WATER SENSITIVE URBAN DESIGN

RAINWATER TANK DISCUSSION PAPER

FINAL

Prepared for the Northern Territory Department of Planning and Infrastructure
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Darwin NT 0801

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1 INTRODUCTION

1.1 Background and Purpose of this Discussion Paper

A Water Sensitive Urban Design (WSUD) Strategy is being developed for Darwin Harbour. One of the core initiatives of WSUD is the conservation of potable water. The import of high quality water into urban areas in Darwin relies on the extraction of water resources that have significant impacts on aquatic ecosystems, such as the Darwin River as well as the sharing of limited resources with other users, such as extractions from the McMinns and Howard East bore field.

Water consumption in the Northern Territory is significantly above the national average. Darwin residents use twice as much water per head as people in other capital cities. While there are contributing factors, such as a warmer and drier climate in Darwin compared to other cities in Australia, there is significant potential for potable water conservation through efficiency measures and non-potable water substitutions measures.

Rainwater tanks are one potential option for substitution that have received considerable discussion in Darwin. It is evident that there is much debate and confusion over the use of rainwater tanks in Darwin in the wet/dry tropics. While some advocates of rainwater tanks promote the use of rainwater tanks for domestic use others consider rainwater tanks inappropriate in the Darwin context due to the highly seasonal nature of rainfall and irrigation. This paper discusses the feasibility of rainwater tanks in the Darwin Harbour and suggests the most appropriate use of rainwater tanks in the Darwin region.

The WSUD Strategy is progressing in accordance with the Workplan shown in Table 1 below. This draft discussion paper has been developed as part of Task 12 (Stage 5) of the Workplan.

1.2 Outline of the document

This paper initially presents a discussion of the issues surrounding the use of domestic rainwater tanks and the feasibility of their use for potable water conservation. This is followed by a review of the relevant positions of the Northern Territory Government and an overview of Australian legislation and policy applying to rainwater tanks.

The key component of this discussion paper is a technical analysis of rainwater tank performance in Darwin under various scenarios. Key considerations of the technical analysis include rainfall variability, residential water consumption patterns, typical roof areas and end uses of rainwater.

The paper explores the limitations of rainwater tanks for residential use in the Darwin region and important design considerations for the use of rainwater tanks are outlined.

Finally key recommendations are made for use of rainwater tanks.

Table 1: WSUD Strategy for Darwin Harbour - Workplan

STAGE	TASK #	Activity
1	1	Refine workplan
	2	Establish project working group.
2	3	Develop WSUD Strategies for case studies in suitable format for communication and identify case studies for sub-catchment scale application of WSUD treatment train. • *WSUD Showcase - Bellamack residential sub-division conceptual WSUD Strategy is complete* • *Design development of Bellamack WSUD Strategy is about to commence (see Task below)*
	4	Identify potential WSUD objectives for Darwin • *Stakeholder workshop held on 14th and 15th June 2007* • *WSUD Objectives for Darwin - Discussion Paper (EDAW, Oct 2007)*
	5	Critical Analysis of WSUD/Stormwater Treatment Options for Darwin • *Stakeholder workshop held on 14th and 15th June 2007* • *Water Sensitive Urban Design Stormwater Treatment Options For Darwin - Discussion Paper (EDAW, Oct 2007)*
3	6	Prepare a stakeholder communication and consultation strategy (including establish website, fact sheets, presentations). *About to commence in collaboration with WQPP*
	7	Prepare and communicate a definition of WSUD within Darwin *About to commence in collaboration with WQPP*
	8	Review and report on policy, programme, technical and decision-support systems for WSUD in Australia (including any barriers to uptake of WSUD and respective jurisdictional responses). About to commence in collaboration with WQPP
	9	Identify potential barriers to uptake of WSUD in the NT. Develop strategy to address barriers. *Much of this work is complete as part of the Darwin Harbour Regional Plan of Management and WSUD projects elsewhere in Australia. This is to be summarised in a discussion paper. If the Working Group identify the need to further define the barriers a stakeholder workshop and interview process will be undertaken.*

STAGE	TASK #	Activity
4	10	Develop WSUD Strategies for case studies in suitable format for communication and identify case studies for sub-catchment scale application of WSUD treatment train. *WSUD Showcase - Complete design development of the Bellamack WSUD Strategy* *Identify and scope work associated with "retrofit" WSUD case study*
	11	Prepare detailed workplan for development of NT WSUD policy, objectives, design manual, performance standards and decision-support tools.
5	12	**Prepare draft NT WSUD policy and objectives for Darwin including understanding existing legislation, workshops etc.**
	13	Assess application of WSUD objectives and management practice options across a range of development situations and/or catchment-scale treatment-train & confirm set of objectives.
	14	Undertake consultation of draft WSUD policy and WSUD objectives to stakeholders and barriers to WSUD.
6	15	Define requirements of WSUD Guidelines and Tools (workshop to define design needs in detail and assess whether exiting guidelines satisfy this need)
	16	Document Draft WSUD Guidelines and Tools in including High Level and Conceptual Design Guideline, Technical Design Guideline and Design Tools (MUSIC Guidelines, Deemed to Comply Solutions, Standard Drawings etc.)
	17	Prepare Draft WSUD decision support tools for Darwin Harbour, consistent with WQPP, linking policy, objectives and guidelines
7	18	Undertake stakeholder consultation of WSUD Policy, WSUD design manual and performance standards, and decision support Tools and seek approval.
	19	Finalise WSUD design manual, decision support tools and performance standards
8	20	Seek NT Government approval for WSUD Policy, WSUD design manual and performance standards and decision support tools.
	21	Develop and publish stormwater management plans for key subcatchment in Darwin to illustrate application of WSUD Policy/Framework, design manual and decision support tools.
9	22	Develop an implementation strategy for incorporating policies and provisions for WSUD within NT planning policies, strategic plans and development approval processes as well as local government instruments
	23	Ongoing communication and website management
	24	Capacity Building and Training including government, local authorities, developers and industry practitioners
10	25	Incorporate policies and provisions for WSD into NT government planning policies, strategic plans and development approval processes, as well as relevant local government instruments. Implement agreed strategy to address barriers to uptake of WSD.

2 Are rainwater tanks feasible for urban use in the Darwin region?

Roughly 3% of households in the Northern Territory use rainwater tanks (RWTs) compared to 13% of households in Australia using rainwater tanks as their primary source of drinking water (enHealth 2004). While rainwater tanks are more commonly used outside of metropolitan centres the use of rainwater tanks is being promoted in urban areas for non-potable uses, in various states around Australia.

In particular rainwater tanks are being installed in new developments in many parts of Australia. For example:

- In NSW BASIX incorporates a 40% potable water reduction target for all new dwellings, of which rainwater tanks are a common water conservation measure,
- In South East Queensland all new detached dwellings have a 70KL/yr potable water reduction target and 42 kl/yr potable water reduction for terrace and townhouse, of which rainwater tanks are one potential water conservation measure,
- In Victoria, new dwellings must include a rainwater tank or a solar hot water system,
- In Canberra all new dwellings require a rainwater tank,
- Substantial rebates are available from State governments and Councils for Sydney, Brisbane, Melbourne and the ACT.

The change in policy in the eastern states has created interest regarding the feasibility of rainwater tanks in urban areas in the Darwin region. The key concern regarding the feasibility of rainwater tanks in the Darwin region is the seasonal nature of rainfall in the wet season and the corresponding but opposite high irrigation demand during the dry season. Irrigation in the top end constitutes a significant portion of household water demand. This is discussed further in Section 2.1.

There is also a secondary concern associated with the supply of hot water systems with rainwater. This is discussed further in section 2.2.

2.1 Climatic challenges to rainwater supply

The marked seasonality of rainfall in the wet/dry tropics is perceived as the major barrier to the adoption of rainwater tanks in urban areas in the Darwin region. The distinct dry season corresponds to the highest demands for garden irrigation. The high irrigation demands would rapidly deplete rainwater tanks of sizes suitable for installation in domestic situations. The tank sizes required to meet demand (especially outdoor) during the dry period would be highly impractical within a residential setting. In contrast, residential tanks under 10 kL will overflow frequently in the wet season, when there is little irrigation demand.

However, if rainwater tanks are plumbed to a regular daily internal use, it is likely that rainwater will supply a high proportion of internal uses during the wet season due to the regular frequency of rainfall. The constant daily internal use draws-down the rainwater tank frequently, creating more room to capture subsequent wet season. These tanks will be empty for most of the dry season.

This discussion paper analyses the volumes of rainwater that can be supplied in this scenario to determine if rainwater tanks are feasible in Darwin and if so under what circumstances.

