

## **Procedures for integrating Water Sensitive Urban Design (WSUD) technologies into the site planning process: Criteria for streetscape scale applied in Melbourne Region - Australia**

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### **ABSTRACT**

Urbanization and population growth pressure on our water environments are two of the biggest challenges to local governments. Rising demand for potable water, the increase of runoff, peak flows and wastewater discharges, as well as pollution and degradation of natural water systems, are now intensified by climate variability and the impacts of climate change. To address and prevent these problems, designers and urban planners should promote better strategies and practices in water conservation in urban environments. This is the main aim of Australia's Water Sensitive Urban Design (WSUD) practice that combines 'Integrated Urban Water Cycle Planning and Management' (IUWCM) and 'urban design' into a new form of planning. Although there are detailed design guides on how to build WSUD technologies, there is a lack of criteria on how they should be incorporated into current planning regulations. This paper aims to present the development of a general framework for integrating WSUD technologies into the site planning process as it was applied to the streetscape scale in the Melbourne metropolitan region, in the state of Victoria, Australia. Also, results indicate the potential area available for fitting WSUD technologies into various types of streets.

### **KEYWORDS**

Australia-Melbourne; Criteria; streetscape scale; urban planning; Water Sensitive Urban Design; WSUD Technologies;

### **INTRODUCTION**

Research over the last three decades has found urban stormwater runoff to be a significant contribution of pollution in urban waterways (Bernhardt et al., 2008, USEPA, 1992 *apud* Morison, 2009). For example the USA EPA has singled out stormwater to be the biggest single source of pollution of coastal waters in America. A significant amount of pollutants, ranging from gross pollutants to particulate and soluble contaminants, are generated from paved urban surfaces, with some studies indicating correlation between the amount of pollutants and road traffic volume (Driscoll et al., 1990 *apud* Wong *et al*, 2000).

To address these problems, designers and urban planners should promote better strategies and stormwater practices in urban environments. This is the main aim of Australia Water Sensitive Urban Design (WSUD) practice that combines ‘Integrated Urban Water Cycle Planning and Management’ (IUWCM) and ‘urban design’ into a new form of urban planning (Wong, 2006). WSUD stormwater management systems (e.g. wetlands, bioretentions, swales, porous pavement, etc), also known as Best Management Practices (BMPs) or Low Impact Development (LID), are slowly gaining popularity across Australia, USA and Europe.

We now have detailed design guides on how to build WSUD stormwater management technologies, as well as how to model their performance (e.g. MUSIC software, CRCCH, 2003). However, the implementation issues of the technologies, that are mainly related to ongoing institutional challenges, are still to be resolved (Morison, 2009). Some of the key problems are associated with low awareness of urban planners and designers; in general they have very low knowledge and understanding of these novel stormwater management systems that present an opportunity for enhancement of urban environments. There is definitely a lack of guidelines on how WSUD should and could be incorporated into current planning regulations. This paper aims to make a first step in closing this gap by presenting the development of general framework for integration of WSUD technologies into the urban planning processes. The general framework was applied to the streetscape scale in the Melbourne metropolitan region, Australia.

