WATER TRANSFORMED:

SUSTAINABLE WATER SOLUTIONS FOR CLIMATE CHANGE ADAPTATION

MODULE C: INTEGRATED WATER RESOURCE PLANNING AND MANAGEMENT

This online textbook provides free access to a comprehensive education and training package that brings together the knowledge of how countries, specifically Australia, can adapt to climate change. This resource has been developed formally as part of the Federal Government's Department of Climate Change's Climate Change Adaptation Professional Skills program.

CHAPTER 7: AUGMENTING TRADITIONAL WATER SUPPLY THROUGH WATER REUSE AND RECYCLING.

LECTURE 7.3: WATER SENSITIVE URBAN DESIGN – THE SYNTHESIS

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Augmenting Traditional Water Supply Through Water Reuse and Recycling

Lecture 7.3: Water Sensitive Urban Design – The Synthesis.

Educational Aim

This lecture provides an introduction and overview of the main concepts and ways to implement Water Sensitive Urban Design (WSUD), also known internationally as Integrated Water Management (IWM). In its broadest context, WSUD is the integrated design approach that seeks to address society's water needs whilst respecting and seeking to work with, not against the natural water cycle. To achieve this goal, WSUD incorporates and integrates the following; reducing potable water demand through water efficient appliances and technologies (Module B, Lectures 2.1-4.3), demand management (Module C, Lecture 5.1-5.2), water source protection (Lecture 5.3), improving water security and self-sufficiency of water supply from treated wastewater and stormwater (Lectures 6.1-6.3 and 7.1), improving urban amenity through utilising natural water features such as constructed wetlands (Lecture 7.1), and greater use of rainwater tanks (Lecture 7.2). Hence this "Water Transformed" online textbook is also designed to be a "how to" manual for Water Sensitive Urban Design. Taken as a whole, WSUD represents a fundamental shift in the way water and water infrastructure are considered in the planning process for cities and towns. To help mainstream the uptake of WSUD, the Commonwealth government in 2009 published, for the first time, national guidelines for WSUD.[1] Increasingly state and local governments are bringing in changes to planning requirements and are using other government mechanisms to encourage the use of WSUD. Hence it is vital that the current and the next generation of practitioners and students in this area understand how to implement WSUD effectively. This lecture, plus its further reading "Key Resources" (listed at the end of the lecture), aims to address this need.

Key Learning Points

1. The significance of WSUD, and the impetus for its application, is succinctly articulated by Associate Prof. Rebekah Brown:

   > *The 21st century marks the first point in recorded history when the proportion of the world's population living in urban environments has surpassed those living in the rural environment, making cities a critical focal point for realising sustainable practices. As growing urban communities seek to minimise their impact on already stressed water resources, an emerging challenge is to design for resilience to the impact of climate change, particularly in regards to ensuring secure water supplies and the protection of water environments.*[2]

2. WSUD seeks to provide urban water/wastewater and stormwater provision and management solutions that are not only more economical than traditional solutions, but are less harmful to the environment. It views all sources of managed water as a resource[3], and seeks to ensure

[1] Joint Steering Committee for Water Sensitive Cities (2009) Evaluating Options for Water Sensitive Urban Design (WSUD). Commonwealth government. At http://www.environment.gov.au/water/publications/urban/pubs/wsud-guidelines.pdf accessed 27 May 2010

[2] Brown, R., Keath, N. and Wong, T. (2008) *Transitioning to Water Sensitive Cities: Historical, Current and Future Transition States*. In Ashley, R.M. (Ed) Proceedings of the 11th International Conference on Urban Drainage, Edinburgh, Scotland, 31st August - 5th September 2008, CD-ROM.

[3] PMSEIC (Prime Ministers Science Engineering Investigation Group) (2007) "*Water for Our Cities Working Group Report*". PMSEIC.

the sustainability of the water cycle is embedded in urban development and re-development processes.[4]

3. The approach to urban development and re-development at the heart of WSUD builds in opportunities to optimise all streams of urban water as a resource. Apart from obvious measures, such as water efficient appliances and re-use of all urban 'waste' water sources, these include:

    - Onsite stormwater detention (and storage), re-use and infiltration, instead of rapid conveyance
    - Preservation of the (water related) environmental, cultural and recreational amenity of development/re-development areas. This can be achieved through such measures as :
        - water efficient landscaping (minimises use of potable water) and using vegetation to filter stormwater prior to re-use
        - maintaining environmental flows in natural and modified watercourses by using storm and recycled water
        - locating wastewater treatment and re-use facilities either onsite, or at least locally to minimise (1) the use of potable water, and (2) discharge of environmentally hazardous wastewater.
    - Emphasis on planning for the longer term, combined with a more flexible approach to institutional arrangements that account for increased climate variability and uncertainty.[5]
    - The continual monitoring, evaluation and review of a diversified range of water resources that are underpinned by centralised and decentralised infrastructure.

4. The main objectives of WSUD can be summarised as follows:

    - Viewing all sources of water in a re/development as a resource, and optimising water related self-sufficiency so as to keep potable water inflows and storm/wastewater outflows to a minimum
    - Effectively employ demand and supply side water management practices to minimise demand for potable water
    - Minimise production of wastewater, e.g. through use of water efficient appliances and fittings,
    - Ensure stormwater and wastewater is treated to a standard appropriate for its reuse and/or discharge
    - Preserve or restore catchments' natural hydrological regimes
    - Adoption of a fit-for-purpose approach to utilisation of appropriate alternative water sources
    - Use water sustainably to enhance a re/development's environmental, recreational and

[4] Joint Steering Committee for Water Sensitive Cities (2009) Evaluating Options for Water Sensitive Urban Design (WSUD). Commonwealth government. At http://www.environment.gov.au/water/publications/urban/pubs/wsud-guidelines.pdf accessed 27 May 2010

[5] Brown, R., Farrelly, M. and Keath, N. (2007), "Summary Report: perceptions of Institutional Drivers and Barriers to Sustainable Urban Water Management in Australia". Report No 07/06, National Urban Water Governance Program, Monash University

cultural amenity.[6]

5. Incorporation of the design of distributed systems (e.g. localised storage, treatment and re-use technologies) is a feature of the more innovative WSUD approaches. These technologies can be applied at the level of a single residential lot, through to commercial, industrial or even high-rise developments.

6. Integrated urban water management practices, of which WSUD is a part, is a growing international trend. WSUD delivers a site-specific (and site-responsive) design solution through its integrated approach to urban water (potable, waste and storm) quantity and quality management.[7]

7. The water management systems applied in a WSUD development are influenced by urban design considerations. Selected systems can involve localised or onsite stormwater detention, filtration and storage as a replacement for potable supplies, groundwater or downstream release. Environmental protection should be factored into the construction phase, e.g. erosion and sediment control, along with protecting the integrity of stormwater treatment systems.

