ECOLOGICAL ENGINEERING

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Kew Residential Services

Water Sensitive Urban Design

Design Principles and Achievable Objectives

July 2003

Report by: *Ecological Engineering Pty Ltd*

PO Box 12, Darling South, Victoria, 3145

Ph 03 9571 0244, Fax 03 9571 0266

Level 1, 302 Waverley Road, Malvern East, Australia, 3145

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Author(s):	Valerie Mag
Approved by:	Dr Tony Wong
Signed:	
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1. Introduction

Ecological Engineering was commissioned by the Vic Urban on behalf of the Department of Human Services (the proponent) to identify the Water Sensitive Urban Design (WSUD) design principles and achievable objectives for the Kew Residential Services site in Princess Street, Kew in support of a re-zoning application on the site.

The proponent wishes to develop a best practice water management system for the site that would ensure the development does not have a detrimental impact on the natural ecological systems and environment of the property and its surrounds.

This report presents a possible WSUD concept plan which has been developed for the Kew Residential Services site using the guiding principles and practices of WSUD (Chapter 3 of the Victorian *Urban Stormwater: Best Practice Environmental Management Guidelines*). The principles of WSUD are defined and possible applications to the site are discussed.

Results of preliminary quantitative analyses are presented to support the environmental benefits of adopting various water management schemes on the site. These results can be used to set reasonable and achievable water management objectives for the site, particularly in regard to potable water conservation and stormwater pollutant export.

2. Objectives of WSUD

Current urban stormwater management aims to meet multiple objectives including:

- Provision of stormwater conveyance capacity to provide for safe passage of stormwater runoff to avoid nuisance flooding and flood damages to public and private property,
- Provision of on-site stormwater retention to mitigate the increased discharge rates and runoff volumes resulting from urban land development so as to protect the aquatic ecosystems of receiving waterways and avoid increased flooding along downstream waterways and drainage systems,
- Provision of stormwater treatment measures to remove water borne contaminants transported within urban stormwater runoff so as to protect (or enhance) the environmental, social and economic values of receiving waterways,
- Integration of stormwater conveyance and treatment systems into the overall urban and landscape design of urban residential areas, and
- Optimising the use of rain that falls within the development by harvesting stormwater for reuse.

2.1 Stormwater Quantity Management Objectives

The Kew Residential Services site primarily drains towards the north east corner of the site. As with current design standards, the minor drainage system should be designed to contain the 5 year ARI (Average Recurrence Interval) flows and the major drainage system should be designed for the 100 year ARI flows.

The criteria which should be used to establish the target peak flow rate objectives for the estate are:

- no increase in the peak flow rates discharged from the estate for the 1.5yr ARI event for protection of aquatic ecosystems within receiving waterways, and
- no increase in the peak flow rates discharged from the estate for the 100yr ARI event for flood protection.

The adopted target flow rates will need to be determined by future hydrological analysis.

2.2 Stormwater Quality Management Objectives

Urban stormwater quality management for the protection of aquatic ecosystems as well as the inherent social and economic values of receiving waterways is a requirement of all new urban

development under current Victorian Planning Policy. The VPP requires new urban development to comply with the stormwater quality objectives provided in the Victorian *Urban Stormwater: Best Practice Environmental Management Guidelines*. These water quality objectives are provided in Table 1.

The water quality objectives in Table 1 form the water quality objectives for the Kew Residential Services site redevelopment.

Table 1 - Victorian Urban Stormwater Quality Management Objectives

Pollutant	Receiving water objective	Current best practice performance objective
Suspended solids	Not exceed the 90th percentile of 80mg/L	80% retention of the typical urban annual load
Total Phosphorus	Base flow concentration not to exceed 0.08mg/L	45% retention of the typical urban annual load
Total Nitrogen	Base flow not to exceed 0.9mg/L	45% retention of the typical urban annual load
Litter	No litter in waterways	70% reduction of the typical urban annual load

2.3 Water Reuse Objectives

An objective for the redevelopment of Kew Residential Services is to minimise the use of potable water and reduce wastewater export from the site. This benefits the environment by conserving a valuable resource, reducing stormwater runoff from the site and reducing the site pollutant load generation.

