ELSEVIER

Desalination 188 (2006) 169–175

DESALINATION

www.elsevier.com/locate/desal

Integrated Water Management in brownfield sites — more opportunities than you think

N. Apostolidis[a]*, N. Hutton[b]

[a]*GHD Pty Ltd, 201 Charlotte Street, Brisbane, Queensland, 4000, Australia*
Tel. +61 (7) 3316-3000; Fax +61 (7) 3316-3333; email: napostolidis@ghd.com.au
[b]*GHD Pty Ltd, 10 Bond Street, Sydney, NSW, 2000, Australia*
Tel. +61 (2) 9239-7322; Fax +61 (2) 9239-7193; email: nhutton@ghd.com.au

Received 4 January 2005; accepted 29 April 2005

Abstract

There are several major greenfield schemes in Australia where integrated water management (IWM) initiatives have been implemented or are in the process of implementation on greenfield sites. This is a great initiative that will assist in reducing the ecological footprint of new developments on Australia's limited water resources. To date little work has been done to determine the feasibility of IWM in brownfield/redevelopment sites. Based on recent work it is clear that significant opportunities exist to achieve similar and even better outcomes in brownfield sites. In some cases it is possible to achieve a net zero-in zero-out outcome cost effectively compared to more traditional schemes. This paper outlines how the concept of integrated water management can be applied on brownfield sites in both domestic and industrial/commercial areas. Case studies are included to demonstrate the concepts and to illustrate the implications for the public and for authorities.

Keywords: Total water cycle; Recycling; Integrated water management; Ecological footprint; Brownfield sites

1. Introduction

The application of Integrated Water Management (IWM) for urban areas of Australia has grown rapidly in recent years. This has most commonly been applied to greenfield residential developments where the greatest opportunities exist to install integrated infrastructure for potable water supply, wastewater management and capture of rainfall.

The applications on brownfield sites, particularly in inner urban areas have been less common and generally display less integration.

*Corresponding author.

Presented at the International Conference on Integrated Concepts on Water Recycling, Wollongong, NSW Australia, 14–17 February 2005.

In the context of this paper, we will consider the definition of Integrated Water Management to be systems that use an integrated combination of techniques applied to an urban area to ensure that water is used efficiently and that the amount of high quality fresh water that has to be withdrawn from the environment is minimised by the capture and reuse of wastewater and rainfall.

2. Integrated Water Management initiatives in Australia

2.1. The Australian context

Despite the size of the Australian continent, the majority of Australians live in cities located close to the coastline. The population of Australia, and the population of the major cities along with it, grew rapidly in the second half of the twentieth century. Much of this new population has been housed in expanding suburbs of the major cities leading to a continuous expansion of the water and wastewater infrastructure of the cities. In recent years there has been a trend towards redevelopment of inner urban areas based on higher density residential living.

One of the historical contributors to the development of Australian cities near the coast has been that the coastal areas generally have higher rainfall than the inland areas. Water supply for the urban areas was more readily available in these areas. But, a combination of ongoing growth and extended drought has stretched these water sources to the limit leading to a willingness to consider the alternatives in earnest.

2.2. Some typical IWM initiatives

2.2.1. Wastewater recycling in greenfield suburban areas

The early initiatives in IWM focussed on the growing suburban residential areas. With relatively low-density development these areas historically have high water use due to the traditions of including substantial garden areas on each residential property.

At Rouse Hill, a fringe suburban development area in Sydney, NSW, a wastewater recycling system has been installed that currently serves 15,000 properties and is being expanded to serve a further 10,000 properties. Here, the wastewater from the treatment plant serving the area is treated and then delivered back to customers through a dual reticulation system. Residents are permitted to use this water in the garden, for toilet flushing and for clothes washing.

This approach is typically only considered feasible in greenfield development areas due to the high cost of installing the distribution pipework. Historically, the recycled water has been sold at a substantial discount to the price of drinking water. The savings of drinking water use with such a scheme are typically 20–30%.

2.2.2. Wastewater recycling and stormwater harvesting

Harvesting of rainwater is resurgent in urban Australia. In many jurisdictions it is now compulsory to install roofwater collection tanks and to use the stored water for outdoor purposes and for toilet flushing. Widespread introduction of this measure is expected to result in significant potable water savings.

Larger-scale harvesting of urban stormwater proves more difficult in Australia due to the extremely variable rainfall patterns. Short periods of intense rainfall followed by lengthy dry periods are typical of the Australian climate. Any stormwater harvesting and reuse system needs to incorporate a substantial storage volume in order to harvest a significant proportion of the available runoff and to maintain satisfactory security of supply through the unpredictable dry periods. Installing a storage large enough to harvest a significant proportion of the available water usually proves uneconomic on brownfield sites.

