Chapter 11 Rainwater Tanks

11.1 Introduction

The core sustainability objective of using rainwater tanks is to conserve mains water. In addition to conserving mains water, rainwater tanks help to protect urban streams by reducing stormwater runoff volumes, particularly from small storms, and associated stormwater pollutants from reaching downstream waterways. Rainwater and stormwater harvesting on individual allotments are some initiatives that can be implemented to deliver a potable water conservation objective.

Another important household initiative to conserve water is the use of water efficient plumbing fittings and appliances. These are often adopted as a first priority in water conservation initiatives as they are easy to adopt, have high cost effectiveness and broader environmental benefits such as reduced wastewater discharges. Recent research has found that the adoption of water efficient showerheads and dual flush toilets can reduce indoor water use by 15 – 20% (11 – 15% of total internal and external water use). Following improving the efficiency of water use within a household, finding supplementary sources for water is fundamental to further reducing demand on mains water. The use of rainwater tanks to collect roof runoff is an accepted means of supplementing mains water supplies which is simpler to implement than other potential alternative water sources such as greywater or surface stormwater.

There are presently no quantitative performance targets (e.g. size of tank, targeted reductions in potable demand) in any existing local government and state authority policies and guidelines regarding the use of rainwater tanks.

This design procedure focuses on factors associated with selecting and using a rainwater tank. Variables that need to be considered in sizing a rainwater tank include the size or area of roof directed to a tank, the quantity and nature of the demand and the rainfall pattern of a particular area.

11.2 Rainwater tank considerations

The use of rainwater tanks to reduce demand on reticulated potable water supplies and stormwater runoff volume need to consider a number of issues. These are:

- *Supply and demand* – conditions such as a low roof area to occupancy ratio (e.g. high density development) and low annual rainfall regions (e.g. northern Victoria) can result in large rainwater tank volumes to provide a "reliable" supplementary water supply to the end-uses connected to a tank.
- *Water quality* – the quality of water from rainwater tanks needs to be compatible with the water quality required by the connected "end-use". There are a number of ways in which the water quality in rainwater tanks can be affected and it is important to understand these so that appropriate management measures can be implemented.
- *Stormwater quality benefits* – the quantity of the stormwater that is reused from a tank system reduces the quantity of runoff and associate pollutants discharging into a

stormwater system. The benefits, in terms of pollutant reduction, should be considered as part of a stormwater treatment strategy.

- *Cost* – the cost of rainwater tanks needs to be considered against alternative demand management initiatives and alternative water sources.
- *Available space* – small lots with large building envelopes may preclude the use of external, above ground, rainwater tanks.
- *Competing uses for stormwater runoff* – there may be situations where a preferred beneficial use for stormwater runoff (such as irrigation of a local public park, oval, or golf course) may provide a more cost effective use of runoff from roofs than the use of rainwater tanks on individual allotments.
- *Maintenance* – most rainwater tanks will need to be maintained by the householder or a body corporate (or similar).

These issues are further discussed below.

11.2.1 Supply and Demand Considerations

Supply and demand considerations are matters that should be examined during the concept investigation phase of a project. Nevertheless, a number of key considerations are discussed below to ensure that they are sufficiently addressed before implementing a rainwater harvesting scheme.

Low Roof Area to Occupancy Ratio

This situation is most likely to arise on projects with medium and high density residential dwellings (i.e. where the ratio of roof area to the number of occupants in the dwelling is low). In these situations, it is probably most important to maximise the use of water efficient fittings and appliances to reduce the demand on the reticulated water supply so that the additional supply opportunities that are presented by a rainwater tank are maximised.

A smaller ratio of roof area to number of occupants (ie. increasing density) has the effect of increasing the size of rainwater tank required to deliver a given *reliability*[3] of supply to the connected end-uses. With high density, multi-storey developments (> people/100 m^2 of roof), there is a diminishing opportunity for the effective use of roof water as a means of supplementary supply for internal uses. In these situations, it may be most practical to capture rainwater centrally for external uses (landscaping and car washing).

