Technical Research Paper 07

Water

city of Melbourne

Contents

Disclaimer

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An Australian Government Initiative
AusIndustry

6 star rating
green star Office Design v1
This rating represents World Leadership

CH_2

Preface

Council House 2 (CH_2) is a visionary new building that is changing forever the way Australia – indeed the world – approaches ecologically sustainable design.

With its Six Star Design Rating granted by the Green Building Council of Australia, CH_2 is one of the cleanest and greenest buildings on earth.

This paper, one in a series of 10 technical papers, investigates the design and systems of CH_2 prior to occupancy and availability of operational performance data. The papers have been written by independent authors from Australian universities, as part of the CH_2 Study and Outreach Program – a coordinated effort to consolidate the various opportunities for study, research, documentation and promotion generated by CH_2.

The aim of the CH_2 Study and Outreach Program is to raise awareness of sustainable design and technology throughout the commercial property sector and related industries.

While the pre-occupancy research papers are a valuable resource, they do have some limitations. For instance, these studies have been written before operational experience. This means the authors' views are based on existing knowledge, which can be difficult to apply when significant innovation exists.

Many of the innovations in CH_2 have been subject to limited, if any, rigorous or directly relevant research in the academic field, which is reflected in the lack of literature cited for systems such as the shower towers and phase change materials used in the cooling system.

Another major limitation is the exclusion, by academics generally, of industry experience of new technologies. The extensive knowledge gained by industry is often not well documented and can be difficult to access through traditional academic channels.

One example, where industry expertise exists, is the use of phase change materials for reducing peak cooling loads and energy use in commercial and institutional settings, such as offices, hospitals, prisons and factories.

In addition, to enable the authors to complete their task, they have based their study on CH_2 project reports prior to the design being finalised. This means some of the descriptions of systems and findings in the papers are to some extent out dated. In particular, findings related to the wind turbines and the heating, cooling and ventilation systems have changed somewhat as a result of final design decisions.

To reduce the impact of these limitations for readers, the Council has provided additional comment as footnotes in some papers.

It is important to inform readers the target audience for these papers is professionals and academics involved in the research, design, engineering, construction and delivery of high performance buildings. This helps to explain the technical detail, length and complexity of the studies.

Although these papers may be of interest to a range of audiences it's important that readers, who possess a limited knowledge of the subjects covered, obtain further information to ensure they understand the context, relevance and limitations of what they are reading.

For more information or to make comment and provide feedback, readers are invited to contact the Council. The details are available at the end of this document.

We hope you enjoy reading these technical studies and find they are a useful resource for progressing your own organisation's adoption of sustainable building principles and encouraging the development of a more sustainable built environment.

Foreword

In 2000 the City of Melbourne made the decision to embark on a revolutionary new project called Council House 2 (CH_2). The decision was due to a pressing need for office space for its administration and the desire to breathe life into an under-used section of the city.

The project gave the Council the opportunity to exercise its environmental credentials by creating a building that was at once innovative, technologically advanced, environmentally sustainable and financially responsible.

This approach allowed the Council to insulate itself against exposure to rising energy and water prices, the diminishing availability of resources and the uncertain long-term availability, while providing a healthy workplace attracting the best workforce in a labour-constrained market.

CH_2 has been designed to reflect the planet's ecology, which is an immensely complex system of interrelated components.

From the revolutionary cooling storage system in the basement to vertical gardens and wind turbines on the roof, the building has sustainable technologies integrated throughout its 10 storeys.

Although the majority of the technologies and principles adopted in the building are not new, never before in Australia have they been used in an office building in such a comprehensive and interrelated fashion.

This includes innovations such as: using thermal mass for improving comfort; phase change material to reduce peak energy demands and energy use; generating electricity onsite from natural gas; and using waste heat for cooling and heating.

Through CH_2, the Council plans to trigger a lifestyle and workstyle revolution. The building will be used as a living, breathing example, demonstrating the potential for sustainable design principles and technologies to transform the way industries approach the design, construction and philosophy of our built environment.

As with many revolutions, there are sceptics. The Council's response has been to patiently press ahead with the construction of CH_2 while actively and energetically encouraging lively debate.

Some of the papers in this pre-occupancy study and outreach series make compelling points in favour of the case for sustainable development. Others reflect a more subtle or sometimes overt scepticism that may be encountered throughout the community.

The City of Melbourne welcomes all of this debate but in the long term intends to demonstrate the effective performance of CH_2 and prove the doubters wrong. Collectively, the studies demonstrate the enormous value to be gained by researching the case for sustainable development and the scope for much more study and documentation in this field in the future.

The City of Melbourne wants CH_2 to be copied, improved on and enthusiastically taken up throughout Melbourne and far beyond.

Technical Research Paper 07

Water

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Abstract

This study addresses the vision and goals of the City of Melbourne and the Victorian Government for reducing water consumption in urban areas and increasing water recycling as part of their commitment to sustainable development. The emphasis of this study is on water management initiatives applicable to commercial buildings, and particularly on those implemented at Council House 2 (CH_2) that aim to achieve water conservation goals within an ecological sustainable development (ESD) framework.

The projected performance of the CH_2 building, barriers for achieving targets, and necessary future research, are detailed and discussed with reference to the following key areas:

- water conservation, efficient water use, water recycling and rainwater collection in the context of sustainable water management plans;
- the innovative onsite sewer mining system;
- national and international best practice in commercial/ office buildings in the area of water recycling and water efficient use;
- public acceptance of recycled water;
- benefits of sustainable buildings to the environment and community; and
- future monitoring for performance evaluation.

Introduction

Australia is the driest inhabited continent, yet its people have recently recorded the second highest per capita water consumption in the world (ATSE, 2004). Many commentators have called for water to be used sensibly and regarded as a finite valuable resource. The current drought, with eight consecutive years below average rainfall, has stressed the need for water use to be responsibly managed if Australia is to achieve sustainable development.

Strategies to address the balance of water supply and demand vary across the Australian states. Some, such as Western Australia, are adopting system augmentation; while others, including Victoria, are promoting demand management.

Average annual water usage in Victoria is about 5800 gigalitres (GL), of which 77 per cent is used for irrigation and eight per cent for Melbourne's water needs. Around 350 GL of Melbourne's wastewater flows to municipal treatment plants, of which 270 GL is discharged to water bodies (Department of Natural Resources and Environment (DNRE) 2002 and 2003), causing various adverse effects on the surrounding environment.

Currently, only 11 per cent of treated wastewater is recycled. This water is mainly used for land applications such as the watering of golf courses and ovals (Melbourne Water 2005, DNRE 2002); and for agricultural production, as demonstrated at the Western Treatment Plant. (Melbourne Water 2005) These consumption and discharge volumes indicate a potential for reduced demand on the potable water supply, from its substitution with recycled water treated to a suitable quality standard.

Metropolitan Melbourne uses approximately 500 GL of drinking water for many uses that do not require drinking quality water. (Melbourne Water, 2005) The average household uses 19-25 per cent of its potable water supply for toilet flushing, and 35 per cent for garden watering. (Water Resources Strategy Committee for the Melbourne Area 2001, ATSE 2004) Some of the strategic measures recommended to reduce potable water demand have been the promotion of water-efficient fittings and fixtures; water education and awareness programs; and the search for and use of all possible non-traditional sources of water substitution. Alternate water sources considered for use where potable water quality standard is unnecessary, include:

- rainwater harvesting;
- stormwater reuse;
- sewer mining; and
- the use of groundwater.

The Victorian Government recognises the role of water conservation measures, and has set targets to reduce Melbourne's per capita consumption of mains supplied potable water by 15 per cent by 2010 compared to the average for the 1990s, and to increase water recycling to 20 per cent by the same year. However, Melbourne is expected to grow a further 32 per cent by 2050. (Water Resources Strategy Committee for the Melbourne Area 2001)

To meet the demand of this increased population, and maintain a sustainable environment, the Melbourne Water Resources Strategy formulated its ‘Preferred Scenario 5’. This calls for water recycling schemes in new developments to reach a target of 35 per cent potable water substitution; and the implementation of some form of water use substitution in existing developments by 2050.