Stormwater can be harvested for reuse within buildings (ie toilet flushing, internal hot water use etc), reuse at the lot scale (ie garden watering) and reuse at the site scale (ie irrigation of public open space areas). Landscape irrigation helps to maintain attractive streetscapes, public open space and regional recreation facilities (eg. sporting grounds). Treated greywater can also be used for site landscape watering.

Appendix A details various water management scenarios which can be applied to the site with regard to minimising the use of potable water by capturing, treating and harvesting stormwater as an alternative source of water for some or all of the above uses. The results of the analysis indicate that an achievable potable water conservation objectives for the redevelopment site is a 30 % reduction in potable water use over a conventional development scenario.

3. Water Sensitive Urban Design

WSUD is a design philosophy that aims to achieve the principles of Ecologically Sustainable Development (ESD) through the planning and design of urban areas to minimise their impact on the hydrological cycle and in-turn on the ecological processes that sustain life.

Chapter 5 of the Victorian *Urban Stormwater Best Practice Environmental Management Guidelines, (published by CSIRO)* provides a detail discussion on WSUD. The key elements of WSUD are summarised in the following sections. The ultimate redevelopment of The Kew Residential Services site may not incorporate all of the WSUD practices discussed below. However they are presented at this time so that a full consideration of all alternatives can be considered prior to adoption of the final water management plan for the site.

3.1 Guiding Principles

WSUD has a number of guiding principles that should be considered during both the initial planning and detail design phases of urban development. These are:

- Ensure road, public open space and lot layouts are configured so as to optimise the opportunities for incorporation of WSUD stormwater drainage elements.

- Incorporate WSUD stormwater drainage elements as landscape features within the urban landscape to heighten community regard for stormwater as a valued resource that enhances both social and environmental amenity.

- Incorporate within stormwater drainage systems elements of runoff storage, infiltration, and transpiration to mitigate the impact of increased impervious surfaces on peak flow rates and volumes within receiving waterways.

- Incorporate within stormwater drainage systems elements of physical screening, water storage facilities for sedimentation, and physical/biological filtration to remove water borne contaminants from stormwater runoff prior to discharge to receiving waterways.

- Minimise the utilisation of potable water for non-drinking water uses by providing systems for the capture, treatment and re-use of stormwater runoff and domestic effluent streams (i.e. greywater[1] and blackwater[2]).

[1] Greywater is wastewater generated from bathroom (excluding toilet) and laundry – likely to contain minimal gross faecal contamination

[2] Blackwater is wastewater generated from kitchen and toilet and contains gross faecal contamination.

3.2 Benefits and Constraints

WSUD can offer a number of economic, social and environmental benefits. However, there are some conditions that may constrain the full implementation of WSUD and there may exist a need to supplement WSUD with elements of convention urban design. The following two tables taken from the *Urban Stormwater Best Practice Environmental Management Guidelines* provide a summary of the benefits and constraints/limitation associated with WSUD.

Table 2 – Economic Benefits and Constraints

Economic opportunities	Economic constraints/limitations
• *Capital cost savings*: reduces capital costs (pipework and drains).	• *Market limitations*: the market may be sensitive to new urban forms.
• *Construction cost savings*: reduces construction costs (e.g. grading, tree clearing).	• *Maintenance/operation costs*: can potentially increase maintenance and operation costs.
• *Water quality cost savings*: potentially reduces the costs of water quality improvement, by retaining existing waterways.	• *Limited developable lots*: potential loss of profits through the reduction in the number of developable lots. This occurs in areas that traditionally have been made available through the piping of water courses.
• *Developer cost savings*: reduces developer contributions for downstream drainage capacities.	• *Storm events and steep terrain*: there may be a possible need to supplement water sensitive treatments (such as swales) with pipes, to accommodate minor storm events and steep terrain.
• *Improved market value*: incorporating water features, water frontages, networked public open space and preserving and enhancing ecological systems tends to make developments more desirable and marketable.	• *Land acquisition difficulties*: fragmented land ownership may limit the opportunity to implement water sensitive initiatives.
• *Improved resource utilisation*: offers cost benefits where areas are unsuitable for residential development, but are suitable for passive recreation and contribute to required public open space allocation.	• *Open space requirements*: the benefits may be reduced where potentially attractive residential areas must be reserved as open space.

