Rainwater tank rebate scheme in Greater Melbourne, Australia

S. Gato-Trinidad and K. Gan

ABSTRACT

A preliminary analysis of the effectiveness of a rainwater tank rebate scheme for both the Victorian Government and individual householders who participated in the scheme was undertaken, together with a determination of the factors affecting the water savings achieved. Yarra Valley Water provided the data for 4,391 households who received a government rebate for installing a rainwater tank and for 4,400 households who did not participate in the scheme. The water savings from different tank sizes were calculated. A comparison of water consumption between households with rainwater tanks and those without was also undertaken to determine the benefit of rolling the rebate scheme to households who are currently not under the scheme. The analysis revealed that installation of rainwater tanks contributed to a reduction of 42.5% in average household water consumption. The results also show that, depending on the tank size and uses of rainwater, the payback period (PP) ranged from 12 to 47 years for householders and 1 to 12 years for the Victorian Government. All rainwater tank sizes except 2,000–4,999 L with connection to toilets and/or laundry have PPs of less than 20 years to householders. This is due to the high capital and operating costs even with higher rebates from the government.

Key words | cost effectiveness, payback period, rainwater tanks, water savings

S. Gato-Trinidad (corresponding author)
Faculty of Engineering & Industrial Sciences,
Swinburne University of Technology,
PO Box 218,
Hawthorn,
Victoria 3122,
Australia
E-mail: *sgatotrinidad@swin.edu.au*

K. Gan
Yarra Valley Water,
Lucknow St,
Mitcham,
Victoria 3132,
Australia

INTRODUCTION

'The Water Smart Gardens and Homes Rebate Scheme' was implemented by the Victorian Government in Australia on 1 January 2007 to reward residential water users who are connected to main water supply for purchasing water-saving devices and services to reduce their water consumption. Householders who purchase and install rainwater tanks are eligible for a rebate of up to A$1,000 per household, depending on the size of the tank and connection for indoor water uses, in particular for toilet flushing and clothes washing. The 'Water Smart Gardens and Homes Rebate Scheme' has undergone the following modifications since its inception in January 2007:

- January 2007
  - A$150–600 for >4,500 L tank size for outdoor use only
  - A$500–2,000 for ≥5,000 L tank size for toilet and/or laundry
  - A$900 for >5,000 L tank size for toilet or laundry
  - A$1,000 for >5,000 L tank size for toilet and laundry
- July 2009 to June 2011
  - Rebate 1 – small rainwater tanks
    - A$150 for 600 L tank or greater for outdoor use
      for new 600–1,900 L tank connected to toilet
      for existing tank >600 L connected to toilet
    - A$300 for only 600–1,900 L tank for outside use and connected to toilet
  - Rebate 2 – large rainwater tanks
    - A$500 for 2,000–3,999 L tank connected to toilet or laundry
    - A$900 for ≥4,000 L tank connected to toilet or laundry
    - A$1,000 for ≥4,000 L tank connected to toilet and laundry

By July 2011 the program was renamed as the 'Living Victoria Water Rebate Program' with the continuation of Rebate 2 only, which remained in place until 30 June

doi: 10.2166/aqua.2014.200

2013. The program was then extended until 30 June 2015 with the following changes:

- Rebate 2 – large rainwater tanks
  - A$850 (was $500) for 2,000–3,999 L tank connected to toilet or laundry
  - A$1,300 (was $900) for ≥4,000 L tank connected to toilet or laundry
  - A$1,500 (was $1,000) for ≥4,000 L tank connected to toilet and laundry
  - A$500 for connection from tank to toilet and/or laundry
  - Extension of tank rebates to existing homes that had received building permits between 1 July 2005 and 1 May 2011

This report presents the results of the preliminary analysis conducted on the cost effectiveness of the rainwater tank rebates provided by the Victorian Government to 4,400 households in Greater Melbourne, as well as the factors affecting water savings from rainwater tanks. The cost effectiveness of the rainwater tank rebate scheme was assessed from the point of view of both the government and the customers. Using the data provided by Yarra Valley Water (YVW), the water savings from different tank sizes were calculated from the 4,400 households who installed rainwater tanks and received rebates. A comparison of water consumption between households with rainwater tanks and those without in some suburbs in Melbourne was also undertaken to determine the benefit of rolling the rainwater tank rebate scheme to households who are currently not under the scheme.

