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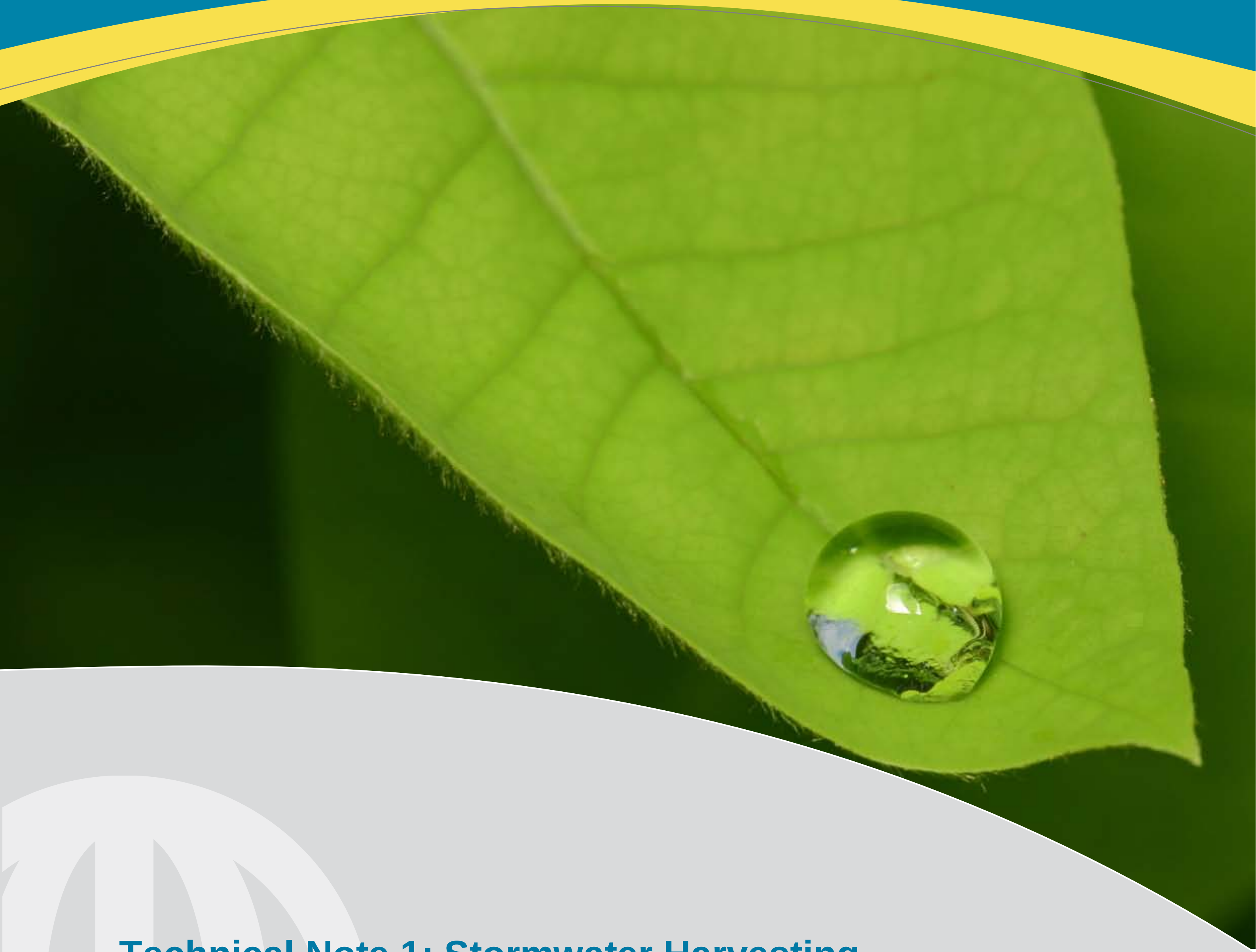

Technical Note 1: Stormwater Harvesting

Prepared for Tweed Shire Council

March 2010

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Tweed Shire Council

Technical Note 1: Stormwater Harvesting

In line with our Quality System, this document has been prepared by Kelly Devrell and reviewed by Shane O'Brien and signed off by Mark Hunting.

BRISBANE Level 3, 35 Boundary Street, PO Box 3602, South Brisbane, QLD 4101

p +61 7 3029 5000, f +61 7 3029 5050

Figures

Tables

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1 Introduction

MWH was commissioned by Tweed Shire Council (TSC) in January 2010 to investigate the feasibility of stormwater harvesting within the TSC area.

Stormwater is water from rain or runoff that enters the drainage system. Urban areas have expanses of constructed hard and impervious surfaces like roads, driveways, car parks, roofs and paving. When stormwater runoff flows over these hard surfaces, it readily accumulates pollutants. Stormwater pollutants originate from many different sources ranging from fuel and oil from our roads, excess fertilisers and soaps for cleaning, to litter dropped on our streets and sediment from building sites. These pollutants are a major cause of pollution in our rivers, creeks, lakes and bays. In general, stormwater contains many of the hazards found in sewage, but at lower concentrations for microbial hazards and potentially higher concentrations for some chemical hazards (e.g. hydrocarbons and pesticides).

In urban areas, the increase in the number and size of impervious areas has reduced the amount of rain that infiltrates the ground or is retained by vegetation. Consequently, increased quantities of stormwater runoff enter the drainage system and the receiving waterways. Urbanisation has also changed the timing for stormwater discharged into water environments. Traditionally, stormwater drainage systems have been constructed to remove stormwater from urban areas as quickly as possible in order to minimise the risk of flooding and to prevent water from becoming stagnant. The increased volume entering waterways causes scouring (in stream erosion) of waterways. In less modified catchments the runoff water is released over a longer period of time, which maintains healthier water environments. A stormwater harvesting scheme that reduces the amount of stormwater runoff discharging to waterways has the benefits of reducing erosion and pollution downstream thereby increasing the water quality of the receiving waters. Stormwater can also be harvested direct from creeks and ponds although this will have a reduced effect on any water quality improvement to these receiving waters.

