Decentralised Wastewater Treatment and Recycling Systems (DeWaTARS) – a legislative framework and regulatory tool for their management in WA urban villages

Technical Report #1/3
Premier’s Water Foundation Project #034/04G

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Centre of Excellence for Industry Focused Research & Development in Environmental Technology

UNEP-IETC Cooperation Centre for the Asia-Pacific Region

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Preface

This technical report is the first to emerge from a project entitled “Demonstration of Decentralised Wastewater Recycling in Urban Villages” funded by the Premier’s Water Foundation and industry partners including National Lifestyle Villages Pty Ltd and Peel Waters Pty Ltd.

The Premier’s Water Foundation was created in response to the State Water Strategy released in February 2003 by the Western Australian Government. The Foundation’s programs will support research and development projects that challenge boundaries and investigate innovative new ways of conserving water and maximising reuse of wastewater. For further information refer to the following website www.statewaterstrategy.wa.gov.au.

The project “Demonstration of Decentralised Wastewater Recycling in Urban Villages” will monitor and evaluate decentralised wastewater recycling and irrigation demonstration projects operating in Perth urban villages. A wastewater recycling trial will be undertaken to demonstrate the performance and reliability to meet regulatory standards, effects on soil and vegetation, pathogen disinfection, nutrients prevented from infiltration to groundwater, maintenance issues of the systems and the effective amount of scheme and bore water saved in the long term. The research will occur in collaboration with National Lifestyle Villages Pty Ltd, Peel Waters Pty Ltd, Mallee Nominees Pty Ltd and other developers with support from the Department of Health (DoH), the Department of Environment (DoE), local government and the Water Corporation. The project is focussed on the Perth metropolitan area and Peel Region over the period 2005-08. The demonstration projects are as follows:

- **Year 1**: Bridgewater Lifestyle Village (National Lifestyle Villages Pty Ltd) with 389 onsite household greywater recycling systems for yard irrigation;
- **Year 2**: Timbers Edge (Peel Waters Pty Ltd) with common greywater collection from 260 houses to a constructed wetland treatment system for irrigation of public open space (POS);
- **Year 3**: to be confirmed. Under consideration is one of several peri-urban sites where all wastewater from several hundred houses in a village setting will be collected via a common effluent treatment plant for irrigation of POS.

Four (originally three) research studies will be completed over the duration of the project:

- Honours project #2 (by Shaun Jamieson 2006): Decentralised wastewater recycling: performance requirements for use in village scale urban environments under current planning, public health and environmental regulatory requirements for irrigation of POS in urban villages: development of a technology systems database for developers and regulators.
- Honours project #3 (by Jatinder Singh 2006): Nutrient Reduction Assessment for Household and Community Scale Greywater Re-use Systems. (This project could be added to those originally proposed for PWF as additional...
scholarship funding was secured from industry partner Peel Waters Pty Ltd after the contract was signed.)


This technical report is the first of four to be prepared during the project:


There will also be at least two papers published in scientific journals.

Good news for this PWF project was received in mid-2005 when land developer Peel Waters Pty Ltd decided to fund an additional Honours scholarship and Jatinder Singh was subsequently appointed to conduct the research project listed above. More good news was received in December 2005 when Murdoch University offered five PhD scholarships to Environmental Technology Centre doctoral candidates including Beth Strang and John Hunt who have both proposed research topics related to this PWF project.

Dr Martin Anda and Professor Goen Ho
Environmental Technology Centre
Murdoch University
January 2006
Executive Summary

The Premier’s Water Foundation provided funding for the “Demonstration of Decentralised Wastewater Recycling in Urban Villages” project. This technical report is the first publication from this project and presents the following findings:

- A new water user category known as Cluster or Village scale;
- A new alternative wastewater system concept known as decentralised wastewater treatment and recycling systems (DeWaTARS);
- A review of DeWaTARS case study sites around Australia;
- A review of the current WA legislative climate;
- A review of the current WA regulatory climate;
- An outline of a new legislative framework;
- An outline of a new regulatory tool; and
- An outline of a new development tool, known as LADERS.

This study considered all the current practices implemented by various WA government departments and developers. By reviewing the constraints and opportunities afforded to existing Australian DeWaTARS case study sites, this project was able incorporate current best practice methodologies. The main deterrents to DeWaTARS projects are:

- Pricing – The initial start-up costs as well as on-going maintenance and monitoring costs;
- Public Confidence – The ability to meet public health and environmental concerns as well as confidence in the final product reliability;
- Technology – The ability to meet public health and environmental concerns, whilst being economical and easily maintained; and
- Legislation – The long turn around times for approval and the various requirements across many governing bodies.

In short, the following are the DeWaTARS management categories developed in the study:

- Village Management – Bridgewater Lifestyle Village, WA, is an example of a village managed system;
- Strata Body – Timbers Edge Lifestyle Village, WA, is an example of a strata body managed development;
- Local Council – Brisbane City Council, Qld, is an example of a local government authority ran system; and
- Wastewater Utility – Mawson Lakes, SA, is an example of a system ran by a wastewater utility.

Further research is necessary to assess these in practice.
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1.0 Introduction

Climate change and increasing demands on resources are placing pressure on cities water system management. Traditional, centralised “big pipes in, big pipes out” wastewater systems have also come under pressure to meet the objectives of cities adopting an evolving sustainability agenda (Newman, 1993, State Water Strategy, 2002). The new agenda encourages cities to look at how they supply water when traditional measures, such as building dams, are no longer viable or sustainable options (State Water Strategy, 2002; Radcliffe, 2004).

Across the world, cities are dealing with the phenomena of urbanisation: the pattern of high-density living incorporating recreation, work and shopping areas within an integrated transport system. Population migration toward cities has been increasing since the 1950s where estimates placed 30% of the world’s population in cities. During the 1980s estimates had 40% living in cities and it is thought that within 20 years, more than 60% of the world’s population will be living in cities (Jackson and Ord, 2000). Led by rapid economic growth, the increasing population concentration is placing huge demands on cities’ water supply systems and it has been essential to develop new water resources (Miller, 2005; Anon, 2005), even in high rainfall countries like Japan and England (Ogoshi et al., 2000).

There is a growing trend towards alternative water supply systems (AWWS), such as decentralisation, including wastewater-recycling options (Douglas, 1998). The reduction in potable water demand, relative initial infrastructure costs, environmental adaptability and ease of incorporation within new urban village developments, has seen an expansion in decentralised AWWS technologies that meet health, environment and legislative requirements.

Perth, the capital city of Western Australia, has seen relatively unrestricted urban growth push the metropolitan boundaries outwards, often resulting in the encroachment of marginal lands located in areas of high conservation value. Within the next 15 years Perth’s population is expected to reach two million (DPUD, 1990, Australian Bureau of Statistics, 2002) and decentralised AWWS can help relieve the necessity to expand existing, and aging, centralised infrastructure (Ho and Anda, 2004), whilst maintaining sustainable development within a region that has experienced decreased rainfall since the 1980s (IOCL, 2002).

Added to a shortage of potable water is an increasing need to consider environmental requirements (WRC, 2004; Gardner and Chung, 2005). The recognition of the effects of current water management practices on the environment - in particular the effect on wetland and river dependent organisms for WA - has seen the environment become an important consideration when determining future water supply options, thereby placing pressure on traditional water supply practices. Over the past 12 months, there have been a number of sewage overflows into the Swan-Canning river system (Dortch et al., 2005) and, in May 2005, traffic in Perth descended into chaos when a burst water main caused
the shut down of the Kwinana Freeway\(^1\). Incidents such as these are becoming commonplace (Dortch \textit{et al.}, 2005), demonstrating a need for major maintenance and/or system upgrades. In light of these factors the adoption of AWWS is growing in popularity.

Analysis of the legislative challenges in WA highlighted the lack of recognition of village scale AWWS as a ‘credible’ user group. The inclusion of village scale decentralised AWWS is important, as once recognised, the specific challenges facing multi-connection, decentralised systems can be clearly seen.

There are economic, social and institutional challenges facing the successful implementation of AWWS into WA. “\textit{...The main barriers to reuse of water in Australia are issues of public confidence, health, the environment, reliable treatment, storage, economics, the lack of relevant regulation, poor integration in water resource management and the lack of awareness...}” (Dimitriadis, 2005 p10). Previous research has shown that by addressing the institutional impediments, the social and economic impediments can be ameliorated. “\textit{...The overarching institutional impediment to conservation and reuse is a lack of coordination of both policies and regulations that govern water conservation and reuse. This problem is endemic to many areas of natural resource policy where local governments, regional authorities, States and the Commonwealth all have roles to play, responsibilities and overlapping concerns. Complicating the challenge to coordinate policy and regulation is the problem of how best to facilitate flows of information to ensure that policy, regulation and practice change with the evolving state of knowledge...}” (MacDonald and Dyack, 2004 p2).

The development of an AWWS concept is key to instituting appropriate legislative frameworks. Frameworks provide a “\textit{...set of assumptions, concepts, values and practices that constitutes a way of reviewing reality...}” (HMC, 2005 p1). Without a defined concept, legislative frameworks will either become too broad, where every alternative option is incorporated, running the risk of having no substance, or very specific, which can lead to confusion when new technologies or practices fall outside the framework parameters.

With the continued threat of water shortages, WA will need to develop and implement a wide variety of water supply strategies to meet demand. With the implementation of AWWS, and the development of new water markets, there will be a need to ensure that regulatory requirements be co-ordinated, across the many government departments, and that a clear framework, which developers can follow, is established.

The recent release of the following studies and regulatory instruments are promising but also highlight the need for co-ordination:

- Department of Health (January 2005), Guidelines for Domestic Greywater Reuse in Western Australia;
- Department of Health (June 2005), New Public Health Act for Western Australia: A Discussion Paper;

\(^1\) The Kwinana Freeway is the main southern arterial road that leads in and out of the city of Perth; and connects with the main northern arterial road, the Mitchell Freeway. The freeway follows the Swan-Canning river system leading into the Mitchell Freeway north connection.
• Water Corporation (September 2005), Non-potable Water Use: Guidelines for Developers and their Consultants, prepared by GHD;
• Water Corporation (draft November 2005), Waterwise Land Development Criteria, a Joint Initiative of the Water Corporation & the Land Development Industry in Western Australia;
• Economic Regulation Authority (November 2005), Inquiry on Urban Water and Wastewater Pricing, Final Report;
• Proposed Model for Integrating Urban Water Management with Land Use Planning, Prepared for the Southern River MOU Group by Essential Environmental Services, October 2005;
• Natural Resource Management Ministerial Council & Environment Protection and Heritage Council (October 2005), National Guidelines for Water Recycling: Managing Health and Environmental Risks, draft for public consultation;
• Department of Parliamentary Services, Parliament of Australia (August, 2005), Issues Encountered in Advancing Australia’s Water Recycling Schemes.

The move into decentralised technologies will require developers to prepare management, monitoring and maintenance protocols to ensure that regulatory requirements from the various government bodies are met. This report describes different management approaches and the options currently available, as well as proposing a new management and water balancing models that are suitable for any AWWS concept implemented in new WA urban village developments.

This technical report is primarily the result of an honour thesis conducted by Beth Strang. A thesis completed by John Hunt provided additional information on the LADERS assessment tool. The following report is structured as follows:

• Chapter two presents a brief methodology, outlines a new user category called village (or cluster) scale and introduces a new alternative wastewater system (AWWS) suitable for implementation in WA;
• Chapter three outlines the interstate and WA case studies used in this research. These are broken down into a description of the site location, management structure and technology implemented, while highlighting issues that have implications for the application of AWWS in WA;
• Chapter four identifies the different legislative bodies and the role played in regulating AWWS in WA;
• Chapter five outlines a new legislative framework and some of the changes required from the various legislative bodies, to ensure the adoption and implementation of AWWS in WA;
• Chapter six outlines the current regulatory tools available to developers implementing AWWS in WA;
• Chapter seven outlines a new regulatory tool that will need to be developed to assist developers meet the necessary regulatory requirements, across the various governing departments; and
Chapter eight discusses a new water balance model and how the application of the model provides developers with the necessary water flow measurements necessary to ensure that the correct system is in place.

The appendices include:
- The components of a local water management strategy;
- The components of an urban water management plan;
- Example operation and maintenance manuals for Bridgewater Lifestyle Village, Timbers Edge and Dizzy Lamb Lifestyle Village;

2.0 Methodology

The research for this technical report was conducted as follows:
- Literature research of current legislation and regulation;
- Literature research of scientific journals and papers;
- Review of existing water modelling concepts;
- Technical reports from WA case study sites; and
- Interviews with key WA stakeholder, including the Water Corporation, Departments of Health and Environment and Developers.

3.0 A New User Category – Village (or Cluster) Scale

In the Perth metropolitan region, legislative frameworks centre on single households and municipal wastewaters. For example the DoE requires a works approval and license for systems processing wastewater volumes of 100kL/day or greater. The DoH requires that individual homeowners, with volumes of 1.8kL/day, wishing to install a greywater system needs to comply with the code of practice for the reuse of greywater in WA (DoH, 2005); highlighting a gap in the current legislation for volumes between 1.8 and 100kL/day. In urban villages looking to incorporate a decentralised wastewater system, where connection services several homes, system capacity will be greater than that of a single system, but may or may not meet the regulatory flow capacity prescribed to municipal wastewater treatment plants, (refer Table 1). The current system only recognises the capabilities of the individual homeowner and large wastewater treatment plants, in meeting health and environmental concerns. In order to encourage wastewater treatment and recycling, it is important to recognise a new user category capable of meeting the health and environmental requirements, whose wastewater volumes fall between the two existing categories, allowing for multiple connections.

By recognising that there is a gap, a new user group can begin to be defined. In the United States, the National On-site Wastewater Recycling Association (NOWRA) describes medium-scale development as those systems with a flow of one million gallons per day; this equates to approximately 3785kL per day, or approximately 2100 homes (NOWRA, 2004; Wallace and Austin, 2004). Using NOWRA as a guide, flow rates, and hence categories, have been proposed for the WA environment, these are:
- cluster scale 1.8 to 100kL/day (2-500 households); and
- village scale 100 to 10,000kL/day (500 to 5500 households).
<table>
<thead>
<tr>
<th>Flow Capacity</th>
<th>Category</th>
<th>Streams</th>
<th>Treatment Required</th>
<th>Typical Systems Employed</th>
<th>Regulatory Framework</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1.8kL/day (10 persons x 180 L/day, the minimum size for a single household w/w systems)</td>
<td>Greywater</td>
<td>Primary +/- or Secondary depending on end use</td>
<td>Grey water diverter</td>
<td>Well documented with clear regulatory frameworks i.e. Code of practice for the reuse of greywater in Western Australia and Health Act 1911: Health (Treatment of Sewage and Disposal of effluent and liquid waste) regulations 1974</td>
<td></td>
</tr>
<tr>
<td>(Existing) Single Household</td>
<td></td>
<td></td>
<td>Septic Tank</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All wastewater</td>
<td>Secondary</td>
<td></td>
<td>ATU</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Micro – ie Membrane units</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEW 1. Cluster Scale Flow 1.8-100KL/day (2-50 homes) eg block of flats</td>
<td>Greywater</td>
<td>Primary +/- or Secondary depending on end use</td>
<td>Coarse mesh grit screen</td>
<td>Unrecognised category with unclear frameworks potential for a Code of practice for Urban DeWaTARS, although in practice regulators refer to DeWaTARS as municipal WWTP. The Department of Environment requires that any sewerage treatment facility producing 20 - 100KL/Day must have a Works Approval or Works Approval and License respectively issued by the DEP prior to construction commencing (Environmental Protection Act 1986). Rights in Water and Irrigation Act 1914, administered by the Department of Environment, states that where high levels of N and P are applied to land and there is a risk to sensitive water resources, a Nutrient and Irrigation Management Plan (NIMP) may be required before a licence is granted. The Water Corporation (Water Corporation Act 1995) controls the engineering design standards for sewers by developers connecting to their pump stations and main trunks.</td>
<td></td>
</tr>
<tr>
<td>NEW 1. Cluster Scale Flow 1.8-100KL/day (2-50 homes) eg block of flats</td>
<td></td>
<td>Secondary</td>
<td>Septic Tank</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Tertiary treatment to class A required if water is to be piped back into the house)</td>
<td>ATUs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wetland &amp; media filter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEW 2. Village Scale Flow 100 - 10,000KL/day (500-5500 homes)</td>
<td>Greywater</td>
<td>Tertiary</td>
<td>Bar screen eg Woodman Point</td>
<td>Well documented with clear regulatory frameworks i.e. Health Act 1911: Part IV for Sewerage Scheme operated by a local government and Financial Administration and Audit Act 1985. Under the Environmental Protection Act 1986, the Department of Environment requires that any sewerage treatment facility producing &gt;100KL/Day needs to be licensed.</td>
<td></td>
</tr>
<tr>
<td>NEW 2. Village Scale Flow 100 - 10,000KL/day (500-5500 homes)</td>
<td></td>
<td></td>
<td>Lagoons eg Broome and currently at Banksia</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SBRs eg Rottnest</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MBRs eg Inkerman</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
By understanding the shortcomings within the current legislation, and by including a new user category called village or cluster scale, a new framework can be developed that can be understood and interpreted easily by developers and regulators alike.

3.0 A New AWWS Concept for WA

Building on the parameters outlined in Table 1, a new AWWS concept, suitable for the WA social, economic and legislative climate, needed to be developed. Radcliffe (2004, p35) states “…it is essential we get it right! One publicised failure could undermine every recycling scheme. This would put at risk all the capital invested…”. With this in mind it was important to review all current AWWS case studies, overseas and interstate, to ensure that past mistakes were not duplicated and that best practice protocols learnt could be developed further.