Increasing the number of end-uses connected to a tank (e.g. laundry and garden in addition to toilets) will reduce the reliability of the supply. While the reliability decreases with increasing end-uses, the total use of available rainwater increases because there is a greater frequency of drawdown and reduced frequency of overflow from the tank during storm events.

[3] The reliability of water supply is simply the percentage of water demand that is met by that supply.

The reliability of supply for internal uses may not necessarily be a concern if potable water is available to supplement a supply (e.g. a mains water top-up or switch-over mechanism).

Low Rainfall Regions

The effectiveness of rainwater tanks as a supplementary water source is reduced in low rainfall regions.

The use of rainwater tanks on projects in low annual rainfall regions will need to be considered carefully for viability as a cost effective alternative water source if mains water is available. Other potential water sources such as reclaimed water and/or greywater re-use may need to be given greater consideration in these regions as these water sources are independent of local climatic conditions and can provide a higher reliability of supply.

11.2.2 Water Quality

Water quality is an important consideration with all roof water systems, especially in urban and industrial areas. Possible pathways for contamination of roof water are:

- Atmospheric pollution settling onto roof surfaces.
- Bird and other animal droppings can pollute the water with bacteria and gastro-intestinal parasites.
- Insects, lizards and other small animals can become trapped and die in a tank.
- Roofing materials and paints. Lead based paints in particular should never be used on roofs where water is collected for potable water uses. Tar-based coatings are also not recommended, as they may affect the water's taste. Zinc can be a significant pollutant in some paints and galvanized iron or zincalume roofs (particularly when new) should not be collected for potable use. Care should also be taken to avoid dissimilar metals that may accelerate corrosion and affect water quality.
- Detergents and other chemicals from roofs painted with acrylic paints can dissolve in the runoff. Runoff from roofs made of fibrous cement should be discarded for an entire winter due to the leaching of lime.
- Chemically treated timbers or lead flashing should not be used in roof catchments and rainwater should not be collected from parts of the roof incorporating flues from wood burners.
- Overflows or discharge pipes from roof mounted appliances, such as evaporative air-conditioners or hot water systems, should not discharge onto a roof catchment or associated gutters feeding a rainwater tank.

The presence of these contamination pathways will vary from project to project and will be largely dependant on:

- The proximity of the project to areas of heavy traffic, incinerators, smelters or heavy industry, and users of herbicide and pesticides (e.g. golf course, market gardens).
- Roofing materials and roof mounted appliances.

- The provision of a well sealed rainwater tank with a first flush device and with inlet and overflow points provided with mesh covers to keep out materials such as leaves and to prevent the access of mosquitoes and other insects.

The quality of roof water collated from relevant Australian studies is summarised and further discussed in Australian Runoff Quality (Engineers Australia, 2006).

Water quality requirements of an end-use connected to a rainwater tank will be the determinant of whether or not additional water quality treatment needs to be provided between the tank and the end-use. For all non-potable uses (e.g. toilet flushing, washing machines, garden watering etc.) available monitoring data indicates that typically there are low levels of risk to consumers if additional water quality treatment (e.g. disinfection) is not provided (Coombes, 2002). One exception in this regard is where a rainwater tank is connected to the hot water system where there is a heightened potential of human ingestion of rainwater (e.g. when showering, children in the bath). If connected to the hot water system, some disinfection is required which may include providing hot water at a certain temperature (to allow for complete pasteurisation) or other disinfection methods (e.g. chlorination).