Stormwater is an alternative to using mains drinking water for many purposes. However, there are human health and environmental risks that need to be managed as stormwater run-off from urban areas is often contaminated with litter, pathogens, oil and other chemicals. If simple management protocols and good catchment management practices are followed, then stormwater can be used safely for low-risk purposes such as open space irrigation. For higher-risk uses, where people are more likely to be in close contact with the water, more complex management controls are necessary. This document will also examine the current position of stormwater harvesting in Australia and compare stormwater harvesting to other source substitution options like recycled water.

An important distinction between stormwater and wastewater is that the quality of wastewater does not vary as much as the quality of stormwater. The quality of wastewater received at a wastewater treatment plant will not vary significantly day to day as industrial wastewater will be used for approximately the same processes and purposes and the uses of domestic wastewater also will not vary widely on a daily basis. Stormwater however, can vary significantly in quality dependent on the catchment and rainfall.

Stormwater harvesting may be adopted:

- To reduce the adverse impacts (social, economic and environmental) of the pollutant and hydraulic loads associated with wet weather events;
- As a form of source substitution in order to improve water supply security, reduce cost and energy use.

The level of treatment required for a stormwater harvesting and reuse scheme and the feasibility of the scheme for source substitution, will depend on the following factors:

- Catchment;
- Scale;
- Topography;
- Climate; and
- End Use – Desired standards of service in terms of reliability and water quality.

Components of a stormwater harvesting and reuse system are:

- Collection;
- Pre-Treatment;
- Raw Water Storage;
- Treatment – provide fit for purpose;
- Post Treatment Storage;
- Storage above or below ground in tanks, storage basins or aquifers;
- Water Treatment for End Use; and
- Distribution.

The main component in terms of cost is the storage; storage size required is dependant on rainfall pattern, reuse demand, and required level of reliability. Due to the highly seasonal rain in the Tweed region, storages need to be large enough to capture the stormwater during the wet summer months and store it to be available throughout the year. Unlike recycled water, which is a relatively constant source of supply, stormwater is climate dependent and supply is not guaranteed during periods of drought or below average rainfall.

2 Current Position

2.1 Case Studies

Details of five case studies from the local area, Australia and internationally are contained in this section. One case study is a proposed development in Bilambil Heights, which is currently in the planning stage.

The end uses identified in the case studies range from toilet flushing to irrigation to direct to potable water supply. The drivers of these projects can be legislation, water supply security or receiving water quality, which shows that stormwater harvesting, is not a "one size fits all" solution and depends on existing catchment and infrastructure and required outcomes.

2.1.1 Banora Point Golf Course, Tweed Shire Council

The local stormwater system delivers runoff directly and via pipes into a canal storage running along the east, south and west boundaries of the golf course. Overflow from the canal during wet weather overtops weirs at the northern ends of each north-south canal section and re-enters the downstream stormwater system to the north.

This stormwater harvesting scheme has been in operation since 1987 and is an opportunistic stormwater management coordinated between the developer and Council which became part of the strategic stormwater management for the suburb. The 45 ML storage, which includes canal and onsite dam is used for the irrigation of the golf course. The onsite treatment is minimal incorporating sedimentation and treatment for mosquitoes and the scheme is influenced by tides and requires salinity monitoring during extended dry periods at which point extraction must be stopped and only the greens are watered, usually from the reticulated water supply. The operating cost of the scheme is unknown. (pers communication Tim Mackney, TSC 15/1/2010)

2.1.2 RISE Subdivision, Tweed Shire Council

The proposed "RISE" subdivision is currently in the planning stage and comprises a residential, retirement living, retail, commercial, school and open space precinct urban development located at Bilambil Heights catering for a population of approximately 3,000.

The proponent intends to provide two different water supplies to the development; potable water from Council's reticulated water supply, and non-potable from recycling storm water collected from roofs and from road ways and open space areas. (TSC, 2009)

The non-potable system will supply water for toilet flushing, outdoor uses and irrigation of public open space via a 3 ML Reservoir – the size and extent of any stormwater collection/retention ponds is unknown. The exact treatment is also unknown but will need to be to a level compatible with the proposed end uses of the water.

If the recycled stormwater system does not proceed, BASIX requirements will apply; i.e. 5 kL rainwater tank at each individual and equivalent tanks for multi-dwelling buildings plumbed to supply water for toilet flushing, laundry cold water tap and external uses.

The concept of stormwater recycling and IWCM is generally supported for the development, however the applicant needs to consider whether the nominated system is the most economical and practical for the development. Ultimately this is a commercial decision for the developer, and not Council. (TSC, 2009)

2.1.3 Blackmans Swamp Stormwater Harvesting Project – Orange City Council, New South Wales

The Blackmans Swamp Creek Stormwater Harvesting project represents the first large scale, direct-to-potable stormwater harvesting project in NSW, if not Australia. This project is capable of providing between 1,300-2,100 ML of additional water into the Orange's raw water supply each year from the city's stormwater system, meeting up to 40 per cent of the city's total water needs.

The basic concept of the Blackmans Swamp Creek Stormwater Harvesting Project involves capturing a portion of the high flows in Blackman's Swamp Creek during storm events, and transferring these into the nearby Suma Park Dam to augment the city's bulk water supply. (OCC, 2009)

Blackmans Swamp Creek is the major drainage catchment in the city of Orange. The creek enters the urban area where it is channelised and piped, it also picks up excess treated effluent from the sewerage treatment plant.

The driver for this stormwater harvesting scheme was water supply security with Orange experiencing water storages below 30% and well below average runoff during the recent drought. The first release of harvested stormwater flowed into Suma Park Dam on 21 April 2009 and the scheme includes a weir on Blackmans Swamp Creek, which creates a 3 ML on stream storage and the site for the first pump station, a 200 ML dam and two 17 ML batching ponds.

Treatment before entering the raw water supply includes Gross Pollutant Traps (GPTs) and flocculation to remove suspended solids, next the raw water undergoes a very high level of treatment to ensure it meets all requirements for potable water supply.

This project was successful due to the close proximity of Blackman's Swamp Creek to Suma Park Dam, the availability of key existing infrastructure and the regularity of flows in Blackman's Swamp Creek. The capital cost of the project was $5 million but the operational costs are unknown.

2.1.4 Parafield Stormwater Harvesting Facility, City of Salisbury, South Australia

The Parafield Stormwater Harvesting Facility supplies 1,100 ML per year of treated stormwater to G.H. Michell & Sons, Australia's largest wool processing company through an Aquifer Storage and Recovery (ASR) system. The stormwater is harvested from Parafield Airport, one of Australia's busiest general aviation airports.