Actions focused on increasing the use of alternative water supplies are outlined within the Victorian Government’s White Paper Securing Our Water Future Together (Victorian Government Department of Sustainability and Environment (DSE), 2004). Detailed water recycling actions are limited to major recycling projects, with the expectation that new developments achieve at least 25 per cent savings in water use through water sensitive urban design initiatives.

The use of recycled water to substitute for potable water consumption in Melbourne has been minimal, at about two per cent a level that is typical of other major Australian cities. (DNRE, 2002; ATSE, 2005) Currently, the main use of recycled water is for urban amenity plantings, which result in little reduction in mains supplied potable water usage. (ATSE, 2005) Therefore, new and innovative approaches are needed, to maximise the use of recycled water from either treated effluents or stormwater so that true reductions in the consumption of mains supplied water are achieved. In urban settings, developers and owners generally focus on small scale, onsite treatment plants; the reticulation of recycled water into new housing developments; and rainwater harvesting and reuse.

Council House 2 (CH_2), under construction on Little Collins Street in the heart of Melbourne’s central business district, is the first multi-storey office building in Australia to achieve a six star rating from the Green Building Council of Australia, the highest international standard in green building. (CH_2, 2004) This rating was made possible by the design solutions implemented in many areas, including innovative water recycling schemes. The CH_2 development directly contributes to City of Melbourne’s goal of 20 per cent recycling and is leading the way in sustainable building design.

Community acceptance, awareness and education are key elements in the successful implementation of water conservation schemes. By demonstrating a number of sustainable alternatives, the CH_2 building will provide society and the building industry with a resource for performance assessment of such alternatives in the short and long term. Therefore, the CH_2 project will set the benchmark for future multi-storey office buildings within Melbourne, throughout Australia and around the world. The objectives of this study are: (i) to document the sustainable features of the water conservation measures adopted at CH_2; (ii) to provide an overview of international best practice of water conservation in commercial/office buildings within an ecological sustainable development (ESD) framework; (iii) to critically comment on the expected success and performance of the CH_2 building; and (iv) to comment on the environmental, social and economic benefits of the building’s ESD features for reducing water consumption and use of mains supplied potable water.

Water Conservation

Water shortages have been recognised as the most immediate and serious threat to humanity. Australia is the world’s driest continent; yet our per capita water use of 320 litres/person/day is the second highest in the world after the United States of America, which is a continent with significantly higher rainfall levels. (ATSE, 2004) Melburnians have been recorded as using 423 litres/person/day on average over 1990-1999. (Water Resources Strategy Committee 2002) In view of projected population growth, it is anticipated that water supply and demand will increase by 50 per cent by 2020. (DNRE 2002) Considering the current persistent drought conditions and catchment storage infrastructure capacity limitations, it is essential to integrate into new buildings measures that reduce water resource use if sustainable development is to be achieved.

Melbourne currently recycles approximately 11 per cent of sewage effluents, which leaves 89 per cent effectively released annually into the environment. To encourage metropolitan water authorities to recycle more water, the Victorian Government has set a target of 20 per cent water recycling by 2020. The best possible outcomes will be achieved via water recycling for potable substitution, as this will also contribute to the target of 15 per cent reduction in water consumption per capita.

In terms of publicly supplied water, the major categories of consumption are domestic, commercial, industrial, and loss via leakages. (ATSE, 2004) Around 11 per cent of this is used in offices and other commercial buildings. Categories of water usage in these buildings comprise drinking water (including kitchen use); fire sprinkler testing; toilet flushing; showering; garden watering; and cooling. This suggests that water consumption in this type of building has the potential to be reduced by 90 to 95 per cent, if mains water was only supplied for use in its kitchens.

The City of Melbourne plans to reduce water consumption in the municipality by 12 per cent by 2020 (based on 1999 usage figures), despite a forecasted residential population increase of 41 per cent during this period. The achievement of this goal will require local households, businesses and industry to reduce per capita water consumption by 40 per cent. (Total Watermark, 2004) This study focuses on water saving measures included in the sustainable water conservation plan for CH_2, in accordance with the City of Melbourne’s proposed plan to reduce water demand. These measures include:

- increasing water efficiency by using water efficient fixtures and appliances;
- rainwater harvesting and fire-sprinkler test water reuse; and
- water recycling by sewer mining.

Increasing Efficient Water Use

Water efficiency can be viewed as 'doing more with less': through the implementation of technology that provides the same or better level of service, while using less water. Saving water through the use of efficient fittings and fixtures is the least sensitive issue of human concern, as it does not require lifestyle changes. Better performance of these fittings is also associated with other advantages, such as operational cost savings and reduced energy consumption, especially for hot water use as less water needs to be heated. There are a number of options available for each type of fitting and fixture, such as toilets, showers, taps and urinals.

Australia has adopted a national water efficiency rating and labelling scheme known as the 'Water Conservation Rating', referred to as the 5As, which is administered by the Water Services Association of Australia (WSAA). Fixtures using water are rated from A to AAAAA, with more As indicating a more efficient product. (WSAA, 2005) The WSAA initiative has been complemented by Federal Government legislation mandating water efficiency labelling of appliances and fixtures from July 2005. A list of water saving devices available off the shelf is listed in Table 1.

A number of studies have assessed the actual benefits and savings of water efficiency on residential water demand. However, few studies have focused on the commercial sector. Two exceptions are Olympic Park at Homebush Bay in Sydney, and the 60L Green Building located at 60 – 66 Leicester Street, Carlton in Melbourne. Case studies carried out by the Institute for Sustainable Futures in Sydney have confirmed that the water demand for commercial buildings could be reduced by 80 per cent, and sewage discharge by 90 per cent, compared to traditional commercial buildings. (Chanan et al., 2003) In general, these savings were achieved through adopting water efficiency measures (Table 1) such as substituting mains water supply for toilet flushing and garden irrigation, with rainwater and treated wastewater.

Table 1: Water Saving Devices

Water saving devices	Description
Low-flow (LF) dual flush	Dual flush, 6/3 litres/flush, approximately 50 per cent savings in water use compared with conventional use of 12 litres/flush. For example, the toilets (6/3 litres) at 8 Brindabella Circuit on average use four litres/flush compared to 10 litres/flush for standard toilets (www.canberraairport.com.au). For households, a saving of approximately 55 per cent was achieved on average water consumption of 24.4 litre/day/household, for houses using dual flush toilets (6/3 and 9/4.5 litres). This compared with those using single flush toilets (six litres and nine litres). (Gato, et al, 2004) A net potential savings of 39.8 litres/capita/day was estimated for homes fitted with Ultra Low-Flush toilets (ULF), compared with non-ULF homes. (Mayer, Deoreo, et al, 1999)
Waterless/water-free urinals	Saving of two litres/flush, potential 45 to 55 per cent water savings, depending on size and flushing method. A waterless urinal system is used in the new visitor centre at the Ightham Mote National Trust property (www.greenbuildingstore.co.uk), and in 60L Green Building (http://www.60lgreenbuilding.com). The system uses two litres/flush less than conventional urinals. Water-free urinals are installed at 8 Brindabella Circuit, Canberra. Water-free urinals use a biodegradable blocking fluid to contain odours, rather than the conventional water flush (www.canberraairport.com.au).
Sensor operated low-flush urinals	2.8 litres/flush. Up to 70 per cent water savings.
Flow regulators or aerators on taps	Flow rate is 6-12 litres/min compared with 15 litres/min. Water savings vary from 30 to 60 per cent depending on the period the tap is run at each use.
Sensor activated (infra-red) taps (used on basins in public toilets)	Same water savings as above, in addition to a potential reduction due to enforced shorter running time at each use. Infra-red taps are also being used in 8 Brindabella Circuit, Canberra. The use of these taps is associated with energy savings. Water is only released when hands are placed under the infra-red beam below the tap spout. Subsequent energy savings were reported, as less hot water is required to be heated (www.canberraairport.com.au).