11.2.3 Stormwater quality benefits

Using collected rainwater reduces the total volume of stormwater runoff from a site and therefore reduces pollutant discharges. The percent reduction of stormwater from a site can be estimated based on the reuse demand, reuse reliability and mean annual rainfall.

$$\text{Percent reduction} = \frac{\text{Reliability} * \text{Reuse Demand (kL)}}{\text{Rainfall Volume (m}^3\text{)}}$$

Where,

Reliability	=	proportion of demand met by supply
Reuse Demand	=	avg. ann. demand per person * Number of occupants
Rainfall Volume	=	mean Annual Rainfall (m) * Contributing Roof Area (m^2)

For example, the percent reduction in stormwater from a rainwater tank that provides 70% reliability for a house in Bendigo (MAR 570 mm) with 3 occupants and a roof area of 120 m^2 is calculated as follows:

$$\text{Stormwater reduction} = (70\%)*(8 \text{ kL/p/yr}*3 \text{ people})/(0.57 \text{ m}*120\text{m}^2)$$

$$= 25\%$$

Therefore, the reduction in stormwater runoff and hence TSS, TP and TN loads from the roof due to reuse from the rainwater tank is 25%.

Additionally, rainwater tanks provide some treatment of water that is not removed from the tank for reuse (ie water that is stored for some period and then spills when the tank overflows). The dominant process is the settlement of suspended solid loads. The reduction in pollutant loads in water that is spilt from rainwater tanks is likely to be small compared with the reduction due to the removal from the system.

11.2.4 Cost Considerations

Typically the cost of a rainwater tank installation for supplementary water source ranges from $600 to $2000 for residential detached or semi-detached dwellings. Three cost components are normally involved, i.e. the cost of the tank, installation and plumbing works and the cost of a pump. Costs may increase with higher density development as space constraints could require more specialised tanks to be fitted (see next section for more discussion) unless communal use of a centralised rainwater tank can be facilitated. Local authorities in some areas also offer rebates for the installation of rainwater tanks.

The typical payback period of a rainwater supply system purely through a reduction in domestic water charges is of the order of 35 years under current two part tariff metered water pricing and will often not be able to justify the use of rainwater as an alternative source of water to mains water. This is mostly due to the present pricing of mains water not reflecting the true environmental and social cost of the water resource. There has been an emergence of terms such as 'total resource cost' and 'total community cost' in addition to the more commonly used terms of 'life cycle cost' and 'whole of life cost' in recent analysis of the value of water to more holistically reflect the beneficial outcomes associated with water conservation practices through the adoption of alternative water sources and associated matching of their respective water quality with fit-for-purpose usage. Researchers (Coombes, 2002) have shown that when such 'total resource cost' issues, and the potential benefits of rainwater capture/reuse in regard to reduced stormwater flows, are considered that more positive economic benefits can apply.

11.2.5 Available Space Considerations

Small allotments with large building envelopes are becoming more common as dwindling land stocks require the provision of smaller lots to meet increasing demand. However, the public's desire for 'traditional' sized houses remains strong and as a consequence front and back yards are being reduced to allow large houses to be built onto progressively smaller allotments. This phenomenon imposes a potential constraint on the use of rainwater tanks where tanks are installed external to a building and above ground (as is conventional practice). Competing demand for the use of external areas raises the potential for resistance to the imposition of rainwater tanks on small allotments with large building envelopes. This can be overcome by burying tanks or placing them underneath houses but these have techniques associated cost implications for construction and maintenance.

Rainwater tank designs have advanced markedly in recent times with slim line rainwater tank designs reducing tank footprints. Modular rainwater tank systems are also now being developed. These systems can be interconnected to form boundary fences or potentially walls for a garden shed or carport. Rainwater tanks in buildings can also provide energy benefits through thermal inertia of the stored water moderating temperature variations within households. Examples of slim line and modular rainwater tanks are shown in Figure 11.1.

Figure 11.1 Slim Line Tank and Modular Rainwater Tank system

The final decision on the acceptability of using rainwater tanks on small lots is likely to be influenced by the size of tank required (which is influenced by the available roof area and the water conservation outcome to be attained from a rainwater tank), the compatibility of commercially available tank systems with the built form and the available area for a tank. This decision needs to be made on a case by case basis.

