A White Paper

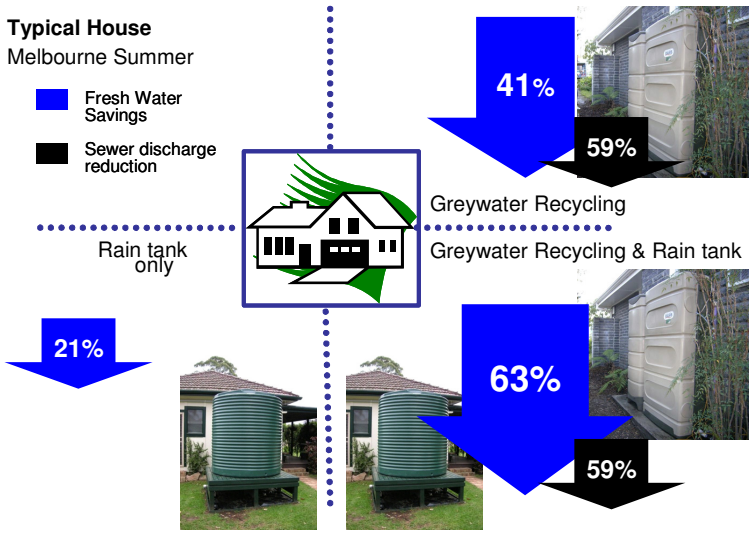
Greywater Treatment & Recycling Water Savings exceed Rain Water Harvesting Efforts

Summary:

Australia, like many other countries, is facing drinking water shortages resulting in increasingly harsh and enduring water restrictions that result in a loss of amenity for consumers. Consumer and government initiatives that address this issue include harvesting and recycling. Initiatives include regulations and financial incentives.

But how does harvesting compare to recycling? Which strategy provides maximum benefit in terms of water savings and consumer amenity? This white paper demonstrates that Greywater recycling systems produce significantly greater water savings. The benefits to the individual consumer are meaningful and reduce the burden on state infrastructure providers. The paper also shows that authorities should improve regulations and incentive rebates to encourage consumer use of superior greywater treatment systems.

A greywater recycling system typically saves around 40% of total household demand for drinking water, and reduces discharge to sewer by more than 50%, based on normal usage patterns. The % savings increase dramatically when outdoor water usage is reduced through severe water restrictions. An optimally sized water tank of 5,000 L saves around 20% of drinking water but does not reduce sewer discharge. Most importantly, recycled water is available every day, winter and summer, rain or drought, without restriction, to enable homeowners to maintain their garden and lifestyle. The value of a house increases by around 8% with green planting. (Rosiers, et al 2001, Morales, et al 1976, Seila and Anderson 1982). Yet rain tanks are preferred and encouraged in many jurisdictions for new homes and renovations



This paper comprehensively analyses recycling and harvesting and their individual and combined impact on drinking water demand, and on water and sewerage bills for a variety of Australian locations and seasons. Nubian encourages debate on these important findings and believes that sustainable water policy initiatives should prioritise support for onsite recycling which maximises water savings, and generates water for garden and internal use everyday.

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1. Analytical Approach for Water Conservation

To undertake the analysis the first priority was establishing water consumption for typical households in different cities at different times of the year. It was essential to analyse data on at least a monthly basis as both demand for garden watering, and average rainfall, varies by season, and location.

The next step was to establish maximum available resources that were available for recycling (using a Domestic Greywater Treatment System - DGTS) or harvesting (Rain Water Harvesting Tank – RWHT), together with efficiency of each approach (as there are some losses with each system). A water balance was established for each scenario, and then combined for an analysis of the impact of both recycling and harvesting. Practical limits were established for each scenario, for example despite how much water is available from recycling and rain, it is either illegal or not practical to save the entire drinking water demand. (Where consumers have eliminated demand for drinking water in urban areas they have either employed water purification technology not explored in this paper, or accepted certain risks).

Following are the key assumptions made for this analysis:

1. The household is a single dwelling domestic house.
2. Number of occupants per household is 4. (The average household size in Australia is 2.6[1] however this includes high and medium density)
3. Indoor usage of water remains constant throughout the year
4. Water from bath, shower, basins and laundry is considered as greywater.
5. The recovery of water after treatment through a DGTS is 93%.
6. Average roof area of household is 150 m^2.
7. The capacity of the rainwater tank is 5,000 litres.
8. Efficiency of the rainwater system varies from 60-95% depending on location.
9. Rainwater is not used for drinking.
10. The calculated savings on the annual water bill do not include the capital costs and ongoing maintenance costs of the DGTS or RWHT.

The statistics for water consumption and rainwater are provided in the appendix.

To compare seasonal effects of recycling and harvesting in the Water Balance, Nubian has combined data from:
Coombes, P. and Kuczera,G.,2003, "Analysis of the Performance of Rainwater Tanks in Australian Capital Cities", School of Engineering, University of Newcastle
Young, R., "National Trends in Urban Water Resource Management", 2005, Water Services Association of Australia
"Water Account" 4610.0, 2001, Australian Bureau of Statistics
To avoid inconsistency when combining data, the prime evidence data was used, and "pro-rata" calculations used to re-calibrate secondary data. For this reason there may be some small differences in data references.

[1] Australian Social Trends,2007,Australian Bureau of Statistics

2. Sources of Greywater and Rainwater

- Greywater is defined as the waste water from washing machines, hand basins, spas, showers and baths[2]. These sources of greywater are commonly found in all households. The generation of greywater is independent of season and circumstances. According to the wide range of resources referred in this paper, the quantity of greywater produced in different Australian cities is approximately 90 to 120 litres per capita per day depending on individual circumstances.
- Rainwater is a valuable resource that can be collected for household use. However, rainfall is quite uncertain and varies from place to place and season to season.

3. Composition of Greywater and Rainwater

- Greywater contains what is washed down the drain, and so varies from house to house. It includes pathogens from humans, soaps, shampoo, toothpaste, shaving cream, food particles, laundry detergents, hair and lint.
- Domestic greywater is the major contributor of Total Suspended Solids (TSS) and Biological Oxygen Demand (BOD) in municipal sewage[3].
- The discharged water stream from washing machines consists of sodium, phosphate and Chemical Oxygen Demand (COD)[4].
- Bacteria, odour, oil and grease, organic matter, turbidity, and high pH occur normally in greywater streams[5].