3.1 Decentralized Sanitation and Reuse (Germany)™

Decentralized sanitation and reuse (DeSa/R)™ involves the separation and treatment of different wastewater streams to promote optimal reuse (Huber, 2004). The Huber Technology Centre (HTC) in Germany coined the term “DeSa/R”. The HTC creates small wastewater treatment plants for up to 150 households. The centre promotes Huber technologies that can be implemented in DeSa/R projects and provides service support for their products such as the MembraneClearBox®, and the membrane technologies VRM® and VUM® (Hackner, 2004; Huber, 2004).

3.2 Ecological Sanitation (Sweden)

In Sweden a similar approach called Ecological Sanitation (EcoSan) has been created. This approach builds on the link between people and the resource (Winbald and Simpson-Hebert, 2004). The EcoSan website describes EcoSan as “…a three-step process dealing with human excreta: containment, sanitization and recycling. The objective is to protect human health and the environment while reducing the use of water in sanitation systems and recycling nutrients to help reduce the need for artificial fertilizers in agriculture. EcoSan represents a conceptual shift in the relationship between people and the environment; it is built on the necessary link between people and soil…” (EcoSan, 2005 p 1).

In Sweden there are over 20 different wastewater service providers. The Swedish experience has shown that “regular monitoring, professional support for service, maintenance and technical support” as well as “service agreements (are) necessary for the whole lifetime of the system” (Anon, 2003 p 1).

3.3 Environmental Protection Authority Model (USA)

The USA Environmental Protection Authority model promotes the best practice model for individual on-site AWWS. This model involves taking management of decentralised AWWS out of the hands of householders and into the professional domain, where professional standards can be monitored and maintained (West, 2000). The system elements include:
• Household watertight interceptor tank (anaerobic or aerobic) with effluent filter;
• Watertight small diameter PVC or polyethylene pipes with heated welded joints;
• On going education of householders, regulators, real estate agents and other stakeholders;
• Remote monitoring; and
• Professional training for on-site service people.

The model is based on single units at the household level within a centralised monitoring and maintenance program. The homeowners are charged a monthly service fee, which is similar to the service fees paid by customers connected to the traditional wastewater system.

3.4 Sydney Water

West (2000) proposed the following model as best practice for wastewater services to Sydney Water:

• Wastewater source control;
• Watertight collection units;
• Watertight reticulation;
• Advanced onsite treatment systems reconfigured to service a cluster/village/town;
• Ultra-violet disinfection;
• Effluent recycling and reuse; and
• Centralised management facilitated by remote monitoring.

West also identified that to be successful this model would need to be supported through a series of manual, technical sheets and management guidelines.

3.5 Decentralised Wastewater Treatment and Recycling Systems (DeWaTARS)

Like the German and Swedish approaches, DeWaTARS connects people with their environment and reduces potable water demand. As the name implies, DeWaTARS refers to wastewater treatment systems being separated from traditional centralised systems, promoting local reuse. The DeWaTARS concept differs in two ways from these international approaches. Firstly, this approach does not promote one particular product or method over another, as in the German model, only the idea of wastewater treatment and recycling. Secondly, DeWaTARS incorporates the American model of centralised management of decentralised systems, whether a single unit or a cluster of units.

Like the USA model and the proposed Sydney Water model, the DeWaTARS concept can be implemented for single on-site household units, with centralised monitoring, but can also be adapted to multiple homes connected to a single off-site unit. The new concept requires only that the chosen DeWaTARS technology implemented,
whether a single home or cluster of homes, has a centralised management approach by a licensed wastewater service provider or LGA.

In order for legislative and regulatory tools to be effective it is important to define the concept of DeWaTARS. Recognition of DeWaTARS allows authorities, involved in regulatory implementation, to provide guidance to developers. This means setting parameters for potential DeWaTARS projects. These are:

- Can apply to any treatment and recycling system that is independent from the centralised wastewater system;
- Involves either a) multiple connections to the chosen DeWaTARS technology; or b) the central management of several on-site DeWaTARS;
- Treated wastewater is used for local reuse; whether that be for in-house, ex-house or for public open space irrigation;
- Will have decentralised management by a licensed wastewater service provider or LGA, who ensures operation, regular maintenance and monitoring;
- Will be required to implement a HACCP/risk management plan; and
- Can include any technology that has been approved by the relevant regulatory authorities.

The acceptance of the DeWaTARS concept, with village/cluster scales a valid entity, raises the question of the capability of the management bodies to manage and operate the technologies implemented. Taylor and Weber (2004, p593) state, “…When developing an effective policy framework, it is necessary to first gain a sound understanding of the management environment in which the framework is to be delivered…”. By reviewing the different management options utilised by various Australian examples, four options shown on Table 2, were identified as being appropriate for WA.

Table 2 MANAGEMENT – Options and the management characteristics of each

<table>
<thead>
<tr>
<th>Option</th>
<th>Land Structure</th>
<th>Land Owners</th>
<th>Management Body</th>
<th>Characteristics</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Single Title</td>
<td>One</td>
<td>Village Mgmt</td>
<td>Small Scale Development (&lt; 40Ha)</td>
<td>Bridgewater Lifestyle Village, Erskine WA; Dizzy Lamb Lifestyle Village, Carabooda WA</td>
</tr>
<tr>
<td>2</td>
<td>Single Title</td>
<td>One or multi</td>
<td>Strata Body</td>
<td>Small Scale Development (&lt; 40Ha)</td>
<td>Timbers Edge Village, Dawesville WA</td>
</tr>
<tr>
<td>3</td>
<td>Multiple Titles</td>
<td>multi</td>
<td>Local Council</td>
<td>Large Scale Development (&gt; 40Ha)</td>
<td>Brisbane City Council, Brisbane QLD</td>
</tr>
<tr>
<td>4</td>
<td>Multiple Titles</td>
<td>multi</td>
<td>Wastewater Utility</td>
<td>Large Scale Development, but can supply to small developments.</td>
<td>Mawson Lakes, Adelaide SA; Rouse Hill, NSW; Aurora, Vic.</td>
</tr>
</tbody>
</table>

The management options listed in Table 2 encompass the breadth of residential management varieties found in Perth, WA. Boller (1997 p 11) states, “…experience has shown that only skilled operation, maintenance and control of small treatment plants can guarantee satisfactory performance…” the following management criteria
has been highlighted as necessary for successful implementation of village scale DeWaTARS:

1. The ability to develop and implement a risk assessment and management plan;
2. Public Liability insurance cover for residents and Workers Liability insurance for employees undertaking maintenance work on the system;
3. Management infrastructure in place to ensure timely and efficient management of the system;
4. Ability to monitor the system;
5. Technical ability to maintain, operate and update the system; and
6. A cost recovery mechanism that is fair and equitable.

Once the management criteria had been identified, the criteria were compared against the outlined management options, as shown in Table 3. It was found that all management options, other than wastewater utilities, could operate greywater systems. The study also questions the ability of management bodies to maintain the chosen AWWS. For example, if the management body is not technically equipped to manage the proposed AWWS, then there will be a requirement to contract external professionals who are.

Table 3 MAINTENANCE – Identified operation and maintenance arrangements and their ability to meet regulatory requirements

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Single Home</td>
<td>Yes</td>
<td>Generally No</td>
<td>Yes</td>
<td>Generally No</td>
<td>Yes</td>
<td>Yes</td>
<td>Generally No</td>
<td>Yes</td>
</tr>
<tr>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Strata Body</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Generally No</td>
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</tr>
<tr>
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<td>Yes</td>
<td>Yes</td>
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</tr>
<tr>
<td>Wastewater Utility</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Generally No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

4.0 Case Studies

The research undertaken reviewed various Australian DeWaTARS case study sites. The sites covered the range of management options identified in Table 2. A complete list of the case study sites and location can be seen in Table 4. The use of case studies highlighted the “…involvement of one or more public organisation (i.e. a city council or water authority) in order to provide demonstration projects, with the intention of stimulating private developers to adopt a more integrated approach to water servicing…” (Mitchell, 2004 p13). The case study profiles include the following:

A. Site description
B. Technology implemented
C. Management option in place; and
D. Implications for DeWaTARS.

Table 4 CASE STUDIES – List of Australian DeWaTARS case study sites considered

<table>
<thead>
<tr>
<th>Site Name</th>
<th>State</th>
<th>Technology (Key feature in bold)</th>
<th>Management Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inkerman D’Lux</td>
<td>Vic</td>
<td>Common greywater and stormwater collection and wetland + MBR + UV treatment for third pipe to toilet flushing</td>
<td>Strata Body (strata-title, multi-connections)</td>
</tr>
<tr>
<td>Mawson Lakes</td>
<td>SA</td>
<td>Common greywater and stormwater collection and wetland + DAF treatment + disinfection for third pipe to toilet flushing and yard irrigation</td>
<td>Local Council (multi-title, multi-connections)</td>
</tr>
<tr>
<td>Aurora</td>
<td>Vic</td>
<td>Common wastewater collection to treatment for third pipe to toilet flushing and yard irrigation and for POS irrigation</td>
<td>Local Council/Water Utility (multi-title, multi-connections)</td>
</tr>
<tr>
<td>Rouse Hill</td>
<td>NSW</td>
<td>Common wastewater collection to treatment for third pipe to toilet flushing, laundry and yard irrigation</td>
<td>Water Utility (multi-title, multi-connections)</td>
</tr>
<tr>
<td>Bridgewater Lifestyle Village</td>
<td>WA</td>
<td>Household greywater filter treatment for yard irrigation</td>
<td>Village Management (single title, multi-connections)</td>
</tr>
<tr>
<td>Timbers Edge Resort Village</td>
<td>WA</td>
<td>Common greywater collection and wetland treatment for POS irrigation</td>
<td>Strata Body (strata title, multi-connections)</td>
</tr>
<tr>
<td>Dizzy Lamb Lifestyle Village</td>
<td>WA</td>
<td>Common wastewater collection and MBBR treatment for POS irrigation</td>
<td>Village Management (single title, multi-connections)</td>
</tr>
</tbody>
</table>

4.1 Interstate: Inkerman D’LUX

A) Site Description
The development, formerly known as Inkerman Oasis, is a 236-multi level apartment redevelopment on 1.2 hectares, which was formerly a council depot for the inner city of St Kilda. The project, on Inkerman Street, is a joint venture between the City of Port Philip and Inkerman Developments Pty Ltd. The federal Urban Stormwater Initiative provided over $250,000 in funding for the enhanced greywater recycling system.

B) Technology Implemented
Integrated Eco Villages (IEC) was contracted to design and supply the DeWaTARS technology implemented. South East Water (SEW) has been contracted for six years to operate and maintain the system with IEC providing consultative services, to SEW, for the first twelve months of the six-year operating period.

Key components are:
- Subsurface flow wetland for stormwater storage;
- Lint trap for greywater pre-treatment;
- A membrane bioreactor for treatment of both stormwater and greywater; and
• A UV disinfection system.

The system is designed to ensure and verify the quality of the final product (fit-for-purpose). A membrane bioreactor removes discharge from the balance tank and wetland, while disinfection is via UV light. The cycle is completed with the pumping of treated wastewater through a ring main in-house for toilet flushing or ex-house for subsurface irrigation of gardens (Coulthurst et al., 2005).

A hazard and operability (HAZOP) study was conducted with the following major issues addressed:
• Ability for greywater to be diverted to sewer in case of breakdown to prevent backlog and allow maintenance/repair;
• Ability for treated water to be diverted to sewer in case of a flood event; and
• Ability for treatment plant to be monitored adequately using telemetry and ability to immediately stop the supply of recycled water and rely on potable backup if required. (Coulthurst et al., 2004 p 620).

C) Management Type
A Strata Body (also known as a body corporate) manages the system, contracting out maintenance and operation of the chosen DeWaTARS technology to a wastewater utility. It is estimated that residents will pay approximately $45 per annum to meet the costs under the contract.

SEW provides financial support for the developer, while operating and maintaining the system under a contract with the body corporate. There is a six-year lease between the body corporate and SEW, with annual payment of fees for the services (Coulthurst et al., 2005). The operation and maintenance period for the recycled water system commenced once the ability of the system to meet the performance requirement was demonstrated.

SEW also provides regular site and equipment inspections (as per an agreed schedule); alarm response; sampling and analysis of samples as per legislative requirements; maintenance (as per an agreed schedule) and report preparation. SEW is also responsible for developing and undertaking the verification process (Coulthurst et al., 2005).

The Body Corporate and SEW acknowledge joint ownership of public liability insurance over the development. This is done by a “…contract between the two parties (that) requires each party to maintain public liability insurance of an equal amount covering such things as damage to property and death, illness or injury to third party. In addition to this South East Water is required to maintain workers compensation insurance and professional indemnity insurance as the operator…” (Coulthurst et al., 2005 p 620). It was considered appropriate that IEC, the project consultants, also carry some of the liability and required that they maintain public liability and professional indemnity insurance equivalent to that held by South East Water.

The Body Corporate has also adopted the Victorian principal of “Plumber Awareness”. This practice requires that all plumbers visiting the site are aware of the dual reticulation system; and are fully trained on the regulations and practices.
governing such a system. This will require ongoing communication with residents to ensure that protocols that ensure health and environmental safety are embraced. The new Australian Code of Plumbing will assist with the education and training of plumbers.

D) Implications for DeWaTARS

System ownership is vested in the body corporate; this raises the possibility that the equipment will be shut down if future costs become unacceptable. To reduce this risk the technology implemented and the maintenance and monitoring schedules required need to be both economically viable and within the management body’s technical capabilities.

The project preceded the development of any Victorian regulatory framework resulting in confusion over regulatory requirements, specifically from the Victorian EPA. This impediment has been amplified by the fact that the designers and suppliers are located in Canberra, ACT, leading to delays due to differing state requirements. This resulted in a situation where the project was well into the construction phase before “…constructive discussions with the regulatory bodies…” occurred (Coulthurst et al., 2005 p 621). This incident led to the introduction of Environmental Improvement Plans (EIP). EIPs assist future developers outline risk management and operational controls being implemented for the short-term construction phase and long-term ongoing system management.

The success of any dual reticulation scheme relies on the willingness of the community in and around the project to take on the technology and to adapt their demand practices. A community education approach was identified though the development process at Inkerman D’Lux, with the main points being:

- Identifying the community, including the physical boundary (where you draw the line);
- Determining the needs and wants of the community;
- Determining the needs and wants of the Water Utility and other stakeholders to ensure that environmental and health issues are managed;
- Determining the engagement/consultation requirements during different phases of the development; and
- Determining the tools for engagement/consultation.

The wastewater is treated to Class A, as per Victorian standards for reclaimed water, specifically to the following maximum levels:

- Bacteria < 10 E.Coli per 100mL;
- Helminth < 1 Helminth per L; (eg Hook, Round and Tape worms);
- Protozoa < 1 protozoa per 50L; (eg Giardia and Cryptosporidium); and
- Virus < 1 virus per 50L. (eg Rotavirus, Hepatitis A, Enterovirus).

By treating to Class A, the end product can be used for non-potable applications inside residences. This development will provide evidence on:

- The reliability of a dual pipe system in meeting these regulatory requirements;
- How the community is adapting to the technology;
- The economic and environmental savings; and
• Provide evidence as to best practices in ongoing management and maintenance schedules.

Due to the inexperience of the Victorian Regulatory Authorities, in regards to wastewater recycling, the approval process was slow, with limited economic incentives for developers and a lack of information on how “…Water Sensitive Urban Design (WSUD) dovetails with the construction process and construction requirements…” (Melbourne Water, 2005). These issues indicate that for DeWaTARS to be accepted and encouraged, the application and approval process needs to be streamlined, mediation of the financial costs needs to occur and universal education on WSUD principles conducted.

4.2 Interstate: Mawson Lakes

A) Site Description
This project is a joint venture between the South Australian Government Land Management Corporation and Delfin Lend Lease, with support from the University of South Australia, the City of Salisbury and Telstra. It is located 12km north of Adelaide on 620 hectares that will include residential (~10,000 people), tertiary education facilities (5,000 students), commercial and industrial (6,000 workers) districts.

B) Technology Implemented
Stormwater is diverted into natural wetlands for cleaning, storage (via infiltration to an aquifer situated underneath Sir Douglas Mawson Lake) and reuse. The natural ecosystem processes also assist with the water quality within the aquifer (Mawson Lakes, 2005). Wastewater from the development is transported to the Bolivar Sewerage Treatment Plant, 8 kms away, and treated using a Dissolved Air Floatation/Filtration plant. The treated wastewater is then transported back, mixed with the treated stormwater and delivered, via a third pipe, to residences for watering gardens and parks, washing cars and toilet flushing. This development aims to save approximately 800ML/year with all pipework coloured purple for clear identification.

C) Management Type
Option 4: Wastewater Utility. In this management group the wastewater utility is in charge of all maintenance, monitoring and operation of the DeWaTARS as well as fee raising. In order to ensure that residents are connected to the dual reticulation systems there is an encumbrance on lands titles. An encumbrance ensures that new homeowners within the development are aware of their obligations.

D) Implications for DeWaTARS
Social research conducted at this site has revealed that recycled water needs to suit the purpose for which it is being used (Hurlimann and McKay, 2005). The current pricing structure of the system includes a once only installation of metre fee and a flat rate of $0.77c/kL. In comparison the current prices for drinking water in Adelaide are $0.44c/kL for the first 125kL then $1.03/kL thereafter as well as an annual meter fee being applicable. Hurlimann and McKay recommend that recycled water pricing should be stepped, as is the current practice for drinking water, and that a review of drinking water pricing should also be undertaken.
4.3 Interstate: Aurora

A) Site Description
Developed by VicUrban, previously known as the Victorian Urban and Regional Land Corporation, the Aurora development is on 668 hectares located 20km north of Melbourne’s CBD at Epping and provides 8500 residential lots with housing and employment opportunities for 25,000 people. There are a variety of land use categories including high/medium/low density and public open space. The project site is away from traditional services, with sewer not expected within the area for eight to ten years.