2.2 Rainwater reuse in hot water systems

Power and Water (2007) does not recommend that rainwater be used in hot water systems based on an 'increased infection risk' and the 'possibility of accelerated corrosion of the hot water service tank'.

The possibility of accelerated corrosion of the hot water service tank primarily refers to the potentially corrosive effect of soft water (rainwater) reuse in hot water systems fitted with anodes designed to cope with hard water. To avoid this potential issue, rainwater tanks in areas that are serviced by a potable water supply that is considered hard (> 200 mg/L of calcium and magnesium) should not be plumbed to hot water systems. This is unlikely to be a concern with hot water systems in the Darwin Region. The hardness and total dissolved solids (TDS) found in Darwin potable water supplies is outlined in Figure 1. This indicates that hot water systems are currently supplied with soft water and anode corrosion is unlikely with rainwater use.

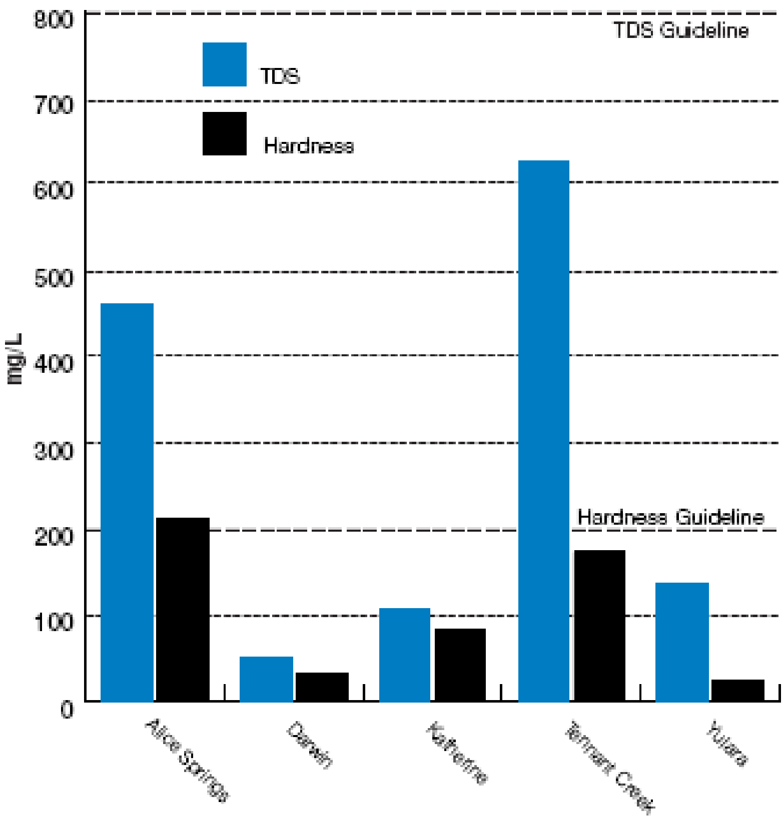

Figure 1 TDS and Hardness values of various water supply systems in the NT (PWC 2004)

The concern of increased infection risk is discussed in the national Guidance on the Use of Rainwater Tanks (enHealth 2004). The NT Department of Health and Community Services considers enHealth (2004) the primary reference in regards to the use of rainwater tanks. These guidelines summaries various research which found that the minimum temperature stipulated for hot water systems inactivated 99% of the enteric illness causing bacteria.

Furthermore various states around Australia are actively promoting connection of rainwater tanks to hot water systems. For example in NSW the introduction of BASIX has seen rainwater tanks connected to almost 10% of hot water systems in new dwellings (DoP, 2007) and more than 70% of washing machines.

2.3 Other Barriers to feasibility of Rainwater Tanks

A study of major barriers by those considering installing a RWT on an existing house were cost (38%) and lack of room (15%) (enHealth 2004). A discussion of cost of rainwater tanks in the Darwin Context is discussed in section 5.

In urban areas the issue of space has been noted as a concern for residents not wishing to lose area to a large tank. In Darwin this discussion paper has found that only small rainwater tanks are required which take up relatively small footprints easily able to be designed into common block sizes in Darwin. Furthermore, there are now a range of rainwater tank designs and shapes providing flexible options for location, further increasing the applicability of rainwater tank installation in a residential setting. Designs include traditional and custom made tanks, as well as modular, slimline and bladder designs in a variety of materials.

3 Policies and regulations for the use of rainwater tanks

3.1 NT Government position on rainwater tanks in urban areas

Rainwater may be collected and used as a private water supply anywhere in the Northern Territory. The reticulated water supplier for the Darwin region, Power and Water Corporation, considers rainwater tanks and greywater systems as alternative supplies of water and hence not handled by the water provision service. A building permit from the Department of Planning and Infrastructure is not required for the installation of a rainwater tank as long as the tank stand is no greater than 600 mm above ground level. In addition, rainwater tanks are not subject to setback requirements.

If a reticulated mains water supply is connected either directly to a rainwater tank (for top up) or through another appliance, a backflow prevention device must be fitted at the meter to prevent rainwater entering the mains system. These devices must be in accordance with the Rainwater Tank Design and Installation Handbook (HB230-2006) published by Standards Australia. Any tank overflows are required to be directed to the stormwater system and not the sewerage system.

The Department of Health and Community Services (DHCS) in the Northern Territory is the primary authority responsible for guidance regarding the residential use of rainwater tanks. The DHCS looks to the enHealth document Guidance on the use of rainwater tanks May 2004 as the peak reference for the use of rainwater tanks as potable water supply.

The installation of a rainwater tank does not require approval from the DHCS Environmental Health Program, which instead provides an ‘Environmental Health Information Bulletin’ on the ‘Requirements for the Use of Rainwater Tanks’ (DHCS 2006). This bulletin indicates that the DHCS considers properly installed and maintained rainwater tanks as an excellent and safe source of potable water, especially in situations where reticulated supply is of poor quality and where low yield bore fields are utilised (DHSC 2006).

Aspects that the DHCS outline as requiring consideration before the installation of a rainwater tank include

- yield feasibility in regards to tank size, roof area and rainfall characteristics.
- the fitting of first flush devices and the provision of adequate screening to prevent insect breeding is also outlined as well as an ongoing maintenance and repairs program for the system (DHSC 2006). Regulation of screen gauges in the NT (introduced in 1998) to prevent insect entry to rainwater tanks stipulate that mesh must be of 33 gauge brass or bronze wire with no more than 7 holes to the centimetre each way.

Currently, Power and Water (2007) does not recommend that rainwater be used in hot water systems. based on an ‘increased infection risk’ and the ‘possibility of accelerated corrosion of the hot water service tank’. A discussion of these issues is discussed in more detail in section 2.2.

The Department of Natural Resources, Environment and the Arts (NRETA) offers a Plumbing Rebate of $500 for the connection of a rainwater tank to internal demand (such as drinking water) for households in Tennant Creek and Alice Springs. This rebate is part of the NT Waterwise Central Australian Rebate Scheme.

3.2 Australian standards

The enHealth Council, a subcommittee of the National Public Health Partnership, produced the Guidance on the use of rainwater tanks (enHealth 2004). In general, the use of rainwater tanks to provide potable water supplies is a low risk activity, especially if a preventative risk management approach is adopted. For domestic rainwater tank users a ‘system analysis’ and ‘system management’ framework is suggested by enHealth (2004) in order to manage tank water quality. System analysis involves identifying and assessing hazards to water quality and system

management involves preventative measures to minimise risk, such as fitting a first flush device (first 20 – 25 L bypasses the tank) and conducting visual monitoring.

Various State Health Departments around Australia support the use of rainwater tanks for a range of end uses including hot water in urban areas. This is discussed in further detail below.

3.2.1 Queensland

Queensland Health (2008) has responded to the changing circumstances surrounding the adoption of rainwater tanks in urban areas by stating its endorsement of the use of rainwater provided that the:

> rainwater tank and rainwater collection and distribution system are appropriately designed, installed and maintained and the quality of the water is appropriate for the intended use. All rainwater tanks, regardless of their intended use, shall be designed, installed and maintained to prevent mosquito breeding.

Queensland Health (2008) supports the use of rainwater for all uses in urban areas, where a reticulated water supplyis available, other than drinking and food preparation. In particular rainwater tanks for hot water is supported provided that hot water is heated to at least 60^{o}C.

Mosquito borne diseases such as Dengue and Ross River fever are a key concern because rainwater tanks are a favoured breeding site for mosquitoes that spread these illnesses and the large volumes makes them more likely to produce large numbers of larvae. Hence for this reason, all tanks must comply with the Mosquito prevention and destruction section of the Health Regulation Act.