11.2.6 Competing uses for Stormwater Runoff

There may be situations, especially on larger precinct-wide projects, where there may be one or more competing uses for stormwater runoff generated from roof areas and ground level impervious surfaces. Rainwater tanks may not provide the optimal strategy from a sustainability perspective, especially when comparing the life cycle cost and resource use outcomes of a centralised stormwater harvesting scheme with a de-centralised rainwater harvesting scheme. These issues need to be investigated thoroughly during the concept design stage of a project.

A common example of such competing uses is that associated with residential development adjoining public open spaces and golf courses. In development scenarios such as this, it is often more cost effective (from both capital and asset maintenance cost perspectives) to implement a precinct-wide stormwater harvesting scheme and supply the water for public open space watering.

11.2.7 Maintenance Considerations

Whilst the maintenance of a rainwater tank based mains supply augmentation system is not particularly arduous for a property owner, it is nevertheless an additional requirement for households that normally would have their water supply sourced from a reticulated water supply system. This may have possible long-term impacts on the sustainability of a rainwater tank supply scheme, especially if homeownership changes, though with more realistic water pricing policies and appropriate education practices, the impacts of this consideration should be minimal. Further discussion on the maintenance elements of a rainwater tank/reuse system is provided in Section 11.5.

11.3 Australian standards for installation of rainwater tank systems

Rainwater tanks need to be installed in accordance with the **National Plumbing and Drainage Code (AS/NZS3500.3:2003)** and the **Tasmanian Plumbing Regulations 2004**.

While not strictly a standard, rainwater should only be sourced from roof sources, and flows from roads, footpaths, and other common areas at ground level, are addressed through separate stormwater treatment processes. If supply is supplemented by an interconnection with a reticulated water supply, backflow prevention via either an air gap or proprietary device is required in accordance with Australian Standard AS 3500.1.2 (1998) and the requirements of the local water supply authority. For treatment and usage it is suggested that[4]:

- The collection system should incorporate a first flush device or "filter sock" to divert or filter initial run-off from a roof.
- The tank system should be connected to the toilet, hot water, laundry and garden irrigation fixtures, and there should be no direct supply from the mains water to these services.
- There should be no connection to other indoor fixtures from the rainwater tank unless measures are undertaken to make the supply fit for consumption.
- The tank is enclosed and inlets screened, in order to prevent the entry of foreign matter and to prevent mosquito breeding.
- Overflow from a rainwater tank should be directed to a detention device, swale or stormwater drain.

[4] Donovan, I., (2003). Water Sensitive Planning Guide for the Sydney Region, Upper Parramatta River Catchment Trust.

11.4Design procedure: rainwater tanks

Design considerations when evaluating a rainwater tank system include the following:

- selection of end-uses
- determination of size of tank required/desired
- hydraulic fixtures
- water filter or first flush diversion
- mains water top-up supply
- on-site detention provisions
- maintenance provisions.

11.4.1 Selection of end-uses

Water consumption in a household varies depending on the type and location of the house. Typical water consumption figures for residential areas expressed on a per capita basis are summarised in Table 11-1.

It is important to not overlook the effect of using water efficient appliances on reducing water demand when sizing rainwater tanks. Consumption of water for toilet flushing has reduced significant since the mandatory introduction of dual flush toilets over a decade ago. Table 11-2 lists the likely reduction in indoor household water demands resulting from the adoption of such water efficient appliances.

Table 11-1 Typical Household Water Consumption in Melbourne [adapted from Water Resources Strategy for the Melbourne Area Committee, 2001]

Water Uses	Per Person Usage (kL/person/yr)	Percentage of total usage
Garden	32	35%
Kitchen	5	5%
Laundry	14	15%
Toilet	18	19%
Bathroom	24	26%
Total	92	
Hotwater	24	26%

Table 11-2 Estimation of Reduction in Water Demand by Water Efficient Appliances [adapted from NSW Department of Infrastructure Planning and Natural Resources, 2004]

