CRC Construction Innovation
BUILDING OUR FUTURE

Final Report
Sustainable Subdivisions – Review of Technologies for Integrated Water Services

Research Project No: 2002-063-B

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ABBREVIATIONS

ABS	Australian Bureau of Statistics
ABS	Acrylonitrile Butadiene Styrene
ACT	Australian Capital Territory
AGO	Australian Greenhouse Office
AHD	Australian Height Datum
ARQ	Australian Runoff Quality
ASR	Aquifer Storage & Recovery
ATA	Alternative Technology Association
AWCRRP	Australian Water Conservation and Reuse Research Program
BCA	Building Code of Australia
BCC	Brisbane City Council
CBD	Central Business District
CRC-CI	Cooperative Research Centre for Construction Innovation
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEH	Department of Environment and Heritage
DoH	Department of Housing
DTS	Deemed to Satisfy
EBPC Act	Environment Protection and Biodiversity Conservation Act
EHO	Environmental Health Officers
EPA	Environment Protection Authority
ERA	Environmentally Relevant Activity (activity licensed by the EPA)
EVA	Ethylene Vinyl Acetate
GCCC	Gold Coast City Council
GFA	Gross Floor Area
GHG	Greenhouse Gas
GIS	Geographic Information Systems
HDPE	High density polyethylene
IWRM	Integrated Water Resources Management
IUWM	Integrated Urban Water Management
KGUV	Kelvin Grove Urban Village
kL	kilolitre
LCA	Life cycle analysis/Land capability assessment
LCC	Life cycle costing
MAV	Municipal Association of Victoria
ML	Megalitre

NRW	Department of Natural Resources and Water, Queensland
OUM	Queensland Office of Urban Management
PV	Photovoltaic
PVC	Poly vinyl chloride
QDPW	Queensland Department of Public Works
QUT	Queensland University of Technology
RIG	Reduced Infiltration Gravity
SEQ	South East Queensland
SHW	Solar Hot Water
TBL	Triple bottom line
UV	Ultraviolet
WSAA	Water Services Association of Australia
WSUD	Water Sensitive Urban Design
WTP	Wastewater Treatment Plant

PREFACE

The CRC's Sustainable Built Assets Program identified Sustainable Sub-divisions as one of five key thematic areas of research for 2001-2007. This publication, Sustainable Subdivisions – Review of technologies for integrated water services (Report 2006-063-B) and its associated industry report, results from a project led by Steven Kenway, Clare Diaper and Grace Tjandraatmadja from CSIRO. The project is the CRC-CI's first project focused on water and wastewater use and management in urban subdivisions. This research report summarises the current status of alternative water servicing options for Australia, specifically technology options, with an emphasis on solutions relevant to South East Queensland.

The report presents information on alternative water servicing options, examining possibilities at household, cluster and sub-divisional scales and examining technologies available for rainwater, stormwater, greywater and wastewater collection, treatment, storage and distribution. The report then presents information on a number of case study sites, both greenfield and retrofit, ranging from single dwellings to sub-divisions. The focus of the case study investigations was to demonstrate the benefits, barriers and lessons learnt from different schemes with particular focus on stormwater, greywater and wastewater technologies. Both new build and retrofit options, high and low density housing and both residential and commercial buildings are included in the case studies.

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- Ben O'Callaghan and Chris Walton from The Ecovillage at Currumbin.

In addition the input from steering committee members; Michelle Hennessey and Scott Prenzler from Brisbane City Council, Stewart Crook, Delwyn Jones and Ron Apelt from Queensland Department of Public Works, Susan Crozier at Queensland Housing and Michael Ryan and Warren Steiner from Brookwater are also gratefully acknowledged.

EXECUTIVE SUMMARY

Water is a current major global, national and local issue. Historic drought and unprecedented restriction levels are now substantially influencing almost all Australia's major cities. Residential design and adoption of appropriate technologies plays a key role in urban water efficiency. This project, the first of the CRC-CI Sustainable subdivisions program with a focus on water, explores the existing technologies available for sustainable suburbs.

Integrated water resources management and water sensitive urban design can incorporate a range of technologies at scales ranging from the individual allotment through to clusters or groups of housing and to subdivisions. Integrated water resources management considers water use and sourcing, available alternatives, water treatment and reduction of stormwater, greywater and wastewater loads into the environment. While a range of technologies have been available for some time, such as rainwater tanks, there have been rapid developments in many fields and many treatment technologies are at the "implementation" stage, with verification of operation and reliability currently being undertaken.

Examples of the technologies adopted in integrated water management schemes and their application and effectiveness can be found in a range of publications in the available literature. There are a number of issues, barriers and benefits associated with the different types of technology and the different scales of application. The aim of this report is to identify these issues, barriers and benefits through a literature review and detailed case study investigation.

Eight case studies were examined in detail and data was collected on; the current status, location, size, topography, demographics and the technologies or techniques used for potable water supply, garden irrigation, wastewater and stormwater systems.

The case studies included four new built sites:

1. Pimpama Coomera at the Gold Coast – a large scale subdivision with WSUD, alternative water sourcing and centralised distribution of recycled water to households for non-potable applications.
2. Payne Road in Brisbane – a medium scale, low density development with rainwater tanks, greywater treatment, WSUD features and timed discharge to sewer;
3. CH2 (Council House Two) in Melbourne – a commercial, medium scale, high density office building with sewer mining and other innovative stormwater features;
4. The Currumbin Ecovillage at the Gold Coast– Medium scale and density development with rainwater tanks, localised treatment and effluent reuse for non-potable applications.

And four retrofit/infill sites:

1. South East Water and Bayside City Council in Melbourne – a medium density, large scale survey on householder attitudes to water conservation and recycling;
2. 60L in Melbourne – a high density, retrofit, commercial, medium scale with rain water collection, on-site wastewater treatment and reuse
3. Atherton Gardens in Melbourne – a high density, retrofit, residential, medium scale with rainwater collection, greywater reuse and stormwater treatment and WSUD features,
4. Sustainable house in Sydney – a single house, medium density, retrofit with on-site wastewater treatment and recycling, rainwater collection and stormwater treatment.

The major benefits of the alternative water servicing approaches reviewed in literature and investigated in the case studies were identified as:

- Improved integration of the urban water cycle
- Reduced potable water use and peak flows
- Reduced wastewater flows and peak flows
- Improved water availability during dry periods
- Reduced materials and energy use
- Reduced greenhouse gas emissions
- Reduced operating cost
- Deferral or elimination of the need for large scale infrastructure i.e. new reservoirs
- Improved amenity
- Improved staff productivity and health
- Potential for improved reputation
- Potential for increased market value
- Reduction in nitrogen and phosphorous discharged to land and waterways
- Increased community awareness and involvement in water and sustainability issues
- Simpler treatment at source
- Water quality ‘fit for purpose’
- Development of appropriate tools and methods for alternative water servicing

However, as many of the techniques, methods and processes used in case studies are at the implementation stage, there are still a number of barriers and gaps in knowledge which need to be addressed to facilitate alternative water servicing. Some of the barriers and gaps are comparable to benefits identified, as different case study sites are at different stages of development. For example, improved materials and energy use was identified as a benefit in many case studies, but others have not monitored energy use, so this is still seen as a data gap. This dichotomy highlights the need for improved information sharing and knowledge transfer.

General barriers to adoption associated with the development and implementation of integrated water services at the case study sites were diverse and evident in different stages of different projects. These barriers include:

- The influence of local conditions (rainfall, temperature, soil) is vital in selecting appropriate technologies. Design and planning need to consider detailed site characteristics, including but not limited to; climate, demographics, water usage, soil type, water table and topography.
- Existing building and sites impose limitations on the selection of technologies and the costs and practicalities of retrofit need to be considered. Additional time is required for planning and surveying for retrofit solutions.
- Developing a clear set of “sustainability” objectives can help guide all stages of the project and provide criteria to review its success.
- New ideas and innovations do not have a “home” within current organisational structures and consequently, traditional approaches continue to be implemented. Institutional adaptive capacity is required as well as a wide range of participants, necessary to contribute to the on-going dialogue on sustainability issues.
- The current approvals process is overly complex and needs to be simplified.
- No clear guidance on selection of appropriate technologies, design, planning and construction selecting appropriate technologies to treat higher-concentration waste streams produced by household and subdivisional systems which are increasingly water efficient
- Consideration of upstream and downstream (off-site) impacts of alternative water-servicing approaches i.e. impacts on sewage transport and treatment infrastructure
- Lack of data on verification, monitoring and accreditation
- Consideration of chemical and energy use of systems

- Consideration of biosolids production and management in the initial design of on-site wastewater management systems
- The cost and economic impacts of scale, considering capital and operating costs are rarely fully understood.

Some research areas which will fulfil some of the knowledge gaps are:

- Monitor and assess existing alternative systems and compare their actual performance to predicted performance prior to implementation. Identify reasons for any sub-optimal performance
- Quantify additional benefits of alternative systems (such as reduced energy and materials usage, and system resilience and tenant/user well being) by detailed lifecycle costing, analysis and monitoring. Also quantify associated benefits from externalities over the life cycle of the technology
- Improve the understanding of the impact of greywater (treated or untreated) on the environment
- Develop options and design criteria for stormwater harvesting for various residential uses
- Assess the potential impacts of alternative water-servicing approaches on existing infrastructure and transitioning strategies, including how these strategies can be built into longer-term infrastructure master plans
- Investigate alternative funding sources and economic incentives and disincentives (such as rebates, headworks charges and planning obstacles) for implementation of alternative water-servicing approaches
- Review legislative and planning process impacts on adoption of integrated water-service options with particular focus on how the multi-disciplines necessary to deliver water services can be streamlined
- Conduct social or behavioural research, including what values lead people to consume or conserve water in different ways.
- Undertake economic analysis of selected water efficient and traditional technologies, as this may help embed new technologies within existing and future urban areas and inform infrastructure planning
- Technology selection guidance framework which accounts for local conditions and infrastructure.
- Develop service models and management framework for maintenance of decentralized treatment systems.

1 INTRODUCTION

This report has been prepared for the Cooperative Research Centre for Construction Innovation (CRC CI) project 2002-063-B Sustainable Sub-divisions: Review of technologies for integrated water services. This project focuses on a review of currently available technologies and techniques which will contribute to integrated urban water management (IUWM) goals at a sub-divisional level. This has been carried out through a literature review and a description and discussion of a number of case study sites. While technologies and case studies have been reviewed nationally, particular consideration has been given to South East Queensland (SEQ) where the majority of the CRC CI project partners are based.

IUWM encompasses the three main water streams in the urban area; water supply, stormwater and wastewater. It also includes their associated flows, groundwater, evaporation and flow through the soil profile. IUWM also incorporates the economic, social and environmental dimensions of water, often in the form of life cycle costing, community engagement and environmental impact assessment respectively. Water sensitive urban design (WSUD) can be seen as a subset of IUWM and focuses particularly on land use, topography and planning. As such, WSUD often only addresses stormwater flow and quality but, in its original concept, was meant to encompass water supply and wastewater issues.

This technology review includes data and information gathered from the open literature and previously published CSIRO studies (Landcom, 2006; Geolink, 2005; Mitchell , 2004; Diaper 2004; Tjandraatmadja and Burn, 2004) and information from CRC CI project partners and technology manufacturers. The review is structured so that information is presented on technologies appropriate to different scales of application, from single house to sub-division and for different water sources; rainwater, stormwater, wastewater and greywater. In addition, the applicability, potential barriers and issues associated with installation of the technologies for new build and retrofit situations are discussed. The technology review has also included, where readily available, preliminary information on other factors influencing selection or adoption of particular technologies. In general these areas can include the natural environment of the selected sites, social and cultural factors, economic and financial incentives and institutional and legislative arrangements. These other “system” influences can be significant but detailed analysis of these influences was not an intended component of this project.

Similarly, the information gathered from the eight case study sites includes a description of the technologies and techniques used and potential barriers and issues associated with their installation. Where available, detail of other factors influencing selection and adoption is included as are other potential impacts, but these are reported in a qualitative manner and no attempt was made to provide quantitative assessment.

1.1 Objectives

The objective of this study is to provide a snapshot of the issues arising from alternative water servicing systems and options that are currently available and have been or could be considered or implemented at a sub-divisional level in Australia. The primary objectives were to identify:

- Types of systems available that have been considered or adopted to date
- Lessons learnt from system consideration and/or implementation
- Identification of technical, institutional and legislative, environmental, financial, social barriers to implementation

A workshop with the CRC CI project partners identified the retrofitting of existing housing stock and servicing for commercial premises as areas of interest, in addition to the primary objectives of identifying available technologies and approaches and their impacts and implications. Greywater use has recently been approved under certain conditions in SEQ and a number of project partners also expressed an interest in this area. Thus, the report includes considering both outer and inner urban developments, high and lower density sites, greenfield, infill or retrofit and residential and commercial developments. Factors that may influence the selection of alternative water servicing approaches are discussed and the basics of option assessment detailed. Technologies appropriate for different scales of application are provided, categorized by the water source:

- Rainwater – water collected from roofs
- Stormwater – water collected from roofs, roads, pavements and open space
- Wastewater – any water that has been used
- Blackwater – wastewater from toilet flushing
- Greywater – wastewater from showers, baths, laundry and kitchen

A further major objective from project partners was to provide information to help clarify future research necessary in the construction of "water smart" suburbs and houses. While this report provides a review of schemes on a national level, the outcomes of the report are particularly focused on South East Queensland to reflect the particular make up of the project partners.

The following objectives were considered by the steering committee but were identified of secondary importance for the purpose of this study and so are not included in detail in the review:

- Financial: Costs of technologies including operating, capital and life cycle costs and cost responsibilities.
- Institutional and regulatory: Management and institutional arrangements for implementation and on-going operation.
- Integration with other services such as energy and transport and integration with building design.
- Social Acceptance by the new residents of the technology, impacts on lifestyle, maintenance requirements, amenity value.

1.2 Project Partners

The partners involved in this research project were:

CSIRO	CSIRO Land and Water Dr Clare Diaper, Grace Tjandraatmadja, Steven Kenway
Queensland Government Department of Public Works	Queensland Department of Public Works Stewart Crook, Delwyn Jones and Ron Apelt Queensland Department of Housing Sue Crozier
BROOKWATER	Brookwater Michael Ryan and Warren Steiner

1.3 Methodology and key assumptions

The methodology used to select case studies and identify specific areas of investigation is provided in Figure 1. Initially, collation of data on all identified Australian case studies, from single house to sub-divisional scale, was carried out by CSIRO (Appendix 1: Full listing of case study sites). A workshop with CRC CI stakeholders was then used to identify their key issues and concerns regarding integrated urban water management in SEQ. At the workshop, background information on a selection of case studies was presented and a listing of all potential sites provided. The listing included case studies of different building types and scales and of both implemented and conceptual studies, as it was felt that valuable lessons could be leant from those projects that did not come to fruition.

Following the workshop a number of case study sites were selected for further investigation. In the original project proposal only three sites were to be investigated, but following the workshop and integration of the issues and concerns of the stakeholders a project variation was sought to increase the case study sites to eight. This allowed the inclusion of single house, small and large developments as well as retrofit and new build sites and residential and commercial sites. Sites were investigated and potential barriers and issues in terms of technical, financial, institutional and regulatory, environmental, social and integration with other services and systems were summarised.

The case studies were selected on their applicability to SEQ climatic, demographic, housing type, topographic characteristics and CRC CI project partner input. These included those case studies exhibiting the following features:

- Appropriate to individual dwelling through to complete subdivisions
- Applicable to retrofit/reengineer of existing housing stock
- Demonstrates alternative water servicing technologies
- Demonstrates transitioning of existing infrastructure
- Provides detail of financial arrangements for project implementation
- Implemented in social housing stock
- Implemented in inner urban areas or commercial premises.

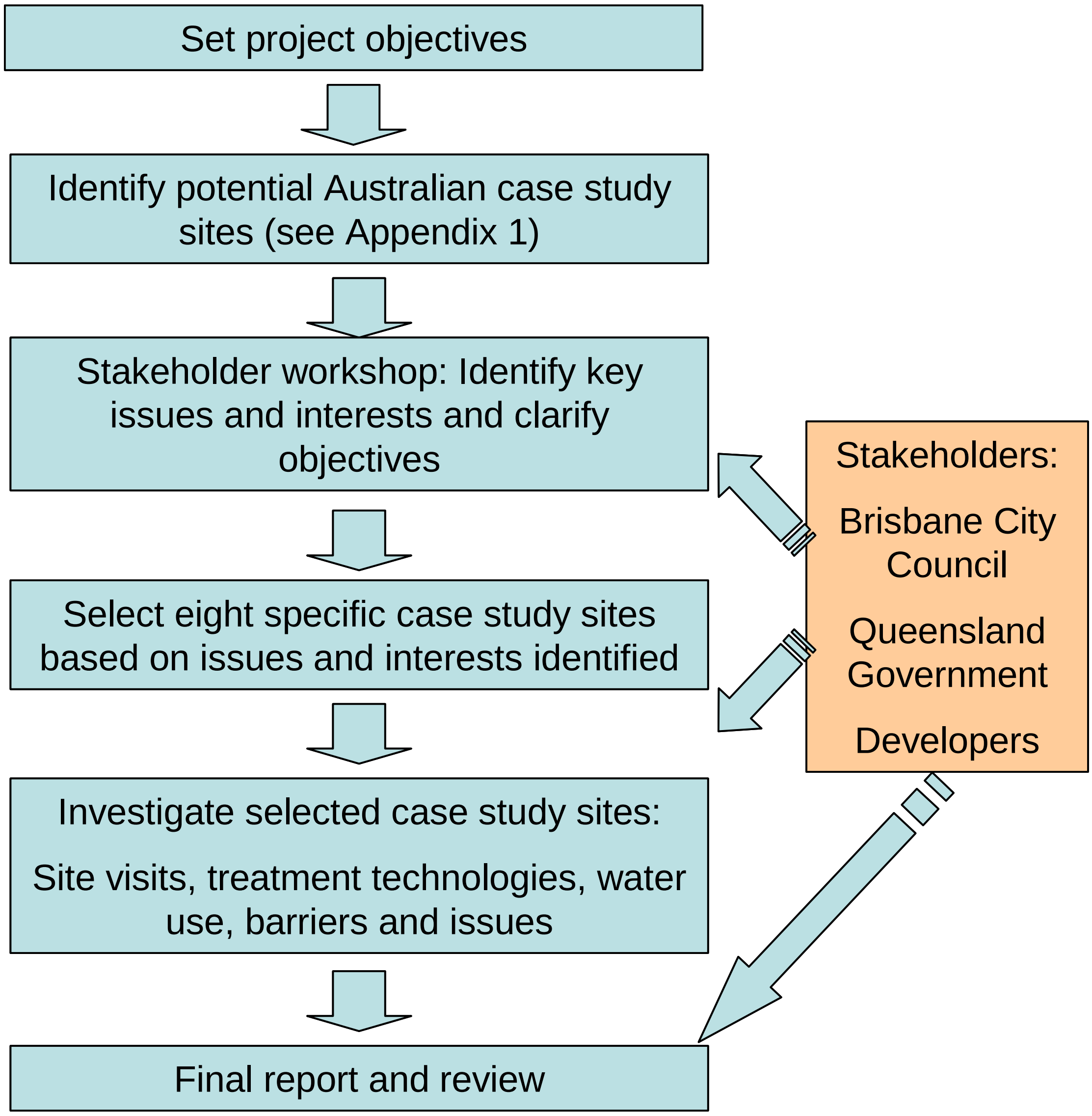


Figure 1: Methodology used for case study selection and investigation

Assessment of the selected case study sites included a site visit and discussion with key proponents of the scheme. The project scope and resources did not allow discussion with all individual case study stakeholders and this is a limitation in the data collected. Data collected included site details; location, topography, demographics and detail of the specific water, wastewater and stormwater treatment technologies used. Where available, details of water savings, reductions in nutrient discharge and water flows were also collated.

Once the research and industry reports for the project were complete they were distributed to the project stakeholders, CSIRO internal reviewers and the CRC CI board for review and comment.

The authors note that there are limitations to case study investigation as many issues can be observed, however few issues can be addressed in detail. This report identifies a number of key lessons around which further investigations are warranted.

1.4 Report Structure

This report consists of five chapters describing different aspects of water use efficiency and reduction in urban sub-divisions.

- Chapter 1 gives a brief introduction and background to the overall project.
- Chapter 2 focuses on detailed information relevant to SEQ in terms of alternative water servicing and provides a summary of existing housing stock and new dwellings, residential water use and other factors that influence selection of alternatives.
- Individual treatment technologies or techniques for rainwater, stormwater, greywater and wastewater collection, treatment and use are provided in Chapter 3 which includes a summary of potential barriers to their implementation.
- Chapter 4 then describes a number of case studies into which integrated water management practices have been incorporated. Case studies include both new build and retrofit and a number of different property types and scales.
- Chapter 5 incorporates the outcomes of the previous two chapters to provide a summary of techniques appropriate to SEQ and a gap analysis identifying areas for further research.

1.5 Next steps

This project identified potential future research areas and recommendations for further investigation, for implementing more sustainable water servicing approaches in SEQ. These outcomes will be presented to the CRC CI board for further discussion and potential inclusion as projects in the program of the eventual successor to the CRC CI.

2 BACKGROUND

2.1 Residential water use overview

Residential water demand comprises a substantial component of total water use. Summary statistics for total and residential water use for Sydney, Melbourne, Brisbane and Perth show large variability in water usage per capita, with lower populations of Brisbane and Gold Coast and Perth, having higher per capita and per property use (Table 1). The data also indicates that in most cities residential water use accounts for more than 60% of total use of water provided through centralised supplies. Residential water consumption per capita and per property is highest in South East Queensland (using data from Brisbane & the Gold Coast) and Perth.

Table 1: Summary water information for 2004-05

	Sydney	Melbourne	Brisbane and Gold Coast*	Perth
Total Water Supplied (GL/a)	526	431	328**	228
Total Residential Water Supplied (GL/a)	330 (63%)	264 (61%)	149 (60%)	159 (70%)
Non-residential water supplied (GL/a)	103 (20%)	118 (28%)	66 (26%)	47 (21%)
Other water supplied (GL/a)	93 (18%)	47 (11%)	31 (13%)	19 (8%)
Population (million)	4.23	3.58	1.47	1.48
Number of properties receiving water (million)	1.57	1.40	0.58	0.57
Residential water supplied (KL/capita)	78	74	101	107
Residential water supplied (KL/property/a)	210	188	257	277

(WSAA, 2005a),
* BCC and GCC data is the average of Brisbane and Gold Coast City Councils. These councils represent approximately 55% of the total SEQ population of 2.66 million (Office of Urban Management, 2005).
** includes 79GL Bulk water sales to neighbouring local government

Figure 2 shows the residential per-capita water use between 1999 and 2005 in major Australian urban centres. South East Queensland consists of an average of Brisbane and Gold Coast data and over the six year period, residential water consumption, shows no reduction compared to other cities. Water usage trends can be influenced by many factors including climate, restrictions and water use and efficiency policies. Separation of the influence of these factors is complex and has not been attempted in this study.

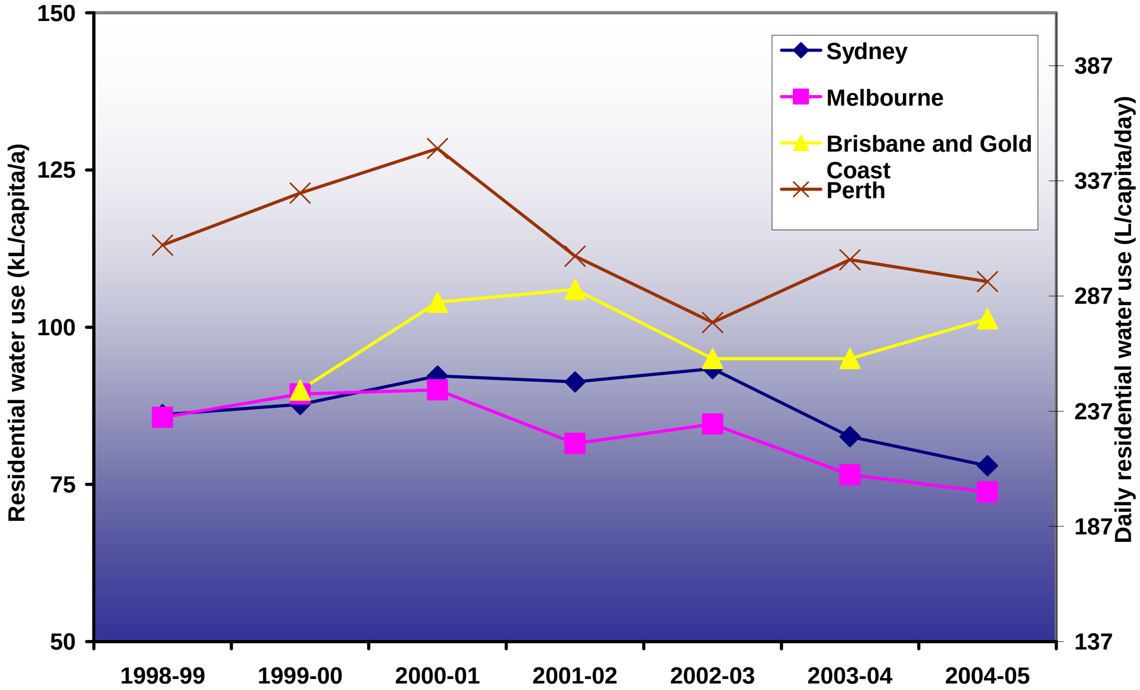


Figure 2: Annual residential water usage for major Australian cities

(Source: WSAA, 2005a)

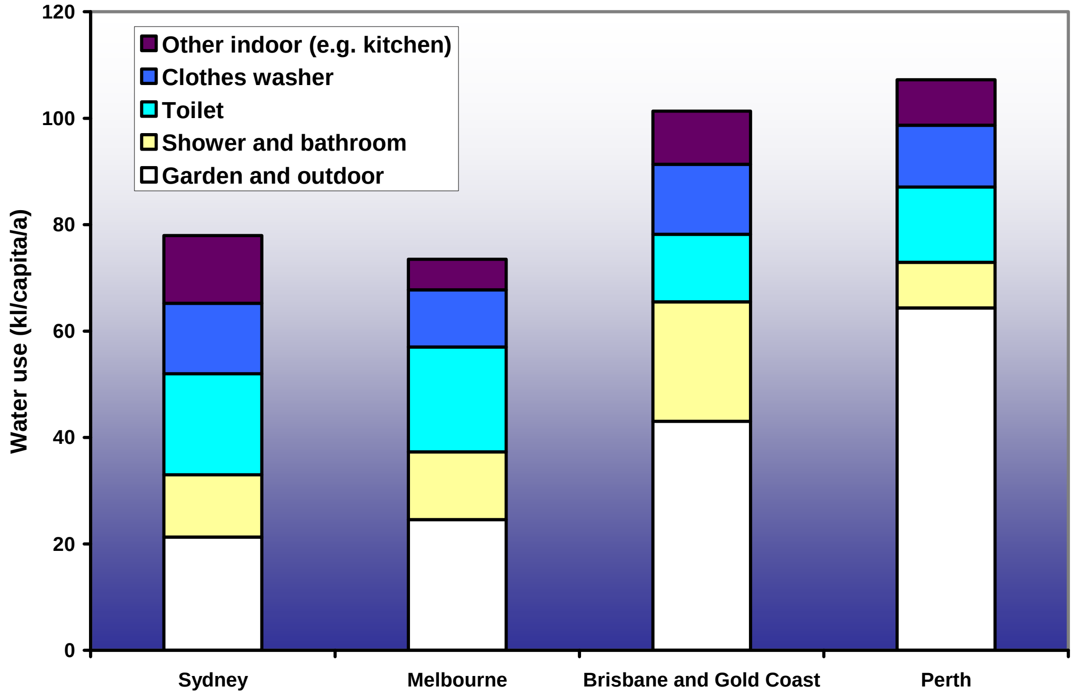
Population projections for all Australia's capital cities show substantial growth through to 2030 (WSAA 2005a) with SEQ demonstrating the highest projected growth rates. Medium-range projections suggest that the current population of 2.7 million will grow to 3.7 million persons in 2026 (Office of Urban Management, 2005). This represents some 50,000 new persons or around 20,000 new residences to be constructed each year. The SEQ Regional Plan recommends that a substantial proportion of this new housing will be infill and redevelopment in addition to greenfield sites. The plan recommends that 40% of all new dwellings constructed between 2004 and 2016 and 50% of new dwellings between 2016 and 2026 are infill or redevelopment sites (Figure 3). This percentage figure is likely to increase if the number of greenfield sites becoming available does not keep pace with development.