B) Technology Implemented
An on-site sewerage treatment plant will supply treated wastewater and be supplied to residences via a third pipe system. The reclaimed water is treated to Class A standard, as per the Victorian guidelines, and can be used for toilet flushing, garden watering, public open space irrigation, car washing and fire services. There are also demand management programs, rain gardens and rainwater tanks at the allotment scale, bioretention trenches and streetscape swales.

As per McLean (2004) the rainwater harvesting system includes:
- Rainwater tank with optimal capacity of 2.3kL;
- Pump with capacity of 24L/min at 200kPa;
- First flush device; and
- UV disinfection unit.

A trial has been set up to review the use of rainwater in hot water systems. Storage and instant hot water systems are being tested, with the information being collected forming part of a new national database on rainwater quality being co-ordinated by the CRC for Water Quality.

C) Management Type
Option 4: Wastewater Utility. In this management group the wastewater utility is in charge of all maintenance, monitoring and operation of the DeWaTARS, as well as fee raising.

D) Implications for DeWaTARS
The use of the Aquacycle water balance model on traditional and alternative water supply/disposal options for the Aurora development, using 20 years of climatic data, allowed various options to be reviewed before deciding on the best option for the project. A general impediment for WSUD introduction is the inability for current financial models to incorporate externalities, such as improved environmental health and delayed infrastructure expansion benefits. A triple bottom line (TBL) model was used to assess the Aurora project. By using the TBL model, values can be given to the externalities, thereby giving a clearer economic, social and environmental cost of a project.

This case study aims to achieve the best practices benchmark for WSUD. Mclean (2004, p22) states “…the project captures the holistic spirit of WSUD in that it
considers water supply, wastewater and stormwater as integrated streams rather than independent systems...”. The WSUD implemented at Aurora is expected to:

- Reduce potable water usage by ~70%;
- Reduce the volume of stormwater discharged from the site; and
- Reduce nitrogen and phosphorus discharged into the environment (Port Phillip Bay), from stormwater and wastewater streams.

The use of recycled water within the project was approved provided “…that the appropriate audit and regulatory regimes (where) implemented and applied including a Hazard Analysis and Critical Control Points (HACCP) based approach to risk management…” (McLean, 2003 p8). This project also highlights how partnerships with government agencies, water authorities and local councils can assist with the development of solutions to site specific challenges facing DeWaTARS implementation.

4.4 Interstate: Rouse Hill

A) Site Description
The Rouse Hill project is northwest of Sydney within the Hawkesbury-Nepean River region. The Rouse Hill Project Area is part of a much larger development incorporating the suburbs of Kellyville, Parklea and Rouse Hill known as the Rouse Hill Development Area. The proximity of the project to the Hawkesbury-Nepean river system necessitated the implementation of a water-recycling scheme. This was to satisfy the requirement that the receiving waters, in this case the Hawkesbury-Nepean River, was not compromised by the development. This case study highlights how developers and regulators can cooperate to ensure the best outcomes for all parties.

B) Technology Implemented
The Rouse Hill Sewerage Treatment Plant has a maximum treatment capacity of 4.4ML/day and incorporates ozonation, microfiltration and super-chlorination techniques to supply treated wastewater to residences (capacity of 35,000 residences), via a dual water supply network, for toilet flushing, garden watering, car washing and laundry use (Radcliffe, 2004 p56).

C) Management Type
During the early stages of the development phase for this project an Environmental Impact Statement (EIS) was conducted. The EIS highlighted the fragile nature of the Hawkesbury-Nepean river system, advising that there would be an adverse environmental impact on the system should additional nutrients enter into it.

A partnership was formed between Sydney Water and the Rouse Hill Infrastructure Development Authority (the Authority). In this management group the wastewater utility is in charge of all maintenance, monitoring and operation of the DeWaTARS, as well as fee raising.

D) Implications for DeWaTARS
Lessons learnt from the Rouse Hill Project provided the following recommendations for future projects (De Rooy and Engelbrecht; 2003, Mitchell, 2004 p35):

- Implementation of adequate management procedures that include quality assessment of the plumbing work, thus minimising the risk of cross-connection (over 50 cross-connections were found and corrected before the connection of recycled water);
- Design the recycled water plant to reliably meet microbiological parameters through the continuous control of critical treatment processes;
- Adequate sizing of the treatment, storage and reticulation system to alleviate the issue of high peak demands for recycled water;
- Continual water conservation program for the residents; and
- The centralised management of operation, maintenance and monitoring.

This project also highlighted the disparity between the pricing of wastewater and the cost of producing each kL. As of 2004, the cost of producing each kL was approximately $3-$4, whilst the sale price was $0.28 per kL; this is compared to the $0.98 per kL for drinking water (Radcliffe, 2004). This price difference between the two water supplies has seen total summer water demand increase to levels much higher than those experienced by similar sized conventional subdivisions. Where the prices of the recycled water and drinking water are comparable there has been no increase in total water demand. This can be seen in Homebush Bay, the site of the 2000 Olympic Games and Newington Village, another Sydney dual supply subdivision, where the price of recycled water is $0.83.

Although not discussed in full in this report, a brief review of Newington Village, another NSW village scale development, by Mitchell (2004, p36), advises “…it is important to develop well thought out operational processes during the planning, design, construction and commission of non-conventional water servicing systems, particularly those with decentralised technologies which require more day-to-day operation and monitoring…”.

4.5 Western Australia: Bridgewater Lifestyle Village

A) Site Description
The site of Bridgewater Lifestyle Village, at Erskine, has previously been used for farming and grazing and is located within the seaside City of Mandurah, south of Perth. The project site is on 14.5ha, with a conservation wetland area on the east boundary and the Peel inlet to the south, separated only by a 50m buffer zone.

B) Technology Implemented
The technologies implemented at this case study were required to achieve the following:

- Provide an environmentally and economic alternative to groundwater reticulation during summer;
- Promote the most appropriate use of decentralised systems within an urban setting that also promotes best environmental management practices and increases the values of surrounding amenities;
- Ensure pollutant/containment emissions to air, soil and water are environmentally sustainable in the long term, with an emphasis on public health; and
• Provide protection to the Peel–Harvey estuary and associated RAMSAR conservation wetlands.

By the incorporation of:
• 389 onsite greywater systems, with centralised monitoring by village management;
• Water Sensitive Urban Design principles i.e. stormwater harvesting;
• Minimisation of groundwater use; and
• Zero pollutant emission into receiving waters.

The proximity to the underlying groundwater table and the various nutrient management requirements across the four stages of this development has necessitated the approval of two greywater systems. The two systems ensure that public health and environmental regulatory requirements are met and are listed below:
1. Grey-flow, by AWWS, pumped to sub-surface dripline irrigation. This system is installed in those stages that are 2m above the groundwater table.
2. Greywater Diverta, by Nylex, gravity fed to an evapotranspiration trench (ETT) for nutrient reduction as per the Department of Environment’s requirements for areas that are less than 2m above groundwater.

The length of each ETT is 7m with a standard depth of 450mm. The width of each ETT will vary depending on the number of bedrooms within each residence. For example one bedroom (2 people) has a design width of 720mm, while a three bedroom (4 people) has a design width of 960mm. Each ETT will become a landscape design feature within each yard, in stages three and four, planted with various native species i.e. *Baumea juncea* and *Juncus kraussii*.

C) Management Type
Village Management: In this management group, it is up to the management body to maintain, monitor and operate the DeWaTARS. A weekly rental is charged to residents, which includes the costs for the system maintenance as well as other services including a community centre. As outlined in the Nutrient and Irrigation Plan, the caretaker “…shall be familiar with and fully aware of all strategies implemented on site…” as well as being a “…source of information for residents…” and “…will undertake monitoring and maintenance of the irrigation system…” (Syrinx, 2004).

D) Implications for DeWaTARS
Bridgewater Lifestyle Village is one of the first village/cluster scale DeWaTARS developments in metropolitan Perth. The original concept vision for this development was to encompass total wastewater recycling. However under the current legislative and political climate the developers chose only greywater recycling and the adoption of WSUD principles. By focusing on localised irrigation of home sites and storm water management, the developers have avoided the management capacity issues and public health concerns associated with third pipe systems.

As this is one of the first projects, there has been much interest in the economics of the project. The developers were able to negotiate a substantial net savings per lot on the standard headworks charged for lots between 200m² and 300m² (refer to Table 5). There is also an economic saving as there is shallower excavation required during the
installation phase, reducing labour and materials costs associated with third pipe systems.

Table 5 Negotiated headworks savings

<table>
<thead>
<tr>
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<th>Supply</th>
<th>Waste</th>
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<tbody>
<tr>
<td>Standard headworks charges (for equivalent lot size)</td>
<td>$455</td>
<td>$1161</td>
</tr>
<tr>
<td>Negotiated headworks charges</td>
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<td>$205</td>
</tr>
<tr>
<td><strong>Total Saving</strong></td>
<td><strong>$1251/hm</strong></td>
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</table>

This case study aims to show that small-scale systems are easy to manage with the limited technical capacity of the village management. However, with 389 systems there will be an increase in the number of pumps and filters requiring management, as well as a respective increase in energy consumption.

### 4.6 Western Australia: Timbers Edge Lifestyle Village

#### A) Site Description
Timbers Edge, situated on the corner of Fernwood Road and Estuary Drive at Dawesville, will provide 260 houses on 18 hectares and is in close proximity to the Peel-Harvey estuary system, in the City of Mandurah.

#### B) Technology Implemented
Gravity is used to collect greywater from the residences, into a below-ground storage tank. After the wastewater is collected (at the lowest point) it is then pumped to a settling tank (at the highest point) before entering a constructed wetland.

Toilet and kitchen wastewater will be pumped to the main sewer system. Greywater from bathroom and laundry will be collected from residences via a parallel pipeline and treated to Class B quality. The treated greywater will be used to irrigate 15,950m² of POS, with an irrigation demand of 70m³/day (expected flow), with surplus being directed to irrigate road reserves, recharging the underlying aquifer. During peak flow events, maintenance and shutdown periods, discharge will divert to the sewer.

To determine the influence of the proposed development on groundwater quality and levels, two monitoring bores will be installed at the eastern boundary of the development (along Fernwood and Estuary Roads) and two on the western side from which periodic sampling can occur. The monitoring of these bores will enable any impacts of the development, including the re-use of greywater, to be detected in the groundwater. The bores will be installed and baseline data collected prior to the development of the landholding to ensure that the original condition is recorded in the monitoring results. Monitoring will be implemented quarterly during the first two years of the development and will be followed by bi-annual sampling with results reported annually to the City of Mandurah and the Department of Environment.

#### C) Management Type
Strata Body Management. In this management group, it up to the management body to maintain, monitor and operate the DeWaTARS by employing either a village maintenance manager or by subcontracting the operating and maintenance to a licensed wastewater service provider.
D) Implications for DeWaTARS
The adoption of a single treatment plant allows for easier management and maintenance programs. The implementation of a constructed wetland, as the treatment system, has allowed for the system to become a ‘nature feature’ of the landscape, blending into the serene surrounds of the ecologically sensitive region. This is an advantage and may increase the community’s acceptance of DeWaTARS technologies. However, not all developments can employ a constructed wetland treatment system due to the relatively large area required for filtration.

With the irrigation of all POS being sourced from treated greywater and stormwater, there is no need to source groundwater. However the added cost of laying a parallel collection network could be seen as a disincentive for developers, so it is important to put an economic benefit on environmental protection. Monitoring at various points, using various parameters, this case study will be able to provide data on the environmental savings as well as lead to a better understanding of the monitoring and maintenance requirements necessary to ensure environmental and public health.

The five stages of monitoring to assess water quality are:
- The point of entry into the system;
- Within the constructed wetland;
- After treatment;
- Ground water quality readings; and
- Via periodical soil sampling of irrigated areas.

The following parameters will be assessed:
- The quantity of treated greywater irrigated (minimum of weekly intervals) and record areas irrigated;
- The pH, salinity of treated greywater irrigated at monthly intervals; and
- Other contaminants in the treated greywater will be determined annually.

The records of monitoring data will be retained on site, with annual reporting being produced for the scrutiny of regulatory bodies when required.

4.7 Western Australia: Dizzy Lamb Lifestyle Village

A) Site Description
The proposed Dizzy Lamb Lifestyle Village, developed by Gold Beach estate Pty Ltd, has 242 park homes on 14.6 hectares of land located within the City of Wanneroo, north of Perth. The site has previously housed the Dizzy Lamb Amusement Park and is not serviced by the centralised sewerage system. The site is located within a region where horticulture is a main industry, with groundwater heavily relied upon to maintain crops. The demand for water is so great that the State Government is contemplating introducing an annual licence fee. Therefore the reuse of water is important to assist with water management demands within the area.

B) Technology Proposed
The treatment process was selected on the following criteria (Moltoni Infra Tech, 2005):

- Reliable and high quality treated effluent;
- A small footprint for the plant;
- Robust and stable operation expectations;
- Low and easy maintenance requirements;
- Low operating costs;
- Low or no odour production expectations; and
- Very small buffer zone requirements.

With these criteria in mind, it was decided that a Moving Bed Bio Reactor (MBBR) followed by a hollow fibre membrane filtration and disinfection system will best ensure a high quality treated effluent, for use on POS and street verges, via subsurface dripline irrigation methods. The MBBR technology is widely used internationally to remove nutrients and organic compounds from wastewater and is based on the assisted media Biofilm process.

C) Management Type

Village Management. In this management group, it is up to the management body to maintain, monitor and operate the DeWaTARS. A weekly rental is charged to residents, which includes the costs for the system maintenance as well as other services including a community centre.

Moltoni Infra Tech Pty Ltd (MIT) will design and implement the chosen DeWaTARS. MIT will also be responsible for the operation and maintenance of the scheme for a 12-month period, at which time maintenance staff from Dizzy Lamb will take over. MIT will also be responsible for the training of the Dizzy Lamb maintenance staff, the creation of the operation and maintenance manual and the identification of responsible parties.

D) Implications for DeWaTARS

A single common effluent scheme collects and treats all wastewater and allows for easier management and maintenance programs that can be easily subcontracted out to either a LGA or licensed wastewater service provider. The system is designed so that there is only one source of treated effluent available for irrigation, thereby helping to reduce irrigation demand on the underlying aquifer. The use of the treated effluent to irrigate POS only, and not being piped into homes via a third pipe supply system, means that the wastewater does not need to be treated to class A standard, which has caused regulatory problems in other case studies such as the Rouse Hill Development. The technology used in this case study highlights the quality that can be produced with modern technology such as the MBBR or MBR plants. However, highly technological systems will require technically qualified personnel to maintain and operate, which may increase the costs of the systems if these procedures need to be outsourced. Highly technical systems may also mean higher energy costs to operate and requires a high quality and reliable disinfection system.

As per the “in principal approval” the proposed DeWaTARS will:

- Become an icon project for technology and water conservation at the state, national and international level;
• Reduce the water consumption of the proposed development, thus achieving state sustainability and water reuse goals;
• Reduce the requirement for scarce scheme water or ground water for irrigation usage;
• Produce treated effluent of a high quality and hence very low risk of groundwater or surface water pollution;
• Demonstrate viable technology for DeWaTARS;
• Enable the owners to upgrade the existing oxidation pond on the site; and
• Demonstrate private sector capability to support the state water strategy, working in liaison with the local government, Department of Health, Department of Environment, and the community.

5.0 Current Legislation

“...Current guidelines, standards and regulations need to be more flexible to allow innovation whilst protecting public health and the environment...” (Dillon et al., 2004 p5). The specific nature of the WA legislation has led to confusion and misunderstanding amongst WA land developers. The most challenging requirement in regards to implementing AWWS is the need for developers to abide by the Government Sewerage Policy: in the Perth Metropolitan Region (the Policy) (WAGov, 1994). The Policy requires mandatory provision of reticulated sewerage to all new subdivisions in the Perth Metropolitan Region, unless special conditions exist. The departments of Health, Planning and Environment endorsed this policy, and have an enormous influence on all wastewater applications. This requirement adds extra costs to developments, with some stakeholders seeing mandatory connection, in case of overflow, malfunction or incident, as overly cautious and a deterrent to AWWS application (Pers. Comm., Cocks Melville Council 2005; Pers. Comm., Broughton NLV 2005). The Policy was re-examined in 1990 (WAGov, 1996) with a two-year trial of small-scale unsewered developments to either R20 or R30². The review, while highlighting the improvements in wastewater technology, remained convinced that reticulated sewerage system remained the most “…reliable and environmentally acceptable means of wastewater disposal...” (WAGov, 1994 p 2). In light of rapid advancements in AWWS technologies in the last decade and increasing number of international and interstate AWWS case studies, another review would be timely. The following chapter outlines current government departments and the main components that are required for a DeWaTARS project.

5.1 WA Planning Agencies

The Department of Planning and Infrastructure (DPI) manages the WA planning system, with the WA Planning Commission (WAPC) acting as arbitrator. There are several policies and planning tools affecting AWWS. The State Planning Strategy provides a framework for land use planning and there are several principal guiding documents to assist project planners, these include:

• **Statement of Planning Policy 2 - Environment and Natural Resource Policy:** This document acknowledges the value of the environment and

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² R20 & R30 is a town planning term and refers to the housing density per hectare. The higher the R numbers the denser the development.
provides information on Stormwater (flooding, nutrients & mosquito control), RAMSAR wetlands, and soil & land quality (waterlogging and acid sulphate soils/salinity);

- **Liveable Neighbourhoods:** This document acknowledges the value of the environment and provides information on Stormwater (flooding, nutrients & mosquito control), RAMSAR wetlands, and soil & land quality (waterlogging and acid sulphate soils/salinity); and

- **Statement of Planning Policy 2.9:** This policy informs the WAPC the DPI and local government in the undertaking of their planning responsibilities in the protection of water resources.