Water Uses	Conventional Demand (kL/person/yr)	Reduced Demand with Water Efficient Appliances and Fittings (kL/person/yr)
Shower	20.8	13.5
Bath	3.2	3.2
Hand Basin	2.2	1.2
Toilet	12.8	7.3
Washing Machine	17.0	11.9
Kitchen Sink	4.4	2.3
Dishwashing	1.1	0.6
Total	61.5	40.0

The most obvious water uses for rainwater are toilet and garden supply as they avoid the requirement for treatment to potable standards. Replacement of mains potable water for toilet flushing is considered to be the more effective of the two because of its consistent demand pattern and thus a higher reliability of water supply can be achieved for a given rainwater tank size. Whilst having a higher water demand, water usage for garden watering is seasonal and the demand pattern is "out-of-phase" with the supply pattern (ie. high garden watering demand occurs during low rainfall periods) and thus a larger rainwater tank storage may be required to achieve comparable reductions in potable water usage compared with toilet flushing.

Following the use of rainwater for toilet flushing and garden watering, the next appropriate use of rainwater is in the laundry (e.g. washing cold tap). Supplementing the supply for hot water is also an effective option. Hot water usage constitutes approximately 30% of household indoor usage. The quality of water delivered from a rainwater tank via a hot water system is improved by the combined effects of high temperature pasteurisation, pressure in the pump and the instantaneous heat differentials between the rainwater tank and a hot water service.

11.4.2 Tank Size and Supply Reliability

The supply reliability of a rainwater tank is directly influenced by three factors,

1. supply characteristics – as defined by the size of the catchment (ie. roof area connected to the rainwater tank) and the rainfall pattern of a region (mean annual rainfall and seasonal pattern).

2. demand characteristics – as defined by the type of uses. If indoor use, this is dependent on household occupancy and if for garden watering, demand is dependent on garden design and climatic conditions of the region.
3. storage size

Owing to the intermittent nature of the supply of rainwater, the most appropriate analytical approach for assessing the reliability of supplies is a continuous simulation (modelling) approach using long records of rainfall data. Australian Runoff Quality (Engineers Australia, 2003) provides a detailed discussion on appropriate modelling techniques for determining a relationship between tank size and rainwater supply reliability.

For any assessments evaluating more widespread usage of rainwater, rigorous assessments using models such as PURRS, AQUACYCLE and UVQ are recommended (see Chapter 5 and 13 of Australian Runoff Quality for guidance in this regard). Mass balance analyses using long-term rainfall data and demand patterns may also be completed using spreadsheet software.

Table 11-3 Sources of further information on the use of rainwater tanks

Source	Web Address
Aust. Environmental Health Council	http://enhealth.nphp.gov.au/council/pubs/ecpub.htm
Gold Coast City Council	http://www.goldcoast.qld.gov.au/attachment/goldcoastwater/GuidelinesTankInstall.pdf
Lower Hunter & Central Coast Regional Environmental Management Strategy	http://www.lhccrems.nsw.gov.au/pdf_xls_zip/pdf_wsud/4_Rainwatertanks.pdf
Sydney Water	http://www.sydneywater.com.au/everydropcounts/garden/rainwater_tanks_installation.cfm
Department of Environment & Heritage, South Australia	http://www.environment.sa.gov.au/sustainability/pdfs/rainwater_final.pdf
Your Home Consumers Guide [A joint initiative of the Australian government and the design and construction industries	http://www.greenhouse.gov.au/yourhome/technical/fs22_2.htm

Inlet Filter

Some form of filter is strongly recommended on all flows being directed to a rainwater tank. This filter will provide a primary treatment role in regard to removing leaf litter and some sediment that would otherwise enter the tank, and possibly contribute to water quality degradation. Such a filter can also serve to isolate the tank from access by vermin and mosquitoes.

First Flush Diverter

Diversion of the 'First Flush' from a roof is also a recommended practice, as this can minimise the ingress to the tank of fine particulates, bird/animal faeces and other potential contaminants. Current research does not enable the specification of a definitive First Flush, with values between 0.25 and 1.0mm of runoff typically being quoted.