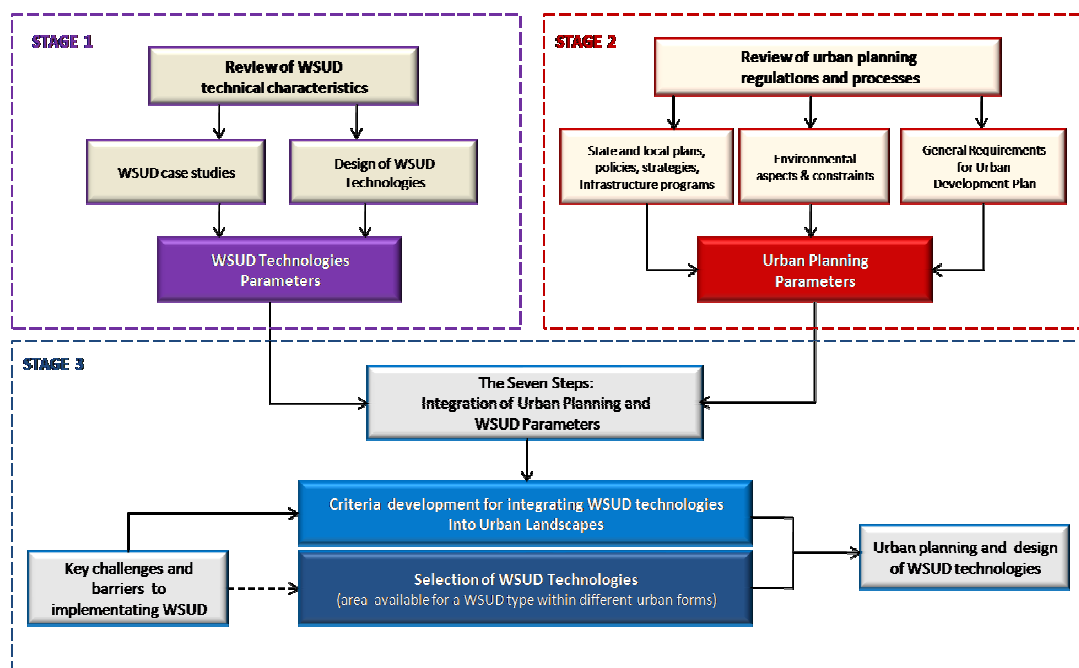
## METHODS

A framework entitled *Benchmarking for Liveable Urban Environments* (or in short BLUE Plan) has been proposed that is a simple procedure for incorporation of Water Sensitive Urban Design systems into local urban plans. It consists of three distinctive stages (Figure 1), that should be applied to a city/region that is examined:

Stage 1 - Review of WSUD technical characteristics for the region;

Stage 2 - Review of the local urban planning regulations and processes; and

Stage 3 - Development of criteria for integrating WSUD into the local urban landscapes.



**Figure 1** – The BLUE Plan overall framework.

The most significant parameters that govern this framework are: (i) scale (lot, streetscape or precinct) and (ii) land use (residential, commercial, industrial, public land use). The BLUE Plan therefore has to distinguish between the scale and land use for each specific region.

### Stage 1 - Review of local WSUD technical characteristics

The first stage of BLUE Plan aims to review the objectives and technical characteristics of WSUD technologies for the region in question. This includes review of local WSUD design guidelines, as well as local case studies. The procedures used for sizing of WSUD systems have to be examined to determine how much space is required for implementation of each WSUD technology in the context of local climate and catchment characteristics (e.g. review of design curves for the region), as well as agreed targets (e.g. required treatment performance of hydrological effectiveness). This also includes opportunities and constraints of the technologies in relation to the site characteristics. The eleven design parameters listed in Table 1 should be identified for each WSUD technology within the regional context (these parameters were chosen to represent a ‘short technical profile’ of each WSUD technology). Some of the listed parameters may not be relevant for a particular technology.

Table 1 – The Design Parameters of the WSUD Technologies (design characteristics of a given WSUD technology for the city/region)	
01	Purpose of the WSUD technology: e.g. treatment for waterway protection, treatment for stormwater harvesting, flood protection, storage of harvested water, etc
02	Suitability for a given urban scale: lot, streetscape, precinct, or regional;
03	Strategic location within the urban catchment (e.g. near to the source or end-of-pipe)
04	Impervious catchment area that it treats (minimum size required of WSUD technology to achieve treatment and hydrological targets)
05	Hydrological performance (hydraulic loading, return period of rainfall even it treats, requirements for flood protections)
06	Treatment performance (expected outflow concentrations and/or pollutant removal rates)
07	Any pre-treatment requirements
08	Opportunities and barriers in relation to catchment characteristics (site soil properties, slopes, local vegetation requirements)
09	Maintenance requirements
10	Infrastructure and services existent or required
11	Amenity and social implications (e.g. does the technology have aesthetic or cultural values etc)

### Stage 2 - Review of Local Urban Planning regulations

The second stage of BLUE Plan should begin with a review of the general principles of urban planning in the region/city. This should include environmental aspects, as well as opportunities and constraints for new developments (Greenfield sites) and/or re-developments (Brownfield sites). This is used to identify the eleven parameters on ‘Environmental Aspects and Constraints’ that are listed in Table 2.

The town planning, environmental and infrastructure legislations should be then examined in detail. The planning and building requirements must be determined, such as standard lot dimensions, street blocks design, minimum pervious area of the allotments, design and geometry of streets, size and demand for public areas (e.g. recreation, parks), etc. In this way, the further eleven urban planning parameters, that were here named as ‘General Requirements for Urban development Plan’ were identified as listed in Table 2. As above, they should be examined for each specific site using local planning regulations.