The driver for this stormwater harvesting scheme was the quality of the receiving waters and the cost of potable supply to large industrial consumer. The scheme began operation in 2000 and supplies water for wool washing and processing. The cost of the scheme was $3.7 million and includes a 50 ML capacity capture basin, pumped to a similar capacity holding basin, from where the stormwater gravitates to a two hectare bird proofed cleansing reed bed before being injected into two ASR bores (depth 180 metres, T2 Aquifer).

2.1.5 Berlin–Lankwitz stormwater plant, Germany

Although Germany is not considered a water-poor country, rainwater utilisation in households became widespread since the 1980s. Decentralised stormwater retention and infiltration in urban areas has been used in Germany since the beginning of the 1980s as a sustainable and cost-effective alternative to combined and separate sewers. In Germany, all new developments are required by law to retain/infiltrate rainwater on site. Rainwater infiltration in the investigated area has been excluded from the beginning due to unfavourable soil permeability and intensive use of the scarce open space. About 11,770 m^2 of sealed surface area are connected to the rainwater reservoir situated in the cellar of a new building. 63% of the collected surfaces originate from the roof, 35% from courtyards and sidewalks and 12% from traffic surfaces. (Nolde, 2006)

The driver for this stormwater harvesting scheme besides the legislative requirements were protection of receiving waters and security of supply. The stormwater harvesting plant supplies 80 apartments and 6 small trade units (200 persons) with high-quality water for toilet flushing and garden watering and has been in operation since 2000.

The scheme includes 190 m^3 initial collection stormwater reservoir and 6m^3 storage reservoir with a daily treatment capacity of 10m^3 through first flush diversion, sedimentation grit chamber, biological treatment and UV disinfection.

2.2 Discussion

The case studies highlighted above show that there are many applications of stormwater harvesting schemes to meet drivers such as legislation or the protection of downstream water quality. The treatment varies according to the end use of the harvested stormwater with minimal treatment required for irrigation of a golf course compared to Orange where stormwater is being used to augment the citys water supply and requires extensive treatment.

The capital cost of both the Orange and Salisbury schemes are less than $0.50 per kL of harvested stormwater however, it is important to realise that both of these schemes utilised existing infrastructure / natural aquifers located nearby thereby avoiding large capital costs. Suma Park Dam is only 4km from the centre of Orange, which is much closer than Clarrie Hall Dam to the centre of the major Tweed population centres of Murwillumbah and Tweed Heads. Although aquifers do exist in the Tweed area, it was identified that

> *"at this time there are no known aquifers in the Tweed area that would provide an opportunity for either enhanced recharge of an existing supply or an aquifer storage and recovery system" (Bligh Tanner, 2004)*

Available land and topography is also an issue when examining cost effectiveness of stormwater harvesting schemes, in the case of Orange where available land was needed to construct a very large 200 ML dam, if suitable land is not already owned by Council costs will increase further.

The proposed RISE subdivision is an important case study for Council in that it is a developer initiated scheme, the cost benefit analysis of how the stomwater harvesting scheme compares to the BASIX requirements is not known but ultimately is a commercial decision for the developer whether any incurred losses can be recouped later on.

Again, these case studies show that stormwater harvesting is not a "one size fits all" solution and any proposal will need to be examined in detail to determine if it is suitable for application in the Tweed area.

3 Regulatory Requirements

A stormwater water harvesting and reuse scheme will be required to comply with a number of relevant legislative and non-legislative regulatory requirements. Regulatory requirements will depend on a number of factors including:

- Planned end use for the captured stormwater; and
- Potential impacts scheme may have on the environment.

3.1 Guidelines

Although not legally enforceable, at both the State and Federal level, guidelines have been developed specifically for stormwater harvesting and reuse. These guidelines, along with other guidelines that may be relevant to a stormwater harvesting and reuse scheme are listed in Table 3-1.

Table 3-1: Guidelines Relevant to Stormwater Harvesting and Reuse

Planned End Use	Guidelines
All	*Managing Urban Stormwater: Harvesting and Reuse*, DEC
All	*Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) Stormwater Harvesting and Reuse* (NRMMC,EPHC & NHMRC, 2009b)
Drinking Water	*Australian Drinking Water Guidelines* (NHMRC & NRMMC, 2004)
Drinking Water	*Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) Augmentation of Drinking Water Supplies* (NRMMC,EPHC & NHMRC, 2008)
Managed Aquifer Recharge	*Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) Managed Aquifer Recharge* (NRMMC,EPHC & NHMRC, 2009a)
Swimming Pools	*Guidelines for Managing Risks in Recreational Water* (NHMRC, 2008)
Pools/Water Features.	*Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC, ARMCANZ, 2000)

3.2 Legislation

There is no specific legislation that regulates stormwater harvesting and reuse in New South Wales, however the following legislation may impact on the requirements and/or feasibility of a stormwater harvesting and reuse scheme:

- *Protection of the Environment Operations Act 1997.*
- *Water Management Act 2000*
- *Fisheries Management Act 1994*
- *Rivers and Foreshores Improvement Act 1948*
- *Threatened Species Conservation Act 1995*
- *Native Vegetation Act 2003*
- *National Parks and Wildlife Act 1974*
- *Dam Safety Act 1978*

4 Water Quality/Scheme Requirements

The relevant guidelines (DSC 2006; NRMMC,EPHC & NHMRC, 2009b) both advocate a risk mitigation approach to the design of stormwater harvesting and reuse schemes, rather than setting prescriptive water quality targets.

The risk based approach involves the following process:

1. Hazard Identification
2. Dose (concentration) – Response (effect) assessment
3. Exposure assessment
4. Risk Characterisation

Based on the risk characterisation, which should take into consideration the entire system associated with the collection, storage, treatment and reuse of the stormwater water, suitable treatment and non-treatment (e.g. the use of a fence to restrict public access while irrigating) mitigation measures are then selected to mitigate the risk to a tolerable level.

Any proposed stormwater harvesting and reuse scheme will be required to adequately mitigate all risks to both humans and the environment.

The risk mitigation is not only incorporated into the design phase of the project but instead the entire life of the project. During the operation phase activities such as regular maintenance, performance monitoring and validation need to be undertaken in order to ensure the desired level of risk mitigation is continually achieved.