A regression analysis was undertaken to determine the factors affecting water savings from rainwater tanks. The factors considered were rainwater tank size, annual rainfall, number of rainless days in a year and household size. Due to limitations of available data, some average values for each suburb were adopted.

STUDY AREA

Melbourne is the capital city of Victoria, Australia, and the major residential, commercial and manufacturing centre for the state. It is the second largest city in Australia and has about 73% of the state's population (Figure 1). Greater Melbourne has experienced the largest growth of any Australian state capital city, with an increase of 406,600 people between 2007 and 2012 (ABS 2012). The average household size in Greater Melbourne is 2.6 in 2011 (ABS 2011) and is projected to decrease to 2.5 by 2031 (DPCD 2012).

Across metropolitan Melbourne, the climate is temperate with a warm, dry summer and a moderate winter rainfall. The average daily maximum temperature is about 26 °C in summer, with extremes of 40 °C or more, in most years. There is little variation across the city in temperature, except in small areas of higher elevation, where temperature is usually marginally lower.

The annual rainfall ranges from about 550 mm in the west of the suburban areas, to about 900 mm in the east. Until the mid-1990s, Melbourne had relatively reliable rainfall. Since then, there has been some of the lowest rainfall on record across a large part of Victoria, including Melbourne. Rainfall recorded at Melbourne's reservoir sites for the 2007/08 financial year was 13 to 26% lower than the 30-year average (1978 to 2007) (Melbourne Water 2009).

Due to low rainfall, the average inflows over the last 11 years have been 35% lower than the long-term average inflow (1913–2008). Inflows to Melbourne's four major harvesting storages for 2007/2008 were 340 GL, 11% less than the average over the last 11 years and 42% less than the long-term average. Around 80% of Melbourne's drinking water comes from closed water catchments in the Yarra Ranges (Yarra and Thomson River catchments) with the remainder extracted directly from the Yarra River or diverted from the Goulburn River Basin (Melbourne Water 2009).

According to Melbourne Water (2013), the average daily total consumption for Melbourne was estimated at 1.215 GL (based on a 5-year winter average, 1 July 2001–30 June 2007) or 1.320 GL (based on an 8-year winter average, 1992–1999). Residential use accounted for 65%, while non-residential use accounted for around 25%. The remaining 10% is considered to be the non-revenue component.

From 2007/08 the annual consumption declined to 345 GL due to water restrictions in place (Stages 1–3A) and the introduction of Target 155 in November 2008. Water restrictions from Stages 1 to 3A were put in place by the Victorian Government to limit watering of residential and