Table 2 – Urban Planning Parameters

<b>Environmental aspects and constraints</b>	01	Population, densities and growth rates
	02	Physical characteristics of the urban catchment
	03	Marine environment
	04	Vegetation – parks, isolated trees, native flora (including fauna or wildlife)
	05	Microclimate
	06	Topography – elevation, slope, orientation
	07	Geology - soil properties
	08	Water quality
	09	Air quality
	10	Natural hazards (floodplain, erosion, landslide, etc)
	11	Nuisances (noises, odors, unsightly views)
<b>General Requirements for Urban Development Plan</b>	12	Location and stage of development: Brownfield (retrofit) or Greenfield (new site)
	13	Scale ( lot, streetscape, precinct, regional), size and shape
	14	Zoning, subdivisions, easements, reserves and site restrictions
	15	Land Use - Residential, Industrial, Business, Mixed use and Public land
	16	Density and/or typology of building types (single or multifamily houses, multifamily towers or mixed-use residential/commercial development)
	17	Heritage, cultural landmark or particular neighbourhood character and other significant site amenities
	18	Standard building requirements
	19	Parking and driveway design and requirements
	20	Minimum requirement for open space (public and private), recreation and parks
	21	Urban design elements and landscaping requirements
	22	Infrastructure system and utility services

### Stage 3 - Development of criteria for integrating WSUD into the local urban landscapes

The last objective is to develop clear quantifiable criteria for integration of the WSUD technologies (designed according to local technical requirements) into the local urban environments (satisfying requirements of the local urban planning procedures). This means estimation of available space/land for implementation of WSUD at a given scale, as well as suitable identification of WSUD technologies for the given planning framework. The following *steps* have been identified in the process:

- I. Urban planning policies – check the legal and environmental conditions of the site;
- II. Site conditions – describe the local main features base on Table 2;
- III. Building requirements – investigate measures, dimensions, geometry and requirements on the urban planning regulations (and other Development Control Plans) according to the specific scale, land use and region – country;
- IV. Design and site layout analysis – list all the needs along with uses and after analyse the layout with all the elements likely build into the spot;
- V. Opportunities and constraints to implementing WSUD technologies - verify the area available, local infrastructure and physical conditions in conformity to the parameters in table 1, and examine if the site is adequate to implementing WSUD technologies;
- VI. Land availability for WSUD – as a result of the previous steps, the percentage of the urban area is determine that can be taken by WSUD technologies;
- VII. Selection of WSUD technology – select type of WSUD technologies suitable for the site and available area, (using the WSUD technical parameters defined in Table 1).

### Application

The BLUE Plan framework was applied to 3 different scales: (i) allotment, (ii) streetscape and (iii) precinct for Melbourne Metropolitan Area. This paper presents its application for the streetscape scale for Manningham City, which is one of the growing shires or councils of the Melbourne Metropolitan Region.

**Stage 1** – After reviewing Melbourne Water Design guidelines for WSUD stormwater technologies (that include the WSUD design curves for Melbourne region, Melbourne Water, *et al.*, 2005) and other WSUD design documents (ABM, 2004; Deletic *et al.*, 2010; Wong, 2006), a specific case study of WSUD implementation into a retrofit area of Manningham City was investigated. The Doncaster Hill development of Manningham City is a 58-hectare area located approximately 12 kilometers from the Melbourne Central Business District (CBD). It has been identifying as a Principal Activity Centre of Melbourne (according to Melbourne 2030 Plan of State Government of Victoria, 2002), and therefore is to be developed as a ‘high-density residential’ and ‘mixed-use’ urban development within an integrated transport system (MCC, 2004). The current plans for the Doncaster Hill development include incorporation of variety of WSUD technologies (proposed by a leading urban planning firm in Melbourne), hence were ideal for this investigation.

**Stage 2** - The principal planning regulations required for the development of this framework for the streetscape scale and Melbourne case study were: Street Design Guidelines for Landcom Projects (Morrish, in press), Austroads Urban Road Design (Austroads 2002, 2003a, 2003b), Water Sensitive Road Design (Wong *et al.*, 2000), Manningham Planning Scheme (MCC, 2010), Doncaster Hill strategies and Doncaster Open Space & Infrastructure requirements (MCC 2002, 2003, 2004, 2009). These guides were incorporated with references based on the principles for smart growth, New Urbanism, Ecologically Sustainable Development - ESD - (LaGro Jr., 2008; Duany *et al.*, 2010) and Melbourne 2030 - Planning for sustainable growth (State Government of Victoria, 2002).