Table 3 Environmental and Social Benefits and Constraints

Environmental and social opportunities	Environmental and social constraints/limitations
• *Hydrological balance*: maintains the hydrological balance by using natural processes of storage, infiltration and evaporation.	• *Water table depth*: opportunities are limited in areas with high water tables.
• *Sensitive area protection*: protects environmentally sensitive areas from urban development.	• *Topography and erosion*: opportunities are limited in areas of deeply dissected terrain and high slope.
• *Waterways restoration*: restores and enhances urban waterways.	• *Ground conditions*: opportunities are limited in areas of poor soil (high slaking or highly dispersive) and shallow depth to bedrock.
• *Impact reduction*: minimises the impact on the environment of urban development.	• *Safety perceptions*: perceived safety risks.
• *Natural habitats enhancement*: can increase the diversity of natural habitats and suburban landscapes.	• *Acceptance*: may experience some public resistance to new forms in urban landscape.
• *Groundwater recharge.*	
• *Amenable urban and residential landscapes.*	
• *High visual amenity.*	
• *Linking*: opportunities to link community nodes through public open space.	

3.3 Best Planning Practices (BPPs)

WSUD Best Planning Practices (BPPs) are land-use planning techniques and concepts that should be considered at the initial site planning phase of an urban development in order to provide a development layout that maximises the opportunities for implementing the WSUD Best Management Practices (BMPs) outlined later.

3.3.1 Public Open Space (POS) Layout

The integration of POS with conservation corridors, stormwater management systems and recreational facilities is a fundamental objective of WSUD. POS areas provide space for incorporating stormwater conveyance and treatment systems as landscape features within a multi-use corridor thus enhancing the communities understanding and regard of stormwater as a valuable resource with both social and environmental amenity.

Key principles to be considered in locating POS are:

- Align POS along natural drainage lines and site outfall points,
- Protect/enhance areas containing natural water features and other environmental values by locating them within POS, and
- Utilise POS to provide links between public and private areas and community activity nodes.

3.3.2 Road Layouts and Streetscaping

Roads account for a significant percentage of the overall impervious area created within a typical urban development and can generate a number of water borne stormwater contaminants that can adversely impact on receiving waterway health (e.g. metals and hydrocarbons). Consequently, it is important to mitigate the impact of stormwater runoff generated from road surfaces by carefully planning their alignment and streetscapes to enable the use of WSUD drainage elements such as bio-retention swales to collect, attenuate, convey and treat the runoff before discharge to receiving waterways.

Inspite of the natural topography of the site being steeper than 7% (as displayed on the subject site) there will be opportunities to lay the majority of roads at grades less than 4% to enable incorporation of WSUD elements into the streetscape.

3.3.3 Lot Layouts

WSUD promotes the layout of housing lots that address POS areas so as to facilitate greater community access to, and regard of, POS and the associated natural and landscaped water features forming the local stormwater drainage system. Where practicable, natural landscape features such as significant remnant vegetation and natural waterways should be incorporated within POS with housing lots configured around the POS and designed to encourage views

over, and access to (where appropriate), the POS. The connectivity of the lots to the POS allows the creation of clustered allotments.