3.2.2 Victoria

The Victorian Department of Human Services (2007) has published a guideline for rainwater tanks in urban communities. This guideline recommends rainwater is suitable for

> a range of purposes, including personal washing, toilet flushing, laundry use, surface and equipment washing, topping up spas and pools, garden irrigation, cooling and heating, and many industrial processes.

Human Services does not recommend rainwater for drinking or food preparation in areas where a mains water supply is provided. In particular Human Services recommends rainwater for hot water services noting that hot water services that heat and store water at 60°C will provide treatment for most microbial contaminants in rainwater, and so the use of untreated rainwater in these systems should be acceptable in most scenarios.

3.2.3 New South Wales

NSW Health (2007) supports in urban areas the use of rainwater tanks for:

> non-drinking uses, such as toilet flushing, washing clothes or in water heating systems, and outdoors for uses such as garden watering, car washing, filling swimming pools, spas and ornamental ponds.

NSW Health has also endorsed the National Guidelines and refers to these guidelines for further detailed information on the correct installation and management of rainwater tanks.

4 Technical analysis of Rainwater tank use in Darwin

A technical assessment of the feasibility of the use of rainwater tanks for use in urban areas in the Darwin region was undertaken. Key input and parameter modelled, using Model for Urban Stormwater Improvement Conceptualisation included:

- residential end use.
- rainfall data
- roof sizes
- tank size

4.1 Modelling Parameters

4.1.1 Estimation of indoor and outdoor residential water demand

The average potable water consumption for residential dwellings in Darwin is approximately 437 kL/house/year (PWC 2006a). Estimates of outdoor water use for the Darwin region vary. Power and Water (2006b) estimated approximately 65% of all water use used for irrigation.

To determine residential indoor demand it was assumed that Darwin was similar to other capital cities around Australia. It is assumed that indoor consumption is relatively constant around capital cities in Australia. Based on an average 2.6 dwellings (ABS, 2006) and approximately 67 kL/person/year of residential indoor demand gives an average indoor consumption of 175 kL/household/year (Wilkenfeld, 2003). Thus the approximate outdoor usage is 264kl/household/yr or 60% of residential demand.

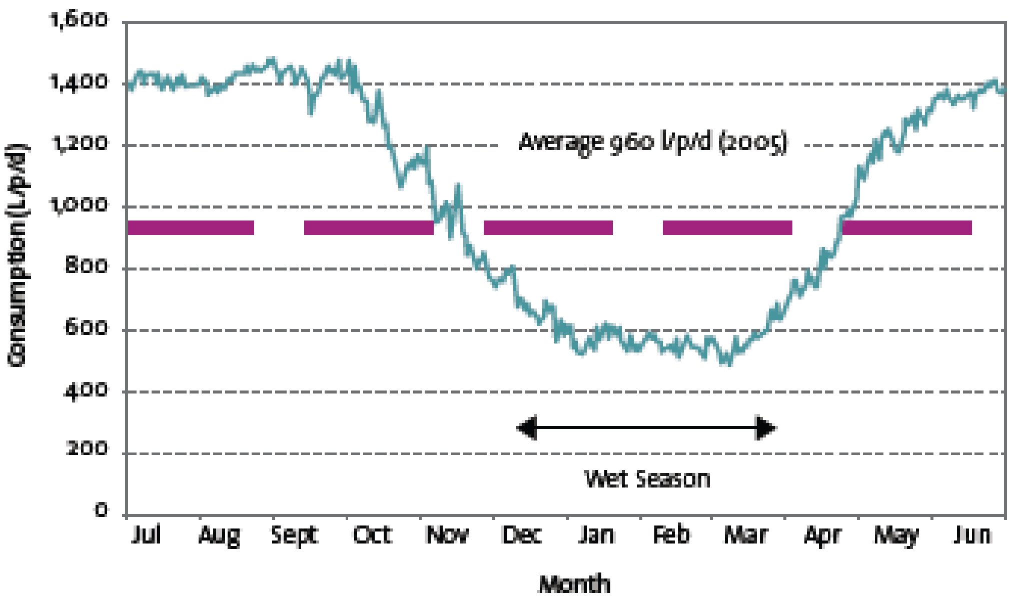

Figure 2 Total annual water demand for Darwin (PWC, 2006b)

Outdoor water use in the Darwin region is characterised by a distinct seasonality in water demand evident in Figure 2. It is important to note that the included figure of 960 L/person/day supplied in Figure 2 is the total residential *and* government/commercial water usage averaged over the regional population.

Irrigation was assumed to primarily occur during the dry season and Figure 2 was used to estimate the seasonality in residential water demand that could reasonably be attributed to outdoor use during this time. The subsequent estimation of the seasonality of residential water use is shown in Figure 3.

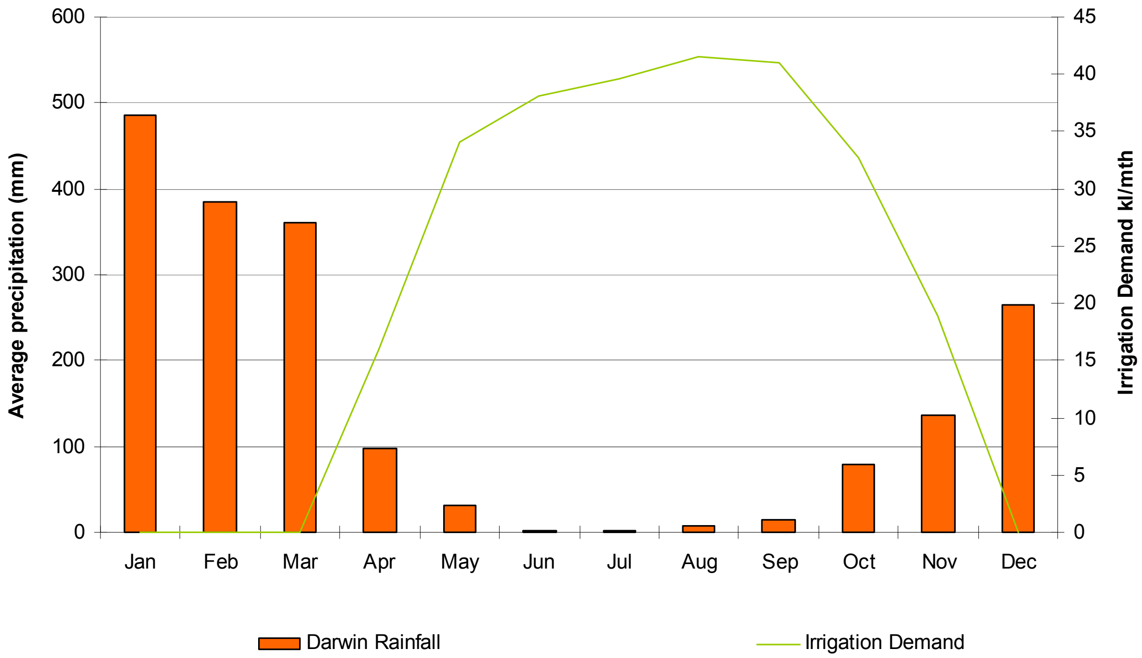

Figure 3 Estimated irrigation use compared to rainfall in Darwin

Indoor consumption was further broken down into *toilet*, *laundry*, *shower* and taps and other use categories based on the proportions in *Darwin Water Story* (PWC 2006b). A further hot water component was extracted from these divisions based on typical residential proportions (Wilkenfeld, 2003). Note that the laundry category used in the construction of various rainwater supply scenarios refers to the cold water component only.

Table 2 Internal End Use Breakdown

End Use	% of internal use	Hot Water Component
Toilet	25	0%
Laundry	27	20%
Shower	40	70%
Taps and dishwasher	8	70%

4.1.2 Examination of spatial rainfall characteristics for the Darwin region

Twenty rain gauges in the Darwin region were examined for data quality and length of record. Four of these gauges were selected, based on continuity and location, in order to assess the spatial distribution of rainfall over the Darwin region. Four rainfall stations were chosen along an east-west gradient with approximately 20km spacing between all the stations. A common 35 year period of rainfall data was used to calculate the average precipitation and number of raindays per month for each gauge and is summarised in Figure 4.

As is shown in Figure 4, differences between the rainfall gauges are minimal. There were minor differences in monthly precipitation and number of raindays during the wet season (December to March). Thus, there is little spatial variation in rainfall over this area. For the purpose of sizing rainwater tanks in the Darwin region it is possible to use one rainfall station to accurately estimate reuse reliability. The Darwin Airport station was used for all analysis due to its central location within the study area and the high data continuity of this record.