Local government area	2001	2004-2016		2016-2026		2004-2026	
	Existing dwellings	Total new dwellings	Infill dwellings	Total new dwellings	Infill dwellings	Total new dwellings	Infill dwellings
Beaudesert Shire	8,800	10,000	1,000	10,000	1,000	20,000	2,000
Boonah Shire	3,400	400	NA	400	NA	800	NA
Brisbane City	359,000	82,000	59,000	63,000	56,000	145,000	115,000
Caboolture Shire	41,900	15,000	3,000	11,400	3,000	26,400	6,000
Caloundra City	32,800	17,500	4,000	17,250	4,200	34,750	8,200
Esk Shire	6,000	900	NA	1,000	NA	1,900	NA
Gatton Shire	5,700	1,300	NA	1,100	NA	2,400	NA
Gold Coast City	180,900	74,000	35,000	62,500	30,000	136,500	65,000
Ipswich City	45,600	42,200	6,000	35,000	7,800	77,200	13,800
Kilcoy Shire	1,400	200	NA	250	NA	450	NA
Laidley Shire	5,000	2,000	NA	2,700	NA	4,700	NA
Logan City	58,200	7,100	1,500	8,500	3,000	15,600	4,500
Maroochy Shire	53,100	30,000	7,000	11,000	6,700	41,000	13,700
Noosa Shire	21,200	3,000	1,500	1,200	1,000	4,200	2,500
Pine Rivers Shire	41,400	16,500	4,000	12,700	4,100	29,200	8,100
Redcliffe City	21,500	4,400	2,500	2,500	2,100	6,900	4,600
Redland Shire	43,400	12,000	4,000	5,500	4,100	17,500	8,100
Toowoomba City	34,300	6,500	1,500	4,000	2,000	10,500	3,500

Notes: NA = not applicable
The figures shown for Beaudesert Shire are notional and will be revised when the planning issues in the Mt Lindesay/North Beaudesert Study Area are resolved.

Figure 3: Projected number of new dwellings and infill in SEQ (from OUM 2005).

Figure 2 shows residential end-uses of mains water on a per capita basis for the major urban centres in Australia. This data has been compiled from water usage data published by the Water Services Association of Australia (WSAA 2005a) and public documents produced by water utilities regarding the approximate breakdown of water use. The figure highlights the substantial variation in the per-capita water use across Australian cities. Similar, and at times even higher, variation can occur within cities and it is important for developments in any particular location to have a good understanding of the factors which influence demand.



* BCC and GCC data is the average of Brisbane and Gold Coast City Councils.

Figure 4: Residential mains water end use 2004-05 for major Australian cities

(WSAA 2005a, BCC 2004, Sydney Water 2006, various water utility public reports and websites)

Current greenfield residential development density in Australia is in the range of 8 and 11 lots per hectare. However, the trend is towards higher density in the existing urban area with support for new and increased activity centres and transit-oriented communities with higher per hectare densities.

A raft of measures has been implemented by all states to respond to prolonged drought and growth projections. These measures include water conservation, development of new water sources (including new dams in Queensland, groundwater and desalination in Perth), as well as some development of alternative water supplies including reuse and to a lesser extent stormwater use (WSAA 2005b). Structural and non-structural measures are proposed including promotion of low water use devices, storage level awareness campaigns, water usage restrictions, two tier water pricing, subsidies and incentives for installing greywater systems and rainwater tanks, catchment management to increase yields, harvesting of "deep" storage from existing dams by altering intake towers and the reuse of wastewater and stormwater. These strategies are applicable at a range of scales.

2.2 SEQ current strategies and initiatives

The current water supplies in SEQ are obtained from a number of surface water sources. For urban potable uses there the main dams include Wivenhoe/Somerset (1545 GL capacity), North Pine (215 GL) Hinze/Little Nerang (164 GL), Cressbrook (82 GL) and Baroon Pocket (61 GL). A borefield on North Stradbroke Island provides some 20 GL/a to Redland Shire and is the largest local groundwater source provided for regional urban use (AWA 2005). Recently additional dam sites have been proposed and some off line supplies are being brought back on line to cope with the current drought which in July 2006 was the worst in recorded history (NRW, 2006).

At the time of writing this report, SEQ is affected by unprecedented Level 4 water restrictions. The SEQ Regional Water Supply Strategy recommends targets for the reduction of potable water use to 270 L/capita/day by 2010 and 230 L/capita/day by 2020 (NRW, 2006).

Strategies proposed in South East Queensland for achieving these targets include:

- mandatory water restrictions on outdoor water use
- WSUD, rainwater tank rebates, and retrofitting (including redesign and re-engineering) incentives
- requirements for water recycling and efficient appliances in new developments
- water recycling targets
- 'fit-for-purpose' strategies for major industrial and commercial users
- progressive upgrades of capacity in wastewater treatment facilities.

This target would appear achievable by BCC and GCC given that (partially restricted) residential consumption has trended around or under this figure for the last seven years (averaging 262 L/cap/day, WSAA 2005a). Other local governments in South East Queensland may have greater difficulty as many regional areas have demonstrated much higher levels of consumption (e.g. Kilcoy 500 L/cap/day, Beaudesert, Caloundra, Cooloola and Noosa around 370 L/cap/day, AWA 2005).

In SEQ, the installation of greywater systems has recently been accepted by the State Government, with final approval still resting with local councils. Consideration of system type and management are important factors to consider as some uncertainty exists regarding the potential impacts of greywater on soils and runoff water quality.

Whilst there has been national coverage of stormwater use, the Stormwater Industry Association Queensland has expressed concern that the SEQ Regional Plan did not highlight the resource value of stormwater (Stormwater Industry Association Queensland, 2006).

The Message from the Minister in the Towards Sustainable Housing in Queensland Discussion Paper (Department of Local Government, Planning, Sport and Recreation, 2004) suggests the use of water efficient appliances, rainwater tanks and pressure reduction devices as potential future options. The introduction of new water savings measures followed a community consultation process of the discussion paper. New measures include the promotion of greywater and rainwater systems as well as various demand management approaches. These are being implemented through the Standard Building Amendment Regulation (No. 1) 2006 which calls up Rainwater Tanks (Part 25) and Sustainable Buildings (Part 29) of the Queensland Development Code.

Some local governments, in SEQ have a policy that all new urban developments reflect WSUD principles by 2010 (for example Brisbane City Council, 2005b). This sound initiative, however, does not specify household water consumption targets to be achieved by new developments.

2.3 Factors affecting technology selection

The following section summarises some the main factors influencing the selection of integrated urban water management and water sensitive urban design measures for a particular site.

2.3.1 Climate

Climate influences selection of approaches to water servicing. While average annual rainfall is a critical indicator of available water in a new or existing sub-division other factors must also be considered including;

- variation in annual, monthly and daily rainfall evaporation rates and
- stormwater and rainwater contaminant balance showing inter-relationships between water and contaminant flows in the complete water cycle.

2.3.2 Topography

Topography can dictate plot and infrastructure layout with graded slopes being the more desirable terrain. Steeper slopes impose constraints on style and form of construction, increasing surface flows and loads and potentially increasing sewage pumping and costs. On the other hand slope can be exploited to capture gravity feed in collection and supply of natural or wastewater flows. At a single lot scale, sloping terrain can improve the potential for storage systems underneath houses.

2.3.3 Lot size and density

For most developments lot size is strongly linked to financial viability but changing demographics, range of dwelling types, consumer expectations and affordability are also influential. Lot size affects selection of water servicing strategies considering potential catchment, storage and irrigation areas. For example a large irrigation area is required to distribute and absorb treated wastewater for many on-site wastewater treatments and rainwater tanks need large areas to capture and store significant water volumes for reliable supply depending on regional precipitation patterns. Lot size and density can also affect the capacity for large scale management of storm and wastewater which often requires large scale storage capacity to cover supply in dry periods.

2.3.4 Occupancy and water use

Household occupancy patterns influence the consumption of potable water and also the quantity and quality of the wastewater produced. Key factors when selecting water servicing options are:

- Generally per capita drinking water consumption and wastewater generation decrease with increasing occupancy levels.
- Trends are for lower-occupancy rates per dwelling and higher dwelling density per land area.
- Water-efficient design/ appliances reduce drinking and wastewater volumes.
- Installation of water efficient appliances will increase wastewater contaminant concentrations with unchanged household product load in lower effluent volumes. Wastewater treatment systems need to be able to treat these higher concentrations.
- Climate effects on water demand should be considered as generally water use is higher in summer when there is less rainfall.
- Average household size in SEQ of 2.6 persons in 2001 is declining to estimates of 2.45 by 2011 and 2.29 by 2026 (Office of Urban Management, 2005).

2.3.5 Water storage and availability

Water demand is primarily dependent on occupancy, water use patterns, block and garden size and is higher in summer when less rainfall is available. At a sub-divisional level, storage of alternative water sources is required during wet months to ensure supply when demand increases during dry periods. Stormwater or treated effluent can be stored in lagoons, ponds or in underground aquifers.

Treated wastewater can provide a reliable source of water but cannot be adopted as the sole supply source, as irrigation use will not be met. There are also issues associated with the build-up of contaminants in the recycling loop and often recycled water is ‘shandied’ with other sources such as groundwater, stormwater and traditional potable supply.

At household scale, the storage of rainwater is possible. At this scale reliability is subject to rainfall, collection area and storage capacity. Greywater, which provides a continuous source of water, is subject to storage period limitations dictated by the degree of treatment, with current legislation limiting the storage of untreated greywater to a maximum period of 24 hours.

2.3.6 Legislation and tools

The legislation surrounding domestic water use and wastewater reuse in Australia is highly complex and varies from state to state and can also vary within a state. Draft National guidelines for wastewater recycling exist although they are not yet mandatory (Environment Protection and Heritage Council *et al.*, 2006).

The principal Commonwealth environmental legislation that could affect water recycling projects is the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act). The *Trade Practices Act 1974* can also be relevant where there is a commercial element to the recycling, or when commercial activities are impacted by wastewater. State legislation however tends to dictate local reuse policy.

A review of legislation applicable to SEQ is outside the scope of this report however an overview is provided below to give context. For other states more information can be found at in the relevant state wastewater reuse guideline or regulator website. The principal legislation governing the use of recycled water in Queensland is the *Environmental*

Protection Act 1994 and its subordinate legislation, the Environmental Protection Regulation 1998 and the *Environmental Protection (Water) Policy 1997*. Water recycling is not an environmentally relevant activity in its own right and no development approval is required from the Environmental Protection Agency (EPA) for water recycling as such. However, it may be an integral part of an activity that is an Environmentally Relevant Activity (ERA), or otherwise, requires a development approval. The *Integrated Planning Act 1997*, *Water Act 2000*, *Plumbing and Drainage Act 2002*, *Health Act 1937*, *Food Act 1981* and *Workplace Health and Safety Act 1995* all have some impact on water recycling, as do local laws.

Wastewater reuse guidelines do not typically cater for stormwater although the Commonwealth Department of the Environment and Heritage has produced an 'Introduction to Urban Stormwater Management in Australia' (Department of the Environment and Heritage, 2002). Another useful reference for urban stormwater management is the Urban Stormwater – Best-Practice Environmental Management Guidelines (CSIRO, 1999).

From March 1st 2006, new laws in Queensland make it mandatory that all new houses be fitted with greenhouse efficient hot water systems, AAA-rated shower roses, dual flush toilets, water pressure limiting devices and energy efficient lighting. The laws also approve the use of greywater throughout the state and give councils the power to require new houses be fitted with rainwater tanks.

A limited number of schemes and tools are available to encourage developers and the general public to reduce water and energy demand of household designs and renovations. These tools are intended for general guidance in some aspects of sustainability and are not a substitute for more detailed assessments. These tools include:

- **BASIX,** the Building Sustainability Index, is a rating tool which aims to promote lower potable water and energy use in NSW. The program, which compares a house or unit design against energy and water reduction targets in NSW, is available free on-line. Information such as site location, house size, type of building materials and fittings for hot water, cooling and heating is required. In NSW, every development application for a new home is submitted to Council with a BASIX Certificate. The commitments made during the BASIX process are shown on the final certificate and must be marked on the plans and adhered to during the building process. Whilst a useful tool in encouraging the adoption of more sustainable practices in design and construction, BASIX does not aim to conduct a thorough assessment of water and wastewater management within a household nor does it conduct a life cycle assessment of a building package (http://www.basix.nsw.gov.au/information/ about.jsp).

- **Water Efficiency Labeling and Standards (WELS)** Scheme is a national rating scheme developed to assist purchasers of household water-using products to compare the relative water efficiency of the available models and hopefully provide manufacturers with incentives to improve the water efficiency of these products (http://www.waterrating.gov.au/index.html). The WELS Water Rating label is similar in appearance to the Energy Rating label and replaces the Water Conservation Rating 'AAAAA' label used in the Water Services Association of Australia's National Water Conservation Rating and Labeling Scheme.

  The water-using products covered by the WELS Scheme currently include clothes washing machines, dishwashers, flow controllers, toilet equipment, showers, tap equipment (for kitchen sink, bathroom basin, laundry tub or ablution trough) and urinals and has become mandatory from July 2006.

The WELS Water Rating label has two main features (Figure 5):

- A star rating that gives a quick comparative assessment of the model's water efficiency
- A water consumption figure that provides an estimate of the water consumption of the product based on its tested water consumption

Labels will display from 1 to 6 stars, with more stars meaning the product is more water efficient. Some products may also be labeled with a 'Zero Star Rated' label, which indicates that the product is either not water efficient or does not meet basic performance requirements. The star rating of a product is determined by water consumption and with some products also by other characteristics, e.g. size, capacity, using test procedures and performance criteria defined under Australian Standards.

Figure 5: Example of WELS water rating label

2.3.7 Implementation and management strategy

Previous work has suggested that the current water industry structure which generally manages stormwater, wastewater and drinking water as separate entities is a barrier to the implementation of alternative integrated water services (Mitchell, 2004). This work also identified that successful projects often involved a high level of public involvement, strong partnerships or alliances not necessarily present in traditional project management strategies or project champions who have provided the impetus to see the project through to completion. Thus, the implementation and management strategy for any development with an alternative water service needs to be considered and new strategies may need to be developed to incorporate new approaches to water servicing.

2.4 Technology assessment

There are a wide range of alternative water servicing technologies available, including systems for the collection and use of rainwater and stormwater and the treatment and use of greywater and wastewater. The task of assessing which type of technology is appropriate is a complex task and is not the focus of this report. The suitability of any particular technology will be influenced by a number of factors including the scale of application (e.g. from

household to subdivisional level) as well as the performance required and operational and maintenance needs. This report focuses on the benefits of the technology in terms of the urban water cycle and on operational, practical and associated issues associated with implementation.
There are a number of methods which can be used to give a thorough and detailed assessment of the different technologies and aid in technology selection. Tools that have been used previously for assessment of options include:

- Water balance analysis
- Contaminant balance analysis
- Life cycle costing (LCC)
- Life cycle assessment (LCA) includes energy, materials and emissions
- Risk assessment and management

Water and contaminant balance assessment of technologies should consider impacts on the entire urban water cycle particularly with regard to water flows and quality. This sort of assessment can evaluate the ability of a technology to meet IUWM objectives, such as reduction in mains water usage or return of surface flows to predevelopment conditions.
An assessment of the water and contaminant balance for a new sub-division or existing urban area is vital in order to understand the complexities and inter-relationships between all water streams. The process allows greater understanding of potential alternatives and their impacts on the entire water cycle. The water balance should address all aspects of water flow in the urban area, both inputs (rainfall, subsurface flows and drinking water) and the outputs (evaporation, stormwater discharges, groundwater and wastewater flows) (Figure 6). A base case or "business as usual" calculation can be calculated to allow comparison of proposed alternatives to a standard development. The water and contaminant balance will provide information which can be used in assessing the overall sustainability of alternative water servicing approaches.

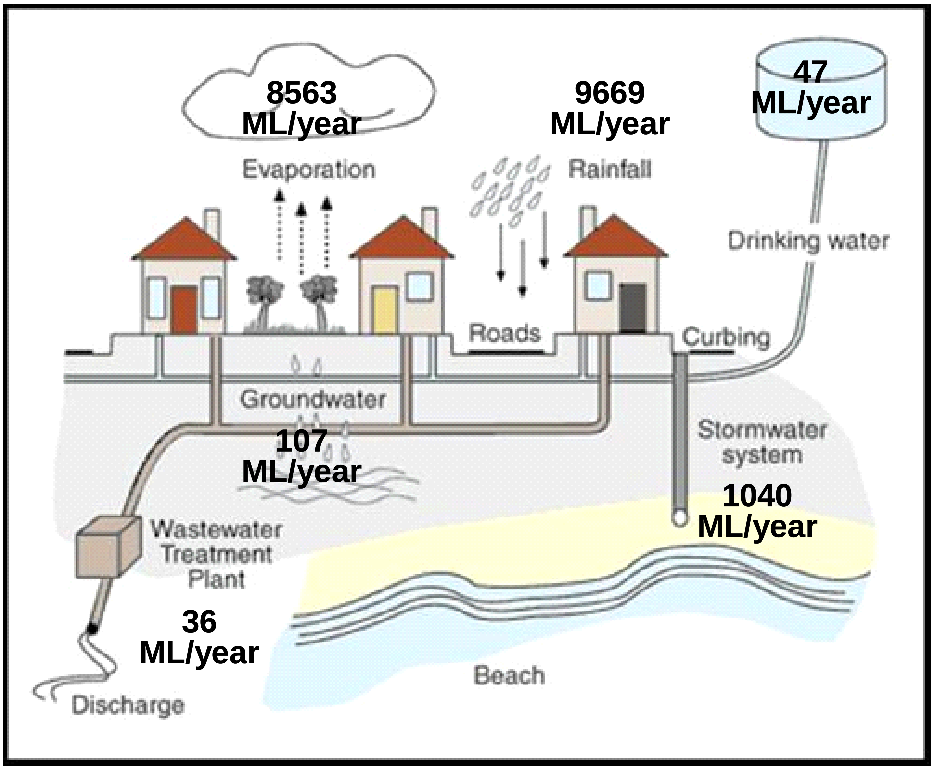


Figure 6: Example of a water balance results for an urban area

Life cycle costing is a process to determine the sum of all the financial costs associated with a technology, including acquisition, installation, operation, maintenance, refurbishment and disposal.
Life Cycle Assessment is an objective process to evaluate the environmental burdens associated with a product, process, or activity from “cradle to grave”. This is done by identifying energy and materials used and wastes released to the environment, and to evaluate and implement opportunities to affect environmental improvements.
There are many risk assessment and management processes which are applied to urban water systems. The assessment of health, environmental, social, institutional, and political risks should also be included in an IUWM process.

3 ALTERNATIVE WATER MANAGEMENT OPTIONS

3.1 Introduction

There is a huge range of water management options applicable to urban residential and commercial development, the selection of which will be dependent on the factors outlined in Section 2. Water management options can take a number of forms, from engineered and designed technologies and appliances to non structural methods such as pricing or rebates. This study focuses on the structural techniques rather than the non structural methods. There are a number of previous publications which have reviewed various aspects of alternative water servicing in the urban environment and data and information from these has been used in this current study.

- Water Recycling in Australia. Review undertaken by the Australian Academy of Technological Sciences and Engineering (2004) Dr J.C. Radcliffe.
- Australian Water Conservation and Reuse Research Program http://www.clw.csiro.au/awcrrp/stage1.html including:
    - Integrated Urban Water Management: A review of current Australian Practice (2004) Dr. V. Grace Mitchell
    - Innovation in on-site domestic water management systems in Australia (2004) Dr Clare Diaper
- Integrated Stormwater Treatment and Reuse Systems: inventory of Australian Practice (2004) Hatt et al., Monash University
- Rethinking urban water systems - revisiting concepts in urban wastewater collection and treatment to ensure infrastructure sustainability. Water Science and Technology: Water Supply 5, no. 2 (2005) Tjandraatmadja,G.F., Burn,S., McLaughlin,M. and Biswas,T.
- A review of technologies for wastewater and bioresource recovery in urban centres (2004) G. Tjandraatmadja and S. Burn.
- ATA Greywater Project Report (2005) supported by the Smart Water Fund http://www.ata.org.au/wp-content/projects/smartwater_final_report.pdf
- Clunes wastewater options report (2005) Geolink,
- Waste reuse in the Urban Environment: Selection of technologies. Landcom (2006)
- Water Sensitive Urban Design (WSUD) Policy Package. Landcom (2004).
- Understanding the Drivers for Implementation of Decentralised Systems in Urban Environments (2006) – Examples of decentralised water and wastewater provision across the world, G.Tjandraatmadja and S.Burn, Enviro 06 Conference Proceedings, Melbourne.

Technologies and techniques collated from the above publications are categorised in to lot scale, cluster and subdivisional groups and then within these the sub-groups of rainwater, stormwater, greywater and wastewater are made. These lists are not exhaustive and some techniques are described generically whilst for other more innovative approaches, a particular technology is named and described. The capital costs and installation costs are not given as these will be labour and location specific but a description of the installation requirements is given where available.

3.2 Lot scale options

Rainwater

The Australian Bureau of Statistics (ABS) reports 1.3 million homes with rainwater tanks installed across Australia (ABS, 2004). The majority of these tanks are in rural areas where they provide household water for all end uses. In urban areas the aesthetic form and physical size of a rainwater tank are important in their selection, rather than their ability to provide a reliable supply. There are many different designs on the market, ranging in size, shape, materials of construction, collection mechanism and treatment, each appropriate for different land availability, housing construction and end use requirement. The rainwater system can be split into four sub-processes; collection, storage, treatment and distribution.

Rainwater collection systems are designed to reduce contaminants entering the system and include gutters and gutter guards, first flush devices and filters. There are three main collection system constructions, the wet system in which collection pipes are buried to reduce aesthetic impact, the dry system which is the most common where all pipes are above ground and the siphonic system in which pipe flow rates are maximised by allowing full bore pipe flow. Some of the advantages and disadvantages of these systems are summarised in Table 2.

Table 2: Rainwater collection system advantages and disadvantages

Collection System type	Advantages	Disadvantages
Wet	Reduced exposed pipework Tank can be located distant from roof area	Stagnant water in collection system More pipework required Installation requires subsurface pipework
Dry	Collection system drains after each rainfall event	Tank location close to roof collection area preferred Exposed pipework
Siphonic	Increased flows and reduced pipe diameters	Increased potential for overflow

There are many methods for excluding contaminants such as leaves, animal faecal matter and airborne pollutants from the collection system. Although there is a wide range of guttering designs which exclude leaf litter, at present there is no comparative data on the relative efficiency of contaminant removal and water collection. Some work has been carried out on first flush devices, which exclude the first roof runoff from the collection tank (Gardner et al., 2004). This work showed that whilst some contaminant concentrations flowing to the collection tank were reduced the design of a first flush diverter could substantially reduce the collection efficiency of the system. Whilst the use of first flush devices is advocated by many there is no statistically relevant data that shows they do improve the quality of stored water. In addition to first flush devices there are also a number of techniques to filter the collected rainwater as it enters the rainwater tank. Again, no statistically relevant data has been identified that verifies these filters improve water quality in the tank.

Table 3: Urban raintank storages – materials and capacity

Storage tank trade name	Materials of construction	Storage capacity (L)	Website
Rain reviva	Fused polypropylene sac	2000 to 7000	rainreviva.com.au/
Nylex Freewater Modular Systems	Polyethylene	220	rainwater.com.au/fms.html
Water wall	Polyethylene	1200	waterwall.com.au/
Slimline Poly tanks	Polyethylene	550-2800	polyworld.com.au/rainwater.htm
Aquarius	Polyethylene	300	aquariuswatermaster.com.au/main.html
Tankmasta Stonewall	Polyethylene	1000	dempseype.com.au/ tankmasta_water_tanks.html
Tankmasta Underground Tanks	Polyethylene	3000 and 5000	www.tankmasta.com.au/

Storage tanks for rainwater in urban areas can take many forms and materials of construction. Some links to particularly innovative or alternative approaches are provided in Table 3 and additional information can be found in Diaper, 2004. There are also some new innovations in monitoring of rainwater tank storage level in the form of simple float systems, such as Yaktek Industries Levetator and Liquidator
(see http://www.m2raintanks.com.au/products.html#yaktek).

Distribution of rainwater is usually via a pump, although in certain situations, end uses could be gravity fed. There is the associated energy use and impacts which need to be considered when installing a rainwater tank. If potable water is used as a backup supply it is not recommended to top up the tank, as the potable water looses potential energy when supplied to the tank and then has to be repumped to required end uses. An automatic diverter device, in which mains water pressure is used when mains water back up is required, will be more efficient in terms of energy use
(see http://www.davey.com.au/rainbank/).

Treatment of rainwater depends on the end use for which it is being used and there are three main types of treatment; filtration, thermal disinfection and UV treatment. Filtration provides a barrier to micro-organisms and both micro and ultrafiltration are used. Thermal disinfection through hot water servicing is currently being investigated and results have shown that there is some bacterial removal at temperatures relevant to domestic hot water systems. None of the treatment processes provides residual disinfection and all have associated maintenance and replacement requirements.

Potable water savings due to the installation of raintanks will be dependent primarily on climate and end uses of the rainwater. Figure 7 shows the results of modelling potential savings for different locations, end uses and for single house blocks and infill dual occupancy blocks (two houses built on one existing block). The graph shows that the under the climatic conditions modelled in the study, the Brisbane climate offers good potential savings for continuous end uses (toilet, laundry and bathroom), particularly in the infill situation where the garden demand is reduced. The raintank size assumed in this study was 5000 L, for other assumptions see Gray (2004).