Water saving devices	Description
Water efficient showerheads. Low flow (LF) showers	5-9 litres/min compared to conventional 20 litres/min water savings: about 50 to 70 per cent compared to conventional showerheads. Efficient showerheads (five litres/min) can save more than 40 litres a shower (based on a seven minute shower) compared with conventional heads (11 litres/min) (www.60lgreenbuilding.com). AA rated showerheads lead to 51 litres/shower water savings (around 48 per cent of water used per shower), compared with non-rated showerheads. (Gato, et al, 2004) Homes with the LF showers used an average of 78.4 litres/household/day and 33.3 litres/capita/day for showering purposes, while the non-LF shower homes used an average of 131.8l litres/household/day and 50.4 litres/capita/day. However, the duration of the average shower in the LF homes was one minute and 48 seconds longer than the average shower duration in the non-LF homes. (Mayer, et al, 1999) Water savings of around 13 kL per household a year are possible by converting standard showers (A rated: 12 to 15 litres/min) to water efficient showers (AAA and AA; 7.5 to 9 litres/min, and 9 to 12 litres/min respectively). This is based on a saving of 2.3 litres/min for a seven minute shower. (Water Resources Strategy Committee for the Melbourne Area, 2002) AAAAA rated showerheads at 8 Brindabella Circuit led to a 60 per cent reduction in shower water usage (www.canberraairport.com.au).
Garden timer taps	Water savings vary depending on garden size and type of irrigation.
Composting toilet	This product has a very low water demand. Its main drawbacks are capital cost (thousands of dollars/single toilet) and negative public perception. It is not widely used globally, particularly in multi-storey commercial buildings. There are a few examples in Sweden and Germany, and one in Australia (a two-storey building on the Thurgoona Campus of Charles Sturt University in Albury). (Chanan, et al. 2003)
Vacuum toilets	Use only 0.3 – 1.2 litres/flush. Mainly used on transport (such as aircrafts, trains and ships). These units are very expensive and energy intensive.

Rainwater Harvesting and Reuse

‘Roof runoff’ results from rainwater that falls directly onto roofs and, if not collected will drain into the stormwater system, adding to the built environment run-off flow volumes. In urbanised areas, rainwater run-off has potential for contamination by a variety of pollutants such as oil, grease, suspended solids, nutrients, litter, heavy metals and organic material. The large impervious surfaces of urbanised areas, such as roads, car parks and buildings, are also associated with a higher potential for contamination. They therefore play a major role in the increased deterioration of water quality in receiving waterways.

By contrast, the collection of rainwater in tanks or ponds reduces the level of pollutants that run off to receiving water bodies, while also reducing peak stormwater flows. This delays the necessary upgrade of existing drainage infrastructure and lowers the construction cost of drainage infrastructure in new ecologically sustainable developments, while providing a substitute resource for mains potable water supply.

Roof water collection in rainwater tanks has not been recently practised in urban areas that are provided with a reliable water supply. This is due to perceived health concerns, and the absence of reliable water quality data to prove otherwise. However, many states now promote the use of rainwater tanks via rebate schemes and educational programs, as part of an urban design water management approach. The quality of harvested water is considered acceptable for non-potable purposes.

The use of this harvested rainwater is not regulated, yet many buildings or developments intending to use rainwater for purposes involving human contact have implemented treatment and disinfection processes to avoid potential health risks.

In cities, most recent applications of rainwater harvesting have been designed to incorporate high-demand potable usages such as toilet flushing and landscape irrigation. This has been aimed at achieving a significant effect on water consumption from the mains supply. If used for garden watering, washing machines and flushing toilets, rainwater tanks can save 35 per cent to 78 per cent of potable water supplies. (Coombes et al., 2001) Variations in savings are due to the roof area utilised, the type of dwelling, and the number of occupants and their water use behaviour.

Rainwater Quantity

Collecting rainwater from a roof and storing it in a rainwater tank will:

- reduce local flooding by minimising stormwater discharged from a property;
- reduce the costs of drainage infrastructure; and
- reduce reliance on the piped potable supply.

The Victorian Government, the Sustainable Energy Authority Victoria, the Building Commission and the Plumbing Industry Commission are working with the industry to implement ’First Rate’, the 5 Star standard for new dwellings. From July 2005, compliance with the new standards will require all new homes to have either a water tank or a solar hot water service, and a 5 Star energy rating for building fabric.

Progress has also been made in the development and implementation of water-sensitive approaches to stormwater management. Potential uses of stormwater include potable water substitution for large irrigators such as golf courses, race courses, sporting grounds and public open spaces, along with suburban, agricultural and domestic applications through third pipe systems. Third pipe systems involve the installation of a third pipe, which is addition to the existing two pipes that are normally installed in a building. Two pipes are normally installed, one to supply potable (drinking) mains water, the second standard pipe is the one for removing liquid waste, which commonly combines grey water from sinks and washing and black water from toilets. When a third pipe is installed this is used to supply re-used water for uses such as flushing toilets, watering plants and cooling towers.

Rainwater tanks can be used on an individual household basis or for several houses via larger storage tanks. The correct sizing of a rainwater tank for a particular house or building depends on the[1]:

- rainfall amount and distribution throughout the year;
- size of the catchment area;
- number of occupants in the building and their water consumption demands;
- cost-effectiveness of a rainwater tank system in comparison with other water saving techniques, such as garden mulching and efficient irrigation; and
- proposed uses of the harvested roofwater (such as drinking, toilet flushing, laundry, hot water and outdoor use).

Over three million Australians currently use rainwater tanks for drinking water in rural and urban regions, with no reported waterborne epidemics or widespread adverse health effects. However, in some instances the use of water storage tanks has lead to epidemiological outbreaks and resulted in health risks for consumers. These situations were mainly caused by water contamination by micro-organisms from animals, or by leakage from septic tanks. In these cases, the poor operation and maintenance of the rainwater tanks was the main cause for the outbreaks. (ATSE, 2004)

The Department of Human Services (DHS) has stated that in general, the use of rainwater may be considered reasonably safe (DHS, 2000), providing that rainwater tanks systems are well maintained, although it is not recommended as drinking water in industrialised areas. In many cases where rainwater tanks are used for storing potable water, treatment using filtration and disinfection is applied to ensure minimal risk. Alternatively, rainwater can be used only for hot water supply as a health safeguard, as most pathogenic organisms are unable to survive temperatures exceeding 55-65C. (Coombes et al., 2000)

Roof water can be collected and stored in underground or above-ground tanks of different materials and shapes. Selection of the type of tank is usually determined by available space and capital cost.

Rainwater tanks to supply water for potable use are usually fitted with a first flush device, to direct the first portion of roofwater away from the storage tank. This will wash chemicals, leaves, and bird droppings away from the storage tank and improve the quality of water collected. All inlets and outlets are covered with mesh screens. Rainwater should not be collected from roofs painted with lead-based paints or tar-based paints, or roofs constructed using asbestos. (Engineers Australia, 2003)

Water Recycling

Water recycling is a process by which treated water becomes suitable for direct use or a controlled use. (Asano, 2002 and ATSE, 2004) The Australian Academy of Technological Sciences and Engineering has suggested the term water recycling be used to refer to generic water reclamation and reuse; hence it comprises the beneficial use of rainwater, stormwater, greywater (wastewater from showers, basins, sinks and kitchens) or blackwater (wastewater from toilets). In this context, the CH_2 building has integrated all aspects of the Water Sensitive Urban Design within its ESD features.