8. The construction costs are a significant contributing factor as to whether a developer will adopt the WSUD approach or apply conventional stormwater design. Studies show that WSUD can, if implemented well, can cost neutral on smaller projects and tend to deliver increasing savings on larger projects through the fact that WSUD reduces drainage infrastructure and other infrastructure costs.[8] Studies also show that once those implementing WSUD projects get familiar with the process the costs come down to levels comparable with conventional methods.[9] Further information to help undertake cost benefit analysis can be found in Taylor's report *Stormwater BMP Cost-Size Relationships*.[10]

9. The integrated approach that underpins WSUD is gaining acceptance as it not only reduces development costs, but significantly reduces a development's potable water inflow and wastewater outflow, and minimises changes in pre-development hydrological regimes (and therefore stormwater pollution & water balance issues). It also has benefits for downstream river morphology/flood/water quality benefits, and the security of potable water supplies. This is very important because it is through an integrated approach that amenity is improved and value is added in ways that can also keep development costs.

10. WSUD approaches are most commonly applied to single residential development, residential subdivision development, residential multi-unit development, streetscape development, vehicle parking areas and commercial and industrial developments. How to do apply WSUD principles to these types of development is considered next.

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[6] Joint Steering Committee for Water Sensitive Cities (2009) Evaluating Options for Water Sensitive Urban Design (WSUD). Commonwealth government. At http://www.environment.gov.au/water/publications/urban/pubs/wsud-guidelines.pdf accessed 27 May 2010

[7] SA Department of Planning and Local Government (2009) WSUD Technical Manual for Greater Adelaide. SA Department of Planning and Local Government at http://www.planning.sa.gov.au/go/wsud accessed 22 May 2010

[8] Boubli, D., Kassim, F (2003) *Comparison of Construction Costs for Water Sensitive Urban Design and Conventional Stormwater Design.* at http://www.wsud.org/downloads/Info%20Exchange%20&%20Lit/Danny%20B%20WSUD%20vs%20Traditional%20Paper.pdf accessed 27 May 2010
Coombes, P. *et al* (2000) *Figtree Place: A Case Study in Water Sensitive Urban Development* (WSUD). at http://www.bonacciwater.com/research/subdivisions%20land%20dev%20-%2001%20-%20figtree%20place.pdf accessed 27 May 2010

[9] Lloyd. S. D. (2001) 'Water Sensitive Design in the Australian Context'. Synthesis of a conference held 30-31 August 2000 Melbourne, Australia. Cooperative Research Centre for Catchment Hydrology Technical Report 01/7.

[10] Taylor, A.C. (2005) "*Stormwater BMP Cost-Size Relationships",* CRC for Catchment Hydrology, Monash University, 2005

Brief Background Information

The National Water Initiative (NWI) commits all states and territories to innovation and capacity building to create "Water Sensitive Australian Cities" (clause 92).[11] However the attributes of a "Water Sensitive City" are not outlined in the NWI. Many experts and organisations have developed definitions and sets of principles for WSUD (see Key References). For instance, according to Engineers Australia, the peak engineering institutional body for Australia,

> *In its broadest context, WSUD encompasses all aspects of integrated urban water cycle management, including water supply, sewerage and stormwater management. As such, it represents a significant shift in the way water and related environmental resources and water infrastructure are considered in the planning and design of cities and towns. This new approach is based upon the premise that the processes of urban development and redevelopment need to adequately address the sustainability of the water environment.*[12]

Water sensitive urban design marks a significant shift in urban water management and water service delivery and treatment.[13] It fundamentally is seeking to retrofit and transform cities in the 21st century into water sensitive cities that are resilient to climate change. Historically, it can be shown that urban water management has focused on a range of other objectives such as ensuring adequate supply, ensuring water quality, protecting against flooding and so on.[14]

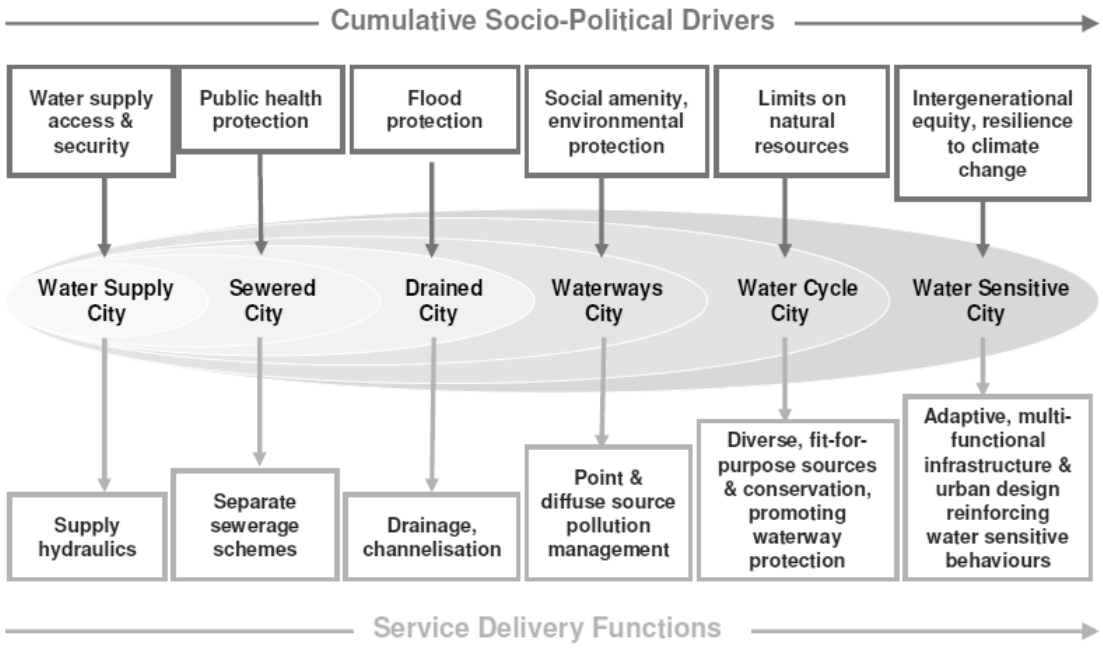


Figure 7.3.1 Urban Water Management Transitions Framework

[11] Monash University (2008) Submissionto the Victorian Environment and Natural Resources Committee Inquiry into Melbourne's Future Water Supply, August 2008. http://www.arts.monash.edu.au/ges/research/nuwgp/pdf/monash-submission-melb.metro-review.pdf accessed 27 May 2010

[12] Engineers Australia (2006) Australian Runoff Quality A guide to Water Sensitive Urban Design. Engineers Australia.