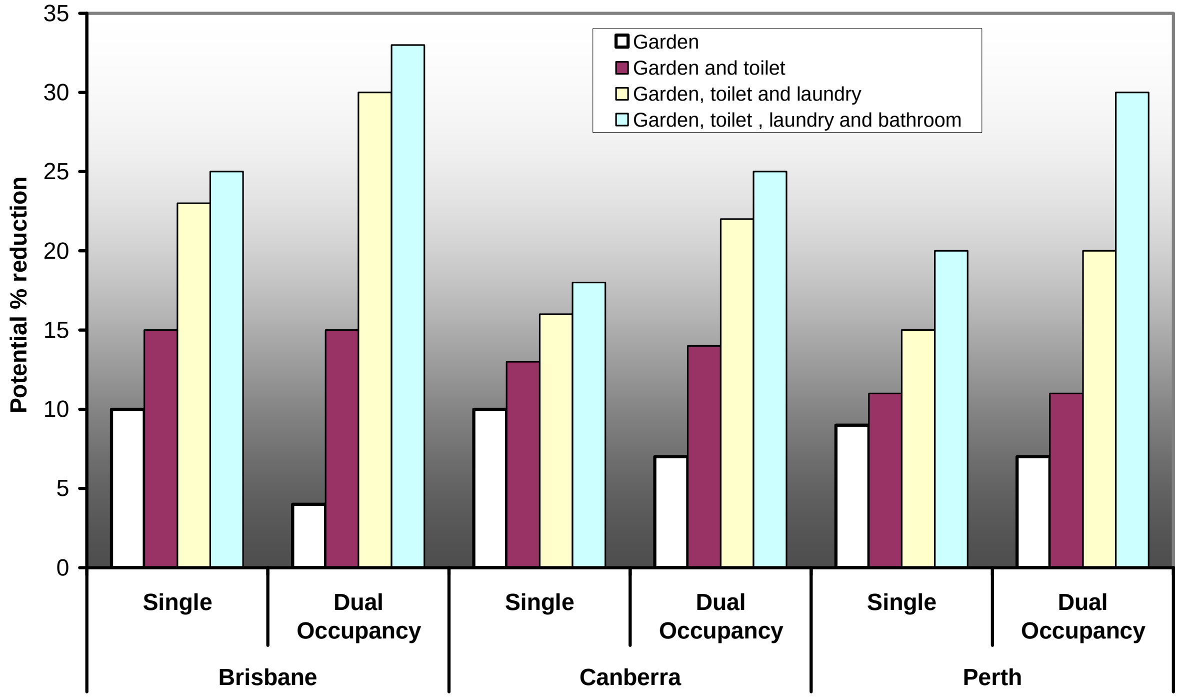


Figure 7: Potential water savings for different raintank installations

(Gray, 2004)

Stormwater

Stormwater is the runoff from pervious and impervious areas collected from a property via the drainage system and is generally diverted to stormwater mains that are maintained by the council. There are some stormwater collection technologies and techniques that are appropriate to household scale, namely permeable paving and reduction of paved areas, although stormwater collection, treatment and storage are most often addressed at the sub-divisional level (Hatt et al., 2004).

Ecopaving is a relatively new concept in Australia and may provide the necessary pre-treatment for collection of stormwater from individual properties. Ecopaving is designed to be permeable, leading to potential reduction in runoff of both flows and pollutants and the recharge of groundwater and aquifers. Currently ecopaving has been used in landscaping, car parks and pedestrian areas (Mitchell, 2004; Shackel, Ball and Mearing, 2003) but only one case study of this type of system at an individual lot has been identified http://www.atlantiscorp.com.au/projects/storm_water_filtration_&_reuse_system. More detail of stormwater collection, treatment, storage and use is given in Section 3.3

Greywater

Greywater is any effluent from a property excluding that from toilets and urinals. However, most greywater systems are designed to collect and treat greywater from the bathroom and laundry only, as the kitchen wastewater usually contains higher concentrations of gross contaminants and fats, oils and greases. There are two basic types of greywater system; the direct diversion system which does not treat the water but directs to an appropriate end use and the collection, treatment, storage and distribution system which can produce a high quality product water. The end uses for the water from these two types of process varies, with direct diversion systems generally for sub-surface garden irrigation only and treatment systems for garden irrigation and other outdoor uses, toilet flushing and potentially laundry washing (Table 4).

Greywater can contain human pathogens and, depending on the source, can contain high concentrations of sodium, phosphorous and other dissolved solids from laundry detergents (see http://www.lanfaxlabs.com.au/;Toowoomba Council, 2005), phosphorous and aluminium in toothpastes, sodium and biodegradable organics in shampoos and nitrogen in shampoos, deodorants, sunscreen and laundry detergents (Figure 8). Note that Gardner and Millar (2003) did not measure sodium and potassium and the data is for a mixed greywater and the Toowoomba council report on greywater quality from the laundry alone (Laundry Greywater Potential Impact on Toowoomba Soils – Final Report 2005). This report also indicates that front loading machines increase the total N and suspended solids concentrations discharged but not salinity or the ratio of Na:Ca:Mg:K. All these components of greywater can have detrimental impacts on the environment in terms of water quality and soil structure.

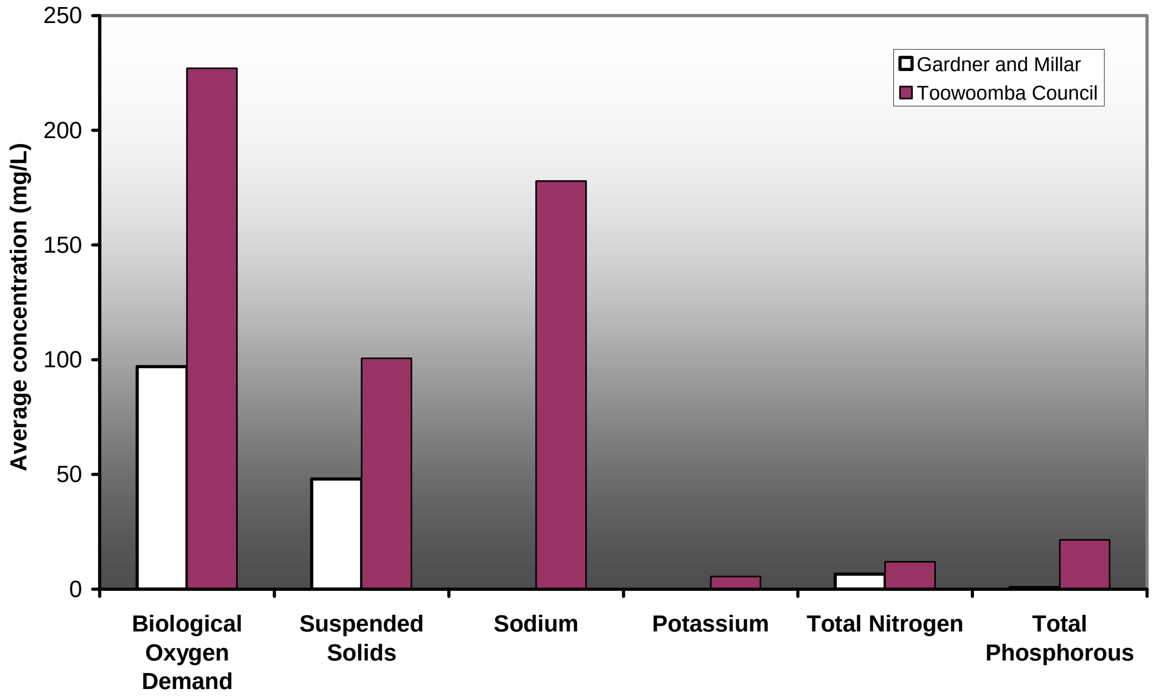


Figure 8: Example greywater quality data

(Gardner and Millar, 2003; Toowoomba Council, 2006)

The installation of greywater systems has recently been mandated in SEQ, with final responsibility for approval of installation residing with local council. However, there is still confusion regarding the potential impacts of greywater use for irrigation and uncertainty as to which system to install. The potential water savings associated with greywater use or treatment and use are well documented and will be primarily dependent on end use (Gardner et al., 2006; Priest, 2003; Diaper et al., 2003). Savings achieved when used for garden irrigation vary depending on the local climate, soil type and irrigation area, whereas for indoor purposes the savings are dependent upon water usage for specific appliances and the collection source (Figure 9, Gray, 2004). Figure 9 shows that for Brisbane, potential savings are higher for single house lots rather than infill dual occupancy lots (two houses built on one existing lot), as the smaller garden area on the dual occupancy lot has a lower water demand. The data also suggests that >20% savings can be made with a 1000L tank collecting both bathroom and laundry greywater and supplying both garden uses and toilet flushing. Overall the graph indicates that water usage patterns and climate in Brisbane do not provide the optimum conditions for greywater reuse when compared to other state capitals. It should be noted that these figures are from a conceptual modelling analysis and the assumptions made should be considered before overall conclusions are made.

Greywater does provide a continuous supply and so is available during dry periods. The installation of greywater technologies at the household scale may also help to increase awareness and aid in community education and understanding of broader water resource issues (ATA, 2005). Also, greywater use at the single house scale has broad community acceptance. Whilst there have been a number of studies to gauge the acceptance of wastewater reuse at a larger scale (Po *et al.* 2003 and 2005, Hurlimann and McKay 2003 and 2004), none have examined the public perception of larger scale greywater reuse.

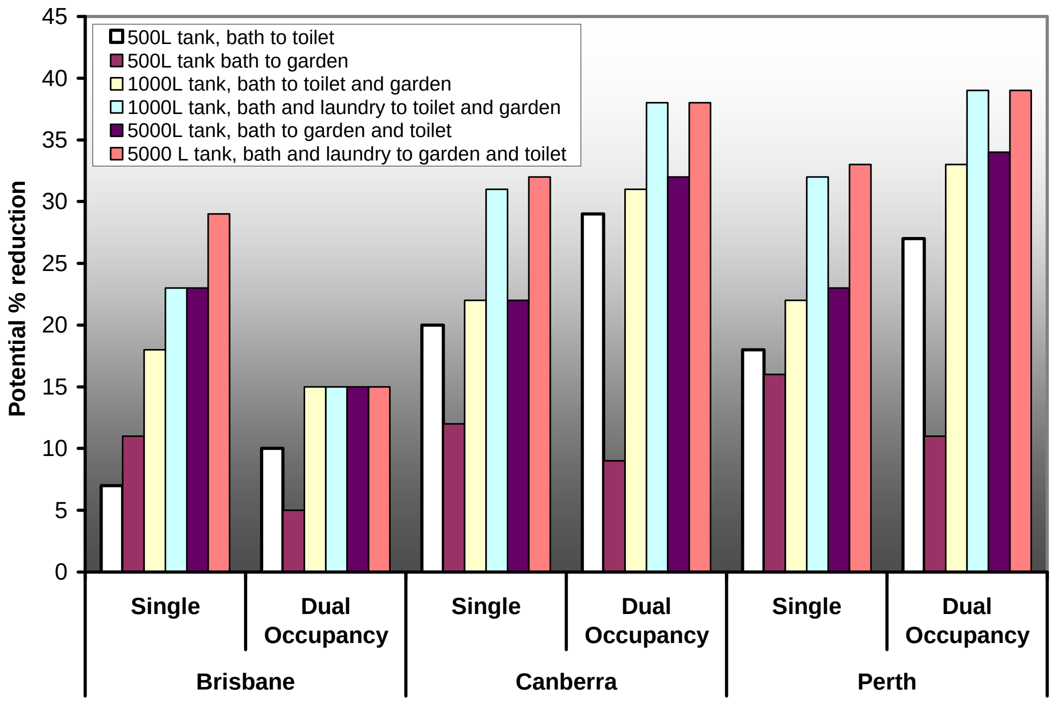


Figure 9: Potential water saving from greywater use

(Gray, 2004)

There are currently many systems available to recycle greywater, from simple filtration and diversion to complex treatment trains (Table 4). These systems will provide different greywater quality, some of the treatment systems meeting Victorian and New South Wales guidelines for recycled wastewater. The costs of the systems vary and will be dependent on house design, space availability and piping requirements. Most systems are suitable for retrofit, although the source separation of greywater from blackwater may limit application in existing houses built on slabs. Queenslander style houses prevalent in existing housing stock in SEQ, may make the collection of individual household wastewater streams more feasible.

Table 4: Greywater technologies – description, greywater sources and uses and potential savings

System Name	System type	Greywater source	Greywater use	Actual/Potential water saving
DIVERSION ONLY				
Greywater Saver (Nylex)	Trench diversion to garden	All except kitchen	Garden irrigation	Actual 150 L/day (summer)[1]
Greywater Diverter (Bunnings)	Trench diversion to garden	Washing machine	Garden irrigation	Actual 100 L/day (summer)[1]
Greywater Gardener (Waterwise)	Drip-fed diversion to garden	All except kitchen sink	Garden irrigation	Actual 0[1]
Wattworks (Nylex)	Diversion to toilet	Shower	Toilet flushing	Actual 54 L/day year round[1]
Garden Saver http://www.gardensaver.com.au/	Diversion of washing machine via filtration	Laundry only	Garden irrigation and toilet flushing	Dependent on storage size (450 to 3900 L)
TREATMENT SYSTEMS				
Slow Sand Filter (bespoke design)	In-ground treatment	All except kitchen sink	Garden irrigation	Potential 100 L/day[1]
Peat Filtration (New Water)	Peat filtration and chemical disinfection	All except kitchen sink	Garden irrigation and toilet flushing	Actual 130L/day (summer)[1]
Pressurised sand filter	Filtration treatment	Shower only	Garden irrigation	No data
Everwater grey2blue	Flocculation, filtration and UV disinfection	Laundry and bathroom (single house and cluster)	Garden irrigation and toilet flushing	No data
Pontos Aquacycle	Two stage biological aeration and UV disinfection	Bathroom only (single house and cluster)	Garden irrigation and toilet flushing	No data
Aquacell	Membrane bioreactor	All except kitchen sink (single house and cluster)		No data

1 ATA 2005

Wastewater

Wastewater is defined as the all the water collected in the sewer network that leaves a property and can be split into greywater and blackwater, with blackwater containing toilet wastes. A large proportion of wastewater is water and organic and inorganic solids only represent 1-2% of the total mass. The organic matter in domestic wastewater is present as carbohydrates, fats and proteins and the inorganic matter as dirt, grit, salts and small concentrations of metals and other contaminants. Wastewater also contains faecal matter, the main source of pathogens in wastewater.

In conventional systems, transport is usually based on gravity flow with water used as the transport medium. As a result, large volumes of water are required to prevent solids from settling in the pipes. Sewers have traditionally been designed from rigid materials and so must account for inflow and infiltration. Settling of the soil after installation can affect the joint alignment and allow the ingress of water during rain events or due to increases in the water table. Low gradients and deep pipe burial result in the need for high capital investment as wastewater is transported long distances in pipes of increasing diameters to the treatment plant.

On-site management of wastewater in Australia is adopted mainly in unsewered areas with the aim to provide adequate sanitation. Single household scale treatment options are defined as those that treat wastewater produced by 1-25 equivalent persons. The most commonly adopted technology is a septic system for collection and primary treatment and a leachfield for further treatment and distribution.

On-site management of wastewater occurs under 2 categories: reduction of water used for transport of waste and treatment and reuse of wastewater on the property. Options for reduced wastewater production on an allotment scale include the reduction or elimination of water for transport of solids i.e. low flush or composting toilets or the separation and individual treatment of solid and liquid fractions in wastewater i.e. source separating toilets.

Options such as dry sanitation via the use of composting toilets or source separation toilets have achieved limited market penetration in urban areas in Australia and other developed countries, possibly due to limited information on technical feasibility, customer acceptance and costs. There is also some reticence from regulators and water authorities to allow the proliferation of such systems because of the perceived increased risks due to maintenance of systems by individual home owners and limitations based on the need to find markets for the composted product (Crockett, 2003).

Treatment and reuse of effluent from wastewater at a household level has been implemented in a number of sites around Australia. The are additional challenges compared to greywater and rainwater use because of the higher concentrations of pathogens and other micro-organisms and the need to prevent health risks to humans, transfer via disease vectors and the contamination of the environment. The effluent is reused for non-potable applications, ranging from garden irrigation and after disinfection for toilet flushing and clothes washing. Sludge is most often removed by a contractor or disposed to sewer.

There are some distinct advantages to treating wastewater at the household scale. For example, as the wastewater tends to have a lower level of persistent contaminants, such as pollutants from stormwater run-off (hydrocarbon residues) or industrial sites, as compared to larger scale wastewater collection, simpler treatment methods can be employed.

A range of advanced wastewater treatment technologies are available for on-site treatment and these have been reviewed elsewhere. (Geolink, 2005; Landcom 2004). Some of the existing installations are represented in Table 5 and Appendix 1.

Public literature provides only limited information on the effectiveness of different wastewater treatment systems and minimal guidance to the householder and local government representatives and this has been seen as a barrier to further implementation. This has been recognised in the industry and there are programs designed to help overcome this. For example the Municipal Association of Victoria (MAV) sponsored the Clearwater project to provide a web based information resource for Environmental Health Officers (EHOs). EHOs in Victoria are charged with the responsibility of managing on-site systems and the web resource was developed to provide technical information, innovation in planning and management, regulatory opportunities and educational information and methods for community participation. More information can be found on the Clearwater website (http://www.clearwater.asn.au/).

Table 5 : Examples of on-site wastewater options

System Name	System type	Water use reduction or end use	Current examples
Dubbletten	Urine separation toilets	5L/3.25L per flush	No known Australian examples
Aquatron	Solid and liquid separation system for use with conventional toilets	6L/3L per flush but with potential reuse of effluent if treated.	Private houses (2 in NSW, 1500 in NZ) http://www.aquatron.se/
Clivus multrum	Composting toilet	No water use.	Public and private facilities in unsewered areas www.clivusmultrum.com.au/
Rotaloo	Composting toilet	No water use.	Public parks and rural properties www.rotaloo.com/
Biolytix	Peat + humus filter located on property	Subsurface irrigation (toilet and washing machine with additional treatment)	Payne Road greywater only (see Section 4.2)
Advantex AX	Textile Filter	Subsurface irrigation (toilet flushing if disinfection included)	Private facilities in unsewered areas www.innoflow.co.nz/

LOT SCALE OPTIONS: BARRIERS AND ISSUES

Below is a summary of some of the potential barriers and issues associated with different lot scale alternative water servicing options. This summary has been collated from information collected during the literature review and case study investigation. In addition to these technology specific barriers and issues there is the overarching need for; accessible information on system installation and design, monitoring of systems once installed to ensure correct performance and dissemination of results from monitoring to all interested parties.

RAINWATER

- Water savings and reliability of supply are dependent on adequate rainfall, climate, storage volume and collection area. A back up supply is required for 100% reliability
- Smaller storage tanks, more common in urban areas, may not provide the treatment capacity of larger tanks
- Additional pumping and energy requirement

STORMWATER

- Minimal innovation for collection, treatment and use at the household scale in this area

GREYWATER

- Separation of greywater from blackwater may require extensive plumbing alterations, especially in retrofit situations
- Potential impact of high sodium and phosphorous detergents on the environment in terms of soil structural degradation, increased soil pH and poor plant growth
- Potential for growing of high water use plants, thus maintaining a high garden water use over the long term
- Not enough information available on garden design and water needs when greywater used for irrigation
- Limited research on the effects of storage on treated greywater

WASTEWATER

- Adequate treatment is required to safeguard the home owners health and minimise potential for transmission by disease vectors
- Expert advice required for set-up.
- Disposal of sludge or biosolids is required and there is a need for increased participation and reliance of the householder to ensure proper functioning of the system, including its operation. Experience with septic system management indicates that the level of diligence tends to vary. No “flush and forget”. *
- Current wastewater operation, maintenance and management arrangements are not geared for decentralised systems, no current systems are in place to ensure compliance and enforcement of proper maintenance of on-site wastewater systems.
- Approvals tend to be complex (regulators, councils and water authorities).

GENERAL

- Contamination and safety of subsurface tanks
- Odours, noise and visual appearance need to be considered
- There is a potential high embodied and operational energy of high tech treatments
- Potential maintenance issues and management of system by homeowner
- Costs can be high
- Lengthy approvals process when new techniques or technologies are used and additional testing or other requirements may increase cost.
- Coordination of trades people is required for more complex systems (electrical, plumbing, excavation etc)

3.3 Cluster scale options

Cluster water and wastewater technologies can be defined as appropriate for larger than a single dwelling up to ~500 population equivalent, although there is no standard definition. High density, high rise developments can be grouped as a cluster system or the cluster can consist of a number of houses or mixes of dwelling types. Cluster options for rainwater, stormwater and wastewater can be a mixture of both single dwelling treatment and larger scale communal treatment (Figure 10). The combination of on-site and larger scale treatment allows a greater level of control of the quality and quantity of water entering the treatment process, thus providing increased system flexibility. In addition, the size, length and depth of the collection and distribution systems and the size and complexity of the treatment plant are reduced, compared to conventional sewerage. A cluster treatment facility also allows the use of a greater range of technologies.

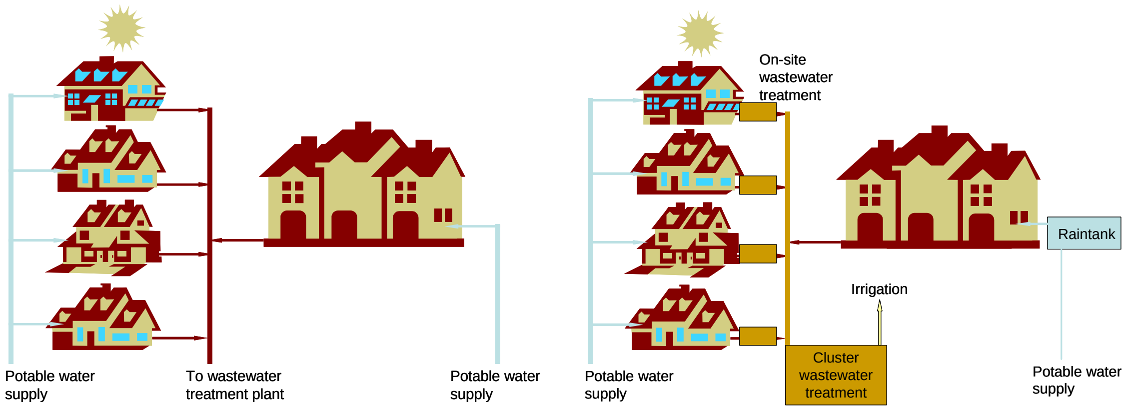


Figure 10: Schematic of traditional water supply and wastewater treatment and possible cluster arrangement.

Rainwater

Rainwater collection can be conducted at cluster level although the majority of case studies are lot scale. Storage and treatment at the cluster level tends to be in sub-surface tanks, as space is often limited in the urban area. Sub-surface tanks reduce light penetration, stabilise water temperatures and reduce evaporation losses. However, care is needed in the location and access design of subsurface tanks to ensure no ingress of contaminants but to allow ease of access for maintenance. There are some new and innovative designs for sub-surface storage which also provide some treatment of stormwater. These systems have been used at single house, residential aged care facilities, parks and schools.
(see http://www.atlantiscorp.com.au/projects/storm_water_filtration_&_reuse_system)

There are a number of case study sites where rainwater is collected from a number of roofs for communal use; Fig Tree Place (Coombes, 2002), Payne Road (Gardner et al., 2006 and Section 4.2) and 60L (see Section 4.8). At Fig Tree Place, Newcastle, 27 residential units are connected in different configurations to four subsurface raintanks of 9 to 15 kL capacity. The water from the tanks is then used to supply toilet flushing and hot water demands in the units. At Payne Road, an urban residential development, a combination of household tanks and communal tanks is used to satisfy both all domestic water demands and fire fighting flows. In 60L, an office building in Melbourne, two large rainwater storage tanks are located inside the building and provide water for toilets and washbasins. The tanks are open to occupants view and are very much an educational feature of the site. All sites use traditional storage tanks, both cylindrical and rectangular for storage of the collected water.

Single house rainwater collection, storage, treatment and use systems are in common use and there are distinct responsibilities and ownership of the water. However, at cluster scale these boundaries are not so clearly defined and this may be an issue in their successful implementation

Stormwater

At cluster scale, there are a number of approaches to stormwater collection, treatment, storage and redistribution. Stormwater sensitive urban design is not covered in this review as the primary objective of this process is reduction of surface runoff and flooding and contaminant flows, rather than collection for use. There are a number of documents in open literature which provide detail of design guidelines and strategies for implementing stormwater systems for environmental protection (City of Melbourne, 2004; Australian Rainfall and Runoff, 2001; Australian Runoff Quality Guidelines, 2003).

There are a number of sites in Australia where stormwater has been collected, treated and usual for a number of end uses, primarily for irrigation (Hatt et al., 2004). In some instances the water is used for fire fighting, toilet flushing and outdoor uses other than irrigation. Treatment process for the collected stormwater vary and of the sites study in Hatt et al. (2004) infiltration systems appear to be the most common method with advanced treatment and disinfection used for higher human contact end uses. Infiltration systems remove suspended material and a proportion of dissolved compounds such at metals or nutrients, depending on their design. Common systems used are eco-paving, sand filters, eco-soils and infiltration trenches. Advanced treatments used for improving the quality of stormwater to a standard suitable for higher contact end uses, such as toilet flushing and other outdoor uses, include combinations of techniques such as microfiltration and reverse osmosis, dissolved air flotation, electrolysis and biological treatment. Chlorine or UV disinfection is most often used for final disinfection.

The review by Hatt et al. (2004) found that stormwater use was largely restricted to smaller scale sites and that treatment is still generally based on systems designed for environmental protection, not human use (Hatt et al., 2004). This is a worrying trend as the water quality may not be suitable for reuse and further work is required to develop reliable, robust techniques and technologies to provide water of a quality suitable for potable substitution. Another study in which a conceptual design of larger scale stormwater, collection, high level treatment and use for irrigation, toilet flushing and hot water services, did show that the concept was practically feasible provided land area was available to store the water (Diaper et al., 2004). In another study based in Melbourne, (Grant et al., 2006) it was demonstrated that a stormwater store covering 1.5% of the total catchment area was required to provide 95% supply reliability for toilets and garden end uses. This may limit the practicality of this type of stormwater use, although the variability of rainfall and seasonality of demand in this location and the high reliability requirement on this study necessitates these large stormwater stores.

Another stormwater collection and treatment technique appropriate to the cluster or sub-divisional scale which can overcome this storage requirement, is aquifer storage and recovery (ASR). The use of this method is dependent on local geology and accessibility of the aquifer. Examples of test sites for stormwater ASR can be found in South Australia (Martin and Dillon, 2004), New South Wales (Argue and Argue, 1998) and Victoria (Dillon et al., 2006) and opportunities have been explored in other states. In addition to the general advantages of stormwater use, ASR also has the benefits of potential reduction in groundwater salinity, reduced storage costs and storage which does not take up land area.

Greywater

At cluster scale, greywater can be treated and reused at each individual household, collected and treated as an individual stream or mixed with blackwater and treated collectively as wastewater at a central location. Economies of scale may make greywater treatment and use at a cluster level more viable than for individual houses. At Atherton Gardens a high density development, greywater is collected from multiple dwellings, treated on-site and reused for garden irrigation. Inkerman Oasis is another example of medium scale greywater use (http://www.melbournewater.com.au/content/library/wsud/case_studies/inkerman_oasis.pdf). Treatment technologies are similar to those used for wastewater treatment and there are examples of wastewater treatment processes being used for this application. For example, the Biolytix system is being used at Payne Road and the Aquacell technology is applied to both wastewater and greywater. In addition, a number of the systems used at single house scale are also available as larger scale units (Table 4). However, the uptake of systems at this scale is minimal and the factors influencing this situation need to be further explored.

Wastewater

In smaller scale wastewater systems a range of technologies and techniques are currently in use where options for collection and treatment vary. Variations in collection systems include the use of vacuum and low pressure sewerage that use smaller diameter flexible pipes and shallower burial depths, to “smart pipes” made of flexible materials with fused joints and inspection points instead of manholes (Table 6).

