Part E – General Controls – Environmental Controls

Chapter E15: Water Sensitive Urban Design

Contents

1 INTRODUCTION

This chapter of the DCP outlines Council's requirements for the incorporation of Water Sensitive Urban Design for certain development types.

The integration of urban water cycle management with urban planning and design is known as Water Sensitive Urban Design (WSUD). WSUD is a holistic approach to the planning and design of urban development that aims to minimise negative impacts on the natural water cycle and protect the health of aquatic ecosystems. WSUD promotes the integration of stormwater, water supply and wastewater management at the development stage. WSUD requires the consideration of the urban water cycle at the early planning stage to ensure all possible opportunities for application of best practice water cycle management solutions can be realised. The urban water cycle involves the cycling of water through the urban environment.

WSUD promotes innovative integration of urban water management technologies into an urban environment.

This chapter focuses on WSUD stormwater quality management and improvement measures only and should be specifically read in conjunction with the Stormwater Management and Floodplain Management chapters contained in Part E of this DCP.

This chapter should also be read and applied in conjunction with other parts of the DCP, especially Part D of the DCP which provides Council's requirements for residential subdivision, residential development, mixed use development, industrial development / subdivision and development in the business zones.

2 OBJECTIVES

1. The main objectives of water sensitive urban design are:

(a) To sustainably integrate natural systems with urban development.

(b) To integrate stormwater drainage treatments into the landscape.

(c) To ensure water sensitive urban design treatment measures are incorporated in new developments taking into account stormwater management and floodplain management issues.

(d) To improve the potential for urban run-off reuse.

(e) To minimise the volume of stormwater run-off.

(f) To protect the quality of water run-off from urban development.

(g) To reduce run-off and peak flows from urban developments by local detention basins and minimising impervious areas, wherever practicable.

(h) To preserve, restore and enhance riparian corridors as natural systems.

(i) To minimise the drainage infrastructure cost of development.

3 KEY PRINCIPLES OF WATER SENSITIVE URBAN DESIGN (WSUD)

1. The key principles of WSUD are to:

   (a) Protect existing natural features and ecological processes.

   (b) Maintain the natural hydrologic behaviour of catchments.

(c) Protect water quality of surface and ground waters.

(d) Minimise demand on the reticulated water supply system.

(e) Minimise sewage discharges to the natural environment.

(f) Integrate water into the landscape to enhance ecological, visual, social, economic and cultural values.

4 DEVELOPMENT TO WHICH THIS POLICY RELATES

1. The incorporation of appropriate water sensitive urban design measures may be required for the following types of development (subject to Council's confirmation at the formal pre-lodgement meeting):

(a) Residential land subdivisions involving 50 or more proposed allotments.

(b) Medium density housing involving 20 or more dwellings.

(c) Residential apartment buildings involving 20 or more residential apartments.

(d) Mixed use developments involving 20 or more residential apartments or a gross floor area of 3,000 square metres or more (whichever the lesser).

(e) Serviced apartment or hotel developments.

(f) Industrial developments (including major alterations and additions to existing industrial buildings) involving a site area of 2 hectares or more.

(g) Industrial subdivisions involving 10 or more proposed allotments or a site area of 2 hectares or more (whichever is the lesser).

(h) Business parks.

(i) Commercial office developments involving a gross floor area of 10,000 square metres or more.

5 STORMWATER TREATMENT TRAINS

1. A series of treatment measures that collectively address all stormwater pollutants is termed a "treatment train". The selection and order of treatments is a critical factor in developing treatment trains. The coarse fraction of pollutants generally requires removal so that treatments target fine pollutants can operate effectively. The proximity of a treatment to its source and the distribution of treatments throughout a catchment are other factors which are important in developing a treatment train.

2. Stormwater treatments that target the removal of gross pollutants and coarse sediments such as gross pollutant traps (GPTs) and sedimentation basins can operate under high hydraulic loading and can treat high flow rates.

3. As the target pollutant particle size reduces, the nature of the treatment process changes to include enhanced sedimentation, bio film absorption and biological transformation of the pollutants. The treatment processes include grass swales, vegetated buffer strips, surface wetlands and infiltration systems which require longer detention times than for GPTs, in order to

allow various pollutant removal processes to occur. The hydraulic loading on these treatment processes is relatively low in comparison to gross pollutant removal measures.