Water recycling of treated wastewater effluents has been practiced since the early 1990s, mainly for irrigation. (ATSE 2004) The effluents are usually treated to a secondary level, using a biological process without the need to disinfect. Secondary level treatment goes beyond primary treatment, which involves the removal of bulk solids from the waste stream, to reduce the amount of nutrients, usually by the action of biological organisms in the presence or absence of oxygen. The increased uses of recycled water for applications that involve human contact have necessitated the inclusion of advanced treatment and effective disinfection processes. These may include combinations of filtration, activated carbon processes, lagooning, constructed wetlands, chlorination, ultraviolet light, and ozonation. Membrane bioreactors and membrane filtration are increasingly being used because of their effectiveness and small footprints, particularly with the successes achieved in reducing their capital and operational costs. (Macpherson, 2004, Metcalf and Eddy, 2003)

On the metropolitan scale, recycled water is generated via the treatment of sewage or municipal wastewater in a centralised wastewater treatment plant, to a quality standard that is regarded as being suitable for discharge or the intended reuse. Currently, the main driver for water recycling from centralised plants is the strict discharge regulations imposed on treatment plants by environment protection agencies (EPAs), to minimise the adverse environmental impacts on receiving water bodies. The requirement for higher treated effluent quality to meet EPAs' requirements has necessitated advanced treatment processes and effective disinfection processes, such as the upgrade of the western treatment plant at Werribee, Melbourne. (Melbourne Water 2005)

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[1] Refer City of Melbourne's Water Sensitive Urban Design Guidelines for rainwater tank sizing graphs.

The market for the recycled water is a key factor in large scale recycling schemes. In addition, the reuse options available for the treated effluents are decisive in the selection of the advanced treatment, such as the disinfection requirements of water recycling for residential use. For example, the effluents from the sewage treatment plant at Rouse Hill, Sydney utilise ozonation, microfiltration and super chlorination to upgrade the effluent quality for a 'third pipe' scheme to service 12,000 homes. Microfiltration was also used to back up ultraviolet (UV) disinfection for virus removal. (Cooper, 2002)

In Melbourne, almost 90 per cent of sewage is treated in two large centralised treatment plants. This limits the opportunities for the use of these effluents, due to the cost of infrastructure required for a third pipe system to deliver the treated recycled water to houses in the metropolitan area. Therefore, recycled water produced at the central treatment systems is mainly marketed for agricultural irrigation and for use in nearby towns.

Recycled water can be produced on a small scale via wastewater systems that serve individual homes or buildings, and provide treatment and disposal onsite. This also includes small-scale collection and treatment systems that serve housing developments or groups of buildings usually referred to as 'decentralised wastewater management systems' or 'cluster systems'. Typically, 60 per cent of water consumption in Australian cities is for residential use. (ATSE, 2004; Water Resources Strategy Committee: discussion starter, 2001) Therefore, onsite systems represent an opportunity for increased water recycling in Melbourne.

A successful example of a decentralised cluster system is the Aurora housing development at Epping North, Melbourne, which has the first 'dual system' third pipe in Victoria. The wastewater generated from the 8,500 homes is collected, treated to a class A standard and returned to houses for toilet flushing, irrigation, fire systems and external uses. In addition, rainwater is collected, disinfected and used for all in-house hot water outlets. The outcome is a 69 per cent reduction in potable water use and a 100 per cent reduction in sewage volumes; associated with an annual reduction of 24 tonnes of nitrogen and eight tonnes of phosphorus. (Roberts, 2004)

Wastewater Treatment Processes

Typical wastewater treatment involves a number of processes that can be grouped as preliminary, primary, secondary and tertiary treatments. Advanced treatment is applied as part of the secondary or tertiary stages, for enhanced nutrients removal and/or treatment of specific organic or inorganic pollutants. Secondary treatment involves a biological treatment process such as activated sludge, trickling filters or lagoons, and generally produces effluents of a Class C quality standard when the ratio of biochemical oxygen demand (BOD) to suspended solids (SS) is equal to a ratio of 20:30 mg/litre. Depending on the processes used, tertiary treatment can produce water of Class B or Class A quality. Tertiary processes must be incorporated in the treatment train, once reuse options involving human contact or potable use are desired.

The selection of the technology depends on factors such as: the water quality required for the end use; cost; reliability; maintenance; and operation.

A typical system would involve a combination of coagulation, flocculation, sedimentation and filtration, through substances such as sand and anthracite. Filtration is effective for the removal of parasites (helminths and protozoa), but not effective for the removal of some bacteria or viruses. Therefore, filtration is followed by activated carbon adsorption for further polishing of the effluent quality, and chlorine or UV disinfection processes. Membranes remove contaminants such as organic components, and microorganisms, by physical exclusion of particles above the pore size of the membrane. Microfiltration is effective for the removal of parasites and bacteria, while reverse osmosis removes the smaller microorganisms and viruses. Membranes are therefore a dual filtration-disinfection process. (Butler, 1996; Fane, 1996 and Masson, 1996)

The use of membrane technology lends itself to lower footprint, remote and real time testing, which alleviates the need for expensive and time-consuming microbiological testing, and allows for close control and performance monitoring. A good example of the changes made to wastewater treatment by the use of membranes is the upgrade of Factory 21 at Orange County Water district in Los Angeles, which has operated since the early 1970s. The treatment processes that preceded the reverse osmosis (RO) process upgrade, included lime coagulation, clarification, recarbonation, chlorine disinfection and multi-media filtration. These were all replaced with one microfiltration reverse osmosis membrane process. (Butler and MacCormick, 1996)

Practice of Sewer Mining

Onsite systems are also used for sewer (or water) mining, where raw sewage is extracted from the local sewer and treated to provide recycled water for reuse onsite and in the nearby area. For example, a sewer mining recycling pilot plant utilising a long treatment train of screening, lime addition, sedimentation, a two-stage biological treatment (biological aerated filter), membrane filtration (MF) and chlorination was undertaken in 1993 in Canberra. (Neal, 1996) The MF and chlorination acted as a dual disinfection. The reclaimed water was fit for the irrigation of playing fields.

The main drawbacks of this system are the number of processes used for a small flow onsite system, leading to increased capital and operation costs. The sludge generated was not returned to the sewer, indicating the need for extra treatment facilities. In view of this 'long train' of treatment it is expected the reclaimed treated water product will have a high cost per volume. Treatment systems using micro-, nano- and ultrafiltration membranes, and membrane bio-reactors (MBR), have been increasingly used for onsite systems including sewer mining.

Other recent sewer mining trials were conducted in the Domain Gardens in Melbourne, using a portable treatment system that fitted into a 12m shipping container. The reclaimed water was first tested for irrigation of the Gardens, then moved to Albert Park Lake and used for lake top-up water. (Mallia 2003, ATSE 2004) The treatment system comprised solids shredding, screening, membrane bioreactors (an aerobic reactor and membrane bioreactor), reverse osmosis and calcium hypochlorite disinfection. This system is distinguished from the CH_2 multi-water reuse (MWR) sewer mining plant, in that it utilises a secondary treatment process, membrane biological reactors (MBR), to remove the organic matter and thus reduces likely fouling problems in the RO unit.

The costs associated with the aeration and operation of the MBR unit increase the cost of the water produced, compared with that from the MWR type plant to be installed at CH_2. Although MBR generates low sludge, there is more sludge handling when using this system compared to the CH_2 plant. A review of water recycling options and assessment of the economic and potential performance of a treatment system similar to the CH_2 MWR plant was carried out by Armstrong and Butler (1996).

A review of literature and the current practices of wastewater treatment show that almost all systems use a form of biological treatment, ie a secondary process, and advanced treatment processes. In the Orange County Water District, California, the Factory 21 wastewater treatment plant operated a six-step lime-based process to treat secondary effluents, upstream of an RO unit to remove fine solids, bacteria and viruses, to produce water of potable quality.