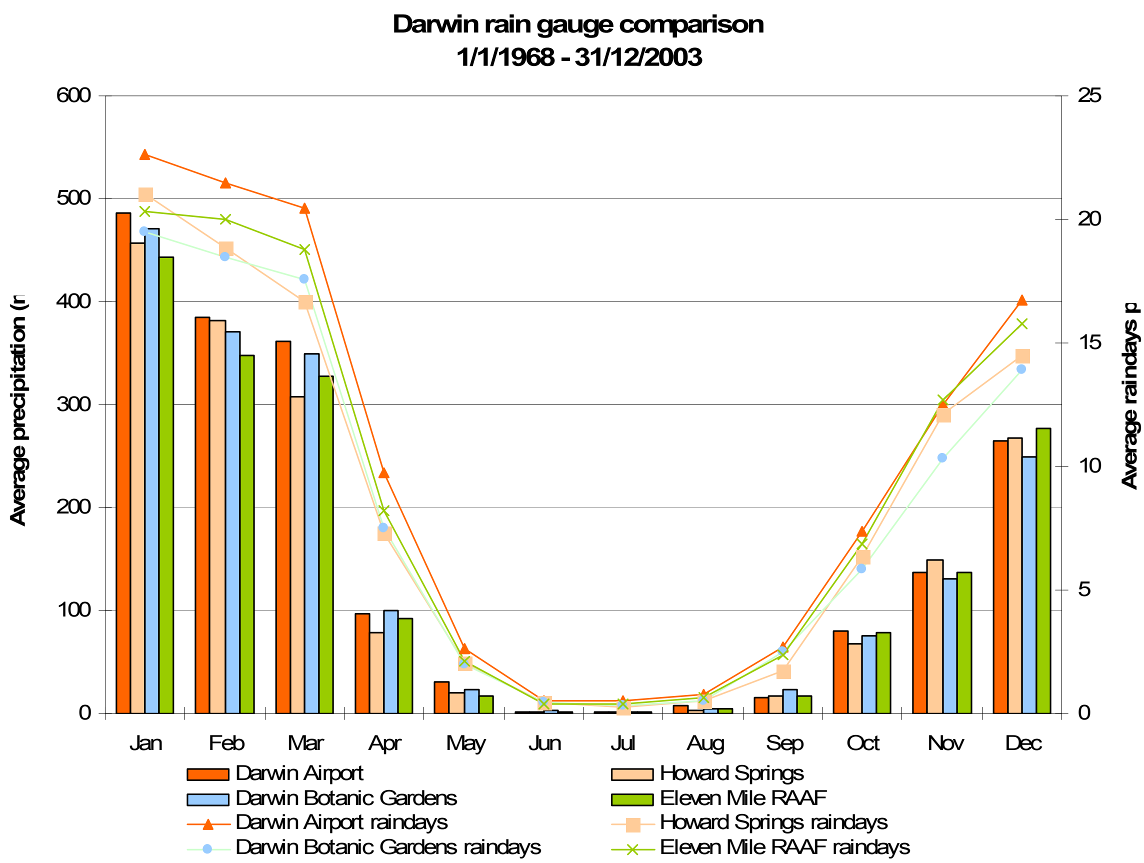

Figure 4 Rain gauge comparison for average monthly precipitation (mm) and number of raindays per month

4.1.3 Rainwater tank sizing

A number of different demand scenarios were modelled using a range of common residential tank sizes from 0.5kL up to 10 kL. These volumes are readily available in several dimensions, materials and designs suitable for residential dwellings.

4.1.4 Roof areas

Roof area measurements were taken from several detached dwellings in urban areas. Four representative roof sizes were selected and 75% of the roof area was assumed to be connected to the rainwater tank, resulting in effective roof areas of 120, 220, 320, and 420 m^2.

4.1.5 Modelling scenarios summary

Every combination of the following parameters, and their corresponding ranges were modelled

- Rainwater tanks:0.5, 1,2,5, 7.5, 10 kL

- End use scenarios: outdoor; toilets; toilets and laundry; toilets, laundry and hot water.
- Roof areas: 120, 220, 320 and 420 m^2
- Occupants: 1,2,3, and 4

4.2 Results

A summary of results of the various modelling scenarios detailed in section 4.1.5 are discussed in the following sections. Detailed charts of the all the scenarios can be found in Appendix A.

4.2.1 Rainwater Tanks and Irrigation

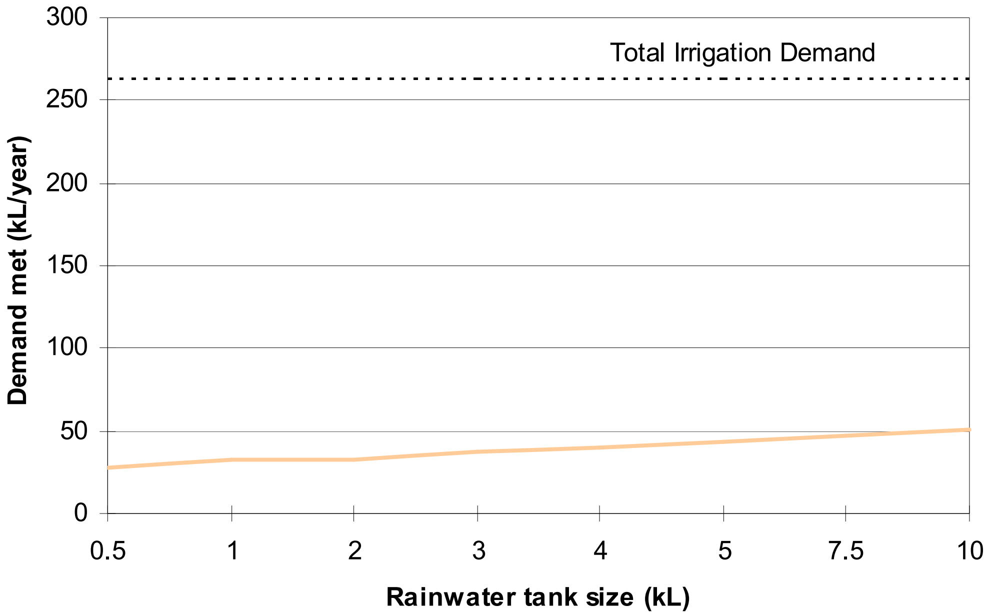

Figure 5 Sizing curves for outdoor demand met (seasonally distributed 262 kL/yr) for a 220 m^2 roof

The proportion of irrigation demand (estimated as 262 kL/house/year) that can be met by the modelled rainwater tanks sizes is summarised in Figure 5. Overall, as expected, the amount of irrigation that can be met by rainwater tanks in the Darwin region is limited by the distinct seasonality of irrigation and rainfall. Figure 5 shows that a 2kL tank can supply approximately 30kL of irrigation demand while a 10 kL tank can meet approximately 50kL of the total irrigation demand (20% of the total irrigation demand).

4.2.2 Rainwater Tanks and Indoor Demand

Three indoor demand scenarios were constructed to investigate the potential for supply from rainwater tanks and to assess appropriate sizing:

- toilet + laundry (cold) + hot water supply,
- toilet + laundry (cold) supply and
- toilet supply only.

Figure 6 summarises the results for a typical household of 3 people with a minimum roof size of 220 m^2 connected to rainwater tanks varying from 0.5kL to 10kL. These results show that

- the greatest replacement of potable water with rainwater occurs when the rainwater tank is connected to toilets, laundry and hot water.

- a 1 to 2 kL rainwater tank is an optimal size for most rainwater tank scenarios with increases in tank sizes beyond 2kL gaining relatively small increments in substitution of potable water consumption.

Based on this modelling it is estimated that a 2kL tank in this scenario will save approximately 80kL of water or 45% of total indoor demand and 18% of total household demand.