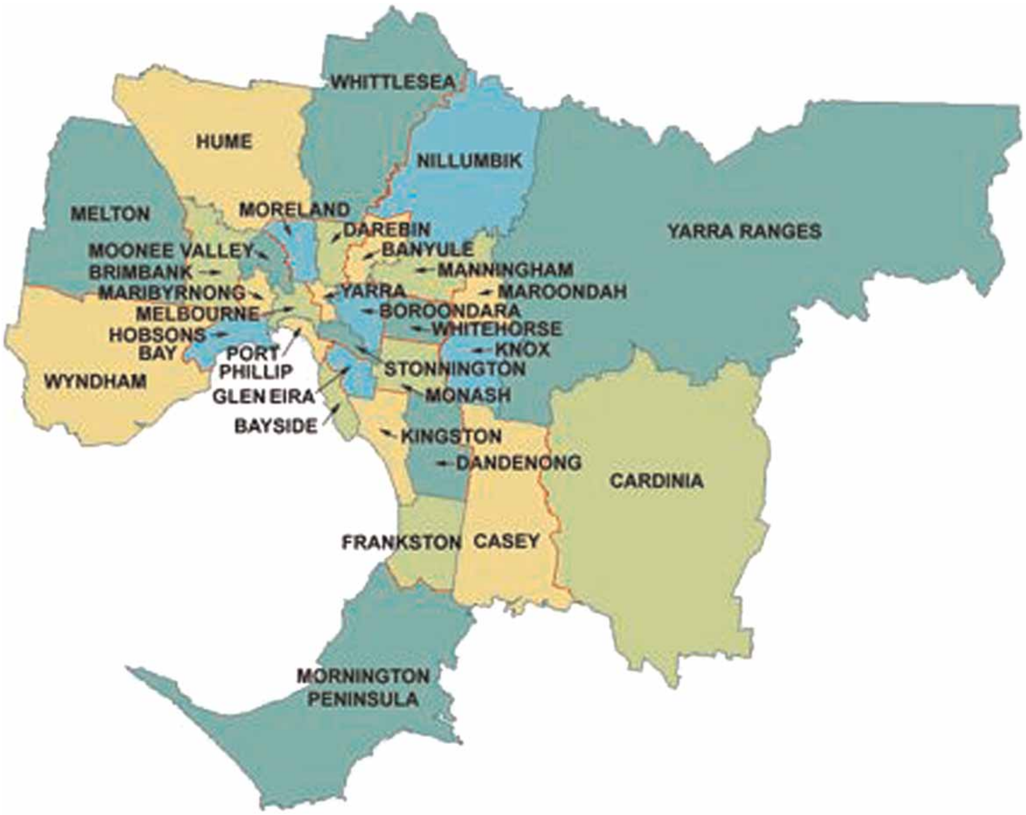

Figure 1 | Locality plan of Greater Melbourne.

commercial gardens and lawns only on various days and times of the day. Odd numbered houses can only water their gardens or lawns on odd dates while even numbered houses can water their gardens on even dates. Depending on the watering system used (manual, automatic, spray or drippers), gardens or lawns can be watered from 2 to 4 hours each in the morning and in the afternoon. Target 155 is another Victorian Government program which encouraged Melbourne residents to save more water by reducing their consumption to only 155 litres per person per day.

LITERATURE REVIEW

Rainwater tanks can save a significant amount of water mains use. There have been a number of studies conducted in Australia and overseas on possible water savings and cost benefits from the installation of rainwater tanks. However, these studies were either hypothetical or based on a limited amount of data, preventing informed decisions being made by householders (about whether to have a rainwater tank installed) or by the government (about whether to continue with the rainwater tank rebate scheme).

Potential water savings depend on roof area, household size and the size of the rainwater tank. Rahman *et al.* (2010) concluded that the most favourable financial condition for a 75 kL rainwater harvesting system is a benefit–cost ratio of 1.39. This is based on a fictitious multi-storey building in Sydney, Australia, with a 1,600 m^2 roof area, a nominal discount rate of 5%, a water price of A$1.634 kL^{-1} and an inflation rate of 4.5% per annum. Thus the benefit–cost ratio is subject to changes in the roof area of the house, the prevailing discount rate, the water price and the inflation rate.

A larger rainwater tank means more possible water savings as reported by Coombes & Kuczera (2003). An evaluation of the performance of 1–10 kL rainwater tanks for small dwellings in four Australian capital cities revealed that the water mains savings per year of 1 and 10 kL rainwater tanks were 18–35 and 25–144 kL, respectively (Coombes & Kuczera 2003).

An investigation conducted in Sweden revealed that possible savings of 30% of the total mains water consumption can be achieved from a 40 kL rainwater tank and large roof areas, with indoor plumbing for toilet flushing and laundry (Villarreal & Dixon 2005).

METHODOLOGY

Data collection

YVW provided the following data used in the analysis:

- Quarterly water consumption records of 4,391 households in 158 suburbs of Greater Melbourne who received government rebates, before and after the installation of rainwater tanks, and the corresponding rainwater tank sizes.
- Quarterly water consumption records of 4,400 households in 158 suburbs of Greater Melbourne who did not receive the government's rainwater tank rebate. These households were chosen based on the similarity of their consumption patterns to the 4,391 households prior to their tank installations.

The cost of rainwater tanks and associated installation as well as ongoing and extra maintenance costs were based on reports by Tam *et al.* (2009) and Marsden Jacob Associates (2007).

Potable water savings

Household potable water savings were calculated by comparing the water consumption of each household before and after the installation of rainwater tanks (12 quarters gap in between).

Factors affecting water savings

Factors considered affecting household water savings in this paper included rainwater tank size, annual rainfall, number of rainless days in a year, household size, and house roof area. The significance of each factor was determined by regression analysis.

Cost effectiveness of rainwater tanks scheme to customers

The cost effectiveness of the scheme to householders was determined using the average payback period (PP) approach. The average PP was determined using the average water savings and the cost of a rainwater tank, its installation, and ongoing maintenance for these households. The dollar value of water savings was calculated using the YVW price structure.

Cost effectiveness of rainwater tanks rebate to the Victorian Government

The average PP approach was also adopted in determining the cost effectiveness of the scheme to the Victorian Government. The cost benefit was calculated by comparing the total amount given to customers as rebates for installing rainwater tanks and the water savings achieved due to the rainwater tanks installation. The 4,400 households without rainwater tanks were used as a control group to determine the amount of water savings that can be achieved by rolling out rainwater tanks to these households.