The Western Australian Planning Commission (WAPC) has identified the need to improve stormwater management and to increase water reuse in all areas. The WAPC is proposing a new model for combining integrated urban water management (IUWM) principles with land use planning practices “…through assessing new developments to ensure the principles and practices of IUWM are incorporated into the design and development of new urban areas...” (Shepherd, 2005 p1). The model will involve a hierarchy of strategic and statutory planning activities, that commence at the State Government level progressing down to lot size. It requires developers to produce a Local Water Management Strategy (LWMS), in conjunction with the Local Government Authority (LGA); and prepare urban water management plans (UWMP) (refer to Table 6). The Model is currently being trialed “…in the development of (an) Integrated Land and Water Management Plan for the Southern River area...” (Shepherd, 2005 p2).

The quality of detail provided on LWMS is dependent on the background information provided in higher-level management plans, and the analytical tasks required of developers’ consultants. It will be important that the Department of Planning and Infrastructure (DPI) have significant input into the development of these plans along with the new Department of Water (DW). A brief outline of the proposed requirements for LWMS and UWMP have been attached in appendices 1 and 2. These are currently in the draft stage and may be subject to change in the final version.

The system will equip developers with the necessary background information to ensure UWMP can be completed. The SWS Irrigation Review observed that “…water allocation and planning need to be based on detailed scientific knowledge which pertains to the availability and status of the water resource…” (GWA, 2005 p44). This system allows developers to make informed decisions. The Review also states that water resource plans “…need to be statutory based in order to support market based systems for water trading…”(GWA, 2005 p44). This requires planning to ensure that the “scientific knowledge” is available. The proposed timeframe for

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3 IUWM can also be known as total water cycle management. IUWM provides communities with a balanced approach to water, wastewater and stormwater infrastructure and incorporates a more economically and environmentally friendly approach for water services, especially when incorporated within new urban developments (Apostolidis, 2004).

4 ‘Strategic planning’ refers to longer-term goals, integrating economic, social and environmental issues.

5 ‘Statutory planning’ refers to the legal arm of planning and is directed by legislation and regulations.
Regional Plans is ten years, District Plans 5 years and Local Plans 3 years. The DPI, Department of Environment, Water Corporation and Local Government have been assigned tasks to ensure completion of the plans, within the stated timeframes (Shepherd, 2005).

Table 6: Scale of the land use planning system and relevant planning tools and the information to accompany planning actions (adapted Shepherd, 2005).

<table>
<thead>
<tr>
<th>Planning Stage/Scale</th>
<th>Land Area</th>
<th>Planning Tool</th>
<th>Water MGMT Information</th>
<th>Responsible Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Regional Planning</td>
<td>&gt;1 LGA</td>
<td>Regional Strategy (Strategic) Regional Scheme (Statutory) Regional Structure Plan (Strategic)</td>
<td>Regional Water Management Strategy, incorporating an arterial drainage plan</td>
<td>State Government</td>
</tr>
<tr>
<td>2. District Planning</td>
<td>Usually &gt;300ha may be &gt;1 LGA</td>
<td>District Structure Plan (Strategic) Regional Scheme Amendment (Statutory) Local Planning Strategy (Strategic) Town Planning Strategy (Statutory)</td>
<td>District Water Management Strategy</td>
<td>State/ Local Government</td>
</tr>
<tr>
<td>3. Local Planning</td>
<td>&lt;300ha</td>
<td>Town Planning Scheme Amendment (Statutory) Local Structure Plan (Strategic) Outline Development Plan (Strategic/Statutory)</td>
<td>Local Water Management Strategy</td>
<td>Landowner/ Local Government</td>
</tr>
<tr>
<td>4. Subdivision</td>
<td>Large &gt;20ha Small &lt;20ha</td>
<td>Subdivision Application with conditions (Statutory) Detailed Area Plan (Strategic/Statutory)</td>
<td>Urban Water Management Plan (UWMP), accompanies application</td>
<td>Land Owner</td>
</tr>
<tr>
<td>5. Construction of Subdivision</td>
<td>Large &gt;20ha Small &lt;20ha</td>
<td>Clearance of conditions Issuing the title</td>
<td>Building plan incorporates requirements of UWMP</td>
<td>Land Owner</td>
</tr>
<tr>
<td>6. Development of Lot</td>
<td>Lot</td>
<td>Development Application (sometimes) Building licence</td>
<td>Building plan incorporates requirements of UWMP, scheme provisions or developer covenant.</td>
<td>Lot Owner</td>
</tr>
</tbody>
</table>

5.2 WA Department of Environment

The Department of Environment (DoE) is responsible for environmental protection, water resource allocation and management. There is a perception that environmental considerations dominate water resource management decisions (SWS, 2005). Some irrigators who perceive a potential for conflict between the department’s role as the water resource manager and the environmental regulator have questioned the DoE’s role. A similar conflict existed prior to 1996 when water resource management was the responsibility of the Water Authority of WA (now operating as WaterCorp) resulting in the creation of the independent Water and Rivers Commission, which has since been incorporated into the DoE.

In order to maintain water quality, Nutrient and Irrigation Management Plans (NIMP) are required by the DoE upon application for a licence to implement a wastewater-
recycling scheme. Problems linked to poor irrigation and fertiliser application practice include:

- Soil erosion and turbidity in water resources;
- Poor performance of turf and crops;
- Excessive levels of leached salt and nitrates entering the water-table, which can harm the health of people and animals using local groundwater resources;
- Eutrophication of streams and lakes (excess aquatic plant growth), which impedes navigation and recreational use of waters, and may displace or kill plants or animals due to toxicity, shading or oxygen starvation;
- Soil salinity and increased/decreased pH;
- Excessive levels of dissolved ammonia-nitrogen, which is toxic to fish; and
- Increased competition (and cost) for limited uncontaminated water resources (DoE, 2003).

The components of a NIMP include:

- Site description;
- Soil description;
- Water resource description;
- Nutrient management;
- Irrigation;
- Drainage controls;
- Water resource protection;
- Pesticide use and storage;
- Monitoring and reporting; and
- Contingency plans (WRC, 1998).

### 5.3 WA Department of Health

In regards to issues of public health, there are two principal legislations influencing the implementation of AWWS; these are the Health Act 1911 (the Act) and the Health (Treatment of Sewage and Disposal of effluent and liquid waste) Regulations 1974 (the Regulations). The Act and Regulations provide public health guidelines for developers implementing AWWS in new urban developments. An important guideline, for developers, is the Code of Practice for the reuse of greywater in Western Australia (CoP); the CoP provides detailed guidance for developments installing greywater systems and has relevance for AWWS implementation, (refer section 7.2).

The Act and Regulations provide general and specific requirements to the installation and operation of sewage systems. For AWWS the main challenge of these documents is the focus on municipal wastewater treatment plants and single dwellings (or a building that produces no more than 540 L/day of sewage). At high population densities, like those in Perth, it is not always feasible to employ individual solutions, such as septic tanks, due to space constraints. Traditional communal sewer networks become expensive over longer distances, so AWWS at the village scale becomes a viable user category (Hermanowicz and Asano, 1999). The lack of recognition along with the prescriptive language and confusing layout of the document has made it challenging for developers trying to interpret system requirements (Cocks, 2005).
The Act and Regulations were designed in an era where sanitary health risks were high. The traditional “big pipes in, big pipes out” systems were considered the best methods to ensure public health. Now, with the growing surge for cities to be more sustainable and improvements in public health, there is a new sustainability agenda driving health reform (DoH, 2005).

In WA the Department of Health (DoH) is the public health regulator and all wastewater reuse schemes need the approval of the Executive Director of Public Health. The DoH, is conducting a review of the Act and Regulations in order to develop a new framework for public health in WA. The proposed changes move away from traditional “Precautionary Principle” and “Command and Control” measures towards one with an underpinning theme of risk management. The DoH suggests that current sanitary provisions of the Act, in which the Regulation is one, “…should be replaced by a general statutory duty vested in all individuals to protect public health by ensuring that actions do not risk harming others…” (DoH, 2005 p4); or put simply, is there a risk to public health and how can identified risk be managed?

As per the Department of Health (DoH, 2005) requirements, an Operation and Maintenance manual includes the following sections:

- a) Operation and Maintenance of the Recycled Water Scheme. The manual is to include a site plan of all sites and their irrigation lines, clear procedure of maintenance, surveillance of operation and inspection of any modifications, a contingency plan detailing corrective and preventative actions to be taken in the event of system failure, and induction/handover procedures for operators and new staff including health and safety issues when dealing with recycled water. The manual should also contain the contact names and telephone numbers of all people involved in the scheme;

- b) Operation and Maintenance of the Chlorination Unit. The manual is to include clear procedure of maintenance and operation of the chlorination unit. A separate logbook is to be kept at the chlorine storage unit to detail all actions and inspections carried out. It must be remembered that proper training must be given to anyone handling chlorine and this advice should be included in the safety and health section of the manual;

- c) Guidelines for Sampling the Recycled Water Scheme. The manual should include guidelines on how to collect samples, where to send them and what to do if results are elevated. In addition, the operator of the system is to request the PathCentre to notify them when results are above the approved standard. This is to be written on the sample request form.

5.4 WA Economic Regulation Authority

The importance of the ERA in approving DeWaTARS cannot be underestimated. The ERA Water Services Operating Licence states ‘…The Authority must not grant a licence unless it is satisfied that the applicant has, and is likely to continue to have, the financial and technical ability to provide the water services covered by the licence

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6 The precautionary principle relates to a risk management approach when scientific knowledge is incomplete.

7 Institutional measures aimed to directly influence the environmental performance of businesses by regulation.
and that the licence proposal would not be contrary to the public interest…”. This indicates that as long as the ERA is satisfied that the service provider is technically and financially able to maintain the selected DeWaTARS, then they will be granted a licence. This places the approval of licenses into the hands of government regulators who may not be conversant with all of the necessary requirements pertaining to DeWaTARS maintenance, operating and monitoring.

However, the Water Services Licensing Act 1995 (WA) requires that when assessing a water services operating application the ERA “…must not grant a licence unless the Authority is satisfied that it would not be contrary to the public interest to grant the licence…”. When considering ‘public interest’, the following may be taken into consideration:

- Environmental considerations;
- Social welfare and equity considerations, including community service obligations;
- Economic and regional development, including employment and investment growth;
- Interests of water services customers generally or of a class of water services customers;
- The importance of competition in water services industry markets;
- Public health considerations relating to the provision of a safe drinking water supply; and
- The policy objectives of government in relation to water.

These ‘public interest’ considerations ensure that the licensees’ have fully comprehended all of the legislative, health, social, environmental and economic implications associated with the DeWaTARS implemented. To ensure that the applications address all of these issues, a detailed examination of the licence application and associated documents will need to be conducted. The expertise required to adequately assess the applications cannot be found in one department, which means that application approvals take a minimum of 90 days, often longer, as each relevant department reviews the application as per their specific requirements. For example, the Department of Environment will check that the NIMP has been completed correctly as per the DoE standards.

The ERA will determine the terms and conditions of each licence on an individual basis. Schedule 1 of the Water Services Licensing Act 1995 sets out the nature of the licence conditions that may be included in the licence. The list is not exhaustive and may include:

- Requirements to comply with specified industry codes and standards;
- Requirements to keep accounting and other records;
- Limitations upon licensee’s business activities;
- Methods or principles to determine fees or charges when included in authorising by-laws;
- Methods or standards to be applied in supplying the service;
- Procedures for the amendment, revocation, or surrender of a licence;
- Requirements for provision of information by the licensee;
- Regulation of construction, operation or maintenance of water service works;
• The range of functions that may be performed by the licensee including performance criteria and community service obligations;
• Terms and conditions to be contained within a standard customer contract;
• Standards of customer service;
• Obligations to public authorities and other licence holders;
• Provisions governing disposal and transfer of property and licences;
• Requirements to develop/provide programs to conserve water; and
• Requirements to establish a consumers’ committee.

6.0 New Legislative Framework

As outlined previously, there is a necessity to install a new legislative framework that incorporates the roles for both federal, state and local government authorities. The following sections outline the roles and responsibilities of each relevant government department.

6.1 Australian Federal Government

The role of the Federal Government, in relation to water governance in WA, is to provide guidance to on water reform processes and to promote best practices within the water industry. This is achieved through the National Water Initiative (NWI), via community education funding, national guidelines and industry codes.

The NWI offers the states and territories a process through which to reform water policy. As shown in chapter two, demand practices, water pricing and institutional reform are three of the challenges facing the implementation of DeWaTARS, which are addressed by the NWI. “…The principles expressed in the National Water Initiative will be highly influential in the development of WA’s water policy; we can learn from the mistakes being made over east…” (Banyard, 2005 p6). The Council of Australian Governments website states “…WA declined to sign the NWI Agreement because there was no real benefit for WA…” (CoAG, 2005b p1). This stance by the WA State Government is in complete contrast to the statement by Banyard, above, and is one that is hard to understand. The benefits of having a nationally cohesive approach, are significant to WA and include:

• Best practice guidelines for wastewater services;
• Federal funding for investment in DeWaTARS projects;
• Community education programs; and
• A federally-supported water reform framework.

The Federal Government’s role in the proposed DeWaTARS legislative framework will be to assist the WA State Government in undertaking water reform, such as the recently released National Guidelines on Water Recycling and the 2004 Australian Plumbing Code (APC). The importance of a national approach to water recycling allows for standard frameworks to be created to help guide and assist future DeWaTARS developments. Had this document been developed earlier, the problems at the Inkerman D’Lux development - where the designers of the technology are located in another state - could have been averted. The new APC guides developers by:

• Creating an accountable and transparent framework for product authorisation;
• Establishing national objectives on a performance basis for plumbing work;
• Fostering water and energy conservation; and
• Providing industry benchmarks for best practice.

6.2 WA State Government: New Department of Water

In light of the State Water Strategy Irrigation Review, the State Government has started to initiate reform with the appointment of the Premier as Minister for Water Resources responsible for:

• New Department of Water (Incorporating aspects from the DoE, Water Corporation, SWS and the Office of Water Regulation);
• Water resource management;
• Water policy;
• Strategy and planning; and
• Water utilities

The Minister has created the Office of Water Strategy (the Office), within the Department of Premier and Cabinet, and given the Office the task of reviewing current water policies. The State Government advises the role of the review is to “…streamline and modernise an archaic and unwieldy catalogue of 14 Water Acts…” (WAGov, 2005 p1). In light of the recent paradigm shift towards DeWaTARS, including significant improvements in technology, a new review of the Government Sewerage Policy (the Policy) is also recommended.

1990 was the last time this policy was re-examined, consisting of a two-year trial of small-scale unsewered developments to the scale of either R20 or R30⁸. The review, while highlighting the improvements in wastewater technology, remained convinced that a reticulated sewerage system remained the most “…reliable and environmentally acceptable means of wastewater disposal…” (WAGov, 1994 p 2). Therefore the Policy remained unchanged in regards to mandatory provision of reticulated sewerage to all new subdivisions in the Perth Metropolitan Region, unless special conditions exist. With the Departments of Health, Planning and Environment endorsement, this policy has an enormous influence on all wastewater applications within the Perth region. This requirement adds extra costs to developments, with some stakeholders seeing mandatory connection, in case of overflow, malfunction or incident, as overly cautious and is seen as a deterrent to AWWS application (Pers. Comm., Cocks Melville Council; Pers. Comm., Broughton NLV).

The State Government has identified the development of strategic water plans as a high priority, including the development of a State Water Plan (SWP) and Regional Water Plans (RWP), and has committed to ensuring that “…the water resource manager is adequately resourced and appropriately skilled to deliver on key strategic and operational priorities…” (WAGov, 2005 p 1). The development of a SWP can promote the DeWaTARS concept, by encouraging IUWM, WSUD and UWMP. Regional Plans can identify areas suitable for DeWaTARS implementation.

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⁸ R20 & R30 is a town planning term and refers to the housing density per hectare. The higher the R number the more dense the development.
To assist The Minister, a Minister Assisting the Minister for Water Resources has been appointed, whose responsibilities include:

- Operational oversight of the Department of Water;
- Legislative responsibility; and
- Coordination for water services, planning and delivery.

The split of powers between the Minister and the Minister Assisting is considered by some as a political strategy rather than an improvement to water services, stating that having two Ministers ‘muddies the waters’ when the importance of the Department of Water dictates that one Minister only should be responsible (Taylor, 2005). Having the Premier, as the Minister for Water Resources, emphasises the political importance that water holds within the WA political arena. The task of water reform will not be easy and needs the cooperation and coordination of many regulatory authorities. The role of the Minister is to focus on the review of policy and strategy, while the Minister assisting can focus on the operational aspects of water reform.

6.3 Department of Environment

Under the new proposed framework, planning and licensing is removed from the Department of Environment (DoE). This would see the Water Services Planning Branch transferred to the new Department of Water. This leaves the DoE solely with the responsibility of assessing applications purely from an environmental impact assessment point of view.

When a DeWaTARS application is submitted the DoE will be notified and forwarded the following:

- Nutrient and Irrigation Management Plan; and
- Environmental Improvement Plans.

