. Assessment of the Physical Characteristics of Rainwater Tank Systems

Under the QDC MP 4.2 (2007), Performance Criteria P2-P6 relate to requirements for rainwater tank installation, capacity and water quality for Class 1 buildings (single detached dwellings) supplied directly from the reticulated town water supply. Acceptable solutions (A2-5) for achieving the performance criteria for a detached Class 1 dwelling, where rainwater tanks are selected as the alternate source for achieving water savings targets, are provided in the QDC as follows:

- Water savings targets:
  - Capacity – minimum storage capacity of 5,000 litres.
  - Catchment - installed to receive rainfall from 50% of total roof area or 100 $m^2$ (whichever is the lesser).
  - Connection - to (1) toilet cisterns and washing machine cold water taps (other than those connected to a greywater treatment plant or alternative water substitution measure) and (2) an external use.

- Water quality protection:
  - Prevention of contaminants from entering rainwater tank – (1) screened downpipe rain-head having a screen mesh 4-6 mm to prevent leaves from entering downpipe (2) discarding of a minimum of 20 litres of first flush where connected to showers, wash basins, kitchen or hot water services.
  - Prevention of mosquito breeding and vermin entering the rainwater tank – (1) mosquito-proof screens (suitable material and not coarser than 1mm aperture mesh) OR flap valves at every opening of tank OR in case of wet systems, mosquito-proofing in accordance with HB230 (2) vermin trap.
  - Prevention of contamination of reticulated town water supply from rainwater tank water– a backflow prevention device must be installed.

In this study, on-site household rainwater tank system assessments were undertaken to determine whether the 223 Class 1 residential dwellings selected in four LGAs of SEQ meet the physical tank installation requirements deemed necessary to achieve the water savings targets set out in the QDC (2007). Of secondary importance (and not reported fully in this report), was data regarding the installation of rainwater quality protection measures, the presence of greywater treatment plants or other alternative water substitution measures, and the installation of water efficient appliances. This information was collected for analysis in other research projects.

# 2. METHODOLOGY

## 2.1. Engagement of Service Provider

For this study, BMT WBM Pty Ltd was selected by the CSIRO research team to conduct the on-site household rainwater tank system inspection after winning a competitive bidding process.

## 2.2. Compilation of List of Requirements

A list of requirements for the household rainwater tank system inspection was compiled, based on a similar audit conducted by Sydney Water, but adapted to relate directly to performance standards in QDC MP 4.2 (2007). The audit was piloted at ten households and, after some refinements based on this data and feedback from the QWC, was rolled out to all 223 dwellings. The final audit covered the following:

- characteristics of individual dwellings (dwelling type, total roof area, property dimensions);
- water efficient appliances and fixtures (showerheads, washing machine);
- rainwater tank systems (tank volume, roof area connected, pump size);
- internal connections for rainwater supply (plumbing connections to/from the tank); and
- other water related features on the property (swimming pool, spa).

## 2.3. Selection of Households for Inspection

An on-site inspection was initially conducted on 200 households with mandated rainwater tank systems in the four local government areas (LGAs) of Caboolture, Gold Coast, Pine Rivers and Redland. These areas were being investigated as part of wider research into water savings from individual rainwater tanks. Previous research indicated discrepancies in water savings results particularly in Caboolture and Pine Rivers where lower than expected water savings were reported (Beal *et al.*, 2011; Chong *et al.*, 2011) and it was requested that a larger sample be drawn from these areas.

These areas were originally selected on the basis that they are high growth areas for residential development. They were expected to have a high proportion of dwellings constructed after January 2007 and thus have mandated rainwater tanks installed - a pre-requisite for inclusion in the study. Also, consent had to be obtained from the owner to conduct an on-site inspection. Both community engagement processes in the preceding stages of this project, telephone survey (Stage 1) and postal survey (Stage 2) asked whether the householder would be willing to provide consent for an on-site inspection of their rainwater system. The 443 households who indicated willingness to consent were sent a follow-up letter, which provided details of the research and a consent form to be completed, signed and returned. The 200 households who returned a completed consent form were contacted by email and post, providing details of the intended site inspection (Appendix 1) and asked to provide a telephone contact so that the audit service provider could arrange appointment scheduling. The site inspections of the initial 200 sites were conducted during the period 27 July to 29 September 2011.

It was found that connected roof area could not be obtained for some households using a wet conveyance system because down pipes were not charged with water due to low rainfall. In the case of wet systems and underground tanks, this meant that connected roof area could not be determined. The service provider revisited some of these sites in January 2012, and due to plentiful rain, was able to measure connected roof area. An additional three sites in Gold Coast were also inspected to increase the sample size in that locality, bringing the sample size to a total of 223 households.

To further improve the sample size, results from the *20 home monitoring study* (another sub-component of the Decentralised Systems project of the Alliance) which collected exactly the same base tank physical set-up data, by the same service provider, in the same time period, were also incorporated into this analysis (Umapathi *et al.*, 2012). The resulting sample size for each LGA is shown in Table 1.

**Table 1: Sample size after Inclusion of additional sites.**

| LGA | Original Number of Sites Inspected | Final Number of Sites Inspected | Estimated no. of Class 1 Dwellings with Mandated Rainwater tanks (QWC, Nov, 2010 - rounded) |
|---|---|---|---|
| Caboolture | 56 | 59 | 4,000 |
| Gold Coast | 38 | 45 | 3,300 |
| Pine Rivers | 69 | 78 | 5,000 |
| Redland | 37 | 41 | 3,300 |
| **Total** | **200** | **223** | **15,600** |

Drawing on the known population of households with mandated tanks, it was possible to calculate the statistical accuracy of the results given the sample number used in this study. The calculation is based on the size of the sample, the size of the population from which the sample is drawn, the level of statistical confidence desired (typically 95%), and the variability in the sample (typically estimated from a worst-case assumption of a sample proportion of 50%). The error margin for the full 223 sample, at the 95% confidence interval, was +/- 6.5%. Hence the sample size was considered acceptable given the scope and objectives of the study, and the availability of external funding.

## 2.4. Site Inspections

### 2.4.1 Appointment Scheduling

A list of addresses and telephone numbers of consenting households was provided to the audit service provider (BMT WBM P/L) together with the total number of sites required to be inspected in each LGA. Each site inspection was organised with a phone call to the householder and a suitable date and time agreed upon. During this phone call, a brief overview of the project was also provided.

### 2.4.2 Site Parameter Assessment

A summary of the final list of requirements and methods used to determine each required site parameter has been extracted from the service provider’s proposal and is provided in Appendix 2.

### 2.4.3 Data Collection, Capture and Submission

For each property, data was directly entered into a Microsoft Access database. This data was later converted into spreadsheet format for submission and analysis.

In addition, a high resolution PhotoMap of each site, accessed from Nearmap, was used to delineate and calculate specific garden and roof catchment areas. Photographs of the rainwater tank system were taken at each site and provided in digital format as a record of particular site characteristics. A summary site report was prepared for each site in hard copy and electronic format for forwarding to those home owners who had requested feedback.

# 3. RESULTS AND DISCUSSION

## 3.1. Rainwater Tank Capacity

### 3.1.1. Rainwater Tank Description

For this study, a rainwater tank system was defined as a single tank or group of tanks on a site that had a dedicated catchment area or pump. The audit did not find any rainwater tank systems that shared a catchment or pumps with another site.

Most tank systems comprised tanks which were cylindrical (47%), while 37% of tanks were rectangular. Irregular shaped tanks, which included one bladder tank, made up 5% of the tank systems inspected. A total of 24 sites (10%) had underground tanks where it was not possible to determine the tank shape (Table 2). Caboolture also had the greatest number of underground tank systems (ten) (Table 2).

Of the total 239 rainwater tanks inspected across 223 sites, most (223 or 93%) were part of a single tank system (1 TS), 14 (6%) were part of a second tank system (2 TS) and two tanks in Caboolture were part of a third tank system (3 TS) (Table 2). Caboolture also had the greatest number of second tank systems (six). All sites with two or more rainwater tank systems had only a single pump serving the whole system.