RESULTS AND DISCUSSION

Tank sizes, costs and installation

There are different types and sizes of rainwater tanks in Australia, including small rainwater tanks, slim line tanks, under deck rainwater tanks, bladder tanks, underground poly tanks and underground concrete tanks. The capacities of these rainwater tanks range from 200 to 45,000 L (Rainwater Tanks Direct 2014). The costs of rainwater tanks also vary depending on their sizes and types. In this study, rainwater tank sizes were based on YVW groupings as shown in Table 1. The groupings were made in order to determine the water savings and the cost benefit of each rainwater tank size group. The results of this grouping will indicate which tank size group is more cost effective for the householders and for the Victorian Government.

The prices of rainwater tanks shown in Table 1 are based on the average prices of the respective range sizes

Table 1 | Rainwater tanks sizes and installation costs (A$) in Melbourne

	For outdoor use only						For indoor and outdoor use[a]		
Item	**600–1,000 L**	**1,001–1,700 L**	**1,701–2,250 L**	**2,251–3,600 L**	**3,601–4,500 L**	**>4,501 L**	**2,000–4,999 L**	**5,000 L T or L**	**5,000 L T & L**
Rebate (A$)	150	150	150	150	150	150	500	900	1,000
Tank	570	680	960	965	1,200	1,520	870	1,260	1,260
Installation	550	550	550	550	550	550	550	550	550
Plumbing	730	730	730	730	730	730	730	730	730
Pump	0	0	0	0	0	0	355	355	355
Total	1,850	1,960	2,240	2,245	2,480	2,800	2,505	2,895	2,895

[a]Rainwater is also used for toilet and/or laundry.

(Rainwater Tanks Direct 2014). The costs for installation and plumbing were assumed to be the same for all sizes of rainwater tank. The cost of the pump was added to rainwater tank systems that required indoor plumbing.

Annual maintenance cost

The annual maintenance cost adopted in this study is composed of a maintenance cost of A$20 and an annual energy cost of pumping for those with indoor connections of 5 cents per kilolitre of water pumped (Coombes 2004).

Water savings

The average water savings per year for each tank size group was calculated for each rainwater tank rebate recipient as the difference in households' water consumption before and after installation of rainwater tanks.

The data received from YVW showed the date the rebates were received by the 4,391 households and not when the rainwater tanks were installed. It was assumed that the rainwater tanks were installed when the rebates were received. Household owners started receiving rebates in September 2006 until January 2009.

There might be cases where rainwater tanks were used before the rebates; thus, in the calculation of the water savings, it was assumed that the 'before installation' was from July 2005 to June 2006 and the 'after installation' was from July 2009 to June 2010 (Table 2).

The average water consumption and water savings per household for each tank size are shown in Tables 3 and 4. Based on 4,391 households, the average annual water consumption per household is 247 kL before tank installation (July 2005 to June 2006) and 142 kL after tank installation (July 2009 to June 2010). This resulted in an average water saving of 105 kL per household per year. Since water restrictions and a strong water conservation campaign were in force over the whole period of analysis, the calculated water savings may include savings due to these other initiatives, rather than due to the rainwater tanks. According to Gato *et al*. (2010), potential household water savings of up to 66 kL per household per year can be achieved by converting to water efficient appliances such as front loaders, dual flush toilets and AAA shower heads. Based on the above,

Table 2 | Household water consumption record, YVW (in litres) as per YVW quarterly billings: 1st Qtr (Jan-Mar); 2nd Qtr (Apr-Jun); 3rd Qtr (Jul-Aug); 4th Qtr (Sept-Dec)

Before				**Rebates received**												**After**			
July 2005–June 2006				**September 2006–January 2009**												**July 2009–June 2010**			
J	S	J	A	J	S	J	A	J	S	J	A	J	S	J	A	J	S	J	A
42	40	63	59	37	44	56	41	29	34	43	40	30	32	41	36	29	29	34	38

J = July; S = September; J = January; A = April.