6.4 Department of Health

Under the new proposed framework the role of the Department of Health remains the same: to protect the health of the public. The review of the Health Act may impact on the health requirements for DeWaTARS applications, as the proposed Act moves away from command and control measures to risk management approach to health management (DoH, 2005). Regardless of whether or not the DoH revises the existing Health Act, it is important for the preparation of either a regulation or code of practice to assist developers wishing to implement DeWaTARS at a scale smaller than municipal, yet larger than an individual household (refer to section 8).

6.5 Department of Planning and Infrastructure

Under the new framework the principle duty of the DPI remains the same. The department is already moving towards connecting land and water use planning by requiring land developers to develop detailed Local Water Management Strategies (LWMS). The quality of detail provided on LWMS is dependent on the background information provided in higher-level management plans, and the analytical tasks required of developers’ consultants. It is important that the DPI and the Department of Water are involved in the development of these plans. This will require adequate resourcing and funding ensuring that the information is available to developers.
6.6 Local Government Authorities

The cooperation and involvement of local government authorities (LGA) is vital for the smooth implementation of the new DeWaTARS legislative framework. LGAs are the public face of the government regulatory bodies; they are first point of call for developers wanting to initiate DeWaTARS. Having a clear framework to work within, the LGA can provide clear and concise instruction to developers. This enables quicker turnaround times for approvals and the early detection of problems.

Within the new concept, LGAs are potential future managers of DeWaTARS. For example, the GoldCoast City Council has developed a Pimpama Coomera Water future Master Plan. The Master Plan incorporates a LGA-run DeWaTARS concept in a new Greenfield development, designed to accommodate 50,000 residences (Gold Coast Water, 2004; Livingston et al., 2004). The Master Plan is “…a good example of what a single authority can do with relatively few impediments in a new greenfield development…” (Livingston et al., 2004 p588). In WA, the City of Mandurah LGA has been supportive in the development of two greywater DeWaTARS projects - Bridgewater Lifestyle Village, Erskine and Timbers Edge Lifestyle Village, Dawesville - and as the council is located on the boundaries of the metropolitan sewerage system it is in an ideal position to develop and manage its own DeWaTARS project.

6.7 Water Corporation

In the new framework, the Water Corporation (WaterCorp) is key to the development of DeWaTARS projects. As the sole service provider for Metropolitan Perth, the WaterCorp is the prime candidate to assist in the development of a new wastewater service industry, in WA. The WaterCorp is best placed, as a 100% Government owned utility, to develop best practice principles to guide DeWaTARS compliant under environment, health and planning regulations. At present, however, WaterCorp is opposed to the development of village/cluster scale, preferring to investigate recycling opportunities within the commercial market; such as the new Wastewater Treatment and Recycling Plant within the Kwinana Industrial Park. Although domestic recycling is not a high priority there is discussion of a proposed treatment and recycling plant at Alkimos, instead of building the standard Wastewater Treatment Plant. This will provide the option of a 3rd pipe system of delivering treated wastewater to homes, in the rapidly expanding northern suburbs of Perth.

The development of a new wastewater service industry, in Perth, dealing with the management and operation of DeWaTARS projects will require technical and managerial expertise; WaterCorp can be a provider of this. At the moment the population of Perth is not sufficient to warrant several new businesses offering wastewater services. With the expertise that WaterCorp has, it would possible to open a new business arm dedicated to the provision of wastewater services. This would provide the opportunity to develop this burgeoning industry under strict protocols and given time provide WaterCorp with another avenue to meet recycling targets set by the State Water Strategy. Alternatively the development of a new business arm will provide WaterCorp with an asset, which could then be on-sold once the industry, is developed and able to sustain itself. This development would need careful consideration, as under the Water Corporation Act, WaterCorp are required to
provide discounts to pensioners, as per their community service obligations. Hypothetically, should the business arm be on-sold, either pensioners, should the community service obligations be withdrawn or the new owners, should the obligations remain, would be at a disadvantage.

What is required in the short-term is for the Government owned wastewater service provider to develop planning tools and best practice principles so that DeWaTARS can be integrated into Perth’s existing centralised system. Two examples of the leading role WaterCorp is playing in providing developers with planning tools are the:

- Proposed model for integrating urban water management with land use planning (the Model) (Shepherd, 2005), Table 6 Section 2.5.3; and

- Non-potable water use: guidelines for developers and their consultants (the Guidelines) (GHD, 2005), Appendix 3.

The model aims to integrate urban water management with land use planning. The Model was initiated to “...aid in the development of the Integrated Land and Water Management Plan for the Southern River area...” (Shepherd, 2005 p 2), and is currently being trialed; the model outlines details required from developers by the DPI; these being:

- Local Water Management Plan (LWMP); and

- Urban Water Management Plan (UWMP) (Shepherd, 2005).

The Guidelines also promote IUWM and highlight alternative water supplies for non-potable use. The Guidelines are still a work in progress; with workshops being conducted to develop best practice options for non-potable use. During the workshops, conducted to date, there has been much debate over the use of non-potable water inside the residence. Representatives from the DoH reinforced the requirement that if recycled water was going in-house for non-potable use, eg toilet flushing, then the treatment process required will be to a Class A standard, refer Appendix 4. The high cost in meeting these requirements deemed in-house use unlikely and therefore the Guidelines did not look closely at this option (GHD, 2005). The Guidelines highlight that groundwater and greywater are the best options for the supply of non-potable water. The economic costs, sewerage connection costs and the lack of technical operating ability were considered barriers that impeded the use of recycled wastewater as a viable supply of non-potable water and without the impetus of a higher SWS target there has been no pressure to investigate these barriers. However the high costs of pumping to the nearest Water Corporation pumping station may justify DeWaTARS.

6.8 A New Framework for WA

A proposed new legislative framework is outlined in Figure 1. The new framework includes the new Department of Water with the Water Services Planning Branch within the new Department. Due to the regulatory requirement to separate service
provision from resource protection the ERA will still manages the OWR. However, there will be a close connection between the OWR and the new Department.

Local Government Authorities provide the public connection to the new framework. The new framework indicates the main regulatory information developers need to provide for DeWaTARS applications in addition to the standard Town Planning Development requirements. The clarity of roles provided by this framework enable LGAs to provide clear guidance to developers implementing DeWaTARS in new urban developments.
Figure 1 Diagram of new legislative framework governing the implementation of DeWaTARS in Western Australia.
7.0 Current Regulation

In WA there are obvious opportunities to adopt DeWaTARS, at small community scales, that can address demand issues and that are affordable, while meeting environmental and public health concerns. Compromising WA’s ability to take up these options is the complex legislative and regulatory framework that prescribes and arbitrates across Ministries and Authorities. The current regulatory tools available to developers are:

- NWQMS Guidelines for sewerage systems: use of reclaimed water (Municipal/community wastewater plants);
- WA DoH Code of Practice for the reuse of greywater in WA (single homeowner);
- WA DoH Code of Practice for the design, manufacture, installation and operation of Aerobic Treatment Units (Single Dwellings);
- WA DoH Guidelines for the preparation of an O&M Plan; and
- WA DoE Guidelines for the preparation of Nutrient and Irrigation Management Plans (including their modelling software “Wasteload”).

These are briefly described below, along with an outline of the relevant sections applicable to a new code of practice for the implementation of DeWaTARS into WA development.


The NWQMS Guidelines for sewerage systems: use of reclaimed water (the Guidelines) provides advice on reclaimed water quality, level of treatment required to meet this quality, and necessary safeguards, controls and monitoring (refer to Appendix 4). The Guidelines “…foster the use of reclaimed water in a way that provides safeguards for public health as well as community and environmental benefits…” (NWQMS, 2000 pV). They address effluent arising from municipal, or community, scale wastewater plants and do not consider reclaimed waters from individual household systems or undiluted liquid wastes of industrial origin. The adaptation of the Guidelines down to village scale DeWaTARS projects can be simple, despite the focus on larger scale infrastructure. The specific areas that can be adapted are:

- Microbiological water quality;
- Chemical water quality;
- Treatment processes;
- Safeguards and controls;
- Public consultation requirements; and
- Legal responsibilities.
7.2 Code of Practice for the Reuse of Greywater in WA

Codes of Practices are becoming a preferred method of implementing legislation. They provide guidance with an element of compulsion, due to regulatory requirements, and are easier to update than regulations, as parliamentary approval is not required before amendment. This enables CoPs to reflect current best practice, now and into the future. The Code of Practice for the reuse of greywater in WA is an example of such a document. The objective of the document is to assist the promotion of acceptable long-term greywater reuse practice and to promote conservation of ground and surface water supplies, by:

1. Establishing acceptable means of greywater reuse as a guide for local government, industry and homeowners;

2. Setting minimum design and installation standards and procedures for gaining approval for greywater systems installations;

3. Safeguarding the community from possible disease transmission arising from improper greywater reuse; and ensuring that greywater installations are designed, installed and operated so that when used in households on a long term basis they do not harm the environment; do not cause a nuisance; and are appropriately sited and maintained to a satisfactory standard.

The DoH, DoE and the Water Corporation prepared this Code of Practice that guides the reuse of greywater in single dwellings. This document describes several points that could be adapted to a new guiding document for village scale DeWaTARS, which are:

- Current list of approved systems;
- Current list of approved suppliers;
- A homeowner’s guide to reusing wastewater; and
- A list of the application requirements.

7.3 Code of Practice for the Design, Manufacture, Installation and Operation of Aerobic Treatment Units (Single Dwellings)

The Environmental Health Service of the Department of Health (EDPH) prepared this Code of Practice. This code sets out the “…requirements for the approval by the EDPH of ATUs serving single dwellings using a combination of anaerobic and aerobic processes for the treatment and disposal of wastewater of domestic origin…” (DoH, 2001 p 2). As the title suggests the code is prepared to guide the design, manufacture, installation and operation for DeWaTARS at the scale of the single dwelling. The technical information provided in this document can be adapted to a new guiding document for village scale DeWaTARS. These include:

- System design parameters;
- Hydraulic and biological loads;
• Materials and construction conditions;
• Compliance testing;
• Effluent disposal methods;
• Maintenance schedules; and
• Technical information.

7.4 Guidelines for the Preparation of an Operation and Management Plan

The required contents of an operation and maintenance manual (for a recycled water scheme) are as follows:

Table 7 Guidelines for preparation of an operation and management plan

<table>
<thead>
<tr>
<th>1. Operation and Maintenance of the Recycled Water Scheme</th>
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<tbody>
<tr>
<td>1.1. Map of pipeline route from WWTP to irrigation sites including location of chlorinators, surge tanks, storage dams, pump stations, sample points etc.</td>
</tr>
<tr>
<td>1.2. Plan of all sites and their irrigation lines.</td>
</tr>
<tr>
<td>1.3. Clear procedure of maintenance.</td>
</tr>
<tr>
<td>1.4. List of all maintenance conducted.</td>
</tr>
<tr>
<td>1.5. Surveillance of operation.</td>
</tr>
<tr>
<td>1.6. Irrigation schedule.</td>
</tr>
<tr>
<td>1.7. A contingency plan detailing corrective and preventative actions to be taken in the event of system failure.</td>
</tr>
<tr>
<td>1.8. Induction/handover procedures for operators and new staff.</td>
</tr>
<tr>
<td>1.9. Health and safety issues when dealing with recycled water (see the Department of Health’s information sheet “Health and Safety Issues associated with Recycled Water/Treated Wastewater”).</td>
</tr>
<tr>
<td>1.10. Contact names and telephone numbers of all people involved</td>
</tr>
</tbody>
</table>

2. Operation and Maintenance of the Chlorination Unit.

Note: Only the contact detail of the person responsible for the operation of the chlorinator is required. It is essential that when a high thermotolerant coliform result is received this person is contacted to see if the chlorinator is working correctly.

| 2.1. Clear procedure of maintenance and operation of the chlorination unit. |
| 2.2. A logbook is to be kept to detail all actions and inspections carried out. |
| 2.3. Safety and health section. It must be remembered that proper training must be given to anyone handling chlorine. |
| 2.4. Contact details of those people responsible for maintaining chlorinator. |

3. Guidelines for Sampling the Recycled Water Scheme

| 3.1. How to collect samples. Include the DOH pamphlet “Recycled Wastewater Sampling Technique.” |
| 3.2. Where to collect samples. |
| 3.3. Where and how to send samples. |
| 3.4. What to do if results are elevated. |
| 3.5. Copy of a correctly completed Path Centre “Sample Request Form”. The form should state that the operator be notified when results are above the approved standard. |

Operation and maintenance manuals have been completed for the three WA case study sites and can be found in Appendix A, B and C.

7.5 Guidelines for the Preparation of Nutrient and Irrigation Management Plans

Components of a nutrient and irrigation management plans are as follows:
Table 8 Guidelines for Preparation of Nutrient and Irrigation Management Plans

1. **Site description**
   1.1. Define the site location and project area. Briefly describe the development proposal.
   1.2. Include a map showing the property in relation to features such as existing structures, road reserves, drainage paths, neighbouring properties, water bores, and land contours.
   1.3. Briefly discuss the present land-use. Details of existing nutrient and water usage should be provided where possible. Details of the historic use of the land are also helpful.
   1.4. Provide maps outlining the existing site vegetation, dominant species, current condition and any proposed changes.
   1.5. Determine average monthly rainfall and evaporation rates for the proposed area and determine the anticipated runoff and infiltration factors.
   1.6. Describe the topography of the site and areas adjacent to the site and whether the site topography will be affected by any proposed cut and fill.

2. **Soils description**
   2.1. Provide details of soil types and landforms present on the site.
   2.2. Provide details of the soil strata below the surface including any drilling or test pit investigations.
   2.3. Determine the soil Phosphorus Retention Index (PRI). PRI tests should be carried out using a sampling grid on the top 300 mm section of the soil column, which will accept irrigation water.
   2.4. Provide details of any fill or soil amendment existing or planned at the site.

3. **Water Resources description**
   3.1. Provide information on any rivers, streams, wetlands or dams present at the site.
   3.2. Provide details of any land subject to flooding.
   3.3. Provide a brief description of any confined and unconfined groundwater aquifers beneath the site (define direction and magnitude of groundwater flow, seasonal variation, minimum depth to groundwater).
   3.4. Provide details of any licensed use of water resources at the site.
   3.5. Provide data on water resources quality eg pH, salinity, nutrients & metals.

4. **Nutrient Management**
   4.1. Sufficient nutrients should be applied to only meet the vegetation needs. They should also be applied in a manner, which is timely and minimises runoff or leaching losses. Planning considerations should include:
     4.1.1. Identification of vegetation species to be grown.
     4.1.2. Determination of fertiliser requirements during the establishment and operational phases of the project and assess technical advice on crop needs (e.g. soil testing, plant tissue testing).
   4.2. Define nutrient needs for:
     4.2.1. Any planned short-term crops at various points in growth cycle.
     4.2.2. Any planned long-term vegetation eg trees based on seasonal needs.
     4.2.3. Outline the types and constituents of fertiliser proposed for application.
     4.2.4. Consider the use of any slow release fertilisers or fertigation and to match vegetation nutrient needs.
     4.2.5. Take into account the input of nutrients already present in irrigation water.
     4.2.6. Identify which areas of the site will be fertilised. Include data on, quantity, duration, frequency and method of application.
   4.2.7. Provide details of any off-season water retention or runoff collection basins designed to hold waters for recycling. Details of leaching, odour and algal controls should be included.

5. **Irrigation**
   5.1. Efficient methods of irrigation not only lower water, power and maintenance costs but also minimise fertiliser leaching. Use of modern technology can permit well-controlled and efficient irrigation systems.
   5.2. Identify area to be irrigated and design of irrigation system to suit climatic, soils and vegetation needs.
   5.3. Outline quantity, quality and availability of the water source.
   5.4. Define how irrigation will be scheduled to avoid runoff, excessive groundwater mounding and leaching.
   5.5. The schedule should incorporate regular monitoring of crop water
usage and soil moisture status to match irrigation with crop requirements. An aim should be for a minimum of irrigation water passing beyond the plant root zone.

5.6. Discuss frequency, rates and timing (time of year and day) of applications to match.

5.7. Discuss evaporation-transpiration rates.

5.8. Discuss irrigation rate considering soil type, root depth and plant species uptake rate.

5.9. Outline how soil structure will be maintained. Intensive cultivation or use of salty irrigation water may harm vegetation and lead to dispersive or poorly drained soils, increasing the risk of runoff soil erosion and crop failure.

5.10. Consider potential to recapture runoff from irrigated areas and recycle the water. The concentration of salts and toxins by evaporative processes may place limits on recycle systems.

6. Drainage Controls

6.1. Drainage systems should be included in the design criteria, especially for high water consumption areas such as golf courses.

6.2. Outline location and size of water bodies on or adjacent to the site.

6.3. Outline the design and function of any artificial water bodies, which are proposed (e.g. multiple use and purpose built wetlands, dissipating basins).

6.4. Incorporate bunding, contouring and/or filtration systems into design where potential exists for export of water off-site via water bodies.

6.5. Describe planned management and monitoring of water bodies affected by irrigation seepage or runoff.

6.6. Describe surface drainage, including gazetted and paddock drains and natural creek lines both on and in close proximity to the site. Describe and provide plans of any proposed diversion drains.

6.7. Outline projected storm and surface water runoff rates and the volume and destination of surface runoff.

6.8. Describe how site drainage be affected by the development proposal? Will any storm water be diverted to storage? How are the effects of extreme storm events managed?

6.9. Drainage design should incorporate the principles of water sensitive urban/rural design (Water Authority, 1994).

7. Water Resources Protection

7.1. Surface Water Protection

7.1.1. Create vegetated buffer zones of at least 50 metres to all waterways and wetlands.

7.1.2. Avoid steep (>10%) and rocky terrain where runoff and erosion is likely to be excessive.

7.2. Groundwater Protection

7.2.1. Groundwater quality is affected by leachate entry. To prevent leachate reaching groundwater, management options include.