4.1 Hazards

Key hazards that may be associated with the implementation of a stormwater harvesting and reuse scheme are listed in Table 4-1.

Table 4-1: Common Potential Hazards Associated with Stormwater Harvesting and Reuse

Area	Hazard
Public Health	Microorganisms (pathogens) in water: • Bacteria, viruses and parasites Chemical toxicants in water: • e.g. metals, nutrients, pesticides, hydrocarbons
Public Safety	Water storage (above ground)
Environmental	Hydraulic Loading Rate Chemical toxicants in water: • e.g. metals, nutrients, pesticides, hydrocarbons

(Adapted from: DCE 2006, NRMMC,EPHC & NHMRC, 2009b)

In general, stormwater contains many of the hazards found in sewage, but at lower concentrations for microbial hazards and potentially higher concentrations for some chemical hazards (e.g. hydrocarbons and pesticides).

For a stormwater harvesting and reuse scheme, unlike a water recycling scheme, the scheme's catchment has a significant impact on the raw stormwater quality, and consequently exposure rate to hazards. The raw water quality will be impacted by factors such as catchment land uses and the proportion of the catchment that is impervious.

In addition, stormwater quality in a particular catchment may vary significantly influenced by rainfall patterns and other events occurring in the catchment (e.g. bushfires or increased erosion and sedimentation due to development).

4.2 Risk Mitigation

The risk associated with exposure to a particular hazard is determined by taking into consideration the consequence of the exposure and the likelihood of the consequence occurring.

In order to reduce a particular risk to a tolerable level, a stormwater harvesting and reuse scheme may incorporate a combination of treatment and non-treatment risk mitigation measures, examples of these are presented in Table 4-2.

Table 4-2: Non-Treatment Based Risk Mitigation Measures

Primary Objective	Types of Processes
Preventing entry of hazard Concentration of hazards in stormwater can be managed by catchment management programs	Protection of stormwater from human and animal waste can prevent the entry of human infectious viruses and greatly reduce the presence of human infectious protozoa. This type of early prevention can greatly reduce the need for downstream treatment (e.g. detention in lagoon or wetland)
Reducing exposure through preventative measures at site Reduce risk by reducing exposure to stormwater.	Restricting uses of stormwater Controlling methods of application Setting withholding periods between application of recycled water and use of irrigated areas or harvesting of produce. Controlling public access during applications or use of recycled water Using signage, labelling and communication to minimise accidental exposure Cross connection controls Using signage, labelling and communication to minimise accidental exposure
Pre-Treatment Remove gross and readily separated contaminants from the harvested stormwater. E.g.: • Litter (man made and natural); • Coarse sediments (gravel, sand and soil); • Other readily separated suspended solids; • Organic, heavy metal and chemical contaminants associated with the sediments; • Hydrocarbons. To help manage contaminant spills within the catchment before they enter the storage and treatment systems where they can create water quality and operational issues.	In-catchment stormwater quality improvement systems including detention storage, swales and bioretention filters. Screening to remove litter and other large debris and objects. Sediment traps to catch the coarse sediment load. Oil and sediment separators to remove finer suspended solids and hydrocarbons. Naturally occurring or constructed natural systems e.g. open water bodies incorporating sedimentation zones and wetlands.

Primary Objective	Types of Processes
Post-Treatment The harvested stormwater is likely to require further treatment so that it is suitable for intended end use. The treatment processes selected will depend on the nature of the intended end use and any water quality requirements.	Flotation if there is a need to remove difficult to filter particles such as algae. Dissolved air flotation is achieved by the use of microscopic air bubbles that become attached to the solid particles in the water. The bubbles then float to the surface of the liquid with the solid particles attached and can be skimmed off. Filtration to reduce suspended solids and turbidity levels and make the water suitable for disinfection (with or without the addition of chemical coagulants and flocculants to enhance efficiency) Activated carbon absorption or advanced oxidation to remove organic chemicals if they are expected in the raw water and if the proposed end use is sensitive to them. Reverse osmosis if dissolved salts are of concern. Disinfection to destroy or inactivate human pathogens and to provide residual protection in the water distribution system.

(Adapted from: NRMMC,EPHC & AHMC, 2006 and Water by Design, 2009)

Treatment based risk mitigation measures will be required to address operational risk as well as environmental and human health risks.

Water quality criteria may also be used to complement the risk mitigation process to enable verification that treatment processes are performing as planned and risk mitigation targets are being met consistently. The level of risk mitigation required for a particular scheme will depend on the catchment's characteristics, raw stormwater quality and the planned end uses for the stormwater.

Some indicative combinations of risk mitigation measures that may be suitable for particular end uses are provided in Table 4-3, although the suitability of these combinations will depend on the scheme's raw water quality. Mitigation measures required to address human health risk were the priority when developing the combinations provided in Table 4-3 so further risk mitigation may be required to address environmental and operational risks.

Storages are included in the indicative treatment process for drinking water augmentation because although storages will form a part of stormwater harvesting schemes which supply other end uses, they are not a treatment component. The greatest advantage provided by detention in storages is time to allow operational monitoring of recycled water treatment processes to be completed and recycled water quality to be assessed before supply of water to downstream drinking water treatment plants and distribution systems. This allows corrective action to be taken or supply to be stopped before unsafe water is provided to consumers.