**Table 2: Rainwater tank number, shape and location.**

| LGA | Shape | | | Location | | Number of Tanks per Tank System (TS) | | |
|---|---|---|---|---|---|---|---|---|
| | Cylindrical | Rectangular | Irregular | Underground | Total | 1 TS | 2 TS | 3 TS |
| Caboolture | 38 | 15 | 4 | 10 | 67 | 59 | 6 | 2 |
| Gold Coast | 21 | 19 | 1 | 6 | 47 | 45 | 2 | 0 |
| Pine Rivers | 33 | 39 | 5 | 4 | 81 | 78 | 3 | 0 |
| Redland | 21 | 16 | 3 | 4 | 44 | 41 | 3 | 0 |
| **Total** | **113** | **89** | **13** | **24** | **239** | **223** | **14** | **2** |

Table 3 provides a breakdown by LGA of the number of rainwater tanks making up the single tank system. Of the 223 single tank systems, 165 (74%) comprised a single rainwater tank only, 54 sites (24%) comprised two tanks and two sites (1%) comprised three tanks. All sites with a second or third tank system installed only ever had a single rainwater tank in those systems.

**Table 3: Number of tanks in single tank systems for each LGA.**

| LGA | 1 TS – Number of tanks | | | | |
|---|---|---|---|---|---|
| | 1 tank | 2 tanks | 3 tanks | Unknown | Total |
| Caboolture | 54 | 4 | 0 | 1 | 59 |
| Gold Coast | 41 | 3 | 0 | 1 | 45 |
| Pine Rivers | 66 | 10 | 2 | 0 | 78 |
| Redland | 4 | 37 | 0 | 0 | 41 |
| **Total** | **165** | **54** | **2** | **2** | **223** |

For the purposes of the capacity analysis, the volumes of all tanks on a particular site were summed to obtain total storage capacity.

### 3.1.2. Volume Measures

Although MP 4.2 is not specific as to how rainwater tank volume is calculated, we assumed it related to the net volume below the overflow pipe (referred to here as storage volume). Manufacturers' claimed volumes are generally also calculated on this basis, although differences exist among manufacturers depending on whether they use national standards such as AS/NZS4766:2006.

Compliance with MP 4.2 was assessed based on: the manufacturer's claimed volume, as indicated on the tank itself, or reported by the home owner with documentary proof; and the storage volume calculated from the geometric dimensions of the tank using Equations 1 and 2.

$$\textbf{Storage Volume (Rectangular)} = \textbf{Length} \times \textbf{Width} \times \textbf{Height} \quad (1)$$
*where height is the height to the base of the overflow pipe*

$$\textbf{Storage Volume (Cylindrical)} = \pi/4 \times (\textbf{Diameter})^2 \times \textbf{Height} \quad (2)$$
*where height is the height to the base of the overflow pipe*

Effective or active volume, which excludes the "dead" volume both above the tank overflow level and below the pump outlet or cut-off switch levels, was also calculated to define the real working volume available for household use. Two forms of effective volume were calculated: one based on the height of the pump outlet (Equations 3 and 4); and the other on the height of the pump cut-off switch or float, used to activate mains water back-up supply (Equations 5 and 6).

$$\textbf{Effective Volume (\^{}1) (Rectangular)} = \textbf{Length} \times \textbf{Width} \times \textbf{Height} \quad (3)$$
*where height = height of overflow - height of pump outlet*

$$\textbf{Effective Volume (\^{}1) (Cylindrical)} = \pi/4 \times (\textbf{Diameter})^2 \times \textbf{Height} \quad (4)$$
*where height = height of overflow - height of pump outlet*

$$\textbf{Effective Volume (\^{}2) (Rectangular)} = \textbf{Length} \times \textbf{Width} \times \textbf{Height} \quad (5)$$
*where height = height of overflow - height of pump cut-off switch*

$$\textbf{Effective Volume (\^{}2) (Cylindrical)} = \pi/4 \times (\textbf{Diameter})^2 \times \textbf{Height} \quad (6)$$
*where height = height of overflow - height of pump cut-off switch*

^1 - excluding the "dead" volume above the tank overflow level and below the pump outlet level
^2 - excludes the "dead" volume above the tank overflow level and below the pump cut-off level

The volume of all tanks could not be estimated due to either: (1) inaccessibility, such as tanks being in confined spaces, underground tanks, submerged pumps; or (2) unavailability, such as claimed volume not being marked on the tank itself or cut-off switch having been disabled. In the analysis, the sample size is thus different for each of the volume measures.

### 3.1.3. Claimed Rainwater Tank Volume

Across the four LGAs, the average claimed tank volume was around 7,000 L per site with a median of 5,000 L (Table 4). On average, the claimed volume of tanks was in compliance with the minimum MP 4.2 storage capacity of 5,000 L. However, the average was skewed by a small number of sites with an exceedingly high capacity (Figure 2). Of the 13 sites which had a capacity greater than 10,000 L, eight sites had a tank capacity of greater than 20,000 L. It was surmised that these households with significantly greater than 5,000 L tanks were aiming for self-sufficiency, rather than compliance with MP 4.2, and were therefore excluded from the average compliance analysis. Once the tanks which were larger than 10 kL were excluded from the analysis, the average claimed tank volume decreased to 4,876 L (Table 4). Only 12% of all sites have a claimed capacity of less than 5,000 L with Caboolture sites having the highest percentage (17%) of below minimum claimed capacities (Table 4).

**Table 4: Claimed site rainwater tank volumes (litres) and compliance with QDC MP 4.2.**

| LGA | Number of sites with tanks of different volumes | | | | | | | Compliance | | Tank volume (L) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | No vol. | <4 KL | >4<5 KL | 5 KL | >5<10 KL | >10 KL | Total (excl. No vol) | % comply | 20% variance | Average | Median |
| Caboolture | 29 | 4 | 1 | 16 | 5 | 4 | 30 | 83% | 87% | 7,390 | 5,000 |
| Gold Coast | 31 | 1 | 0 | 10 | 1 | 2 | 14 | 93% | 93% | 7,228 | 5,000 |
| Pine Rivers | 33 | 4 | 1 | 33 | 4 | 3 | 45 | 89% | 91% | 5,608 | 5,000 |
| Redland | 24 | 2 | 0 | 10 | 1 | 4 | 17 | 88% | 88% | 9,764 | 5,000 |
| **Total** | **117** | **11** | **2** | **69** | **11** | **13** | **106** | **88%** | **90%** | **6,993** | **5,000** |
| **Total excl. tanks >10KL** | | | | | | | | | | **4,876** | **5,000** |

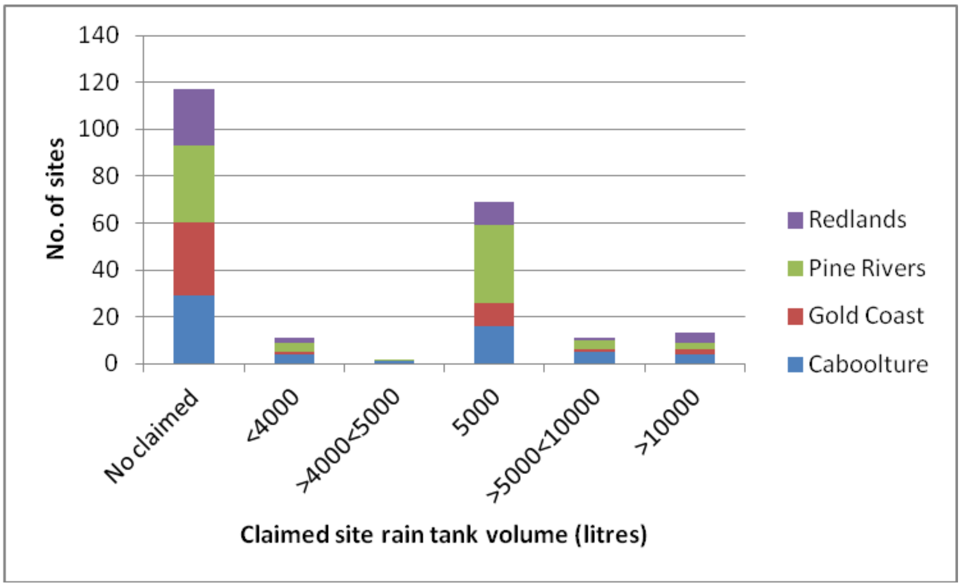


**Figure 2: Distribution of rainwater tank size from manufacturer's data for the four LGAs.**

## 3.1.4. Rainwater Tank Storage Volume

Claimed volume was available for only 106 tanks, so, in order to assess levels of compliance with MP 4.2 across all sites inspected, it was necessary to calculate storage volumes using the tank dimensions collected during the physical site inspection. The storage volume was calculated for 181 sites, however the tank volume for 42 sites could not be calculated as the tanks were either inaccessible for measurement or very irregular in shape (eg., bladder type).