[13] Monash University (2008) Submissionto the Victorian Environment and Natural Resources Committee Inquiry into Melbourne's Future Water Supply, August 2008. http://www.arts.monash.edu.au/ges/research/nuwgp/pdf/monash-submission-melb.metro-review.pdf accessed 27 May 2010

[14] Brown, R., Farrelly, M. and Keath, N. (2007), "Summary Report: perceptions of Institutional Drivers and Barriers to Sustainable Urban Water Management in Australia". Report No 07/06, National Urban Water Governance Program, Monash University at http://www.urbanwatergovernance.com/pdf/11ICUD_Brown_Keath_Wong_310308.pdf accessed 27 May 2010

(Source: Brown et al, 2008[15])

The need for such a shift is now widely acknowledged. For instance, the Prime Minister's Science, Engineering and Innovation Council, in their 2007 report - *Water for our Cities: Building Resilience in a Climate of Uncertainty* wrote

> *Water supplies to Australia's cities need to move from reliance on traditional sources to an efficient portfolio of water sources which can provide security through diversity. Like a share portfolio, flexible and cost effective access will be underpinned by diversity, including centralized and decentralised water infrastructure. Like a share portfolio, the composition of water source portfolios also needs to be reassessed as new information on costs, prices, climate, environmental objectives and impacts, and risks becomes available.*[16]

WSUD is being encouraged widely across Australia, with the transition of such to real, on the ground, works having been more readily accepted in some areas than others. The Commonwealth government has published guidelines which are intended to assist with the adoption of WSUD on a more widespread scale.[17] In some States/Territories, WSUD is mandatory for certain scales and types of developments. State and local governments have all been encouraged to embrace water sensitive urban design and many are leading in this area. Many state and local governments have developed urban water sensitive design guidelines and requirements of their own. (See Key References section below)

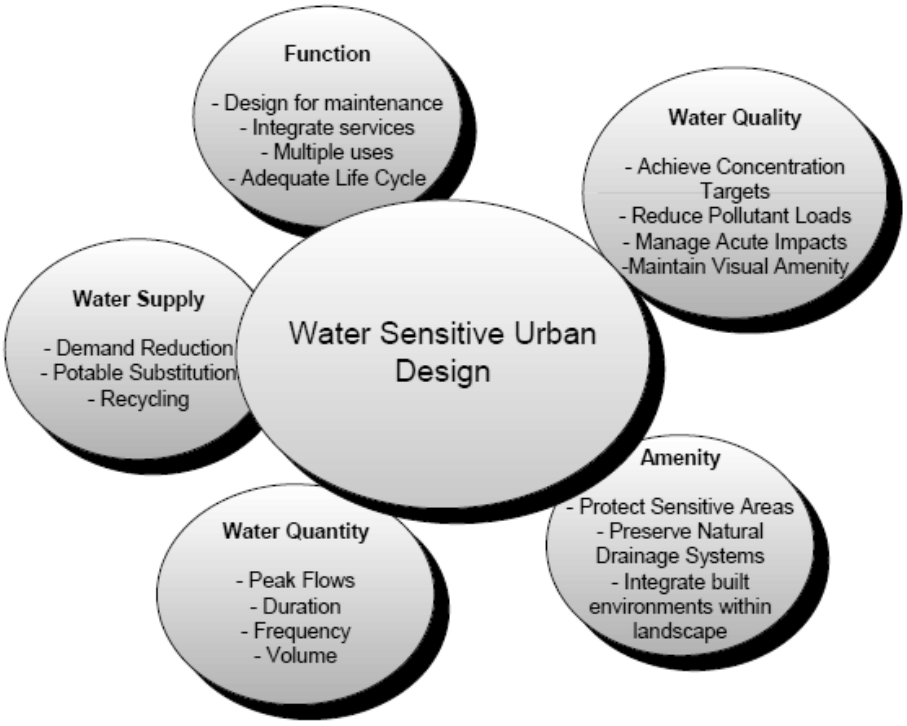


Figure 7.3.2 Water Sensitive Urban Design Objectives

[15] Brown, R., Farrelly, M. and Keath, N. (2007) Summary Report: perceptions of Institutional Drivers and Barriers to Sustainable Urban Water Management in Australia. Report No 07/06, National Urban Water Governance Program, Monash University at http://www.urbanwatergovernance.com/pdf/11ICUD_Brown_Keath_Wong_310308.pdf accessed 27 May 2010
Brown, R. & Clarke, J. (2007) Transition to Water Sensitive Urban Design, The story of Melbourne, Australia. Monash University, Available at: http://monash.edu/fawb/publications/final-transition-doc-rbrown-29may07.pdf. accessed 27 May 2010
[16] PMSEIC (Prime Ministers Science Engineering Investigation Group) (2007) "*Water for Our Cities Working Group Report*". PMSEIC
[17] Joint Steering Committee for Water Sensitive Cities (2009) Evaluating Options for Water Sensitive Urban Design (WSUD). Commonwealth government. At http://www.environment.gov.au/water/publications/urban/pubs/wsud-guidelines.pdf accessed 27 May 2010

Most water sensitive urban design manuals and guidelines seek to inspire the achievement of a series of objectives and outcomes summarised in Figure 7.3.1 namely protecting water quality, managing the variable quantity of water, meeting water supply needs, restoring natural function and improving amenity, and finally designing to ensure low maintenance requirements.

In broad terms these objectives can be summarised as seeking to achieve environmental sustainability by restoring, as much as possible, natural hydrological cycles through doing the following;

Protecting water quality - as much as possible by protecting source water and incorporating natural approaches to water treatment to protect and enhance ecological function of local and regional receiving environments. (Module C, Lectures 5.3-5.4, Lecture 7.1) The implementation of WSUD is a key technique to minimise the diffuse the pollution load which is produced from urban areas and restore natural drainage systems to improve water quality outcomes.[18]

Managing Water Quantity - to minimise the negative hydrologic impacts by reducing runoff and peak flows by using design techniques focussing on water detention, harvesting/reuse and infiltration are included.

Encouraging A Portfolio Approach to Urban Water Supply - through an integrated set of diverse water sources, including rainwater, stormwater, greywater, sewage and seawater. (Module C, Lectures 6.2-7.2) Diverse water sources are vital to ensuring cities successfully can adapt to both water scarce and water abundant conditions.