Table 4-3: Indicative Combinations of Risk Mitigation Measures for Selected End Uses

Use	Indicative Treatment Process	On-site Preventative Measures	Health Based Water Quality Criteria
MUNICIPAL USE / NON FOOD CROPS			
Municipal use with unrestricted access – open spaces, sports grounds, golf courses and non-potable construction uses (e.g. dust suppression) OR Irrigation of non-food crops	Filtration Disinfection	No specific measures	Turbidity: <25 NTU[1] (median) <100 NTU (95th %ile) *E.coli*[2] <10/100mL
Municipal use with restricted access and application	No Treatment	Restricted public access during irrigation Minimum 25 to 30 m buffer to nearest point of public access and spray control	Not applicable
Municipal use with drip irrigation	No Treatment	Drip irrigation of plants	Not applicable
THIRD PIPE / FOOD CROPS			
Dual reticulation with indoor and outdoor use OR Irrigation of commercial food crops	Screening Filtration (if required) Disinfection	Strengthened cross-connection controls required including ongoing education of householders and plumbers (for dual reticulation)	Turbidity: <2 NTU (target) <10 NTU (95th %ile) <25 NTU (maximum) *E.coli* <1/100mL
DIRECT TO POTABLE REUSE			
Drinking Water Augmentation	Diversion Oil & Sediment separator Raw Water Storage Pre-Filtration Ultra filtration Activation Carbon filter UV Treated Water Storage	Catchment management programs applied to prevent animal and human waste entering the stormwater.	Various

(Adapted from: NRMMC,EPHC & NHMRC, 2009b)

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[1] NTU (Nephelometric turbidity units) – measure of how much sediment is suspended in the water
[2] E. coli is used as an indicator of faecal pollution

5 Current Funding Arrangements

As part of the Rudd Government's $1 billion National Urban Water and Desalination Plan to help secure the water supplies of Australian cities $200 million will be provided to undertake innovative stormwater capture projects to help secure water supplies for Australian cities.

Support will be available for urban stormwater harvesting and reuse projects in both large cities and smaller towns that contribute to:

- Improving the security of water supplies in Australia, without adding to greenhouse gas emissions;
- Reducing the demand on potable water supplies; and
- Helping to reduce the impact of urban run-off on water quality in receiving waters.

Project funding is available for up to 50 per cent of eligible capital costs. The minimum project size is $4 million (eligible for funding of $2 million). While there is no maximum project size, funding is capped at $20 million (GST exclusive) per project.

Projects will need to source 100 per cent of their energy needs from renewable sources or fully offset the carbon impact of the project's operations.

The successful projects in the first round of funding are shown in Table 5-1 which has been adapted from the "$86 Million for stormwater harvesting and reuse" Media release from Senator the Hon. Penny Wong, 2 November 2009. The second round of funding closes on 10 February 2010.

As mentioned the funding shown in Table 5-1 can be up to 50% of the total project cost, very little information is available about the cost benefit analysis of these projects so it is unclear whether they are cost effective without government funding.

Table 5-1: Funded Projects – National Urban Water and Desalination Plan (first round)

State	Council / Authority	Project Name	End Uses	Funding Received ($000,000)	Potable Demand offset (ML/yr)	Yield (ML/yr)
Victoria	Ballarat City Council	Harnessing Ballarat's Stormwater	Irrigation	$2.377	189	189
	Yarra Valley Water	Kalkallo Stormwater Harvesting and Reuse	Potable water supply	$9.665	365	365
	Melbourne Water	Clayton South Retarding Basin & Namatjira Park Stormwater Reuse	Irrigation	$2.4275	92	92
	City of Greater Geelong	Stormwater Harvesting - Geelong's Plan	Irrigation	$2.7945	222	222
Queensland	South Bank Corporation	South Bank Stormwater Harvesting and Reuse Centre	Irrigation	$3.3	77	77
South Australia	City of Unley	Stormwater Harvesting and Reuse	Irrigation and environmental flows	$2.558	98	114
	City of Salisbury	Unity Park Biofiltration and Reuse	Unknown	$6.99	400	8,000
	City of Onkaparinga	Water Proofing the South Stage 2	Irrigation	$14.97	1,300	
	City of Playford	Playford Stormwater and Reuse	Irrigation	$9.6	640	
	SA Water	Adelaide Airport Stormwater Scheme	Unknown	$4.864	400	
	Adelaide Botanic Gardens and SA Dept. Environment & Heritage	Botanic Gardens First Creek Wetland ASR	Irrigation	$2.935	100	
	City of Charles Sturt	Water Proofing the West Stage 1	Irrigation and Industrial	$20	555	
	SA Water	Barker Inlet Stormwater Reuse Scheme	Industrial, Commercial and Irrigation	$3.925	170	

6 Considerations

An evaluation of stormwater harvesting is shown in Table 6-1 with some identified advantages and disadvantages of this method of source substitution.

Table 6-1: Stormwater Harvesting considerations

Advantages	Disadvantages
Significant mitigation of post development stormwater runoff rates, minimising potential downstream impacts of the development	Climate dependent
Reduction in potable water demand	Required storage footprint – the storage has to be large enough to capture the wet summer rainfall and store it to cater for the winter demand. Due to the regions strong seasonal variation in rainfall storage requirements will be larger than those in climates with less seasonal variation e.g. Melbourne, Germany
Dual reticulation system based on recycled stormwater is likely to have a higher community acceptance than a recycled sewage effluent system. (RISE Concept Plan, TSC, 2009)	Susceptible to drought and not a reliable source of supply, water infrastructure will still need to be sized to cater for peak demand with no reduction due to stormwater harvesting.
Reduction of stormwater pollution	Likely to have a higher cost per kilolitre of water than rainwater tanks (DEC, 2006)
Reduced potential for wet weather sewage overflows due to reduced ingress of stormwater into the sewerage network	Conservative design required
	Variable quality of stormwater – concentration of pathogens can vary by many orders of magnitude between catchments and storm
	The pathogen reduction achieved by most wastewater treatment systems are expected to be greater and more consistent when treating wastewater than stormwater. This is due largely to the more variable quality
	Environmental impact of storages, environmental flows in creeks and rivers need to be maintained which needs to be balanced with the goal of stormwater harvesting. Storages can also provide potential mosquito habitats and increase the potential for upstream flooding
	High relative unit costs of treated stormwater compared to recycled water, rainwater and potable water (DEC, 2006)

7 Opportunity Assessment

7.1 Methodology

A desktop review exercise was undertaken using GIS data from TSC including aerial photography, stormwater infrastructure, contour information and water infrastructure including water treatment plants and reservoirs.

Suitable sites were identified based on the following criteria:

- Proximity to large external demand;
- Low lying areas; and
- Proximity to existing stormwater infrastructure.

Using this methodology, it was identified that sports fields and other recreation areas are the most suitable typical urban developments for the retrofit of a stormwater harvesting system.

Stormwater harvesting can also be used to supply non-potable water for toilet flushing and garden irrigation direct to properties via a third-pipe system, this is suitable for new Greenfield developments as retrofitting is generally uneconomic except to large users. (KBR, 2004)

The viability of third pipe systems supplied with stormwater have been examined in this document by comparing the requirements and costs of stormwater harvesting for public irrigation with the requirements and costs of third pipe recycled water systems.