The average storage volume, calculated from the tank dimensions, to the height of the overflow pipe, was 6,659 L with a median of 5,716 L (Table 5). This was less than the claimed volume by about 5%. Larger tanks may have influenced the claimed volume sample being higher than the calculated volumes. When tanks larger than 10 kL were **excluded,** average measured storage volume (5,521 L) was slightly higher (12%) than claimed volume (4,876 L) (Table 5). This is more in line with expectations given that manufacturer's claimed volume are more likely to be accurately calculated, accounting for exact shaping of tanks, such as rounded edges of rectangular tanks, and thickness of tank material resulting mostly in slightly lower net claimed volumes than calculated available volumes, which do not account for exact shapes. Likewise, the calculated median storage volume (5,385 L) was 8% greater than claimed volume (5,000 L) when large tanks were **excluded** in the analysis (Table 5). A direct comparison between sites where both claimed and measured storage volumes were available (86 sites, including large tank sites) confirmed that, on average, calculated storage volume (7,126 L) was higher than claimed volume (6,372 L).

**Table 5: Calculated site rainwater tank storage volumes (litres) and compliance with QDC MP 4.2.**

| LGA | Number of Sites with Tanks of Different Volumes | | | | | | | | Compliance | | Tank Volume (L) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No vol. | <4 KL | >4<5 KL | >5<6 KL | >6<7 KL | >7<10 KL | >10 KL | Total | % Comply | 20% variance | Average | Median |
| Caboolture | 12 | 4 | 7 | 26 | 4 | 1 | 5 | 47 | 77% | 91% | 6,818 | 5,664 |
| Gold Coast | 12 | 0 | 4 | 17 | 7 | 3 | 2 | 33 | 88% | 100% | 7,575 | 5,766 |
| Pine Rivers | 10 | 4 | 3 | 43 | 11 | 3 | 4 | 68 | 90% | 94% | 6,174 | 5,733 |
| Redland | 9 | 2 | 5 | 19 | 1 | 1 | 4 | 32 | 78% | 94% | 6,509 | 5,445 |
| **Total** | 43 | **10** | **19** | **105** | **23** | **8** | **15** | **180** | **84%** | **94%** | **6,659** | **5,716** |
| **Total excl. tanks >10KL** | | | | | | | | | | | **5,521** | **5,385** |

Over the four LGAs, 84% of sites with calculated storage volume were at or above the MP 4.2 minimum compliance volume of 5,000 L (Table 5), with most sites (58%) in the 5,000 L to 6,000 L class and 13% in the 6,000 L to 7,000 L class (Figure 3). Around 16% of sites had storage volumes that were less than the required 5,000 L. When sites which are within a 20% variance of the minimum volume were included, 94% of sites were at or near the minimum compliance level. However, even allowing for a 20% variance, there were only 10 sites (0.5%) which were below the minimum compliance level. Caboolture had the lowest level of compliance at 91% with Gold Coast the highest at 100% compliance. Allowing for the 12% over-estimation in calculated storage volume, compliance in all LGAs was well above the required 5,000 L specified in MP 4.2.

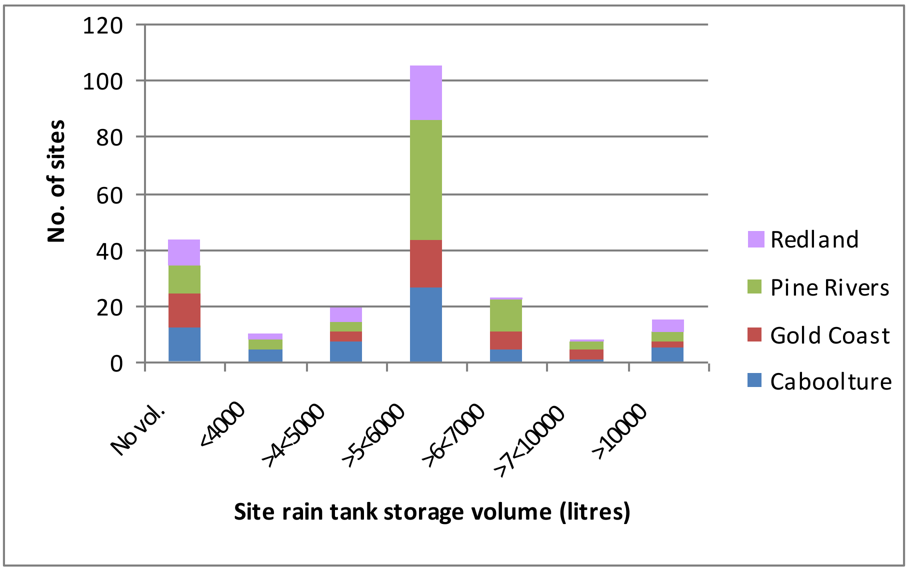


**Figure 3: Distribution of measured rainwater tank storage volumes (litres).**

### 3.1.5. Effective Rainwater Tank Volume

While the above analysis of rainwater tank volume indicated overall compliance with MP 4.2, there was the need to consider the "dead" volume, the tank storage area above the overflow outlet and below the pump outlet (effective volume ^1). When effective volume was calculated by excluding the dead volume, the average across all inspected sites (including the very large tanks) was 6,342 L with a median of 5,451 L (Table 6), which was still above the MP 4.2 requirement of 5,000 L. There were 48 sites which had a lower effective volume than 5,000 L, although 34 of these were within a 20% variance. Pine Rivers had the greatest percentage of sites (79%) with an effective volume greater than 5,000 L, while Caboolture and Redland had the lowest percentage (63%). If sites with a 20% variance were included, Gold Coast had the greatest percentage of sites (97%) greater than or equal to the minimum required 5,000 L, whilst Redland had the lowest percentage at 88%.

**Table 6: Calculated rainwater tank effective volume (^1) (litres) using tank overflow and pump outlet heights.**

| LGA | No volume | <4KL | >4<5KL | >5<6KL | >6<7KL | >7<10KL | >10KL | % comply | 20% variance | Total | Average | Median |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Caboolture | 12 | 4 | 10 | 17 | 3 | 0 | 4 | 63% | 89% | 38 | 6,393 | 5,380 |
| Gold Coast | 11 | 1 | 7 | 17 | 3 | 3 | 3 | 76% | 97% | 34 | 7,276 | 5,623 |
| Pine Rivers | 10 | 5 | 9 | 40 | 8 | 2 | 4 | 79% | 93% | 68 | 5,939 | 5,570 |
| Redland | 9 | 4 | 8 | 15 | 0 | 1 | 4 | 63% | 88% | 32 | 6,130 | 5,202 |
| **Total** | **42** | **14** | **34** | **89** | **14** | **6** | **15** | **72%** | **92%** | **172** | **6,342** | **5,451** |

Figure 4 shows the distribution of effective tank volumes excluding the dead tank storage area above the overflow and below the pump outlet (effective volume ^1) across the four LGA.

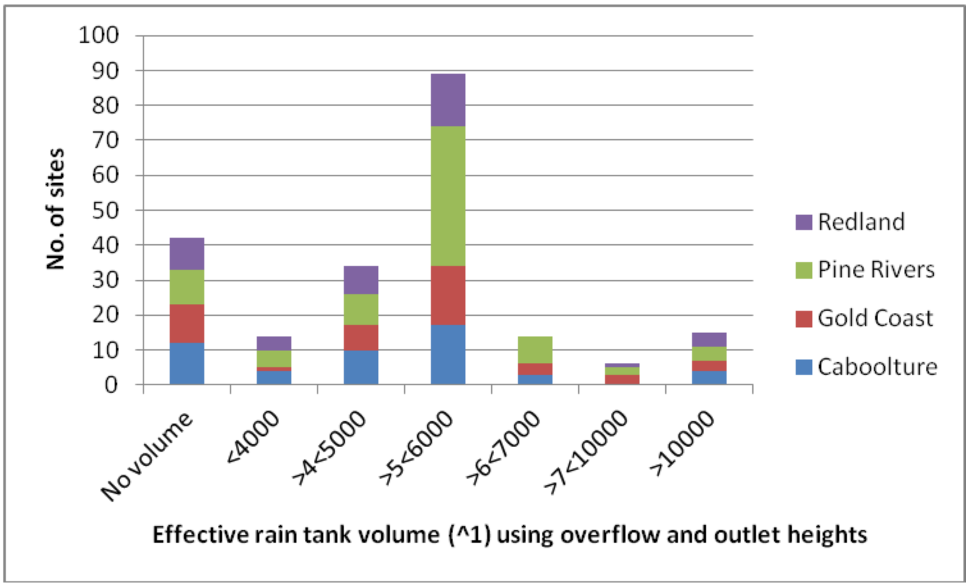


**Figure 4: Distribution of site rainwater tank effective volume ^1 (litres) using heights from pump outlet to tank overflow.**

The second form of effective volume calculated (effective volume ^2), excluded the dead volume above the tank overflow level, and below the pump cut-off level, which is higher than the pump outflow. Hence these calculations yielded a lower calculated volume than effective volume ^1.