Taking an Integrated Approach – to integrate this diverse approach to water supply, treatment, recycling and reuse into and with the whole water cycle. (Lectures 6.2-7.2) The Australian Senate recognised the importance of this approach in its review of urban water management: *"Each component of the urban water management system cannot be viewed in isolation from other parts of the system and it must be integrated with the management of other urban infrastructure"*[19]

Maintain and Enhance Visual and Social Amenity Values - and add environmental, social and community value whilst reducing development and maintenance costs.

Ensure Operational Efficiency – by ensuring the design results in a system requiring low maintenance costs and which is easy to maintain. Make sure it is designed with maintenance requirements in mind such as including access pathways and consideration of machinery required. The Commonwealth government's WSUD guidelines provide further detail on all these objectives of WSUD.[20]

[18] Compliance of a WSUD project with such objectives can be assessed using commonly applied and accepted software tools such as MUSIC (Model for Urban Stormwater Improvement Conceptualisation) for stormwater quality - (http://www.toolkit.net.au/cgibin/WebObjects/toolkit.woa/1/wa/productDetails?productID=1000000&wosid) and Aquacycle for potable water and wastewater flow management assessments (http://www.toolkit.net.au/cgibin/WebObjects/toolkit.woa/1/wa/productDetails?productID=1000043&wosid=GwTxvc4k2nQrgDnRdOZBbw). Other tools such as UVQ, WaterCRESS and Hydroplanner may also provide benefit. Ongoing research in Australia by the eWater CRC (http://www.ewatercrc.com.au/) and other bodies will progressively provide new and improved tools in this regard.

[19] Commonwealth of Australia (CoA) (2002) *The Value of Water: Inquiry into Australia's management of urban water*, Report of the Senate Environment, Communications, Information Technology and the Arts Reference Committee, Commonwealth of Australia.

[20] Joint Steering Committee for Water Sensitive Cities (2009) *Evaluating Options for Water Sensitive Urban Design (WSUD)*. Commonwealth government. At http://www.environment.gov.au/water/publications/urban/pubs/wsud-guidelines.pdf accessed 27 May 2010

Joint Steering Committee for Water Sensitive Cities (2009) *Evaluating Options for Water Sensitive Urban Design (WSUD)* Appendices. Commonwealth Government at http://www.environment.gov.au/water/publications/urban/pubs/wsud-guidelines-appendices.pdf accessed 27 May 2010

WSUD Planning and Design Processes

WSUD planning and design processes refer to undertaking an assessment of the site and its physical form and hydrological features. The goal of the process is to integrate the design of the development into the natural environment and hydrology. Some of the important issues and decisions to be made here are

- The identification and protection of land to allow for an integrated stormwater system, incorporating storage locations, drainage and overflow lines and discharge points;
- The identification of developable and non-developable areas;
- The identification and protection of public open space networks including remnant vegetation, natural drainage lines, recreational, cultural and environmental features; and
- The identification of options for potable demand reduction and stormwater management, harvesting and reuse at the design level for different types of building and residential estate design, commercial & industrial, sub-divisions, and urban retrofit housing layout. (See Table 7.3.1)

Table 7.3.1 Potential WSUD Options for Various Development Types and Scales

Option and Relevant Lectures		Single Residential Building.	Residential Sub-division.	High Rise/Multi-Story Units.	Street-scape Development.	Vehicle Parking Areas	Commercial and Industrial
Potable Water Demand Reduction Strategies	Water Efficient Appliances, Fittings &Technologies (Module B – Lectures 2.1-4.3)	Y	Y	Y	N	N	Y
	Water Efficient Design and Process Improvements (Module B – Lectures 2.1-4.3)	Y	Y	Y	N	N	Y
	Greywater treatment and reuse (Lectures 6.1-7.2)	Y	Y	Y	Y	Y	Y
	Reticulated recycled water	N	Y	Y	N	N	Y
	Stormwater harvesting and reuse (Lectures 6.3 and 7.1)	N	Y	N	Y	Y	Y
	Managed Aquifer recharge, recovery and reuse. (Lecture 7.1)	?	?	?	?	?	Y

	Rainwater tanks (Lecture 7.2)	Y	Y	Y	N	Y	Y
Storm-water Management Techn-iques (Lecture 6.3-7.1)	Sediment Basins	N	Y	N	?	Y	N
	Bio-retention Swales	?	Y	N	Y	Y	Y
	Bio-retention Basins	Y	Y	N	Y	Y	Y
	Sand Filters	N	Y	N	?	Y	Y
	Swales and Buffer Strips	Y	Y	N	Y	Y	Y
	Constructed Wetlands	N	Y	N	Y	Y	Y
	Ponds and Lakes	N	Y	N	Y	Y	?
	Infiltration Systems	?	Y	N	Y	Y	Y
	Aquifer Storage and Recovery	?	Y	N	Y	Y	?
	Porous Pavements	Y	Y	?	Y	Y	Y
	Retarding Basins	N	Y	N	Y	Y	?
	Green roofs/roof Gardens	Y	N	Y	N	N	Y
	Stream and riparian vegetation rehabilitation	N	Y	N	Y	?	?

Y = Yes, N = No, ? implies that it could be used depending on the site. *(Source: Adapted from Joint Steering for Water Sensitive Cities, 2009[21])*

WSUD Measures for Different Types and Scale of Development

As Table 7.3.1 shows WSUD measures can be incorporated into most types of and scales of urban development. Different combinations of WSUD measures are appropriate for different types of development. As outlined in Table 7.3.1, there is a wide range of WSUD measures available which can be incorporated into development or redevelopment projects. So next we provide an overview

[21] Joint Steering Committee for Water Sensitive Cities (2009) Evaluating Options for Water Sensitive Urban Design (WSUD). Commonwealth government. At http://www.environment.gov.au/water/publications/urban/pubs/wsud-guidelines.pdf accessed 27 May 2010
Joint Steering Committee for Water Sensitive Cities (2009) Evaluating Options for Water Sensitive Urban Design (WSUD) - Appendices. Commonwealth government. At http://www.environment.gov.au/water/publications/urban/pubs/wsud-guidelines-appendices.pdf accessed 27 May 2010

of the most suitable approaches for implementing WSUD across the most common urban development types namely, single residential development, residential subdivision development, residential multi-unit development, streetscape development, vehicle parking areas and commercial and industrial development.

Single Residential Buildings

The main Water Sensitive Urban Design options at this scale of development are demand reduction through water efficient fittings and appliances, use of rainwater and reuse of grey-water, designing low water landscapes, infiltration systems, ponds or rain gardens.