Table 3 | Average water consumption per household for each tank size (kL)

		Before tank installation				After tank installation			
Tank size	No. of HH	3rd Qtr 05	4th Qtr 05	1st Qtr 06	2nd Qtr 06	3rd Qtr 09	4th Qtr 09	1st Qtr 10	2nd Qtr 10
All	4,391	51	49	76	71 (247)	31	32	37	41 (142)
600–1,000 L	237	42	40	63	59 (204)	29	29	34	38 (130)
1,001–1,700 L	279	47	44	71	62 (224)	30	31	36	40 (137)
1,701–2,250 L	855	49	46	73	69 (236)	31	33	38	41 (142)
2,251–3,600 L	846	52	48	77	74 (253)	33	34	39	44 (151)
3,601–4,500 L	211	50	50	84	70 (254)	31	35	41	45 (153)
>4,501 L	409	61	57	97	92 (306)	35	37	45	50 (167)
2,000–4,999 L T and/or L	507	47	45	64	59 (216)	26	27	31	35 (119)
>5,000 L T or L	482	57	53	85	77 (273)	35	36	40	43 (154)
>5,000 L T&L	565	52	51	74	67 (244)	26	28	32	35 (122)

Note: Figures in brackets are the average annual water consumption per household. HH: Households; 1st Qtr: water consumption from Jan–Mar; 2nd Qtr: Apr–Jun; 3rd Qtr: Jul–Aug; 4th Qtr: Sept–Dec.

Table 4 | Average water savings per household for each tank size (kL)

Tank size	HH	July	September	January	April	Annual total	Savings (%)
All	4,391	20	16	39	30	105	42.5
600–1,000 L	237	14	10	29	21	74	36.3
1,001–1,700 L	279	17	13	35	22	87	38.3
1,701–2,250 L	855	18	13	35	28	95	40.2
2,251–3,600 L	846	19	14	38	30	102	40.3
3,601–4,500 L	211	19	15	43	24	101	39.8
>4,501 L	409	25	20	51	42	139	45.4
2,000–4,999 L T and/or L	507	21	18	33	24	96	44.4
>5,000 L T or L	482	23	17	45	34	119	43.6
>5,000 L T&L	565	25	23	41	32	122	50.0

HH: Households.

the resulting water savings from rainwater tanks would only be around 40 kL/household per year if the average household installed efficient water appliances after the tank installation period considered in this study. However, due to limited information for each household, a saving of 105 kL per household per year was adopted in the following analysis and discussion.

As the calculated water savings covered all installed tank sizes and different rebates for different tank sizes, water savings for each tank size were also calculated (Tables 3 and 4). Results revealed that the size of rainwater tanks chosen by householders increases as their annual water consumption increases. Householders with the lowest annual water consumption (204 kL) owned 600–1,000 L tanks and those with the highest (306 kL) chose >4,501 L tanks. For households where rainwater tanks are connected to a toilet and/or laundry, those with the lowest average annual consumption per household (216 kL) chose 2,000–4,999 L tanks and those with the highest annual consumption (273 kL) owned >5,000 L tanks. Householders tend to choose bigger sizes of rainwater tanks when uses also include toilet flushing and/or laundry.

Due to the limitation of the data, it could not be inferred whether choice of rainwater tank size was based solely on the household's water consumption or on the roof size of the home, garden/lawn size and household size.

Factors affecting water savings

A regression analysis was undertaken to determine what significant factors affect household water savings. The factors considered included rainwater tank size, household size, household roof area, annual rainfall and the number of rainless days in a year. The analysis resulted in a poor correlation (low R^2 value) with these factors but rainwater tank size and household size were found to be significant factors. The results could mean that there are other factors aside from tank size and household size affecting water savings, such as the size of gardens and lawns where most rainwater is being used.

Payback period (PP)

The PP is perhaps the simplest method of looking at one or more investments. The PP method focuses on recovering the cost of investments. PP represents the time that it takes for a capital project to recover its initial cost (Value Based Management 2011).

The PP calculation is as follows:

$$PP = \frac{\text{Cost of project}}{\text{Annual cash inflows}} \quad (1)$$

The PP concept holds that, all other things equal, the better investment is the one with the shorter payback. PP has the virtue of being easy to compute and easy to understand but that very simplicity carries weaknesses with it. It ignores any benefits that occur after the PP and so does not measure total incomes. This is not an issue in this report however, since the objective is to determine how long will it take for individual households or the government to recover the capital cost of the system.

Using Equation (1) to calculate the PP of rainwater tanks for individual households, the cost of the project is considered to comprise the tank and installation costs as shown in Table 1, the cost of maintaining the rainwater tank of A$20 per year, and the annual energy cost (for those with indoor connections) of 5 cents per kilolitre of water pumped (Coombes 2004).

