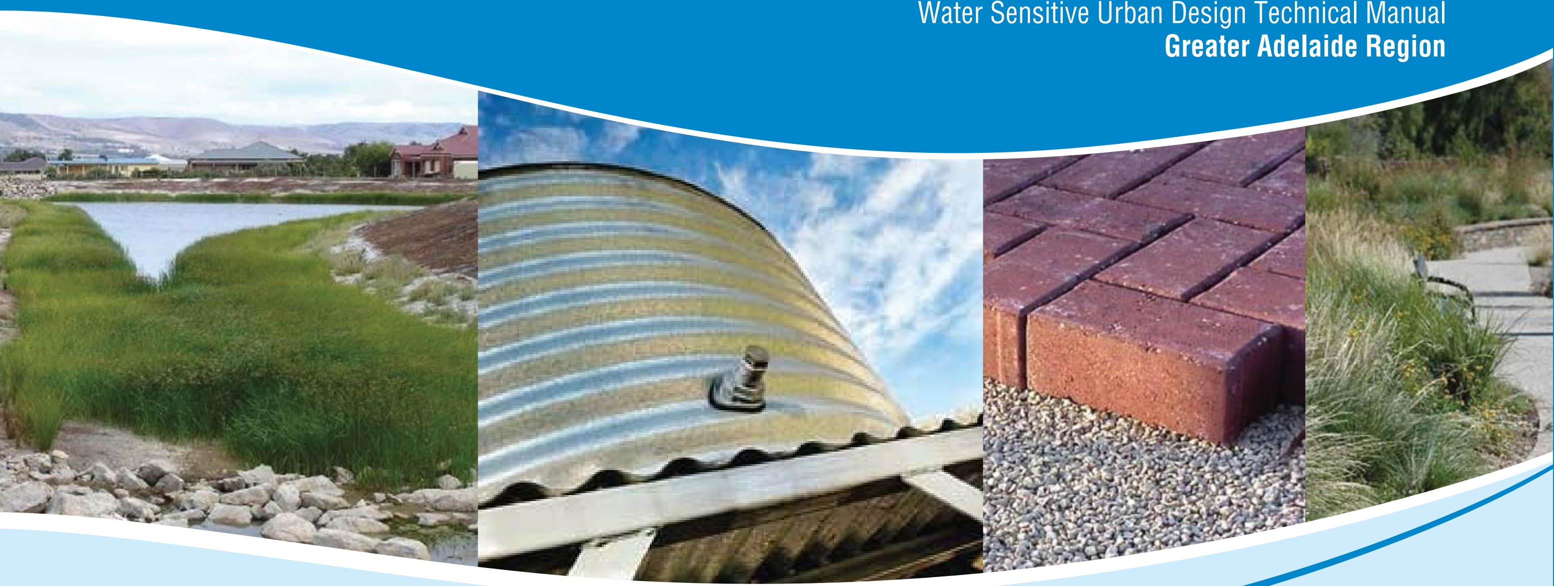
December 2010

Chapter 2

WSUD Measures for Different Types and Scale of Development

Water Sensitive Urban Design Technical Manual
Greater Adelaide Region



Government of South Australia

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Department of the Environment, Water, Heritage and the Arts

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Water Sensitive Urban Design

Water Sensitive Urban Design (WSUD) is an approach to urban planning and design that integrates the management of the total water cycle into the urban development process. It includes:

- Integrated management of groundwater, surface runoff (including stormwater), drinking water and wastewater to protect water related environmental, recreational and cultural values;
- Storage, treatment and beneficial use of runoff;
- Treatment and reuse of wastewater;
- Using vegetation for treatment purposes, water efficient landscaping and enhancing biodiversity; and
- Utilising water saving measures within and outside domestic, commercial, industrial and institutional premises to minimise requirements for drinking and non drinking water supplies.

Therefore, WSUD incorporates all water resources, including surface water, groundwater, urban and roof runoff and wastewater.

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The project partners gratefully acknowledge all persons and organisations that provided comments, suggestions and photographic material.

In particular, it is acknowledged that material was sourced and adapted from existing documents locally and interstate.

Overall Project Management

Christine Lloyd (Department of Planning and Local Government)

Steering Committee

A group of local government, industry and agency representatives provided input and feedback during preparation of the Technical Manual. This group included representatives from:

- Adelaide and Mt Lofty Ranges Natural Resources Management Board;
- Australian Water Association (AWA);
- Department for Transport, Energy and Infrastructure (DTEI);
- Department of Water, Land and Biodiversity Conservation (DWLBC);
- Environment Protection Authority (EPA);
- Housing Industry Association (HIA);
- Local Government Association (LGA);
- Department of Planning and Local Government (DPLG);
- South Australian Murray-Darling Basin Natural Resources Management Board;
- South Australian Water Corporation;
- Stormwater Industry Association (SIA); and
- Urban Development Institute of Australia (UDIA).

Technical Sub Committee

A technical sub committee, chaired by Dr David Kemp (DTEI), reviewed the technical and scientific aspects of the Technical Manual during development. This group included representatives from:

- Adelaide and Mt Lofty Ranges Natural Resources Management Board;
- City of Salisbury;
- Department for Transport, Energy and Infrastructure (DTEI);
- Department of Health;
- Department of Water, Land and Biodiversity Conservation;
- Department of Planning and Local Government; and
- Urban Development Institute of Australia.

From July 2010, DWLBC was disbanded and its responsibilities allocated to the newly created Department For Water (DFW) and the Department of Environment and Natural Resources (DENR).

Specialist consultant team

Dr Kylie Hyde (Australian Water Environments) was the project manager for a consultant team engaged for its specialist expertise and experience in water resources management, to prepare the Technical Manual.

This team comprised Australian Water Environments, the University of South Australia, Wayne Phillips and Associates and QED Pty Ltd.

Beecham and Associates prepared Chapter 16 of the Technical Manual.

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WSUD Measures for Different Types and Scale of Development

2.1 Introduction

As outlined in **Chapter 1**, there is a wide range of WSUD measures available which can be incorporated into development or redevelopment projects.

This chapter provides general guidance about potentially suitable approaches for implementing WSUD across a range of different development types:

- Single residential development (see **Section 2.3**);
- Residential subdivision development (see **Section 2.4**);
- Residential multi-unit development (see **Section 2.5**);
- Streetscape development (see **Section 2.6**);
- Vehicle parking areas (including driveways and access ways on public or private property) (see **Section 2.7**);
- Commercial and industrial development (see **Section 2.8**);
- Upgrade of drainage systems or pavements; and
- Publicly owned land (see **Section 2.9**).

Table 2.1 summarises the potential applicability of various measures.

It should be noted that the preferred optimum solution at one site (i.e. approaches to utilising runoff – e.g. rainwater and stormwater – or reusing treated wastewater) may not be appropriate at another site. A wide range of feasible solutions is usually available and these solutions may need to be ranked according to specific criteria to differentiate them, with selection based on the most suitable solution for the site in question.

Which strategies are selected will depend on factors including:

- Individual site conditions and catchment characteristics (e.g. location, geography);
- Building function and occupancy (e.g. residential, commercial, industrial);
- Development or redevelopment scale and type (e.g. greenfields, brownfields, infill);
- Water use and demand (e.g. garden irrigation demand, industrial use, etc.);

- Water sources available, including local climate (e.g. rainfall seasonality);
- On-site catchment area (e.g. roof and surface);
- Urban landscape design (e.g. architectural and landscape); and
- Greenhouse gas emissions.

It should be noted that WSUD requirements in the Greater Adelaide Region may be different from requirements in other parts of Australia. The Adelaide climate is quite unique and rainfall is highly seasonal. This impacts on everything from supply characteristics for rainwater tanks to irrigation requirements for vegetated WSUD systems, such as rainwater gardens and bioretention systems. Small bioretention basins designed to rely solely on stormwater inflows may work in Melbourne but these same systems may not survive the hot dry summers commonly experienced in Adelaide, where seven to ten day periods of plus 40°C temperatures are not uncommon. Adelaide also has the longest consecutive dry periods of any capital city in Australia. This does not mean that vegetated systems should not be used in Adelaide but it does mean that such systems will often require consideration of additional on-line or off-line storage to provide irrigation water in the inter-storm periods. Chapter 10 describes how to incorporate storages into vegetated WSUD systems.