In 1992 Orange County replaced the expensive and troublesome six pre-treatment process steps with a one-step microfiltration process following satisfactory performance-based assessment trials. (Butler & MacCormick 1996) Consequently, the MWR to be used at CH_2 is relatively unique, as it is a system that utilises membranes to physically filter or separate the water from the contaminants contained in the wastewater. The MWR plant being installed in CH_2 has been developed based on extensive operational experience of a sewer mining plant at Flemington racecourse, Melbourne. This plant produces water that meets EPA approval and several improvements to the Flemington design have been incorporated in the CH_2 sewer mining plant. This may explain why there is a lot of speculation as to the likely success of this system, its operational problems, and costs.

Recycled Water Quality Standards

Guidelines for recycled water vary across the Australian states. In general, Australia has particularly stringent standards for recycled water, with limits of less than 1 virus per 50 mL, which is the lowest limit in the world. (Chapman et al., 2004) In Victoria, guidelines for reclaimed water produced from treated sewage 'centralised treatment' are outlined in The Guidelines for Environmental Management: Use of Reclaimed Water. (EPA Victoria, 2003) This guide categorises treated effluents based on water quality in four classes ranging from A to D, where Class A denotes the highest quality, and sets the acceptable uses for each water class. The quality parameters specified in the guidelines are BOD, SS, turbidity, pH, and faecal coli forms.

The focus of the guidelines is irrigation and garden watering, however no guidance is provided for domestic uses such toilet flushing and clothes washing, or external uses such as fire fighting systems. The guidelines require Class A water for urban use, which is classified as a tertiary treated wastewater with pathogen reduction. Where urban use is expected, with high human contact with the recycled water, the level of faecal coli forms should be less than 10 per 100 mL. This compares with less than 1000 per 100 mL for low contact uses which involve controlled public access, such as the irrigation of golf courses. Recycled water microbiological quality is based in indicative criteria of less than 10 E.coli per 100 mL; less than two NTU; less than 10:5 mg/L BOD/:SS; less than one mg/L Cl2 residual; and less than one virus/50 mL (the same limit is applicable for helminths and protozoa).

Draft Guidelines for Dual Pipe Water Recycling Schemes were released in May 2005 to complement the Guidelines for Use of Reclaimed Water. The Dual Pipe Guidelines provide the minimum regulatory requirements for the management of health and environmental risks associated with urban dual pipe schemes. The Guidelines are not intended for small on-site treatment plants with a design or flow rate of less than 5,000 litres a day, however the principles outlined, endorsed by the EPA and the Department of Human Services, can be applied to most treatment schemes. The CH_2 sewer mining plant and recycling scheme complies with these guidelines and will deliver EPA Class A quality water – the highest quality achievable.

Water Smart Buildings and Star Rating

Green buildings, through their systems and techniques, send a message to the building industry and the wider community: that profitable, environmentally responsible, healthy, commercial and residential spaces are achievable through appropriate architectural, engineering and construction practices. These buildings are one tool for demonstrating an effective approach to pollution prevention, via reduction of consumption, reuse of materials, and the exhaustion of all possible recycling possibilities. (Welch, 1998)

The Green Building Council of Australia launched a Green Star – Office Design rating tool in 2003, which is similar to the United States green building rating system LEED‘ (Leadership in Energy and Environmental Design). It is a ‘whole of building’ protocol for assessing the environmental performance of new or renovated commercial buildings, on the basis of criteria in: management; water; energy; materials; transport; land-use and ecology; pollution and indoor environment quality. Criteria for water include water efficiency, water substitution, water metering, cooling towers and landscape irrigation. (IISBE 2004)

Australian state governments supporting green buildings give preference to tenders for new developments that apply themselves to an assessment system such as the Australian Building Greenhouse Rating Scheme (ABGRS). This process has had little impact in terms of market uptake, which has led local authorities in some cities, including Melbourne, to adopt minimum environmental standards in new buildings in an effort to enforce responsible practices on an unresponsive market. As a result, Victoria will demonstrate leadership in sustainable development.

From July 2005, all new residential buildings will have to be ‘first rate’ 5 star energy efficient, have fittings and taps at a minimum AAA level, and a water tank connected to all flushing toilets or solar hot water system. By incorporating these measures an average household is expected to save approximately 25 per cent of its annual water consumption. (Media release 2003) A study that involved a 500 person office building in the US found the majority of the office building’s wastewater (40 kL/day out of total waste flow of 45.4 kL/day) is blackwater, with greywater comprising only 4.5 kL/day. This indicates 90 per cent of the water usage inside the building was for uses that did not require potable drinking water quality. (ATSE 2004)

“According to the Australian Greenhouse Office in 1990, Australian commercial buildings were responsible for producing 32 megatonnes of greenhouse gases, a figure projected to double by 2010. This makes Australia’s commercial buildings the fastest growing source of greenhouse gas pollution, with the worst offenders being government buildings.” (ReNew 2004) Water demand management design features will also contribute to savings in energy use, and thus greenhouse gas emission reductions. This shows the significance of the green star as a tool to encourage adoption of environmentally sustainable development features in the building industry.

CH_2 Water Conservation Design Feature

CH_2’s overall design strategy, including water saving impacts of the cooling and ventilation systems, has established a total water consumption design performance target of just under 31 litres per day per person. Water management measures implemented by CH_2 fall primarily into four categories, namely (i) water efficiency; (ii) water reuse (rainwater harvesting and fire sprinkler test water); (iii) water recycling by sewer mining; and (iv) innovative water saving techniques. Measures (ii) and (iii) are predicted to reduce the dependency on mains water supply by more than 72 per cent, from 31 litres per day per person to just 8.4 litres per day per person, compared with using no sewer mining water recycling or reuse systems (CH_2, 2004) The design aspects, features and innovative use of technology within each of the four categories are further described below.

Water Efficiencies

CH_2 will provide a high level of saving by utilising fittings and fixtures labelled “AAAA”, as per the Water Services Association labelling system, throughout the building. Taps and showerheads of low water flow rate of approx 2.5 litres/min and nine litres/min respectively, will be fitted in the building. Spring-loaded taps will be fixed to all basins, to control total flow quantity. A series of 6/3 dual flush toilets and 2 litre flush urinals will be used. The option of composting toilets, although having less water requirements, was not adopted due to operational and handling requirements, and aesthetic and unfavourable user perceptions.

An approximate 30 per cent saving in mains water supply compared to conventional fittings is predicted. Water loss via leakages usually accounts for 11 per cent of mains supply, both for cities or houses. (ATSE, 2004) Therefore, water meters will be installed on the inputs and outputs of all water services, to monitor water usage and ensure early detection of leaks. This will allow immediate repair, and produce better management of water demand and supply.

Maintenance works will be undertaken in accordance with the national water efficiency labelling standards (Department of Environment and Heritage, 2005).

Water Reuse

The current Victorian Plumbing Regulations and Australian Standards related to fire systems[2] require the use of mains water to test the sprinkler system. It is estimated CH_2 will need 10,000 litres per week for regular testing. This water runs through the pipes and valves and is normally wasted to the sewer. In CH_2 the sprinkler water will be collected and used in conjunction with mains water for showers and taps. The risk of contamination via the sprinkler system was considered and determined to be nil. (CH_2, 2004) A schematic of the process is shown in Figure 1.

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[2] City of Melbourne update note: The Plumbing Industry Commission of Victoria is currently conducting a review of relevant legislation and standards to identify ways to improve test regimes and reuse of water.