**Stage 3** – The *seven steps* discussed above were followed to integrate WSUD technologies into urban planning process of Doncaster Hill. Despite the sustainable strategies and a contemporary redevelopment plan produced for Doncaster Hill, opportunities were still found for implementing WSUD elements into the urban landscape, mainly at the streetscape scale. Ten streets were examined in detail (each with different functional classifications), with Firth Street being chosen as an example presented in the paper.

## **RESULTS AND DISCUSSION**

The results of each step undertaken in Stage 3, that lead to the development of criteria for the incorporation of WSUD within streetscapes of Manningham City brownfield developments, are presented in Table 3. In Step I, the clauses 56.07 and 56.06 of the Manningham Planning Scheme (MCC, 2010) were used as the regulatory base for implementation of WSUD into the development. Step II, reviled opportunities for WSUD implementation within the given site (e.g. mixed-use place with residential and commercial parking areas). On the other hand, Steps III and IV identified restrictions related to geometry and design of the street, because Firth Street (classified as Local Street) do not contain large verge (pathways + nature strip), as well as do not have central median and outer separator (usually present on Major Roads only).

In relation to Step V (the site opportunities and constraints to implementing WSUD technologies into the built environment of Doncaster Hill), it was found that there is significant potential for water harvesting within the site. However, steep slopes of this urban catchment provided a serious challenge for implementation of some WSUD techniques.

Step 6, that is about determination of available space for WSUD technologies within the site (Table 4), differentiates porous pavement from other WSUD technologies, since it was decided to keep the pathways as exclusive areas for these systems. Therefore, the calculation of the percentage of porous pavement for the target area was based on the proportion between

the verge (pathways + nature strip) and the total width of streets. This range was established for two reasons: (i) standard size variation of the street between many countries and (ii) different levels of institutional commitment and capacity related to technical knowledge and organizational behaviour (proactive, reactive, conservative or traditional), as well as local socioeconomic conditions for incorporating urban stormwater management and WSUD elements.

<b>Table 3 – BLUE Plan Criteria for integrating WSUD technologies into streetscapes of Doncaster Hill</b>	
<b>Steps</b>	<b>Parameters examined and criteria developed</b>
<b>I. URBAN PLANNING POLICIES</b>	Manningham Planning Scheme (MCC, 2010); Doncaster Hill Strategy (MCC, 2004); Doncaster Hill streetscape Infrastructure report (MCC, 2003); Doncaster Hill Precinct 1 Masterplan (MCC, 2009); Doncaster Hill assessment of social, recreation & open space Infrastructure requirements (MCC, 2002)
<b>II. SITE CONDITIONS</b>	A. Stage of Development: Redevelopment area B. Land Use: residential and mixed-use C. Scale: streetscape scale D. Functional Classification of Roads: Local street
<b>III. BUILDING REQUIREMENTS</b>	A. Traffic Volume = up to 3000 B. Target Speed = 50 Km/hr C. Carriageway width = 7.0m up to 7.5m D. Parking line = 2.3m E. Verge Width (Nature Strip + footpath) = 2.0m + 1.5m F. Cycle Path Provision = none G. Service Road = none H. Outer separator and/or central median = none
<b>IV. DESIGN AND SITE LAYOUT ANALYSIS</b>	A. Street Detail Plan (inc. lot access) and neighborhood context; B. Min and Max total width (range) and other measures (criterion III); C. All design elements, including kerbing design; D. Allocation of space for utility services: sewer, telephone, water, drainage, electricity and gas.
<b>V. OPPORTUNITIES AND CONSTRAINTS TO IMPLEMENT WSUD TECHNOLOGIES</b>	A. Infiltration capacity of the soil; B. Topography and Slope site; C. Infrastructure available; D. Area Available. E. Other parameters present in Table 1
<b>VI. LAND AVAILABILITY FOR WSUD TECHNOLOGY</b>	See table 4
<b>VII. SELECTION OF WSUD TECHNOLOGY</b>	See table 5

The designated areas for WSUD technologies include the nature strip and other street elements (except pathways and carriageways), that are function of the total width of the street and as prescribed by its functional classification. Hence, the results in Table 4 demonstrate that the possibilities for implementing WSUD systems increase according to the street reserve width, as well as the presence of a parking line, central median, outer separator and service road. Major roads offer wide spread of space availability (Table 4 shows that it varies between 7.5 and 35%), due to diverse regulations for implementation of the central median, outer separator and nature strip in cities around the world. At the same time, major roads usually carry more traffic and consequently cause a degradation in the stormwater quality and therefore require adequate runoff treatment solutions. The next largest range was found for applying porous pavement in lanes; this is justified in circumstances where cars are not allowed, but only pedestrian traffic.