Selecting the most appropriate WSUD approach will require input from a range of disciplines, including architects, landscape architects, engineers, planners, regulators and local community members with an appreciation of WSUD to produce innovative and optimal solutions.

In some cases the application of certain WSUD measures will be limited due to various constraints which might include space requirements, soil types, groundwater, regulations, etc. A list of potential constraints for each of the WSUD measures presented in this Technical Manual is provided in Error! Reference source not found..

As a general rule, site conditions and the characteristics of any target pollutant(s) influence the selection of an appropriate type of treatment measure, while climate conditions and catchment characteristics influence the hydrologic design and ultimately the overall pollutant removal effectiveness of the measures.

It must also be recognised that all WSUD measures should be assessed for design flood capacity. Consultation with local government with regards to local policies should be the first step. Most councils adopt guidelines and procedures for minor and major flood drainage systems as outlined in *Australian Rainfall and Runoff* (IE Aust. 1987).

Table 2.1 Applicability of WSUD Measures to Different Development Types in the Greater Adelaide Region

Situation/Location	Gross Pollutant Trap	Swale	Buffer Strip	Bioretention Swale	Infiltration Trench	Bioretention System	Rainwater Tank	Pervious Pavement	Underground Storage Tank	Managed Aquifer Recharge	Constructed Wetland	Onsite Wastewater Management	Community Wastewater Management
New Streets In large or small development areas:													
- on slopes less than 4%	X	✓	✓	✓	✓	✓	-	✓	√	X	-	-	-
- on slopes greater than 4%	O	X	X	X	O	O	-	X	O	X	-	-	-
Existing Streets and Roadways Where drainage or pavements to be substantially upgraded or roadway duplicated:													
- on slopes less than 4%	X	✓	✓	✓	✓	✓	-	✓	✓	X	-	-	-
- on slopes greater than 4%	O	X	X	X	O	O	-	X	O	X	-	-	-
Publicly Owned Land Where land area and land use allow additional facilities to be incorporated	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X
Residential Development													
- detached housing (on lots > 500 m²)	-	-	-	-	✓	✓	✓	✓	✓	X	-	O	-
- medium density or integrated housing (lots < 500 m²)	-	-	-	-	O	O	✓	✓	✓	X	-	O	-
Commercial Development Commercial / Industrial properties	✓	✓	✓	✓	✓	✓	✓	✓	✓	O	O	O	
Carparks – Public or Private Property New carpark construction	✓	✓	✓	✓	✓	✓	✓	✓	✓	O	O	O	

✓ - appropriate O limited, requires investigations or approvals X not appropriate - not applicable

Source: Adapted from Knox City Council (2002)

Table 2.2 Potential Constraints Associated with WSUD Application

WSUD Measure	Potential constraints:								
	Steep site/catchemnt slope	High water table	Shallow bedrock	Land availabilty limitation	Installation underground is required	High sediment input	Requires pre-treatment	Hydraulic head loss limitation	Installtion in tidal system
Sediment traps	●	●	○	○	●	○	○	○	○
Gross pollutants traps	●	○	○	○	○	○	○	⊕	○
Filter strips	⊕	⊕	○	⊕	⊕	●	●	●	⊕
Grass swales	⊕	⊕	○	⊕	⊕	●	●	●	⊕
Bioretention systems	⊕	○	●	●	●	○	●	⊕	○
Infiltration trenches*	⊕	⊕	⊕	○	●	⊕	●	○	⊕
Rain Gardens	⊕	⊕	⊕	⊕	○	⊕	●	○	⊕
Pervious pavements	⊕	⊕	⊕	⊕	●	⊕	●	○	⊕
Sedimentation basin	○	○	○	⊕	⊕	⊕	●	○	○
Constructed wetlands	⊕	○	○	⊕	⊕	○	●	○	○

Legend:

⊕ Constraint may preclude this measure.

○ Constraint may be overcome with appropriate design.

● Generally not a constraint

* Pretreatment required to remove litter and sediment

2.2 Treatment Train

Runoff can carry a wide range of pollutant types and sizes and in most cases no single treatment measure is able to effectively treat all pollutants carried by runoff.

A series of treatment measures that collectively addressed all runoff pollutants is termed a treatment train. The selection and order of treatments is a critical consideration in developing treatment trains. The coarser pollutants generally require removal so that treatments that target fine pollutants can operate effectively. Other considerations when determining a treatment train are the proximity of a treatment to its source as well as the distribution of treatments throughout a catchment.

It is therefore important to understand the locations where treatment measures may be utilised within a site so that quantities of pollutants and flow likely to be received at each location are appropriate.

Table 2.3 shows a generalised relationship between pollutant characteristics (defined by particle size) and effective treatment processes. It can be seen from these figures that a treatment train needs to include a range of treatment measures in order to address the full range of pollutants likely to be found in urban runoff.

The treatment processes listed in **Table 2.3** can be achieved through:

- Screening – pre-filtering technologies, litter baskets, gross pollutant traps;
- Sedimentation – sedimentation basins, ponds, wetlands;
- Adhesion and filtration – bioretention systems, infiltration systems and wetlands; and
- Biological uptake – wetlands and biofiltration systems.

Table 2.3 Stormwater Pollutant Management Issues and Appropriate Treatment Processes

Particle Size Grading	Management Issue					Treatment Process
	Visual	Sediment	Organics	Nutrients	Metals	
Gross solids	↑	↑	↑			Screening
> 5000 µm						
Coarse to Medium					↑	Sedimentation
5000 – 125 µm				↑		
Fine Particulates		↓				Enhanced sedimentation
125 – 10 µm						
Very Fine / Colloidal	↓				↓	Adhesion and filtration
10 – 0.45 µm						
Dissolved Particles			↓	↓		Biological uptake
< 0.45 µm						

Source: Adapted from Wong et al. (2002)

2.3 Single Residential Development

Description

A single residential development refers to a dwelling on an individual allotment.

Objectives

Example WSUD objectives for a single residential development include:

- Maintain availability of water during restrictions;
- Maximise the efficient use of rainwater and mains water;
- Assist maintenance of garden / landscaping;
- Ensure water supply for fire protection (where appropriate);
- Reduce flood risk;
- Reduce greenhouse gas emissions;
- Improve biodiversity;
- Prevent erosion; and
- Improve water quality.

A range of other objectives can be found in **Appendix C** of **Chapter 3** of the WSUD Technical Manual.

Common Techniques

There are various WSUD techniques which can be used when developing water management strategies for single residential developments. These techniques can assist in achieving mains use reduction, water quality and water quantity targets.

The common techniques are described in detail in the relevant chapters of the WSUD Technical Manual for the Greater Adelaide Region:

- Demand reduction including water efficient fittings and appliances (**Chapter 4**);
- Landscaping (throughout various chapters, but predominantly **Chapter 4**);
- Rainwater tanks (**Chapter 5**);
- Rain gardens (**Chapter 6**);
- Green roofs (**Chapter 6**);
- Infiltration systems (**Chapter 6**);

- Pervious pavements (**Chapter 7**); and
- Wastewater reuse (**Chapter 14**).

Site Strategy

Any combination of the measures (i.e. rainwater tanks, pervious paving, filtration/infiltration devices, landscape practices) listed above can be very effective at achieving the objectives and targets on a single residential development. For maximum effectiveness, these measures need to be carefully designed as part of an overall strategy that considers local site conditions, development scale and layout.

Figure 2.1 opposite shows a possible overall strategy for a typical suburban home. A rainwater tank supplies water for toilet flushing, washing machine usage, and for outdoor use while water efficient fittings reduce mains water consumption elsewhere.