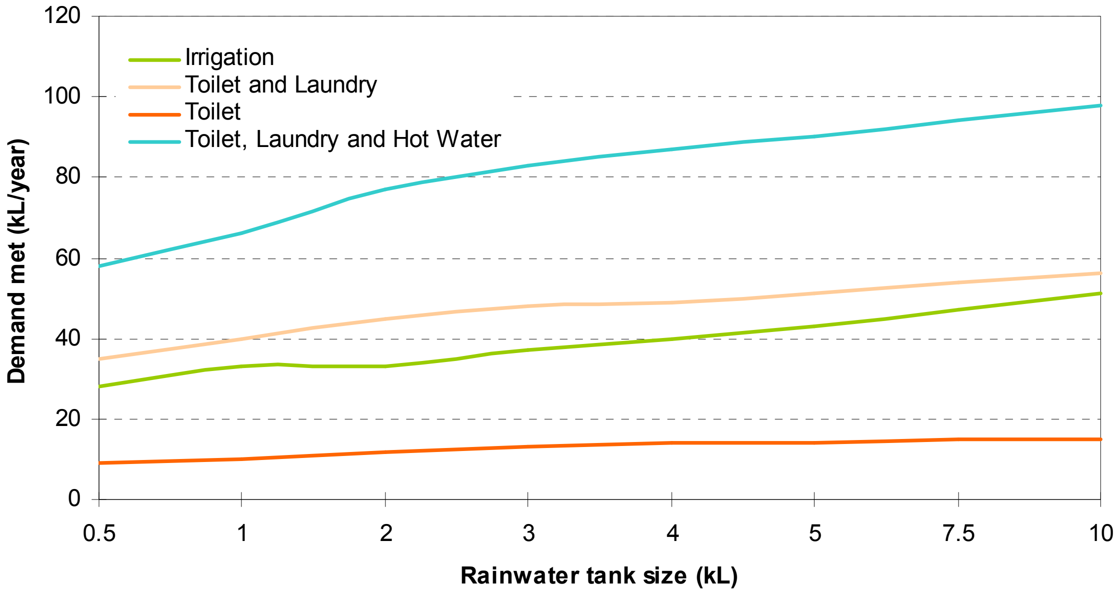

Figure 6 Rainwater tank reuse volumes and indoor demands

4.2.3 Rainwater tanks and indoor and outdoor demand

Two demand scenarios were constructed for a combination of indoor and outdoor use including

- toilet + laundry (cold) + hot water + outdoor situation and

- toilet + laundry (cold) + outdoor situation.

Figure 7 summarises the results for a typical household of 3 people with a minimum roof size of 220 m^2 connected to rainwater tanks varying from 0.5kL to 10kL. These results show that

- adding outdoor demands to rainwater tank models saves an additional 10 to 15kL a year of potable water in most scenarios.

- the greatest replacement of potable water with rainwater occurs when the rainwater tank is connected to toilets, laundry and hot water and irrigation

- a 1 to 2 kL rainwater tank is an optimal size for most rainwater tank scenarios with increases in tank sizes beyond 2kL gaining relatively small increments in substitution of potable water consumption.

Based on this modelling it is estimated that a 2kL tank in this scenario will save approximately 90kL of water or 51% of total indoor demand and 20% of total household demand. A rainwater tank connected to a laundry, toilet and irrigation will save approximately 70kL of water and less than a tank connected to a tank connected to indoor uses.

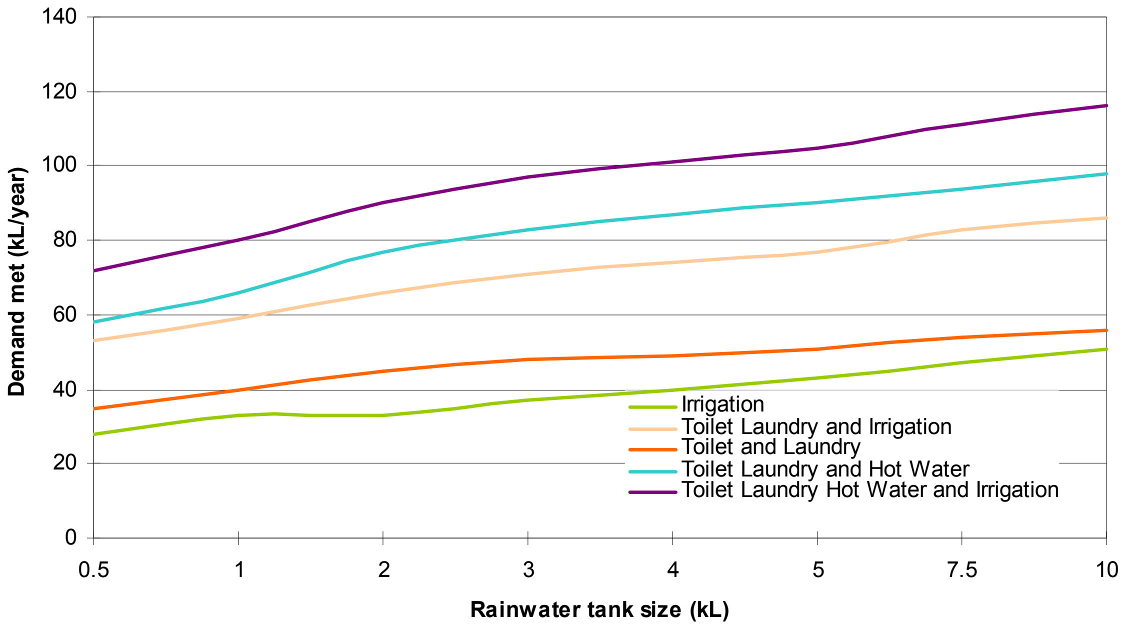

Figure 7 Rainwater tank reuse volumes and indoor and outdoor demands combined

4.3 Comparison to Rainwater Tanks in Sydney and Brisbane

To compare yields of rainwater tanks in Darwin compared to yields in other capital cities in Australia, rainwater tank modelling was undertaken for Brisbane and Sydney. An equivalent scenario to the Darwin scenario was modelled, including 75% of roof area to tanks and a 3 person household. The results are shown in Figure 8 and Figure 9. These results show that:

- In general, rainwater tanks in Darwin supply similar yields to Sydney and Brisbane in terms of volume of potable water substituted
- Small rainwater tanks, 3kL or less, supply more rainwater in Darwin than in Sydney or Brisbane when connected to hot water supplies, washing machines, toilets and irrigation
- Larger rainwater tanks in Sydney and Brisbane provide more yields than the equivalent in Darwin
- Compared to Sydney and Brisbane increasing rainwater tank size provides significantly smaller increases in yields. This supports the conclusion that small rainwater tanks are most suitable for Darwin.

It is clear from Figure 8 and Figure 9 that rainwater tanks can supply similar yields to other capital cities, such as Sydney and Brisbane when connected to internal non-potable end use. The major difference between other capital cities and Darwin is that rainwater tanks cannot supply adequate supplies to outdoor irrigation uses. Due to the large volume of this use outdoor use in Darwin while rainwater tanks can supply approximately a third or more of all household water demand in Sydney and Brisbane, rainwater tanks can only supply up to a fifth of all household demand in Darwin.