Composition of Rainwater

- Rainwater compositions vary significantly from place to place in Australia because the regional geology can greatly affect the types of particulates in the atmosphere i.e. In open ocean and coastal areas they have a salt content essentially like that of sea water with the same ionic proportions but much more dilute[6].
- The image of falling rain is that it is pure and refreshing but that is not true all the time. Rainwater in certain urban areas may contain various impurities absorbed from the atmosphere, including arsenic and lead[7].
- Therefore rainwater collected in rainwater tanks should preferably be treated before use. However, the extent of pre-treatment depends on the usage.

[2] Greywater,2006, Sustainable sources, http://www.greenbuilder.com/sourcebook/Greywater.html
[3] Friedler, E.2004,"Quality of Individual Domestic Grey Water Streams", Faculty of Civil and Environmental Engineering, Israel
[4] Greywater Re-Use, by Glenn Marshall, http://www.rosneath.com.au/ipc6/ch08/marshall/
[5] Greywater Re-Use, by Glenn Marshall, http://www.rosneath.com.au/ipc6/ch08/marshall/
[6] Smith, R. 2003, "Rainwater Quality", Water conservation techniques, Western Australia
[7] Smith, R. 2003, "Rainwater Quality", Water conservation techniques, Western Australia

4. Analysis of Greywater Availability and Reuse

4a. Estimated water consumption in Australian households:

The rate of water usage depends on several factors such as:

- Type of household e.g. person living alone, married couple, or groups of three, four or more.
- Type of dwelling[8] e.g. house, semi or town house, low rise units, units having four or more stories.
- Type of tenure[9] e.g. owned, paying off, rent privately, rent publicly, etc.
- Area of usual residence.

While in urban areas all mains water is treated to drinking water standards, as little as 1% of domestic water consumption is actually used for drinking[10]. Toilet flushing, laundry, kitchen and outdoor uses represent the bulk of domestic water consumption.

Below is the approximate total water (indoor and outdoor) consumption in different cities of Australia.

Total approximate water consumption / capita / day[11]:

Sydney : 225 Litre (L)
Melbourne : 220 L
Brisbane : 329 L
Adelaide : 274 L

Water consumption in Household by location of use[12]:

Location	**Sydney** **%**	**Melbourne** **%**	**Brisbane** **%**	**Adelaide** **%**
Bathroom	26	26	19	15
Laundry	16	15	10	13
Kitchen	10	5	9	9
Toilet	23	19	12	13
Outdoor	25	35	50	50
Total	**100**	**100**	**100**	**100**

The difference in usage of water in different cities depends on individual circumstances such as climate conditions, age group, type of water consumption devices, internal plumbing materials, daily lifestyles, etc.

[8] Troy, P. Holloway, D. and Randolph, B.,2005,"Water Use and Built Environment: Patterns of Water Consumption in Sydney", Faculty of the Built Environment, University of NSW
[9] Troy, P. Holloway, D. and Randolph, B.,2005,"Water Use and Built Environment: Patterns of Water Consumption in Sydney", Faculty of the Built Environment, University of NSW
[10] "Rainwater Tank", 2004, WaterSmart Practice Note No. 4. by Water Sensitive Urban Design in Sydney Region Project
[11] Young, R.,"National Trends in Urban Water Resource Management", 2005, Water Services Association of Australia
[12] "Water Account" 4610.0,2001,Australian Bureau of Statistics

4b. Volume of greywater produced in major cities of Australia:

The calculation for the average water consumption per household is based on four occupants in each household. Therefore average total water consumption is as follows[13]:

Sydney : 328 kL/household/year = 900 L/ household /day
Melbourne : 320 kL/household/year = 880 L/ household /day
Melbourne : 480 kL/household/year = 1316 L/ household /day
Adelaide : 400 kL/household/year = 1096 L/ household /day

Based on the above mentioned water consumption in the average household, the following table shows the volume of greywater produced in each household in different cities of Australia.

Average volume of greywater produced in Litres (L)/household/day:

Component of greywater	Sydney	Melbourne	Brisbane	Adelaide
Bathroom	234	229	250	164
Laundry	144	132	132	142
Total	**378**	**361**	**382**	**306**

4c. Drinking water savings:

- If the greywater generated in each household is recycled and reused for irrigation, toilet flushing and clothes washing, drinking water demand can be reduced significantly.
- The use of treated greywater can help develop a greener Australia as it provides essential nutrients for maintaining gardens. There is no difference from the hygiene point of view between clothes washed with treated greywater or with drinking water[14].
- The calculation of the recovery of water from greywater after recycling is based on the OASIS GT600 developed by Nubian Water Systems Pty Ltd.
- The recovery of water depends on several factors[15].
    1. Water losses during the recycling process.
    2. Inlet greywater compositions which vary from place to place. i.e. more contaminated water will need more frequent backwashing.
- Based on the actual results from the accreditation trial and results obtained by independent investigators from installed systems the recovery of water after treatment is approximately 93%. By considering the rate of recovery of water as above, the total savings on drinking water demand **per household** in different cities of Australia are shown below.

[13] Young, R.,"National Trends in Urban Water Resource Management", 2005, Water Services Association of Australia

[14] Department of Infrastructure, Planning and Natural Resiurces, 2004,"Greywater Reuse Systems", Preparation of Guidelines and Approval/ Certification of Process Documentation.
[15] Actual results from accreditation trial by Nubian Water Systems Ltd.

City	Water consumption in L/day	Greywater produced in L/day	Approx. water recovery after treatment in L/day	**Approx. drinking water savings in kL/year**
Sydney	900	378	352	128
Melbourne	880	361	336	123
Brisbane	1316	382	355	130
Adelaide	1096	306	285	104

- The above calculations show that the use of recycled greywater reduces total drinking water demand by approximately 35-40%.