Table 6: Options in wastewater collection infrastructure

Collection system	Description	Benefits	Disadvantages
Conventional sewer	Collection network made of vitrified clay, PVC and lined mains and sized to allow transport by gravity	Most common system available	High capital investment. Infrastructure generally oversized as design is based on 5 x ADWF. Prone to infiltration, inflow and leakage. Cost of installation Pipes buried at 4-6m depth.
Pressure collection	Collection network where wastewater is transferred via a system of pumps in wells located at pre-specified intervals (e.g. individual properties or every few properties)	Smaller pipe diameter required. Effective in undulating terrain Pump wells can serve as intermediate storage reducing diurnal flow peaks. Leakage reduction Potential for timed release of wastewater. Reduced disruption due to pipe installation	Cost Energy use Potential for odour if not properly maintained (can be overcome with filters on all gas release points)
Vacuum system	Collection system operated on a vacuum (negative pressure) system.	Uses small pipe diameter buried in shallow systems. Highly effective for limited distances. Able to handles slurries and sewage with low water content. Seamless construction reduces inflow and infiltration and leakage.	Power requirements. Cost (vacuum generation requires installation of a vacuum station at set intervals 6-10m).
Smart pipe	PVC collection system designed on smaller diameter pipe	Smaller pipe diameter and access infrastructure No bedding material required Less prone to infiltration. (Design based on 3 x ADWF)	Requires education of contractors and installers.

Table 7: Examples of semi-centralised wastewater and greywater treatment options

Model	Typical components	End use/Water Quality	Current examples
Biolytix (Greywater and Blackwater)	Natural humus filter situated at each house (can be retrofitted to exiting septic tank)	Subsurface irrigation (toilet flushing and washing machine if ultrafiltration used) Class A	Macleay Island www.biolytix.com/index.php
Orenco/Innoflow/Advantex	Watertight septic system with filter at household to centralised recirculating textile filter	Toilet flushing and outdoor uses (disinfection required) Class A	Currumbin Ecovillage (see Section 4.4) www.innoflow.co.nz/index.php
Clearwater Aquacell (Greywater and Blackwater)	Membrane bioreactor	Toilet flushing, outdoor uses and laundry Class A	See aquacell.com.au/
NuSource Water (Greywater and Blackwater)	Sewer mining and with screening, microfiltration and or ultrafiltration and reverse osmosis	Outdoor uses, toilet flushing and laundry Class A	CH2 office building (see Section 1.1) www.nusourcewater.com/
Rootzone (horizontal wetland)	Subsurface flow wetland followed by a vertical filter	Toilet flushing and outdoor uses (disinfection required) Class A	See www.rootzone.com.au/index.html
WaterPac	Primary settling and recirculating media filtration	Restricted irrigation	www.waterpacaustralia.com/
Packaged Environmental Solutions	Biological treatment and membrane filtration	Toilet flushing and outdoor uses	http://www.pescorporation.com/

There are a range of technologies and techniques available for collection of wastewater at the cluster scale, recently reviewed in a report by Landcom (2006), which include biological, chemical and physical processes or combinations of these (see Table 7 for examples). Some technologies are appropriate for both greywater and wastewater treatment, the selection of source water type being dependent on the water balance, end use applications and regulatory requirements. The report provides a detailed overview of the technologies with a summary table describing appropriate scale, end uses, physical footprint and capital and operating costs. The report also provides details of Australian case study applications of the technologies, in addition to those given in Table 7.

There are a variety of end uses for wastewater treated at a cluster scale. The effluent produced is generally treated to a quality suitable for:

- Irrigation of public spaces, golf courses, e.g. Loxton, Clunes (Geolink, 2005), Onkaparinga,

- Toilet flushing, household outdoor use and irrigation, e.g. Currumbim (Section 4.4), Aurora, Pimpama Coomera (Section 4.1) .
- Cooling towers or indoor irrigation, e.g. CH2 (Section 1.1)

Many of the technologies will provide water of a quality suitable for use within the home and for unrestricted outdoor use, with low biochemical oxygen demand and suspended solids content in the treated effluent (Table 7). However, the salt content of greywater and wastewater needs to be considered as most treatment technologies do not remove this component. Source reduction methods, such as use of low sodium detergents or changes to standard detergent formulation will reduce the detrimental impacts of greywater and wastewater in the environment.

A more detailed report which considers the assessment of one on-site and two cluster scale wastewater management options for a specific case study site provides further detail of the technical, social, environmental and management issues that need to be considered when installing alternative systems (Geolink, 2005). All the systems assessed could achieve relevant water quality for recycling of wastewater to irrigation of outdoor areas. However none could achieve the Department of Environment and Conservation Advanced Modern Technology (AMT) effluent quality standards for discharge to sensitive inland waters.

Wastewater management at a cluster level is exemplified by individual collection and a shared treatment facility managed by a central body such as a body corporate, a householder's association or council with maintenance conducted via a service contract with the treatment technology provider. Such systems remove the onus of maintenance from the individual householder and allow the governing authority to exert a greater degree of control on the infrastructure system and its upkeep. Benefits are also generally achieved by economies of scale as the treatment facilities are shared for multiple dwellings. Examples include the Currumbin Ecovillage and the 60L Building where management of the system is enforced by the body corporate and homeowners/tenants are required to abide by those rules.

CLUSTER SCALE OPTIONS: BARRIERS AND ISSUES

Below is a summary of some of the potential barriers and issues associated with different cluster scale alternative water servicing options. Rainwater and stormwater have been grouped together, as have greywater and wastewater, as there are many similarities between the barriers and issues at this scale. This summary has been collated from information collected during the literature review and case study investigations. As with lot scale system there is the overarching need for; accessible information on system installation and design, monitoring of systems once installed to ensure correct performance and dissemination of results from monitoring to all interested parties.

RAINWATER and STORMWATER

- Allocation of responsibility for cluster scale storage and treatment is not well defined
- Space limitations for storage
- Subsurface tanks need to be accessible and limit potential contaminant ingress

GREYWATER and WASTEWATER

- Barriers to greywater use at the cluster scale are not well understood
- Approvals tend to be complex (regulators, councils and water authorities).
- Householder education regarding cleaning products and what they flush away
- Segregation of domestic from industrial or trade wastewater streams
- Flexibility of design to allow expansion
- Effluent quality for environmental flows needs to be considered
- Changes in detergent and cleaning product formulation to minimise environmental impacts

GENERAL

- Limited information on life cycle costing of options
- System ability to cope with power failure or shock loads (robustness)
- The visual, odour and noise acceptance of the new technology should be
- considered
- Consideration of human health and other social factors
- Remote monitoring and centralised management
- Treatment technology energy and chemical usage
- Integration of the entire water cycle in the development and selection of alternatives and evaluation of interactions and impacts of the alternative process on the environment
- Use of water balance calculations to assess the viability of different options
- Multi scale systems should be considered i.e. raintanks at lot scale and stormwater at cluster scale
- Understanding of site characteristics and technology interactions with the built environment

3.4 Sub-divisional scale options

Rainwater

There are no large scale demonstrations of rainwater collection as this technique is more suited to the cluster or single household scale as described in the sections 3.2 and 1.1.1.

Stormwater

Recently, use of stormwater as a large-scale supply source has gained media attention throughout Australia (Urban Stormwater Initiative Executive Group, 2004; State Government of Victoria, 2004; Stormwater Industry Association Queensland, 2006).). As stated in Section 3.4 on stormwater use at cluster scale, large scale stormwater management practices also traditionally focused on reducing potential for flooding and protecting human settlement. Techniques were then improved to help protect the environment and minimise contaminant flows. The technology requirements for the next level of use, substitution of potable water, include a higher and more consistent level of treatment, compared to systems installed for environmental protection alone. The review of current stormwater use sites (Hatt et al., 2004) found that this higher level of treatment was not always provided.

The benefits of stormwater use at the sub-divisional scale are the same as those for cluster scale stormwater systems.

- Reduced volume of runoff
- Reduced peak flows
- Improved quality of runoff
- Reduced potable demand
- Habitat protection

In addition, the public acceptance of using stormwater may be better than wastewater, but there are currently no studies to verify this.

There are some challenges with collection and use of stormwater at the large scale in that significant investment is required for; collection, storage and distribution infrastructure, new and advanced technology and improved system control and monitoring. There is also the need for; storage to provide for seasonal demand, robust installation procedures to prevent cross connections in third pipe systems and robust technologies to cope with fluctuations in flow and quality. There are currently no standards or guidelines for stormwater use in Australia but these are being developed through the National Water Recycling Guidelines and there has been a recent announcement that funds will be available through the Raising National Water Standards Programme for development of tools to assess the viability of recycling of stormwater and reclaimed water via aquifers across Australia..

Greywater

There are no large scale demonstrations of greywater collection as this technique is more suited to the cluster or single household scale. Hence, in subdivisions greywater collection and reuse are conducted at lot or cluster scale as described in the sections 3.2 and 1.1.1.

Wastewater

As with stormwater use, wastewater re-use at a sub-division scale (>2500pe) offers added challenges and opportunities in the provision of services. The investment required for the provision of water and wastewater services to systems of such magnitude is significant and greater control is required to ensure the robustness of the system and minimise the risks. Additionally, the volume of wastewater generated, the concerted implementation of infrastructure for collection and distribution of recycled water, the adoption of more costly and advanced technology for wastewater/water treatment, storage and distribution require a higher degree of investment. Management of the system is centralised and effluent quality controlled by a water authority or local council.

Typical models adopted for such systems range from household pre-treatment combined with centralised treatment to centralised treatment alone. Provision of treated effluent to households for non-potable applications via third pipe is also observed in a number of developments, e.g. Aurora, Rouse Hill, Newington/Homebush, Pimpama Coomera (see Section 4.1).

At the sub-divisional scale (>2500pe), the collection system is generally similar to that adopted at the cluster scale (Table 6). This system covers larger areas and a larger number of households, potentially benefiting from economies of scale. The size of the development will limit the application of vacuum and pressure collection systems.

Alternative treatment processes for sub-divisional scale application are reviewed in the Landcom report (2006). As for the cluster scale, there are chemical, biological and physical treatment processes, the difference at this scale that the treatment train is composed of more unit processes, providing a multiple barrier approach to minimise potential health risks.

Challenges associated with the size of the development include:

- Need for storage of treated effluent to counter demand seasonality in third pipe systems
- Prevention of cross-connections and improper use in third pipe systems
- Reliability of supply
- Robustness to interference from individual householders

The quality of the effluent for urban reuse is dictated by its end use. Effluent for indoor use currently needs to be treated to class A+ standard (http://www.epa.qld.gov.au/register/p01734ai.pdf). However, the guidelines for water quality of recycled water are currently under review, (Environment Protection and Heritage Council, 2006). The guidelines focus on large-scale treated sewage and grey-water to be used for residential garden watering, car washing, toilet flushing and clothes washing, irrigation for urban recreational and open space and agriculture and horticulture, fire protection and fire fighting systems industrial uses, including cooling water; and grey-water treated on-site (including in high rise apartments and office blocks) for use for garden watering, car washing, toilet flushing and clothes washing. The guidelines when completed will comprise a risk management framework and specific guidance on managing the health risks and the environmental risks associated with the use of recycled water.

SUB DIVISIONAL SCALE OPTIONS: BARRIERS AND ISSUES

RAINWATER

- In subdivisions, rainwater is managed at the allotment scale, hence the barriers and issues are the same as those explained in sections 3.1.2.

STORMWATER

- Large storage volumes required
- Balancing peak collection and demand
- Application of inappropriate technology for potable water applications
- Limitations to treatment performance of ecological systems
- No guidelines for use of treated stormwater

GREYWATER

- Barriers to greywater use at the sub-divisional scale are not well understood but may be the same as those explained in sections 3.1.2.

WASTEWATER

- Increased control and monitoring required to reduce potential health risks
- Need for storage of treated effluent to counter demand seasonality in third pipe systems
- Prevention of cross-connections and improper use in third pipe systems.
- Significant capital investment required for system implementation if third pipe is intended.
- Education and involvement of community on water conservation to avoid misconception that recycled water is of less value than potable water

GENERAL

- Limited information on Life cycle assessment

4 CASE STUDY SITES

There are a plethora of case study sites in Australia where alternative water servicing options have been implemented or are currently being constructed (Appendix 1). The sites consist of both new build and retrofit developments, some with an overall sustainability focus encompassing energy, materials usage and operating costs, others focusing on water services alone. From the full list of case study sites, eight were selected for further investigation. The selection process was based on feedback from the project stakeholders, BCC, Brookwater and Queensland Government departments and included case studies which exhibited the following features:

- Appropriate to individual dwelling through to complete sub-divisions
- Applicable to retrofit of existing housing stock
- Demonstrate alternative water servicing technologies
- Provides demonstration of transitioning of existing infrastructure
- Provides detail of financial arrangements for project implementation
- Implemented in social housing stock

In addition CSIRO selected studies for which detailed published literature was freely available and were available for site visits within the scope of the project budget. This meant a number of sites were not located in SEQ but it was felt their inclusion in the detailed case study would demonstrate some valuable lessons and approaches which would be applicable to SEQ.

The case studies suggested to the project stakeholders were:
New build

1. Pimpama Coomera (in SEQ) – large scale
2. Payne Road (in SEQ) – medium scale, low density
3. The Currumbin Ecovillage (in SEQ) – Medium scale and density
4. CH2 (in Melbourne) – commercial medium scale, high density

Retrofit/Infill

5. South East Water and Bayside City Council (in Melbourne)– medium density, large scale
6. Atherton Gardens (In Melbourne) – High density, retrofit, residential, medium scale
7. Sustainable house (In Sydney) – Single house, medium density, retrofit
8. 60L (In Melbourne) – High density, retrofit, commercial medium scale

All project stakeholders were provided the opportunity to comment on the selected sites and provide information on additional sites. Feedback from all stakeholders was positive and the above listing was accepted.

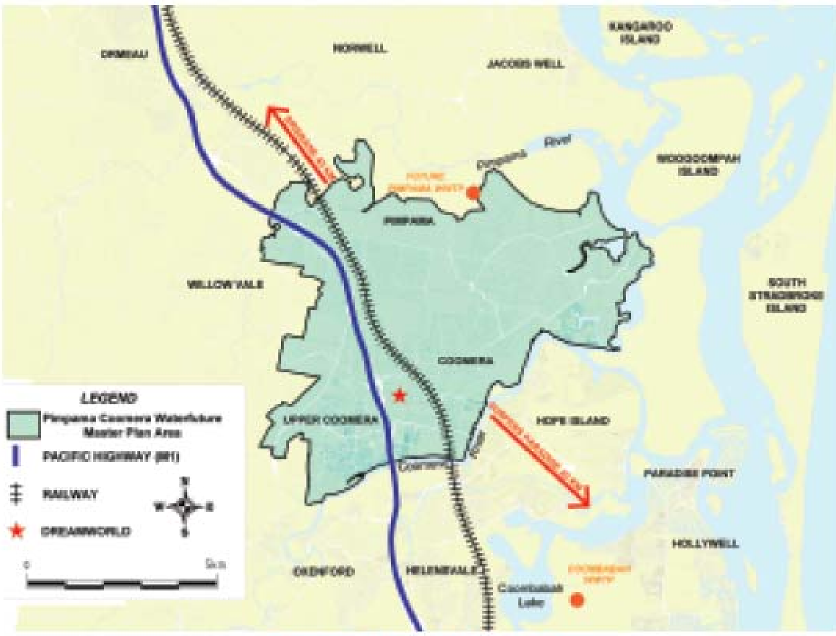
CSIRO then initiated the more detailed review of these sites. Where possible site visits were undertaken, which provided researchers with direct interaction with site developers or managers and data was collected on; the current status, location, size, topography, demographics, technologies or techniques used for potable water supply, garden irrigation, wastewater, stormwater systems, other techniques used, institutional arrangements, savings, benefits and lessons learnt. The following sections provide the detail of this information for all the case studies.

4.1 Pimpama Coomera Water Future, Gold Coast

Summary: Pimpama Coomera is a growing greenfield development area with a mix of residential, commercial and industrial use in a water constrained region. Water supply and wastewater provision based on a business as usual approach will not meet the population demand or allow for climate change impacts. To allow the development of the region, the local council (Gold Coast City Council) in consultation with other stakeholders conducted an extensive study of the area and developed a Masterplan and strategy for sustainable development in the region.

Pimpama Coomera is an important case study as an example of large scale implementation of integrated water services provision. The study is unique as an initiative by government, as the aim is to create a framework and an implementation strategy that encourages the adoption of integrated water management. The project alos aims to address the gap experienced in many other case studies in regards to information, legislation and institutional support for sustainable alternatives.

Location: Pimpama Coomera region, Gold Coast. The area is bounded by the Coomera River to the south, Coomera River North Branch and Pimpama River estuary to the east, Pimpama River and Hotham Creek to the north and the Upper Coomera locality boundary to the west. Cabbage Tree Point and Jacobs Well areas are also included. The region includes ecologically sensitive areas such as RAMSAR wetlands, the Moreton Bay Marine Park and the Pimpama and Jumpinpin-Broadwater Fish habitat areas (Figure 11).



Pimpama Coomera Master Plan Region

Figure 11: Pimpama coomera region (Pimpama Coomera Masterplan 2004)

Size: 5945 hectares.

Topography: The area consists of steep topography in the west and central areas, with gentle slopes falling towards the two bordering rivers. Grades of 15% to 25% are common in the higher areas with land reaching up to 150 m Australian Height Datum (AHD). Development on the steep areas has been restricted due to the steep grades and environmental protection areas. The East Coomera area is generally low-lying coastal plain around 5 m AHD. Isolated ridges of 20 m to 40 m AHD exist at the eastern end of Yawalpah Road. Jacobs Well and Cabbage Tree Point are located on the flat low lying coastal plain, at or below 5 m AHD

Soil type: Variety of soil types (shale, clay, sand, alluvial, sandstone)

Demographics: Low density residential, with some commercial and industrial. The area has a population of approximately 5000 (2002), but is expected to grow to 150,000 people by 2056 (Masterplan 2006).

Background: The region is a major growth corridor in Queensland and the area faces potential water scarcity. Future development of the area would be restricted if dependent on conventional water sources alone. To ensure continuity of supply an 84% decrease in the consumption of potable water is required. The region is surrounded by environmentally sensitive areas and there are increasingly stringent quality standards for wastewater effluent and stormwater discharged into waterways.

Existing infrastructure: The area has a potable water main along the Pacific Highway and along Foxwell Road to Coomera Waters, reticulation in the Upper Coomera and the Marine Precinct areas. No current reservoirs are in the catchment, the closest reservoirs are located in the suburbs of Canowindra (NSW), Helensvale (to be upgraded to 20ML in 2007) and Oxenford.

There is no existing Wastewater Treatment Plant (WTP) in the catchment. Wastewater pumping infrastructure exists in Upper Coomera, Coomera Village and Marine Precinct areas. Wastewater is transported to the south into the Helensvale catchment and then to the Coombabah WTP as a short to medium term strategy.

The stormwater infrastructure is implemented on each new subdivision at the time of development.

The Masterplan

The Pimpama Coomera Masterplan is one of the pilot projects in the Waterfuture strategy developed by the Gold Coast City Council (GCCC) and aims to promote sustainable development and management of water resources via the integration of water, stormwater and wastewater services. The plan is unique due to the size of the region and the challenges associated with its implementation. There is a strong focus on sustainability and the triple bottom line (environmental, economic and social impact) for the region. In assessing water supply and wastewater options for the region, the framework encourages the re-thinking of the values, assumptions and concepts traditionally adopted in the design of water and wastewater services and has identified the need for changes to the existing institutional and legislative scene to allow successful implementation. The project leads the way by encouraging the use of emerging technology and non-conventional infrastructure that have historically been adopted only at smaller scale developments.

Development of the Masterplan took a period of 18 months and required extensive research (Pimpama Coomera Masterplan 2004). GCCC initiated the plan with a series of stakeholder workshops (including local governments and State government) followed by the appointment of an Advisory Committee with representatives from various stakeholder groups including state departments, GCCC council, resident associations, landholders, developers, industry associations and environmental groups. This committee then identified objectives and the required environmental, economic and social outcomes, some of which were:

- Potable water to kitchen and trickle feed to rainwater tank 16%
- Rainwater to bathroom laundry, hot water systems 25%
- Recycled water for toilet flushing and external uses 45%
- Water conservation through greater use of technology and education 14%.
- Reduction in use of potable water to 258L/ET/day (-75%minimum, expected -84%)
- Reduction in stormwater run-off by a minimum of 10% (expected 17%)
- Reduction in infiltration and inflow into wastewater systems by a minimum of 50%.
- Treated wastewater released to Pimpama River maximum12.5ML/d (expected 3.6ML/d)
- Reduction in nitrogen and phosphorus released in treated water to the Pimpama River by a minimum of 50%
- Reduction in greenhouse gases by a minimum.20% (expected 30%) achieved by the adoption of integrated infrastructure.

The Committee then developed 40 initiatives and selected 24 of these to develop 10 scenario options. These options were evaluated using a Multi Criteria Assessment methodology based on environmental, social and economic sustainability criteria and included minimum requirements of public health and service standards. This resulted in the narrowing down to 5 major options which were evaluated in more detail. The 5 options were submitted to a community consultation process via public displays and focus groups. The feedback led to the selection of the preferred option adopted in the Masterplan.

The final option includes: rainwater tanks, recycled water, water sensitive urban design, wastewater management, demand management for potable water, substitution of fire fighting water, water conservation, landscaping policy, infrastructure delivery, system operation and monitoring.

The process recognised gaps in the existing knowledge and the need for research on health risks, water quality, social perception and treatment of recycled water, rainwater tank hydraulics, consumer behaviour on water conservation, reduced infiltration gravity (RIG) Sewer and wastewater treatment plant and storage.

The Masterplan will be reviewed continually to allow for future innovation and feedback from dialog with the development industry and broader community.

Implementation

Implementation of the Masterplan has led to the development of the Gold Coast City Council's Waterfuture Strategy for Pimpama Coomera. The strategy has been a massive undertaking with extensive efforts based on education campaigns, development of materials for stakeholder information and guidance (engineering) and controls for government, community, developers and contractors.

To implement the strategy an extensive review of the Council's existing institutional framework and verification of state of art knowledge on initiatives was required (Pimpama Coomera Masterplan 2004). This included:

- Revision of Council's policies and regulations, including the planning scheme, to allow recycled water use;
- Health impact assessments;
- Community and stakeholder engagement to keep the community educated on the reasons for change and the benefits it can generate;
- Revision of Council policies and regulation to include mandatory rainwater tanks and water sensitive urban design;
- Revision of relevant council business and operational systems;
- Preparation and revision of water infrastructure Planning reports;
- Feasibility and technical reports on wastewater treatment, rainwater tanks, transfer stations and Aquifer Storage and Recovery.
- Revision of the council's infrastructure charge.

The implementation also requires the provision of infrastructure, which is being developed by the council in a staged process. The infrastructure goals include:

- Provision of potable water, wastewater and recycled water infrastructure as development of sub-divisions occurs on specific sections of the region.
- Construction of Pimpama Coomera WTP and education centre Stage 1 in 2007/8.
- Construction of the Pimpama Recycled Water Treatment Plant in 2008.
- Expansion of wastewater infrastructure for reduced infiltration.
- Construction of a trunk recycled water infrastructure from 2005 to 2008.
- Development of aquifer storage and recovery ASR system in 2009+ (if proven feasible)
- Further installation of rain water tanks and WSUD systems for stormwater in the area, for domestic and commercial applications

The Masterplan and the guidelines were designed under the assumption that advanced technologies and strategies would be developed to facilitate further recycled effluent reuse, but also include contingency provisions for the event of a slower uptake and acceptance of recycled water by the community.

Technologies

Developments in the area adopt variations and combinations of the following:

- Rainwater tanks (5kL and 3kL) fitted to all households for use in laundries, bathrooms and hot water systems (currently laundry & external).
- Grass swales, bio-retention devices, ponds and wetlands for stormwater control, infiltration and amenity development

- Purple pipe (third pipe) for recycled water class A^+ supplied for open spaces, garden water and toilet flushing. There is also provision for future use in fire fighting.
- Water efficient fittings and devices (4As) encouraged in households.
- Potable water use is minimised by restricting use to kitchen and trickle top feed of rainwater tanks only.
- Reduction of stormwater infiltration to sewers via Reduced Infiltration Gravity Sewers (RIGS) (i.e. PVC wastewater collection) with raised maintenance shafts instead of manholes. Vacuum sewers and low pressure sewers are also adopted where necessary.
- Landscaping with native and drought tolerant species to reduce water demand.
- Regional wastewater treatment plant to Class B and recycled water treatment plant to Class A+ with aquifer storage (proposed 1 to 1500 ML) and recovery for supply of recycled water to households.

Other tools:

- Extensive community consultation and education strategy, e.g. fact sheets for householders and developers, market research of community and consultation with stakeholder groups, community focus groups, public displays and surveys.
- Council Policy modified to promote the adoption of sustainable measures:
    - Requirement and set-up of training courses on green plumbing for contractors operating in the developments in the area.
    - Developers are required to submit water and energy management plans as part of the approvals process.
    - Council aids such as Land Development Guidelines for designers and developers (Gold Coast Planning Scheme) including Standard Specifications and Drawings for Roads, Drainage, Water, Sewerage, Parks and Beaches and Waterways.

Examples of Pimpama Coomera sub-divisions:

Five greenfield housing estates located along the Pacific Motorway corridor were observed to determine how integrated water management was incorporated. In all the developments stormwater was contained locally using swales and/or ponds designed with engineered soils, but the extent of WSUD integration with the landscape varied.

All developments were designed with dual pipe reticulation for use of recycled effluent to be supplied from the local treatment plant which will treat wastewater to effluent class B. A tertiary treatment plant will be built beside it for polishing the effluent to class A+ and the effluent will be sent to aquifer storage (capacity 1000ML) and used for non-potable water supply.

The landscape aspects were seen as a favourable lifestyle feature by home buyers, but environmental or sustainability characteristics alone were not an attraction to home buyers (B. Douglas 2006, personal communication).

4.1.1 Greenfield site 1

Description:

Greenfield development with 5000 lots with a group title of 300m^2.

Technologies and techniques

The development incorporates footpaths and swales for stormwater. The topography of the complex directs all stormwater to external swales and a creek that directs the stormwater to a bioretention lagoon for infiltration and dry-out (Figure 12). Silt removal from the lagoon is currently required, but is hoped that this maintenance requirement will reduce as the vegetation develops and the system becomes self-maintaining.

The development has been constructed with infrastructure for supply of recycled water to households (third pipe, Figure 13). The third pipe is currently supplied with potable water, but future supply with recycled water (class A+) for toilet flushing and garden irrigation is expected when the recycled water plant is commissioned.

Reduced infiltration gravity sewers made of PVC are used for wastewater collection and to prevent leakage.

Figure 12: Bioretention basin for stormwater infiltration

Figure 13: Purple Recycled water covers for identification of water source

4.1.2 Greenfield site 2

Description:

Greenfield development with 3.5 ha lots.

Technologies and techniques

Stormwater is directed via kerbs and channels fitted with in-ground pipe to a series of 3 ponds used for water storage and treatment. The water is intended for irrigation of open public spaces and sports fields.
Dual reticulation and the mandatory rainwater tanks have been installed in each household.

4.1.3 Greenfield site 4 (Jacob Creek's Estate)

Description

Greenfield development with preservation of some of the native, mature trees and integrated landscape with incorporation of WSUD into the aesthetic features as parks and green open spaces.

Technologies and techniques

Swales constructed with stone and grass with pipes at the bottom of the swale.
Stormwater weirs constructed with stones, gross pollutant traps (Figure 14) and intermittent lagoons with plant growth.
Retention basins available for stormwater control and infiltration (Figure 15).
Reduced infiltration gravity sewers.
Rain water tank (3kL/house) installed in each house for flushing, outside use and laundry tubs.
Initial maintenance was arranged using a developer/builder/purchaser covenant. In a number of developments council has jurisdiction of swales, parks and ponds.