3.4 Best Management Practices (BMPs)

WSUD Best Management Practices (BMPs) address conveyance, treatment and re-use of stormwater runoff and domestic wastewater. The *Urban Stormwater Best Practice Environmental Management Guidelines* provide a detail description of stormwater treatment BMPs.

Table 4 shows the inter-relationship between site (lot), precinct and regional scale applications of WSUD BMPs.

Table 4 - Site (lot), Precinct and Regional Scale WSUD BMPs

Site (lot)	Precinct	Regional
Porous pavements	Porous pavements	
Buffer Strips	Buffer Strips	
Vegetated Swales	Vegetated Swales	
Bio-retention systems	Bio-retention systems	
Rain gardens	Urban forest	
On-site detention	Retarding basins	Retarding basins
	Constructed wetlands and ponds	Constructed wetlands and ponds
Rainwater tank for stormwater re-use	Pond storage for Stormwater re-use	Pond storage for Stormwater re-use
Light greywater re-use	Treated effluent re-use (third pipe)	Treated effluent re-use (third pipe)

Blue - flow management and water quality treatment BMPs
Green - re-use BMPs

3.5 Description of WSUD BMPs

3.5.1 Porous Pavements

Porous pavements are an alternative to conventional road pavements. They consist of modular pavements cells with gaps between cells to allow infiltration of stormwater.

Porous pavements:

- Must have the capacity to detain stormwater to allow it to infiltrate into the subsurface,
- Require some pre-treatment of stormwater inflow by means of removal of gross pollutants, and coarse to medium size sediment is desirable to reduce the likelihood of clogging, and
- Should not be constructed within 2 m from building structures.

Porous pavements require washing with high pressure hose once every year.

3.5.2 Grass buffers

A grassed (or vegetated filter or buffer strip) is capable of treating shallow overland flow before it enters the drainage network. It requires uniform inflow of stormwater runoff to promote "sheet-flow" condition inflow conditions.

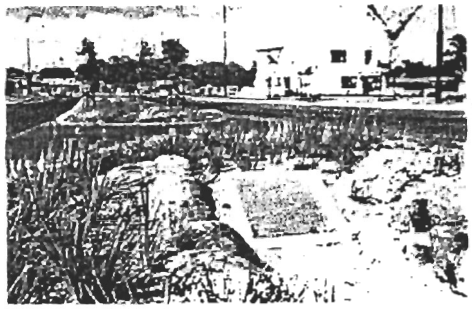
3.5.3 Vegetated swales

A grassed or vegetated channel can be used as an alternative to kerb and gutter or within POS reserves to convey stormwater runoff.

Ideally the bed slope of vegetated swale should be between 2% and 4%. Vegetated swales steeper than 4% should have regular check-dams built to promote uniform flow distribution across the swale. The vegetation in vegetated swales can range from mown grass to dense native vegetation. The swale system is to be designed to carry the peak discharge corresponding to that for the minor drainage system.

Maintenance of the vegetation cover is primarily replacing plants and weed control. Use of dense native vegetation can reduce maintenance significantly.

5.3.4 Linear Bioretention systems



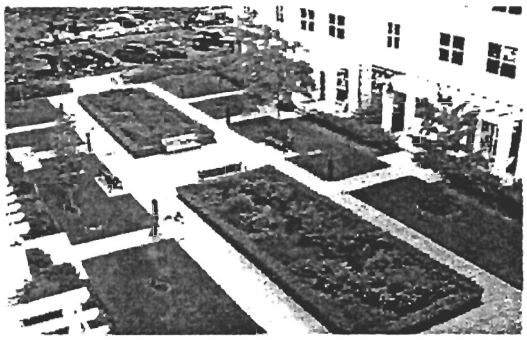
Linear bioretention systems are combined vegetated swale and stormwater filtration systems. Stormwater is filtered through a prescribed media (eg. Sandy loam) before being collected by an underlying perforated pipe for subsequent discharge to a stormwater system.