Direct to potable use similar to the Blackmans Swamp Creek (Orange) stormwater harvesting case study has not been examined due to this project being the first of its kind in Australia and very limited data being available. The indicative risk mitigation measures for a direct to potable scheme are shown in Table 4-3 and would have a significant impact on the capital and operating costs of the scheme.

7.2 Stormwater Harvesting for Municipal Use

7.2.1 Cost Assessment

A review of 11 case studies was done in New South Wales by the NSW Department of Environment and Conservation (2006) of stormwater harvesting schemes predominately for irrigating public spaces.

The study also identified the capital and operating costs for each project, which are shown per kL of stormwater produced in Figure 7-1 and Figure 7-2 respectively. It can be seen that there are economies of scale with larger projects costing less per kL than projects with smaller reuse volumes. These figures do not account for the additional water quality benefits from the projects.

These case studies were all taken from projects in Sydney, which the Bureau of Meteorology classifies as being in a uniform rainfall zone; storages in Tweed would need to be larger to cater for the same reuse volume due to the highly seasonal Tweed rainfall pattern. As a result, it is expected that capital costs for stormwater harvesting projects in Tweed would be higher on average per ML than those shown in Figure 7-1.

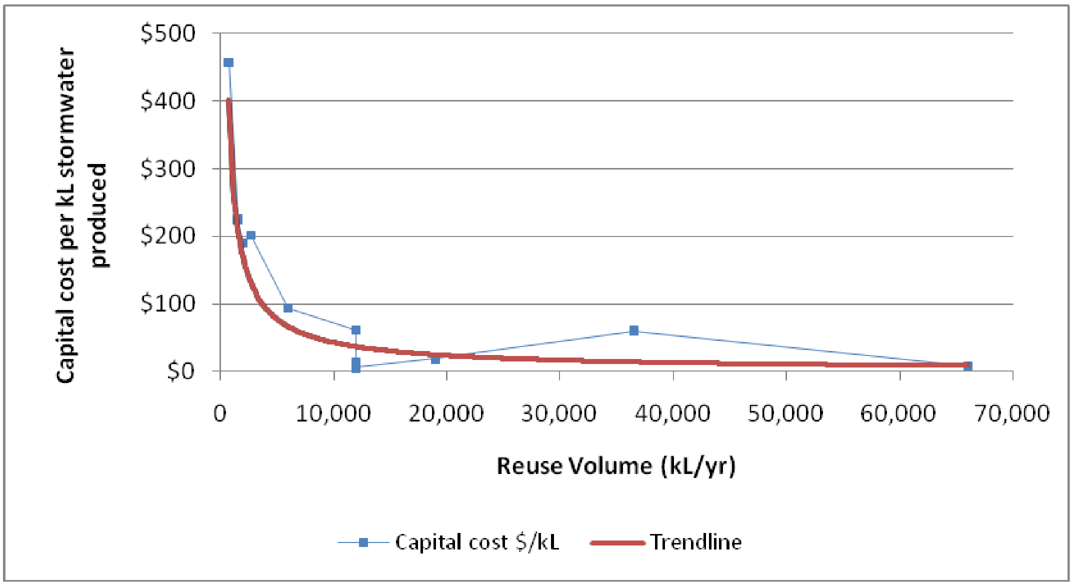

Figure 7-1: Capital cost per kL for stormwater harvesting case studies based predominantly on public space irrigation (DEC, 2006)

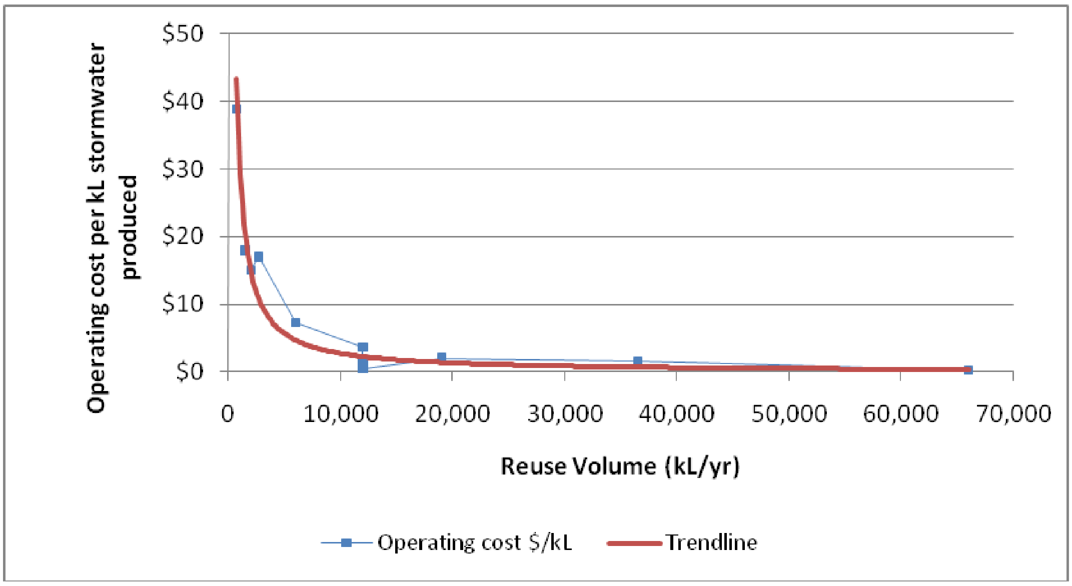

Figure 7-2: Operating cost per kL for stormwater harvesting case studies based predominantly on public space irrigation (DEC, 2006)

In terms of reuse volume, the case studies shown in Figure 7-1 and Figure 7-2 are of a much smaller scale than the Blackmans Swamp Creek (Orange) and the Parafield (Salisbury) case studies, which shows why these two large projects appear to be relatively inexpensive and highlights the economies of scale that can be achieved through large projects.

7.2.2 Identified Sites

The sites shown in Table 7-1 were identified as being suitable for stormwater harvesting based on the criteria in Section 7.1. The indicative capital and operating costs were calculated using the formula of the trendlines shown in Figure 7-1 and Figure 7-2.