The average effective volume ^2 was greater than the MP 2.4 minimum capacity requirement of 5,000 L, but this time only marginally at 5,019 L, with a median of 4,947 L (Table 7). When the tank volume below the pump cut-off level was excluded, eight sites (13%) had an effective volume of less than 4,000 L (Table 7).

**Table 7: Rainwater tank effective volume ^2 (litres) using tank overflow and pump cut-off heights.**

| LGA | No cut-off | <4 kL | >4<5 kL | >5<6 KL | >6<7 KL | >7<10 KL | >10 KL | Total Number | % comply | 20% variance | Average (L) | Median (L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Caboolture | 50 | 0 | 6 | 2 | 0 | 0 | 1 | 9 | 33% | 100% | 5,562 | 4,947 |
| Gold Coast | 30 | 0 | 7 | 5 | 2 | 1 | 0 | 15 | 53% | 100% | 5,256 | 5,258 |
| Pine Rivers | 52 | 3 | 12 | 9 | 1 | 1 | 0 | 26 | 42% | 88% | 4,834 | 4,937 |
| Redland | 31 | 5 | 1 | 3 | 1 | 0 | 0 | 10 | 40% | 50% | 4,656 | 4,377 |
| **Total** | **163** | **8** | **26** | **19** | **4** | **2** | **1** | **60** | **43%** | **87%** | **5,019** | **4,947** |

Only 60 sites had sufficient measurements to calculate effective volume ^2, thus the results should be considered with caution. The reason for this low return of data was that, in addition to reasons of underground and inaccessible tanks, many pumps use an electronic pressure sensor, not the water level, to control activation of the mains water back-up. Hence, the water level could not be measured in these cases nor for those pumps which were submerged in the tank.

### 3.1.6. Comparison of Volume Measures

On average, rainwater tank volumes were largely compliant with MP 4.2 capacity requirements, regardless of volume calculation method used, even though MP 4.2 does not require that "dead" volume at the base of the tank be allowed for in the calculation. All methods indicated an average and median rainwater tank volume above 5,000 L except for the Redland median value which was slightly lower at 4,947 L (Table 8). Allowing for a 20% variation, the percentage number of sites with a volume above 4,000 L was above 90% with the exception of the effective ^2 method which was 87%.

**Table 8: Effective site rainwater tank volume ^2 (litres) using overflow and pump cut-off heights (large tanks included).**

| Volume Measure | % Sites Over 5,000L | 20% Variance | Average (L) | Median (L) | Worst Performing |
|---|---|---|---|---|---|
| Claimed | 88% | 90% | 6,993 | 5,000 | Caboolture/Redland |
| Storage | 84% | 94% | 6,659 | 5,716 | Caboolture |
| Effective ^1 | 72% | 92% | 6,342 | 5,451 | Redland/Caboolture |
| Effective ^2 | 43% | 87% | 5,562 | 4,947 | Redland |

Caboolture and Redland consistently performed slightly worse than the other LGAs in terms of volume compliance which may be why mains water savings in these areas in previous studies were lower than expected. However, due to the small sample size with the margin for error calculated at around 11-15%, these differences among LGAs cannot be considered as statistically significant as the differences between % compliance (with 20% variance) were less than the margin of error. Obtaining a larger sample to gain more confidence in the differences may not be worthwhile as yield modelling of 20 household's rainwater tanks indicated that tank volumes are less important in achieving water savings than other physical rainwater tank set-up factors such as connected roof area (Chong *et al.*, 2012).

### 3.1.7. Implications for Future Estimation of Effective Tank Volume

MP 4.2 was not specific about whether the required 5,000 L minimum storage capacity is "gross" or "net" in terms of volume. The results indicated that gross and net measures of tank volume were mostly above 5,000 L. When water level activated pump cut-off effects were included, the average tank volumes were marginally above the minimum capacity requirement at 5,019 L, with the median of 4,947 L (Table 7). Measuring the level at which cut-off takes place is difficult. Manufacturer's claimed volumes (which already account for the “dead” volume above overflow level) may be adequate for future modelling, if one allows for a reduction of around 10% for the dead volume below the outlet level (difference between claimed volume and effective volume ^1 averages), and around 20% if pump cut-off factors are included. Further investigation of the impact of pump cut-off on effective volume would be required before sufficient confidence in this proposed 20% reduction factor is obtained. The sample size of tanks with cut-off levels provided was too small in this survey to provide that level of confidence (60 tanks with cut-off level measures).

In the absence of manufacture’s data on claimed volumes, if storage volumes are calculated using gross physical tank dimensions, the calculated volume should first be reduced by about 12% to account for volume lost due to tank shapes which generally round off edges and are not perfectly square or round as discussed in Section 3.1.4 above.

## 3.2. Roof Catchment Area

To achieve the water savings target, MP 4.2 requires that rainwater tanks be connected to a minimum of 50% of the total roof area or 100 m², whichever is the lesser. The average roof area across the four LGAs was 300 m² (Table 9), which means that average house in this study need only have 100 m² of roof area connected to the rainwater tank to comply with MP 4.2 (the lesser of 150 m² and 100 m²).

**Table 9: Average total roof area (m²) for the four LGAs.**

| LGA | Average Roof Area(m²) |
|---|---|
| Caboolture | 310 |
| Gold Coast | 326 |
| Pine Rivers | 281 |
| Redland | 294 |
| **Total** | **300** |

Average connected roof was 118 m², and was therefore compliant in terms of the lower 100 m² criterion (Table 10). However, considering all 223 sites, 58% complied in terms of having connected roof area of >100 m² (Table 10). Only 24% of sites complied in terms of having more than 50% of their roof area connected, whilst 55%, of sites had less than 40% of their roof area connected to the rainwater tank. Applying the MP4.2 “either/or” rule for compliance, there was 60% compliance across all four LGAs, with Gold Coast (54%) the least compliant and Caboolture (64%) the most complaint.

**Table 10: Connected roof area (m²) and percentage of total roof area connected to rainwater tanks for the four LGAs.**

| LGA | Connected Roof Area (m²) | | | | | | % Connected Area | | | | | Total Sites With Area | No. comply | Comply (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | <80 | 80-100 | 100-200 | >200 | Av. m² | % comply >100 | <40 % | 40-50 | >50 % | Av. % | Comply (%) | | | |
| Caboolture | 14 | 5 | 28 | 6 | 119 | 64% | 26 | 16 | 11 | 44% | 21% | 53 | 34 | 64% |
| Gold Coast | 12 | 7 | 15 | 5 | 136 | 51% | 23 | 6 | 10 | 41% | 26% | 39 | 21 | 54% |
| Pine Rivers | 23 | 10 | 37 | 6 | 110 | 57% | 42 | 17 | 17 | 39% | 22% | 76 | 44 | 58% |
| Redland | 9 | 7 | 18 | 4 | 113 | 58% | 22 | 4 | 12 | 41% | 32% | 38 | 24 | 63% |
| **Total** | **58** | **29** | **98** | **21** | **118** | **58%** | **113** | **43** | **50** | **40%** | **24%** | **206** | **123** | **60%** |

Figures 5 and 6 illustrate in bar chart format the data from Table 10 of connected roof area and percentage of total roof area connected to the rainwater tanks, respectively, for each of the four LGAs. For example in Pine Rivers, 23 houses (30%) had <80 m² connected roof area and 42 houses (55%) had <40% roof area connected to the rainwater tank.