So firstly, demand for water can be reduced by using water efficient shower heads, toilets, appliances and aerators on taps in the house is the most cost effective way to improve water productivity in the home. Water efficiency measures are the most cost effective way to improve water productivity in the home. The use of efficient shower heads and water efficient appliances, dual flush toilet, and aerators for taps can improve the water productivity for an average home by over 50 per cent.[22]

In addition, rainwater tanks can capture this water so that it can be used for watering gardens, flushing toilets or in showers. Greywate can be re-used outdoors as well as indoors for toilet flushing and laundry after appropriate treatment as we discussed in Lecture 7.2.[23]

During prolonged or heavy storms, rainwater can overflow from the rainwater tank to an infiltration (or retention) trench. Runoff from paths, driveways and lawns can be directed to garden areas (i.e. a rain garden). Excess runoff from impervious surfaces is directed to the retention trench, or overflows to the street drainage system. Pervious pavements can be installed to minimise runoff and improve infiltration to groundwater. See Figure 7.3.3.

Finally, up to 60 per cent of household water is used outdoors on gardens.[24] The landscape of the garden can be re-designed cost effectively to be made up of plants that need significantly less water than the average household garden. Planting drought tolerant species, mulching around plants to reduce evaporation, installing drip irrigation systems can all significantly reduce demand.

Outstanding examples of WSUD applied to the home include Michael Mobbs and Helen Armstrong's home in Sydney. They have gone further than most so that their home is almost completely self sufficient in water. Michael Mobbs and Helen Armstrong, retrofitted an old Terrace House in one of the most densely populated suburbs in Sydney. Through onsite collection of rainwater, as well as onsite waste water treatment, the owners have reduced their already relatively low consumption of mains water to virtually zero. This house does not have a particularly large roof but nevertheless It can still capture enough water in the 8,500 litre tank, located beneath the back deck, to meet the potable water needs of the family of four. [25]

[22] Stasinopoulos, P., Smith, M., Hargroves, K. and Desha, C. (2008) *Whole System Design: An Integrated Approach to Sustainable Engineering*, Earthscan, London, and The Natural Edge Project, Australia
[23] DEWHA (2009) *Your Home Technical Manual: Australia's Guide to Environmentally Sustainable Homes - Water Use*. Department of Environment, Water Resources, Heritage and the Arts (DEWHA) at http://www.yourhome.gov.au/technical/fs71.html accessed 27 May 2010
[24] Ibid.
[25] Mobbs, M (1999) *Sustainable House: Living for Our Future*,. Choice Books, Sydney.at http://www.sustainablehouse.com.au/ accessed 18 April 2009

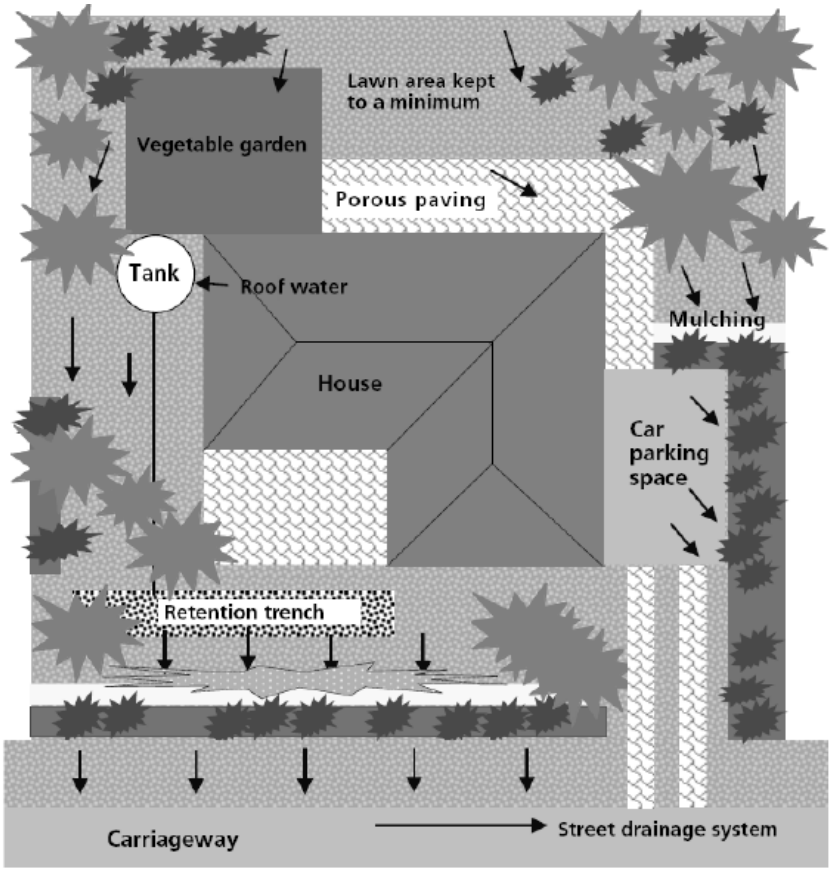


Figure 7.3.3 Example of an Overall WSUD Strategy for a Typical Suburban Dwelling

Source: LHC CREMS (2002)[26]

Another outstanding example comes from the Gold Coast known as the "healthy house", it has a submerged concrete tank which stores rainwater from the roof, and a UV filtration system disinfects the water for indoor, potable use. An onsite aerobic wastewater treatment system cleans the greywater, which is recirculated for outdoor, non-potable uses. The house uses 50 percent less mains water than the average Queensland home.[27]

Residential Subdivision

As Table 7.3.1 shows there are numerous WSUD options that can be incorporated into the design of residential subdivisions. In addition to all that can be incorporated into the design of residential homes, as outlined above, the extra space and scale of development both enables and benefits from the use of other WSUD techniques such as bio-retention systems, swales and buffer strips, sedimentation basins or constructed wetlands. These can be combined, for instance, to help manage housing developments around waterways and manage heavy flood events. (See Figure 7.3.4) Figure 7.3.4 highlights how a residential subdivision layout can be adjusted to maximise natural open space and enhance natural waterway and drainage corridors. WSUD tries to incorporate multi-purpose vegetated drainage corridors in residential developments because these make the most of the available space by integrating public open space with conservation corridors

[26] LHCCREMS (2002) WaterSmart Practice Note No. 1, Lower Hunter and Central Coast Regional Environmental Management Strategy, Hunter Region Organisation of Councils.
[27] McGee, C. (2008) *7.8 Water Case Studies,* Your Home, Queensland Government. Available at: http://www.yourhome.gov.au/technical/fs78.html, accessed 27 May 2010.

and natural stormwater management systems. Figure 7.3.5 shows what can be done with a water sensitive design approach versus a 'conventional' approach to a residential subdivision to integrate with public open space (P.O.S.).