During prolonged or heavy storms, rainwater can overflow from the rainwater tank to an infiltration (or retention) trench. Runoff from paths, driveways and lawns is directed to garden areas (i.e. rain garden). Excess runoff from impervious surfaces is directed to the retention trench, or overflows to the street drainage system.

Landscape practices also influence selection (and location) of species to reduce water demand and to achieve biodiversity outcomes.

Utilising greywater for garden watering and toilet flushing is an emerging area of investigation and technology.

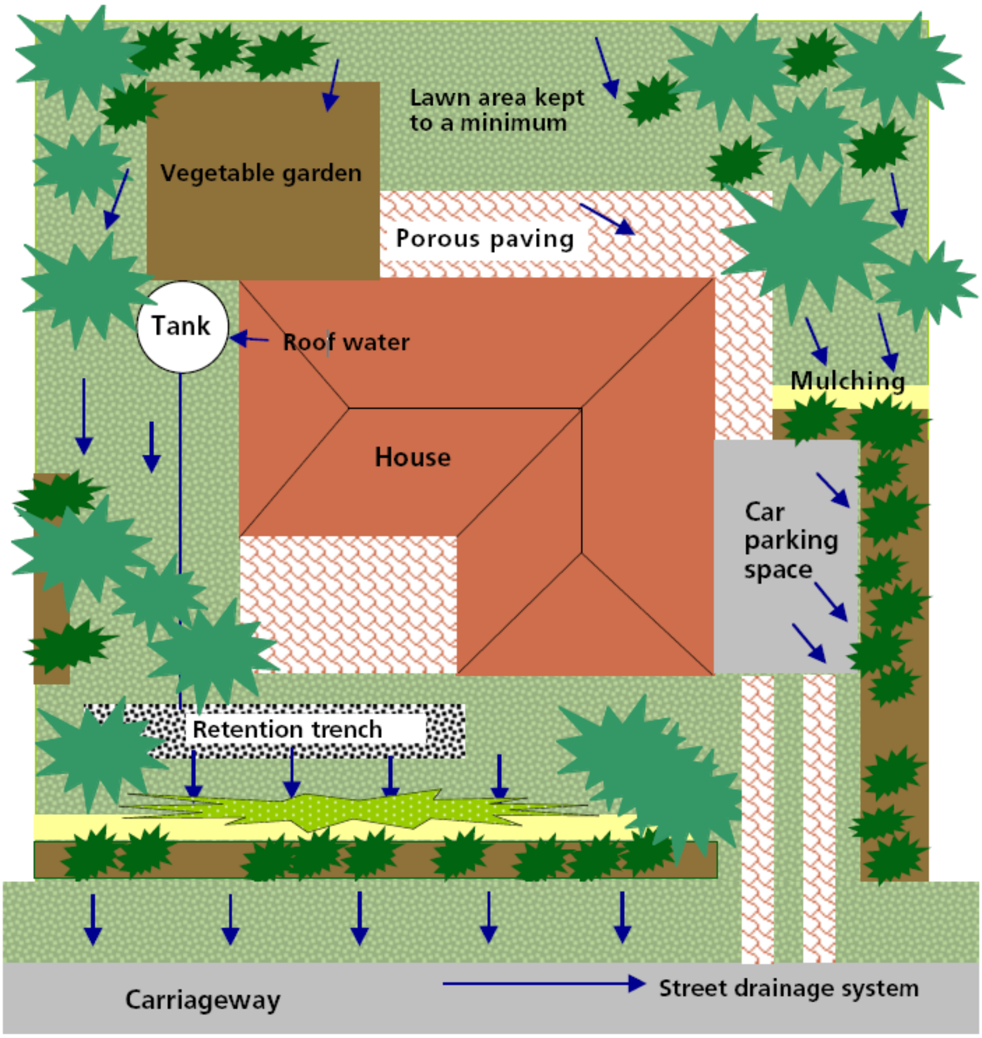

Figure 2.1 Example of an Overall WSUD Strategy for a Typical Suburban Dwelling

Source: LHC CREMS (2002)

2.4 Residential Subdivision

Description

A residential subdivision refers to an area with numerous dwellings on individual allotments.

Objectives

Example WSUD objectives for a residential subdivision development include:

- Integrate natural and/or existing site topographical features into the subdivision design;
- Maximise use of natural and/or existing features for multiple use;
- Minimise capital and maintenance costs per household for municipal infrastructure;
- Maximise amount of public open space;
- Maximise opportunity to direct runoff into the ground or water body (where safe, compatible and appropriate to the function of the area or water body);
- Maintain availability of water during restrictions;
- Maximise efficient use of water;
- Assist maintenance of garden / landscaping;
- Maximise development amenity;
- Ensure water supply for fire protection (where appropriate);
- Reduce flood risk;
- Prevent erosion; and
- Improve water quality.

A range of other objectives can be found in **Appendix C** of **Chapter 3** of the WSUD Technical Manual.

Common Techniques

There are various WSUD techniques which can be used when developing water management strategies for residential subdivision developments. These techniques can assist in achieving mains use reduction, water quality and water quantity.

The common techniques are described in detail in the relevant chapters of the Technical Manual for the Greater Adelaide Region:

- Landscaping (throughout various chapters, but predominantly **Chapter 4**);
- Rainwater tanks (**Chapter 5**);
- Pervious pavements (**Chapter 7**);
- Gross pollutant traps (**Chapter 9**);
- Bioretention systems (**Chapter 10**);
- Swales and buffer strips (**Chapter 11**);
- Sedimentation basins (**Chapter 12**);
- Constructed wetlands (**Chapter 13**); and
- Wastewater reuse (**Chapter 14**).

Site Strategy

Any combination of the techniques (i.e. landscape practices, bioretention systems, swales, constructed wetlands) listed above can be very effective at achieving WSUD objectives and targets for residential subdivision sites. For maximum effectiveness, these measures need to be carefully designed as part of an overall strategy that considers local site conditions, development scale and layout.

WSUD subdivisions offer opportunities for:

- Narrow road reserves which reduce the area requiring irrigation (and maintenance);
- Integrating design of access and crossovers to maximise scope for retention of existing vegetation and for new plantings which minimise water requirements;
- Variation in road reserve widths to facilitate integrated stormwater management and substantial plantings;
- Footpath alignments that respond to natural features and stormwater management to create spaces that are easy to maintain and efficient to irrigate (if necessary);
- Pervious paving for footpaths and parking areas;
- Common trenching and closer alignment of services to improve scope for reduced verges to retain existing vegetation and plant new vegetation;
- Appropriate landscape practices that include the selection of species to reduce water demand;
- Constructed wetlands to detain, retain and treat urban runoff;
- Wastewater treatment and reuse to irrigate public open spaces.

WSUD facilitates the use of smaller, more compact housing lots adjacent to open space areas that typically have high amenity value. This allows greater community access to open space, improving social connectivity and interaction. WSUD measures include 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 open space, with housing lots configured around the open space and designed to encourage views over and access to the open space.

The connectivity of the lots to the open space allows the creation of smaller lots through provision of less lawn and garden area on the lot. The reduced lot size is balanced by each lot's direct connectivity to the adjoining open space. Experience would suggest that lots with direct access to open space and water features have elevated values compared to conventional lot designs.

At the subdivision scale, sustainable stormwater management includes conveyance controls such as grass swales and bioretention swales, water sensitive road design and natural waterways, and storage methods such as open ponds or covered tanks, constructed wetlands and aquifer recharge. These storage methods offer opportunities to utilise stormwater for irrigation of parklands, sporting fields and for cluster housing groups thus reducing the importation of water and the subsequent transmission costs and associated greenhouse gas emissions.

2.5 Residential Multi-unit Development

Description

Residential multi-unit development refers to developments such as:

- High rise residential units;
- Retirement villages;
- Aged accommodation;
- Townhouses; and
- Single storey units.