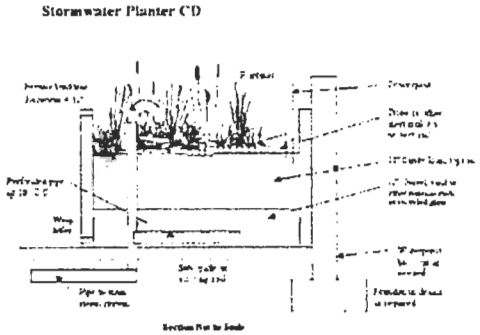
The bed slope of a bioretention system should be less than 4% (preferably less than 2%). Filter media for the bioretention system can range from coarse gravel to a sand/organic mulch mix.

The provision of an underdrain using a perforated pipe is essential for collection and conveyance of filtered stormwater to the receiving water.

Vegetation in surface of the bioretention system can range from mown grass to native vegetation. The surface swale system should be design to carry the peak discharge corresponding to that for the minor drainage system.

5.3.5 Rain Gardens

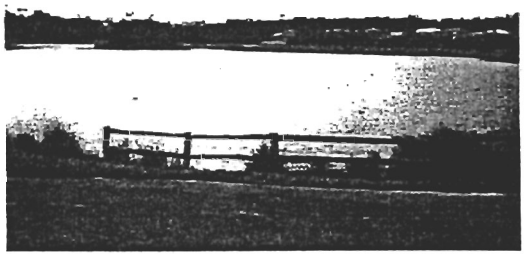




Rain gardens are a form of bio-retention system where traditional garden beds are designed to allow stormwater runoff to be directed into the garden where it is filtered through a prescribed media (eg. Sand/loam) before being collected by an underlying perforated pipe for subsequent discharge to a stormwater system.

Garden bed needs to be depressed to allow for temporary ponding of stormwater on the surface of the garden to allow sufficient time for water to infiltrate into the garden growing media. Provision of an overflow path to either stormwater or sewer (depends on whether rain garden treating stormwater or greywater) may be necessary.

5.3.6 Ponds



Ponds are open water bodys used as storage of stormwater runoff for reuse and/or to serve as an ornamental lake.

Location of the inlet and outlet devices should be placed to minimise short-circuiting of flowpath. The level of pre-treatment of stormwater inflow is dependent on the final use of the water body.

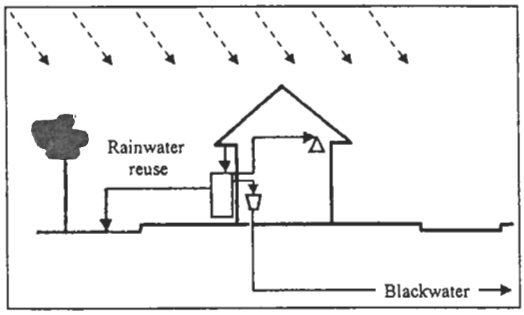
The de-silting frequency of the pond is dependent on size of pond but is typically once every five years to ten years.

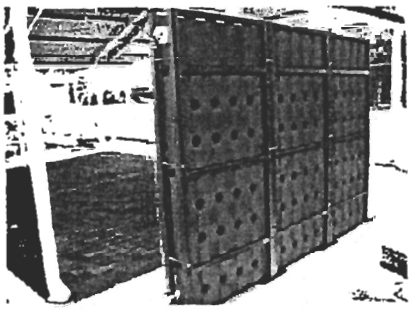
5.3.7 Wetlands

A constructed wetland system is a shallow waterbody system designed to regularly fill and drain. Wetlands tend to be heavily vegetated with emergent aquatic macrophytes which facilitate the removal of fine particulates and soluble pollutants. Wetlands are generally comprised of:

- a sedimentation pond: a relatively deep open water body with vegetated edge and possibly submergent macrophytes (aquatic plants); and
- a wetland: a macrophyte zone, or a permanent or ephemeral shallow water body with extensive emergent vegetation.