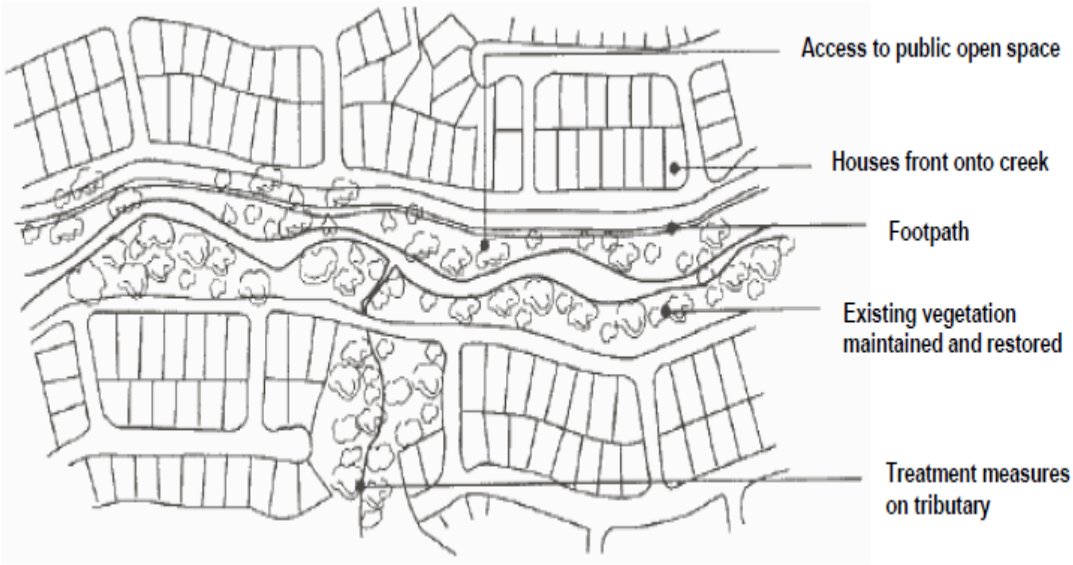
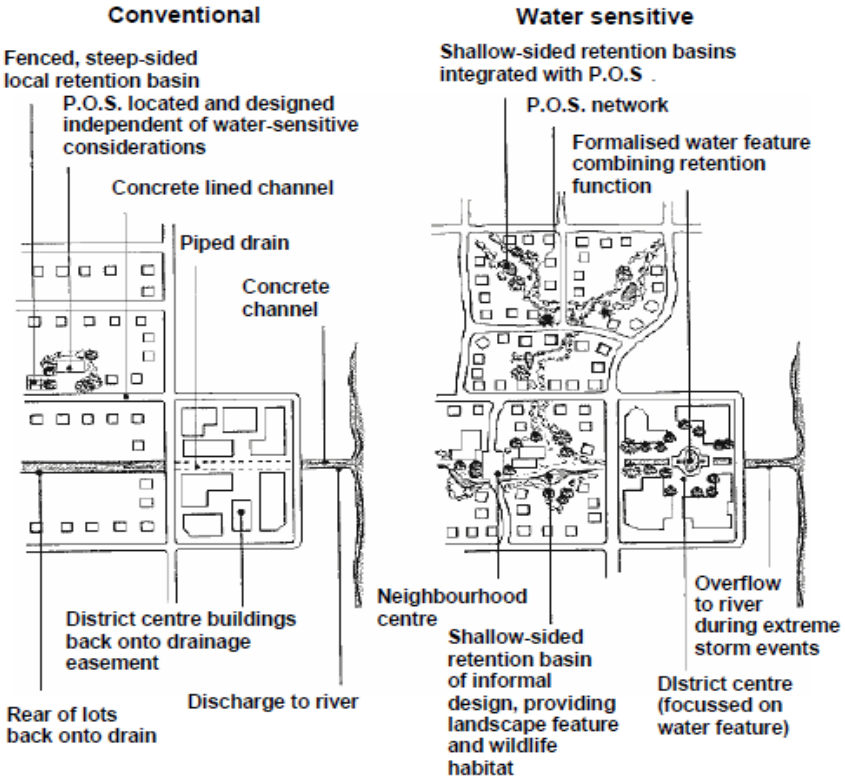


Figure 7.3.4 Integration of a Residential Subdivision with a Waterway Corridor

(Source: Whelands *et al*, 1994[28])



[28] Whelans and Halpern Glick Maunsell (1994) 'Planning and Management Guidelines for Water Sensitive Urban (Residential) Design'. Report prepared for the Department of Planning and Urban Development, the Water Authority of Western Australia and the Environmental Protection Authority.

Figure 7.3.5 Networked Public Open Space Incorporated in A Residential Subdivision

(Source: Whelands *et al*, 1994[29])

Residential estates can also be designed with dual reticulation systems which enable recycled water to be used for flushing of toilets and gardens. Dual reticulation is the use of two water supplies - recycled water and drinking water. An example in Australia is the Aurora Estate.[30] It is a 8,500 real estate development, led by Vicurban and Yarra Valley Water, that is incorporating dual reticulation along with all the strategies outlined above.[31] Pimpana-Coomera Scheme in the Gold Coast area is another impressive application of duel reticulation, this time for 150,000 people. Building on from the Aurora Estate it

> *"incorporates new materials, technologies, standards and practices to reduce the size and capital and maintenance costs of water collection and distributions systems. The scheme will provide overall an 80 percent reduction in demand for potable water with capital costs only 10 percent above conventional approaches and lower life cycle costs if headwork costs are incorporated*."[32]

Currumbin Ecovillage, in northern NSW, is also showing what is possible through water sensitive urban design. It is the first Australian self-sufficient residential (off both the mains water and sewerage systems) sub-division which captures, treats and recycles water onsite to meet all its needs in a closed loop water cycle. Water efficiency measures are employed, as well as landscaping techniques such as swales and retention ponds. Over 80 percent of the water used by households is recycled, however even though this is used for non potable purposes it is still treated to A+ standards. Other outstanding examples include Silva Park Estate, Brisbane, which is a residential estate using WSUD to reduce potable mains use by 75 percent, wastewater by 66 percent and to protect the creek and its riparian zone and replenish groundwater[33] and Salisbury in Adelaide. As we discussed in Lecture 7.1, managed aquifer recharge, storage and recovery (ASR) has been pioneered in Salisbury, where natural processes have been mimicked and amplified to provide water storage for the city which is not impacted by evaporation or contamination and which uses minimal space above ground. During high rainfall periods, water is filtered and cleaned by wetlands before being pumped into an aquifer lying 164 meters below ground until it is needed during the dryer months of summer.[34] (See Lecture 7.1 for more details)