In most of these types of development, residential water demand is similar to a typical household with the exclusion of garden irrigation. Rainwater capture from the roof is limited due to the relative small surface area ratio to water demand (i.e. number of people).

Objectives

Example WSUD objectives for a residential multi-unit development include:

- Integrate natural and/or existing site topographical features into the development design;
- Maximise use of natural and/or existing features for multiple use;
- Minimise capital and maintenance costs per household for infrastructure;
- Maximise amount of public open space;
- Maximise opportunity to direct runoff into the ground or water body (where safe, compatible and appropriate to the function of the area or water body);
- Maintain availability of water during restrictions;
- Maximise efficient use of water;
- Assist maintenance of garden / landscaping;
- Ensure water supply for bushfire protection (where appropriate);
- Reduce flood risk;
- Prevent erosion;
- Improve water quality; and
- Reduce greenhouse gas emissions.

A range of other objectives can be found in **Appendix C** of **Chapter 3** of the WSUD Technical Manual.

Common Techniques

There are various WSUD techniques which can be used when developing water management strategies for residential multi-unit developments. These techniques can assist in achieving mains use reduction, water quality and water quantity targets.

The common techniques are described in more detail in the relevant chapters of the WSUD Technical Manual for the Greater Adelaide Region:

- Demand reduction including water efficient fittings and appliances (**Chapter 4**);
- Landscaping (throughout various chapters, but predominantly **Chapter 4**);
- Rainwater tanks (**Chapter 5**);
- Rain gardens (**Chapter 6**);
- Green roofs (**Chapter 6**);
- Infiltration systems (**Chapter 6**);
- Pervious pavements (**Chapter 7**);
- Gross pollutant traps (**Chapter 9**);
- Bioretention systems (**Chapter 10**);
- Wastewater reuse (**Chapter 14**); and
- Siphonic roofwater systems (**Chapter 16**) for multi-storey residential development.

Site Strategy

Any combination of the techniques (i.e. rainwater tanks, pervious paving, filtration/infiltration devices, landscape practices) listed above can be very effective at achieving the objectives for multi-unit developments. For maximum effectiveness, these measures need to be carefully designed as part of an overall strategy that considers local site conditions, development scale and layout.

Figure 2.2 below shows a possible overall strategy for a multi-unit development. In addition to the features shown, a multi-unit development offers opportunities for:

- Narrow driveways to maximise the pervious area;
- Integrating the design of driveways to maximise scope for retention of existing vegetation and for new plantings;
- Variation in driveway widths to facilitate integrated stormwater management and substantial plantings;

- Footpaths integrated with driveways which respond to natural features and stormwater management to create spaces that are easy to maintain and efficient to irrigate;
- Pervious paving for driveways and parking areas;
- Common trenching and closer alignment of services to improve scope for reduced disturbance and trenching to retain existing vegetation and plant new vegetation;
- Appropriate landscape practices that include the selection of species to reduce water demand;
- Water efficient fixtures and appliances; and
- Community scale wastewater capture, treatment and reuse.

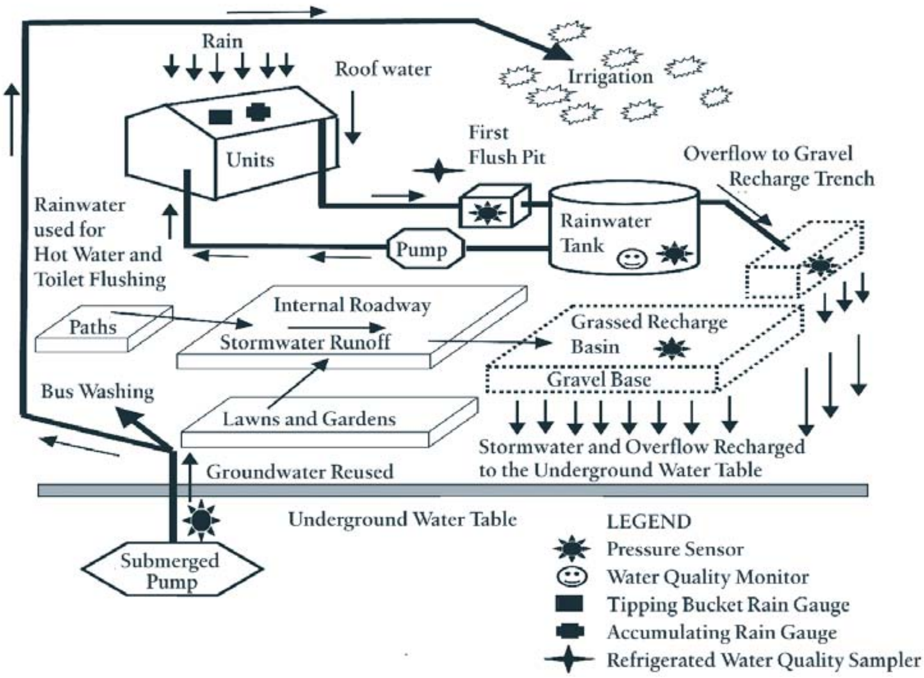

Figure 2.2 Schematic of a WSUD Multi-unit Layout Utilising Groundwater Recharge and Stormwater Reuse

Source: Hobart City Council (2006)

2.6 Streetscape Development

Description

Roads account for a significant percentage of the overall impervious hard surfaces created within a typical development and therefore can significantly change the way water is transported through an area and the volume of runoff that is generated. These areas also generate water borne pollutants that can adversely impact on receiving waterway health (e.g. fine sediments, metals and hydrocarbons). Consequently, it is important to mitigate the impact of runoff generated from road surfaces.

Road alignments and streetscapes should be carefully planned to incorporate some degree of treatment. WSUD drainage elements can be used to collect, attenuate, convey and treat the runoff before discharge to receiving waterways.

Objectives

Example WSUD objectives for a streetscape development include:

- Integrate natural and/or existing site topographical features into the development design;
- Maximise use of natural and/or existing features for multiple use;
- Minimise capital and maintenance costs for infrastructure;
- Maximise opportunity to direct runoff into the ground or water body (where safe, compatible and appropriate to the function of the area or water body);
- Maximise efficient use of water;
- Assist maintenance of landscaping;
- Reduce flood risk;
- Prevent erosion;
- Improve water quality;
- Improve amenity; and
- Improve biodiversity.

A range of other objectives can be found in **Appendix C** of Chapter 3 of the WSUD Technical Manual.

Common Techniques

No single street layout will be appropriate for all development and it is largely dependent on topography, density of development and traffic volume. Areas of low traffic volume (i.e. local access streets) may have the greatest flexibility in design alternatives.

The following techniques are commonly used in WSUD strategies for streetscape development. These techniques can assist in achieving mains use reduction, water quality and water quantity targets.

The common techniques are described in more detail in the relevant chapters of the WSUD Technical Manual for the Greater Adelaide Region:

- Landscaping (throughout various chapters, but predominantly **Chapter 4**);
- Infiltration systems (**Chapter 6**);
- Pervious pavements (**Chapter 7**);
- Gross pollutant traps (**Chapter 9**);
- Bioretention systems (**Chapter 10**);
- Swales and buffer strips (**Chapter 11**); and
- Sedimentation basins (**Chapter 12**).

Site Strategy

A WSUD streetscape integrates road layout, vehicular and pedestrian requirements with water management needs. It uses design measures such as maximising pervious areas, local stormwater detention (and retention) in road reserves and managed landscaping.

Any combination of the techniques (i.e. pervious paving, filtration/infiltration devices, landscape practices) listed above can be very effective at achieving the objectives and targets for streetscape design. For maximum effectiveness, these measures need to be carefully designed as part of an overall strategy that considers local site conditions.

Figure 2.3 Retrofit of Street with a Swale, City of Onkaparinga

Source: Courtesy of City of Onkaparinga

Figure 2.4 shows a possible overall strategy for streetscape development and **Figure 2.5** shows an example of alternative verge design and incorporation of WSUD features.