A comprehensive scheme was installed at Homebush Bay, Sydney when the site was developed for the 2000 Olympic Games. This system enables runoff from much of the site to be collected and stored for later treatment and then reuse. This system was made possible because the site was largely a greenfield site, giving the opportunity to install the entire infrastructure from the start. The site also had existing features that could be used to develop a very large storage economically. The scheme on this site also included the facility to "mine" sewage from a trunk sewer that crosses the site. A facility on the site treats this sewage along with harvested stormwater. The treated water is then reticulated throughout the site and to an adjacent residential area to be used for toilet flushing, laundry washing and for outdoor uses.

2.2.3. Commercial buildings

There have been some high profile commercial buildings developed in Australia in recent years that have been designed with a wide range of "green" features to make them water and energy efficient. The more widely publicised examples of these have been those that have incorporated a range of innovative features and have achieved significant savings in water use. In general, these approaches require a significant effort in the planning stages to gain approvals for the non-standard ways of managing water and are considerably more costly than a standard approach. Hence these examples have been driven by a stated objective in the development of the building to "do things differently".

Achievement of significant savings in water use in commercial buildings presents a range of technical challenges as well. An office building has a very intermittent water use pattern, generally for less than half of the day for five days per week. This results in significant peaks in the demand for water and the generation of wastewater. Ensuring that water of appropriate quality is available requires buffering storage. It is also a challenge to match the supply of water to the demand over an extended period, if reliance on the authority supply as a back-up is to be minimised.

3. Integrated Water Management on brownfield sites

Brownfield sites in urban areas present a number of challenges and opportunities for the implementation of integrated water management. Brownfield sites are typically surrounded by existing built up areas that constrain the opportunities for the installation of water treatment and storage infrastructure and make it more difficult to match the availability and demand for different classes of water. At the same time, the fact they are adjacent infrastructure it provides opportunities not available to greenfield sites. Some of the challenges include:

- Small roof area for collection of rainwater
- Little greenspace that needs irrigation
- Little space for storage and treatment facilities
- Mismatch between temporal distribution of availability of water and demand
- Additional cost of IWM with no payback for developer
- Regulations
- Regional recycled water not available due to cost of installation of distribution pipework in built-up areas

Roofwater harvested from the buildings on a site is usually the cleanest alternative water source available, requiring little treatment before being suitable for a wide variety of uses. However, as the density of development increases, the building roof area as a proportion of the total building floor area decreases, so that the quantity of roofwater that can be harvested becomes a less significant proportion of the overall water requirements.

Irrigation of greenspace provides an easy opportunity for substitution of potable water with water from other sources. In brownfield development sites, the area of greenspace is commonly small, so the water usage is also small, limiting the opportunity for significant substitution of potable water use.

Redevelopment of brownfield sites is a commercial enterprise requiring revenue-earning area to be maximised and minimising any non-revenue areas. The allocation of space for water storage and treatment facilities is seen as a choice between traditional water servicing infrastructure that requires virtually no non-revenue space on the site and the alternative that requires space to be provided. Hence, even though advances in water treatment technology continually reduce the size of facilities, any space used is a significant expense to the development.

Despite these challenges, it is possible to find significant opportunities for the application of IWM initiatives. Fig. 1 shows some of the IWM opportunities available in a typical residential/commercial re-development.

4. A case study

A desktop study of the opportunities to implement IWM initiatives was carried out for a 32,000 m^2 site in Western Sydney. The site comprises a complete city block in a suburban centre. The existing buildings will be demolished and replaced by a new integrated development containing a diverse mix of residential, retail, office and commercial uses in buildings up to 20 storeys in height.

Traditional servicing of this brownfield site would involve connection to the water supply system to supply water for all uses and connection to the existing sewerage system to take away all