Residential Multi-Unit Development

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 and usage is similar to a typical household with the exclusion of garden irrigation. Hence most of the WSUD approaches for the residential home are also relevant here. Residential multi-unit development often have an open space landscaped are common to all the units. Thus many of the WSUD approaches used in a residential subdivision

[29] Whelans and Halpern Glick Maunsell (1994) 'Planning and Management Guidelines for Water Sensitive Urban (Residential) Design'. Report prepared for the Department of Planning and Urban Development, the Water Authority of Western Australia and the Environmental Protection Authority.
[30] Bowmer, K. (2004) *Water Innovation: A New Era for Australia*. CI Creations.
[31] Ibid.
[32] Ibid..
[33] Australian Green Development Forum (2006) *Residential Case Study – Silva Park Estate*, Australia. Available at: http://www.agdf.org.au/Images/ftp/Information/Projects/AGDFCaseStudy_Silva%20Park.pdf accessed 27 May 2010
[34] Naumann, B. (2006) 'Water Projects in the City of Salisbury', *Geography Teachers Association of South Australia* Volume 21 No 3 November 2006. p12. Available at gtasa.asn.au/file.php?f=A9-3ik.OnaGSo.46, accessed 09 September 2008

are also relevant here. Figure 7.3.5 sums up many of the WSUD approaches for this type of development.

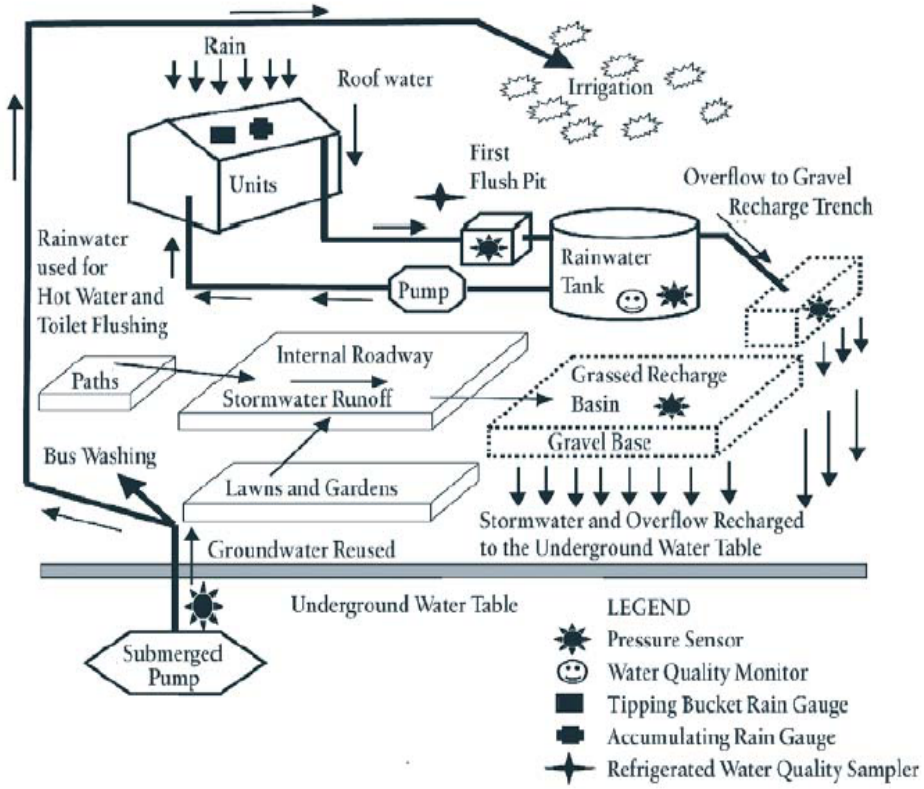


Figure 7.3.5 Schematic of a WSUD Multi-unit Layout Utilising Groundwater Recharge and Stormwater Reuse. (Source: Hobart City Council.[35])

In addition to the features shown in Figure 7.3.5, a multi-unit development offers opportunities for:

- Narrow driveways to minimise the impervious area;☐☐
- Pervious paving for driveways and parking areas;☐☐
- Appropriate landscape practices that include the selection of species to reduce water demand;
- Water efficient fixtures and appliances to reduce demand for water; and
- Community scale wastewater capture, treatment and reuse allotments.

Streetscape Development

Streets and roads, as impervious surfaces, affect the quantity and quality of water and runoff that is generated in urban developments. These areas generate fine sediments, metals and hydro-carbons and other pollutants. Therefore we need to reduce the impact of such runoff and utilise natural ways to reduce pollutant loads. A WSUD streetscape design seeks to optimise the best options for road layout design with cycling and pedestrian requirements with water management, pollution reduction and soil erosion issues. Water sensitive streetscapes offer opportunities for:

[35] Hobart City Council (2006) *Water Sensitive Urban Design Site Development Guidelines and Practice Notes*. Hobart. http://www.hobartcity.com.au/HCC/STANDARD/PC_1124.html accessed 27 May 2010

- Increasing as much as possible the pervious surface area through varying road widths to enhance and incorporate natural drainage facilities and water retention landscape features;
- Utilising pervious paving in footpaths and driveways where appropriate to reduce the amount of run-off onto streetscapes;
- Incorporating local filtration by using rock/gravel filter beds with drainage channels to divert water from the streetscape so that it irrigates open public spaces; and
- Appropriate landscape practices that include the selection of species to reduce water demand such as the grassy swales in Figure 7.3.6

Figure 7.3.6 Retrofit of Street with a Swale, City of Onkaparinga.

(Source: City of Onkaparinga)

Vehicle Parking Area Development

In our urban spaces vehicle parking areas now constitute a significant percentage of urban space with equivalent run off and water pollution issues. Numerous WSUD options can be used to minimise the negative impacts of such developments.

WSUD techniques are also useful as they lend themselves well to handling a range of rainfall and run-off events including major storms whether they be maximising pervious surfaces, infiltration systems, gross pollutant traps, bio-retention systems, swales and buffer strips, sedimentation basins and constructed wetlands.

Any combination of these techniques needs to be chosen to address local site conditions. Figure 7.3.7 and Figure 7.3.8 shows a sample WSUD design for a car park. The main WSUD approach commonly used is to direct the runoff from the car park into garden beds/bioretention areas/cells.