Figure 14: Weir to stormwater gross pollutant trap

Figure 15: Landscapes for stormwater collection and infiltration at Pimpama Coomera

4.1.4 Greenfield site 5 (Coomera Waters)

Description

Gated greenfield development with 2500 lots, patches of mature vegetation and landscape with WSUD incorporated into the aesthetic features as parks and green open spaces and use of ponds and mini wetland systems for treatment of stormwater.

Technologies and techniques

Stormwater management is via kerb and channel to small patches of forests and lagoons (Figure 16) or using swales and detention/infiltration ponds some of which were aesthetic features (Figure 17).
The development has 7km of boardwalks and walkways (.
All of the remaining native vegetation after construction of lots was retained.
Dual reticulation was installed around the estate (development added a cost of $20k/lot)
High value houses located around a lake jetty were serviced with vacuum sewers.
Maintenance of the landscape was conducted by the body corporate, whilst the council was responsible for bitumen, sewage mains and water pipes.

Figure 16: Swales with rocks and native vegetation for stormwater management.

Figure 17: Small pond used for stormwater treatment

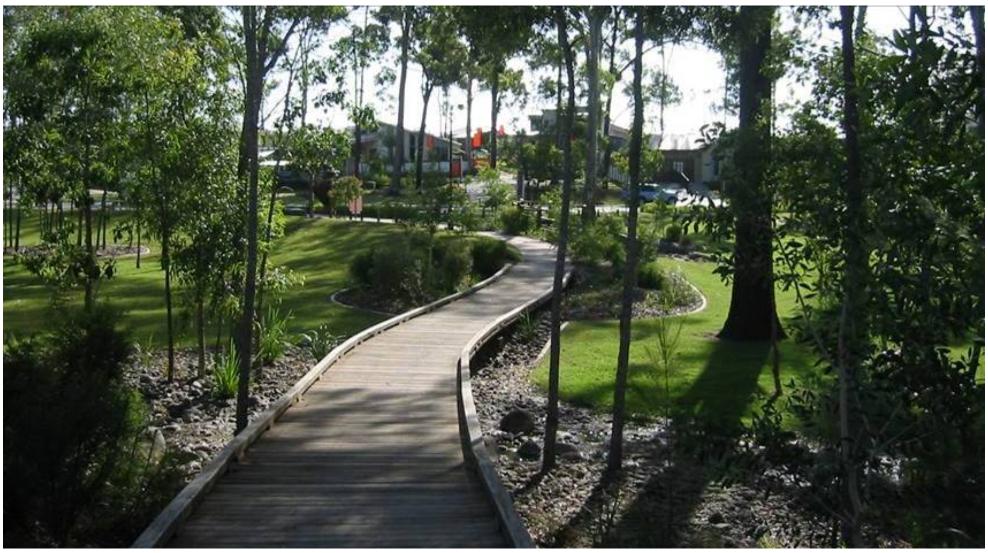


Figure 18: Boardwalk in Pimpama Coomera

Costs:
The scheme has only been possible due to implementation of the infrastructure by the council on a large scale. A comparison of the options of provision of services was evaluated during the Masterplan development. The total cost of the new infrastructure was equivalent to the cost of conventional service provision (including dam construction) due in part to the offset by smaller pipe sizes used for water and stormwater infrastructure.

Despite the added costs, demand for the houses and lots has been steady. The features do not act as a selling point on their own merit. However the improvement in amenity (e.g. green landscape, vegetation, open spaces) provided by the integrated water features has been an attraction to home buyers who are willing to pay a higher price for these amenities.

Savings
Benefits are expected from improvements to sewage infrastructure and reduced requirement for capacity upgrade for the treatment works. Savings are also expected from the reduction in nutrient and sediment loads from stormwater and wastewater reaching waterways and less infrastructure requirements for stormwater transport.

Improved amenity in parks and street areas is achieved by promoting localised infiltration of stormwater and reducing reliance on potable water for irrigation.

Developers are required to pay bonds for silt run-off to encourage builders to reduce contamination of stormwater during the construction of properties.

References/contacts:
Pimpama Coomera Waterfuture Alliance
MWH Australia
Gold Coast City Council
Gold Coast Water

Government Reference Group:
Environmental Protection Agency
Queensland Health
Queensland Department of Natural Resources Mines & Water
Queensland Department of Local Government, Planning, Sports, & Recreation

Pimpama Coomera Lessons:

- The whole area has access to sewerage and potable water. But drought conditions have forced changes to total daily consumption from 230-240ML/day to 180ML/day forcing the uptake of IUWMM.
- GCCC encourages developers to adopt sustainable water and wastewater management in their developments. One of the major challenges has been to shift the mindset of developers, householders and contractors, building an understanding of the need for sustainable practices in their enterprises and management of water and energy resources during design, planning, construction and operation.
- The requirement of reduction in stormwater loads using WSUD is being fulfilled by a number of developers. However, it was observed by CSIRO that the extent of the investment and integration achieved varied, this may be a reflection of the interpretation and understanding of developers on WSUD. In some developments WSUD was restricted to the addition of swales in the mid-section of the road, whilst in others open landscaped common areas were integrated into the layout of the development. A step-by-step learning process is underway with Gold Coast Water, GCCC, developers and the community.
- The region does not have a retrospective policy on existing developments. The checkerboard concept had to be accepted with intermingling of existing traditional developments and new IUWM developments (B.Douglas, personal communication 2006).
- Political support has been essential for the projects. The Project is strongly supported by Local council and other government authorities.
- Government regulators offer strong support to stormwater collection and WSUD measures, but there is limited acceptance of rainwater and on-site recycled greywater.
- Greywater use is still an issue in the state due to the difficulty in controlling quality and the requirement for a limited storage life (maximum 24h storage).
- Community involvement: in the evaluation of technologies and options, (extensive & intensive) consultation with community and other stakeholders was used to determine acceptance, however real acceptance will only be determined when the project is fully operational.
- The development strategy for the region has to deal with uncertainties and gaps in the current institutional framework. Uncertainties, such as community attitudes to supply of recycled water, will only be clarified as the area becomes more densely inhabited. Gaps in the current legislative framework can increase the difficulty in implementing many of the initiatives adopted, but the GCCC has been in close consultation with regulators and associated governmental authorities to address such challenges.

4.2 Payne Road, Brisbane

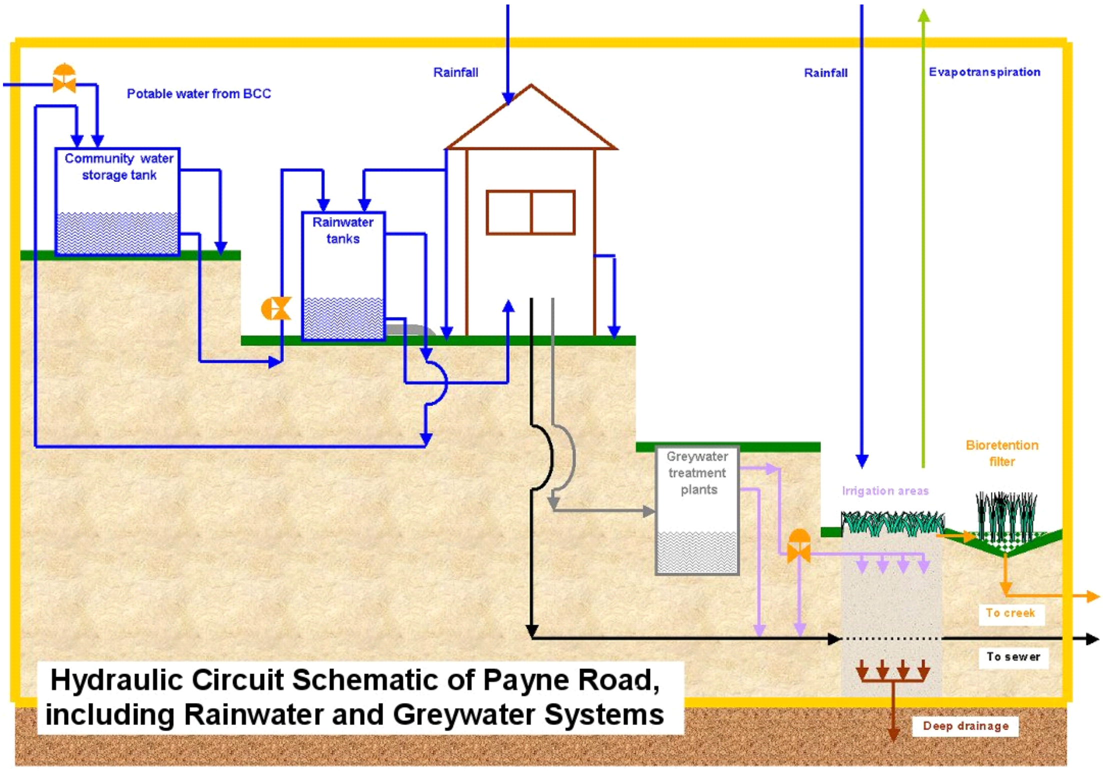


Figure 19: Schematic of water systems at Payne Road

Summary: Payne Road is a greenfield development at the fringe of sewerage and water supply services in Brisbane. The subdivision showcases sustainable features and offers a great level of self reliance via alternative energy and water supply, including greywater treatment and reuse, stormwater management and timed release of wastewater to sewerage and is intended as a demonstration project. The site is located on a steep slope and borders Brisbane State Forest and Enoggera Reservoir. Enoggera Creek, flows along the north-east boundary of the development. The development is located at the end of council water and sewerage reticulation services which has also had an influence on design

Status: 6 houses constructed with 3 houses inhabited.

Location: 599 Payne Road, The Gap, Qld (9km from Brisbane), borders Brisbane State Forest and Enoggera Reservoir

Size: 3.75 hectares, 22 lots at completion, currently 6 lots built, average lot size 1100m^2

Topography: North East facing slope of 20% with a 40m drop

Demographics: Low density residential (5.8 lots per hectare, 800 to 1800 m^2)

Figure 20: Household raintanks, stormwater tanks and outlets at Payne Road

Technologies summary

- 18kL to 22kL rain water tank (2-3.6m diameter) for each household. Treatment by activated carbon filters (1μm) and UV for all household applications. Excess rainwater is diverted to communal tanks located at the bottom of the development.
- Two 75kL communal rainwater tanks (6.7m diameter) for storage of household rainwater excess, provision of fire fighting and future supply of households at bottom of subdivision.
- Greywater and kitchen waste treatment via 'Biolytix' aerobic vermiculture system for each household. Treated water reused for sub-surface garden irrigation with moisture sensor. Overflow sent to sewer.
- Bioretention basin and filter for stormwater.
- Data logging of meters at rainwater tanks, pumps and treatment systems to allow monitoring of water and energy use.
- Reticulated gravity sewer and communal sewer pump well.
- Sewer collection tank/sump for discharge to sewerage at non-peak hours.

Potable water supply

Each household is equipped with one or more rainwater tanks for all household purposes. There are no first flush diverters installed on these tanks but a geotextile filter sock and 1mm mesh screen are installed at the tank inlet to prevent entry of sediment, leaves and mosquitoes. The water is pressurised by a submersible pump and treated with activated carbon and UV before entering the household (Figure 21).

Communal rainwater tanks provide back-up to household tanks. These tanks are equipped with a float valve and are trickle fed from the local water authority mains water supply (Figure 21. A backflow prevention device is fitted to the trickle feed supply. Top up water from these tanks is supplied to residences via a small 0.75kW pump and a matching pump is used to recalculate water through the communal tanks. These small pumps start automatically when reticulation pressure drops below 350kPa. A 22kW diesel pump is available for fire fighting requirements and this is also started automatically.

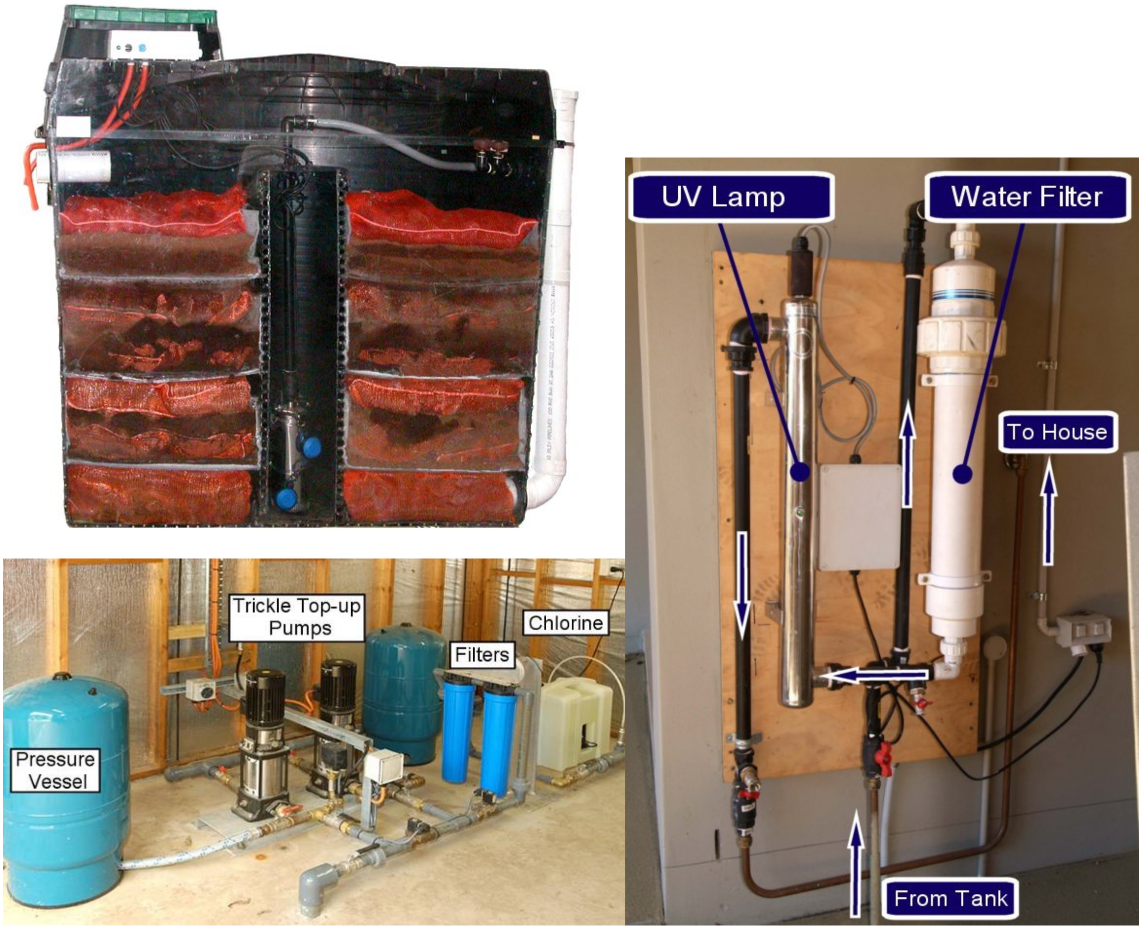


Figure 21: Payne Road greywater treatment cutaway (top left), rainwater treatment (right) and stormwater tank trickle top up

Garden irrigation

Greywater from the household is treated via a Biolytix system (Figure 21) on each property and the treated effluent is used for subsurface garden irrigation. Irrigation volumes are controlled by soil moisture sensors and solenoid valves which divert greywater to sewer if the soil becomes saturated.

Wastewater

Blackwater from the toilet and the kitchen is transported via a low infiltration, reticulated gravity sewerage system that drains into a communal pump well. Sewage is discharged from the pump well to the Council's sewerage system during off-peak periods.

Stormwater

The landscape of the development ensures that stormwater drains to the bottom of the subdivision where a bioretention basin allows controlled discharge off the site and eventually back into Enoggera Creek. The basin is 25m wide and 80m long with a central trench filled with sandy loam and incorporates four crushed-rock filters and two 0.5m high rock weirs.

Other tools:
Extensive monitoring of the major water flows in the development including trickle top ups, household use, hot water, greywater and sewer and stormwater. Energy monitoring includes rainwater and greywater systems, air conditioning, hot water, trickle top up and sewage pumping. There is water quality monitoring of potable water supply, greywater and sewage. Biolytix technology has its own control system and there is a soil saturation sensor to control irrigation.

Costs:
The additional costs for alternative water servicing in the development and the houses have been paid by the developer. No detailed lifecycle assessment has been performed on the development yet.

Implementation and management strategy
Maintenance and operating costs will come from a community title scheme once 50% of homes are sold. Prior to this the contractor is responsible for maintenance.

Reported savings and benefits:
The development is designed to be self-sufficient in regards to water provision so no headworks infrastructure was required for provision of water supply or expansion of sewerage by the local authority. The development is also expected to minimise contaminant loads to the local Enoggera Creek by diversion and treatment of stormwater. Projected reductions in water flows and contaminants are given in Figure 22.

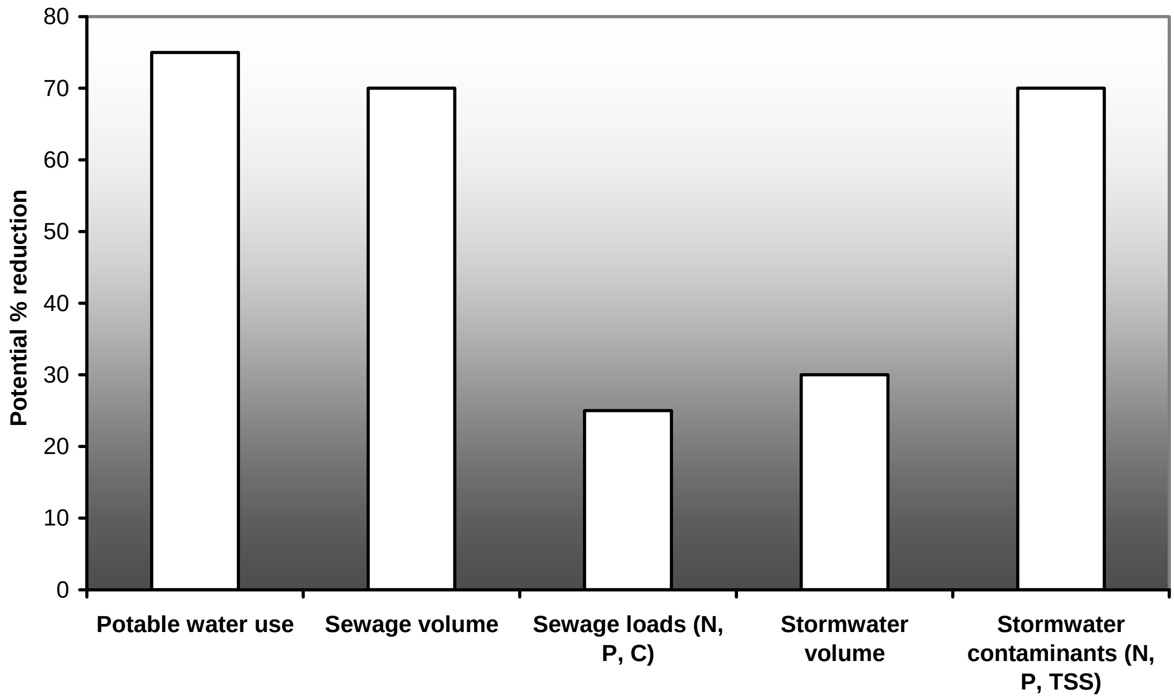


Figure 22: Potential reductions in volumes and loads of water streams for Payne Road

(adapted from Gardner et al., 2006)

Expected outcomes:
Due to the extensive monitoring of the site it is hoped the project will:

- Quantify the efficiency of rainwater tanks when used to supply all household requirements.

- Demonstrate and quantify the impact of a modified sewerage system on nutrient and carbon (BOD) export from urban subdivision.
- Demonstrate the technology is reliable and cost-effective compared with traditional ‘big pipe’ solutions.
- Demonstrate stormwater management and quality of the proposed system, which involves on-site detention storage, water-sensitive road design, contour banks, grassed swales and bio-retention, will reduce stormwater peak flows, sediment and nutrient exports to near pre-development levels.
- Demonstrate and quantify the water and energy savings that are achieved by sensitive earthworks, responsive house design, use of gas energy for heating, low water use plumbing (aerated faucets, low flow shower roses, etc.), recycled water and rainwater tanks. To demonstrate to the urban development, local authority and state regulatory sectors that decentralised water, modified sewerage supply and a water-and-energy sensitive urban design can provide a safe, cost-effective and sustainable marketable alternative to traditional urban solutions.
- Provide guidance to and promote contemporary Queensland architecture and energy efficient housing as a sustainable alternative to traditional urban solutions.
- Enhance biodiversity and integrate with the natural environment, re-establish fauna corridors, control invasive weeds and incorporate a native species landscape philosophy.
- Demonstrate that the urban metabolism of a largely conventional urban community can be reduced using a suite of relatively simple existing technologies in an integrated manner.

References/contacts:
Ted Gardner (07) 3896 9488
Col Christiansen, Nathaniel Parker
http://www.payneroad.com.au/mainpages/home.htm

Project Partners:
Bligh Tanner Pty Ltd (the designer)
Queensland Department of Natural Resources, Mines and Water
Brisbane City Council
Queensland Department of Energy
CRC Water Quality and Treatment

References

Gardner T., Millar G., Christiansen C., Vieritz A. and Chapman H. (2006) Urban metabolism of an ecosensitive subdivision in Brisbane, Australia. In Proceedings of Enviro 06, 9-11th May, Melbourne

Livingston D. (2005) Decentralised Innovations in Australian Urban Water Management: An Institutional Perspective UNSW Water Researchers Symposium, July 22 http://www.water.unsw.edu.au/200507-phd-symposium.html

In addition to the work carried out in this current study two other research projects have investigated the alternative water servicing approach at Payne Road. One focused on institutional barriers to decentralised systems (Livingston, 2005) and the other has focused on the monitoring a performance of the technologies utilised at Payne Road (Gardner et al., 2006). Lessons from both of these studies are reported below.

Lessons:

- Water use is similar to average Gap house and there is a low self awareness of water supply and energy use.
- Water saving comes at an extra energy cost. High energy use for rainwater pumping (linked to pump start up) and UV disinfection. Also potable water top up to rainwater tank requires pumping of potable water supply to provide household demands. Greywater and sewerage systems used more energy per ML than conventional sewage pumping and treatment although the extra energy cost was only a small fraction of total energy use.
- Assessment of alternative systems requires detailed analysis i.e. LCA.
- Pressure sensor for rainwater pumping is too sensitive.
- Requirement for wet collection system for rainwater for aesthetic purposes may impact water quality and produce odours.
- Housing market slow down has meant development of vacant lots is slow. Costs of extensive initial infrastructure have not yet been recouped.
- Low density development allows installation of large tanks and storages

Lessons: From Livingston (2005)

- The main barrier in this process was the meeting of regulations and approvals and finding the necessary knowledge and expertise. Fighting entrenched values or knowledge was not seen to be a barrier.
- Competition from private developers may provide impetus toward more sustainable developments

Lessons: From Gardner et al. (2006)

- There is an information gap between technologies and the householder understanding of the biophysical systems supplying water and sewerage services. Householder still watering from raintank (probably potable water backup) even when restrictions were in place.
- Automated irrigation systems can be neglected and will still water even when not needed.
- Distributed storage help maintain supply during dry periods and large communal storage provides fire fighting flows and pressure
- Errors can occur during set up of communal tanks (e.g. via contractors)
- Lack of data on the % of indoor use that is used for hot water services
- High salinity of greywater may have a detrimental impact of soil structure and permeability

4.3 Council House 2 (CH_2), Melbourne

Figure 23: Artist's impression of CH2 after completion

(Source: http://www.melbourne.vic.gov.au/info.cfm?)

Summary: Council House 2 is a new office building built as an infill in the busy Melbourne CBD. It is a showcase of ecologically sustainable design incorporating ventilation, heating, water and energy use, material use, lighting. The building was the first Australian building awarded a 6 Green Star rating placing it among the world leaders in office building design and performance based on criteria such as energy and water efficiency, quality of indoor environments and resource conservation.

In its conception and design the architect aimed at minimizing the environmental impact of the building by maximizing the use of sustainable features using new and existing technology including:

- Water use: Sewer mining, water efficient features,
- Phase-change materials for cooling, automatic night-purge windows, wavy concrete ceilings, a façade of louvers (powered by photovoltaic cells) that track the sun, thermal mass use.
- Plants to filter light.

The building also aims to encourage use of non-motorised transport as it incorporates 80 bike spaces and 9 showers for cyclists, 20 car spaces plus one disabled space. The car park can be converted to office space or other uses. The project was initiated by the City of Melbourne with two justifications in mind, one being that in the future, water prices may become much higher creating pressures on industry to reduce usage. The second is that of resource conservation and efficiency, as water efficient fixtures and water efficient landscape design have a strong business case if integrated at the design phase.

Status:
CH2 is in the final stages of construction with operation expected to start in mid 2006.

Location:
CH2 is located on 218-242 Little Collins St, in the heart of the Melbourne Central Business District in Victoria. It is constructed on a site previously occupied by an existing building that was demolished.

Size: The CH2 building is a 10 storey office building for 450-600pe with commercial leases at the ground floor. The total area is 12,536m² comprising:

- 1,995m² gross floor area (GFA) basement areas
- 500m² net lettable area (NLA) – ground floor retail
- 9,373m² total NLA
- 1,064m² GFA – typical floor

Water consumption is estimated at 19 kL/day (5 ML/year).

Technologies summary
- 4A fittings to conserve water.
- On-site rainwater collection: rainwater is collected from the roof of the building and stored in a 20 kL rainwater tank.
- Sewer mining: the treatment system had the capacity for 100kL wastewater from public sewer treated to class A. Treatment by membrane water reuse plant with ultrafiltration and reverse osmosis.
- Vertical gardens on north façade with special water retentive potting and plant selection.
- Treated blackwater and greywater are used for supply of non-drinking water (plants irrigation, cooling, toilet flushing, street washing and open spaces). This is expected to supply 72% of water needs.
- 25% of potable water used in the building is supplied by rainwater and by water collected from fire sprinkler testing.

Wastewater sewer mining
Greywater and blackwater from the building are directed to the basement where they are supplemented with wastewater extracted from a sewer main that passes under the building. The wastewater is treated by a Multiwater treatment system in the basement of the building to produce Class A effluent.

The system has capacity to provide 100 kL per day, 45 kL of which will be used in CH2 and 55 kL for other Council purposes such as street cleaning and garden irrigation. The system has been designed to allow flexibility in the amount of water that is extracted to meet the needs of the building, for example during low occupancy periods such as Christmas, the system can decrease production to only 20 kL without any adverse effect (Gorman, personal communication 2006).

Sanitary design principles including stainless steel pipes and fittings were used in the treatment plant to prevent recontamination of the treated water in the plant. The plant design and configuration ensures that it is odour free to comply with EPA regulations.

The plant stages consist of:
- Holding tank
- 200μm filter
- Ceramic filters (ultrafiltration)
- Reverse osmosis
- Chemical dosing

Figure 24: Multiwater treatment plant at CH_2 building

(Source: NuSource Water 2006)

The treatment system is based on physical processes to ensure that the quality of the effluent can be maintained independently of any variation in the quality of wastewater extracted from the sewer and to minimise the use of chemicals in the treatment process and their discharge to sewer. The ceramic membranes used are chemically inert and can be cleaned and disinfected primarily using hot water, operating continuously in cross-flow mode. This is followed by a reverse osmosis stage for the removal of salts and remaining pathogens. This arrangement of multiple barrier treatment is designed to ensure that greater than 7 log reduction of viruses is achieved. The turbidity and conductivity of the treated water is measured continuously as part of the on-line critical control monitoring process.