Proprietary devices are available, that often provide a joint 'Filter/First Flush' diversion role. Alternatively, a first-flush device can be made from readily available PVC fittings.

Maintenance Drain

Periodic removal of sludge and organic sediments that accumulate in the base of a rainwater tank may be necessary is build up is excessive, and as such a suitable outlet should be provided. It has been suggested that this sludge layer, and biofilms that develop on the walls of a tank, may play a role in the natural purification processes occurring in the tank therefore removing a sludge layer should only occur when build up impedes the tank operation.

Mains Top up

Most rainwater tanks will require an automatic top-up system to ensure uninterrupted supply to the household. This top-up should occur as a slow 'trickle' such that there are benefits in regard to reducing peak flow rates in the mains supply system (which, if properly planned, can enable smaller mains infrastructure to be installed in a 'greenfields' situation).

The volume/rate of top-up should be such that there is always at least one day's supply contained within the tank. Top-up should also occur when tank levels are drawn down to a depth of 0.3m, or one day's capacity, whichever is the greater, to both guarantee supply and to minimise sludge/sediment resuspension.

A final consideration with any top-up system is that there is a requirement for an 'air gap' between the top-up supply entry point and the full supply level in the tank in order to ensure there is no potential for backflow of water from the tank into the potable supply system. A suitable air gap is of the order of 100mm. Backflow prevention should also be installed at the property stop-tap.

Alternatively, a proprietary device to automatically switch from tank supply to the mains supply when the tank is low may be installed. This negates the need for moving parts inside the tank or the potential for a top-up mechanism failure causing the mains supply to run into the tank when not required. A failure such as this may not be noticed by the property owner until the next water bill arrives as the mains water could be running through the full tank and into the overflow stormwater connection.

Overflow

Rainwater tank overflows should be directed to the stormwater collection system. In areas with suitable soils and slopes, discharge to a lot scale infiltration trench may also be possible (see Procedure 8 for more detail in this regard).

Overflows should also be located below the mains top-up supply point in order to prevent the potential for backflow.

Pump

The supply to the household from the rainwater tank can occur via a pressure pump system, or alternatively a solar panel/pump/header tank system may be implemented, if low heads are acceptable. Careful selection of a suitable pump system is recommended to minimise operational costs and noise issues.

On-site Detention

In some situations, rainwater tanks can be configured with an active 'detention' zone located above the 'capture and reuse' zone. This system reduces the effective yield from a tank, but may deliver greater downstream stormwater conveyance benefits through the delivery of lower peak flows for low to moderate ARI events. In such applications, it is important to ensure that the potable supply top-up is located above the 'detention' zone, not just the 'capture and reuse' zone.

11.5 Inspection and maintenance

Rainwater tanks are low maintenance, not no maintenance systems. Good maintenance practice is necessary and should include:

- Routine inspection (every 6 months) of roof areas to ensure that they are kept relatively free of debris and leaves. Roof gutters should be inspected regularly and cleaned if necessary. There are special gutter designs available for limiting the amount of debris and litter that can accumulate in the gutter to be subsequently transported to the rainwater tank. These special gutters cost about twice normal guttering but require little maintenance. Leaf screens may also be installed in most standard gutters and provide a cheap method of preventing excessive leaf litter accumulating in the guttering.
- It may be necessary to prune surrounding vegetation and overhanging trees which may otherwise increase the deposition of debris on the roof.
- First flush devices should be cleaned out once every 3 to 6 months, or as required.
- All screens at inlet and overflow points from the tank should be inspected regularly to check for fouling, at least every 6 months.
- Tanks should be examined for the accumulation of sludge at least every 2 to 3 years. If sludge is covering the base of the tank and affecting its operation (i.e. periodically resuspending, or reducing storage capacity) it should be removed by siphon, flushed from the tank or by completely emptying of the tank. Professional tank cleaners can be used.
- Any pumping system should be maintained in accordance with the manufacturer's specifications.

11.6 References

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