7.2.1.1. Amend soils to increase moisture retention and minimise leaching of nutrients.

7.2.1.2. Describe any soil amendment program (e.g. nature of amendment, application rate, incorporation method and depth).

7.2.1.3. Provide design details of expected performance and effective life of the soil amendment program.

7.2.2. Avoid areas where the seasonal depth to the water table is less than 2 metres.

7.2.3. Construct leachate barriers, which drain to collection basins.

8. Vegetation Management

8.1. Careful management of vegetation can minimise nutrient loss.

8.2. Provide a brief description of how vegetation will be maintained.

8.3. What happens to protected soils and water resources when any crop is harvested?

8.4. Explain how water and nutrients are applied only when plants need them and target the feeder root zones.

8.5. Describe any remnant or other vegetation buffers along property boundaries and on unused land.

8.6. Where practical, select vegetation species that have low water and nutrient demands.

8.7. Select vegetation species appropriate to the seasonal waste loads anticipated from the proposed activity.

8.8. Specify windbreaks to reduce the amount of water used, stabilise sands and reduce sandblasting, particularly in horticultural activities.

8.9. Explain management of the site to avoid soil compaction and salinity problems.

9. Pesticide Use and Storage

9.1. Some pesticides remain mobile and toxic in the environment. Such
pesticides and sometimes their carrier solvents don’t degrade, and have the potential to be transported in the same way as nutrients. Application near rivers and wetlands should be carried out in accordance with manufacturers, Health Department and AgWest guidelines and to be target specific where possible. Provide details of pesticides used.

9.1.1. Outline form and type of pesticides, frequency, and rate of application.

9.1.2. Discuss potential for site export and impact on non-target species.

9.1.3. Provide details of a secure chemical storage facility.

10. Monitoring and Reporting

11. Pre-development nutrient and irrigation management.

11.1. Outline programme of soil, plant tissue, groundwater and irrigation water testing.

11.2. Determine soil and water pH, salinity, PRI, phosphorus and nitrogen concentrations over subject land.

11.3. Identify the methods used in above.

11.4. Where aquifers are present, establish monitoring bores for groundwater quality assessment.

11.5. Determine a water balance i.e. seasonally how much water enters and leaves the site.

12. Post-development Nutrient and Irrigation Management

12.1. Determine PRI of amended soils at annual intervals.

12.2. Outline specific tests to show effectiveness of any storage or nutrient stripping ponds.

12.3. Specify attributes of consultants and laboratories proposed for implementing a monitoring program.

12.4. Outline procedures for recording the use and rates of application of various artificial fertilisers.

12.5. Describe the monitoring system to be implemented.

12.6. Determine whether application rates need altering on the basis of results from monitoring bores.

8.0 New Code of Practice

With the Health Act currently under review, it is an opportune time to consider the best practice approach for DeWaTARS projects to ensure the best public health outcomes. The review discussion paper proposes a new Health Act be based on a risk management approach. The new Act will require projects to be assessed on the level of risk to public health. When there is a risk, there will be a series of Codes of Practices or Regulations to guide developers.

It is feasible for the existing Health Act Regulations to become guiding Regulations under the new Health Act. The Regulations would be a stand-alone regulatory document and not a referred adjunct of the Health Act. Unless there are significant changes to the Regulations, this is not the preferred option, as the prescriptive language and the complicated layout of the document is impeding the implementation of DeWaTARS. Regulations, by their nature, take a long time to amend, as they need to have parliamentary approval. Codes of Practices on the other hand are easier to implement and amend, normally use simple language and offer options rather than prescriptions. A new regulatory tool is required to ensure that:

- The concept of DeWaTARS is clearly defined;
- Clear performance standards in the system design are outlined;
- There are clear health and environment targets;
- Standards and targets are presented in a clear and user friendly manner;
- Homeowners and developers have clear guidance on how to meet their legal responsibilities when implementing DeWaTARS technologies;
- Local Government Authorities (LGA) recognise DeWaTARS applications and application protocols;
• LGA have a tool that aids in the application approval process and are sufficiently resourced; and
• By using the tool, developers will be able to easily incorporate DeWaTARS principles into the planning process.

8.1 New Code of Practice for DeWaTARS in Village (or Cluster) Scale Developments (CoP)

Currently the DoH refers to the NWQMS Guidelines for guidance in approving applications, and it is this document that forms the basic background information required for the new CoP. The critical sections from this document used in the outline of a new CoP are as follows:

• Principles;
• Public consultation requirements;
• Legal requirements;
• Contractual arrangements and provisions;
• Essential consideration;
• Water quality parameters;
• Treatment processes;
• Management operating strategies;
• Hazard Analysis and Critical Control Points (HACCP) risk management approach;
• Safeguards and controls (including hazard and risk management protocols);
• Monitoring and reporting;
• Specific reclaimed water applications; and
• Potable and non-potable.

The new document will need to be written in easy to understand, non-prescriptive language (other than when referring to water quality standards) and should present information in a methodical manner. One method that developers, incorporating DeWaTARS, can use to meet health and environmental monitoring and maintenance requirements, is to develop and incorporate management operating strategies (MOS). The Water Allocation branch of the Department of Environment, in Statewide Policy 10, states that the use of MOS “…allows the licensees to participate more effectively in managing the impacts of taking the water, increasing awareness and responsibility…” (SPP, 2000 p8). Although this statement relates to water access licenses, the use of MOS can be correlated and adapted to DeWaTARS projects.

Implementation of MOS enables clear documentation of commitments and responsibilities for the management of impacts, to residents as well as the environment, of any DeWaTARS being installed. The underlying theme of risk management will enable uniformity of requirements while being flexible enough to allow for varying site conditions.

There is a broad spectrum of DeWaTARS technologies available and the new CoP will need to be able to recognise the different technical capabilities of the various management bodies. In order for a document like this to encapsulate the broad spectrum of management bodies and to give valid guidance to them, a new subsection is suggested at the beginning of the document. Entitled ‘Management Options’ this
new subsection will identify the different management types and highlight the different requirements necessary for DeWaTARS implementation. For example, a small greywater DeWaTARS project managed by a village management, such as the one employed at Bridgewater, WA, might be capable of managing and operating a greywater recycling system but may struggle to manage and operate a combined wastewater stream. A strata management body, eg at Timbers Edge, may not have the technical capacity to manage a full wastewater treatment plant so may need to subcontract this out to a licensed service provider. Furthermore, it is important that such a strata management body has a “sinking fund” into which monies are collected for asset replacement at the end of the plant’s useful life. These examples will require specific management conditions to be set for different management types and provides clearer trains of responsibility for DeWaTARS projects.

9.0 The LADERS Assessment Tool

LADERS uses a water balance model to produce the development’s water efficiency score. All water flowing into the development (supply) and all water flowing out of the development (disposal) is quantified in order to determine the water balance. Any reuse of water is accounted for in the development’s score by the resulting reduction in supply and disposal streams.

Three flow streams constitute the water supply; scheme water, storm water and ground water. Water disposal consists of five flow streams; sewer, stormwater leaving the site, evaporation, evapotranspiration and infiltration (Figure 1). The eight flow streams are the significant routes via which water enters and leaves the boundary of the development. Other means of water entering or leaving the site, such as water brought onto the site in groceries is considered negligible and to some extent is negated by water leaving the site via similar routes.

In order to determine the quantities of the eight flow streams it is necessary to examine some water use internal to the development. The areas of internal water use that are investigated include in the LADERS tool include irrigation, rainwater harvesting, the use of open water bodies (lakes) and, of relevance to this discussion, water reuse.

Using the model shown in Figure 2, LADERS was developed to automatically calculate the water efficiency score for a development. The platform used to produce this program was the spreadsheet program Microsoft Excel. Data for each development is entered into the program and the water efficiency score for the development is then produced.
9.1 Application of the LADERS Assessment Tool to Case Studies

The LADERS assessment tool has been applied to four land developments as case studies. Three of these developments are case studies for the Premier’s Water Foundation (PWF) Grant to the Environmental Technology Centre.

The data for the three PWF case studies (Table 10) was placed into the assessment tool to determine a score for each. The scores and closures (the difference between the volume of water into and out of a development expressed as a percentage) for the lands developments are shown in Table 9.

Table 9 Case study water efficiency score and closure

<table>
<thead>
<tr>
<th>Development</th>
<th>Bridgewater Lifestyle Village</th>
<th>South Beach Village</th>
<th>Timbers Edge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>27.9 /40</td>
<td>21.4 /40</td>
<td>25.7 /40</td>
</tr>
<tr>
<td>Closure</td>
<td>12%</td>
<td>3%</td>
<td>8%</td>
</tr>
</tbody>
</table>

9.2 Using the LADERS Assessment Tool

The development of the model consisting of the eight flow streams provided the framework upon which the computer assessment tool took shape. The resultant computer tool consists of eight work sheets with 81 questions in total. These 81 questions quantify the entire development’s water balance and determine the development’s water efficiency score.
The first sheet labelled “Start Here” introduces the user to the tool by briefly outlining what the tool does as well as providing some general instructions. The next six sheets asks questions about the development. The first sheet labelled “General Information” asks general questions about the development beginning with the name of the development. The other five sheets are divided into different categories of water use within the development. These are labelled “Wastewater Reuse”, “Open Water Body (Lake)”, “Irrigation”, “Rainwater Harvesting” and “Stormwater Runoff”.

The final sheet labelled “Score” gives the supply and disposal water balance, that is, the total of each of the three supply water streams and each of the five disposal water streams. It also displays the final water efficiency score for the development.

9.3 Calculation of the Score

To obtain the score, the quantity of water flow through the eight flow streams are compared to what could reasonably be achieved for a development of this type. ‘Reasonable’ is a subjective word but is defined to include water reuse, in-house use of rainwater, no stormwater runoff from the site and efficient irrigation practices.

The percentage difference between each of these ‘reasonable’ flow quantities and the estimated development quantities are calculated. A weighting is applied to each stream to differentiate which flow streams are more favourable to utilise than others. This provides a score for each of the eight flow streams the sum of which determines the water efficiency score for the development.
<table>
<thead>
<tr>
<th>Case Study Data for LADERS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Information</strong></td>
</tr>
<tr>
<td>1. Name of Development</td>
</tr>
<tr>
<td>2. Location of Development</td>
</tr>
<tr>
<td>3. Total Area of development (Ha)</td>
</tr>
<tr>
<td>4. Total residential area</td>
</tr>
<tr>
<td>5. Number of detached dwellings in development</td>
</tr>
<tr>
<td>6. Average occupancy rate of detached dwellings (p/dw)</td>
</tr>
<tr>
<td>8. Public buildings scheme water use (kL/yr)</td>
</tr>
<tr>
<td>10. Total Public Open Space (POS) Irrigatable Land Area (Ha)</td>
</tr>
<tr>
<td><strong>Reuse</strong></td>
</tr>
<tr>
<td>12. Efficiency of Reuse system (%)</td>
</tr>
<tr>
<td>13. Homes with Reuse system (%)</td>
</tr>
<tr>
<td>14. Reuse system fed by Clothes Washer</td>
</tr>
<tr>
<td>15. Shower</td>
</tr>
<tr>
<td>16. Basin</td>
</tr>
<tr>
<td>17. Trough</td>
</tr>
<tr>
<td>18. Toilet</td>
</tr>
<tr>
<td>19. Sink</td>
</tr>
<tr>
<td>20. Reuse systems feeds (outside) Plants</td>
</tr>
<tr>
<td>21. Toilet</td>
</tr>
<tr>
<td>22. Other Outdoor</td>
</tr>
<tr>
<td>23. Reuse systems feeds (centralised) Lake</td>
</tr>
<tr>
<td><strong>Open Water Body</strong></td>
</tr>
<tr>
<td>26. What source is used to top up the water body?</td>
</tr>
<tr>
<td>27. Catchment Area (m2)</td>
</tr>
<tr>
<td><strong>Irrigation</strong></td>
</tr>
<tr>
<td>33. Will the developer install the household irrigation?</td>
</tr>
<tr>
<td>34. Will the developer encourage waterwise landscaping in HH?</td>
</tr>
<tr>
<td>35. Irrigatable Area per household (m2)</td>
</tr>
<tr>
<td>36. Will the HH irrigation water be supplied centrally</td>
</tr>
<tr>
<td>37. Expected percentage of houses with private bores</td>
</tr>
<tr>
<td>38. What is the ground water allocation for the POS (kL/a)</td>
</tr>
<tr>
<td>39. Type of Vegetation</td>
</tr>
<tr>
<td>40. Irrigation by Spray or Drip</td>
</tr>
<tr>
<td>41. Land Area (m2)</td>
</tr>
<tr>
<td>42. Type of Vegetation</td>
</tr>
<tr>
<td>43. Irrigation by Spray or Drip</td>
</tr>
<tr>
<td>44. Land Area (m2)</td>
</tr>
<tr>
<td>45. Type of Vegetation</td>
</tr>
<tr>
<td>46. Irrigation by Spray or Drip</td>
</tr>
<tr>
<td>47. Land Area (m2)</td>
</tr>
<tr>
<td>48. Type of Vegetation</td>
</tr>
<tr>
<td>49. Irrigation by Spray or Drip</td>
</tr>
<tr>
<td>50. Land Area (m2)</td>
</tr>
<tr>
<td>51. Type of Vegetation</td>
</tr>
<tr>
<td>52. Irrigation by Spray or Drip</td>
</tr>
<tr>
<td><strong>Rainwater</strong></td>
</tr>
<tr>
<td>57. What percentage of homes will have raintanks?</td>
</tr>
<tr>
<td>58. Average home catchment area (m2/home)</td>
</tr>
<tr>
<td>59. Efficiency of catchment A</td>
</tr>
<tr>
<td>60. Cost of Water $/kL</td>
</tr>
<tr>
<td>61. Avg first flush size (L/home)</td>
</tr>
<tr>
<td>62. Water in tank at start of year (L)</td>
</tr>
<tr>
<td>64. Rainwater feeds Clothes Washer</td>
</tr>
<tr>
<td>65. Shower</td>
</tr>
<tr>
<td>66. Basin</td>
</tr>
<tr>
<td>67. Trough</td>
</tr>
<tr>
<td>68. Toilet</td>
</tr>
<tr>
<td>69. Sink</td>
</tr>
<tr>
<td>71. Plants- plumbed</td>
</tr>
<tr>
<td>72. Other Outdoor</td>
</tr>
<tr>
<td>73. Enter the Average Recurrence Interval (ARI) in years for each given duration for which all storm water can be held on site or in a nearby infiltration basin</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>74. Score</td>
</tr>
</tbody>
</table>

**Note:** Cells with white background are assumed values with no data available.
9.3.1 Closure

The calculations of the flow streams rely upon some assumptions in order to determine flow quantities. Different assumptions are used to determine each stream’s quantity and therefore the accuracy of each stream flow is different. This also means that the accuracy for total supply and total disposal will differ. Closure, that is the difference between total inflow (supply) and total outflow (disposal), cannot be guaranteed to be zero because of the inaccuracy of these assumptions. The closures for each case study are shown in Table 1.

9.3.2 Discussion

The effectiveness of the program to reliably determine the water efficiency of a land development is difficult to gauge. There are many assumptions and values placed into the calculations which one person may view very differently from another. For example, a development, which relies heavily upon infiltration, could be penalised if it is decided that infiltration is not as favourable a method of disposal as another. This is an inherent weakness in the model, which could only be overcome by unanimous agreement on the relevant values associated with each flow stream. Paradoxically, the strength of the program is that the same assumptions and values apply to each development ensuring all developments are scored against the same criteria.

The integrated approach is the only way in which the accurate assessment of water efficiency technologies can be implemented. For example the reuse of water requires an integrated understanding of the water demand in the first instance and the demand of the application for which the produced wastewater will be utilised.

The investigation of the eight flow streams results in a highly comprehensive method for calculating water efficiency. Within the bounds of the assumptions made from the available data, the calculations of rainwater use, irrigation design, open water body design and stormwater flows provide as accurate a representation of the development’s internal water regime as can be expected. This ensures that the development’s score is a fair representation of its water efficiency.

Application of the case studies to the computer program provided feedback on the ease of use of the tool, the appropriateness of the model in producing a score, ease of data collection as well as the respective efficiencies of the developments. Through the case studies it was determined that the program is an effective way to measure water efficiency with the data available and that the model was a suitable choice. Closure limits were adhered to for all four case studies indicating the program was of sufficient accuracy.

The weightings applied to the different flow streams make this model acutely area-specific. If the computer program were to be used in other areas of Australia these weightings would need to be adjusted to suit the local environment.
9.4 Use of the LADERS Assessment Tool as Guide for DeWaTARS System Selection

The implementation of a DeWaTARS system requires an understanding of volumes of water to be reused. There are two aspects to be considered. The first is the quantity of water available to the reuse system and the second is the quantity required by the reuse application. To achieve this, modelling of the development’s water systems is required.

There are very few tools available to developers to determine the flow regime of their development. One tool that achieves this goal and more is LADERS, which is an acronym for Land Development Efficiency Rating System. This computer assessment tool developed at the Environmental Technology Centre (ETC) at Murdoch University quantifies all aspects of water flows within and through a proposed land development.

The purpose of the LADERS tool is to measure the water use of a land development as a whole and to give each development a score in terms of water efficiency. In this way an understanding of how well developers have used their water resources can be gained and a comparison made with other developments. Regulators to ensure developments meet a minimum standard of water efficiency may also use this point of comparison.