The area to be irrigated for each site was assumed to be 2/3 of the total area for parks and fields and 1/4 of the area for golf courses as irrigation is typically focussed at the fairways and greens.

The annualised costs shown in Table 7-1 vary from $1 to $22 per kL with an average value of $5.60 which is higher than mains water price.

Table 7-1: Identified Sites potentially suitable for Stormwater Harvesting (public space irrigation)

Site	Total Area (ha)	Assumed Irrigation Area (ha)	Assumed Demand[1] (kL/yr)	Indicative Capital Cost	Indicative Annual Operating Cost	Annualised cost ($/kL)
Bridge Club Park	3.8	2.5	9,500	$424,200	$27,500	6.9
Banora Green Soccer	6.7	4.5	16,800	$461,600	$26,700	4.0
South Tweed Heads Football Club	8.2	5.5	20,600	$475,700	$26,500	3.4
Arkinstall Park	11.9	7.9	29,800	$502,900	$26,000	2.4
Coolangatta and Tweed Heads Golf Course	84.4	21.1	79,400	$581,800	$24,700	1.0
Murwillumbah Golf Club	44.0	11.0	41,400	$528,000	$25,500	1.8
Jim Devine Soccer Field	1.7	1.1	4,300	$376,300	$28,600	14.7
Knox Park	7.5	5.0	18,800	$469,400	$26,600	3.6
Les Cave Fields	18.4	12.3	46,100	$536,600	$25,400	1.6
Willward Park	3.5	2.3	8,800	$419,000	$27,600	7.4
SDA Primary and High School	12.9	8.6	32,400	$508,900	$25,900	2.2
Murwillumbah Showground	13.0	8.7	32,600	$509,500	$25,900	2.2
Queens Park	1.1	0.7	2,800	$352,700	$29,200	22.1

1 The potential irrigation demand of sports fields/open spaces was determined using MWH's Irrigation Tool for Active Playing Surfaces. Using climate data for Bray Park for the period 1970 – 2007, the irrigation demand was determined to be 3,762 kL/ha/yr.

7.2.3 Storage sizing

Sizing of stormwater storages is dependent on a number of factors:

- Yield and reliability required;
- Contributing catchment area (i.e. how much land drains to the storage);
- Contributing catchment landuse (i.e. how much runoff will the catchment produce, less runoff will occur from permeable surfaces compared to impermeable roads, roofs and paved surfaces);
- Climate (average rainfall and seasonality); and
- Treatment adopted (e.g. an underground aquifer storage will occupy less area than using a wetland for treatment).

All of these factors are site specific and will need to be examined on a case by case basis.

To give an indication of the storage sizes required, details of two of the 11 case studies by the NSW Department of Environment and Conservation (2006) are shown below.

Bexley Municipal Golf Course, Bexley

The contributing catchment area comprises 77 ha of urban landuse and 5 ha of golf course. Stormwater from this catchment flows through the 20 ha golf course in a concrete-lined channel.

No information is known about the reliability of the supply and how much of the total golf course demand is met by the system however the annual stormwater reuse volume is 66 ML and potable water is available as a back-up supply.

The capacity of the stormwater channel is 7 ML, assuming a 2 m deep channel gives a required surface area of 3, 500 m^2 or five 700 m^2 average size house blocks.

Riverside Park, Chipping Norton

The contributing catchment area comprises 47 ha comprising urban landuse and parkland.

This system irrigates an area of 2 ha (baseball fields) and potable water provides a back-up supply for the irrigation system. The estimated annual stormwater reuse volume is 12 ML.

The harvesting system consists of a 2.4 ML storage and sedimentation pond and three treatment wetlands. It is unknown how large the wetlands are but from satellite imagery they appear to be approximately the same size as the two baseball fields that they are used to irrigate (2 ha). This project also has water quality benefits with the treated stormwater not used for irrigation flowing to the Georges River.

These case studies were taken from projects in Sydney, which the Bureau of Meteorology classifies as being in a uniform rainfall zone; storages in Tweed would need to be larger to cater for the same reuse volume due to the highly seasonal Tweed rainfall pattern.

7.3 Comparison of Source Substitution Options

The costs and demands shown in Table 7-2 have been taken from the Demand Management Strategy (MWH, 2009). The average capital and operating cost per kL for the proposed dual reticulation (third pipe) recycled water schemes are $32 and $0.30[3] respectively. These schemes treat water to A+ quality.

Table 7-2: Recycled Water costs

Development	Annual Demand in 2036 (kL/yr)	Total Capital Cost	Capital Cost per kL	Opex Cost/annum at 2036	Opex Cost per kL	Annualised cost ($/kL)
Cobaki Lakes	430,000	$13,490,000	$32	$117,000	$0.30	$7.1
Bilambil Heights	280,000	$10,408,000	$37	$77,000	$0.30	$7.8
Terranora	165,000	$5,910,000	$36	$45,000	$0.30	$7.3
Kingscliff	90,000	$2,433,000	$27	$29,000	$0.30	$6.4
Kings Forest	440,000	$12,825,000	$29	$146,000	$0.30	$6.9

Annualised costs for dual reticulation A+ quality recycled water is approximately $7/kL as shown in Table 7-2 for schemes ranging from 90 to 440 ML/year. By comparison, stormwater harvesting costs for lower quality municipal use water shown in Table 7-1, show that schemes reusing volumes of 10 ML/year also cost approximately $7 per kL. The largest schemes (up to 80 ML/year) may cost as little as $1/kL for the lower quality municipal use water[4].

However, stormwater for municipal use is more practically implemented for small irrigation schemes. The recycled water schemes shown in Table 7-2 are much larger in scale and using stormwater instead of recycled water to service these developments would not be feasible.

Stormwater harvesting for third pipe systems is less cost effective than stormwater harvesting for municipal reuse due to the more stringent and costly treatment requirements as shown in Table 4-3. Similarly harvesting, treatment and storage for third pipe stormwater schemes is more costly than the equivalent recycled water scheme due to stormwater being climate dependent, having a variable quality and requiring larger storages.

Analysis of various development servicing options for a Greenfield site at Kalkallo in Melbourne showed that recycled water supplied by third pipe requires significantly less storage space than stormwater. To supply garden and toilet with 95% reliability and adopting end-use management measures, a 22 ML recycled water storage is required compared to a 1,100 ML stormwater storage. This equates to 0.9 hectares compared to 44 hectares (assuming a uniform 2.5 metre storage depth) or 0.2% of the storage requirement.