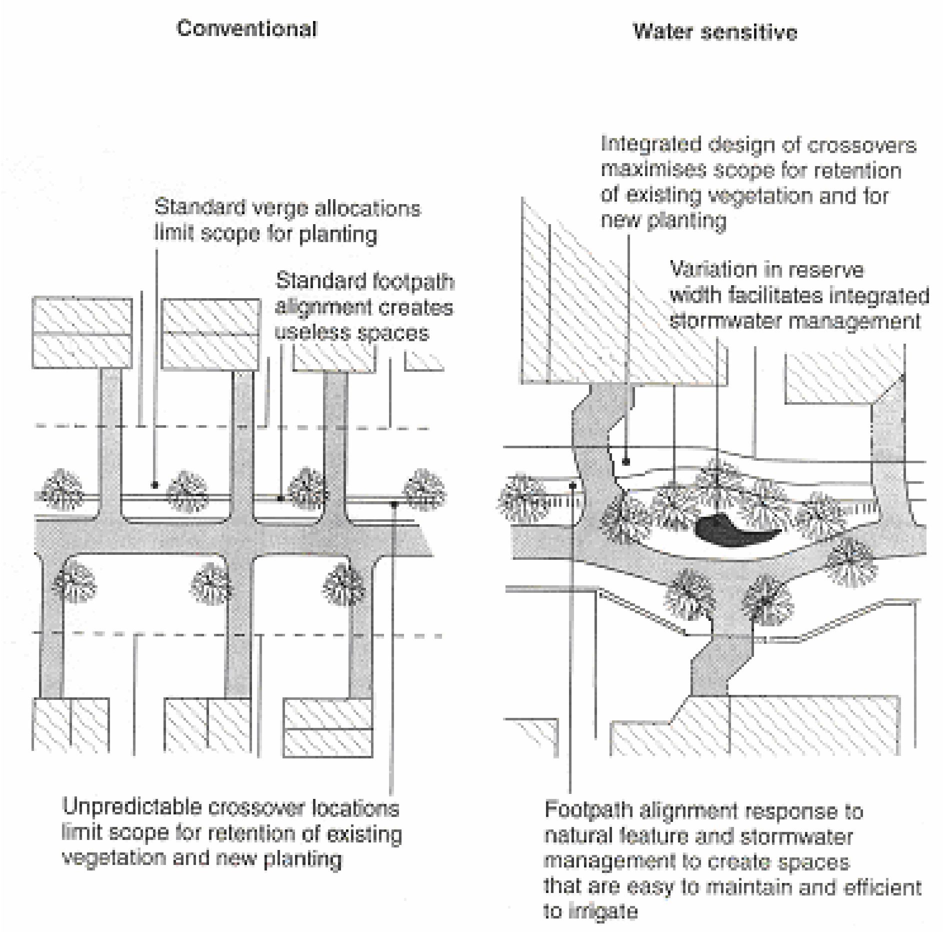

Figure 2.4 Conventional vs Water Sensitive Road Layout

Source: CSIRO (1999)

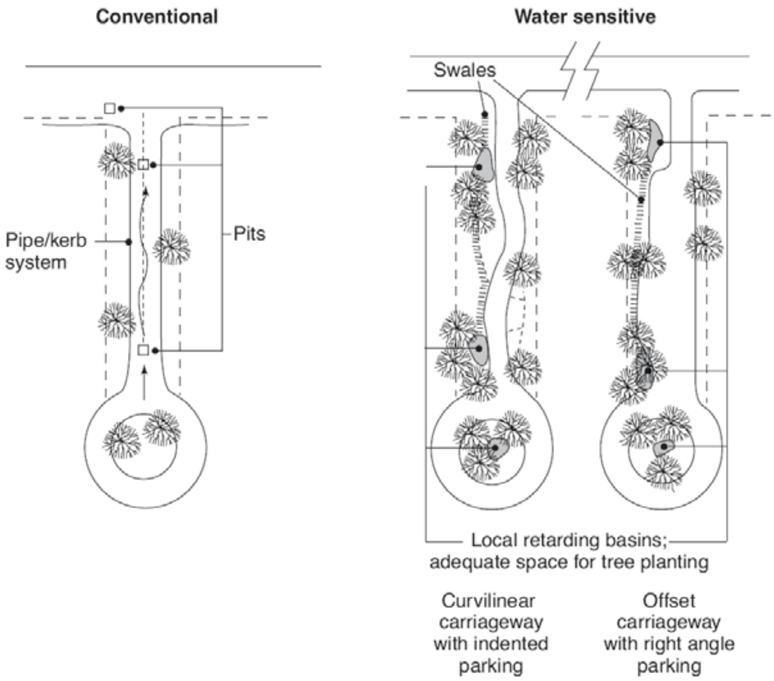

Figure 2.5 Verge Design and Maintenance

Source: CSIRO (1999)

In addition to the features shown, water sensitive streetscapes offer opportunities for:

- Narrowing roads to reduce impervious paved areas (however not at the expense of pedestrian and vehicle connectivity);
- Integrating design of driveways and crossovers to maximise scope for retention of existing vegetation and for new plantings;
- Varying road and road reserve widths to facilitate integrated stormwater management, maximise and enhance open space and landscaping possibilities and streetscape amenity;
- Integrating footpaths within road reserves to respond to natural features and stormwater management to create spaces that are easy to maintain and efficient to irrigate;
- Incorporating pervious paving in roads, driveways and parking areas where appropriate;
- Incorporating water absorbing drainage facilities (e.g. swales or bioretention swales) into the streetscape, using surface exposed systems, rather than underground piping systems;
- Incorporating local filtration by using rock/gravel filter beds with drainage channels;

- Common trenching and closer alignment of services to improve scope for reduced disturbance and trenching to retain existing vegetation and plant new vegetation;
- Installing aesthetically appealing features, with emphasis on verge treatment via natural elements such as locally occurring rock, vegetation, etc., rather than via concrete or bitumen pavement; and
- Appropriate landscape practices that include the selection of species to reduce water demand (including artificial turf).

Roads and streetscapes are continually upgraded in the Greater Adelaide Region. Opportunities exist for incorporating WSUD measures in roadways by diverting the flow from the road to a treatment system, as illustrated in **Figure 2.6** including:

- Traditional road features such as medians, traffic calming bays, street trees and car parking nodes designed to be lower than the road level to collect runoff from the road;
- Kerb and channel can be replaced with swales;
- Street trees can be retrofitted into stormwater treatment bioretention planter boxes whereby stormwater is diverted into the planter box and filtered through a sandy loam prior to discharge to the stormwater systems; and
- Medians and traffic calming bays can be retrofitted as bioretention systems.

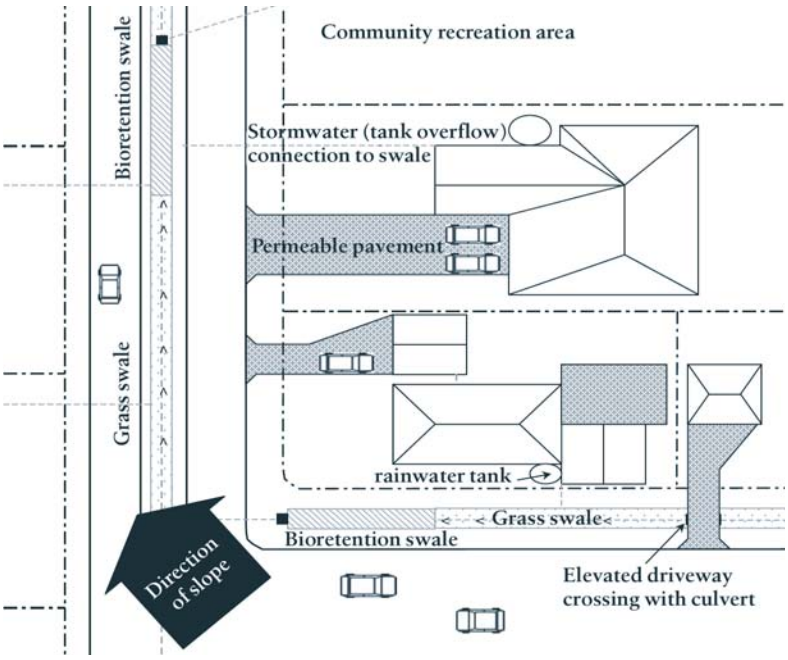

Figure 2.6 Diagram of Water Sensitive Residential Streetscape Showing Bioretention Swale Street Drainage

Source: Hobart City Council (2006)

2.7 Vehicle Parking Area Development

Description

Vehicle parking areas include small scale to large scale car parks. While vehicle parking areas can be large generators of polluted runoff, creative design options can minimise the extent of impervious surfaces in parking areas and subsequent impacts on downstream water bodies.