Rainwater

A 20 kL rainwater tank stores rainwater collected from the roof of the building. The rainwater supplements the treated water from the wastewater treatment system. This water will be used for the cooling towers, irrigation of plants, toilet flushing and for filling of street sweeping vehicles.

Garden irrigation

Plants on the façade and the roof garden will be irrigated using mined water enriched with oxygenated rainwater. Some of the water recycled from the sewer mining plant will be used in the vertical gardens that will run the full height of the northern façade. The plants will be grown from special planter boxes built into the balconies on every storey. The role of these boxes is to grow three-to-four metre vines up the façade of the building via stainless steel mesh stretching from the ground to the roof. The boxes are filled with Fytogen Flakes, a soil additive that acts as a large water crystal, storing a large amount of water and air until the soil requires moisture replenishment.

Each planter box is fitted with a sub-surface irrigation system: when the crystals dry out and the water is used up, a float triggers the device to re-fill with water. The combination of this device and the crystals provides the ideal wet-and-dry cycle required for the plants to thrive.

Sprinkler water collection
CH2 will reuse potable water from the sprinkler system (providing 25 per cent of potable water). An equivalent office building wastes 10 kL of drinking water a week to test the sprinkler system pressure, discharging the water to sewer. CH2 will collect this water, store it in a 20 kL tank and draw on it for water needed for sinks and showers.

Other tools:
A comprehensive water monitoring system in CH2 will record all water supply and use, producing valuable data on how water is used and how it can be saved. Water meters will be installed on all major water uses in the building, including the cooling systems, hot water systems, irrigation and other services. These meters will be linked to the building management system and offer remote and real time monitoring benefits, with a greater ability to detect leaks and identify high water use areas and inefficiencies.

Maintenance
The contract between the technology providers (NuSourceWater) and the City of Melbourne specifies that the sewer mining plant will be maintained by NuSourceWater for 3 years with potential for extension.

CH_2 building costs:

- Total building costs: $51.045 million
- $29.9 million for the base building ($2,334/m^2 or 58.5 per cent of cost).
- $11.3 million for sustainability features including a portion of the building cost of purge windows, light harvesting devices, pre-cast ceilings, timber shutters, pre-cast exhaust ducts, solar hot water collectors, photovoltaic cells, chilled water cooling system, shading screens, co-generation plant, air conditioning and beams and slabs. (884$/m^2 or 22.1 per cent of cost).
- $2.8 million on education and demonstration including a portion of the cost of shower towers, multi-use water treatment plant, PCM modules, roof landscaping and chilled ceiling panels/beams. (218$/m^2 or 5.5 per cent of cost).
- $7.1 million on requirements specific to Council use including a portion of the cost of vertical landscape, balconies, access floors, lift finishes, communication cabling, stand-by generator, security system and building automation system. (553$/m^2 or 13.9 per cent of cost).

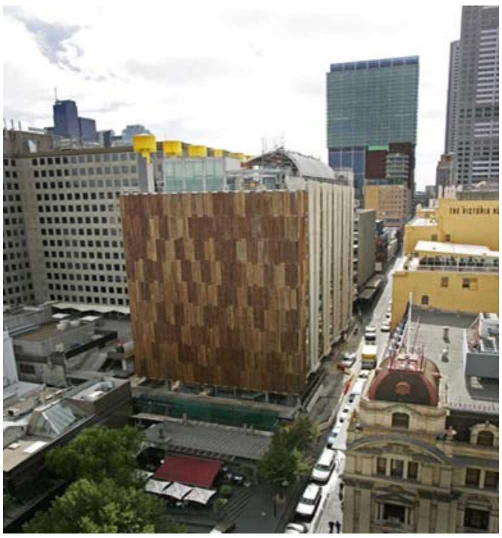


Figure 25: CH2 building (February 2006).

Reported savings and benefits
At the time of the site visit the following savings were expected;

- Overall 72% of the total building water needs are supplied from treated blackwater and greywater in conjunction with rainwater.
- The remaining 28% of the building's water is supplied through mains water and reuse of water used for fire sprinkler testing. The recycled fire sprinkler water provides 25% of the potable water needs, (i.e 7% of overall building needs
- This equates to savings of 10kL per week of potable water. Estimated cost saving from reduced water usage is $50,000/yr
- Water mining plant will draw about 100 kL of black (toilet) water from the public sewer for recycling. The plant, along with rain water tanks, will supply 100 per cent of the non-drinking water for plant watering, toilet flushing and cooling for the building, with the surplus directed to other buildings, fountains, street cleaning and plant irrigation.
- Potential services cost savings due to 60% load reduction
- Reduced wastewater flows
- Development of technology and knowledge that can be used in other projects
- Meeting policy commitments and providing leadership through demonstration

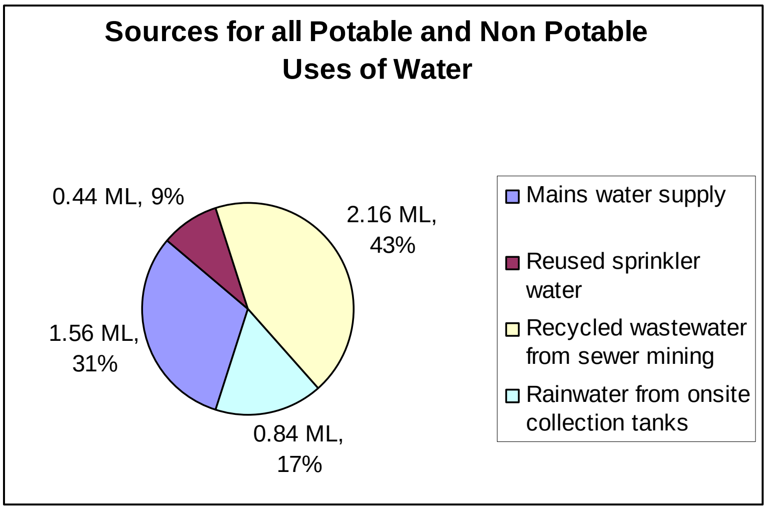


Figure 26: Volumes of water sources for CH2

(Gorman, personal communication 2006)

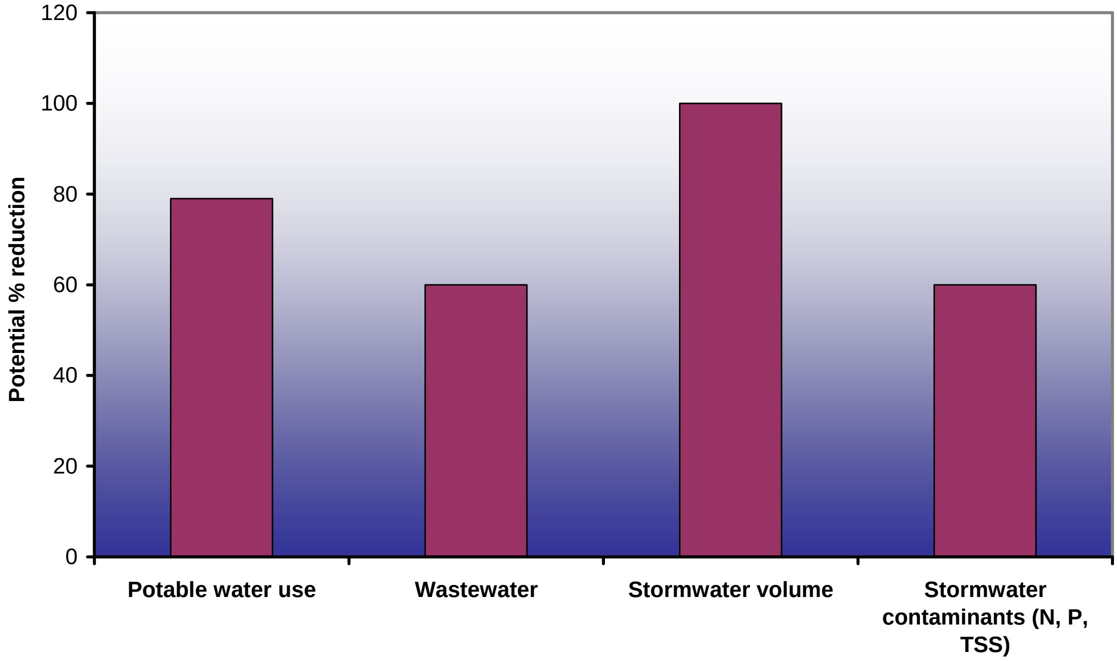


Figure 27: Potential reductions in volumes and loads of water streams for CH2.

References/contacts:
Kate Gorman, Melbourne City Council.
http://www.melbourne.vic.gov.au/info.cfm?top=171&pg=2021
Peter Cooper, NuSource Water (sewer mining/water reclamation plant)
Tel. (03) 9542 6000
Mick Pearce, Principal Design architect, Melbourne City Council
Tel. (03) 95658 9042

Principal consultants
- City of Melbourne (Design and Culture Division) – Design and Project Management
- Design Inc – Architectural Design and Documentation
- Lincolne Scott – Services Engineering
- AEC – Advanced Environmental Concepts
- Bonacci Group – Structural and Civil Engineering
- Donald Cant Watts Corke – Quantity Surveying
- Hansen Yuncken – Building Contractor

Supporting consultants
- Marshall Day Acoustics – Acoustic Consultant
- Melbourne Certification Group, MCC – Building Certification and Inspection
- CSIRO Evergen – Process and Materials Consultant
- SEAV – Scientific Simulation
- Carl Mahoney & Associates – Climate Consultant
- TDC – Vertical Transport
- Flagstaff – Program Consultant
- DEGW – Accommodation Consultant
- Vawtex Ltd UK – Turbine Design Consultant
- Golder Associates – Geotechnical Consultant
- Ancon Beton P/L – Concrete Technology
- Andrew O'Brien – Traffic Engineering
- Reeds Consulting – Land Surveying

- Andrew Long & Associates – Archaeological Investigation
- Blythe Sanderson – Disability Management
- Direct Access – Cleaning Access
- Oid Design – Graphic Design
- Formtech – West Wall Timber Louvre Mechanical and Hydraulic Design

Study and Outreach Program consultants

- RMIT Centre for Design
- University of Melbourne
- Deakin University

With support from

- AusIndustry
- Australian Greenhouse Office
- The Building Commission
- The Sustainable Energy Authority of Victoria
- The Green Building Council of Australia

CH2 Lessons:

- Extensive verification and proof of the water recycling and wastewater treatment system was required to ensure that public health standards could be attained. Backup systems to sewer were also required for the project.
- Another of the difficulties was proving to regulators and health authorities that the technology was adequate and safe. Current regulation has been developed for conventional membrane filtration processes and no benchmark exists for ceramic membranes, despite their use in the treatment of industrial water (Cooper 2006, personal Communication).
- The council initiated sit in meetings with developers, constructors, architects and other stakeholders during the early stages of planning and construction to ensure that background could be established early and that understanding of the whole process could be established.
- Accreditation of the treatment system and the plant has been one of the most important steps in the development. In particular close and early collaboration between DHS, EPA and plant designers/management company.
- Due to inner city location the prevention of odour has been one of the major requirements from the EPA and the plant has been designed for such purpose.
- The building will be used for extensive research in partnership with major universities to determine the impact of the sustainable features including energy consumption, economics, human psychology and productivity.
- Water production from the plant is designed to supply the needs of the building and also supply other council needs in the area (street cleaning and sweeping).

4.4 Currumbin Ecovillage, Gold Coast

Figure 28: Layout design of The Ecovillage at Currumbin Village Centre

Summary: *The Ecovillage at Currumbin* is a greenfield development which is currently in the development phase, with the first stage over 90% sold. Water features are in place and the roads and laneways for the first phase of the development are complete. The wastewater treatment system is being installed and a straw bale building has been constructed to house some of the pumping, polishing and monitoring equipment and will act as a community meeting place. Office accommodation and the visitor centre with many demonstration technologies and techniques are already completed. The site will have no municipal sewerage or main potable water connection and is Australia's first major residential subdivision to be totally self-sufficient in water and wastewater treatment.

Location: 639 Currumbin Creek Road, Currumbin Valley, Gold Coast.

Size: 110 ha, 144 residential allotments and Village Centre commercial and recreational facilities to be developed in 3 stages: Creek Ecohamlets (stage 1), Valley Terraces (stage 2) and The Highlands (stage 3). House sizes are regulated by Planning Approvals to cater for social diversity:

- 17 x one bedroom
- 26 x two bedroom
- 101 x three bedroom +

Houses will be regulated by a rigorous Architectural Code that mandates lightweight construction and with thermal mass for optimum climatic performance. All homes will be built

600mm above ground to minimise environmental impacts. Stage 1 is due for completion in March/April 2006.

Topography: The site varies in elevation from the phase 1 development, Creek Ecohamlets, at reduced level (RL) 10 m to the phase 3 developments, the Highlands, at RL 100 m

Demographics: Low density residential and commercial/community development including a pre/primary school. Phase 1 lots vary from around 400 to 1600 m^2 (6 to 20 lots/hectare). Later stages have larger lots from 800 to 10,000 m^2

Technologies summary

- A combination of centralised and on-site systems will be used throughout the development to treat the wastewater. Properties on the lower plains will be connected to a local cluster wastewater treatment plant and houses in the highlands will have their own on-site treatment systems.
- Rainwater is collection at household level with the following recommended tank sizes: 22.5 kL/1 bedroom, 33,75kL/2 bedroom, 44-45kL/3+ bedrooms. This capacity includes a 5kL fire fighting requirement.
- Other features have been designed into the subdivision and will be mandated on-site by the body corporate and include rainwater tanks, solar water system, 3A or 4A rated appliances and the use of recycled water
- A temporary demonstration system at the Interpretive Centre treats grey and blackwater using an Aquanova system followed by chlorination and pumping of the water to irrigation and shows rainwater tanks with first flush diverters.

Potable supply:
Each household will be equipped with rain water tanks which will supply all household uses including drinking. The treatment of rainwater prior to use will be at the discretion of the householder, Landmatters providing information on local suppliers of treatment devices. All properties will have 3A or 4A rated appliances. Restrictor valves will be fitted on rainwater supplies to the houses, to provide feedback to the householder when water levels are low.

Garden Irrigation:

All wastewater is ultimately used for irrigation of on lot commercial and community gardens providing recycling of nutrients. This aims to close the nutrient loop as food grown on site is consumed, then wastewater is treated and put back to gardens.

Wastewater
The wastewater treatment plant installed at Currumbin is an Orenco Advantex textile filter coupled to a Memcor micro filtration system, designed by Sustainable Solutions International and installed by Walter J Pratt Pty Ltd. The recycled water will be of Class A quality and will be recirculated to the households for toilet flushing, laundry use and garden irrigation. Polyethylene pipes are used for all wastewater and water supply transport as developers did not want to use PVC.

Stormwater
There is extensive stormwater design measures incorporated into the site to ensure predevelopment water quality and flows are maintained. Site roads have been designed to minimise hard kerbs and allow natural drainage and to make best use of the existing vegetation. Stormwater swales and ponds provide further treatment of stormwater and a natural feature for birdlife and villagers to enjoy.

Other tools:
Provision of a list of potential suppliers of technologies and services will be supplied to all householders.
Landscaping at the site designates 80% of the site as open-space, with more than 50% environmental reserve. The preservation of landforms and rehabilitation of the site's environmental integrity has been considered and integrated into design to the optimum extent. There are also extensive wildlife corridors, negligible vegetation loss and minimal native plant regeneration requirements.

Extensive resource and performance monitoring systems for each household will be mandated by the body corporate. Initially the electricity use in and out of home, Reticulated LPG Gas (Liquid Petroleum Gas) and rainwater use will be monitored at a cost of $3.5K per house. It is hoped to extend this monitoring to potable water, hot water and building temperature in the future.

Waste recycling strategies including a recycling centre. There will be no council waste collection from site encouraging villagers to reduce, reuse and recycle wastes.

An Interpretive Centre has been built and this will provide continuing education in sustainable practices to both Ecovillagers and visitors. Landmatters is making available its documentation and learning to developers and interested parties to assist uptake of sustainable practices.

The Ecovillage targets long-term food self-sufficiency with strategies for on lot gardens, extensive areas designated for food production. Street plantings are also mostly productive trees.

Costs
Total about $15-20k/house for sustainable features
Photovoltaic (1kW PV) $8k
Rainwater tank $4-6k, piping $100
Solar hot water (flat panel or tube) $3-5k
Monitoring equipment $3.4k (IMCS)
Body corporate rates $190-200/month.

Stage 1 - Land costs $175,000 with home parcel sizes ranging between 600m^2 to 1600m^2 along a creek. Average price $250,000.
Stage 2 - Lot sizes ranging from 750m^2 - 2560m^2 on valley terraces.
Stage 3 - The Village Centre includes Home Studios - first level apartment living with ground floor shop / work street frontage space opening onto the Village Centre hub; convenience store, health practitioner rooms, office accommodation, café, bakery and Village hall meeting facilities.
Stage 4 **-** The Highlands offers acreage home parcels with sweeping valley and ocean views. This stage enjoys life on the other side of the ridge with private and larger sized lots **(**3000m^2 to 8000m^2**).** Release of this stage is expected around the end of 2006**.**

Savings:
The village is designed to be totally self-sufficient for sewerage and water supply so there will be no potable water use or wastewater discharge from the site. Stormwater flows and quality should mimic the predevelopment values.

References/contacts:
http://www.theecovillage.com.au/index2.htm

Project Partners:
Landmatters Pty Ltd (Developer and Designer)
Bligh Tanner Pty Ltd - Engineering Services
Landscape Architects - John Mongard Landscape Architects Pty Ltd and Stephen Pate Landscape Architects Pty Ltd
Architects Gall & Medek Architects Pty Ltd and Davis & Josephson Architects
WBM Oceanics Australia - Water Quality and Environmental Service
Humphreys Reynolds Perkins - Planning Consultants

In addition to the work carried out in this current study another research project has investigated the alternative water servicing approach at Currumbin Ecovillage, focusing on institutional barriers to decentralised systems (Livingston, 2005). The lessons from this study are reported below.

Lessons:

- The process of set-up has taken 10 years with many instances of difficult negotiation with the council – all desired aspects of the development have been consented. Currently, the council has one main officer that acts as contact person facilitating the approval process.
- An extensive consultation program was vital to the success. This involved a strong design input from indigenous groups, residents, stakeholder groups, referral agencies and others.
- Application for funding sources for major wastewater infrastructure to be installed prior to occupancy of homes (Water Smart Australia) has not been supported. Developer has researched World's Best Practice technology from overseas and implemented Australia's first application without Government assistance.
- Creating a community with on-site work strategies, farming and facilities promoting community engagement, knowledge transfer and community learning
- Mandating monitoring will provide much needed feedback on the performance of alternative approaches. Some issues regarding privacy laws had to be overcome to allow this approach.

Lessons: From Livingston (2005)

- There are fewer internal institutional barriers for a private developer and there is better capacity to adapt to new ideas and values
- The main barrier in this process was the meeting of regulations and approvals

4.5 City of Bayside, Melbourne

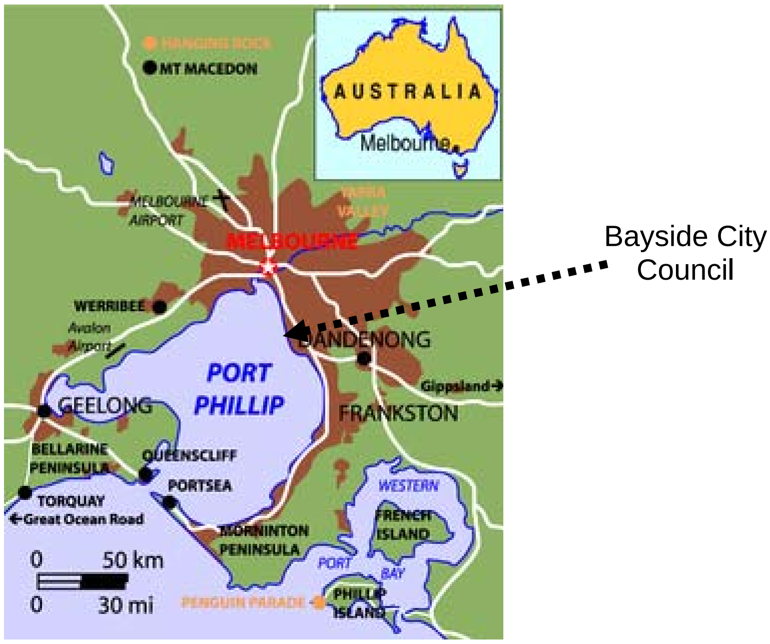


Figure 29: Bayside City Council location

Summary: The City of Bayside area, a coastal suburb in south east Melbourne is one of the highest per capita water consuming municipalities in Melbourne covering an area of approximately 37 km^2. It is a well established community with old urban infrastructure and as such offers some significant challenges in retrofit of alternative approaches.

Both Bayside City Council and the local water authority (South East Water) were keen to participate in research to identify householder's responses to alternative water servicing and their perceived barriers to adopting water reuse and other water saving technologies. This case study reports on the results of this survey to provide some ideas for installation of alternative water servicing in existing suburbs.

Status: Householder survey completed and program for implementation being developed

Location: South east Melbourne

Size: Total area of approximately 37 km^2

Topography: The City of Bayside is a relatively flat area with elevation ranging from sea level at the coast to no more than 50m throughout the area.

Demographics: The population in 2001 was around 83,000 with nearly 60% in the 18 to 64 year old age bracket. There are over 32,000 properties in the City Of Bayside with around 35% of these family homes (couples with children) and around 25% couples without children. There are slightly higher population densities around main shopping areas, but generally the population is evenly distributed with a number of parks and golf courses. The area does contain a higher percentage of separate houses and a lower percentage of units and apartments compared to other Melbourne suburbs[1].

Other site information: Falls in the Dandenong catchment and in the South East Water area and Port Phillip and Westernport Bay Catchment Management Authority.
Bayside Council has developed a Sustainable Water Management Plan for the area in 2005 which was completed in partnership with the International Council for Local Environmental Initiatives (ICLEI), Melbourne Water and South East Water.

Methodology:
A voluntary anonymous mail out household survey was sent to 10,000 residences within the City, with a 26% response rate. This was recognised as a high response rate for a survey of this type and it is thought to be a combination of the prize draw incentive offered upon completion of the survey, the provision of reply paid envelopes and a strong local interest that produced this response.

References/contacts:
Clarke and Brown (2006)
Rebekah Brown – Monash University Rebekah.Brown@arts.monash.edu.au
John Edwards - Bayside City Council
[1]http://www.bayside.vic.gov.au/index.html
[2]http://www.dse.vic.gov.au/CA256F310024B628/0/3784563D65C800A2CA256FCE00171737/$File/Edition+21+Sep+03.pdf
[3]http://www.aius.org.au/indicators/Theme.cfm?ThemeID=2

Project Partners:
Bayside City Council
South East Water
Monash University

Bayside City Council Barriers and Lessons:

- Water is a topical issue in Bayside with 95% of respondents stating that saving household water is important and there are number of education campaigns in the area (Be a Bayside Water Saver, Waterwise in the Garden). However, the area is one of highest water consumers in Melbourne[2,3] suggesting there are other needs to be addressed to reduce water use
- Over 60% of respondents to the survey were prepared to use rainwater and seawater for showers, laundry, toilet flushing, car washing and garden watering
- Over 60% of respondents to the survey were prepared to use greywater for toilet flushing, car washing and garden watering
- Over 50% of respondents had installed water efficient shower heads, while only around 5% had installed rainwater or greywater systems. The water efficient showerheads were installed in both owner occupied and rental properties.
- Installation of greywater treatment or rainwater tanks was viewed as ‘too expensive’ or ‘too difficult to organise’.
- Respondents who had not installed water efficient shower heads cited ‘poor performance’ as a potential barrier
- Overall, the survey found that acquisition and application barriers such as costs and renter status were more of a barrier to implementation of alternative water servicing approaches in this community, than community receptivity

4.6 Atherton Gardens, Melbourne

Figure 30: Atherton Gardens

Summary:
Atherton Gardens is a high density residential estate comprising four high rise towers and built in the 1970's and maintained by the Department of Human Services. The overarching project is the first stage of an upgrade of site amenities which includes a redesigned landscape that incorporates four water sensitive urban design systems. The water project is a small component of this larger project, instigated in order to preserve the investment in the garden in view of current water restrictions.

Two of the water systems implemented treat stormwater and passively irrigate landscape areas and two other systems harvest greywater or stormwater for controlled drip irrigation. All of the systems are currently being assessed and monitored as part of a case study. The project is expected to be fully functioning by the end of 2006.

Location: two buildings situated in Brunswick Street between Gertrude and King William streets (blocks 90 and 140) and two situated in Napier Street (blocks 95 and 125), Fitzroy, Melbourne, Vic (Figure 31).

Size: Each tower block comprises 200 flats (10 flats on each floor x 20 floors per block) making a total of 800 high rise units and a population of approximately 3000 residents.

Soil type: Silty clay
The building is made of pre-cast concrete slabs and wall panels with a service core of lifts and a laundry on each floor. The towers were constructed over an old slum/industrial area of Melbourne.

Demographics:
The multicultural community on the site includes Vietnamese, who constitute the majority of the estate population, followed by Chinese and Turkish residents, with lesser proportion of Eastern European origin (predominantly Macedonia) and a small percentage of Horn of Africa countries, plus a distinct Hmong community (initially hill tribes from Laos). Many tenants of non-English speaking background initially arrived in Australia as refugees and asylum seekers.

Figure 31: Atherton Gardens aerial view

(http://www.yarraweb.infoxchange.net.au/public_housing/fitzroy_estate.htm#)

Background:
Before the redevelopment of the gardens, the existing grounds contained a range of shrubs and trees that provided enclaves of poor visibility in the area. As a result the area was often used by drug dealers and users and the garden was used essentially as a thoroughfare with very little communal use due to risk to personal safety. The redevelopment of the garden improved the visibility of the grounds and also created a low maintenance garden by using xeroscopic plants (low water requirements).

Technologies
The development has implemented 4 water sensitive urban design systems on the site to determine their effectiveness in stormwater treatment and greywater recovery. Two of the systems recover water for garden irrigation (the grey water system and the roof water tank system) and the other 2 systems are stormwater treatment systems which passively irrigate the landscape. Implementation and technology selection were constrained by the existing infrastructure and configuration of the buildings. The total irrigated area is 4000m^2 of garden beds.

System 1 - Rainwater is collected from the roof area of 95 Napier St. (470m^2) and is stored in two existing de-commissioned fire service water tanks (9kL each) located in the building's ground floor plant room (Figure 32). Pipes from the tank pass water through a filter and the water is fed through drip irrigation lines buried around the gardens in front of 95 Napier St. With all irrigation distribution systems underground, there is no waste from spray drift, evaporation or runoff. Water goes directly to the roots of the plants. The irrigated area is 800m^2. Volumetric reliability of the system is currently 75% as water requirements are high during dry periods, when rainfall is low. The supply is supplemented with main’s water during these periods.

Figure 32: Atherton Garden fire tanks used for rainwater storage

System 2 - Rainwater collected from a downpipe connected to 260m^2 roof area, is diverted to an open top bioretention tank called a rain garden. The system is located at the entrance of building 90 Brunswick St. and consists of a 6m^2 heavily planted box containing filter layers of sandy soil, coarse sand and recycled glass. The rainwater enters the surface of the rain garden where it flows over the planted area and percolates down through the filtering media. This waters the plants in the planter box, filters the rainwater and buffers stormwater flows. The water is picked up by perforated pipes at the bottom of the tank and delivered to the stormwater system (Figure 33). The stormwater pipes from the building end 1-2m below ground, whilst the rainwater garden is at surface level requiring a minimum head to feed the rainwater into the garden. This limits the amount of water that can be recovered from the system.