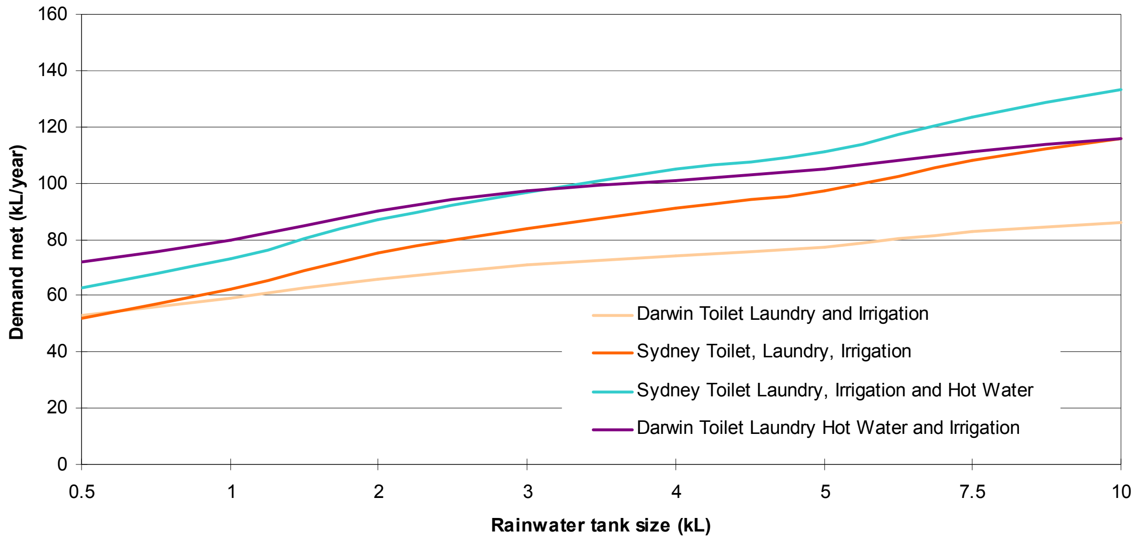

Figure 8 Comparison of Sydney and Darwin Rainwater Tank Volumes

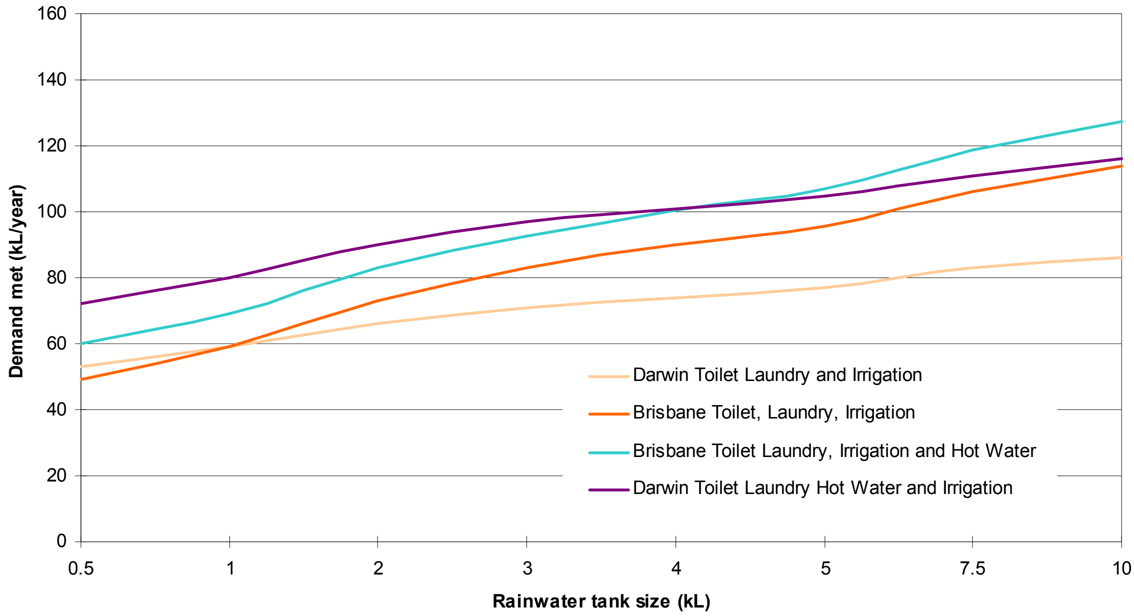

Figure 9 Comparison of Brisbane and Darwin Rainwater Tank Volumes

4.4 Results Summary

The modelling results show that:

- rainwater tanks are most effective in Darwin if they are connected to high volume internal uses including toilets, laundry and hot water services.
- rainwater tanks are not effective in meeting seasonal irrigation demands, although they can meet some of the irrigation demands at the beginning and end of the wet season.
- a 1 to 2 kL tank is the most efficient tank size for Darwin when connected to constant high volume indoor demands. This is a significant advantage of using rainwater tanks in the Darwin region. Small rainwater tanks can provide a high reliability of supply due to the high reliability of rainfall in the wet season in Darwin.

- In general, large rainwater tanks are not required in Darwin, thus reducing the costs, and the size of rainwater tanks.
- The volumes of rainwater that can be reused in Darwin are equivalent to, or more than, the volumes of water that are being saving in other capital cities around Australia.

5 What are the limitations of rainwater tanks?

The use of rainwater tanks in the Darwin region to reduce/slow demand on potable water supplies requires consideration of several factors. These include:

- Water quality: the quality of water from a rainwater tank should be matched appropriately to the connected 'end uses'. The management of a rainwater tank needs to be informed by a number of factors which can impact upon water quality, an understanding of which factors apply to a particular situation, the quality required for the 'end-use', and an acceptable level of maintenance for the users.

- Cost: the cost of rainwater tanks needs to be weighed up against available alternatives such as demand management, efficiency devices and alternate water supply sources

- Lot size: there may be limited space for aboveground tanks depending on building size to site size

- Competing uses for stormwater treatment and aquifer storage: situations where stormwater is used for a preferred beneficial use (such as irrigation of public parks/playing fields) may be more cost effective than rainwater tanks on individual allotments

- Maintenance: rainwater tanks need to me maintained either by a household or a body corporate/community management

5.1 Water quality considerations

Water quality is a potential problem with roof collection systems and possible pollution pathways should always be realistically assessed. This can be especially pertinent in urban or industrial areas. Water quality in rainwater tanks can be influenced by pollution pathways including:

- Atmospheric pollution settling onto roof surfaces and being carried into the tank

- Bird and animal droppings on roofs can be a source of bacteria

- Insects, lizards, frogs and other small animals may gain access to the tank and perish

- Lead paints should never be used on a roof connected to a rainwater tank, nor should tar based paints be used as they impart a taste to the water

- Chemicals may leach from roofs painted with acrylic paints and water collected from roofs made of fibrous cement should be discarded for the first 3 months due to the leaching of lime. This water may be used on an established garden, however acid loving species should be avoided

- Chemically treated timbers or lead flashings should be avoided and sections of roof containing wood-fire flues should not drain into the tank

- Overflows/discharges from roof mounted appliances such as evaporative air-conditioners or hot water systems should not drain to gutters associated with the rainwater tank

These pollutant pathways will vary in relevance depending on the location and are largely dependant on:

- Proximity to heavy/congested traffic, incinerators, smelters or heavy industry

- Type of roof materials used

- The provision of a first flush device, well fitted seals around tank connections and wire mesh of appropriate fine gauge to exclude leaves and insects such as mosquitoes

The water quality required by the desired end use in conjunction with the general level of pollutant pathways present will determine whether or not additional treatment is required. When rainwater tanks are connected to hot water systems and the tank is not maintained as a drinking water supply, it is important to ensure that water temperature is maintained above 55oC for complete pasteurisation as there is an increased risk of water ingestion during showering.

5.2 Cost considerations

When considering the use of a rainwater tank it is important to weigh up the cost of alternative water sources such as greywater reuse and reclaimed water. Typically a RWT will cost between $1000 – 2000 for a 1 to 2 kL tank depending largely on materials and type. In addition to the initial tank purchase is the cost of a pump, a first flush device a potable mains top up or switching device and the cost of plumbing/installation which will add an additional $1000 to $2000 to the cost. The cost of a tank would likely increase with higher density developments requiring more specialty designs/dimensions to fit limited spaces, including underground tanks. When weighed against the cost of mains water it is often more expensive to utilise rainwater tanks as an alternate source of water to a reticulated system. This is largely due to the artificially low cost of water supplies that do not take into consideration the environmental and social costs of supply or Government subsidies.

5.3 Lot size

Increasingly larger dwellings are being constructed on smaller allotments as compared to historical trends. This has led to the scaling down of front and rear yards which has increased resistance to the loss of space associated with the conventional above ground installation of RWTs. As outlined in Section 2, there has been considerable advancement in the design of rainwater tanks which now includes slim line models, module systems, systems that double as screens/fences or as walls for garden sheds/carports as well as bladder systems for under building cavities. As urban design advances it is likely that further integration of rainwater tanks will be incorporated into the building itself so that external space is not compromised.

5.4 Competing Uses

It is possible that there may be one or more competing uses for stormwater generated in a particular urban sub-catchment that may preclude the widespread use of rainwater tanks. Examples of this include adjoining sports grounds, parks or golf courses that would otherwise be irrigated with the reticulated potable water supply. In such circumstances it would be necessary to evaluate the cost benefits of each option to ascertain the most advantageous use of resources. This highlights the need for a flexible approach to Water Sensitive Urban Design that is ultimately informed by the specific character of particular sites within a holistic framework. As such, a 'blanket mandate' in regards to measures such as retrofit rainwater tanks can be inappropriate in some on the ground situations.

5.5 Maintenance considerations

Whilst rainwater tanks are considered low maintenance systems there is often an unfortunate misunderstanding that this implies a no maintenance system. Whilst the level of maintenance required is not particularly arduous and is relatively similar to good house maintenance, it does represent slightly more attention than is required for a reticulated water supply only. Maintenance necessary to maintain good water quality should include:

- Routine inspection of roof areas every six months to clear out any build up of leaves or debris. Gutters should be regularly inspected and cleaned if necessary, the regularity of which is dependant on the amount of overhanging trees etc. There are gutters available that are designed to exclude the majority of debris and litter (such as EnviroFLOW) and require little cleaning but cost more than standard guttering.

- First flush devices should be inspected and cleaned every 3 to 6 months depending on the level of debris reaching the guttering

- All screens at inlets and overflows should be regularly inspected to check for fouling and to ensure that there is a clear seal between the inlets and overflows to ensure that rainwater tanks do not allow entry by mosquitoes. Previously rainwater tanks have contributed to serious health consequences in Darwin, such as the spread of dengue fever by mosquitoes, due to the poor sealing of inlets and outlets.