The annual cash inflows were based on water savings. The cost of water saved was based on the YVW pricing structure (YVW 2008). YVW uses the following 'three tier block tariff' to charge for water use:

- Block 1: 0–440 litres per day = A$1.5343/kL
- Block 2: 441–880 litres per day = A$1.8000/kL
- Block 3: 881 + litres per day = A$2.6594/kL

A price increase of 6% was adopted as the increase in the cost of water over time. This is a conservative assumption since the price increase by Melbourne Metropolitan water retailers (City West Water, YVW and South East Water) was 14% in January 2009 (ESC 2009). The annual average GDP real growth rate for Australia for 2000–2010 is 3% (IMF 2010).

PP for the household owners

Based on the analysis undertaken, the resulting PP ranges from 12 to 47 years depending on the tank size and the uses of rainwater (Figure 2). All those with connections to toilets and/or laundry take longer to recover the capital and operating costs than those using the water for outdoor purposes only, due to the pumping and plumbing costs; however, in terms of water savings, more can be achieved in the former than the latter (Figure 2).

All sizes except the 2,000–4,999 L tank with connection to toilets and/or laundry have PPs of less than 20 years, which is the expected life of rainwater tanks. This is due

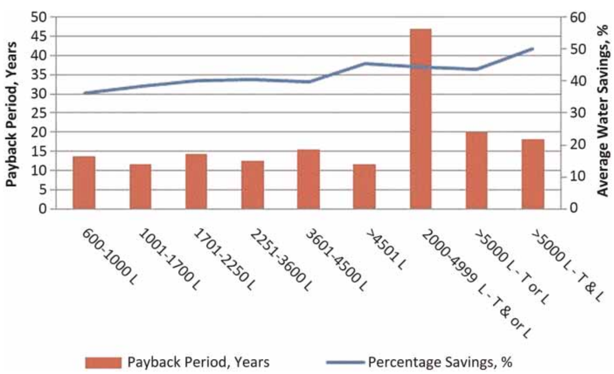

Figure 2 | PPs (years) for different rainwater tank sizes to the households and the corresponding percentage of water saved.

to pumping costs and lower rebates when compared with other systems with indoor connections. A 10% increase in total costs (capital and operating) will result in an average 25% increase in PPs.

PP for the government

To determine the PP of the scheme for the government, a set of control data was also analyzed. The control data contained a record of water usage from 4,400 households who did not receive government rebates as per YVW records. However, it can be argued that some may have installed rainwater tanks without receiving the rebates and this could not be reflected in the record. This was not verified within this study and it has therefore been assumed that all the households in the control group did not receive rebates.

A comparison of the water usage revealed that the control group used less water than those that received government rebates before the installation of rainwater tanks (July 2005–June 2006) but, after installation (July 2009–June 2010), their water usage surpassed those that installed rainwater tanks (Figure 3).

The water savings adopted as savings for the control group was calculated as the average water saved per household per year of those who received rebates (Method 1), and as the calculated average percentage water savings in Table 4 (Method 2). The PP of the scheme for the government ranged from 1 to 12 years (Figure 4). Due to the limitations of the PP approach, the results did not take into account the long-term benefits of rainwater tanks, as there may be more water saved in these tanks than those with no indoor plumbing.

Net present value (NPV) analysis

Due to the limitations of the PP approach, NPV analysis was also conducted to determine the cost effectiveness of the scheme to the government. In this analysis, a discount rate of 6% and an expected life of the tank of 20 years were adopted. The price of water adopted was A$1.13 kL^{-1}, the long-run marginal cost of supply augmentation to the Melbourne system (personal communication with YVW staff).

Results revealed that, with the rebates given, the rainwater tank size in the range of 2,251–3,600 L without indoor plumbing yielded the highest NPV of A$980,566 (Table 5).

If the scheme were to be extended to the 4,400 households (control group), the analysis showed that tanks with indoor plumbing have lower NPVs than those without, with the >4,500 L tank having the highest NPV of A$7.32 million.

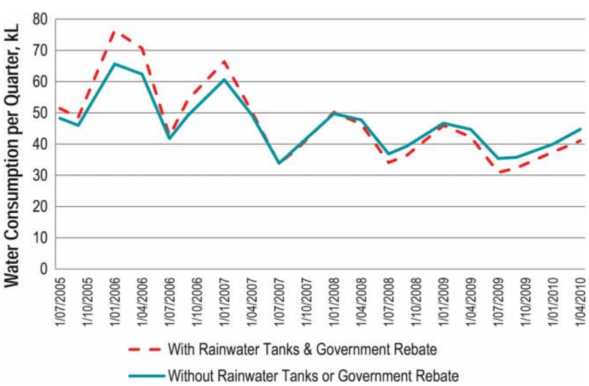

Figure 3 | Comparison of water usage with and without rainwater tanks.