Objectives

Example WSUD objectives for vehicle parking area development include:

- Integrate natural and/or existing site topographical features into the vehicle parking area design;
- Minimise capital and maintenance costs;
- Maximise opportunity to direct runoff into the ground or water body (where safe, compatible and appropriate to the function of the area or water body);
- Maintain availability of water during restrictions;
- Maximise efficient use of water;
- Assist maintenance of landscaping;
- Achieve high amenity;
- Reduce flood risk;
- Prevent erosion;
- Improve water quality; and
- Improve vehicle parking facility aesthetics.

A range of other objectives can be found in **Appendix C** of **Chapter 3** of the WSUD Technical Manual.

Common Techniques

No single vehicle parking area layout will be appropriate for all sites and it is largely dependent on topography, area available and traffic volume.

There are numerous techniques which can be used in WSUD strategies for vehicle area development. These techniques can assist in achieving mains use reduction, water quality and water quantity targets.

The common techniques are described in the following chapters of the WSUD Technical Manual:

- Landscaping (throughout various chapters, but predominantly **Chapter 4**);
- Rain gardens (**Chapter 6**);
- Infiltration systems (**Chapter 6**);
- Pervious pavements (**Chapter 7**);
- Gross pollutant traps (**Chapter 9**);
- Bioretention systems (**Chapter 10**);
- Swales and buffer strips (**Chapter 11**);
- Sedimentation basins (**Chapter 12**); and
- Constructed wetlands (**Chapter 13**).

Figure 2.7 Road Verge and Carpark Area

Source: Courtesy of City of Salisbury

Site Strategy

It is desirable to incorporate various WSUD measures in the design of vehicle parking areas.

Water sensitive vehicle parking areas are best achieved on sites that are relatively flat to gently sloping, with soils suitable for infiltration (e.g. sandy soils). It is essential that overflow paths for major storms are identified and that these conform to established standards.

Gently sloping grassed areas or recessed basins can be incorporated in vehicle parking areas. These may be used to pond water to allow filtration of pollutants and the deposition of sediment. This is commonly accomplished by incorporating specifically designed or modified inlet structures that permit the temporary storage of runoff.

Any combination of the techniques (i.e. pervious paving, filtration/infiltration devices, landscape practices) listed above can be very effective at achieving the WSUD objectives and targets for the site. For maximum effectiveness, these measures need to be carefully designed as part of an overall strategy that considers local site conditions.

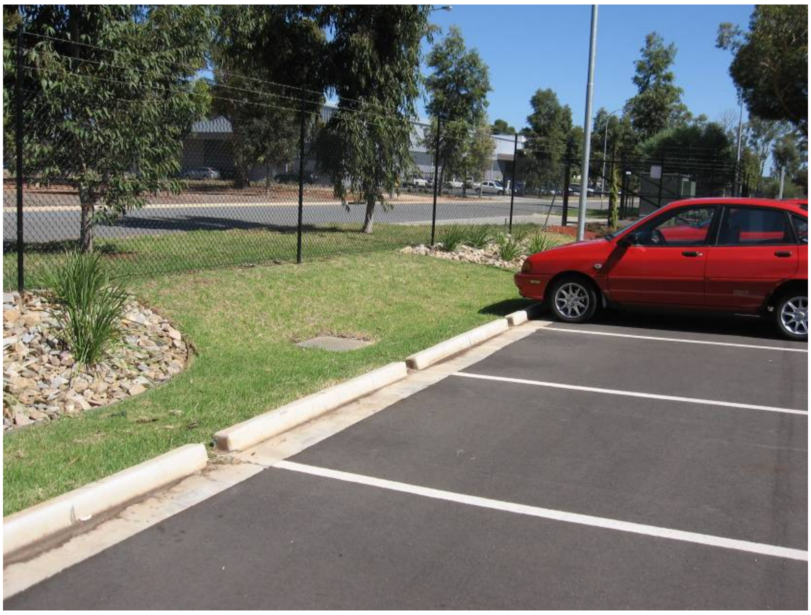

Figure 2.8 Carpark Design Incorporating WSUD Measures

Source: Courtesy of City of Salisbury

Figure 2.9 shows a sample overall strategy for a vehicle parking area which incorporates WSUD measures. In addition to the features shown, vehicle parking areas offer opportunities to:

- Optimise lane widths to maximise the pervious area (if harvesting is not an objective);
- Integrate design of lanes to maximise scope for retention of existing vegetation and for new plantings;
- Integrate stormwater management and substantial plantings;
- Integrate footpaths to respond to natural features and stormwater management to create spaces that are easy to maintain and can be irrigated efficiently;
- Include pervious paving for laneways and parking spaces;
- Incorporate common trenching and closer alignment of services to improve scope for reduced disturbance and trenching to retain existing vegetation and plant new vegetation.

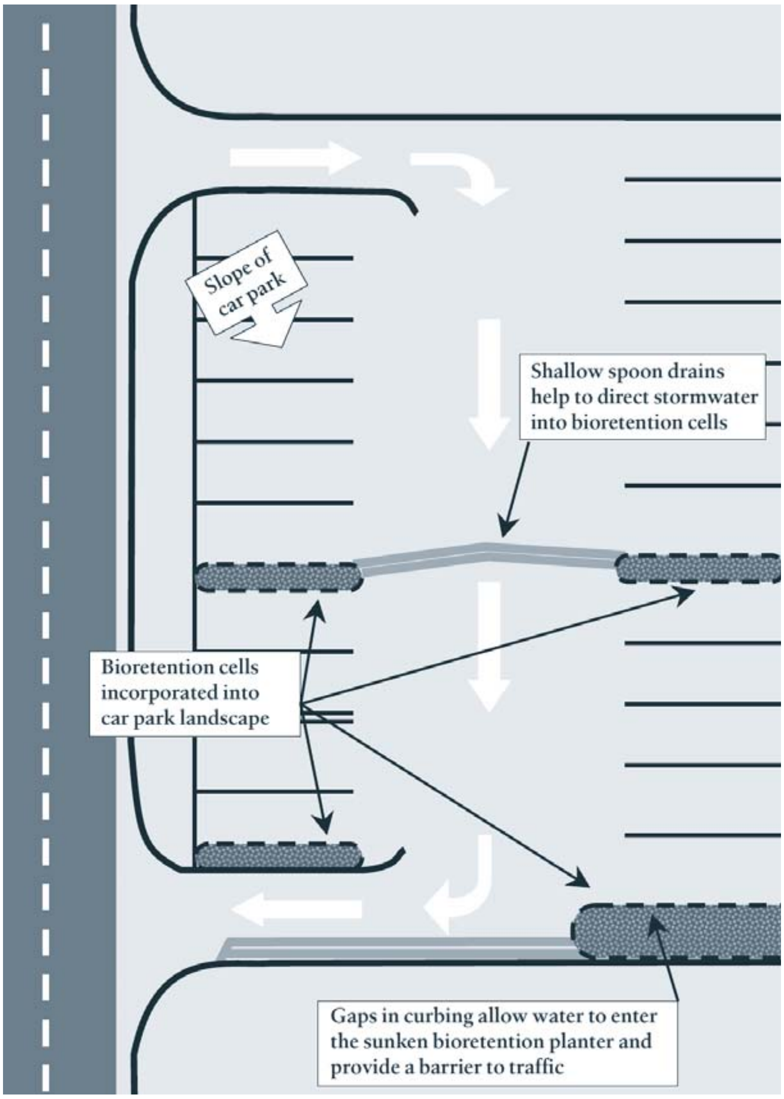

Figure 2.9 Vehicle Parking Area Layout Example Incorporating WSUD Measures

Source: Hobart City Council (2006)

2.8 Commercial and Industrial Sites

Description

Typically in office buildings, water usage is dominated by toilet flushing. Relatively small demand exists for drinking water and garden irrigation. Little greywater generation is expected as there is generally minimal showering in these buildings.