Figure 33: Atherton Gardens features of the rainwater garden

System 3 - Stormwater run-off from a multi-storey car park is collected from 4 existing downpipes which previously discharged into the stormwater system. The downpipe outlets at the base of the building are diverted into an oil interceptor, followed by a 55m swale and a 10m long sandy soil bioretention system, with collector pipes and end at a stormwater culvert, improving the quality of the water discharged and creating an attractive landscape feature.

Figure 34: Atherton Gardens multistorey car park and treatment system before discharge to sewer

System 4 - Greywater from communal laundries (40 washing machines) located at each floor of 90 Brunswick St is diverted to a system comprised of a modified CDS with a lint separation system, an underground concealed detention tank and a subsurface wetland. The detention tank evens out peak flows and provides a steady controlled flow via an underground supply pipe to a sub surface wetland that acts as the treatment system and forms a landscape feature.

The wetland is clay lined and has 6 trench grates that collect the treated water. The subsurface feed and the location of the collector trench grates just below the surface ensure that there is no standing water.

Filtration occurs via the upflow passage of the greywater through the layers of sand, crushed glass and plant roots before exiting the system. The irrigation system is made of PVC pipes and fittings. Drainage pipes were made of composite recycled materials. Recycled glass was also used for the drainage aggregate. After filtration through the wetland, the water is directed to a 15kL buried storage system comprised of oversized pipes. The system will offer a continuous and reliable supply of water throughout the year for garden irrigation when fully implemented, in addition to the irrigation system sourced from the tanks at 95 Napier St.

The treated effluent is currently being diverted to sewer, as it is currently undergoing monitoring and verification of treatment and effluent quality as requested by the EPA.

Majority of the retrofitting has been conducted at ground or subsurface level via the landscaping and installation of irrigation systems.

Figure 35: Atherton Gardens greywater treatment, CDS screen and subsurface wetland

Maintenance:
Whilst the project is in its early stages, the landscape and the systems have been designed to minimise maintenance. Selection of plants ensures that plants at full growth will maintain the visual clearance and amenity of the open landscape. Separation of plant species and designation of beds and garden areas by the use of wide concrete garden bed edging facilitates grass cutting and prevents invasion by foreign plant species. The major maintenance item is the garden, which is conducted by a maintenance contractor and the greywater system which requires regular emptying of the lint trap.

Other tools:

- The gardens have been landscaped and designed to retain stormwater using water retaining aggregate (Hydrocell) and plants with low water demand that are tailored to the water load that the building can deliver.
- A control box automatically directs the areas in the garden that are irrigated so that each of the 7 zones is irrigated to the minimum requirement of the planting types. Each irrigation day utilises 15,000 L of recycled water.
- Tenant's participation: tenants have been involved in the project via early consultation and information sessions. A list of environmentally friendly detergents has been provided to the tenant association.

Participation of tenants via detergent selection and feedback has been encouraging. The partnership with the Tenants Association has assisted in the education process and the development of a scheme to motivate tenants to use washing powders that are less harmful to the garden. Notices have been fitted to each washing machine to inform householders which powders are better for the garden. The Tenant Association also bulk buys a brand of environmentally friendly washing powder and sells it at the community shop at a cheaper price than supermarkets, encouraging adoption of this brand.

Costs:
Infrastructure cost:
Greywater recovery system $115,000.
Car park system $27,000.
Rain garden system $26,000.
Retrofit of fire tanks $11,000.
Overall project cost including landscaping $1.6 million.

System performance:

- The greywater and rainwater systems reduce the use of drinking water in the landscape by over 2.5 million litres per year.
- The greywater recycling system at 90 Brunswick Street treats over 6.5 million litres of greywater each year,of which 2.35 million litres per year is required for summer irrigation of the garden beds.
- Roof water collection system at 95 Napier St. saves approximately 180,000 litres of drinking water per year.
- The stormwater systems will treat a total of 1.2 million litres of stormwater per year, capturing around 250kg of sediments and 2.2 kg of nitrogen each year, preventing them from reaching downstream waterways (car park swales 1.1 ML/year and raingarden 130 kL/year)

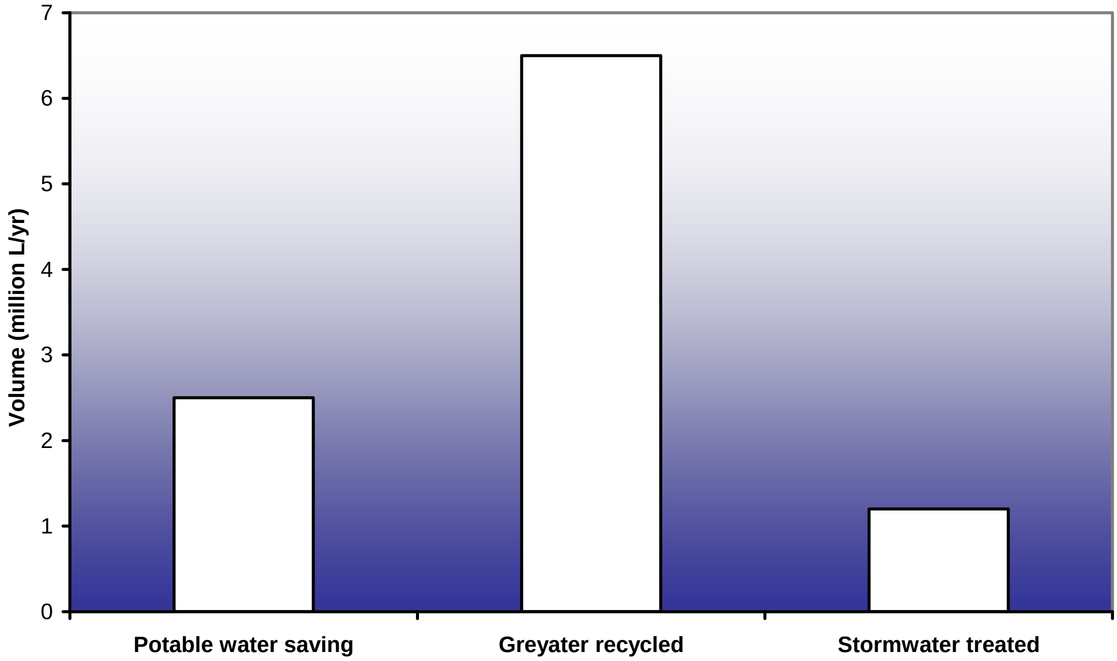


Figure 36: Potential savings in water streams from Atherton Gardens.

Expected Outcomes:

- Improvement in community space and garden amenities including housing for ecosystem birds and wildlife.
- Maintenance of the garden is not subject to water restrictions ensuring the life of the investment in the landscape.
- The project is being heavily documented, including a survey of community attitudes and perceptions to the project.

References/contacts:
Peter Hiho – Project Manager
Tel. (03) 9096 5430, Email: peter.hiho@dhs.vic.gov.au

Steve Wallbrink – Consultant design and feasibility assessment
Tel. (03) 9589 2154, Email: Steve@wallbrink.com.au

Maria Peterson – Policy and Strategy
Tel. (03) 9616 2908, e-mail: maria.peterson@dhs.vic.gov.au

http://thesource.melbournewater.com.au/content/Issue/August2003/public.htm

Department of Human Services, Fact sheet: Atherton Gardens Sustainable Landscape Upgrade-Four Integrated water sensitive urban systems to conserve and treat water.

Department of Human Services, Fact sheet: Atherton Gardens Sustainable Landscape Upgrade.

Project Funding Partners:
Department of Human Services - Engineering Services Branch
Victorian Water Trust
Melbourne Water

Design Team:
Department of Human Services Engineering Services Branch
Project Management: Wallbrink Consulting Landscape Architects
Landscape Architects: Wallbrink Consulting Landscape Architects
Water Sensitive Urban Design: Ecological Engineering
Engineers: Dalton Consulting Engineers
Construction Contractor: Canteri Brothers Construction Pty Ltd

Project Liaison:
Atherton Gardens Tenants Association
City West Water
City of Yarra
EPA Victoria

Atherton Gardens Lessons:

- The 95 Napier St Building recovers 50% of roof water because of limitations imposed by the locations of the downpipes in relation to the existing storage tank.
- Collection of greywater (40 washing machines) allows continuous and reliable water supply for the garden even in dry periods.
- Absence of existing legislative and policy framework for the project, the process of approvals has been very rigorous, requiring the incorporation of extensive back-up systems, e.g. transfer to sewer and rigorous monitoring and sampling to evaluate water quality.
- Education of contractors to understand the configuration and principles of the design and to ensure fidelity to the plans.
- Cost of retrofit – external funding and in-kind collaboration was obtained to finance the project. The retrofit process required a large amount of planning and surveying as the site used to be an old industrial site before the estate had been built and records of previous services had not been updated. Delays were caused by incomplete records and uncovering of old service infrastructure, however the project installation was completed within the expected project timeframe. The cost of the water treatment features was small compared to the overall investment in the project.
- Commissioning and customisation of technology for greywater treatment – Improvements to the design of the greywater collection and treatment system were developed to respond to the particular characteristics in greywater flow pattern and quality. Lint in the greywater and peaks in volumetric flow were, respectively, the main cause of blockages and malfunction of the system in its initial stages. The CDS unit, traditionally designed to deal with stormwater, was modified to cope with the flow pattern and the quality of the greywater by modification of screens to prevent overflow and by improving lint filtration systems. More effective methods for removal of lint are being investigated.
- Integrated approach provides major benefits over lifetime of investment: in the evaluation of the project the whole integrated system needs to be considered (social, environmental, economic benefits). Whilst initial costs were high, the long term benefits, including externalities, need to be considered over the life of the development. The social aspect in this example is seen as the major advantage in improving the well-being of the community and the preventing vandalism. Evaluation of community impact is currently being conducted.

4.7 Sustainable House, Sydney

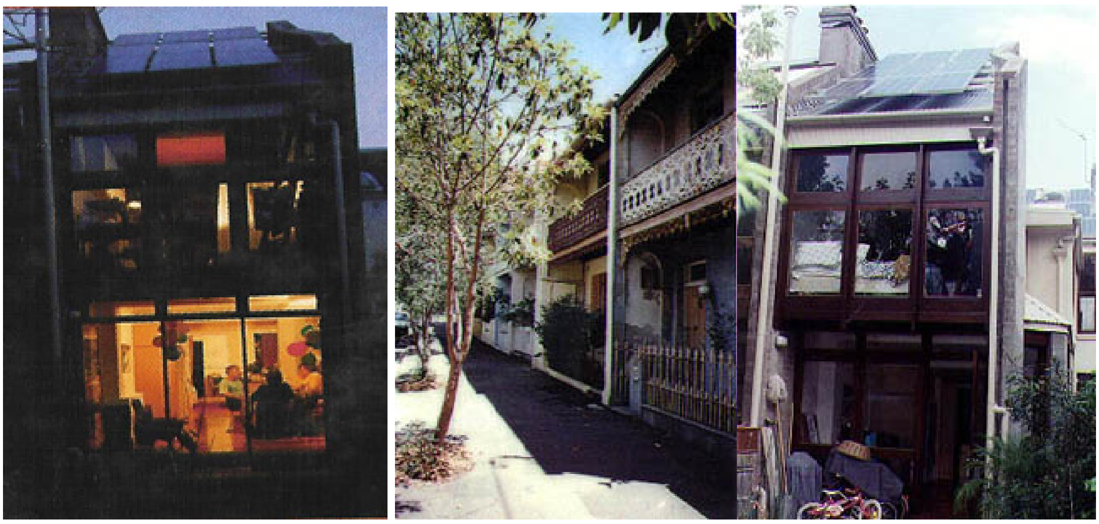


Figure 37: The Sustainable House

(Earthbeat http://www.abc.net.au/rn/science/earth/handouts/chippendale.htm)

Summary: Sustainable house is a 100 year old terrace house in an inner suburb of Sydney that has been retrofitted to become self sufficient in water and energy provision and is not connected to sewage and water mains. The household collects rainwater for potable applications and treats and reuses wastewater on-site for non-potable applications.

Location: Chippendale (2 km from Sydney CBD), NSW

Size: 1 Double storey terrace, block 5 x 35 m^2 (only 48m^2 garden area)

Soil type: Layers of sandy clay (top 0.5 m) and clay soil (0.5 - 2m depth)

Demographics: Family of 4 (2 professional parents and teenage children).

Technologies summary

- Rainwater is collected from the roof into a concrete tank and is used for drinking/cooking, shower and cold water for the washing machine
- Wastewater is collected and treated via a biological treatment system and is used for toilet flushing, washing machine (hot water), garden irrigation.
- Stormwater is contained on the property boundary. An 800 l mini-wetland acts as a retention basin for overflow management.
- Water efficient appliances are installed; dual flush toilet 3L/6L, front loading washing machine, 3A dishwasher and shower

Potable Water supply

Rainwater is collected from the roof with enclosed gutters for removal of leaves, a sloping mesh trap at downpipe, first flush diversion into the garden and a sump for sediment removal. Rainwater is collected in a 9.5kL concrete tank installed under a deck in the backyard with overflow into a mini-wetland. Maintenance of the system consists of cleaning

the first flush diverter (10 min every 3-6 months), sump cleaning which takes 20 min once per year and gutter cleaning every 3-6 months.
A water filter in the kitchen removes metals that might accumulate in the system. The quality of collected rainwater has been analysed and found to be within Australian Drinking Water guidelines, despite the location of the house in a busy traffic area.

Wastewater
Wastewater is collected via a single pipe into a concrete tank to which food scraps are added via a hatch. The tank contains 3 filter beds of sand and geofabric with worms and other organisms that treat the water to secondary standard. The effluent passes through a carbon filter and a solar powered UV disinfection system as it exits the tank. The current system is designed for 9 people capacity.
The UV disinfection system requires a lamp replacement one per year at the cost of $50-$60/lamp. Monitoring and validation of the effluent quality had to be conducted for 2 years to prove that the system did not pose a health risk. Sludge removal is required every 2 years.

Stormwater
Stormwater is directed into a mini-wetland system with reeds (capacity 800L) that acts as a retention basin for rainwater overflow management and treatment. The mini-wetland has become the habitat of small native frogs.

Other tools:
- Solar hot water system
- Sunlight collection cells for power generation
- Household cleaning products are selected according to their potential impact on the wastewater treatment system
- Metering of recycled and rainwater used and produced

Institutional
During project conception and approval, there was great difficulty in obtaining information on requirements and approvals for on-site wastewater systems. The householders conducted their own research on the technologies and treatment requirements and provided the information and suggestions from their research to councils and government agencies when requesting approvals to aid the process.

Detailed specifications were developed by the householders to guide contractors. The owners involved trades people, architects and technology providers to brainstorm potential ideas and issues on the renovations during the design of the system.

Reported Savings
25 kL/year are supplied by rainwater and 100 kL/year of recycled effluent is used for irrigation, gardens, washing machine and toilets. Additionally, there have been significant reductions stormwater runoff and contaminants into the environment with over 80kL/year reduction in stormwater flows and contaminants and more than 100kL/year reduction in wastewater flows and associated contaminants. This will reduce the treatment requirements prior to discharge into the bay.

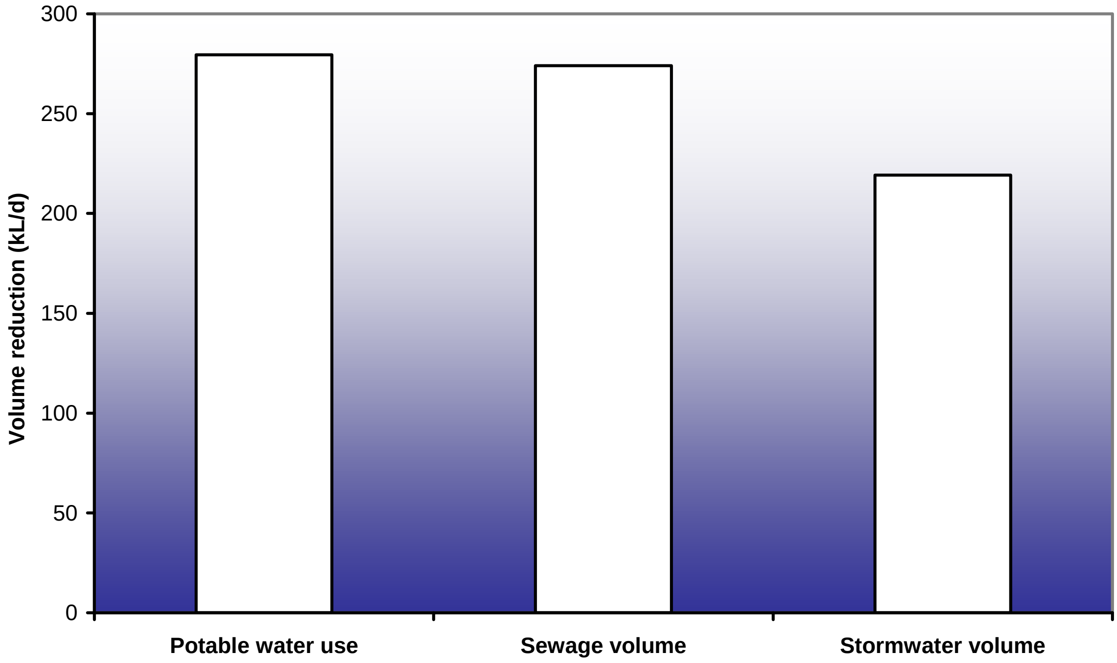


Figure 38: Reductions in volumes of water streams for Sustainable House

Payback period: Payback for the whole house (including solar power) was estimated as 10 years from project completion. Further benefits that could reduce this figure include savings due the externalities of less stormwater discharge and contaminants and no wastewater discharge for treatment. Factors contributing to the high cost of the retrofitting an existing propoerty were the narrow short site and the terrace style house with shared walls. Similar features in a greenfield site would be expected to cost less.

References/contacts:

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http://www.sustainablehouse.com.au/
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http://www.abc.net.au/rn/science/earth/handouts/chippendale.htm
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Project Partners:
University of Technology Sydney (School of Civil Engineering) (Water quality monitoring)
UNSW (Lifecycle assessment)
Dowmus Resource Recovery Pty Ltd (Wastewater tank)
Biolytic (wastewater treatment)
UVS Ultraviolet Pty Ltd (UV system at discounted cost)
Sustainable Energy Development Authority

Sustainable House Lessons:

- The rainwater collected has been within Australian Drinking Water guidelines, despite the location of the house in a busy traffic area.
- Be aware of limitations imposed by the established building and site. For example the roof area poses limitations on the amount of water collected and the household ran out of rainwater 4 times, this could be reduced by use of a larger size tank (10kL for 4 people). The dimensions of the block also required the storage tank to be customised, added savings could be achieved if an off- the shelf tank could have been used.
- Set guidelines and specifications for contractors and involve them in the design/concept process. Early involvement in the design and planning process between householders and contractors was beneficial.
- Detailed system and design analysis prior to implementation can be effective in evaluating design pitfalls and to achieve cost savings. After installation and operation householders identified a range of design changes that could reduce costs and improve the performance of the system, for example locating the rainwater tank at a height to allow gravity feed would dispense the need for pumps and the development of techniques for ensuring uniform organic waste dispersion. Integration of plumbing and electricity cabling also reduces installation costs.
- The renovations on the site have attracted interest from the community. Visitors interested in seeing the house come frequently. There has also been strong support from neighbours who also utilise the scraps shoot for their organic waste disposal.
- At the time of the project initiation (1995) WSUD and sustainability were not common concepts and extensive negotiations with regulators and council were required to obtain approvals and implement the systems. Early consultation in the planning stages with the council, health agencies and water authorities and provision of information to the agencies on the systems were effective in streamlining the process.
- The house is self-contained in regards to water and wastewater services. It has a lower ecological footprint than conventional houses, whilst offering all the commodities of modern living (dishwasher, shower, water quality, etc).
- At the time of construction there was very little information to provide guidance to the householders on selection and procurement of appropriate technology and design. A period of trial and error and design adjustment was required to optimise the performance of the system.
- No standards or legislation were available at the time for onsite wastewater recycling and treatment at such small scale.
- Monitoring of water quality had to be undertaken for 2 years to validate the system. No coliforms were detected in the recycled water.

4.8 60L Building, Melbourne

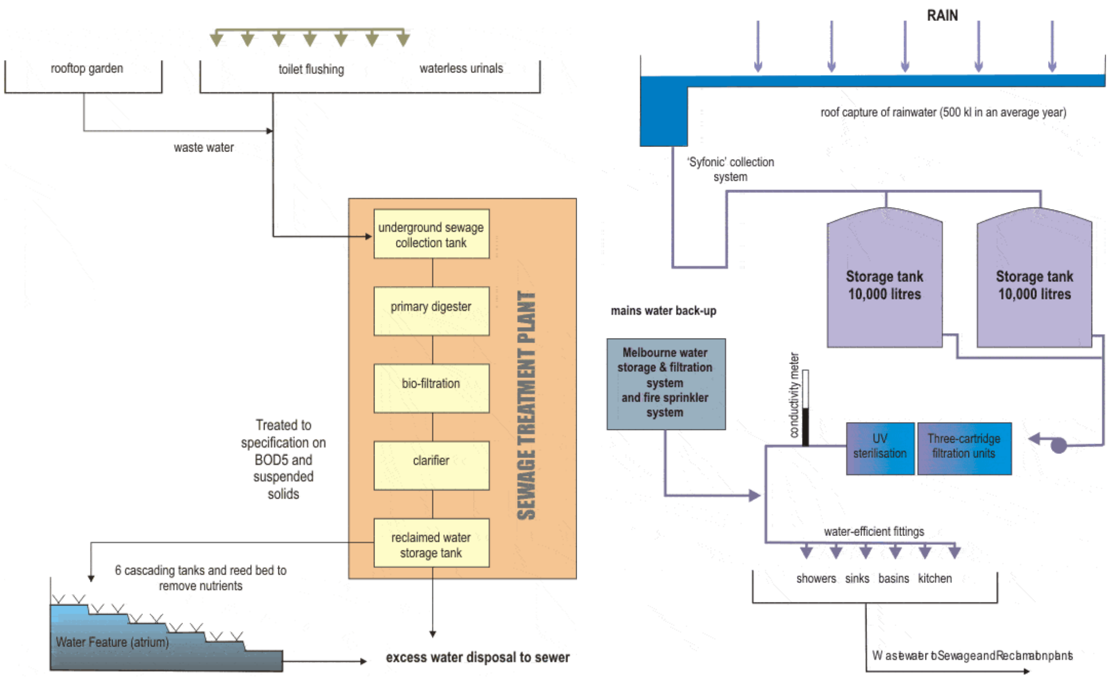

Figure 39: 60L wastewater and rainwater systems

Summary: 60L is a commercial office building in Melbourne, on the northern edge of the Central Business District, which was refurbished from a 19th century factory and old commercial building. The building has been in operation since 2002 and the approach to the design and construction of the site has incorporated many sustainability principles including energy and water consumption and the use of recycled and re-used materials during construction. The aim was to provide a commercially viable, healthy, low energy, resource-efficient workplace with minimal impact on the environment.

Current status: The building has been operational since 2002 and since that time there has been some evolution of both the energy and water systems servicing the building. The rainwater harvesting and treatment system is fully operational but the wastewater treatment system has been upgraded and is currently being recommissioned.

Location: 60 Leicester St, Carlton, Vic 3053

Size: 3375m^2 Office space, 4 levels, 15 tenant organisations and more than 200 people

Topography: Flat inner suburban surrounded by similar height buildings.

Demographics: Inner suburban office building with approximately 17m^2 per person

Figure 40: 60L Building facade, rainwater storage and treatment (centre) and reclaimed water feature

Technologies summary:

- Water efficient fixtures & fittings
- Roof collection of rainwater uses a siphonic gravity collection system to two 10kL storage tanks. Four stage treatment including filtration and UV to supply potable water to sinks, basins and showers
- All wastewater and sewage is collected and treated via a modified package treatment plant with aerobic and anaerobic processes and a membrane filter. Effluent from the plant will be used for flushing toilet pans and irrigating a 135m^2 rooftop garden. Excess recycled water will be directed to a water feature in the atrium that contains aquatic plants feeding on residual nutrients before being discharged to sewer (Figure 40).
- There is central water and wastewater automated system control, including automatic conductivity monitoring. There is also a rooftop weather-station.

Potable water supply

A range of water saving appliances are used throughout the building including; water-less urinals with oil seal (maintenance: cartridge replacement after 8500 uses at $40/cartridge), low flush volume toilet pans (3 L dual flush toilets) and low flow shower heads (5 L/min). There have been occasional problems with the waterless urinals with blockages of the cartridge due to hair and precipitation of salts. Also, cleaners needed training in the correct procedures to be used for the waterless systems. Water supply to showers, basins and sinks is from 2 x 10kL rainwater storage tanks on the ground floor (Figure 40). Rainwater is collected from the 1000m^2 roof area and there are strict roof maintenance and access procedures in place. This collected water is treated through a three stage micro-filtration (final stage nominally 1μm) and UV disinfection system. There is ‘on-line’ conductivity monitoring and other controls and interlocks to ensure no overpressure, flooding and reduced water quality at end use. Routine weekly testing for microbiological contaminants is undertaken. The pumps used are variable speed which reduces noise and power consumption.

Garden irrigation
Irrigation of the rooftop garden is controlled by moisture sensors. The garden was being watered with drinking water (from the rainwater system) at the time of the site visit (April 2006) but once the wastewater treatment plant is recommissioned, treated wastewater will be used.

Wastewater
The original treatment system installed was a three stage package treatment plant. This system did not perform well due to the increased concentration of wastewater caused by the use of highly water efficient appliances. The design of the system was problematic as appropriate data for hydraulic design was difficult to source, only once the building was operating was a figure of 15 L/person/day available. Initially, sink macerators were installed in all sinks in the tenant organisations. However, due to problems with treatment of wastewater these have been temporarily decommissioned. During the initial operation of the original plant some problems were experienced with pump blockages, leading to overheating of the pipework and subsequent pipe fracture, resulting in effluent spillage in the plant room. A additional problem with the original plant room design was that ducting for one of the meeting room air-conditioning units had been installed in the sewage treatment plant room and when odours were released following treatment plant malfunctions there were odour problems in the meeting room.

The package sewage treatment plant has recently been extensively modified and a membrane filter installed to treat the biofilter discharge. Maintenance of the system will probably be carried out by a sub-contractor, combined with daily and weekly in house checks, once the system is operating. In retrospect the building designer would consider recycling of greywater only, rather than the combined grey & blackwater streams. As the treatment plant volume is < 5000L/day, EPA works approval requirements do not apply.

Melbourne Water, the EPA, Department of Health and the local authority were all consulted regarding the installation of the water and wastewater treatment systems but all declined to approve or disapprove of the system design. Consequently, the building management aim for compliance with the Australian Drinking Water Guidelines and a high level of management control.

Stormwater
Stormwater is collected from a roof area of about 1000 m^2 (75% of the total area) into the rainwater collection tanks with runoff from small roofs and the roof garden (a potential source of contamination) discharging direct to the stormwater drainage system. This system produces 1000 litres of collected water for every mm of rainfall. After significant rainfall events the collection tanks overflow to the drainage system. There is no ‘first flush’ diversion of rainwater (because of the high level of treatment provided in the drinking water treatment system) thus optimising the volumes collected.