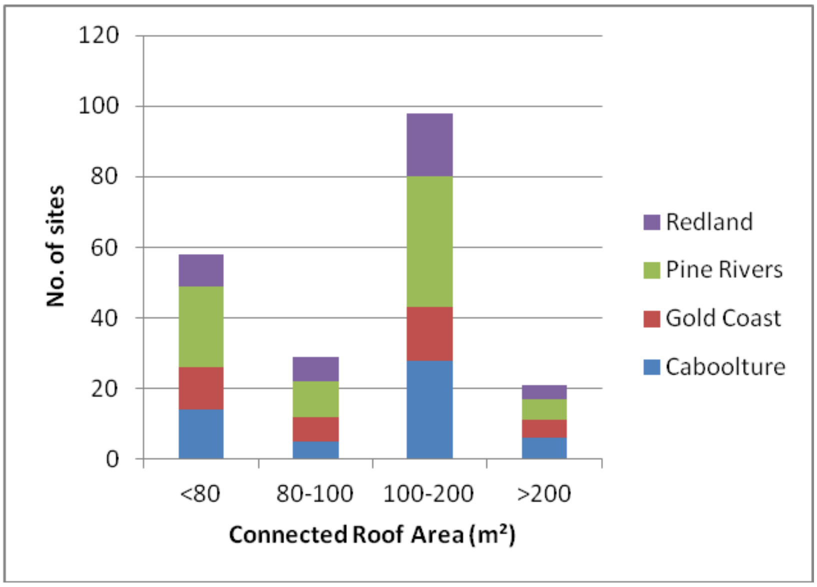


**Figure 5: Connected roof area ($m^2$) for the four LGAs.**

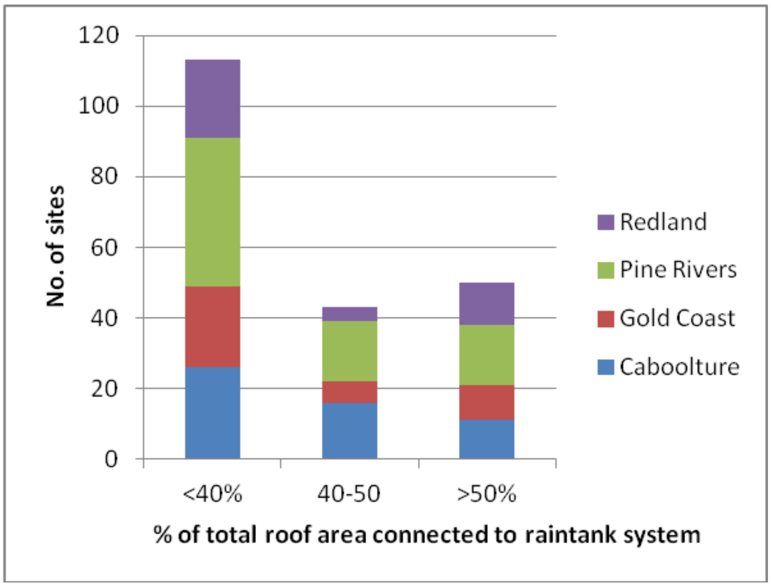


**Figure 6: Percentage of total roof area connected to rainwater tanks for the four LGAs.**

## 3.3. Connection to Toilets, Washing Machines, External Use

The more household appliances that are plumbed or connected to rainwater tank, the more rapidly the water level in rainwater tanks will be drawn down, resulting in a higher rainwater use and greater mains water savings. MP 4.2 (A2(c)) requires that rainwater tanks be connected to: (1) toilet cisterns and washing machine cold water taps (other than those connected to a greywater treatment plant or alternative water substitution measure); and (2) an external use. Most of the sites inspected were fully compliant with regard to required connection to household appliances and to an external tap. All homes inspected had one washing machine present and only 2% of households (five sites in Caboolture) did not have their washing machine connected to the rainwater system. 93% of sites had two toilets connected to the rainwater tank with only five sites not having any toilet connected at all (Figure 7). Except for one site, all homes inspected had at least one external tap connected to the rainwater tank system (Figure 8).

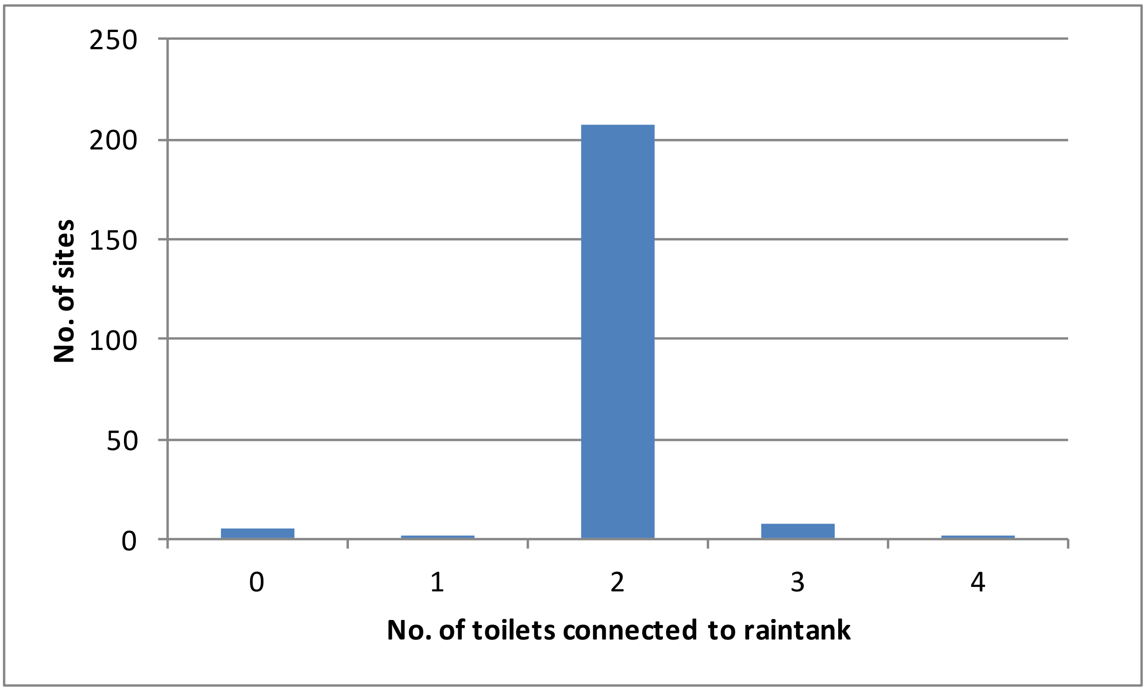


**Figure 7:** **Number of toilets connected to the rainwater tank system.**

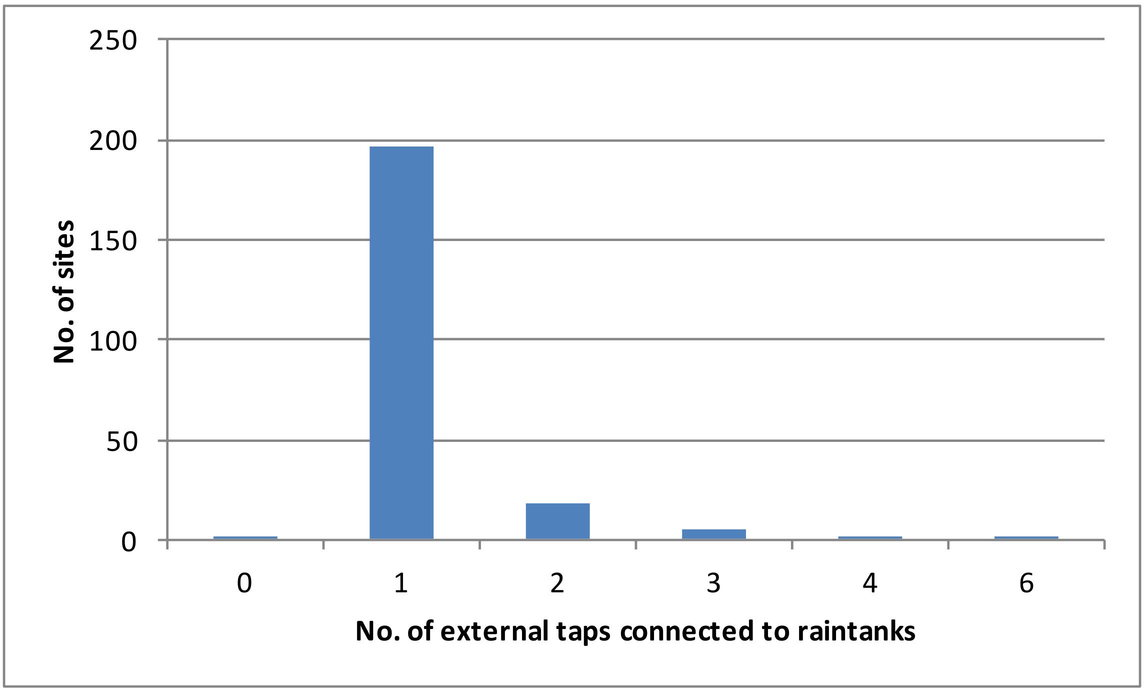


**Figure 8:** **Number of external taps connected to the rainwater tank system.**

Additional rainwater tank connections were observed at some sites. Five sites had hot water connected to rainwater tanks and six sites had rainwater tanks connected for drinking water.