- Tanks should be examined for sludge build up every 2 to 3 years. If there is an accumulated sediment layer on the bottom of the tank it should be removed by a siphon, or flushed from the tank, or removed by emptying the tank entirely. There are also professional tank cleaners available in most regions

6 Conclusions and Recommendation

Despite the high seasonality of rainfall in the Darwin region significant volumes of rainwater can still be harvested during the wet season. Rainwater tanks are effective in Darwin when connected to high volume indoor uses such as washing machines and hot water services.

The high volumes and high reliability of rainfall during the wet season means that rainwater tanks will supply almost all of the internal non-potable end-use demands during the wet season. This high reliability for up to six months of the year compensates for the lack of rainfall during the three to four months during the dry season when no demands are being supplied by rainfall.

For the Darwin region and its particular climate and end use demands:

- the most efficient tank size that balances yield with roof size, climate and demand scenario is almost consistently a 1 to 2 kL tank.
- Rainwater tanks to be effective need to be connected to high volume indoor uses such as washing machines and/or hot water services

The installation of rainwater tanks requires consideration of several factors such as intended end-use, yield, climate, maintenance and cost of alternative water sources.

It is recommended that Power and Water's current recommendations regarding the connection of rainwater tanks to hot water services be updated to align itself with current national and inter-state guidelines on rainwater tanks for the Darwin region. The Australian Government as well as State Government Health Departments around Australia all support the use of rainwater in hot water systems. Furthermore TDS of the Darwin water supply is similar to that expected in rainwater tanks and is thus unlikely to cause issues with corrosion in hot water systems.

Rainwater tanks if not installed or maintained properly can be an ideal breeding site for mosquitoes that spread serious illnesses such as dengue fever. Rainwater tanks in the Darwin environment need to ensure that inlets and outlets to rainwater tanks prevent access to mosquitoes. Design guidelines have been developed to prevent mosquito access, such as those in the Queensland Building Code. These guidelines are a good resource for installation of rainwater tanks in the Darwin region.

In summary, due to the significant yields of rainwater systems during the wet season, there is a realistic possibility of reduction of demand placed on reticulated water supplies from rainwater tanks, especially if no other non-potable source is available. These significant savings can alleviate the need for additional supply systems (such as new dams) for high growth urban areas.

In addition, the capture of roof runoff in rainwater tanks reduces the amount of water reaching the stormwater system, thus decreasing the potential for flooding and degradation of local water ways. Although rainwater tanks only reduce runoff from residential roofs, wide scale use of rainwater tanks can have significant impact on the levels of stormwater flows especially for high frequency rain events. Furthermore rainwater tanks reduce the amount of nutrients that are delivered to local aquatic ecosystems.

It is recommended that rainwater tanks be considered as one component of a flexible suite of water sensitive urban design measures aimed at potable water conservation and stormwater management.

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Appendix A

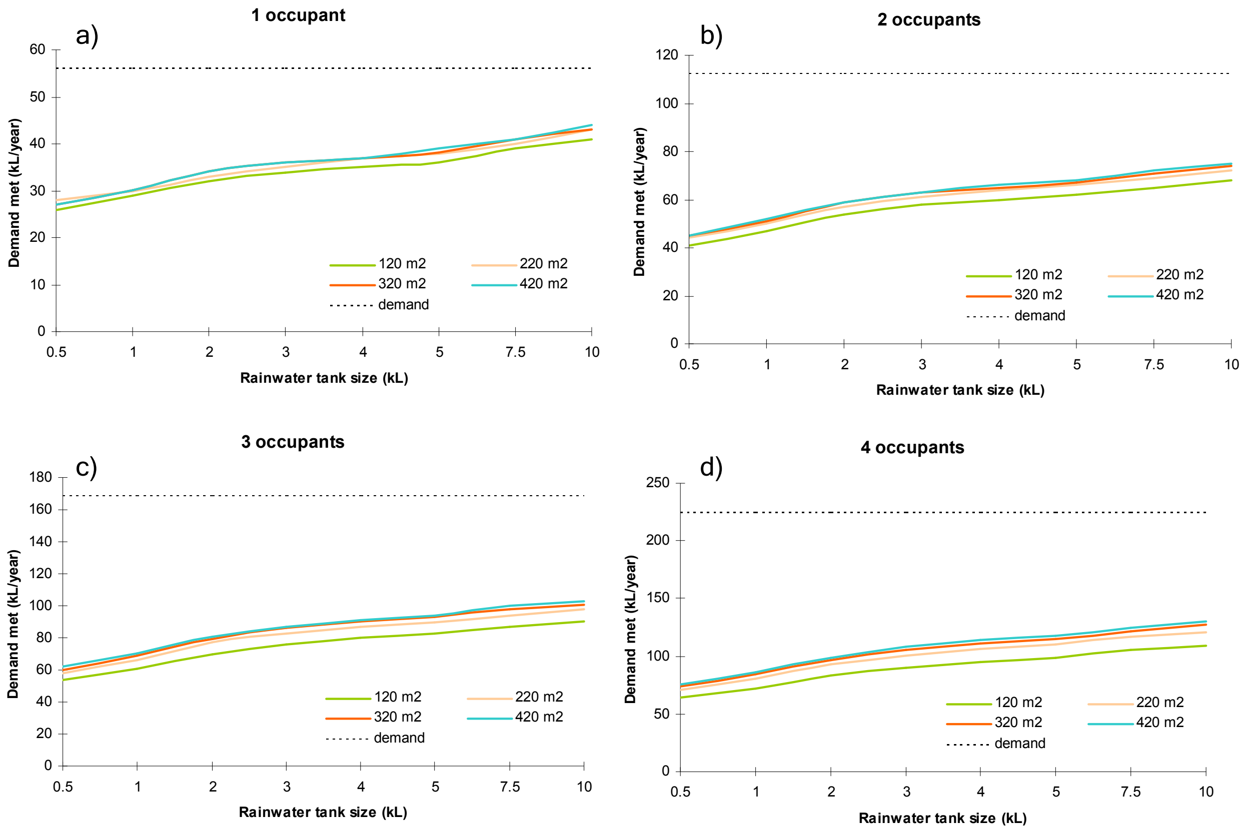

Figure 1: Rainwater tank sizing curves for supplying indoor water use (kL/yr) from effective roof areas (75% of total) of 120 m^2, 220 m^2, 320 m^2, 420 m^2 for the Darwin region. Reuse scenario consists of *toilet + laundry (cold) + hot water* demand for: a) 1 occupant- 56 kL/yr; b) 2 occupants- 112 kL/yr; c) 3 occupants- 168 kL/yr; d) 4 occupants- 224 kL/yr