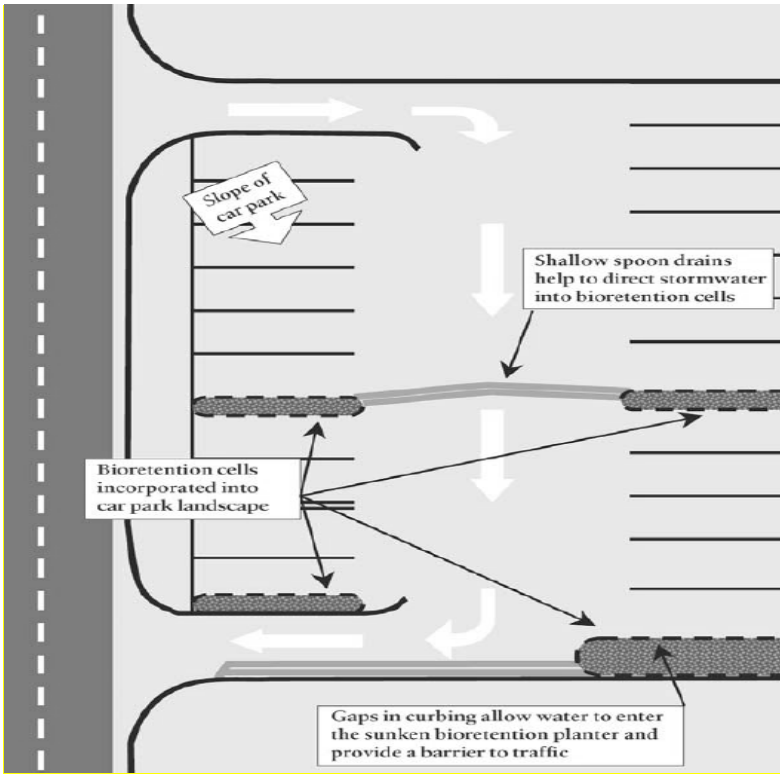


Figure 7.3.7 Retrofit of Street with a Swale, City of Onkaparinga.

(Source:Hobart City Council, 2006[36])

Figure 7.3.8 Car park run-off directed into garden beds.

(Source:Hobart City Council, 2006[37])

[36] Hobart City Council (2006). *Water Sensitive Urban Design Site Development Guidelines and Practice Notes.* Hobart.http://www.hobartcity.com.au/content/InternetWebsite/Environment/Stormwater_and_Waterways/Water_Sensitive_Urban_Design.aspx accessed 27 May 2010

[37] Ibid.

Commercial and Industrial Sites

Commercial sites includes all types of buildings used both by business and the public sector (schools, universities, hospitals). Industrial sites refers to heavy and light industry sites from mining to manufacturing to processing. Module B Lectures 2.4-4.3 and Module C Lecture 6.2 provide a detailed overview of how to reduce mains water demand through both water efficiency and water treatment and recycling.

These strategies outlined in those lectures can be incorporated into a broader WSUD site plan that also looks holistically at how better to manage rainfall, run-off and storm events. Any combination of the full range of WSUD techniques (i.e., rainwater tanks, porous paving, filtration/ infiltration devices, landscape practices) can be very effective at achieving such goals. For maximum effectiveness, these measures need to be carefully designed as part of an overall strategy that considers local site conditions. Figure 7.3.9 below shows just some of the WSUD options for industrial / commercial developments. Further options are explored in the "Key Resources" listed below.

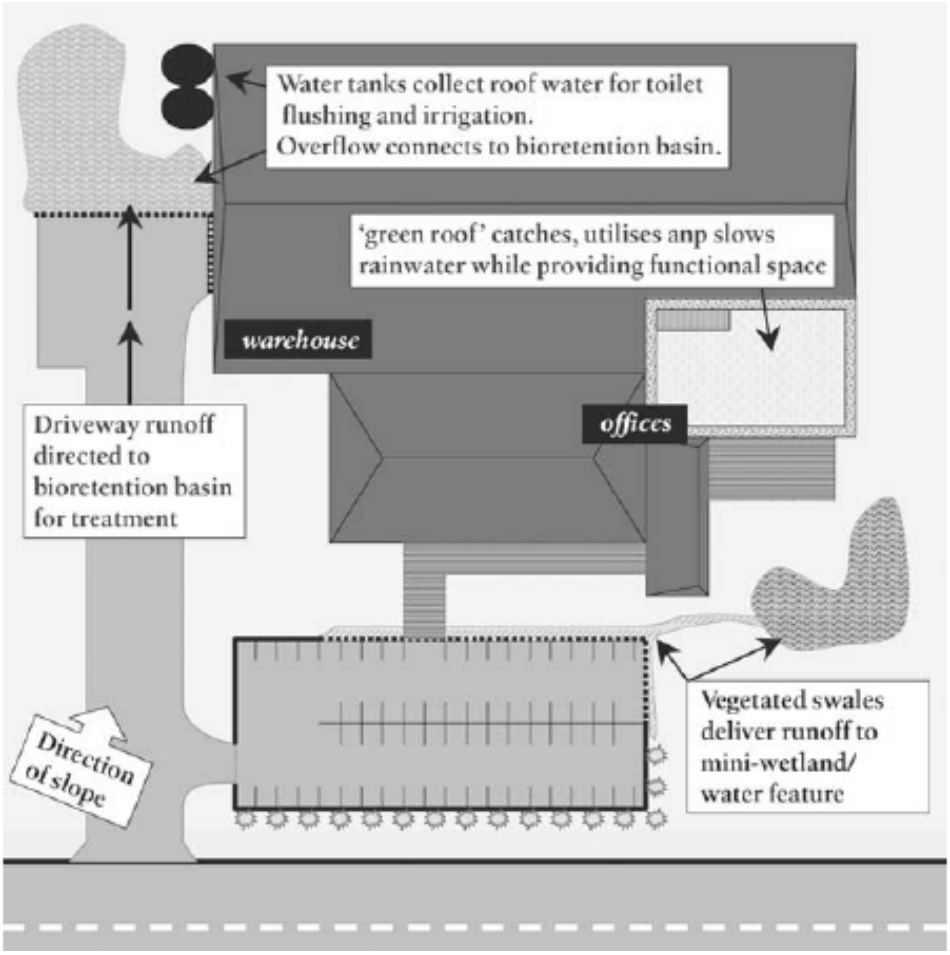


Figure 7.3.9 Industrial or Commercial Site Layout Example Incorporating WSUD Measures.
Source: Hobart City Council (2006)[38]

[38] Hobart City Council (2006) Water Sensitive Urban Design Site Development Guidelines and Practice Notes. Hobart. http://www.hobartcity.com.au/content/InternetWebsite/Environment/Stormwater_and_Waterways/Water_Sensitive_Urban_Design.aspx accessed 27 May 2010

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