## 3.4. Rainwater Quality Protection

Although water savings–related issues are the main purpose of this study, information regarding the presence of MP 4.2 (P3 and P4) water quality protection measures was also collected as part of the site inspection and is presented briefly below.

MP 4.2 (A3) requires screened downpipe rain-heads and first flush devices as suitable measures to prevent contaminants from entering the rainwater tank. 95% of rainwater tanks inspected in the study had a screened downpipe rain-head installed (Table 11). Only 37% of rainwater tanks inspected had a first flush device installed (Table 12), but this requirement is only necessary when the rainwater tank is connected to showers, wash basins or hot water services, or if required by a local planning instrument which was not the case in the LGAs studied.

**Table 11: Screened downpipe rain-head Installation.**

| | No. | % |
|---|---|---|
| Present | 211 | 95% |
| Absent | 12 | 5% |
| **Total** | **223** | |

**Table 12: First flush device Installation.**

| | No. | % |
|---|---|---|
| Present | 72 | 37% |
| Absent | 121 | 63% |
| **Total** | **193** | |

MP 4.2 (A4) requires: mosquito-proof screens, flap valves, or in cases of wet systems, mosquito-proofing in accordance with HB230 (Rainwater Tank Design and Installation Handbook, 2008); and vermin traps to prevent mosquito breeding and vermin entering the rainwater tank system. Of the sites inspected, 96% had some form of mosquito breeding prevention device installed (Table 13) and 95% had a vermin trap installed (Table 14).

**Table 13: Mosquito breeding prevention device installation.**

| | No. | % |
|---|---|---|
| Present | 189 | 96% |
| Absent | 7 | 4% |
| **Total** | **196** | |

**Table 14: Vermin trap installation.**

| | No. | % |
|---|---|---|
| Present | 187 | 95% |
| Absent | 9 | 5% |
| **Total** | **196** | |

MP 4.2 (P6) requires a backflow prevention device to prevent the contamination of the reticulated town water supply by rainwater. All tanks with a trickle top-up system must have an air gap present between the overflow and the trickle top up device as a backflow prevention device. This question considered whether an additional backflow prevention device had been installed. Only 45% of rainwater tanks inspected had such an additional device present (Table 15).

**Table 15: Backflow prevention device installation.**

| | No. | % |
|---|---|---|
| Present | 95 | 45% |
| Absent | 116 | 55% |
| **Total** | **211** | |

## 3.5. Continuous Supply

MP 4.2 (P5) also requires a continuous supply of water to internal fixtures supplied from a rainwater tank through a trickle top-up or an automatic switching device. The most commonly used measure at the sites inspected was an automatic switch (70%), while 23% employed a trickle top-up system. Of particular note, 14 houses (6%) had no device in place to ensure continuous supply to internal fixtures (Table 16). This is a major failure for the homeowner and one must wonder about the efficacy of the inspection protocol undertaken to approve the installation at these houses.

**Table 16: Type of potable top-up system installed.**

| | No. | % |
|---|---|---|
| Trickle top-up | 51 | 23% |
| Automatic switch | 155 | 70% |
| None | 14 | 6% |
| **Total** | **220** | |

## 3.6. Condition of Tank System

Good condition of the tank system is essential in maintaining required water savings, although this is not a specific requirement of MP 4.2. A qualitative assessment of the general condition of tanks, gutters and pumps was included as part of the inspection. It was found that most tank system components were in good condition, with some issues related to the pump component (4% of tanks classed as being in a poor condition and 7% only satisfactory) (Table 17). The person undertaking the field audit reported that most operational problems were associated with the pump condition and operation, such as poor installation and pump leaks.

**Table 17: Qualitative assessment of condition of tank system components.**

| Condition | Tank | | Gutter | | Pump | |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % |
| Poor | 1 | 1% | 1 | 0% | 8 | 4% |
| Satisfactory | 5 | 3% | 13 | 6% | 15 | 7% |
| Good | 192 | 97% | 189 | 93% | 180 | 89% |
| **Total** | **198** | | **203** | | **203** | |

## 3.7. Site Occupancy

Household occupancy for sites investigated was collated to enable comparison with other studies (Table 18). Two-person households were most common (36%), followed by households with four people (26%). Gold Coast had the highest average occupancy rate of 3.38 people per site and Caboolture had the lowest occupancy rate of 2.74 people per site.

The occupancy rates found were comparable to those obtained in the earlier telephone survey with 1,134 respondents (Chong *et al.*, 2011) and the Desktop Analysis (Beal *et al.*, 2010) (Table 19).

**Table 18: Number of tenants occupying each site.**

| LGA | 1 Tenant | 2 Tenants | 3 Tenants | 4 Tenants | 5+ Tenants | Unknown | Total | Average |
|---|---|---|---|---|---|---|---|---|
| Caboolture | 3 | 31 | 7 | 14 | 4 | | 59 | 2.74 |
| Gold Coast | 4 | 11 | 8 | 14 | 8 | | 45 | 3.38 |
| Pine Rivers | 6 | 25 | 20 | 19 | 8 | | 78 | 3.02 |
| Redland | 3 | 14 | 7 | 12 | 3 | 2 | 41 | 2.94 |
| **Total** | **16** | **81** | **42** | **59** | **23** | **2** | **223** | **3.00** |

**Table 19: Comparison of average occupancy rates with those obtained in other studies.**

| LGA | Desktop Analysis (Beal *et al.*, 2010) | Benchmark Analysis (Chong *et al.*, 2011) | 200 Rainwater tank System Assessment (present study) |
|---|---|---|---|
| Caboolture | - | 3.20 | 2.74 |
| Gold Coast | 3.20 | 3.34 | 3.38 |
| Pine Rivers | 3.00 | 3.21 | 3.02 |
| Redland | 2.90 | 3.18 | 2.94 |

## 3.8. Other Alternative Supply Systems

No alternative water supply systems were identified at any of the sites. There was no evidence of any stormwater tank, greywater diversion, greywater treatment, reticulated recycled water, private dam, bore or any other system present.

## 3.9. Other Information Collected

Additional information not directly related to water savings targets and physical tank set-up, but collected to compare with other survey results outside of the purpose of the present study, is presented in Appendix 3. Information was collected on showers, shower flow rates, toilet flush volumes, star rating of washing machines and site characteristics which may influence the end use of rainwater tank water, for example swimming pools, spas and garden characteristics.

In addition, information was also collected on pump size, brand and type. These data were not analysed in any detail in this study.

# 4. CONCLUSION

This report has summarised the results of an audit of 223 Class 1 detached dwelling sites with mandated rainwater tanks. The rainwater tank systems were assessed in relation to the requirements of the QDC MP 4.2 to determine if there were installation factors that may adversely impact on achieving the mains water savings target of 70 kL/hh/yr for Class 1 detached dwellings.

The three main installation requirements of MP 4.2 for achieving the water savings target related to: rainwater tank storage capacity, connected roof catchment area, and connection to appliances.

The results of the on-site assessment have shown that:

- Installed storage capacity is mostly above the required 5,000 L, although 16% of sites inspected had storage volumes of below 5,000 L.
- Roof catchment area does not meet requirements in 40% of cases, either in terms of having 100 m² or 50% of total roof area (whichever is the lesser) connected to the tank.
- Connection to toilets, washing machine (cold water tap), and external tap(s) meets requirements in most cases.

Bearing in mind the relatively small sample size and the related margin of error in making comparisons among areas, there was no clear evidence to explain some of the "confounding" results obtained in earlier desktop studies that found lower than expected mains water savings for households with mandated rainwater tanks, especially in Caboolture, Pine Rivers and Redland. Caboolture and Redland did perform slightly worse than the other LGAs in terms of rainwater tank volume compliance but due to the small sample size, the differences among LGAs cannot be considered as statistically significant. In addition, the study found that claimed volume should be reduced by about 10% to account for the dead volume below the outlet level and by about 20% if pump cut-off factors are also included. In the absence of manufacturers' specified volumes, storage volumes can be calculated using external physical tank dimensions, but should first be reduced by about 12% to account for volume lost due to wall thickness and tank shapes which generally round off edges and are not perfectly square or round.

Neumann *et al.* (2011) found that, in SEQ, connected roof area is relatively more important that increases in tank volume in improving yield from household rainwater systems, and thus reducing potable water demand. Therefore the finding in this report that a significant number of households with mandated rainwater tanks are not complaint in terms of connected roof area requires consideration of policy interventions to improve the yield from mandated rainwater tanks. While there was little difference in the percentage of roof catchment area non-compliance for mandated rainwater systems, non-compliance was greatest in Gold Coast and Pine Rivers LGAs. Specifying a minimum connected roof area, rather than a minimum proportion of total roof area may provide a clear target for developers, but would also potentially limit the flexibility in applying rainwater systems to different types of dwellings and urban form.