Of benefit to the implementation of DeWaTARS, is the quantification by the LADERS assessment tool of all flow streams. This allows the designer of the DeWaTARS system to identify the appropriate source of water for reuse and the how best to reuse that same water in terms of quantities.

9.4.1 Conclusion

The purpose of producing a water efficiency score is to inform developers, potential home purchasers, authorities and regulators about the water efficiency of a particular development and how it compares to other land developments. Developers who implement the necessary requirements for increased water efficiency would benefit from the rating system by having a marketing advantage and potentially increased sales. Home purchasers could make a more informed decision, as the rating system would serve as an indicator with which to compare developments. Authorities could utilise the rating system to determine if a particular developer is not implementing sufficient water efficiency practices and therefore intervene at an early stage or conversely encourage those developments that are water efficient.

As the use of DeWaTARS systems become more commonplace, tools to assist in determining appropriate systems are required. LADERS provides a method of determining the most suitable water source, the most suitable method of reuse and therefore the correct size of the reuse unit based on the quantities of water available for reuse. This is vital step in ensuring the success of any DeWaTARS project.
10.0 Conclusion

The increased urbanisation of Perth is placing pressure on the aging centralised wastewater system. The threat of yet another summer of water restrictions demonstrates a need to develop and implement alternative strategies to meet existing and future water supplies of the city. The “big pipes in, big pipes out” traditional systems do not fit in with the new sustainability agenda. There has been a shift towards decentralised systems that include water-recycling measures. The ability to recycle water reduces demands on potable water supply.

Recycling water at the village or cluster scale will help reduce the demand on potable water supplies. International and interstate concepts and models have provided the basis for the new decentralised wastewater treatment and recycling systems (DeWaTARS) concept. The concept of DeWaTARS differs from the other concepts and models by incorporating the use of management options, which include the following characteristics:

- Management infrastructure needs to be in place to ensure timely and efficient management of the system;
- Ability to monitor the system;
- Technical ability to maintain, operate and update the system;
- The ability to develop and implement a risk assessment and management plan;
- Public liability insurance cover for residents and workers’ liability insurance for employees undertaking maintenance work on the system;
- A cost recovery mechanism that is fair and equitable.

There will be many challenges to implementing DeWaTARS, the most significant being the legislative and regulatory impediments. These impediments can be addressed in three ways:

1. Adoption of the DeWaTARS concept and management options by developers, regulators and households, these are:
   - Village management;
   - Body corporate;
   - Local government authority; and
   - Wastewater utility.
2. Adoption of a new legislative framework that incorporates the DeWaTARS concept; and
3. The adoption of a new regulatory tool, the Code of Practice for village (or cluster) scale DeWaTARS.

WA is in a prime position to start initiating the DeWaTARS concept. The experiences in the eastern states, where the National Water Initiative has delivered best practice models, can assist the development of a WA model. For example, the installation experiences of the Rouse Hill Development in NSW can be used to deliver best practice procedures, as we can learn from the problems experienced in other case studies.
11.0 References


IOCI. (2002). *Climate variability and change in the south west of Western Australia* in IOCI Technical Report. Indian Ocean Climate Initiative Panel.


West, S. M. (2000). *Innovative on-site and decentralised sewage treatment, recycling and management systems in northern Europe and the USA* at www.aquatron.se/uk/reports.uk2.html accessed 21/5/05

## Appendix 1: Local Water Management Strategy

Components of a local water management strategy:

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction</strong></td>
<td>Total water cycle management; principles and objectives, planning requirements and background information from previous studies.</td>
</tr>
<tr>
<td><strong>Proposed Development</strong></td>
<td>Key elements of the structure plan; and environmental report and management plan.</td>
</tr>
<tr>
<td><strong>Pre-development Environment</strong></td>
<td>Geotechnical information; soils; environmental assets and water dependent ecosystems (WDE); existing information; recent investigations; surface water flows and quality; and groundwater flows.</td>
</tr>
<tr>
<td><strong>Design Criteria</strong></td>
<td>Water conservation; stormwater management; groundwater management; and commitment to best management practice.</td>
</tr>
<tr>
<td><strong>Water Conservation Strategy</strong></td>
<td>Drinking water; fit-for-purpose use; and wastewater.</td>
</tr>
<tr>
<td><strong>Stormwater Management Strategy</strong></td>
<td>Flood management; impact on WDE; surface water quantity; and surface water quality.</td>
</tr>
<tr>
<td><strong>Groundwater Management Strategy</strong></td>
<td>Groundwater levels; impact on WDE, implications for fill; and groundwater quality-nutrient/contamination ‘hot spot’ management.</td>
</tr>
</tbody>
</table>
Appendix 2: Urban Water Management Plans

A proposed model for integrating urban water management with land use planning: the next stage, subdivision and urban water management plans – matters to be addressed in the urban water management plan.

<table>
<thead>
<tr>
<th>Monitoring</th>
<th>Recommend a program for UWMP and post-development program.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementation</td>
<td>Roles and responsibilities; funding; and review.</td>
</tr>
</tbody>
</table>

Urban water management plan components:

<table>
<thead>
<tr>
<th>Introduction</th>
<th>UWMS; and land use and subdivision plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design objectives</td>
<td>Demonstration of compliance</td>
</tr>
<tr>
<td>Site characteristics</td>
<td>Existing information; and more detailed assessments</td>
</tr>
<tr>
<td>Water Conservation Strategy</td>
<td>Water supply and efficiency; fit-for-purpose strategy; and wastewater management.</td>
</tr>
<tr>
<td>Stormwater and Groundwater Management Design</td>
<td>Flood management; groundwater levels; quality and contamination; structural and non-structural BMP and treatment trains; protection of waterways, wetlands (and their buffers), remnant vegetation and ecological links; and management of disease vector and nuisance insects.</td>
</tr>
<tr>
<td>Management of Subdivisional Works</td>
<td>Construction activities.</td>
</tr>
</tbody>
</table>
Appendix 3a Bridgwater Lifestyle Village Operation and Management Plan

NLV Bridgewater
Systems for domestic greywater treatment and reuse
Operation and Maintenance Manual

Version 1.4- DRAFT
January 16, 2006

1.0 DOCUMENTATION

This manual has been prepared with reference to the following documents:
- Greywater Reuse System (Grey-Flow) - Conditions of Approval, App. No. GW0402 (DoH, 2005)
- Nutrient and Irrigation Management Plan (NIMP) for Bridgewater NLV (2xxx).
- Required contents of an OPERATION AND MAINTENANCE MANUAL for a recycled water scheme (DoH, 2004), Section 1
- Code of Practice for the Reuse of Greywater in Western Australia (DoH, 2005)

2.0 SYSTEM COMPONENTS

This document describes the necessary operation and maintenance (O&M) requirements of the following system components:
- Grey-Flow unit
- Evapotranspiration trench (ETT) – where installed
- Subsurface drip irrigation system

2.1 Grey-Flow unit
The Grey-Flow unit consists of an interception unit, a sensor activated pump station, a primary and secondary filter, and is typically then connected to a low pressure subsurface drip irrigation system. The Grey-Flow is designed to intercept domestic greywater (laundries, basins and bathrooms only) and to discharge it immediately. Filtration of the greywater is required to prevent clogging of the subsurface drip irrigation system and this is achieved by two sponge type filters in series. If these filters become clogged greywater will flow across the surface of the filters and flow to the sewer. Untreated greywater can also be diverted directly to sewer when and as required, for example, during winter and maintenance.

2.2 Evapotranspiration trench (ETT)
The evapotranspiration trench is a low maintenance biological system for the treatment of domestic greywater. It is a plastic lined gravel-filled trench planted with various hardy aquatic plants through which the greywater is retained for several days before discharging to subsurface leach drains. The greywater is maintained in sealed...
pipes and below the gravel surface of the system at all times to ensure there are no mosquito or odour issues.

2.3 Subsurface drip irrigation system
Subsurface drip irrigation is the most efficient means of irrigation as evaporation is kept to a minimum and water is delivered directly to the soil surface. Regulations require that the piping be purple in colour to denote that non-potable water is being used and the piping should be covered with a minimum of 100mm of mulch to avoid any potential contact with people or animals.

3.0 RESPONSIBILITIES

Responsibility for carrying out the O&M requirements is to be borne by both the householders and maintenance staff of the NLV Bridgewater development and is described in the following.

4.0 GREY-FLOW UNIT

4.1 The principal operation and maintenance requirements of this unit are described in the manufacturer’s O&M, which is attached to this document. The procedures to be carried out by maintenance staff of the NLV Bridgewater development are:

4.1.1 Cleaning of the primary and secondary filters and flushing of the system with freshwater once a month and not less than every three months (note: if these filters become clogged greywater will divert by default to the sewer);

4.1.2 Acid-flushing of the entire system once every year.

4.2 The householder should have familiarised him/herself with the Grey-Flow unit’s O&M manual and is required to attend to the following:

4.2.1 Notify NLV Bridgewater staff immediately in the event of any visible greywater ponding, strong odours or structural damage to the Grey-Flow unit;

4.2.2 Avoid disposing of any chemicals or materials down household sinks that may affect the functioning of the Grey-Flow unit;

5.0 EVAPOTRANSPIRATION TRENCH (ETT) - where installed

5.1 ETTs are safe, low-maintenance biological wastewater treatment systems. For their continued safe operation the following periodic O&M procedures apply. The most critical element for the continuing safe and reliable operation of the ETT is to ensure that the greywater is well filtered prior to entering the ETT. This is achieved by the Grey-Flow system and its O&M requirements, which were described previously in 4.0.

5.2 The principal operation and maintenance requirements of the ETT to be carried out by maintenance staff of the NLV Bridgewater development are:

5.2.1 To ensure that the greywater remains 5-10cm below the ETT surface in order to prevent odour and mosquitoes gaining
access to the water to breed. Should the greywater remain at a level consistently less than 5cm below the gravel surface the following remedial action is required:
5.2.1.1 Firstly divert all greywater to sewer;
5.2.1.2 Inspect the outflow pipe for blockages;
5.2.1.3 If no blockage in the outlet pipe is evident it is likely that the system has been overloaded. Allow the ETT system to rest for a minimum of three weeks before reconnecting the greywater to the ETT and monitor the water level;
5.2.1.4 If this procedure does not overcome the problem the system will need to be overhauled.

5.2.2 Plant maintenance and harvesting:
5.2.2.1 Supplementary planting is likely in the first 12 months due to normal plant mortality of 10-20%;
5.2.2.2 Any weeds should be removed as they may out-compete the desired wetland species. Hand weeding is generally sufficient;
5.2.2.3 Some supplemental fertiliser addition may occasionally be required in which case an organic balanced NPK fertiliser should be used;
5.2.2.4 Occasional pruning should typically be undertaken after flowering and this material composted.

5.3 The **householder** should be familiar with the ETTs purpose and function and is required to attend to the following:
5.3.1 Notify NLV Bridgewater staff immediately in the event of any visible greywater ponding, strong odours or structural damage to the ETT;
5.3.2 Notify NLV Bridgewater staff if overland stormwater runoff is entering the ETT in rainfall events for any reason;
5.3.3 The householder is encouraged to be involved in plant maintenance and harvesting for example and this may be arranged with the Bridgewater management.

6.0 SUBSURFACE DRIP IRRIGATION SYSTEM

6.1 The principal operation and maintenance requirements of the subsurface drip irrigation system are described in the Grey-Flow manufacturer’s O&M manual which is attached to this document. The irrigation piping will be purple in colour to indicate non-potable water. The procedure to be carried out by **maintenance staff of the NLV Bridgewater development** is:
6.1.1 Acid-flushing of the entire system once every year;
6.1.2 Provide assistance to divert greywater to sewer while cleaning and inspection of flushing points takes place as described in 5.2.2 below.
6.2 The **householder** will need to be familiar with the subsurface drip irrigation system and is required to attend to the following:

6.2.1 Provide top-up mulch over the dripline to a minimum depth of 100mm at all times;

6.2.2 Ensure dripline flushing valves (refer irrigation layout diagram) are functioning correctly. In the event of greywater ponding immediately around the flushing point the householder should contact the Bridgewater maintenance staff in order that the greywater can be diverted to sewer while the flushing mechanism is cleaned and inspected.

7.0 OCCUPATIONAL HEALTH AND SAFETY

7.1 During any maintenance work involving any part of the greywater treatment or reuse system, protective waterproof gloves and eyewear must be worn. Hands must be washed thoroughly with warm water and soap afterwards.

8.0 ATTACHMENTS

8.1 O&M manual for Grey-Flow Greywater Interception and Reuse System;
8.2 Site plans, location of different systems and house plans to be included in final version of this manual;
8.3 Location of monitored systems to be included.
GREY FLOW GREYWATER INTERCEPTION & REUSE SYSTEM

The Advanced Waste Water System's Grey-Flow is a compact greywater interception & reuse system consisting of an interception unit, a sensor activated pump station, a primary & secondary filter, and a low pressure sub-strata drip irrigation system. The Grey-Flow is designed to intercept domestic greywater (laundries, basins and bathrooms only) from the main greywater streams and to discharge it right away *(no greywater is stored at any time)* into a state of the art sub-strata drip irrigation system over a garden area ranging from 30 to 200 m².

Although the Grey-Flow is ideally suited to new homes where the plumbing is designed to cater for greywater reuse, the system can also be installed into existing properties where changes to the plumbing configuration can easily be performed (get informed advice from your plumber or your plumbing supplier).

The following gives an indication of the amount of water saved, the minimum garden area irrigated and the required dripline spacing:

**Table 1**

<table>
<thead>
<tr>
<th>Number of Bedrooms in the house</th>
<th>Quantity of Greywater reused in L/day &amp; (L/annum)</th>
<th>Minimum area of garden to irrigate in square meters (WA) [Other states]</th>
<th>Recommended dripline spacing in m</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>279 (101,835)</td>
<td>(30) [60]</td>
<td>(0.2) [0.4]</td>
</tr>
<tr>
<td>3</td>
<td>372 (135,780)</td>
<td>(40) [80]</td>
<td>(0.25) [0.5]</td>
</tr>
<tr>
<td>4</td>
<td>465 (169,725)</td>
<td>(50) [100]</td>
<td>(0.3) [0.6]</td>
</tr>
<tr>
<td>5</td>
<td>558 (213,870)</td>
<td>(60) [125]</td>
<td>(0.4) [0.8]</td>
</tr>
</tbody>
</table>

I. GREY-FLOW COMPONENTS

1. Double entry interceptor unit with primary filtration, overflow and approved reflux valve *(Quantity 1). This item requires installation by a licensed plumber.*
2. Grey-Flow underground pit all inclusive with lid, pump, inlets, outlets, bleed, sensor, relay & secondary filter unit (Quantity 1).
3. 150 m coil of Grey-Flow dripline - 8L/h dripper @ 0.3m Spacing (Quantity 1).
Note: The system will require additional plumbing fittings and possibly a pit extension. These items are not included in the Grey Flow package and will be supplied at extra cost by the installer at the time of the installation.

II. Installation procedure

Interceptor unit

1. The installation of this apparatus should be undertaken by a licensed plumber, in accordance with local regulations and accepted codes of good practice (refer to attached drawing 1). When a reflux valve is required only an approved reflux valve can be installed.

Underground Grey Flow pit

1. The installation of the underground Grey Flow Pit should be done in such a way that the outlets from the interceptor unit are at least 10 cm higher than the 1” inlet to the pit and the 32 mm flexible hose connecting pipe should be on a constant descending slope.
2. Connect the overflow flexible hose to the overflow PVC fitting positioned in the interceptor unit just upstream of the reflux valve.
3. Adjust the spring loaded check valve to open at one third of the pump flow capacity.
4. Connect the irrigation supply pipe to the secondary filter outlet.
5. Connect pump & sensor leads to outdoor pump relay unit and to the outdoor power point. Ensure that the 5m flexible orange conduit has a minimum 600 mm cover. A licensed electrician is required for connection to power sources other than a standard three pin power point.
6. Additional underground pit extension units are available from the manufacturer at extra cost and should be added when the top level of the pit falls below ground level.
Drip irrigation system

The installation of the irrigation part of the Grey-Flow should follow the following sequence and procedure.

1. For each zone lay the 25mm polypipe as header line on the ground across the wider section of the garden bed and not further than 15 meters away from the end of the bed. Close the end of the 25mm header line with end plugs.
2. Connect the start connectors by punching a whole in 25mm polypipe using a 7 mm punch tool. The smallest end of the start connector is then inserted into the hole made in the polypipe.
3. The hole spacings should conform to the table above and can vary from 0.2 to 1.0 meters.
4. Connect to the start connectors the Grey-flow dripline and lay it above ground in one of the three layout models (grid, spiral or s-curve). Always keep the dripline as close to the plant as possible. Leave the end of the dripline open.
5. Stake the Grey-Flow dripline to the ground every 3 meters.
6. Connect the end of the driplines into a 25mm polypipe flush manifold.
7. Insert a barbed flush valve into the flush manifold at its lowest point.
8. Flush thoroughly the whole system by running tap water through you shower, basin, or trough.
9. Cover the Grey-flow dripline with a minimum of 100mm thickness of bark mulch.

Recommended layout of the Grey-flow dripline
III. Maintenance procedure
To retain the original reliability and performance of the Grey-Flow system the following maintenance procedure should be followed:

Make sure to wash your hands with soap after contact with greywater or after handling any part of the Grey-flow system.

The following maintenance steps should be carried out once a month and not less than every 3 months:

a. Open top cover of the interception unit
b. Remove primary sponge filter and wash thoroughly in a bucket, with a garden hose or in any basin not connected to the dedicated greywater line.
c. Open the lid of the secondary filter located in the underground pit, remove lint filter and wash thoroughly with fresh water from the same source of water as in b.
d. Thoroughly flush the whole system by running tap water through the shower, basin, or trough.
e. The Grey-flow system is ready to operate again.