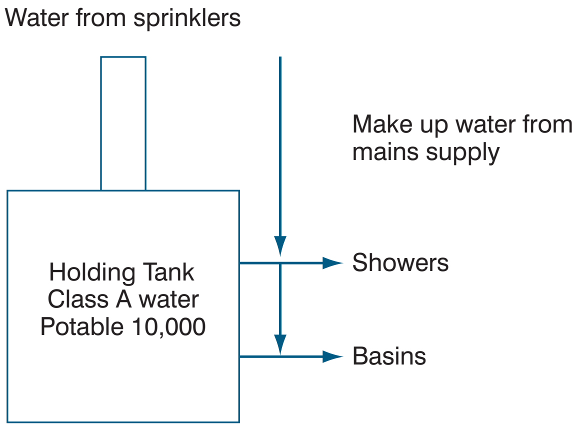

Figure 1: Water collection from sprinklers and its reuse.

Rainwater Harvesting

The total roof area of the CH_2 building will be used for capturing rainwater. Both conventional and siphonic roof drainage were considered for the rain water collection system. The siphonic system was not recommended, due to insufficient roof area to allow high enough water flow rates through the pipes to achieve siphonic flow conditions. The roof area is 1500m2, so assuming 70 per cent capture and with rainfall in Melbourne being approximately 55 mm/month, a yield of 57 kL/month (0.7 ML/year) is expected. The rainwater collected will be used in conjunction with the extracted water from the sewer for toilet and urinal flushing, landscape watering, cooling towers and street washdown (Figure 2). A storage tank with a capacity for one week's capture at 15 kilolitres will be located in the basement. The holding tank will be connected to a flooded suction style pump.

Wastewater Recycling and Sewer Mining

The process of selecting a wastewater system for CH_2 considered quantity, quality and space requirements, among other aspects including end use of water and variability of seasonal demand. A primary decision criteria for selections was also the practical strategy of removing the water at site, while allowing the solids to be transported to the central treatment plant to avoid investment in a full black-water treatment system onsite. The system selected was the Multi-Water-Reuse (MWR) plant, which comprises three stages of filtration (see description under the MWR plant) to separate high quality water from the waste contained in the buildings grey and black water waste streams and mined sewerage. To ensure a cost-effective water reuse system and provide water quantities that meet the needs of the building's users an additional wastewater source, sewer mining of the Swanston Street main drain, was incorporated in the design of the system.

The initial plan was to design the system for a capacity of 45 kL/day. Discussion considering future plans of the City of Melbourne led to an increase to 100 kL, to meet the future needs of 200 Little Collins street and landscape management in parks and gardens. Increasing the capacity should have a positive effect on the viability and performance of the system as per the manufacturer design data provided to the CH_2 design team, with only a 20 per cent increase in capital costs. The system has the merits of avoiding wastage of energy or water, as it has the ability to operate at full or a fraction of capacity (necessary during holidays) without any adverse effect on the process units operating performance or efficiency.

The MWR plant will separate water from the waste water produced by occupants in CH_2 and from the sewerage extracted from the Swanston Street sewer by filtering it and treating it to Class A standard required for non-potable reuse involving unrestricted human contact. (EPA 2002) In the process of separation the water loses most of its oxygen (life) during the process, it is therefore reinvigorated with rainwater (Figure 2). The main features of the MWR plant is its relatively low energy input, small footprint and innovative use of available technology. (NuSource, 2005) Sewer mining provides the potential to remove up to 95 per cent water from the sewer system without effecting its ability to transport solids.

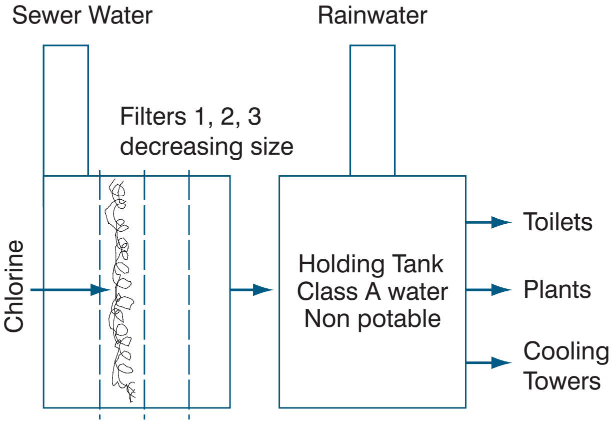

Figure 2: Sewer mining, treatment, storage and uses.

Multi-Water-Reuse System (MWR)

The MWR system is essentially a three-stage filtration process: (i) a 200 micron pre-screen; (ii) a ceramic ultra-filtration (UF) process; and a (iii) reverse osmosis (RO) process. A schematic diagram of the MWR plant is shown in Figure 3.

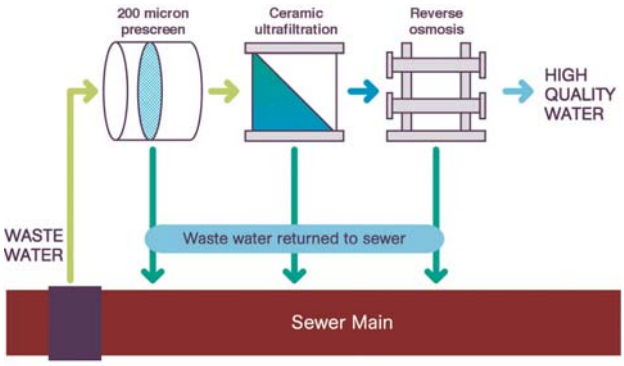

Figure 3: Schematic of the MWR "sewer mining" process.

The first filtration stage removes suspended solids, and most of the oil and grease present in the wastewater. Screenings caught on the 200 micron pre-screen are washed away with filtrate from the second stage ceramic ultrafiltration (UF) unit, drained and returned to the sewer on a continuous basis without any handling. The UF comprises hundreds of tubular ceramic porous membranes of 0.02 micron in size. These membranes physically remove all particles of nominal size greater than the pore size of the membranes. Smaller particles will not pass through, and accumulate on the membrane surface.

At this stage, most of the suspended solids, bacteria and viruses are removed. The RO unit removes 95 – 99 per cent of the total dissolved solids (TDS) and 99 per cent of all bacteria. Hence, it acts both as a filtration and disinfection process. The plant applies automated chemical cleaning about every 14 days to remove any biofilm growth that has formed on the membranes due to the continual operation of the system. (NuSource, 2005)

The recycled water produced at CH_2 using the MWR plants meets all Class A water criteria. Some parameters such as TDS levels at 12 mg/L, and E.coli at <0.1/100 mL, far exceed the minimum standards set for potable water. Any incident of cross contamination is not possible due to separation of water supply system design for human contact and consumption and non-human contact, such as flushing toilets, watering plants with subsurface flow and cooling tower system. Communication by the author with NuSource Water, in mid-2005, confirmed that the MWR process has now achieved Class A approval by DHS/EPA, which requires a minimum 6 log removal of bacteria and 7 log removal of virus. (Cooper 2005)

Parameter	Screened Sewage	Microfiltration Filtrates	Reverse Osmosis Permeate
Biochemical oxygen demand, BOD (mg/L)	230	89	< 2
Total organic carbon, TOC (mg/L)	103	46	0.8
Suspended solids, SS (mg/L)	144	<2	
Total dissolved solids, TDS (mg/L)		103	12
Total Kjeldahl nitrogen, TKN (mg/L)	50	51	5.5
Total phosphorus (mg/L)	11.2	9.0	0.03
Faecal coliforms (cfu/100 mL)	$5.1x10^{33}$	1.3	<0.1

Table 1: Characteristics of water produced by MWR.

Innovative Water Saving Techniques

Vertical Gardens Watering System

The provision of the same number of leaves on the building as would be present if the site was still in its natural state is an innovative concept that CH_2 will showcase to the world. This will be achieved via the roof garden, together with the northern green façade of the building. In addition, there will be internal plantings in the office areas and on the summer and winter terrace at the west end. Recycled water will be used to water the plantings.