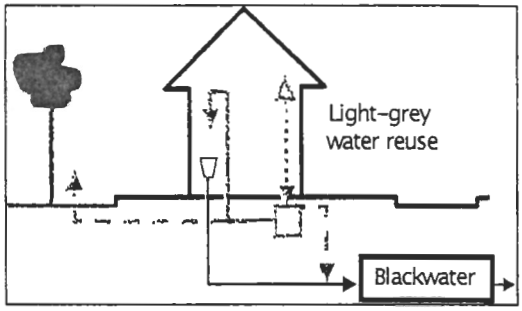
5.3.8 Rainwater tanks





Rainwater tanks are sealed tanks capable of collecting stormwater directly from a roof or other above ground surface. They are designed to allow reuse of the collected water as a substitute for reticulated water either internal or external to a building.

5.3.9 Light Greywater Re-use Systems



These systems are usually closed systems that collects greywater from shower and bathroom basin within an underground tank where the water is disinfected using continuous UV before re-use for toilet flushing and external garden watering. Storage tank volumes need to be optimised depending on the reuse intention.

An alternative system is one whereby light Greywater is collected and treated within subsurface wetland systems (or similar), before being reused for applications such as landscape watering.

4. Suggested Water Management Strategy Development

4.1 Application of WSUD Principles and Practices

Appendix A shows a possible WSUD opportunities analysis of the Kew Residential Services site. This assessment is presented to demonstrate that the objectives of WSUD presented in Chapter 2 are able to be met on the site though the adoption of BPP's and BMP's. Possible considerations in respect of WSUD opportunities are included in Table 3.

Table 3 Possible Application BPP's and BMP's

BEST PLANNING PRACTICES	BEST MANAGEMENT PRACTICES
Integrating POS with stormwater management systems and recreational facilities Incorporating stormwater conveyance and treatment systems as landscape features within the POS areas. Planning road alignments to facilitate the use of WSUD drainage elements either within the road reserves themselves or within adjacent POS areas... Utilising housing orientation and congregation so that dwellings address POS areas so as to facilitate greater community access to, and regard of, POS and the associated natural and landscaped water features forming the local stormwater drainage system. Natural landscape features, such as significant trees on the site should be incorporated within POS with housing lots configured around the POS and designed to encourage views over, and access to (where appropriate), the POS.	Vegetated Swales could be Incorporated within POS areas. A meandering alignment and check dams required to regulate slope. A pond could be located at the lowest point in the site. This should be considered a landscape feature, not a treatment element. Water within the feature could be reused for irrigation. Rainwater tanks could be incorporated at the lot scale to facilitate stormwater reuse for toilet flushing.Greywater could be reused to facilitate POS irrigation. Pre treatment would be required.

The assessment presented is not intended to represent the final WDUD solution for this site. Rather it is an example of how the best practice initiatives can be incorporated to ensure all WSUD objectives are met.

5. Concluding Remarks

The WSUD opportunities identified for the Kew Residential Services site within this report show that current best practice WSUD principles and practices which comply with state planning policy can be applied to this redevelopment.

Through the use of industry standard quantitative modelling techniques (Appendix A) it has been demonstrated that the redevelopment can be designed so as to not have a detrimental impact on local stormwater drainage or receiving waterway ecosystem health. In addition it has been determined that a reduction in post development potable water use of 30 % can be obtained.

WSUD represents a paradigm shift from conventional stormwater drainage techniques, which have focused on flood mitigation with little regard to the impact of urban stormwater quality on receiving waters. Recent legislative and policy directives have necessitated the development of new multi-function stormwater systems that address stormwater quality management, water conservation as well as storm flow conveyance. The analysis detailed in this report show that stormwater treatment elements and water conservation techniques representing the latest technology currently available can be applied to this site. As such the site has great potential to provide an exciting demonstration of WSUD within a redevelopment site.

APPENDIX A

Water Sensitive Opportunities Analysis
Kew Residential Services Redevelopment Site