**Table 4 – Land Availability for WSUD Technology  
(Streetscape scale of Doncaster Hill)**

	Functional Classification of Roads				
	Lanes or access ways	Minor Local Street	Local Street	Collector Street	Major Roads
<b>WSUD technologies</b>	10%-25%	5%-15%	10%-25%	5%-25%	7.5%-35%
<b>Porous pavement</b>	10-50%	10%-25%	5%-20%	5%-15%	2.5%-10%

Legend: Lanes = access ways; Minor Local St.= Access place; Local St.= Access St.; Collector St = connector St.; Major Rd = Arterial Rd

Table 5 presents results from the last step of BLUE Plan framework, related to the selection of WSUD technologies for the streetscapes of Doncaster Hill development. It was found that the porous pavement, bioretention systems and swales are the best options, independently of the functional classification of roads. The off-line WSUD systems (such as sedimentation basin, wetlands, ponds, etc) that should be located out of the street reserve width, could also be used in combination with other techniques (as a part of treatment trains).

**Table 5 – Selection of WSUD Technologies into Streetscape scale**

WSUD Technologies	Functional Classification of Roads				
	Lanes	Minor Local St.	Local St.	Collector St.	Major Rd.
1. Gross pollutant traps	—	—	□	□	□
2. Sedimentation Basins	—	—	□	□	□
3. Swales or buffer strips	○	●	●	●	●
4. Bioretention systems	●	●	●	●	●
5. Sand Filters	○	○	○	○	○
6. Constructed Wetlands	—	—	□	□	○
7. Ponds	—	—	□	□	□
8. IS – Infiltration Systems (pits, basin and trenches)	—	—	□	□	□
9. IS - Porous Pavement	●	●	●	●	●
10. Aboveground Storage Tanks -AST	—	—	—	—	—
11. Underground Storage Tanks-UST	—	—	□	□	□
12. Aquifer Storage Recovery - ASR	—	—	—	—	—

Legend: Best option ●; applicable ○; applicable off-line □; Not applicable —

Morrish (in press) emphasizes in Street Design Guidelines that it is not necessary to provide WSUD techniques on all streets because stormwater can be directed to a series of wide development systems. Moreover, the specific number and location of WSUD systems in the urban catchment are not objectives of this framework, because they should be determined by modeling - such as Model for Urban Stormwater Improvement Conceptualisation - to achieve the best performance and efficient treatment outcomes integrated with the overall site design.

## CONCLUSIONS

Well-designed cities and towns should integrated Water Sensitive Urban Design (WSUD) elements to create more liveable neighbourhoods. There is a lack of planning tools that could lead to better and easier integration of WSUD stormwater technologies (such as ponds, wetlands, biofilters, swales, etc) into urban planning regulations. To fill the gap, the BLUE Plan has been developed aiming to establish a better linkage between WSUD engineering practices, urban planning regulations, and urban design experiences. This framework contains 3 stages that lead to assessment of the potential area available for WSUD technologies and

their appropriate selection for site conditions. It distinguishes between three scales (lot, streetscape and precinct) and several land-uses (residential, commercial, industrial, public land use), as well as development types (greenfield and retrofit).

To demonstrate potentials of BLUE Plan, it has been applied for a 58-ha retrofit development of Manningham City, located in Melbourne, Australia. Its application to the streetscapes of the development resulted in the assessment of available space for WSUD implementation within different street/road types (porous pavements was distinguished as the only technology that required revision of the figures). WSUD technologies that could easily be implemented in the examined situation were the porous pavement, bioretention systems and swales, and their implementation of independently of the functional classification of roads.

BLUE Plan, that may be very initiative and not necessary for experts that have both urban drainage and urban planning background, it may be valuable tool for capacity building of industry by bridging the gap between these two very distinctive disciplines.

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