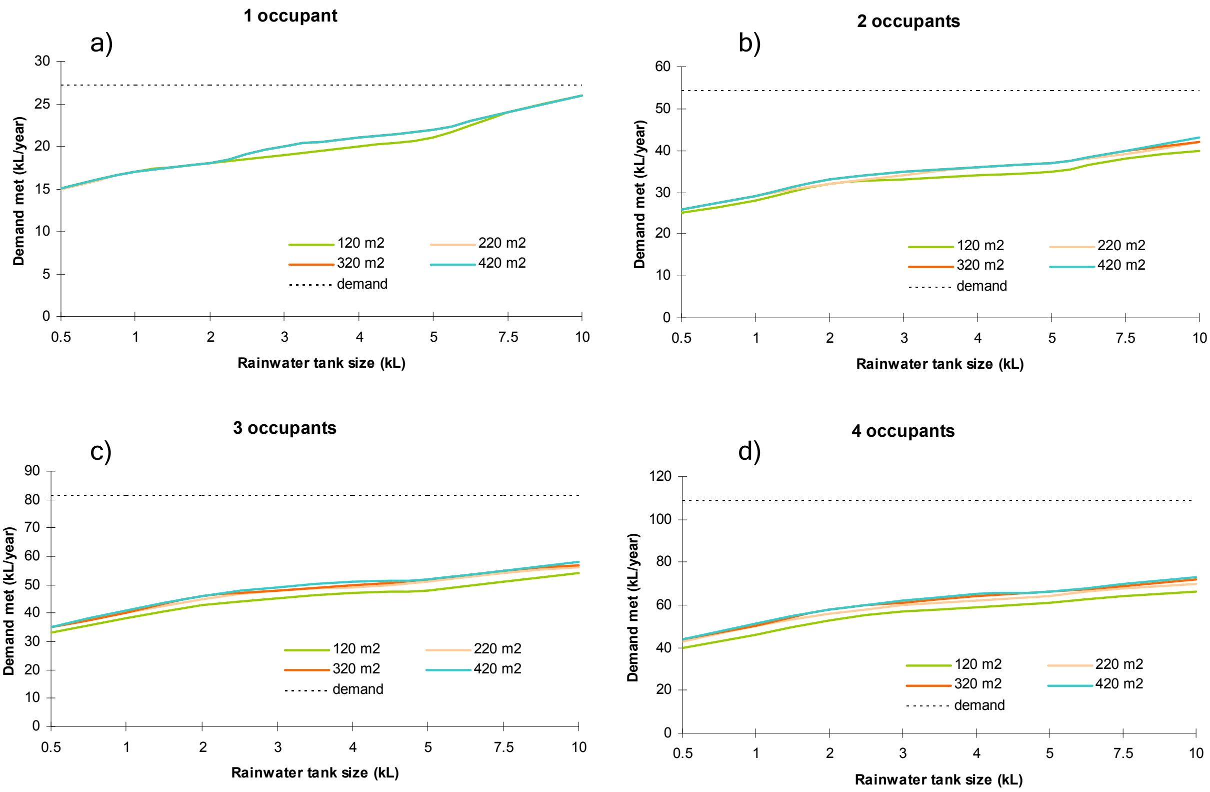

Figure 2: Rainwater tank sizing curves for supplying indoor water use (kL/yr) from effective roof areas (75% of total) of 120 m^2, 220 m^2, 320 m^2, 420 m^2 for the Darwin region. Reuse scenario consists of *toilet + laundry (cold)* demand for: a) 1 occupant- 27 kL/yr; b) 2 occupants- 54 kL/yr; c) 3 occupants- 81 kL/yr; d) 4 occupants- 109 kL/yr.

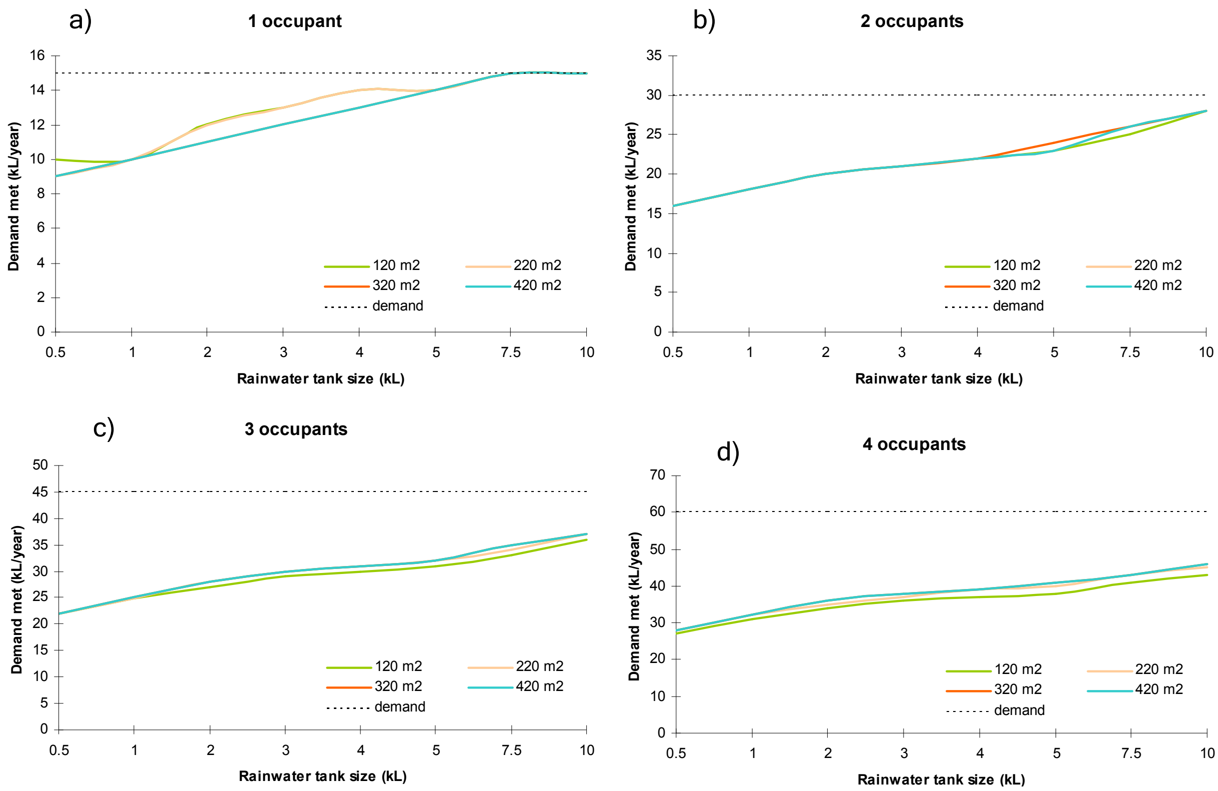

Figure 3: Rainwater tank sizing curves for supplying indoor water use (kL/yr) from effective roof areas (75% of total) of 120 m^2, 220 m^2, 320 m^2, 420 m^2 for the Darwin region. Reuse scenario consists of *toilet* demand for: a) 1 occupant- 15 kL/yr; b) 2 occupants- 30 kL/yr; c) 3 occupants- 45 kL/yr; d) 4 occupants- 60 kL/yr.

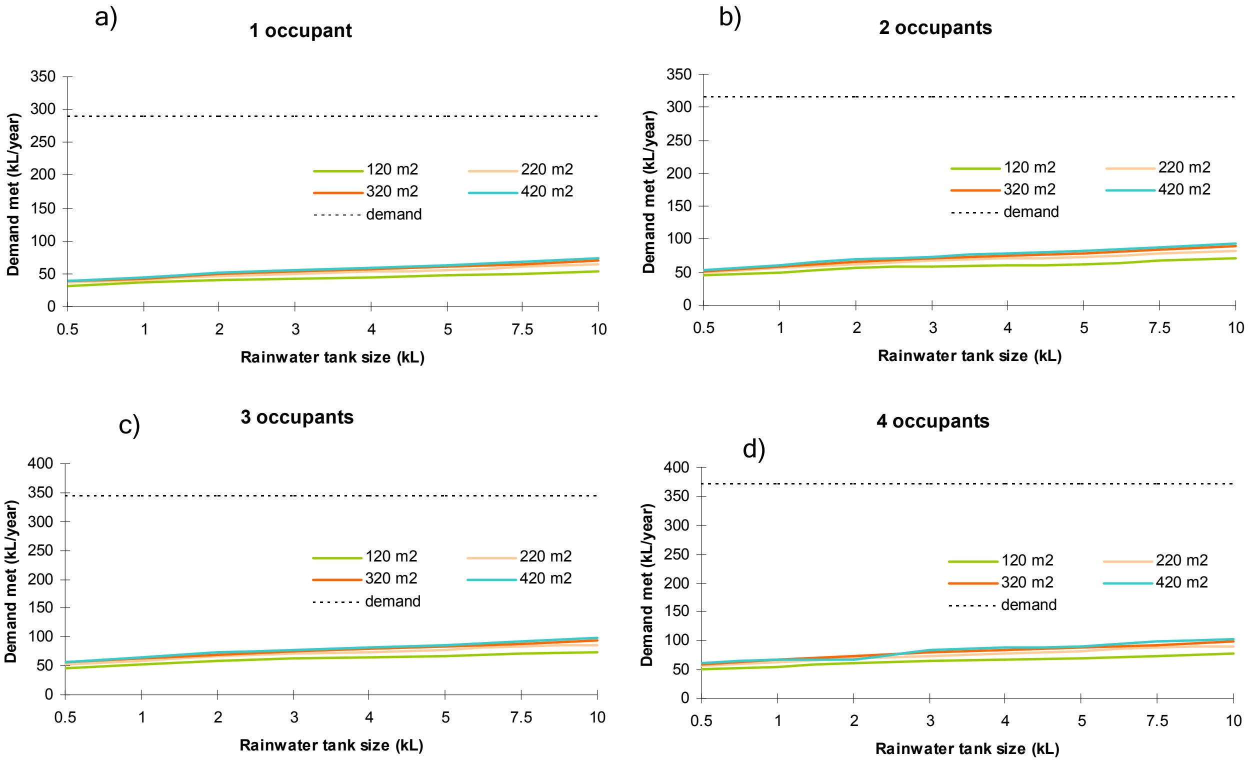

Figure 4: Rainwater tank sizing curves for supplying elements of indoor and outdoor water use (kL/yr) from effective roof areas (75% of total) of 120 m^2, 220 m^2, 320 m^2, 420 m^2 for the Darwin region. Reuse scenario consists of *toilet+ laundry (cold)+ outdoor* demand for: a) 1 occupant- 289 kL/yr; b) 2 occupants- 316 kL/yr; c) 3 occupants- 343 kL/yr; d) 4 occupants- 371 kL/yr.