5. Analysis of Rainwater Availability and Reuse

5a. Average rainfall (mm) in major cities of Australia during last six years:

Tables (in appendix 6a) represent the average rainfall measured at different locations in each month of the last six years in different cities of Australia.[16]

Based on this, the annual mean rainfall in last six years is:
Sydney : 1037 mm
Melbourne : 524 mm
Brisbane : 850 mm
Adelaide : 534 mm

5b. Rainwater available for harvesting based on roof area and annual rainfall:

- The maximum volume of rainwater that can be harvested can be calculated using the formula[17]:

  Run off (litres) = A x (rainfall – B) x roof area

  'A' is the efficiency or "retention factor" of collection and values of 0.6–0.95 (that is, 60–95% efficiency) have been used.
  'B' is the loss associated with absorption and wetting of surfaces and a value of 2 mm per month (24 mm per year) has been used.

  'Rainfall' should be expressed in mm and 'roof area' in m^2.

- Local "retention" factors were calculated by reference to Appendix 6c and drinking water savings achieved with a 5,000 tank with a 4 person household compared to available rainfall
- Based on the above formula and the average annual rainfall data, the average volumes in kilolitres (kL) of rainwater available for harvesting by households in different cities are as follows:

[16] Climate statistics for Australian locations, 2007, Australian Bureau of Meteorology
[17] enHealth council, 2004, "Guidance on use of rainwater tanks", Australian Government

City	Average Annual Rainfall (mm)	Roof area (m^2) 50	100	150	200	250	Retention Factor
Sydney	1037	40	81	122	162	203	60%
Melbourne	524	20	40	60	80	100	89%
Brisbane	850	33	66	99	132	165	95%
Adelaide	534	20	41	61	82	102	70%

5c. Rainwater harvested based on roof area, tank size and usage:

- A rainwater harvesting tank which is used to supply water for multiple uses will save more water than a tank used to supply water for a single use only. For example, if tank water is used for the garden only, very little water will be used in the colder months, so the tank is likely to fill and overflow. Year-round toilet flushing or laundering reduces the likelihood of overflow losses and increases the volume of water harvested.
- The charts (in appendix 8b) show the average volume of water in kL available for use each year from rainwater tanks[18]. This will vary from year to year depending on rainfall and individual households' rainwater usage. The charts are based on the assumption that there is an enough rainfall to fill the tank, and the following average water consumption per household.

Water Use	% of Total Use
Garden watering & other outdoor use	43 %
Toilet flushing	18 %
Laundry	13 %
Other internal uses (Kitchen, shower, bath, etc.)	26 %
Total	**100** %

The charts (in appendix 6b) show that,

- The larger the roof area connected to the rainwater tank, the greater the amount of rainwater that can be collected, particularly for larger tanks.
- The more uses of water made from tank water, the greater the quantity of water saved overtime.
- Increasing the tank size to more than 1000 litres for 50 sq m of roof gives little additional savings.
- For roof areas of 100 to 200 sq m, installing a tank of greater than 5,000 litres has limited benefits. For example, a tank of 5,000 litres for 200 sq m provides 100 kL per year. Doubling the tank size only increases this to 110 kL per year.

[18] Guideline for residential properties in Canberra, 2005, "Rainwater tanks", ACT Government

5d. Drinking water savings based on roof area and tank size:

- This study evaluates drinking water savings in major cities of Australia based on the roof size of dwellings and the size of the rainwater tank.
- Drinking water savings that result from the use of rainwater tanks used to supply domestic hot water, toilet, laundry and outdoor uses in Western Sydney, Melbourne, Brisbane and Adelaide are shown in appendix 6c [19].

Sydney:

- Rainwater tanks connected to roofs with areas of 100 m^2, 150 m^2, and 200 m^2 produced average annual drinking water savings of 25 kL to 56 kL, 32 kL to 87 kL and 37 kL to 114 kL respectively.
- Drinking water savings ranged from 6% to 33% of total household water use for a dwelling with roof area 100 m^2 to savings of 10% to 58% for a dwelling with a 200 m^2roof.
- Drinking water savings provided by rainwater tanks increase with larger roof areas. Moreover tanks with volumes in the range 1kL to 5kL produce the majority of drinking water savings.

Melbourne:

- Rainwater tanks connected to roofs with areas of 100 m^2, 150 m^2 and 200 m^2 produced average annual drinking water savings of 20 kL to 30 kL, 29 kL to 55 kL and 35 kL to 81 kL respectively.
- Drinking water savings range from 7% to 27% of total household water use for a dwelling with roof area 100 m^2 to savings of 13% to 67% for a dwelling with a 200 m^2 roof.
- Rainwater tanks with volumes of 1 kL provide significant drinking water savings. A 5kL rainwater tank appears to be the optimum size for providing drinking water savings.
- For households with roof areas of 150 m^2 and 200 m^2 drinking water savings increase with the number of occupants although the increase in yield from the tank decreases with increasing tank size and greater numbers of occupants.

Brisbane:

- Rainwater tanks connected to roofs with areas of 100 m^2, 150 m^2, and 200 m^2 produced average annual mains water savings of 31 kL to 85 kL, 37 kL to 119 kL and 40 kL to 144 kL respectively.
- Substantial drinking water savings of 12% to 74% were produced by the use of rainwater tanks.

Adelaide:

- Rainwater tanks connected to roofs with areas of 100 m^2, 150 m^2, and 200 m^2produced average annual mains water savings of 17 kL to 25 kL, 25 kL to 45 kL and 31 kL to 67 kL respectively.
- Drinking water savings provided by the rainwater tanks are shown to increase with larger roof areas. Significantly, small rainwater tanks with volumes of 1 kL to 5 kL produce the majority of mains water savings.

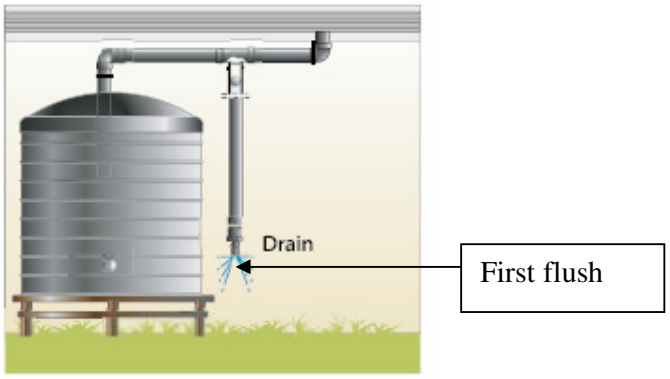
[19] Coombes, P. and Kuczera,G.,2003, "Analysis of the Performance of Rainwater Tanks in Australian Capital Cities", School of Engineering, University of Newcastle

The results show that greater drinking water savings can be achieved with more occupants per household. The impact of this phenomenon on drinking water savings is limited by the availability of rainfall. Dwellings with 5 occupants do not show significantly greater drinking water savings than dwellings with 3 and 4 occupants because the supply from the rainwater tank is limited by rainfall depth, tank volume and roof areas.