The commercial sector goes beyond offices to include retailing centres, markets, schools, universities, hospitals and event venues.

Industrial water use is dependent on the specific industry and site. For example, water use ranges from cooling water for industrial equipment to very high purity water for technology companies. Industry should use 'fit-for-purpose' water and be able demonstrate best water management and practice.

Objectives

Example WSUD objectives for a commercial or industrial development site include:

- Integrate natural and/or existing site topographical features into the development design;
- Maximise use of natural and/or existing features;
- Minimise capital and maintenance costs for service infrastructure;
- Maximise amount of open space for employee use;
- Maximise opportunity to direct runoff into the ground or water body (where safe, compatible and appropriate to the function of the area or water body);
- Maintain availability of water supply during restrictions;
- Maximise efficient use of water (including reuse);
- Assist maintenance of landscaping;
- Ensure water supply for fire protection (where appropriate);
- Reduce flood risk;
- Reduce peak discharges downstream;
- Prevent erosion;
- Improve water quality;
- Improve biodiversity; and
- Improve aesthetics.

A range of other objectives can be found in **Appendix C** of **Chapter 3** of the WSUD Technical Manual.

Common Techniques

There are numerous techniques that can be used in WSUD strategies for industrial and commercial development sites. These techniques can assist in achieving mains use reduction, water quality and water quantity targets.

The common techniques are described in the following chapters of the WSUD Technical Manual:

- Demand reduction (**Chapter 4**);
- Landscaping (throughout various chapters, but predominantly **Chapter 4**);
- Rain gardens (**Chapter 6**);
- Infiltration systems (**Chapter 6**);
- Green roofs (**Chapter 6**);
- Pervious pavements (**Chapter 7**);
- Bioretention systems (**Chapter 10**);
- Swales and buffer strips (**Chapter 11**);
- Sedimentation basins (**Chapter 12**);
- Constructed wetlands (**Chapter 13**);
- Wastewater reuse (**Chapter 14**); and
- Siphonic roofwater systems (**Chapter 16**) (for buildings over 4.5 metres in height).

Site Strategy

Any combination of the techniques (i.e. rainwater tanks, pervious paving, filtration/infiltration devices, landscape practices) listed above can be very effective at achieving the WSUD objectives and targets for industrial and commercial sites. For maximum effectiveness, these measures need to be carefully designed as part of an overall strategy that considers local site conditions.

Figure 2.10 shows a possible overall strategy for industrial or commercial developments.

Commercial and industrial sites can reduce water demand through efficient toilets and appliances. Buildings with large catchment areas can harvest rainwater which can be utilised for toilet flushing and irrigation, as such sites often have large garden areas. Runoff can also be harvested from large carpark areas.

Other opportunities for industrial sites include multiple uses of water within a manufacturing site, the use of treated wastewater for process cooling applications and harvesting runoff for on-site use. As industrial developments and their water use are varied throughout the Greater Adelaide Region, approaches should be developed on a case by case basis.

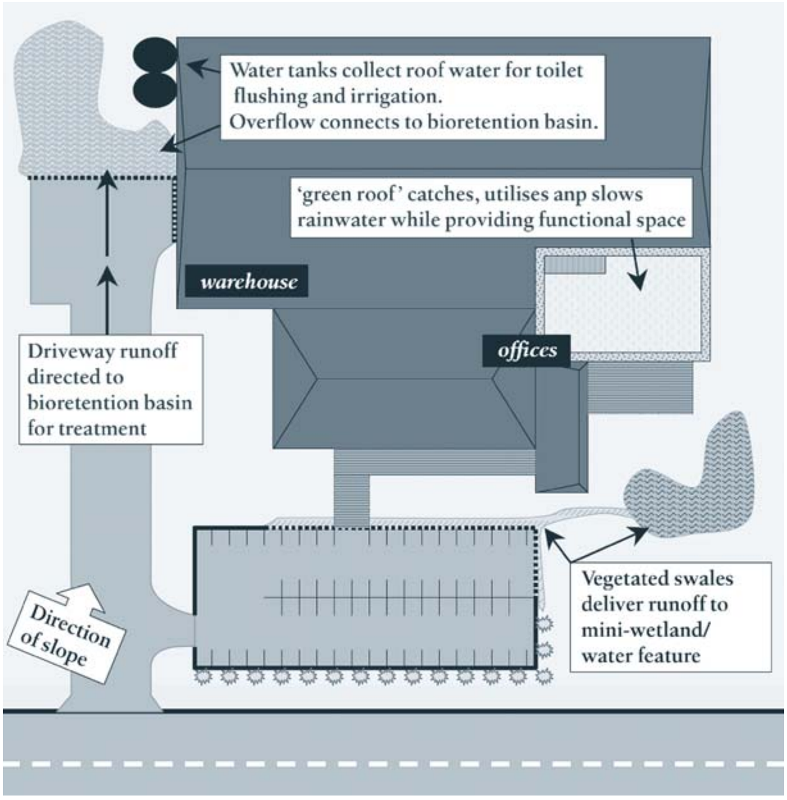

Figure 2.10 Industrial or Commercial Site Layout Example Incorporating WSUD Measures

Source: Hobart City Council (2006)

In addition to the features shown in **Figure 2.10**, industrial and commercial developments offer opportunities for:

- Maximising pervious areas including using pervious paving for driveways and parking areas;
- Integrating design of driveways and parking areas to maximise scope for retention of existing vegetation and for new plantings;
- Varying driveway widths to facilitate integrated stormwater management and substantial plantings;
- Integrating footpaths with driveways to respond to natural features and stormwater management to create spaces that are easy to maintain and efficient to irrigate;
- Incorporating common trenching and closer alignment of service infrastructure to improve scope for reduced disturbance and trenching to retain existing vegetation and plant new vegetation; and
- Using appropriate landscaping measures and practices that include the selection of species to reduce water demand.

2.9 Public Open Space

Description

Integration of public open space with conservation corridors, stormwater management systems and recreational facilities is a fundamental objective of WSUD. Public open space areas can potentially incorporate stormwater conveyance, detention, and retention and treatment systems as landscape features within a multiple use corridor.

This can provide a recreation focus (such as a linear park with bike path or an urban forest) as well as enhancing community understanding and regard of stormwater as a valuable resource.

Objectives

The open space system should be developed with the aim of establishing a network of natural features and compatible land uses that will act as a green network throughout the development.

Key principles and objectives to be considered in locating public open spaces are:

- Align public open space along natural drainage lines;
- Protect/enhance areas containing natural water features (such as creeks and wetlands) and other environmental values by locating them within public open spaces; and
- Utilise public open spaces to provide links between public and private areas and community activity nodes.

A range of other objectives can be found in **Appendix C** of **Chapter 3** of the WSUD Technical Manual.

Strategy

Figure 2.11 compares examples of public open space provision within a conventional urban design layout and a WSUD layout. It shows how stormwater conveyance and treatments systems can become visual focus points of developments.