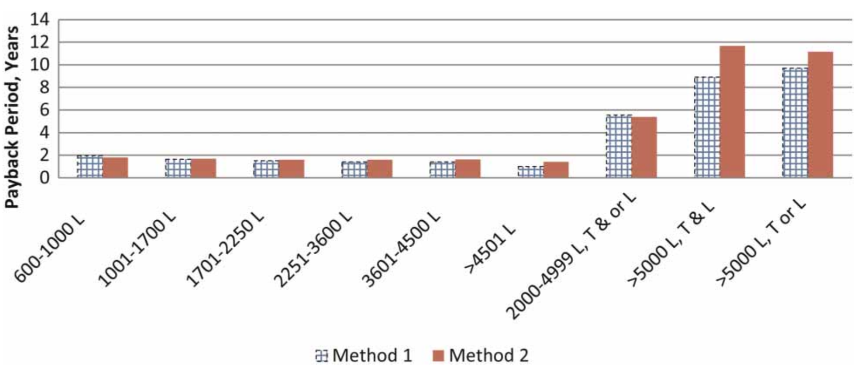

Figure 4 | PPs (years) of the scheme for the government for different rainwater tank sizes.

Table 5 | NPV for each rainwater tank size

Tank size	HH	Annual total	Savings (%)	NPV (A$)	HH	NPV[1] (A$ millions)	NPV[2] (A$ millions)	A$ kL^{-1}
600–1,000 L	237	74	36.3	191,760	4,400	3.56	3.94	0.18
1,001–1,700 L	279	87	38.3	272,753	4,400	4.03	4.20	0.15
1,701–2,250 L	855	95	40.2	913,426	4,400	4.07	4.44	0.14
2,251–3,600 L	846	102	40.3	980,566	4,400	5.10	4.45	0.13
3,601–4,500 L	211	101	39.8	247,297	4,400	5.16	4.38	0.13
>4,501 L	409	139	45.4	680,798	4,400	7.32	5.10	0.09
2,000–4,999 L T and/or L	507	96	44.4	377,338	4,400	3.28	3.43	0.45
>5,000 L T or L	482	119	43.6	303,370	4,400	2.77	1.57	0.66
>5,000 L T&L	565	122	50.0	335,725	4,400	2.61	1.94	0.71

Note: NPV[1] was based on Method 1 and NPV[2] on Method 2 as described in the section 'PP for the government'. HH: Households.

Levelised cost analysis

Another useful way of measuring water conservation options for the water utility perspective is through the levelised cost, or amortised cost, of water analysis. The levelised cost of water is calculated as the NPV cost of the scheme divided by the present value of the total amount of water saved under the scheme (White 1998). Based on the levelised cost analysis undertaken, it was found that the tank size group of >4,500 L yielded the lowest cost of A$0.09 kL^{-1} (Table 5).

CONCLUSIONS

Based on the available data and the analysis undertaken, the following can be concluded:

1. Households with higher water consumption and those with rainwater tanks connected to toilet and laundry installed larger rainwater tanks. Due to unavailability of information, the basis of such choice was not determined.
2. Installation of rainwater tanks contributed to the 42.5% reduction in household water consumption (105 kL per year) over the whole sample. Other contributors may include the installation of water efficient appliances, as well as Target 155 and other water conservation programs implemented during the period of analysis.
3. Larger rainwater tanks and those with indoor plumbing for toilet flushing and laundry yielded higher water savings than smaller tanks (up to 50% of average household water consumption or 122 kL/year).
4. Rainwater tank size and household size were found to be significant factors in the amount of household water savings.
5. All sizes of rainwater tanks analyzed in this study except the 2,000–4,999 L tanks have PPs of less than 20 years for the householders. For the government, the PPs ranged from 1 to 12 years.
6. With the rebates given, the 2,251–3,600 L rainwater tank without indoor plumbing yielded the highest NPV in water savings of $980,566.
7. If the government extends the scheme to the 4,400 households, the rainwater tank size >4,500 L will have the highest NPV in water savings of A$7.32 million and a lowest levelised water cost of A$0.09 per kL.