4. A treatment train consists of a combination of treatment measures that can address the range of pollutant particle sizes in stormwater. Therefore, a treatment train employs a range of processes to achieve pollutant reduction targets such as physical screening, enhanced sedimentation and filtration.

6 SELECTING A WSUD TREATMENT MEASURE

1. The Water Sensitive Urban Design (WSUD) treatment measures can be grouped into three (3) main categories, namely:

   (a) *Primary Treatment* – Physical screening or rapid sedimentation techniques – gross pollutants and coarse sediments.

   (b) *Secondary Treatment* – Finer particle sedimentation and filtration techniques – fine particles and attached pollutants.

   (c) *Tertiary Treatment* – Enhanced sedimentation and filtration, biological uptake, absorption onto sediments.

2. The CSIRO *Urban Stormwater : Best Practice Environmental Management Guidelines* 1999 recommends that a range of treatments may be required to reduce one or more of the following pollutant categories, in order to protect receiving waters:

   (a) *Gross pollutants* – trash, litter and vegetation larger than 5 millimetres;

   (b) *Coarse sediment* – contaminant particles are between 5 millimetres and 0.5 millimetres;

   (c) *Medium sediment* – contaminant particles are between 0.5 millimetres and 0.062 millimetres;

   (d) *Fine sediments* – contaminant particles are smaller than 0.062 millimetres;

   (e) *Attached pollutants* – Those pollutants that are attached to fine sediments, specifically, nutrients, heavy metals, toxicants and hydrocarbons and / or;

   (f) *Dissolved pollutants* – typically, nutrients, heavy metals and salts.

7 TYPES OF WATER SENSITIVE URBAN DESIGN (WSUD) TREATMENT MEASURES

7.1 General

1. The main WSUD treatment measures include:

   (a) Rainwater tanks.

   (b) Gross Pollutant Traps / Litter Traps.

   (c) Grassed and Vegetated Swales.

   (d) Bio-Retention Systems.

(e) Bio-Retention Basins.

(f) Sedimentation Basins.

(g) Constructed Wetlands.

(h) Infiltration Measures.

(i) Aquifer Storage and Recovery.

(j) Porous Pavements.

2. The role and function level of the various WSUD treatment measures is summarised in the following Table 1:

Table 1: Primary Role and Function of WSUD Treatment Measures

WSUD Treatment Measure	Water Quality Function	Water Quantity Function
Rainwater Tanks	Low	High
Gross Pollutant Traps (GPTs)	High	Low
Grassed and Vegetated Swales	High	Low
Bio-retention Systems	High	Medium
Bio-retention Basins	High	Medium
Sedimentation Basins	High	Medium
Constructed Wetlands	High	Low
Infiltration Measures	High	Medium
Aquifer Storage and Recovery	Medium	Low
Porous Pavements	Medium	Medium

7.2 Rainwater Tanks

1. Rainwater tanks reduce the hydraulic loading supplied to on-site treatment measures (therefore improving treatment measures) and act as detention systems for storing rainfall that would otherwise be conveyed to a point of discharge.

2. The water from a rainwater tank may be used for internal toilet flushing and hot water uses and for external uses such as watering gardens, car washing and topping up swimming pools etc.

3. Rainwater tanks are a suitable WSUD element for all scales of residential, mixed use, commercial and industrial development.

4. Rainwater tanks are particularly suited to detached housing, multi dwelling developments and high density residential apartment buildings and mixed use buildings where a greater proportion of the site (roofing area) contributes to rainwater tanks and minimises adverse effects associated with stormwater runoff.

5. Where rainwater tanks are not fitted during the initial development phase, it is recommended that the development be designed to enable the retrofitting of rainwater tanks at a later stage.