Other water tools:
There is heat tracing on all the main hot water pipes so that minimal amounts of water are wasted whilst waiting for hot water to arrive at the tap.

One objective of the development was to minimise, when practicable, the use of PVC (poly vinyl chloride), hence ABS (Acrylonitrile Butadiene Styrene) and HDPE (high density polyethylene) piping is used throughout.

Water for the automatic sprinkler system and general fire fighting is supplied direct from the water mains.

Monitoring of many water and energy features in the building is in place to record the performance, water and energy use.

Other tools:
The building is designed to promote the tenants well-being and also requires their cooperation to optimise the environmental performance of the building. The tenancy lease agreements incorporate clauses with regard to tenant and landlord responsibilities and a requirement for tenants to comply with the building's environmental management plan. It also allows the landlord to monitor the building performance of each tenant and provide feedback on this and general building performance to the tenants. Guidelines are also in place for tenancy floor space fit-out plans, each of which must be approved by the Landlord.
There is a large emphasis on education of tenants and visitors and the building developers provide education kits for tenants and their staff on sustainability, manuals on the building features, briefings. An automated feedback system from building monitors to tenants will be available but at the time of the site visit was not yet commissioned.

There is no central air conditioning in the building but each office area has individual user controlled reverse cycle air conditioners with a requirement that set points conform to the Building Rules. Passive air flow through the building is enhanced by four thermal chimneys and there is automatically controlled night purging of air in the summer. Not all ceilings in office building have hung ceilings as this allows increased contact between air flow and the thermal mass. No central air conditioning reduces the total building water use dramatically compared to other commercial premises with centralised systems.

Institutional arrangements:
The building's designers shared the same philosophy and belief in the need for green and significantly more environmentally sustainable commercial buildings in the city. At the time of construction (2002) there was limited institutional set-up and experience in the area. For instance, there were no guidelines for wastewater treatment in commercial buildings. Hence much of the development happened outside of the traditional comfort zone of designers, planners and builders.

Developers had to persuade people to examine normal operation and procedures to minimise environmental impact. This also included preparing construction specifications that required a much higher level of detail than normal in regards to environmental requirements, for individual trades.

Care was taken to avoid claiming the main objective as providing a sustainable building as this was not deemed feasible. A range of environmental objectives were set at the beginning of the project (see Appendix 2) and these were generated by both The Green Building Partnership (owners and building managers) and the Australian Conservation Foundation. The initial design was formulated by a design consortium with input from all key stakeholders. Environmental issues dictated the form of the building - a central atrium with light wells on the north & south boundary walls - and refurbishment of the existing building to maximise reuse of available structure and materials. These preliminary designs were then passed on to the architect and sub-consultants to finalise the building design. The usual engineering approach (which is usually based on potential maximum requirements plus a safety factor) was discouraged since this generally leads to over-design of systems.

Costs:
Overall the building is quoted as costing 5% more than a comparative building of the same standard (brochure of 60L history) and the water/wastewater system constituted only 2-3% of the overall cost. The cost of the system in isolation was higher than that for the conventional set-up, but savings in other areas (e.g. no central air-conditioning system) off-set those costs, resulting in the overall building cost being comparable to commercial buildings of similar size and use.

Savings:
80% reduction in potable water consumption to date, compared to usage prior to recycling treated wastewater. The surplus of treated wastewater is discharged to sewer, being of better quality than normal wastewater. The building uses only about 30% of the energy of the average commercial building in Melbourne and generates a small amount of solar power, purchasing the balance as 'green power' from the electricity retailer.

Benefits:
The incorporation, as far as practicable, of sustainability principles and features into the building has been achieved at similar cost to a conventional building of similar size and use. Most importantly, despite the sustainability features the building is commercially viable and tenants benefit commercially from the increased productivity of staff that arises due to the building environment and provision of a healthy and pleasant workplace. A sense of pride is generated from the environmental features of the building by most tenants and staff operating in the building.

References/contacts:
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http://www.harvesth2o.com/zerowater.shtml
http://thesource.melbournewater.com.au/content/Issue/November2002/lastword.htm
http://www.dpc.vic.gov.au/domino/Web_Notes/MediaRelArc02.nsf/6612047368a7dd1e4a256 8110023abe6/87b275f02a65b0dfca256c58007f2094!OpenDocument&Click=
http://www.lawyersweekly.com.au/articles/0F/0C01F90F.asp?Type=53&Category=853

Collaborators/Stakeholders:

Advanced Environmental Concepts	Environmental Engineering - Che Wall
Australian Conservation Foundation	Don Henry & Michael Krockenberger
Donald Cant Watts Corke	Cost planning - Tim Hogg
Herbert Geer & Rundle	Lawyers - Adam Bratt
John Mullen & Partners	Structural engineers - Mark Byrne
Lincolne Scott	Services engineers - Ray Lacey, Alan Roshan, Paul
Carey & Ben Jordan	
Spowers Architects	Ros Magee, Mike Brickell & Kerryn Wilmot
Steve Paul & Partners	Hydraulic engineers - Steve Campbell
Sustainable Solutions	Peter Brotherton & Alan Pears
Taylor & Cullity	Landscape architects - Perry Lethlean
University of Melbourne	Jon Robinson
Watson Moss Growcott	Noise consultants - Jim Watson
Wilsmore Consulting	Building Surveyor - Len Nelson

60L Lessons:

- Set clear environmental objectives at project initiation
- Consider existing building form when selecting design options for retrofit
- Ensure adequate training and understanding of alternative water features by all building users
- Guidelines for water/wastewater provision for commercial buildings would be useful for future developers and the industry. These were not available at the time of design and development.
- Consider noise and odour issues when citing sewage treatment plant inside building envelope
- Install all services in common trenches to reduce costs and soil disturbance
- Design of the wastewater treatment plant needs to allow for higher concentrations of wastewater due to reduced water usage on site
- Additional time is often needed to source recycled items

5 KEY MESSAGES and LESSONS LEARNT

Traditional water management and policy approaches are under substantial challenge. Projected population growth and increased urban housing densities also impact the water cycle and are important factors in considering future water management.

There is growing recognition that large-scale strategies need to be supported by improvements in water management by business and industry including new residential development. Typically, improvements at this level require involvement from the construction and development industry and local government, the latter to provide the right mix of regulatory control and incentive. There is also growing recognition that “water smart” development can be both cost-effective and value-adding and add considerably to overall sustainability.

There is a need to meet specific local circumstances and to recognise that one solution is not appropriate in all cases. For example, a number of studies have shown that new suburban developments in coastal South East Queensland could be water self-sufficient provided storage is available for highly variable local rainfall (Gardner and Sharma, 2005). However, in inland areas where rainfall diminishes greatly, this option may not be viable. In addition to the practical feasibility of options other environmental, infrastructure, social, economic and institutional influences need to be considered.

Summary key messages and recommendations for further studies for the different technology types are provided below. Additional learnings and issues identified in this project are also presented.

Technologies and technology adoption:

RAINWATER

- Water quantity and quality need to be considered in the design of rainwater collection, storage and distribution systems
- Water savings and reliability of supply depend on climate, storage volume, collection are and end uses
- Careful design of mains back up supply is required to minimise energy use and ensure householder is aware back up supply is in use
- Allocation of responsibility for maintenance and operation of cluster scale storage and treatment is not well defined

STORMWATER

- Robust and reliable methods of treatment need to be developed in order to provide stormwater suitable for mains water substitution
- Large storage volumes for stormwater may be required when used for seasonal end uses
- Space limitations in existing urban areas may limit the feasibility of stormwater collection in this application
- Subsurface tanks need to be accessible and limit potential contaminant ingress
- There are currently no legislative guidelines for use of treated stormwater. Options and design criteria for stormwater harvesting for residential and commercial use are requried

GREYWATER

- Components of household products found in greywater may affect the environment through soil structural degradation, increased soil pH and poor plant growth.

- Separation of greywater from blackwater may require extensive plumbing alterations, especially in retrofit or re-engineering situations.
- There is a lack of information on garden design and watering requirements when greywater is used for irrigation.
- High-technology treatments may have high embodied and operating energy requirements and the capital costs may be high
- The maintenance and management of household and multi dwelling greywater systems needs to be considered
- Style of housing affects the feasibility of greywater use
- Storage and use of greywater can reduce sewer peak flows
- Barriers to greywater use at the cluster and sub-division scale are not well understood

WASTEWATER

- Current wastewater operation, maintenance and management arrangements are not geared for decentralised systems. No current systems are in place to ensure compliance and enforcement of proper maintenance of on-site wastewater systems and current approval processes can be complex.
- The maintenance and management responsibilities of household and multi dwelling wastewater systems needs to be considered
- Knowledge and understanding of the interactions between the built environment, specific site aspects and the wastewater technology is necessary.
- Storage of treated effluent is required to allow for seasonality in demand
- Effluent quality for environmental flows needs to be considered

GENERAL

- The influence of local conditions (rainfall, temperature, soil) is vital in selecting appropriate technologies. Design and planning need to consider detailed site characteristics, including but not limited to; climate, demographics, water usage, soil type, water table and topography.
- Existing building and sites impose limitations on the selection of technologies and the costs and practicalities of retrofit need to be considered. Additional time is required for planning and surveying for retrofit solutions.
- Additional project time is required for verification of the safety and reliability of new or innovative systems
- The visual, odour and noise acceptance of the new technology should be considered
- The energy, materials and chemical usage and amenity value of technologies and systems should be considered in the selection process
- Different scales of collection, treatment and storage can be incorporated into one development i.e. rainwater tanks at lot scale and stormwater at cluster scale
- Alternative water servicing approaches can be incorporated as educational features of a building. Household technologies can also provide increased community understanding of water resource issues.
- There are lengthy approval processes when new techniques or technologies are used and there are no national guidelines for system testing or approvals. A review of legislative and planning process and their impacts on adoption of integrated water service options is required.
- Design guidelines for new technologies need to incorporate potential changes in flows and quality due to other water saving measures i.e. demand management
- Biosolids management needs to be considered during the design of treatment systems
- There is mixed acceptance of household and cluster systems by different stakeholders

Setting objectives and design, planning and construction:

- Developing a clear set of “sustainability” objectives can help guide all stages of the project and provide criteria to review its success.
- Benefits can be maximised when integrated approaches are taken. The integration of water management, demand management and landscape configuration provided the best overall performance in the case studies assessment. Integration of improved water management practices to the overall design and construction processes is also suggested.
- Early consultation and involvement of potential stakeholders during project conception is beneficial to improve communication and also to minimise pitfalls.
- Many technologies are not suitable for the retrofit scenario as the infrastructure required to support them may not be available. For future development the installation of infrastructure to enable separation of different water sources (potable, grey and stormwater) would enable flexibility and “fit for purpose” uses of water in the future.
- Development of clear guidelines for the establishment and design of an implementation program and strategy would help streamline the process by and for developers and help align regional-scale and development scale planning. Design also needs to consider adaptability of the system to future expansion or upgrade and changes in water use patterns.
- Systems must be designed to minimise potential health risks including the risks of cross connections, improper use and accidental use of the “wrong” water
- The impact of householder/tenants behaviour on the performance of the system needs to be considered. For instance, water use and quality patterns differ between commercial and residential households.
- Allowing for fire fighting flows or alternative fire fighting strategies needs to be part of the overall design as design for these flows limits the reduction in water supply infrastructure.
- Guidance is required regarding rainwater tank sizing, greywater system design and many other individual components in schemes.

Verification, monitoring and accreditation

- More information on the performance of newly implemented technologies is necessary. Wider compilation, reporting and benchmarking of the performance and operation of alternative water systems and increasing the availability of this information would aid in this aim.
- Improved understanding of the risks (and relative risks) of some alternate schemes such as greywater storage and irrigation is necessary.
- Pollution and impacts of many of the technologies are still to be verified.
- Remote monitoring is frequently required to ensure adequate monitoring and control particularly of sub-division and cluster-scale technologies.

Social - Institutional and community

- Extended experience indicates that water management practice is stabilised by convergent ideas and values. New ideas and innovations do not have a “home” within organisations. Consequently, traditional approaches continue to be implemented and institutions and management frameworks do not lend themselves to encouraging alternative or decentralised systems and in some situations, actively discourage them. Industry and regulators are still unfamiliar with many of the technologies however the knowledge “bank” is growing particularly about the process of managing integrated water services;
- Institutional adaptive capacity is required as well as a wide range of participants, necessary to contribute to the on-going dialogue on sustainability issues.
- The current approvals process is overly complex and needs to be simplified.

- Generally, the level of householder/tenant impact on system performance increases as the water or wastewater system treatment scale decreases, as flows and loads are not equalised as well as in a cluster or large scale system.
- There is limited experience with developer or homeowner management of alternative systems and alternative management models (including biosolids management) need to be considered. Overseas and Australian experiences also indicate that there is a high potential for development of management and service structures to cater for decentralised water services and reduce the reliance on the householder for maintenance.
- There appears to be a contradiction between householder perceptions of alternative water servicing and actual behaviour. Further investigation in this area is required with assessment of the social benefits and barriers to adoption of particular water technologies.
- There is evidence that the community expects the same level of service from alternative systems as they receive from centralised systems but perceive wastewater to be less valuable than drinking water.
- There is a substantial perceived benefit of amenity (as opposed to water reliability) among many users of alternative water technologies.

Additional recommendations

There are many data gaps identified in this study with respect to technology adoption or operation as listed above. During the course of this study some additional data gaps and concerns were identified relating to broader systems impacts.

There is currently little readily-available information on the water use in commercial, municipal and community buildings. This use can be significant and a non-residential Water Efficiency Guide has recently been released from Department of Heritage and the Environment (2006). Other data is becoming progressively available. For example some extensive data records exist for Sydney University Campus which includes a hospital, sports fields and university departments and is the 23rd biggest water user in Sydney (McManus et al., 2006).

In addition to saving water, water-efficient homes can have additional benefits, such as reduced energy consumption. For example, water-efficient homes can reduce the amount of pumping required to supply water to the property and the amount of energy required to heat water within the home. Unpublished work by CSIRO suggests that the energy required to supply water and wastewater services (mains water and sewerage collection and treatment) to residential and non-residential users in Australia currently contributes only 0.2 percent of the greenhouse gas emissions of the average Australian while the energy associated with heating water within homes is around 1.5 to 2.0 percent.

Other data gaps include:

- The cost and economic impacts of scale, considering capital and operating costs. This needs to consider the impact of pricing mechanisms (including infrastructure charges) and the resultant influence on the viability of integrated water service options.
- The need for, consistency of approaches around and information needs for full life cycle assessment of integrated water service developments.
- Investigation of alternative funding sources for implementation of alternative water servicing approaches.
- Enhanced analysis for water end-use and consumption trend including spatial analysis (to characterise variability within cities) – may be warranted in some cities.

To adequately address these research challenges there is a need for initiation of work by a wide range of organisations collaboratively with research providers. This needs to include contribution from Federal, State and local government, water service providers, technology developers and the development industry. Potential research initiators have been summarized in an industry report based upon this project (Diaper, C., Tjandraatmadja, G and Kenway, S 2007) available from the CRC for Construction Innovation.

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Appendix 1: Full listing of case study sites

Site	***Location***	***Scale (households)***	***Key Features***
60L Green Building	Melbourne, VIC	Commercial, high rise building, 3,375 m^2	Waterless urinals, low flush toilets and low flow showers Rainwater to hot water, bathroom and cold water Wastewater treated for toilet flush + garden
ACT Canberra	Canberra, ACT	6 houses	On site Wastewater Treatment to garden
Agnes Water	Agnes Water, Bundaberg, QLD	32 units	Roof, road and paved runoff to hot and cold water Cluster wastewater treatment to garden, toilet flushing and external uses
Atherton Gardens & King St Housing Estates	Melbourne, VIC	4 high rise	Greywater and stormwater to public open space irrigation Reuse of existing infrastructure
Aurora	Melbourne, VIC	4000 homes with 10,000pe	Rainwater tank with disinfection for hot water to laundry, bathroom and kitchen. Sub-division wastewater treatment to garden + open space Third pipe system Stormwater treatment via planted swales
Ausbuild	Redlandshire, QLD	Proposed greenfield sub division	Stormwater run-off treatment and reuse Landscaping Rainwater tank Energy and water efficient appliances and fittings
Baldwin Riverlands	Brisbane, QLD	Proposed greenfield sub division	Stormwater run-off control on allotment Vegetation buffers along downstream perimeter of site Porous pavement 10 kL Rainwater tank for reuse
Brazil	South of Brisbane, QLD	Proposed greenfield sub division	Third pipe system for wastewater reuse to open space irrigation Stormwater reuse Rainwater tank for 50% of residential lots and all industrial allotments
Carindale Pines	Brisbane, QLD	31 households on 14 hectares	Rain water tank (25kL)for household and drinking. Landscape and road design conforms to natural landform.

Site	***Location***	***Scale (households)***	***Key Features***
			Stormwater control via vegetated swales and ground infiltration AAA water saving appliances
Charles Sturt University – Thuragoona Campus	Albury, NSW	University campus on 87 ha	Water efficient taps, shower heads Stormwater treatment and use for irrigation Greywater reuse for irrigation and laundry Composting toilets Rainwater for temperature control and laundry
Christie Walk	Adelaide, SA	27 households	Water efficient appliances Rainwater and stormwater to toilet flushing and irrigation All wastewater treated and used for open space irrigation
CH2	Melbourne, VIC	Commercial infill 450 pe	4A rated fittings Sewer mining and rainwater for supply of non-drinking water (plant irrigation, cooling, toilet flushing, street washing and open spaces) 25% of potable water used in fire sprinkler testing is collected for reuse as potable water Vertical gardens on north façade.
Coomera Waters Village	Gold Coast, QLD	Greenfield subdivision, 1100 allotments	Stormwater management by swale drains Retention/infiltration basins integrated into design Potential wastewater reuse
Crib Road	Cairndale, QLD	Greenfield subdivision, 43 allotments	Porous paving Grass swales Rainwater tanks Waterway corridors preserved
Currumbin ecovillage	Gold Coast, QLD	Greenfield subdivision, 111 allotments	Recycled wastewater or onsite wastewater treatment Rainwater tanks Solar water system 3A or 4A appliances
Fig Tree place	Newcastle, NSW	Infill development, 27 allotments (1.1 ha)	Rainwater for hot water and toilet flushing Stormwater and aquifer storage
Healthy Home	Brisbane, QLD	1 (460m^2)	3A appliances

Site	***Location***	***Scale (households)***	***Key Features***
			Rainwater to indoor uses Greywater treated but currently not recycled
Homebush Bay	Newington, Sydney, NSW	2,000	Water efficient fittings Dual reticulation of stormwater and wastewater to toilet flushing and irrigation
Inkerman Oasis	Melbourne, VIC	236 units	Greywater and stormwater to toilets flushing and irrigation Indigenous planting
Kelvin Grove	Brisbane, QLD	Proposed high density, 400 -500 pe	Drainage swales with sand filters Grated trench drains (infiltration strips) that feed into planter boxes Pollution traps in gully pits and porous pavement.
Lismore Retrofit Case Study – Stuart White's house	NSW	1 (0.125ha)	Greywater recycled for sub-surface garden irrigation Composting toilet with effluent diversion to greywater treatment system.
Lynbrook Estate	Melbourne, VIC	270 lots on 32 ha	Stormwater treated with bio-filtration and wetlands to ornamental lake An infiltration system is gravity fed from the lake to ensure adequate water supply to remnant river red gums.
Manly West ESRD	Sydney, NSW	20 lots on 1.9 ha	Rainwater for kitchen, bathroom, laundry end uses, back-up of potable water supply Treated greywater for toilet flushing, backed up by rainwater tanks Blackwater used for subsurface irrigation Wetlands used for treating road and open space runoff and overflow from wastewater treatment plant Composting of biosolids and other site organic waste
Mawson Lakes	Adelaide, SA	4,000 (ultimate) Residential/Industrial/ Commercial	Aquifer storage and recovery Dual reticulation of non-potable water fitted to all houses, commercial and industrial properties for toilet flushing, garden watering, car washing and external use, including lake feature. Stormwater run-off from roads and roofs quality

Site	Location	Scale (households)	Key Features
			management uses wetland treatment. Storage in urban lakes and wetlands. Wastewater treatment and utilisation
Moray 93	New Farm, QLD	Residential medium density apartments	Rainwater tank Greywater reuse Hydronic heating (water heated by solar power)
New Haven	Adelaide, SA	65	On-site treatment and re-use of blackwater and greywater for irrigation, toilet flush and oval irrigation. Stormwater collection for first 50kL of rain. Any excess is diverted to a sports field.
North Watson,	Canberra, ACT	3 properties	Rainwater tanks Greywater diversion systems (No.9 Sand filter, No.11 Ecocare, No.13 Perpetual) Drip irrigation with moisture sensors Drought-resistant plants
Oaklands Park	Melbourne, VIC	80 lots on 174 ha	Stormwater for hot water, laundry and drinking water Individual wastewater systems for garden use
Payne Rd	QLD	22	Rain water tanks for reuse within the house. Excess rainwater is diverted to communal tanks located at the bottom of the development. 2 Communal Rainwater tanks (75kL) for storage of household excess for provision of fire fighting and future supply of households at bottom of subdivision. Greywater and kitchen waste treatment for sub-surface garden irrigation. Bioretention filter for stormwater. Sewer collection trunk for discharge to sewerage at non-peak hours.
Pimpama Coomera (general)	Gold Coast, QLD		Rainwater tanks Grass Swales for stormwater control and infiltration

Site	***Location***	***Scale (households)***	***Key Features***
			Purple pipe (third pipe) for recycled effluent supply for open spaces and subsurface irrigation Water efficient fittings and devices encouraged in households
Research House	Rockhampton, QLD	Single house	Fittings: water flow restriction devices for shower, kitchen sink, taps and washing machine. 3A appliances, dual flush toilet Electronic garden sprinklers and sensors Rain water tank
Reservoir Civic Centre	Melbourne, VIC	Civic centre and community facilities	Hot water services located as close as possible to the point of use. Low flow taps, toilets and showers, waterless urinals, efficient dishwashers. Rainwater collection and use for toilet flushing. Stormwater collection from car park runoff used for garden bed irrigation. Real time reporting of water use and rainwater tank storage
The Ridge	Binna Burra, SEQ	108 units in 66 buildings on 96 ha including cabins, holiday homes and apartments in an educational eco-village	Stormwater sensitive design to maintain natural hydrology and water quality. Minimal groundwater extraction for emergency top up and indoor and outdoor baths balanced by equivalent recharge. All wastewater treated on-site to Class A for irrigation. Composting toilets, rainwater collection, water saving appliances and indoor use of reclaimed water
Rochedale	Brisbane, QLD	390 ha low density and 23ha high density with residential, commercial and school	Water tight sewers Local wastewater treatment plant to class A is reused in properties for non-drinking purposes. Rainwater tanks and on-site infiltration technique
Rouse Hill	Sydney, NSW	12,000 households	Dual reticulation of treated wastewater and reuse in toilet flushing, garden watering and car wash Stormwater flow and quality management via ponds and wetlands Wetlands for treated wastewater prior to discharge into receiving waters

Site	***Location***	***Scale (households)***	***Key Features***
Salisbury	Salisbury, SA	Retrofit of backlogged sewage area (No information on scale at present)	Septic Tank Effluent Drainage System Treatment of stormwater via wetlands followed by aquifer storage and recovery. Re-use in non-residential applications
Sharland Park	Geelong, VIC	36 households, greenfield low density	Landscaping and drought tolerant plant selection Stormwater stored in a 120,000 litre underground tank for irrigation of space and parkland Pervious gravel pathways
Springfield	QLD	16 houses + school (ultimately 18,000 h=60k people)	Wastewater for irrigation of public spaces Dual reticulation sample house and industrial park
Sustainable house	Sydney, NSW	1 (175m^2)	Rainwater for indoor use Stormwater for hot water, bathroom and cold water Wastewater for toilet flushing, laundry and garden
Tenterfield	Melton, VIC	Proposed development of 1200 allotments	Water sensitive urban design features, 33% open space, extensive use of hiking and cycling paths
Wagga Wagga	Wagga Wagga, NSW	85 properties	Wastewater supplied for reuse by households
West Wyck	Melbourne, VIC	3 units (12 ultimately) 5 buildings 7 apartments 32 people	Low water use fittings Greywater for toilet flushing On site blackwater treatment for irrigation Rainwater tanks for potable uses
Weyba Ranch Residential Estate	Noosa, QLD	160 lots	Landscape features Treatment and re-use of stormwater run-off within development

Appendix 2: Currumbin Ecovillage project statement and objectives

1. GENERAL CRITERIA – PROJECT STATEMENT & OBJECTIVES

PROJECT STATEMENT
Landmatters Currumbin Valley Pty Ltd intends to practically and successfully develop the subject land and achieve a vision of inspiring sustainable living / development practice and awareness by creating an Ecovillage that exemplifies World's Best Practice in its design, construction and accompanying processes. The project is intended as an inspirational model to the development industry and the broader community.

All activities included in undertaking the development must recognise the following factors:
(a) Environmental Sustainability / Ecology
(b) Social Sustainability / Ecology
(c) Economic Sustainability / Ecology
with each being given equal consideration, without marginalisation of any one factor in decision making processes.

PROJECT OBJECTIVES
To achieve the development's objectives, it will be important to challenge conventional industry thinking by employing practices, processes, systems & designs that embody innovation & excellence in keeping with the project goal. Private & public referral agencies will be asked to participate in this approach.

To achieve the project goal, each of the following principles will require consideration - again without individual marginalisation of any other of the principles. The principles should be utilised to achieve a desired project outcome that:

(a) Is sustainable over time
(b) Relates to the local and global environments
(c) Provides & allows for future beneficial change to occur in design, infrastructure & regulatory mechanisms.

(i) Environmental Principles

Env.1 Restore, maintain & enhance biodiversity acknowledging the intrinsic right to life of all species
Env.2 Strictly minimise impact & change to air, soil & water in any way to ensure equity for all elements of the
natural environment whether living or inanimate
Env.3 Strictly minimise consumption of resources & energy both now & in the future
Env.4 Minimise impact on the local and global environments optimising local ecological food & material production
opportunities
Env.5 Foster a deep sense of human connection to & interdependence with the land, flora & fauna

(ii) Social Principles

Soc.1 Respect & honour cultural, historical & spiritual values
Soc.2 Enable sustainable community by designing for social equity, diversity & interdependence, honouring
differences & catering for the needs of individuals through the different stages of life

Soc.3 Maximise health, safety & comfort of the built environment to provide enduring quality of life
Soc.4 Promote awareness & education of ecological issues including sustainability
Soc.5 Utilise aesthetic sensitivity to create a continuing sense of place and beauty that inspires, affirms & ennobles
Soc.6 Ensure regulatory mechanisms that ensure social equity over time
Soc.7 Promote social connectedness, empathy, ownership & attachment to place & community.

(iii) Economic Principles

Econ.1 Promote ecovillage economic viability through excellence of design
Econ.2 Ensure enduring property value growth
Econ.3 Ensure minimising of maintenance & operational costs
Econ.4 Minimise obsolescence through design of enduring component life cycle;
Econ.5 Provide for change & re-use at minimal cost / loss
Econ.6 Enable economic productivity & contribution to local & world systems & economies.

These are the specific goals of the development that should guide project management, specialist consultants & referral agencies in the intrinsic decision making processes. The above principles are interpreted to achieve Ecologically Sustainable Development outcomes, which are detailed in the following Environmental, Social & Economic Criteria specification.

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