However, the challenge for CH_2 was to get the water to them efficiently. The solution came via a water-sufficiency based system that will provide the ideal wet-and-dry cycle required for healthy plants. This system comprises a watering device and a soil additive. Each planter box is filled with Fytogen Flakes, a soil additive that looks like polystyrene flakes but acts like water crystals, storing water until the soil needs it. The planter boxer is also connected to a system functioning in a similar way to a toilet cistern, which is triggered to refill with water when the crystals dry out. The ESD aspects of this system maintain a healthy green environment without any water wastage.

Shower Towers and Cooling Towers

The shower and cooling tower systems use water as the cooling –media, allowing for an energy-efficient cooling system. Recycled water is used in the cooling system while the shower towers use mains water. These two features are a good example of the efficient use of a value added product, recycled water, to improve the energy efficiency of a building while reducing greenhouse gas emissions. In addition, it is likely that the use of shower towers would not have been possible had CH_2 not had access to a substitute water resource that reduces reliance on mains water. This is a significant factor considering drought conditions and Melbourne's current permanent water restrictions, where the use of a limited resource may not outweigh savings in energy use and greenhouse gas emissions.

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74 See footnote n.13.

Overall Water Demand and Water Savings Forecast

Design stage estimates of water demands for the CH_2 building assuming a total of 600 employees based on the use of water efficient fittings is 5 ML/year, which is equivalent to around 31 litres per day per person, as summarised in Table 2. (CoM, 2004)

	Male water usage	Female water usage
Use of urinals	4 times/day x 3 L/flush = 12 L	
Use of toilet	1/day x 6 L/flush = 6 L	1 x 6 L + 4 x 3 L = 18 L
Washing hands	5 times/day x 0.5 L/wash = 2.5 L	
100 people ride/jog and use showers each day at 50 L/shower, averaged over 600 people	8.5 L	8.5 L
Sink use: Assume each person uses the sink twice per day, max 2.5 L/day	2.5 L	2.5 L
Total per person/day	31.5 L	31.5 L
Total for 300 males and 300 females	9450 L	9450 L
Total water demand	18,900 L (19 kL/day) 5 ML/year	

Operation of sprinkler water reuse, sewer water recycling, rainwater collection, will reduce the demand for consumption of mains water by more than 70 per cent, resulting in a demand for mains water of about 8.4 litres per day per person. The following table breaks down the sources of water for all potable and non-potable water use in CH_2.

	Water Use	Water Source	Demand ML/year	Recycled Water ML (% of total demand)
Potable	Drinking Showers and sinks	Mains water Reused sprinkler water	1.50 0.50	0.5 (10%)
Non-potable uses	• Toilets • Watering of plants integrated into design of building • Cooling Towers	Recycled wastewater from sewer mining Rainwater from onsite collection tanks	3.0	2.2 (43%) 0.8 (17%)
Total demand (using efficient fittings and fixtures)			5.0	70%

CH_2 Expected Performance and Future Needs

The sewer mining system at CH_2 will be the first large scale recycled water treatment plant in the Melbourne CBD. The water savings targets set by the CH_2 design team lead the way in water sensitive building practices and establish new standards for water consumption in commercial buildings. The CH_2 water management approach will set a benchmark for future multistorey commercial buildings in Victoria and Australia. It is projected that hundreds of megalitres will be saved annually for the Melbourne district once the building industry adopts the CH_2 building model as best practice. (CoM, 2004)

The MWR system will be the first of its kind in the world; it has not been applied at this scale for an inner city commercial building before, although similar systems have been in operation in non-building settings, such as Flemington Racecourse, Melbourne. The application of this system in this new setting to handle raw wastewater provides the opportunity to demonstrate performance capability of the system and prove that the technology works well in a office building installation. As part of this demonstration process, it will be important to document its feasibility, reliability, durability, compatibility, ease of use, and cost-effectiveness.

The major challenge to the use of RO has been biofouling. (Ghayeni et al. 1996, Fane 1996) The use of the MWR for physical separation of particulates and dissolved matter is likely to increase fouling of both the MF and RO units, hence increase backwashing frequency and the use of chemical cleaning. This has the potential to increase operation and maintenance requirements, and may also reduce the lifetime of the membranes. Therefore, monitoring of the operational and maintenance requirements of the system, and dissemination of this information is essential to prove (or disprove) the practicality of the onsite wastewater system at CH_2. In addition, assessment of the system's achievement of its target performance measures in terms of recycled water quality and energy cost per unit volume of water is vital to CH_2's goals of showcasing and demonstrating how technology assists in an ecologically sustainable building.

Performance Monitoring

There have been a notable number of houses and building developments that have incorporated ESD features, although mainly addressing energy and water efficiency. There has been little follow-up work done to determine whether or not these buildings achieved their goals. Limited literature is available in this area, and it mainly addresses water use demand. For example, the Canada Mortgage and Housing Corporation carried out an intensive monitoring program on the performance of a multi-unit residential building in terms of water use and indoor environment. The water conservation features in the building were mainly water efficient fixtures appliances, (CMHC, 2004) so monitoring involved readings of water meters.

In most cases, sampling programs undertaken by management authorities, system operators or owners showed the quality of recycled water met the specified class of reclaimed water. However, a more comprehensive sampling would show some indications of turbidity, and faecal indicators or the presence of contaminants. This demonstrates the importance of establishing effective monitoring, as an aid to successful management and accurate assessment of the system performance.

A barrier to the acceptance of recycled water and reuse systems is the lack of data pertaining to reused water quality, regulations for monitoring protocols, and responsibilities involved in using and monitoring these systems. The CH_2 proposed monitoring program includes real time data recording and central data retrieval. The program will be a valuable resource for data on recycled water safety, and will examine the monitoring needs for onsite water recycling systems. CH_2 intends to provide performance data on the adopted water reuse systems during the early stages of operation, via publications to which the community will have full access.

Furthermore, CH_2 as part of the proposed educational and water savings promotional program will collaborate with tertiary education institutions to facilitate students' learning. For this, undergraduate students studying engineering, and environmental science and management, will be able to tour the CH_2 building and inspect the MWR plant and have access to the performance data to conduct their own scientific analysis. The CH_2 monitoring program will provide statistical data on the performance of the system and other water conservation systems in the building. The students, researchers and professionals in the area can use this data for an understanding of the relationship between systems sizing, and loading and design projects of similar buildings.

Public Perception on the Use and Recycling of Water

There are a number of barriers to the successful implementation of sustainability related projects such as water recycling. These include economic factors, community acceptance, and support and technical issues.

Community attitude towards water recycling is strongly related to the type of reuse. The responses from different studies showed that more than 95 per cent of the Australian community supports the use of recycled water for irrigation of residential gardens, parks, and open spaces, and for toilet flushing. (Neal, 1996, ATSE, 2004) The support for different personal uses varies between the published studies, such as clothes washing from between 70 to 85 per cent support, and 48 to 78 per cent support for bathing. However, support for its use for drinking purposes dropped to one per cent in some cases, and 24 per cent in others. (ATSE, 2004, McKay, 2003) There is a possibility that variations in responses are due to how the questions were addressed in the surveys. (Marks 2005)

A key issue in public acceptance is of a psychological nature, namely fear of health risks associated with recycled water, or the perception of ‘toilet to tap’ and the feeling of lack of control. This is what drives many that promote the technology to believe that the true resistance presented by apparent community opposition to water recycling is questionable. Supporters knowledgeable about the technology consider that the introduction of quality controls, community consultation, education and awareness programs would be able to achieve broad public acceptance.

Community involvement in the planning of recycling strategies is crucial for the successful implementation and acceptance of recycling projects. A community meeting for concerned residents in the township of Landsborough, north of Brisbane, designated seven criteria to assess alternative sewage strategies. The community group rated four alternative sewage strategies against the set criteria, giving highest preference for recycling to houses as non-potable water than to irrigation reuse, while discharge to surface water was the least preferred.