5e. Pre-treatment/ Precautions before using rainwater:

- If harvested rainwater is intended to use internally, to prevent the risk of potential contaminants adversely affecting the rainwater quality and human health, the water from rainwater should be treated before use.
- A range of treatments are available and the appropriate choice is dependent on the user and the intended use of rainwater. For example, a rainwater treatment system for supply to laundry, toilet, hot water and outdoor uses could involve a leaf diverter, a first flush device, a rainwater tank and a pump. However, a rainwater treatment system supplying all household water demands might also include a first flush device to remove sediments, with an inline filter and UV disinfection on the drinking water supply line. Note that the NSW Department of Health does not prohibit the use of rainwater for any household purpose, but recommends that an adequately treated reticulated water supply should be used for drinking purposes where available[20].
- To improve rainwater quality, a minimum 20 litres per 100 m^2 of the first flush of roof catchment should be diverted/discarded before entering the rainwater tank. Individual site analysis is required in heavy pollutant areas to determine if larger volumes of first flush rainwater should be diverted[21]. Therefore First flush devices, or acceptable alternatives, must be designed and installed with an automated diversion and drainage system.

Schematic diagram of fabricated first flush[22]



[20] "Rainwater Tank", 2004, WaterSmart Practice Note No. 4. by Water Sensitive Urban Design in Sydney Region Project
[21] Planning scheme policy 20,2007,"Rainwater tanks", Gold coast city council
[22] Guideline for residential properties in Canberra, 2005, "Rainwater tanks", ACT Government

6. CONCLUSIONS on Savings Comparison, Regulations and Rebate Incentives

6a. Water Savings Data Comparison

Appendices 7a to 7e reflect calculations using rainfall data, greywater generation and extraction, and anticipated reuse. The information clearly shows consistently higher water savings from greywater treatment systems regardless of season.

In Summary, savings by major state cities are as follows:

	Greywater Treatment System kL/year	Rainwater Tank kL/year
Sydney	121	92
Melbourne	141	68
Brisbane	191	119
Adelaide	132	54

The savings reflect advantages averaged over six years in a 4 person household. The recent drier years would have reflected greater savings using greywater treatment systems.

6b Building regulations as focus for Consumers

Regulations in various states are designed to encourage and force consumers and building companies to identify savings in water and energy consumption. There are minimum requirement for new houses and major renovations that must be met before approvals will be granted. These regulations are variously BASIX in NSW, the 5 Star Code in Victoria, and the QLD Building Codes.

Rainwater tanks have become a frequent inclusion in new houses to meet the water savings requirements. NSW, Vic and QLD accept that greywater treatment systems in single residential use can meet these requirements with varying approvals for consumer application use. The regulations however do not explicitly state this equivalence which may account for uncertainty in choice by consumers and in approvals by some councils of greywater systems. Nubian would recommend more explicit clarity in regulations confirming greywater systems are acceptable alternatives to rainwater tanks to meet water savings targets.

6c Rebate Incentives and Recommendation

Governments and councils offer varying rebates to consumers to purchase and connect rainwater tanks and greywater systems. The rebates are viewed by consumers as an important guideline to state preferred strategy in reducing consumption of drinking water. The rebates paid annually by some states exceed $100m.

Rebates may be varied based on the applications chosen by consumers. The highest rebates are paid where consumers connect back to internal reuse in laundry and toilets, rather than just for irrigation use. Consumer choice is regulated by plumbing codes and health accreditation set at state level.

In all cases, the rebates for rainwater tanks exceed those offered for greywater treatment systems. In some states, rebates for greywater treatment systems are the same as for greywater diversion systems that have little or no filtering of harmful

particles, pathogens, chemicals and viral content. No state allows greywater that has not been treated to levels approved by health departments or EPAs for internal reuse or above ground irrigation. QLD in January 2008 joins NSW, ACT and Vic in allowing recycled water from accredited greywater treatment systems to be used for laundry and toilets.

State	Greywater Treatment System $ rebate	Rainwater Tank $ Rebate for irrigation only	Rainwater Tank $ Rebate Plumbed for Internal Reuse
NSW	Nil	$150-500 varies based on size	Additional $500
QLD	$200 - $500	$1000	$1000
Vic	$550	$150 varies on size	$1000 varies on size
SA	Nil	$400	$400

There is therefore a strong case for improving rebates on greywater treatment systems accredited for above ground irrigation and internal plumbing reuse to be at least the same level as for rainwater tanks. On a volume savings basis, the rebate should be higher.

The improvement in rebates and specific clarification on equivalence in meeting building code targets for water saving, will be a meaningful indicator to consumers and building companies of the accepted opportunity for saving water using greywater treatment systems. It will also encourage councils to support applications for accredited systems.

7. Appendices:

7a. Average rainfall (mm) in major cities of Australia during last six years:

Following tables represent the average rainfall measured at different locations in each month of last six years in different cities of Australia[23].