MP 4.2 also includes requirements for water quality protection through prevention of contaminants and vermin from entering the rainwater tank, prevention of mosquito breeding, and prevention of contamination of reticulated town water supply. The results of the on-site inspection have shown that in general, except for prevention of contamination of reticulated town water supply through an additional backflow device, requirements are adequately met:

- screened downpipe rain-head installation largely meets requirements;
- first flush device installation meets requirements under the circumstances that rainwater is mostly not connected to showers, wash basins or hot water services;
- mosquito breeding prevention device installation meets requirements;
- vermin trap installation mostly meets requirements; but

- backflow prevention device installation does not meet requirements, with only 45% of rainwater tanks having an additional backflow device installed. Trickle top-up systems have a mandatory air gap and all switching valves (installed in most houses) should have a backflow prevention valve as part of its factory design and manufacture.

Other MP 4.2 requirements not directly relating to water savings or quality include MP 4.2 (P5) which requires a continuous supply of water to internal fixtures supplied from a rainwater tank through a trickle top-up or automatic switching device. The results indicated a high level of compliance in this regard. However, 14 homes (6%) had no device in place to ensure continuous supply to internal fixtures. This is a major installation and inspection error and one must wonder about the efficacy of the inspection protocol undertaken to approve the installation at these houses.

# APPENDIX 1: Letter to Homeowners

24 August 2011

Dear Rainwater Tank User

In the last 12 months, you took part either in a CSIRO phone or postal survey relating to rainwater tanks in which about 2,000 people in South East Queensland (SEQ) participated. You subsequently signed a consent form earlier this year, giving permission for the CSIRO's consultants to undertake a free rainwater tank inspection at your home.

We are contacting you now because we are ready to commence with the rainwater tank inspection at your home. CSIRO has engaged the consulting firm, BMT WBM Pty Ltd, to undertake the inspection at 200 homes in SEQ. Your home has been randomly selected for the inspection to take place sometime during August and September 2011. The consultant, Tom Paterson, will contact you in the next few weeks to arrange a suitable time to conduct the assessment at your home. **Please email a contact telephone number to Sharon.Biermann@qwc.qld.gov.au as soon as possible in order for us to set up the appointment.**

The consultant will only require access to the house and garden, without any further imposition on you, except for a few questions to confirm that your home was built after 1 January 2007 and the number of people who usually live in your home. Answering these questions will be entirely voluntary.

In this rainwater tank inspection, which is part of a larger SEQ Rainwater Tank Study, the consultant will carry out a standard checklist assessment of rainwater tanks at your home including the following aspects:

(1) characteristics of individual dwellings (eg, dwelling type, total roof area, property dimensions);
(2) choices made in water efficient appliances and fixtures (eg, showerheads, washing machine);
(3) information on the rainwater tank systems (eg, tank volume, roof area connected, pump size);
(4) internal connections for rainwater supply (eg, plumbing connections to/from the tank); and
(5) other water related features on the property (eg, swimming pool, spa).

The information obtained from this simple assessment will enable CSIRO researchers to understand whether there are any issues with the installation and functioning of rainwater tanks under Queensland Development Code MP4.2.

For you, the homeowner, this thorough assessment of your home and tank will be highly beneficial in identifying leaks in your rainwater tank system, checking plumbing connections and obtaining other valuable information on how well your rainwater tank is functioning. The consultant will ask if you would like to have a copy of the inspection report and if so, for the address to which this report should be posted. In addition, if there appears to be any major issue with the installation and operation of your rainwater tank, a project team member will contact you.

We would like to take this opportunity to thank you again for your involvement in this research. We will be happy to provide access to the final report once the results have been analysed and documented. Information from your assessment will be treated confidentially and no reference to individual rainwater tank assessments will be made in the final report.

Kind regards,

Dr Meng Chong
CSIRO Land and Water
meng.chong@csiro.au
07- 3833 5593

Dr Sharon Biermann
Urban Water Security Research Alliance
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# APPENDIX 2: Site Parameters and Assessment Methods

| Parameter | Method |
|---|---|
| **Characteristics of Individual Dwelling** | |
| Dwelling type | Visual inspection. The suggested dwelling types are: detached house; semi-detached house; townhouse; studio / granny flat; or other (described) |
| Total roof area | The total roof area determined using Nearmaps. |
| Number of bedrooms | Visual inspection of all of the rooms in the house |
| **Water Efficient Appliances and Fixtures** | |
| Number of showers and showerheads – check/calibrate the flow rate in<br>Litres per minute for each showerhead | The number of showers and shower heads determined through inspection of each of the bathrooms and asking the owner. Occasionally there are showers located in the garden.<br>The flow rate of each of the shower heads will be determined using a stopwatch and measuring jug. Each shower will have the time measured to fill the measuring jug to three litres. |
| Number of washing machines, which includes (for each washing machine);<br>– Type<br>– Brand<br>– Model<br>– Load size (kg) | Manufacturer's plate has the information required. |
| Are any of the washing machines connected to the rainwater tank? If yes,<br>is it connected to the cold tap? Specify other washing machine cold tap<br>configuration (if any) | Two effective methods of assessment. The first is turning on the washing machine and checking whether water is being pumped. The second is to turn off the rainwater supply while leaving the mains water supply on and check whether water flows into the washing machine. Some washing machines are plumbed with a separate rainwater cold tap. |
| Number of toilets – check /calibrate the flush volumes for half and full flushes | The method for determining the flush volumes of the toilet is to turn off the water leading into the cistern, noting the water level and then flushing the toilet. A measuring jug is then used to fill the cistern back up to the previous level and the water required to do this is noted. |
| Is/Are the toilet(s) connected to the rainwater tank? | The same method used as for testing the connection of the washing machine. Either the toilet will be flushed and the system examined for pumping, or the rainwater supply will be switched off and the toilet checked to see if water fills the cistern. |
| **Information on Rainwater Tanks** | |
| Number of rainwater tanks | Inspection and asking owner to check that no underground or hidden tanks have been missed. |
| For each tank, the followings should be recorded:<br>– Type of tank<br>– Shape | Visual inspection - Either underground, above ground or bladder style. |
| Tank dimension (height x length x width) | Measured in millimetres using a tape measure. Underground tanks could not be measured. |
| Tank diameter | Measured using a tape measure. |
| Tank volume (claimed) | If the tank has a volume written on it, this will be recorded. |
| Tank materials( e.g. Polyethylene, galvanised steel, stainless steel, concrete) | Determined by visual inspection. Unless convincing evidence can be given by the owner (such as a receipt) the material of underground tanks will not be able to be determined. |
| Actual tank volume in storage | This will be determined by noting the shape, measuring the height of the off-take, cut-off switch, overflow and total height of the tank. In instances where there is a trickle top-up the float level will not be able to be measured as it is in the tank and accessing it is a safety issue. However the measurements that are able to be obtained will give valuable information on the effective tank volume and any dead spaces in the tank. |