Environmental and health risk issues were of equivalent significance to the group and outweighed economic and job opportunities. (Butler & MacCormick, 1996) On the other hand, a potable water-recycling scheme did not proceed and contributed to the defeat of a medium-sized local government in the election. A change in community acceptance and support was achieved via demonstration projects and involvement in all levels of decision making. (Gibson and Apostolidis 2001)

Communities are extremely sensitive to health risks associated with water. Community health concerns stem from lack of knowledge on the quality of recycled water, including microbial and chemical contaminants; as well as the technologies available and their effectiveness. Demonstration and educational programs have proven beneficial in reinforcing acceptance. One example was a set of demonstrations conducted in Singapore to reinforce acceptance of the recycled water ’NEWater’ as a source of drinking water. (Macpherson, 2004)

Managing the Risks at CH_2

As discussed in the previous section, public perception and economic factors play a major role towards driving water recycling forward. An additional key barrier to water recycling initiatives is legal risk. Moore (2003) examined the key sources of legal risks for suppliers of recycled water, and discussed management options in the Victorian context. Liability due to exposure to potentially harmful material in recycled water can be categorised as (i) recycled water that has not been treated to the standard that suits the end use; or (ii) the customer or third party misuses the reclaimed water.

Risk analysis of each water saving measure, in the context of its end use, should be performed in the design phase of any project to alleviate potential legal liability. A risk assessment carried out by the CH_2 design team rated increasing cost of water and electricity as second on the list of main risks to the Council. (CH_2, 2004) Reducing the consumption of water to a minimum by good design and further reducing the demand for mains water by 72 per cent will minimise this liability risk. In terms of financial savings, considering current water prices and savings on services, the financial payback period for the wastewater treatment system will be between 15 to 20 years. It should be noted however that the payback period will progressively reduce with each incremental increase in the cost of water expected during this period.

Health Risks will be managed in accordance with preventative risk management measures outlined in the Draft Guidelines for Dual Pipe Water Recycling Schemes (EPA Victoria, 2005).

Best Practice

There are numerous programs in Australia targeting more efficient water use; but less has been done to reduce water demand in the built environment, especially commercial buildings. Internationally, it is only recently that sustainable building developers paid attention to water management aspects, and moved beyond energy efficiency and lowering greenhouse gas emissions. This trend could well be related to the development of ‘green building’ concepts and the tools to assess the performance of these buildings, such as the Leadership in Energy and Environmental Design (LEED‘) system in the USA, Building Research Establishment’s Environmental Assessment Method (BREEAM) in the UK and Green Star in Australia..

Almost all the buildings listed in the European Catalogue of Best Practice Examples, published by the European Green Building Forum (EGBF), approached water management through water efficiency and rainwater harvesting. Greywater recycling dominated the practice of wastewater treatment, perhaps due to the costs and requirements for the treatment of blackwater. (EGBF, 2005)

In the USA, recent moves towards building self-sufficiency, including water recycling within the built environment, seem to be within the context of centralised wastewater treatment using a third pipe system as seen in the Irvine Ranch Water District in Southern California. (ATSE 2004) The Australian experience has similarities to European precedents, showing more attention to water resources in addition to energy efficiency. The following are some national and international experiences.

National Case Studies

Brindabella Circuit, Brindabella Business Park, Canberra International Airport. This is the first building in Australia to achieve a 5 star 'Australian Excellence' green star rating from the Green Building Council of Australia. To achieve this rating, the building had to achieve the highest level of energy savings as well as an innovative approach towards other areas such as water conservation, waste management, material selection and avoidance of volatile organic compounds (VOCs). This raised the benchmark for ecologically sustainable design, and the environmental performance of office buildings in Australia. The building utilises 775,000 litres less of potable water than other buildings of the same size, achieving a 53 per cent reduction in water consumption compared with a standard building of similar size. Water savings are achieved via water-free urinals, efficient fittings and fixtures, and water metering and leak detection. (Canberra International Airport 2005)

60L Office Building, Victoria. The building located at 60 Leicester Street, Carlton, Victoria, known as 60L, is one of Australia's leading examples of commercial buildings implementing sustainable design features, including water use. The primary element to reduce mains water use at 60L is rainwater collection from the roof and storage in two 10,000 litre tanks located on the ground floor. In a year with average rainfall and variability about 500 kilolitres of rainwater is designed to be collected, which is enough to make the building self-sufficient (except for the need to test the fire sprinkler system with mains water). The stored rainwater is treated, when needed, to Class A, 'potable' water quality, for use in showers, sinks, basins and kitchens. The treatment system is comprised of a three stage filtration process and UV disinfection system. Treated water is monitored regularly for conductivity and biological growth. The environmental performance of the building shows that 60L uses 90 per cent less mains water compared to a traditional commercial building of a similar size and function.

International Case Studies

De Waterspin, The Hague, The Netherlands. This building's plan and design has similarities to the CH_2 building. Special attention has been paid to sustainable design aspects such as the use of second-hand materials, ecology, self-management, energy and water conservation, and the integration of living with working. The main features of the building include rainwater collection and its use for flushing toilets; water efficient fittings; and the use of treated greywater for room cleaning, washing machines and garden sprinklers. (EGBF, 2005)

The De Waterspin building won the 1999 Hague City renewable prize, and stands as a demonstration model for related industry and the community.

Green on the Grand, Canada. Green on the Grand is the first building to meet the requirements of Canada's C-2000 program. The building uses 30 per cent less water than a conventional office building of the same size. The main features of the building which contribute to these savings include efficient fixtures, rainwater collection with reuse for landscape watering, cooling towers, and an optimal design for its hot water systems. (GGC, 2004)

Lewis and Clark State Office Building, Missouri, USA. This building is accredited by LEED, the US green building rating assessment system. The main design features of the building that demonstrate "best practice" in water-efficient use include rainwater collection with use for toilet flushing; greywater recycling; efficient fittings; and bio-swales and detention ponds. (DNR, 2004)

Phillip Merrill Environmental Centre, Annapolis, USA. The main water conservation design features comprise rainwater collection and its use for non-drinking purposes such as bathrooms and fire prevention. The other feature is the use of composting toilets, which has lead to savings of US $29,000 a year on water and sewage bills. (Construction Innovation Forum, 2003)

Conclusion

Beyond economic considerations, it is important to acknowledge the environmental and public infrastructure benefits offered by practical limits to the availability of water resources. Both of these issues, normally the result of external, economic factors, have contributed to a decision by the CH_2 design team to advance water consumption reduction measures with a greater investment in the building's water management system. Benefits include:

- a reduction in the need to develop new water storage capacity or import water from beyond existing water catchments;
- a reduction in the need to upgrade existing sewage and potable water infrastructure;
- a reduction in the energy costs of sewage and potable water pumping and treatment;
- the ability to obtain full value from a precious resource;
- best practice sustainable design at the 'top end' of the property and building industry – commercial offices; and
- a reduction in the treated flow volume from sewage treatment plants to receiving environments.

The onsite Multi Water Reuse separation system selected for CH_2 removes the water contained in the building's waste stream and sewage stream through mining, but does not reduce the nutrient or pollutant loading to the central treatment plant.

Organic, chemical and nutrient pollutants contained in the sewage extracted from the Swanston Street main sewer, and that generated by the building's users, will be returned to the central sewer system to be treated at Werribee Treatment Plant. In addition, there is potential for increased chemical loading due to the use of disinfectant chemicals in the operation of the system. As part of the proposed monitoring program, organic and chemical loadings associated with the system's operation will be assessed.

It is expected there will be small savings in greenhouse gas emissions, from lower energy consumption due to reduced water consumption and wastewater discharge. However, this greenhouse benefit needs to be tested against the energy consumption associated with using the sewer mining technology. Although the MWR system utilises low pressure, it is still not known what the final cost of recycled water per unit volume will be, including maintenance, chemical and energy use. The data available at design stage shows the benefit should include a net energy saving due to the use of recycled water in the cooling and shower towers.

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