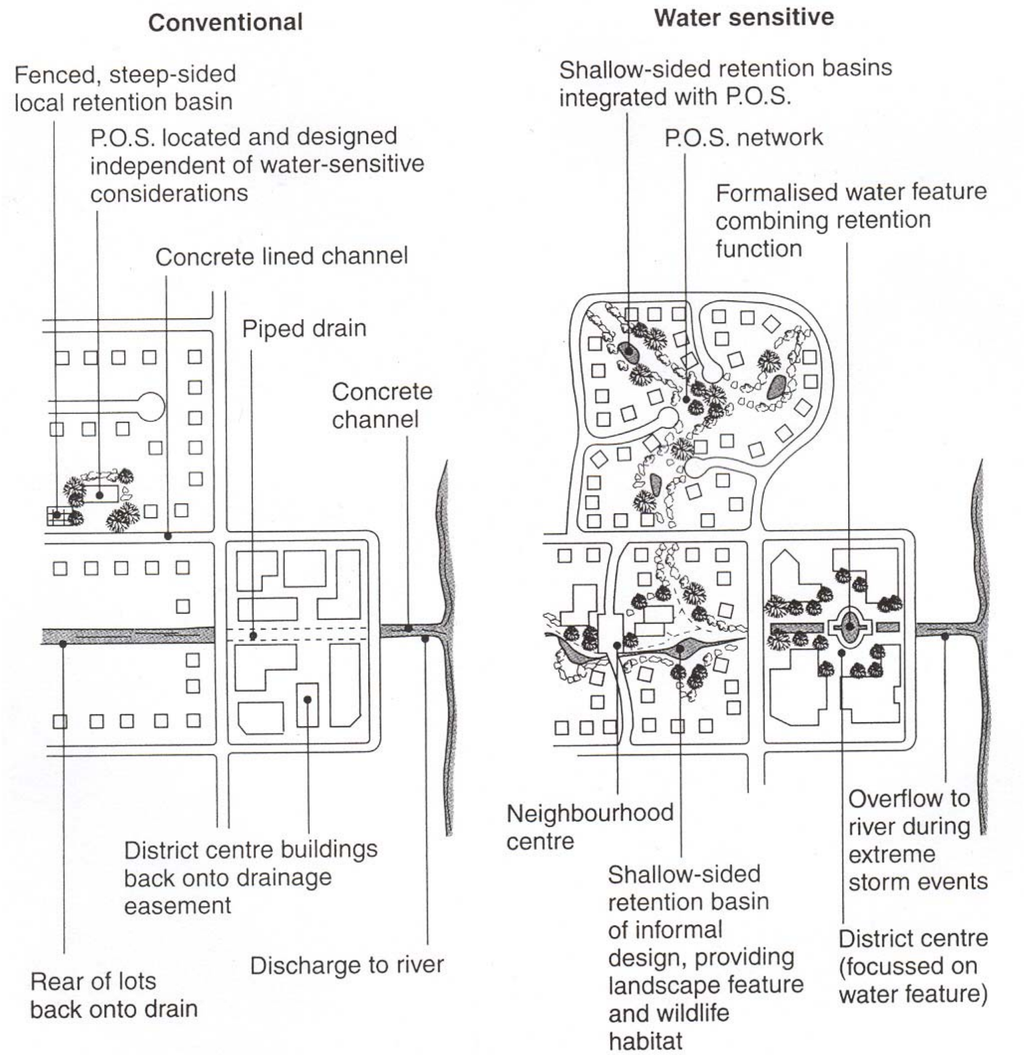

Figure 2.11 Conventional Urban Layout vs WSUD Urban Layout (Showing Public Open Space Provisions)

Note: POS = public open space

Source: CSIRO (1999)

The integration of stormwater management initiatives as components of the open space system contributes to open space outcomes by increasing the physical area of general open space and green elements within a community, enhancing terrestrial and aquatic habitat diversity, and recreational and educational opportunities.

The following are examples of techniques which can be used to integrate water management and the open space network:

- Incorporation of waterways and wetlands within parks as ecological and/or recreational features;

- Integration of playfields within the basin of a dry detention basin;
- Design of subsurface storage and/or infiltration systems beneath playfields within parks or school yards; and
- Development of gardens within open space areas such as bioretention systems.

When public open spaces include waterways it is usually preferable to emphasise natural channel systems rather than engineered solutions. Modifications to catchments contributing to each waterway occur due to urbanisation. This affects natural processes which occur including stream flows and sedimentary processes (sediment nature, delivery rate and transportation). Streams seek to achieve their own dynamic equilibrium, and seek further to adjust, repair and sustain themselves according to their modified environments. Therefore, over time, urban streams respond to a change in catchment conditions and hydrologic response by attempting to modify channel dimensions, and become subject to bed and bank erosion.

To maintain a healthy riverine environment, it is advisable to promote the re-establishment of a naturally functioning system, albeit modified by catchment response. The re-establishment of riparian buffer strips, where necessary along waterways, will maintain and enhance the vegetation corridor and habitat links.

A naturally functioning stream system is often made up of a combination of pool, riffle and chain-of-ponds systems. Riffles (located between meanders in the stream alignment) may be made up of rock, hard bed material, tree stumps or simply gravel bars. A varied pool and riffle system may provide the following stream functions:

- Varied aquatic habitats;
- Bed stabilisation; and
- Improvements in water quality through oxygenation.

2.10 Opportunities for Retrofitting

Description

Retrofitting is the process of installing or undertaking additional water management devices or approaches in an existing developed area. These techniques include increasing storage and infiltration areas to reduce peak flows and using vegetated systems to facilitate pollutant filtration.

Retrofitting can include both structural techniques and non-structural techniques.

Objectives

The multiple WSUD objectives of retrofitting include:

- Reduce flood risk;
- Improve public health and safety;
- Improve water quality;
- Restore and conserve environmental condition;
- Create more attractive and liveable neighbourhoods;
- Enhance the cultural values of the urban water landscape;
- Improve use of open space and enhance recreational opportunities;
- Improve community environmental awareness;
- Increase cost effectiveness;
- Demonstrate best management practices; and
- Utilise alternative water sources to reduce importation of water supplies.

A range of other objectives can be found in **Appendix C** of **Chapter 3** of the WSUD Technical Manual.

Strategy

Retrofitting includes techniques implemented at a variety of scales:

- Lot scale:
  - Maximising opportunities for capture and use of rainfall on site by techniques such as installing rainwater tanks and directing overflow to infiltration systems;
  - Changing gardening practices;
  - Replacing impervious paving with pervious paving;

- Redirecting/disconnecting stormwater pipes to rain gardens;
- Demand reduction through installation of water efficient fixtures and fittings.

- Block and neighbourhood scale:
  - Removing kerbs from some sections of roads, such as where road runoff can flow into adjacent parkland;
  - Installing infiltration devices within roadways/road reserves;
  - Replacing impervious paving with pervious paving.
- Catchment scale:
  - Rehabilitating open urban drains or removing sections of subsurface pipes and allowing surface flow through swales;
  - The removal of 'gross' pollutants from the system through the relatively straight forward installation of gross pollutant traps, trash baskets in existing side entry pits and retrofitting of side entry pits to grated pits.

Another important opportunity is presented by the public open space system in the scope it creates to provide effective water quality improvement (via constructed wetlands) and the potential retardation of runoff in certain rainfall events (retarding basins). This reduction of peak flows in frequent rainfall events has the important consequence of reducing flooding and riparian and aquatic habitat disturbance, a key detrimental impact of urbanised catchments.

However, it is acknowledged that the opportunities for these installations may be somewhat limited and that the primary function of public open space systems is to cater for the leisure and recreation needs of the community.

Another area of retrofitting opportunity lies in the performance improvement of retarding basins to improve water quality, as well as retardation of discharge. Wetland treatments can be constructed within retarding basins with no reduction of their effective volume, but to provide improved water quality outflows, as well as improving the aesthetics and landscape amenity of some of these structures.

2.11 References

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