RECOMMENDATIONS

To date, most of the studies on rainwater tank usage have relied on hypothetical studies. This study has the advantage of using actual water consumption information from a large number of households. However, some of the information such as lawn/garden size, roof size and household size needed to determine the most cost effective rainwater tank size in individual households was not included in this enormous set of data. It is therefore recommended that such additional information relating to the sample of households used in this study be collected and further analyzed.

ACKNOWLEDGEMENT

Yarra Valley Water provided all the data used in this study.

REFERENCES

ABS (Australian Bureau of Statistics) 2011 Census quickstats: Greater Melbourne. http://www.censusdata.abs.gov.au/census_services/getproduct/census/2011/quickstat/2GMEL (accessed 4 September 2013).

ABS (Australian Bureau of Statistics) 2012 3218.0-regional population growth, Australia, 2012. http://www.abs.gov.au/ausstats/abs@.nsf/Products/3218.0~2012~Main+Features~Main+Features?OpenDocument (accessed 4 September 2013).

Coombes, P. 2004 Rainwater tanks. In: *Water Sensitive Resource Kit for the Sydney Region*. Upper Parramatta River Catchment Trust, New South Wales.

Coombes, P. & Kuczera, G. 2003 Analysis of the performance of rainwater tanks in Australian capital cities. *Proceedings of the 28th International Hydrology and Water Resources Symposium*, Engineers Australia, 10–14 November 2003, Wollongong, New South Wales.

DPCD 2012 VIF 2012-one page profiles, Department of Transport, Planning and Local Infrastructure, Victoria, Australia. http://www.dpcd.vic.gov.au/home/publications-and-research/urban-and-regional-research/census-2011/victoria-in-future-2012/VIF-2012-One-page-Profiles (accessed 16 April 2014).

Essential Services Commission Victoria. 2009 Metropolitan Melbourne water price review 2009 – final decision.

Gato-Trinidad, S., Jayasuriya, N. & Roberts, P. 2010 Calculating potential water savings of efficient water using appliances. In Water 2010, Quebec City, Montreal, Canada, 5–7 July 2010.

International Monetary Fund 2010 World Economic Outlook, April 2010. http://www.imf.org/external/pubs/ft/weo/2010/01/pdf/text.pdf (accessed 16 April 2014).

Marsden Jacob Associates. 2007 *The Economics of Rainwater Tanks and Alternative Water Supply Options*. Prepared for the Australian Conservation Foundation, Nature Conservation Council (NSW) and Environment Victoria.

Melbourne Water 2009 Melbourne water 2009 water plan. http://www.esc.vic.gov.au/getattachment/605e8199-df87-49b2-969d-670d22062786/Water-Plan-Melbourne-Water.pdf (accessed 16 April 2014).

Melbourne Water 2013 Water use data. http://www.melbournewater.com.au/waterdata/wateruse/Pages/default.aspx (accessed 17 February 2014).

Rahman, A., Dbais, J. & Imteaz, M. 2010 Sustainability of rainwater harvesting systems in multistorey residential buildings. *American Journal of Engineering and Applied Sciences* **3** (1), 889–898.

Rainwater Tanks Direct 2014 The benefits of buying a rainwater tank. http://www.rainwatertanksdirect.com.au/blog/category/water-tanks (accessed 16 April 2014).

Tam, V. W. Y., Tam, L. & Zeng, S. X. 2009 Cost effectiveness and tradeoff on the use of rainwater tank: an empirical study in Australian residential decision-making. *Resources, Conservation and Recycling* **54**, 178–185.

Value Based Management.net 2011 Payback period. In http://www.valuebasedmanagement.net/methods_payback_period.html (accessed 16 February 2011).

Villarreal, E. L. & Dixon, A. 2005 Analysis of a rainwater collection system for domestic water supply in Ringdansen, Norrköping, Sweden. *Building Environment* **40**, 1174–1184.

White, S. 1998 Wise Water Management: a Demand Management Manual for Water Utilities. *Research Report No. 86* (prepared for Water Services Association of Australia). NSW Department of Land and Water Conservation, Sydney, pp. 1–158.

Yarra Valley Water 2008 Water plan 2009/10–2012/13. http://www.yvw.com.au/yvw/groups/public/documents/document/yvw000704.pdf (accessed 18 April 2014).

First received 26 December 2013; accepted in revised form 28 March 2014. Available online 5 May 2014