Sydney: (Location: Sydney Observatory Hill)

	2001	2002	2003	2004	2005	2006
January	186.4	98.4	13.6	50.8	67.8	121.4
February	109.0	348.2	59.4	129.4	125.0	51.2
March	110.2	45.4	132.0	100.8	153.6	40.2
April	162.2	68.4	192.2	33.2	33.4	9.8
May	371.4	92.8	348.6	8.0	48.4	40.4
June	22.0	28.4	76.4	39.0	79.0	176.8
July	128.0	24.2	58.2	43.8	62.8	140.2
August	72.8	19.8	43.0	153.4	1.6	86.0
September	27.6	21.8	5.8	60.2	51.2	192.0
October	30.6	5.8	102.8	234.0	43.0	17.2
November	98.4	31.8	108.8	66.8	125.0	44.6
December	40.2	75.0	59.6	75.8	25.2	74.2
Annual	**1358.8**	**860.0**	**1200.4**	**995.2**	**816.0**	**994.0**

Aannual mean rainfall in last six years in Sydney is: 1037 mm

Melbourne: (Location: Melbourne Regional Office)

	2001	2002	2003	2004	2005	2006
January	11.8	38.2	10.6	63.2	23.8	54.2
February	11.6	68.0	20.0	13.0	167.4	72.4
March	86.6	21.0	22.6	14.8	8.6	16.0
April	125.6	39.4	73.2	51.8	30.6	45.0
May	14.6	36.8	23.6	29.2	10.6	67.0
June	59.8	27.2	35.2	38.2	42.6	8.8
July	12.4	19.6	68.0	27.6	25.2	51.6
August	49.0	35.6	49.4	72.2	59.4	34.4
September	39.4	39.2	29.2	65.0	41.0	36.6
October	70.2	34.2	70.8	64.8	41.6	9.2
November	74.8	25.4	19.2	123.4	57.6	24.8
December	49.4	12.0	71.2	59.0	81.6	18.4
Annual	**605.2**	**396.6**	**493.0**	**622.2**	**590.0**	**438.4**

Annual mean rainfall in last six years in Melbourne is: 524 mm

[23] Climate statistics for Australian locations,2007,Australian Bureau of Meteorology, http://www.bom.gov.au

Brisbane: (Location: Brisbane Aero)

	2001	2002	2003	2004	2005	2006
January	47.2	60.8	9.4	284.8	71.0	168.4
February	173.6	46.2	211.4	120.8	33.8	49.8
March	154.4	57.8	102.6	144.8	19.8	76.0
April	33.6	49.2	51.2	47.4	83.8	15.0
May	37.0	64.2	127.6	12.6	53.6	9.4
June	17.2	67.8	80.6	5.6	166.2	60.8
July	28.8	1.0	40.4	4.0	15.2	28.4
August	12.0	101.0	25.6	11.2	26.0	25.6
September	12.6	21.6	5.8	33.4	22.0	38.4
October	92.8	40.4	65.8	41.6	133.4	9.0
November	212.6	38.4	46.4	121.4	125.2	56.2
December	77.6	177.4	140.4	253.4	121.8	75.2
Annual	**899.4**	**725.8**	**907.2**	**1081.0**	**871.8**	**612.2**

Annual mean rainfall in last six years in Brisbane is: 850 mm

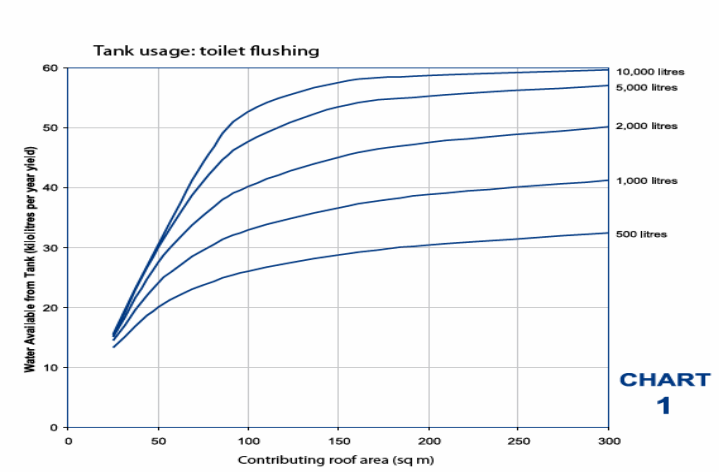
Adelaide: (Location: Adelaide Kent Town)

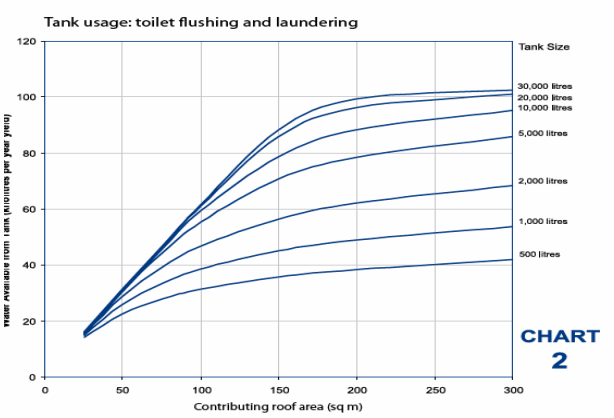
	2001	2002	2003	2004	2005	2006
January	19.6	20.6	23.2	9.8	37.0	22.4
February	10.4	0.0	63.0	5.2	10.4	15.6
March	49.0	12.2	10.2	24.2	11.6	20.2
April	20.0	10.8	28.0	18.8	3.2	52.4
May	87.4	62.8	69.6	62.8	8.2	48.8
June	105.0	60.0	124.2	125.0	142.0	12.4
July	61.4	83.6	39.2	75.0	42.8	36.0
August	87.8	26.6	93.8	94.0	90.8	11.4
September	137.2	39.4	47.0	58.0	59.2	32.6
October	80.6	22.4	64.8	10.6	88.4	1.0
November	43.6	31.0	12.0	64.8	79.6	18.0
December	14.2	9.0	34.2	32.0	56.4	16.8
Annual	**716.2**	**378.4**	**609.2**	**580.2**	**629.6**	**287.6**

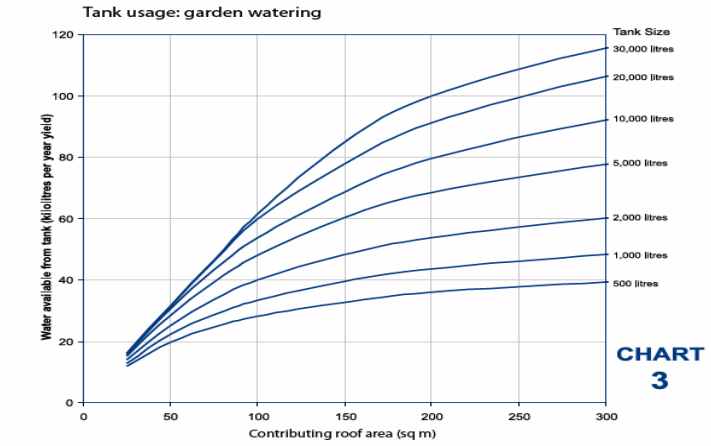
Annual mean rainfall in last six years in Adelaide is: 534 mm