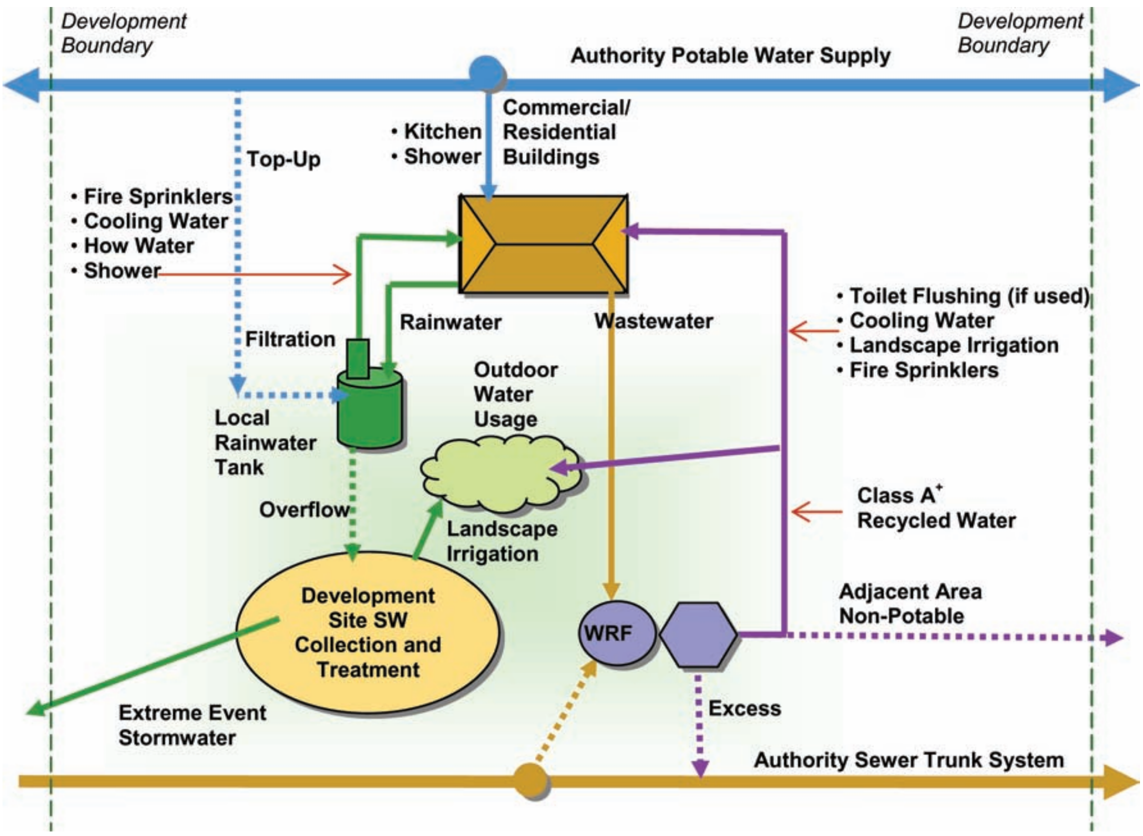

Fig. 1. IWM opportunities in a brownfield site.

wastewater. These services are readily available in the area and would have had capacity to serve these functions. However, one of the development objectives was to consider ecological sustainable development (ESD) as a founding principle in the design of the new functions for the site. With these objectives in mind, a range of water cycle management approaches were conceived that would target the following outcomes:

- Reduction of the demand for potable water from the authority's water supply system by water conservation.
- Reduction of the demand for potable water from the authority's water supply system by the use of alternate water sources including water recycling.
- Reduction of the discharge to sewers and the impact to receiving waters.
- Prevention of pollution entering the stormwater system using stormwater quality best practice principles, and hence improve the quality of receiving waters.

The approaches to achieving these objectives fell into three main categories:

- **Water efficiency** — which would directly reduce drinking water demand and wastewater discharge. These options include water demand management and the use of water efficient fixtures and appliances.
- **Water recycling** — to reduce drinking water demand by substitution of alternative water sources, and also reduce stormwater and wastewater volumes exported off site. Alternative sources such as rainwater, stormwater, greywater and sewerage are available.
- **Water trading** — provides an opportunity to reduce water demands and discharges to the environment by utilising sources and physical infrastructure adjacent to the site. Water trading is an approach where water use and/or sewage discharge in one area is offset against efficiency gains in another.

The use of water efficient fixtures and appliances has become standard practice in Australia in recent years to the extent that levels of water efficiency considered to be leading technology only five years ago are now the standard fixtures available in the marketplace. For this site, it was estimated that the use of these types of fixtures and appliances throughout the new development would result in water usage approximately 30% less than would have occurred with traditional fixtures.

The 'water recycling' scenario was characterised by maximising the collection and reuse of water on the site. To achieve this, all fixtures would have high efficiency levels. Water from the potable mains supply would be supplied for drinking, showering/bathing and hand washing. Rainwater, stormwater and grey-water would be collected and treated as necessary for reuse for other purposes including cooling towers, laundering and toilet flushing. For this site, it was estimated that these measures would result in water usage approximately 60% less than would have occurred with traditional servicing.

The main constraint to the reduction in water usage possible with this 'water recycling' approach is that the quantity of rainwater, stormwater and greywater available on the site is insufficient to meet the demands from cooling towers, laundering and toilet flushing. Hence, part of the water requirements for this system need to be made up from the potable water supply system.