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[3] This cost aligns to estimates of recycled water system's operational costs investigated for the South East Queensland Water Strategy, which range from $236 to $274 per ML, approximately $0.30 per kL (Cardno, 2006).

[4] As discussed in Section 7.2, the stormwater harvesting costs were taken from Sydney case studies and the costs may be slightly higher in the Tweed area due to the different rainfall pattern.

8 Discussion

Stormwater harvesting is under review as cities across Australia look for alternate sources of water to ensure reliable water supplies. As part of the Rudd Government's $1 billion National Urban Water and Desalination Plan to help secure the water supplies of Australian cities $200 million will be provided to undertake innovative stormwater capture projects to help secure water supplies for Australian cities.

Unlike recycled water, which is a relatively constant source of supply, stormwater is climate dependent and supply is not guaranteed during periods of drought or below average rainfall. Because this supply is not guaranteed, the size of potable water infrastructure cannot be downsized as it will still need to be able to cater for peak water demand.

Being climate dependent also has implications on the size of storage required for stormwater harvesting schemes, which need to be large enough to capture the wet summer rainfall and store it to cater for the winter demand. The required size and yield of any proposed stormwater harvesting storages will need to be assessed individually to account for connected catchment area and demand. There is also a 'point of diminishing returns' in storage size, where increasing the size further does not provide a significant increase in yield and will determine the most cost-effective storage for a given demand and catchment, this will mean a reliability less than 100% and will require an additional water source to meet the required demand.

Compared to other source substitution options like recycled water and the rainwater tank requirements of BASIX, stormwater harvesting is generally less cost-effective but this is dependent on the size of the scheme and existing infrastructure as there are economies of scale with larger projects. Costs of stormwater harvesting schemes also need to be examined in terms of integrated water cycle management. For example if downstream pollution and waterway health is an issue, the cost of any necessary stormwater treatment should be considered to determine whether stormwater harvesting is a feasible addition. This would need to be examined on a case by case basis.

In general, stormwater contains many of the hazards found in sewage, but concentrations will vary with lower concentrations for microbial hazards and potentially higher concentrations for some chemical hazards (e.g. hydrocarbons and pesticides). For a stormwater harvesting and reuse scheme, unlike a water recycling scheme, the scheme's catchment has a significant impact on the raw stormwater quality, and consequently exposure rate to hazards. The raw water quality will be impacted by factors such as catchment land uses and the proportion of the catchment that is impervious.

In addition, stormwater quality in a particular catchment may vary significantly influenced by rainfall patterns and other events occurring in the catchment (e.g. bushfires or increased erosion and sedimentation due to development). Due to this variable quality, the pathogen reduction achieved by most wastewater treatment systems is expected to be greater and more consistent when treating wastewater than stormwater.

The relevant guidelines both advocate a risk mitigation approach to the design of stormwater harvesting and reuse schemes, opposed to prescriptive water quality targets.

The level of risk mitigation required for a particular scheme will depend on the catchment's characteristics, raw stormwater quality and the planned end uses for the stormwater.

The risk mitigation is not only incorporated into the design phase of the project but instead the entire life of the project. During the operation phase activities such as regular maintenance, performance monitoring and validation need to be undertaken in order to ensure the desired level of risk mitigation is continually achieved.

Stormwater harvesting, is not a “one size fits all” solution and depends on existing catchment, infrastructure and required outcomes. Whilst it is generally considered a less cost-effective method of source substitution compared to recycled water or the rainwater tank requirements of BASIX there can be economies of scale and any proposed stormwater harvesting scheme will need to be analysed on its own merits. From the review of stormwater harvesting case studies, the most cost effective scheme appears to be municipal schemes which are greater than 10 ML and require limited treatment.

9 Conclusions

- Unlike recycled water, which is a relatively constant source of supply, stormwater is climate dependent and supply is not guaranteed during periods of drought or below average rainfall. Because this supply is not guaranteed, the size of potable water infrastructure cannot be downsized as it will still need to be able to cater for peak water demand.
- The pathogen reduction achieved by most wastewater treatment systems is expected to be greater and more consistent when treating wastewater than stormwater.
- 13 sites were identified as being potentially suitable for stormwater harvesting in the Tweed area, however areas of irrigation and demand for these sites have been assumed and these sites would need to be individually assessed. Using a coarse comparison curve based on DEC (NSW) case studies for public irrigation, the indicative annualised costs of these sites vary from $1 to $22 per kL with an average value of $5.60, which is higher than mains water price.
- The required size and yield of any proposed stormwater harvesting storages will need to be assessed individually to account for connected catchment area and demand. There is also a 'point of diminishing returns' in storage size, where increasing the size further does not provide a significant increase in yield and will determine the most cost-effective storage for a given demand and catchment, this will mean a reliability less than 100% and will require an additional water source to meet the required demand.
- Stormwater reuse systems are generally most cost effective where treatment requirements are minimal. Other reuse options such as recycled water are generally more cost effective for 'higher end uses' such as third pipe or potable systems. There are economies of scale with larger projects and stormwater harvesting schemes reusing greater than 10 ML/year for municipal use can potentially cost less than $7 on an annualised cost per kL basis.
- Stormwater harvesting for third pipe systems will be less cost effective than stormwater harvesting for municipal reuse due to the more stringent and costly treatment requirements. Similarly harvesting, treatment and storage for third pipe stormwater schemes is more costly than the equivalent recycled water scheme due to stormwater being climate dependent, having a variable quality and requiring larger storages.
- Direct to potable use similar to the Blackmans Swamp Creek (Orange) stormwater harvesting case study has not been examined due to this project being the first of its kind in Australia and very limited data being available. This scheme appears relatively cheap as the project utilised existing infrastructure located nearby thereby avoiding large capital costs. Suma Park Dam is only 4km from the centre of Orange, which is much closer than Clarrie Hall Dam to the centre of the major Tweed population centres of Murwillumbah and Tweed Heads.
- At this time there are no known aquifers in the Tweed area that would provide an opportunity for either enhanced recharge of an existing supply or an aquifer storage and recovery system.

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