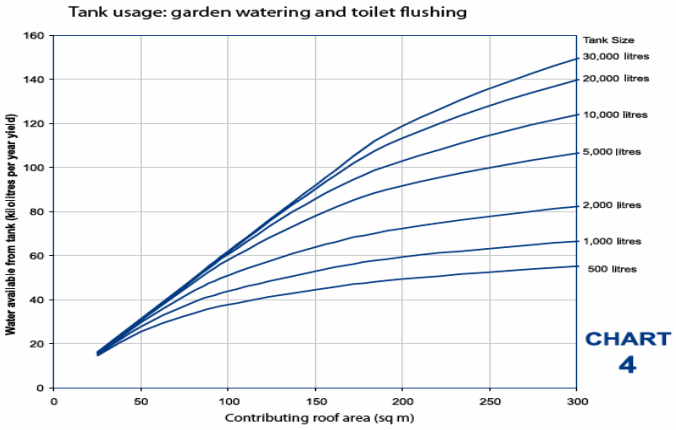
7b. What Size Rain Tank - Volume of water available for use each year from a Rainwater tank[24]:

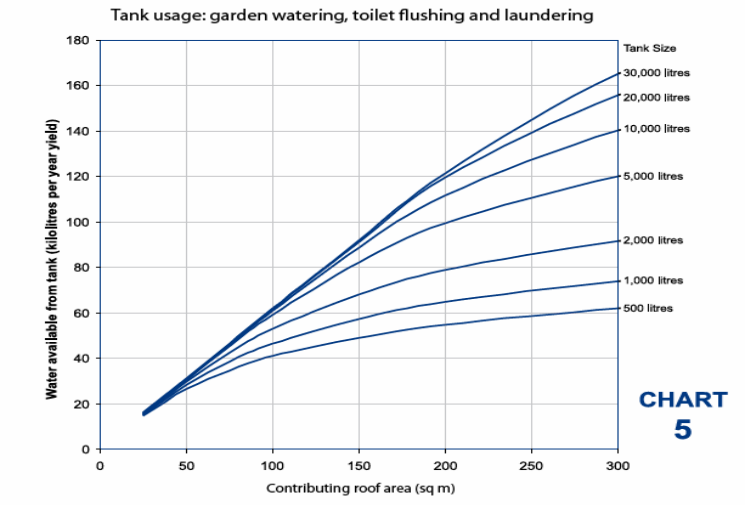
These diagrams demonstrate that up to a 30,000 litre tank is required to maximise harvesting, subject to roof area and re-use options. A 30,000 litre tank is typically impractical for typical urban areas, and significantly more expensive than 5,000 L tank assumed for this whitepaper.







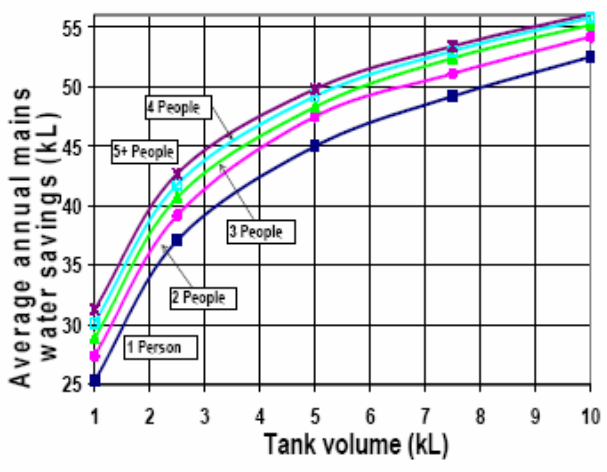




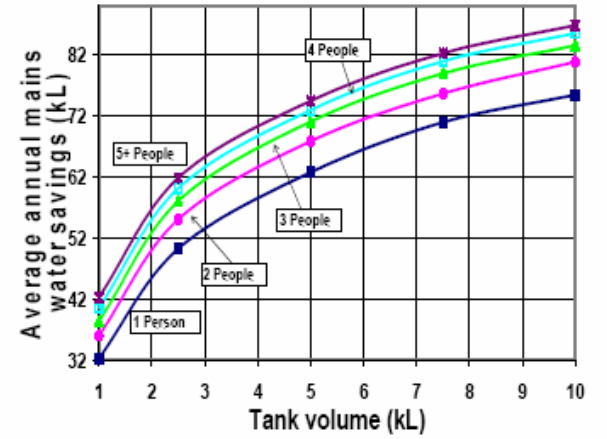
[24] Guideline for residential properties in Canberra, 2005, "Rainwater tanks", ACT Government

7c. Drinking water savings resulting from the use of RWHT[25]:

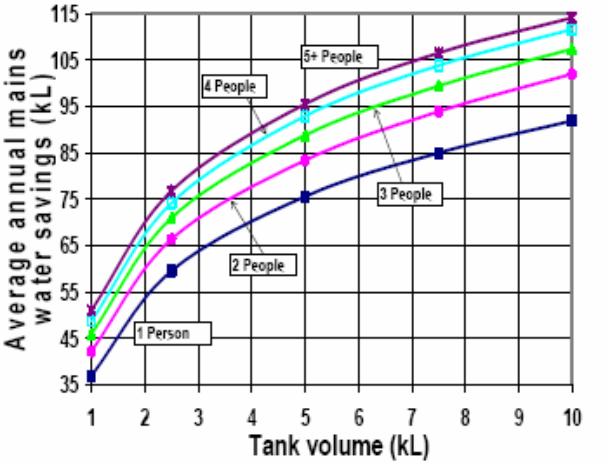
Sydney:
Potable water savings at dwelling with 100 m^2 roof areas