The 'water trading' scenario was based on looking outside the boundaries of the site to maximise the available sources of water and potential uses for this water. To achieve this, all fixtures would have high efficiency levels, or even be 'water-less'. Extensive use would be made of water recycling systems. The use of offset approaches — that is collection, treatment and use of water sourced from off-site were also included. For this site, it was estimated that these measures would result in drinking water usage approximately 90% less than would have occurred with traditional servicing.

For the site studied, this approach meant that a public sewer passing through the site could be ‘mined’ and the wastewater treated to a standard suitable for the non-potable uses indicated. The treated water would then be used to ensure that 100% of non-potable demands on the site could be met from recycled water. There would also be the opportunity then to ‘export’ some of that treated water to adjacent sites. In this case adjacent sites included a public park that currently uses potable water for irrigation and an indoor entertainment complex that attracts large numbers of people and currently uses a large quantity of drinking water for toilet flushing.

Indicative estimates of the cost to include such systems into the buildings indicated that as expected the cost of construction would be slightly higher than traditional servicing. However, if the reduced demands on the public water supply and wastewater systems are taken into account in the setting of headworks charges by the authorities, it is likely that the overall cost to the site developer and to the community would be equivalent to traditional servicing.

5. Implications for the community and for authorities

The application of ‘water trading’ approaches to water servicing on brownfield sites offers significant opportunities, including:

- A reduction in the ecological footprint of our cities at the same time as they continue to develop and accommodate more people;
- A net reduction in the load on existing water infrastructure, avoiding the need to increase capacity with the associated disruption and costs.

However, the initiatives mooted here also present some challenges for the community and for authorities.

5.1. Health authorities

The types of schemes that enable ‘water trading’ to take place will involve more localised treatment and distribution of water. This raises concerns about the potential public health implications if the water is inadequately treated, a particular issue for authorities responsible for public health. Such risks are clearly manageable by the use of appropriate technologies and the application of suitable management systems. It will be a particular challenge for health authorities to avoid prescription of overly conservative infrastructure and to facilitate the development of new management systems that respond to the requirements of distributed infrastructure.

Health authorities will also have a leadership role in providing guidance on the ways in which recycled water can be used. The case study explored here was based on the use of recycled water from any source only for non-potable uses. A clear framework based on risk assessments is needed.

5.2. Water authorities

The cost to install and operate water-servicing systems that provide substantial recycling can be significantly higher than a conventional water-servicing system on a brownfield site. However, if the reduced loads on the existing infrastructure are recognised, the cost of an IWM scheme can be similar to a conventional scheme. To achieve this, the water authority needs to apply a suitable discount to the headworks or capital works charges that would normally be applied to brownfield developments, reflecting the significant reduction in the system load. The water authority also needs to recognise the reduced operation costs due to reduced load – where services are charged on a metered basis this will happen automatically through reduced charges, but where the charges are based on fixed rating systems, the water authority would need to develop an equitable discount arrangement to reflect the reduced loads.

IWM systems that involve supply of recycled water from one property to another also present legal and management challenges. Water authorities in Australia have a monopoly position in the market for the supply of water in urban areas. Suitable legal mechanisms will need to be developed to allow for the situation where recycled water from one property is sold to a nearby property. Some water authorities may wish to remain involved in this but others will not and these will need to facilitate the development of suitable legal and management structures that provide an equitable allocation of responsibilities and risks.

5.3. Communities

The key to successful application of IWM schemes in brownfield sites is acceptance by the community. There needs to be universal use of appropriate water-efficient fixtures, there needs to be water-efficient behaviours in water use and there needs to be acceptance of the use of recycled water for applications where drinking water might have been used previously.

6. Conclusions

The results achieved by the application of IWM principles to brownfield sites are generally limited by the constraints imposed by the site boundaries. In cases where demand for recycled water exceeds supply on the site, it is prohibitively costly to bring recycled water to the site from existing treatment facilities due to the difficulties of installing pipelines in developed areas. And in cases where supply of recycled water exceeds demand on the site, there is a lost opportunity for reuse.

By looking outside the boundaries of a brownfield site, broader opportunities for water sources and for recycling can be identified. This approach could yield outcomes that include:

- A reduction in the ecological footprint of our cities at the same time as they continue to develop and accommodate more people;
- A net reduction in the load on existing water infrastructure, avoiding the need to increase capacity with the associated disruption and costs.

The technical solutions to the challenges of these systems are readily available. However there are a number of legal, economic and regulatory challenges that will need to be addressed by water and health authorities if these initiatives are to prove viable and sustainable.