| Parameter | Method |
|---|---|
| Size of roof catchment area connected to the tank | If the system is uncharged, it is relatively clear which downpipes feed rainwater to the tank. Once this has been determined examination of the roof shows which area drains to the downpipe. Where a section of roof is drained by two downpipes, one draining to the tank and one not, the slope of the gutter will be used to determine which part of the roof drains to which downpipe and from there the tank. For charged systems the downpipes feeding the tanks were those full of water. After that the same method will be used as above. This information will be marked on a satellite image of the house and this information used in conjunction with Nearmaps to determine the area. |
| Rainwater pump brand and model number | It was first proposed that this be determined from the manufacturers plate on the pump but found that plates often in awkward position, damaged or lack required data. In these cases, pump parameters determined form manufacturers specifications. |
| Type of potable top-up system (description and model) | Written on the manufacturers plate on the pump |
| Minimum level setting in rainwater tank (in litres) | This will be either the cut-off switch or the off-take |
| Is there an automatic switching device providing supplementary water or a trickle top-up system from the reticulated town water supply? | The difference between trickle top up and automatic switching devices can be determined by a simple examination of the system |
| Is there any backflow prevention system? | Backflow prevention systems are located either immediately upstream side of the mains input into a switching device, or on the mains meter. They are quite distinctive fittings. |
| Is there any screened downpipe rainhead, having screen mesh 4-6 mm and designed to prevent leaves from entering each downpipe? | Rainheads are easy to identify visually. A measuring tape used to measure the screen mesh. |
| Is there any first flush device. If yes, what is the volume capacity of the device? | First flush devices are easily recognisable visually. Volume of first flush devices can be estimated either by measuring the length and diameter of the structure and calculating the volume or by taking a photo, writing down the product name and comparing with manufacturers specifications. |
| Is there a mosquito-proof screen of brass, copper, aluminium or stainless steel gauze not coarser than 1 mm aperture mesh or flap valves at every opening of the rainwater tank? | This can be assessed through visual inspection. |
| Is there a vermin trap, wet system used to harvest rainwater, mosquito proofing in accordance with HB230? | Visual assessment |
| Is the rainwater tanks openings are constructed to prevent ingress of surface stormwater and groundwater? | This can only be assessed to a limited degree as some of the openings will be below surface level. However, where possible, all water entry points into the tank will be assessed to ensure there is no potential contamination from groundwater or surface water. This may include assessment of invert levels, quality of fittings and quality of lid design and construction. |
| If multiple tanks exist, are they connected to each other? | Assessed by visual inspection of connections, usually at the base of tanks |
| Number of external taps connected to each rainwater tank | Assessed by turning on the tap and assessing the pump for flow. |
| Is the rainwater tank connected to the hot water system? | This is done by turning off the rainwater tank system and trying to operate a hot water tap. |
| Is the rainwater used for drinking water and other household supply? | The same process as for assessment of connection to the hot water supply, turning off the rainwater system and attempting to use the kitchen tap, laundry tap, bathroom tap, etc. |
| Is the overflow connected to stormwater tank? If yes, is there a physical air break or non-return valve on the outlet from the rainwater tank overflow before connecting to the stormwater drainage system? | From experience in the past this has been almost impossible to determine without either digging up the pipes or running enough water through the rainwater overflow to discharge from the stormwater tank. |
| **Condition of Tanks, Gutters and Pumps** | |
| What is the rainwater tank condition (good, satisfactory or poor) | Visual inspection including:<br>- Leaks from the tank<br>- Rust<br>- Corrosion<br>- Quality of foundation |
| Rainwater tank installation year | Assessed by questioning the owner. There is rarely an installation date placed on the tank. |

| Parameter | Method |
| --- | --- |
| Condition of the gutters (good, satisfactory, poor) | Gutters will be assessed with respect to the quality of joins, sufficient fall to tank, and amount of sediment. Sediment and litter will be assessed using a mirror on the end of a pole. |
| Condition of the pump (good, satisfactory, poor) | The pump will be assessed for:<br>– Whether the pump is working<br>– Presence of rust<br>– Previous downtime<br>– Leaking of pipes<br>– Improper running. |
| **Information on other Alternative Supply Systems** | |
| Is there any other alternative supply system, such as:<br>– Stormwater tank<br>– Greywater diversion<br>– Greywater treatment<br>– Reticulated recycled water<br>– Private dam<br>– Bore<br>– Other, please specify | These will all be assessed by visual inspection of the property and asking the owner. |
| For greywater treatment system, if present, is it installed to receive greywater from all bathrooms? | Assessed by running water through the showers in each of the bathrooms and checking the system to see if it receives the water. |
| What is the minimum processing capacity for the system? Is it possible to sustain volume for 24 hours? | Check whether the system has a storage tank (or is connected directly to theirrigation system) and measure the size of the tank where relevant. The treatment capacity will be determined from manufacturers specifications. |
| Has a storage capacity not exceeding 2,000 L? | Checking the storage tank and if there are no manufacturer's specifications, measuring the dimensions and outlet positions to determine volume. The same procedure that was used to determine the volume of the rainwater tank will be used for the greywater storage tank. |
| Is the greywater system connected to all toilets, washing machine cold water taps, external use or other fixtures (please specify)? | This will be assessed by turning off the mains water and the rainwater system (if present) and seeing which fixtures have water flow. |
| What is the proportion of the untreated greywater to the sewer? | If this is measured by the system it will be noted. |
| **Other Water-Related Features** | |
| Is there any swimming pool at the dwelling? | Visual inspection |
| If yes, what is the:<br>– Pool area (m2)<br>– Depth (m) – deep and shallow ends<br>– Pool volume<br>– Heating system, if any<br>– Pool cover | Measured using a tape measure<br>Calculated using area and depth measurements<br>Visual inspection |
| Is there any spa installed at thee dwelling? | Visual inspection |
| If yes, what is the:<br>– Spa volume, if any<br>– Spa heating system<br>– Spa cover? | Measure area an depth<br>Visual check |
| **Additional Voluntary Information (if household representative is happy to provide)** | |
| How many people live on this property? | Assessed by asking owner |

# APPENDIX 3: Other Information Collected

## Water Efficient Appliances

Not directly related to water savings targets and physical tank set-up but collected to compare with other survey results outside of the purpose of the present study, information regarding shower flow rates, toilet flush volumes and star rating of washing machines was collected as part of the site inspection. 78% of sites inspected had two showers present (Table 20), with most showers having a flow rate of between 7 and 9 litres per second (l/s) (Table 21).

**Table 20: Number of showers in the home.**

| | 1 Shower | 2 Showers | 3 Showers | 4+ Showers | Total |
|---|---|---|---|---|---|
| No. Homes | 4 | 158 | 36 | 5 | 203 |

**Table 21: Number of homes per average shower flow rate category (litres/second).**

| Flow rate | 3-4.9 l/s | 5-5.9 l/s | 6-6.9 l/s | 7-7.9 l/s | 8-8.9 l/s | 9-9.9 l/s | 10-10.9 l/s | 11+ l/s |
|---|---|---|---|---|---|---|---|---|
| No. homes | 19 | 33 | 45 | 140 | 130 | 54 | 26 | 31 |

Full flush volume for 63% of toilets is six litres and is 4.5 litres for 35% of toilets (Table 22). Half flush volume of all toilets inspected is 3 l.

**Table 22: Toilet full flush volume (litres).**

| Volume (litres) | 4.5 | 5-5.9 | 6 | >6 | Total |
|---|---|---|---|---|---|
| No. Toilets | 206 | 6 | 374 | 9 | 595 |
| % | 35% | 1% | 63% | 2% | |

Most washing machines (53%) for which star rating could be determined had a rating of 7 stars, with 31% having a rating of 8 or higher (Table 23).

**Table 23: Star rating of washing machines.**

| Star Rating | 2-6 star | 7 star | 8 star | >8 | Total |
|---|---|---|---|---|---|
| No. Washing Machines | 12 | 41 | 21 | 3 | 77 |
| % | 16% | 53% | 27% | 4% | |

## Other Water Features

Information regarding site characteristics which may influence the end use of rainwater tank water was collected but not analysed in any detail. Swimming pools were present at 24% of sites and 9% of sites had spa baths (Table 24). With the exception of a single site or two, rainwater tank water is used to fill all swimming pools and spas. Gold Coast has the highest percentage of pools at 46% of sites while the other LGAs had around 18% of sites with pools.

**Table 24: Presence of swimming pools and spas.**

| LGA | Pool | No Pool | Rainwater to Fill Pool | Spa | Rainwater to Fill Spa |
|---|---|---|---|---|---|
| Caboolture | 10 | 46 | 10 | 3 | 3 |
| Gold Coast | 19 | 22 | 19 | 1 | 1 |
| Pine Rivers | 13 | 56 | 13 | 2 | 0 |
| Redland | 7 | 30 | 6 | 1 | 0 |
| **Total** | **49** | **154** | **48** | **7** | **4** |

Gold Coast also had the largest average garden area at 521 $m^2$ with the smallest garden area occurring in Pine Rivers at 227 $m^2$ (Table 25). The most dominant garden type observed was lawn with Caboolture having the greatest number of sites with gardens comprising other than lawn i.e. drought resistant/native plant cover and mixed plant cover (Table 25). Caboolture also exhibits higher levels of maintenance than the other LGAs which could indicate greater use of rainwater tank water for garden watering (Table 25).

**Table 25: Garden characteristics.**

| LGA | Av Size ($m^2$) | Garden Type (no. homes) | | | Maintenance Level (no. homes) | | | Foliage Density |
|---|---|---|---|---|---|---|---|---|
| | | Drought Resistant/Native | Mixed | Lawn | Low | Med | High | |
| Caboolture | 305 | 21 | 34 | 55 | 15 | 66 | 29 | Mod-dense |
| Gold Coast | 521 | 1 | 7 | 33 | 4 | 25 | 12 | Dense |
| Pine Rivers | 227 | 4 | 9 | 55 | 9 | 41 | 19 | Dense |
| Redland | 378 | 4 | 3 | 30 | 2 | 21 | 14 | Dense |

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