Potable water savings at dwelling with 150 m^2 roof areas

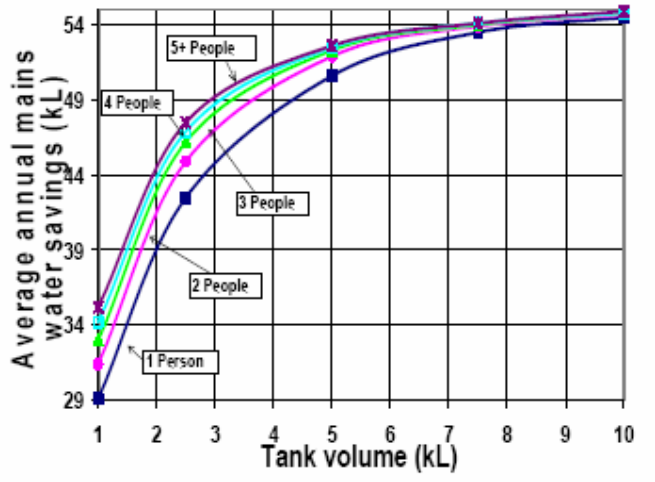


Potable water savings at dwelling with 200 m^2 roof areas

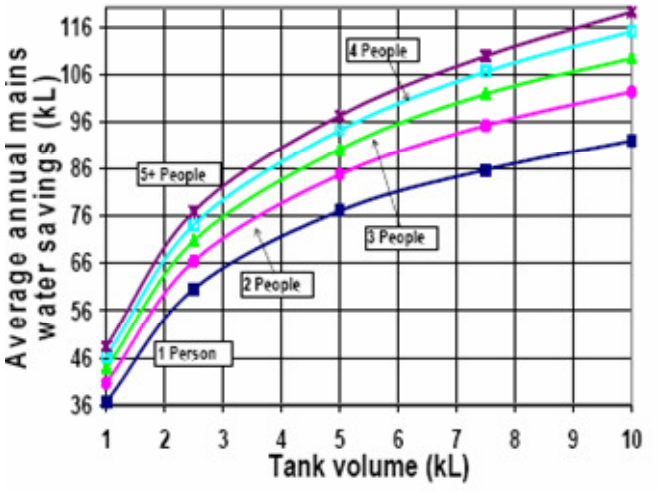


[25] Coombes, P. and Kuczera,G.,2003, "Analysis of the Performance of Rainwater Tanks in Australian Capital Cities", School of Engineering, University of Newcastle

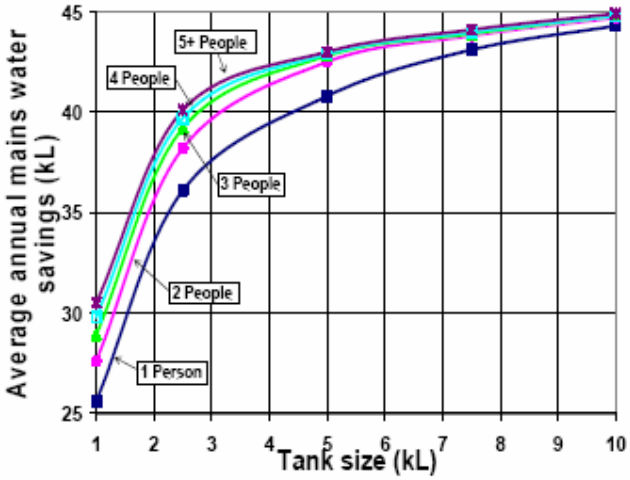
Melbourne:
Potable water savings at dwelling with 150 m^2 roof areas



Brisbane:
Potable water savings at dwelling with 150 m^2 roof areas



Adelaide:
Potable water savings at dwelling with 150 m^2 roof areas



7d. Water bill charges for Australian cities

Sydney:

Water bill charges[26]:
Water supply: Fixed charges + $1.339/kL up to 1.096 kL/day,
$1.828/kL in excess of 1.096kL/day
Sewage charge: Fixed charges

Melbourne:

Water bill charges[27]:
Water supply: Fixed charges + $0.80/kL (Average of city west water, south east water & Yarra valley water)
Sewage charge: $1.084/kL (Average of city west water, south east water & Yarra valley water)
(Volume of sewage disposal is considered as approx. 90% of total water supply in winter and approx. 70% of total water supply in summer[28])

Brisbane:

Water bill charges[29]:
Water supply: Fixed charges + $0.84/kL
Sewage charge: Fixed charges

Adelaide:

Water bill charges[30]:
Water supply: Fixed charges + $0.50/kL for first 125kL/year
Fixed charges + $1.16/kL for in excess of 125kL/year
Sewage charge: Fixed charges based on capital value of the property

[26] Sydney water
[27] Water Service Association of Australia, city west water, south east water & Yarra valley water
[28] city west water, south east water & Yarra valley water
[29] Water Service Association of Australia
[30] SA water

7e. Overall water balance for major Australian cities

SYDNEY:

Water Consumption	Greywater Treatment System			Rainwater Tank			Combined System		
	Winter L/day	Summer L/day	Average L/day	Winter L/day	Summer L/day	Average L/day	Winter L/day	Summer L/day	Average L/day
Bathroom	222	222	222	222	222	222	222	222	222
Kitchen	84	84	84	84	84	84	84	84	84
Toilet	197	197	197	197	197	197	197	197	197
Laundry	136	136	136	136	136	136	136	136	136
Garden	151	344	261	151	344	261	151	344	261
Total Consumption	**790**	**983**	**900**	**790**	**983**	**900**	**790**	**983**	**900**
Greywater produced	358	358	358	0	0	0	358	358	358
Garden usage	151	344	261	151	344	261	151	344	261
Water to sewage	281	281	281	639	639	639	281	281	281
Treated greywater available	333	333	333	0	0	0	333	333	333
Water to sewage from DSTS	25	25	25	0	0	0	25	25	25
Total water to sewage	**306**	**306**	**306**	**639**	**639**	**639**	**306**	**306**	**306**
Total reduction in sewage	333	333	333	0	0	0	333	333	333
% reduction in sewage	**52**	**52**	**52**	**0**	**0**	**0**	**52**	**52**	**52**
Average Rainfall / month - mm	0	0	0	70	95	86	70	95	86
Rainwater harvested	0	0	0	204	279	253	204	279	253
Total Drinking water Consumption	**457**	**650**	**567**	**586**	**704**	**647**	**253**	**371**	**314**
Savings of Drinking water	**333**	**333**	**333**	**204**	**279**	**253**	**537**	**612**	**586**
Savings of Drinking water (kL/year)	121	121	121	74	102	92	196	223	214
Savings on Annual waterbill ($)	**$163**	**$163**	**$163**	**$100**	**$136**	**$124**	**$262**	**$299**	**$286**
% Savings of Drinking water	**42**	**34**	**37**	**26**	**28**	**28**	**68**	**62**	**65**