The following maintenance steps should be carried out once a year:
a. Contact your servicing agent to perform an acid flush of the entire system.
b. Top-up mulch over the Grey-flow dripline to a minimum depth of 100mm.

The Grey-Flow dripline will need to be replaced every 5 to 8 years.
V. Servicing Contact details

Your local irrigation suppliers & plumbing outlets nationwide.

VI. Disclaimer

“Whilst Advanced Waste Water Systems Pty Ltd has taken all reasonable opportunity to ensure the accuracy of the content of these guidelines. Advanced Waste Water Systems does not take any responsibility for any changes to the Grey-flow Recycling System or requirements pursuant to the Municipal or Council laws and regulations. Accordingly, each end user is to ensure that prior to purchasing and installing the Grey-flow Recycling System they make full enquiries with all relevant authorities and where appropriate take independent advice. Accordingly, and except to the extent permitted by law, Advance Waste Water Systems does not make any warranties in relation to the information herein provided nor to the fitness for the use of the Grey-Flow Recycling System to your particular needs. The end user hereby acknowledges and confirms that Advance Waste Water System Pty. Ltd. and its associated entities, directors and staff, are not liable or responsible for any loss or damage suffered by the end user of what so nature and kind including but not limited to loss or damage to or arising out of property damage or consequential loss and damage from or caused by the information contained in this guideline or by the use of the Grey-Flow Recycling System“.
1.0 DOCUMENTATION

This manual has been prepared with reference to the following documents:

1.1 Timbers Edge Greywater Treatment System Design for DoE and DoH approval (Syrinx, 2004).
1.2 Timbers Edge Drainage Nutrient and Irrigation Management Plan (ATA Environmental, 2004).
1.3 Response to Department of Health Mosquito Concerns (Syrinx, 2004).
1.4 Required contents of an OPERATION AND MAINTENANCE MANUAL for a recycled water scheme (DoH, 2004), Section 1.
1.5 Code of Practice for the Reuse of Greywater in Western Australia (DoH, 2005).

2.0 SYSTEM COMPONENTS

This document describes the necessary operation and maintenance (O&M) requirements of the following system components:

- Balance tank.
- Reactivator clarifier and sump.
- Subsurface flow biofilter cells.
- Irrigation collection tank.
- Subsurface irrigation system.
- Winter excess recharge zone.

2.1 Balance Tank

All greywater is pumped from the development’s main collection point to the Balance Tank located in the greywater treatment plant. Greywater is then pumped to the reactivator clarifier.

2.2 Reactivator Clarifier

The greywater receives chemical dosing immediately prior to entering this vessel for phosphorus precipitation. A turbine agitator mixes the chemicals and sludge is periodically discharged to sewer or filtered to a solid waste product, which can be used as compost. The treated greywater then discharges to a pump sump via gravity before being pumped in 10m³/hr pulses to the biofilters.

2.3 Subsurface Flow Biofilter Cells
Six biofilters comprise the main biological greywater treatment process and cover a total area of 1600m². They have an average depth of 0.55m with the water level maintained at least 40mm below the gravel media surface to avoid mosquito and odour issues. The biofilters will be planted with *Schoenoplectus validus* and *Baumea articulata* with each species comprising approximately half of each biofilter. Following treatment in the biofilters the treated greywater flows via gravity to the irrigation collection tank.

2.4 Irrigation Collection Tank (27m³)
The treated water is pumped to the subsurface irrigation system from this vessel. Any water surplus to the irrigation requirements will be diverted to the on-site recharge zone immediately west of the biofilters.

2.5 Winter excess recharge zone
This zone consists of subsurface gravel percolation drains in the western section of the development (immediately west of the biofilters) where the distance to groundwater level is highest.

3.0 RESPONSIBILITIES
Responsibility for carrying out the O&M requirements is to be borne solely by the Timbers Edge Corporate Body. A fulltime caretaker will be appointed to take care of the day-to-day servicing of grounds and infrastructure.

4.0 BALANCE TANK
4.1 The principal operation and maintenance requirements of this unit are described in the Timbers Edge Greywater Treatment System Design for DoE and DoH approval (Syrinx, 2004). These procedures, which are to be carried out by maintenance staff of the Timbers Edge development are.
4.1.1 Monthly monitoring of balance tank sludge via dipper tube. Discharge to sewer as required.
4.1.2 During start-up quarterly water quality monitoring will take place. This will be undertaken by a third party.

5.0 REACTIVATOR CLARIFIER AND SUMP
5.1 The principal operation and maintenance requirements of this unit are described in the Timbers Edge Greywater Treatment System Design for DoE and DoH approval (Syrinx, 2004). The procedures be carried out by maintenance staff of the Timbers Edge development are.
5.1.1 Filling hoppers with dosing chemicals weekly and adjusting dosing rates as required.
5.1.2 Carry out mechanical inspection of unit quarterly and according to manufacturer’s specifications.
5.1.3 Clean unit with scheme water biannually to remove build-up.
5.1.4 Check weekly that pumps are operational.

6.0 SUBSURFACE FLOW BIOFILTER CELLS
6.1 While the biofilter cells have been designed to have a low maintenance requirement they should however be operated and maintained by qualified personnel.
A commissioning and operational risk assessment is provided in Timbers Edge Greywater Treatment System Design for DoE and DoH approval (Syrinx, 2004).

6.2 The principal operation and maintenance requirements of the biofilter cells, which are to be carried out by maintenance staff of the Timbers Edge development, are:

6.2.1 Ensuring that the greywater remains at least 40mm below the biofilter surface, and not more than 100mm below the top water level (TWL). This should be checked weekly.

6.2.2 Checking plant health and density and weed abundance quarterly (refer to 6.2.8).

6.2.3 Checking for and removal of debris, tree branches, rubbish etc as required, typically monthly.

6.2.4 Flushing of biofilter inlet to clear any blockages, typically quarterly.

6.2.5 Backflushing of biofilter outlet to clear any blockages, typically quarterly.

6.2.6 Checking for any odours, as required and typically quarterly.

6.2.7 Checking for signs of mosquito proliferation according to the mosquito monitoring program and take required actions as necessary (refer document 1.3 Section 1.0).

6.2.8 Plant maintenance and harvesting.

6.2.8.1 Supplementary planting is likely in the first 12 months due to normal plant mortality of 10-20%.

6.2.8.2 Any weeds should be removed as they may out-compete the desired wetland species. Hand weeding is generally sufficient.

6.2.8.3 Some supplemental fertiliser addition may occasionally be required in which case an organic balanced NPK fertiliser should be used.

6.2.8.4 Occasional pruning should typically be undertaken after flowering and this material composted.

7.0 SUBSURFACE DRIP IRRIGATION SYSTEM

7.1 The principal operation and maintenance requirements of the subsurface drip irrigation system are to be carried out by maintenance staff of the Timbers Edge development according to the manufacturer’s requirements.

8.0 WINTER EXCESS RECHARGE ZONE

8.1 During winter months, when treated greywater production is in excess of irrigation requirements, it shall be directed to subsurface recharge zones located on the western bund wall of the biofilter cells.

8.2 Re-direction of the treated greywater will be undertaken by maintenance staff of the Timbers Edge development as required. Monitoring of flow to ensure no back-up as a result of blockages should be undertaken weekly during this period.

9.0 WATER QUALITY MONITORING

9.1 Chemical and microbiological monitoring of reclaimed water quality will be undertaken. Monitoring will assess water quality at four stages: 1) the point of supply, that is, the point of entry to the treatment system; 2) after treatment; 3) the quality recorded in groundwater monitoring facilities; and 4) through periodical soil sampling from irrigated areas.
9.2 The following parameters will be monitored with records retained on site for scrutiny by regulatory bodies.
9.2.1 The quantity of treated greywater irrigated (minimum of weekly intervals) and record areas irrigated.
9.2.2 The pH, salinity of treated greywater irrigated at monthly intervals.
9.2.3 Total N & P in treated greywater irrigated at three monthly intervals.
9.2.4 Other contaminants in the treated greywater will be determined annually.
9.3 Flow meters shall be installed at 1) greywater overflow to sewage pump station, 2) greywater pumped to treatment unit, 3) greywater pumped to irrigation, 4) greywater pumped to aquifer recharge.
9.4 Monitoring bores shall be installed along Fernwood and Estuary Roads from which periodic sampling can occur.

10.0 OCCUPATIONAL HEALTH AND SAFETY

10.1 During any maintenance work involving any part of the greywater treatment or reuse system Personal Protection Equipment (PPE) must be worn.
10.2 The minimum PPE requirements for the Timbers Edge system are protective waterproof gloves, eyewear, steel capped boots and apron.
10.3 The appropriate signage and barriers to public access must be maintained at all times.
10.4 Hands must be washed thoroughly with warm water and soap afterwards.

11.0 ATTACHMENTS

11.1 System layout, manufacturer’s O&M manuals and drawings for all system components will be included in the final version of this manual.
11.2 All documents referenced in 1.0 which should be readily available to the Timbers Edge maintenance staff at all times.
Appendix 3C Dizzy Lamb Lifestyle Village Operation and Maintenance Plan

BRIEF INFORMATION ON THE OPERATION AND MAINTENANCE OF THE DIZZYLAMB LIFESTYLE VILLAGE WASTEWATER TREATMENT PLANT

1. INTRODUCTION

Gold Beach Estate Pty Ltd is planning to develop a Lifestyle Village at the location, previously known as Dizzy Lamb Amusement Park. As the property is not serviced by Water Corporation’s sewerage system and there is a significant amount of water shortage for the planned development, the developers contracted Moltoni Infra Tech Pty Ltd (MIT) to plan, design and implement a reliable and effective method for the on site sewage wastewater treatment with the intention of recycling the treated water for irrigation.

The technology, which MIT will use in the 120 m3/day treatment plant, could be summarized as Moving Bed Bioreactor (MBBR) with Hollow Fibre Membrane Filtration followed by a residual disinfection unit. This document is prepared to provide information on the basic operational principals and maintenance procedures of the plant’s components. It also contains information on the safeguards and contingency measures incorporated in the treatment plant design in order to protect the public health and environmental integrity.

2. PRIMARY TREATMENT

2.1 Operation

The wastewater from the units of the village will be collected through backflow prevention units and be fed to the treatment plant via subsurface sewage reticulation pipes. It will be screened by a bar screen in order to trap any unwanted materials before it is released to the pre treatment/emergency storage tank. During storage compressed air through sparger piping will be pumped to retain solids in suspension and to keep the oxygen concentration in the wastewater at a desirable level.

The primary effluent from the pre treatment/emergency storage tank will be pumped into the secondary treatment stage through the fine screen chamber by a submerged sewage pump with its own high/low level switch. The pump flow rate will be manually controlled by a return control valve at the exit of the pump well, and monitored by a flow indicator with local display.

2.2 Maintenance

Maintenance of the both screens will be achieved by periodic scraping. The seals and bearings of the air blower and the pump will be replaced annually. Pre treatment/emergency tank might require desludging after more than five years of operation.

3. SECONDARY TREATMENT

The secondary treatment component of the Dizzy Lamb Wastewater Treatment Plant will be a Clearflux® MBBR. The technology behind Clearflux® MBBR has been used in more than 5,000 treatment plants in more than 45 countries since 1982 for efficient removal of organic compounds and nutrients from wastewaters generated by multiple sources.

3.1 Operation
MBBR technology is based on the Assisted Media Biofilm (AMB) process and comes with two moving bed bioreactors in series. The first reactor acts as a roughing reactor to shave peak loads and remove most of the influent BOD. The second reactor is a polishing reactor designed to reach the required effluent BOD.

The bioreactors are filled with ‘AMB Bio Media’ a specially designed biofilm carrier element which free floats and moves around in the reactor with the flow. The AMB bio medium provides an effective biofilm surface of 500 m2 per m3 bulk material. Biomass is trapped inside the carrier elements, providing additional biosludge without the need for the conventional activated sludge return. The bioreactors are aerated through a coarse bubble air distribution system at the bottom of the tank from a rotary displacement air blower.

The biodegraded water flows by gravity into the clarification stage where the suspended solids settle by gravity. The water is directed through a skim well to an inclined plate settling zone, which provides the final clarification of the effluent, and where the sludge settles easily to the bottom of the tank. The sludge is removed by a timer controlled hydro cyclone assembly that separates volatile sludge from non volatile sludge. The excess sludge is transferred to a waste sludge holding tank which may be integrated in the holding tank system, or arranged as freestanding thickener tank for further processing of the sludge.

Clearflux® MBBRs operate automatically once started. Remote or local operator is not required to run the plant. In case of power failure the plant restarts itself.

3.2 Maintenance

The only maintenance requirements of the Clearflux® MBBR unit are the annual and biannual replacement of pump and blower seals and bearings and biannual replacement of pH and flow sensors of the plant.

The proposed sludge management as it currently stands involve the excess sludge produced during the process to be pumped to drying beds. These beds will be built out of masonry with an impermeable membrane liner to prevent infiltration to the ground. They will be made up of filtration media allowing the water to be drained to the bottom of the beds. The water will be collected in a sump and pumped back to the MBBR. The sludge mass will remain on top of the bed. After 3-4 days when the sludge dries out, it will be used as compost on site landfill or sent to a municipal landfill.

4. TERTIARY TREATMENT

There are two subcomponents of the tertiary treatment stage. The first subcomponent is the hollow fibre membrane filtration unit and the second one is the residual disinfection unit.

4.1 Hollow Fibre Membrane Filtration

Treatment of secondary wastewater is traditionally done by conventional physicochemical processes. However, these processes suffer from high cost and unstable water quality as well as secondary pollution because of the chemical dosing required in the process. Hollow fibre membrane filtration technology delivers high and reliable performance at a potentially low cost. Its efficiency in removing the suspended material and nutrients as well as the pathogens has been well documented by various scientific studies and field applications.

4.1.1 Operation: In the MIT treatment plant the secondary wastewater produced from
the Clearflux® MBBR will be pumped into the membrane unit. The unit has a number of membrane modules which are designed for inside-out flow. Each module contains 10800 capillary hollow fibres made from polyacrylonitrile with each fibre having inner and outer diameters of 0.8mm and 1.3mm, respectively. After treatment by hollow fibre membrane modules, tertiary wastewater will be separated into two streams. The permeate (~80%) will be primarily sent to the disinfection unit and the concentrate (~20%) will be sent back to the primary wastewater stream of the MBBR. Like the MBBR unit, the operation of the hollow fibre membrane unit is fully automatic.

4.1.2 Maintenance: Fouling of the hollow fibre membranes will be prevented by an automated backwash system, which will use the part of the permeate and sodium hypochlorite solution. Periodic addition of the sodium hypochlorite to the backwash tank will be required. The seals and bearings of the pumps will need to be replaced annually for the most efficient operation of the unit. If maintenance procedures are carried out as required the membranes expected to last more than seven years.

4.2 Residual Disinfection

Previous experiences show that adequate removal of pathogens occurs with the hollow fibre membrane filtration making disinfection unnecessary. However, residual chlorination will be carried out at the final stage of the treatment to provide a safety blanket for the whole system. It will destroy the remaining disease-causing bacteria, nuisance bacteria, parasites and other organisms at the point of treatment and by its residual effect it will control the microbial activity down stream from the point of treatment; that is in the post treatment storage tank, irrigation pipes and drip lines in the case of this project. In addition to these, chlorination will also remove soluble iron, manganese and hydrogen sulphide from water, which would increase the life span of the irrigation system components by reducing build up and clogging.

4.2.2 Operation: Chlorination will be achieved by automatic dosing in the disinfection tank. This tank will be configured according to the principles of either plug flow or complete mix process.

4.2.2 Maintenance: Maintenance of the disinfection unit will be achieved by periodical topping up to sodium hypochlorite solution tank. If the disinfection system is determined to be a complete mix system annual maintenance of the mixer will also be required.

5. SAFEGUARDS AND CONTINGENCY MEASURES

Dizzy Lamb wastewater treatment plant will have the following safeguards and contingency measures in order to protect the public health and environmental integrity:

- Pre wastewater treatment plant plumbing works will be carried out according to AS 3500 guidelines;
- The collection lines will be fitted with a backflow prevention device;
- Capacity of the treatment plants will be at least 25% more than the full capacity of the village;
- Treatment plant will be designed with 100% redundancy principle for all the
moving parts and power sources;
• Treatment plant will have an emergency storage capacity equivalent of at least 3 days of peak wastewater generation;
• The scheme will have a HACCP plan and will be operated according to it;
• The technology used will be able to deliver Class A level effluent according to Department of Health guidelines. MIT would guarantee Class B level effluent during operation. It should be noted that the approved water quality level for treated wastewater used for subsurface irrigation is Class D; and
• Monitoring of the wastewater treatment plant performance will be done according to the Department of Health guidelines by Murdoch University research personnel and the results will be in the public domain.

6. CONCLUSION
Before commissioning and the final approval by the authorities MIT will provide and operation and maintenance manual for the treatment plant, prepared according to guidelines of the Department of Health. As well as the detailed procedures of operation and maintenance, this document will contain technical plans and diagrams, details of the monitoring program, log book entry sections, details of the surveillance operation and contingency plans and the contact details of the responsible parties. The operation and maintenance of the treatment plant will be carried out by MIT technicians for 12 months after commissioning according to the WA Department of Health and Department of Environment guidelines and AS/NZS 4801:2000 standards. During the 12 months the developer’s maintenance staff will be trained to operate the plant. After that they will be in charge of the operation and maintenance procedures with ongoing support of MIT technicians.