Melbourne:

Water Consumption	Greywater Treatment System			Rainwater Tank			Combined System		
	Winter L/day	Summer L/day	Average L/day	Winter L/day	Summer L/day	Average L/day	Winter L/day	Summer L/day	Average L/day
Bathroom	263	263	263	263	263	263	263	263	263
Kitchen	51	51	51	51	51	51	51	51	51
Toilet	192	192	192	192	192	192	192	192	192
Laundry	152	152	152	152	152	152	152	152	152
Garden	144	279	222	144	279	222	144	279	222
Total Consumption	**802**	**937**	**880**	**802**	**937**	**880**	**802**	**937**	**880**
Greywater produced	415	415	415	0	0	0	415	415	415
Garden usage	144	279	222	144	279	222	144	279	222
Water to sewage	243	243	243	658	658	658	243	243	243
Treated greywater available	386	386	386	0	0	0	386	386	386
Water to sewage from DSTS	29	29	29	0	0	0	29	29	29
Total water to sewage	**272**	**272**	**272**	**658**	**658**	**658**	**272**	**272**	**272**
Total reduction in sewage	386	386	386	0	0	0	386	386	386
% reduction in sewage	**59**	**59**	**59**	**0**	**0**	**0**	**59**	**59**	**59**
Average Rainfall / month - mm	0	0	0	40	47	44	40	47	44
Rainwater harvested	0	0	0	169	200	185	169	200	185
Total Drinking water Consumption	**416**	**551**	**494**	**633**	**737**	**695**	**247**	**351**	**309**
Savings of Drinking water	**386**	**386**	**386**	**169**	**200**	**185**	**555**	**586**	**571**
Savings of Drinking water (kL/year)	141	141	141	62	73	68	203	214	209
Savings on Annual waterbill ($)	**$250**	**$220**	**$235**	**$110**	**$114**	**$113**	**$360**	**$334**	**$348**
% Savings of Drinking water	**48**	**41**	**44**	**21**	**21**	**21**	**69**	**63**	**65**

Brisbane:

Water Consumption	Greywater Treatment System			Rainwater Tank			Combined System		
	Winter L/day	Summer L/day	Average L/day	Winter L/day	Summer L/day	Average L/day	Winter L/day	Summer L/day	Average L/day
Bathroom	369	369	369	369	369	369	369	369	369
Kitchen	175	175	175	175	175	175	175	175	175
Toilet	233	233	233	233	233	233	233	233	233
Laundry	194	194	194	194	194	194	194	194	194
Garden	181	434	345	181	434	345	181	434	345
Total Consumption	**1152**	**1405**	**1316**	**1152**	**1405**	**1316**	**1152**	**1405**	**1316**
Greywater produced	563	563	563	0	0	0	563	563	563
Garden usage	181	434	345	181	434	345	181	434	345
Water to sewage	408	408	408	971	971	971	408	408	408
Treated greywater available	524	524	524	0	0	0	524	524	524
Water to sewage from DSTS	39	39	39	0	0	0	39	39	39
Total water to sewage	**447**	**447**	**447**	**971**	**971**	**971**	**447**	**447**	**447**
Total reduction in sewage	524	524	524	0	0	0	524	524	524
% reduction in sewage	**54**	**54**	**54**	**0**	**0**	**0**	**54**	**54**	**54**
Average Rainfall / month - mm	0	0	0	40	118	71	40	118	71
Rainwater harvested	0	0	0	181	551	327	181	551	327
Total Drinking water Consumption	**628**	**881**	**792**	**972**	**854**	**989**	**448**	**330**	**465**
Savings of Drinking water	**524**	**524**	**524**	**181**	**551**	**327**	**704**	**1075**	**851**
Savings of Drinking water (kL/year)	191	191	191	66	201	119	257	392	311
Savings on Annual waterbill ($)	**$161**	**$161**	**$161**	**$55**	**$169**	**$100**	**$216**	**$330**	**$261**
% Savings of Drinking water	**45**	**37**	**40**	**16**	**39**	**25**	**61**	**76**	**65**

Adelaide:

Water Consumption	Greywater Treatment System			Rainwater Tank			Combined System		
	Winter L/day	Summer L/day	Average L/day	Winter L/day	Summer L/day	Average L/day	Winter L/day	Summer L/day	Average L/day
Bathroom	209	209	209	209	209	209	209	209	209
Kitchen	125	125	125	125	125	125	125	125	125
Toilet	181	181	181	181	181	181	181	181	181
Laundry	181	181	181	181	181	181	181	181	181
Garden	208	499	400	208	499	400	208	499	400
Total Consumption	**904**	**1195**	**1096**	**904**	**1195**	**1096**	**904**	**1195**	**1096**
Greywater produced	390	390	390	0	0	0	390	390	390
Garden usage	208	499	400	208	499	400	208	499	400
Water to sewage	306	306	306	696	696	696	306	306	306
Treated greywater available	362	362	362	0	0	0	362	362	362
Water to sewage from DSTS	27	27	27	0	0	0	27	27	27
Total water to sewage	**334**	**334**	**334**	**696**	**696**	**696**	**334**	**334**	**334**
Total reduction in sewage	362	362	362	0	0	0	362	362	362
% reduction in sewage	**52**	**52**	**52**	**0**	**0**	**0**	**52**	**52**	**52**
Average Rainfall / month - mm	0	0	0	72	22	45	72	22	45
Rainwater harvested	0	0	0	245	70	149	245	70	149
Total Drinking water Consumption	**542**	**833**	**734**	**659**	**1125**	**947**	**297**	**763**	**585**
Savings of Drinking water	**362**	**362**	**362**	**245**	**70**	**149**	**607**	**432**	**511**
Savings of Drinking water (kL/year)	132	132	132	89	26	54	222	158	187
Savings on Annual waterbill ($)	**$153**	**$153**	**$153**	**$104**	**$30**	**$63**	**$257**	**$183**	**$216**
% Savings of Drinking water	**40**	**30**	**33**	**27**	**6**	**14**	**67**	**36**	**47**

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