6. Rainwater tanks must be:

   (a) Sized to have a rainwater storage volume not less than that required by any BASIX

   Certificate issued for the development, and configured in accordance with the requirements of that Certificate;

   (b) Sized to have a rainwater storage volume not less than that defined in this DCP;

   (c) Designed and located to capture rainwater from at least 50 per cent of the roof area in low and medium-density residential developments, and 100 per cent of the roof area for high-density residential developments;

   (d) Designed and connected to provide water at least for site irrigation (garden watering etc.) and toilet flushing;

   (e) Fitted with a first-flush device, which diverts a maximum of 1mm of roof water. The device is to include a primary litter/leaf mesh screen and a first-flush containment storage with a small orifice to empty the storage between rain events. The first-flush water is to be directed to a vegetated area or other WSUD measure, before discharging to the drainage system;

   (f) Designed and configured to ensure provision of water for all purposes in the event of a power failure or the tank water level falling below a defined level or volume. This may comprise:

      (i) A bypass mechanism to allow mains water to be used for toilet flushing, site irrigation etc. in the event of power failure disabling the pump (subject to water authority approval). The tank bypass line must incorporate an appropriate backflow prevention device; or

      (ii) A float-valve system (or equivalent) to allow the tank to be filled to a pre-determined level when the tank water level fall below a defined volume.

   (g) Designed so the overflow drains to a bio-retention system and may incorporate additional storage volume for (temporary) on-site detention of stormwater.

7.3 Gross Pollutant Traps (GPTs)

1. A gross pollutant trap (GPT) is a sediment trap incorporating a litter or trash rack (with vertical steel bars), at the downstream end of the trap.

2. Gross pollutant traps (GPTs) are designed to screen and trap litter and debris before it enters watercourses. Some GPTs also remove bed load sediments and some suspended sediments through rapid sedimentation. Gross pollutant traps are used in conventional drainage systems either in stormwater drainage pipes, at outfalls and in open channels and may also be used as pre-treatments for WSUD elements including the protection of rehabilitated waterways.

3. Gross pollutant traps generally remove coarse litter and sediment greater than 5 millimetres.

4. Gross pollutant traps enable coarse sediments to settle to the bottom by decreasing the stormwater flow velocity. This is achieved by increasing the width and depth of the channel of the GPT wet basin. The trash rack at the downstream end of the basin is intended to collect floating and submerged debris as per a conventional trash rack.

5. Gross pollutant traps are designed to retain solid litter that has washed into the system without retarding flows or increasing water levels in the drainage system. However, many water sensitive urban design (WSUD) elements do not require a GPT as the entry of litter and debris into the stormwater system can be restricted by filtration media.

6. The type and capacity of the GPT should be based upon the likely pollutant loading expected which may be determined using computer simulation modelling.

7. The selection and design of the GPT is dependent upon the land uses in the catchment, the likely pollutants and the treatment provided upstream. In this regard, GPTs can be designed for different catchment scales from less than one (1) hectare to more than 100 hectares. Different GPTs employ different methods of litter separation and containment and their performance varies greatly.

8. The regular maintenance of the GPT structure is required and involves the removal of litter and debris as well as the removal of collected coarse sediment.

7.4 Vegetated or Grassed Swales

1. Swales are vegetated or grass lined channels used as an alternative to kerb and channel.

2. Vegetated swales are used to convey stormwater in lieu of underground stormwater piped drainage systems and are designed to remove coarse and medium sediment.

3. Swales are beneficial in providing a ‘buffer’ between the receiving water and the impervious areas of a catchment such as roads. Swales work by interacting and slowing stormwater runoff as it passes through a locality. This control of flow means pollutants can settle in the vegetation contained in the swale.

4. Swales form part of an overall stormwater ‘treatment train’ to deliver acceptable stormwater quality for discharge to aquatic ecosystems or for potential reuse applications.

5. Swales should also be designed to disconnect impervious areas from hydraulically efficient piped drainage systems, in order to protect aquatic ecosystems in receiving waterways by managing the frequency of damage to aquatic habitats by storm flows. This is achieved by slower travel times for flows along swale systems compared with efficient pipe drainage systems. This reduces the rapid response from impervious areas, particularly for frequent storm events and resultant impact on natural receiving waterways.

Figure 3: Example of grassed swale (top) and vegetated swale (bottom) (Source: Water Sensitive Urban Design of the Sydney Region)

6. The longitudinal slope of a swale is recommended to be between 2% to 4%, in order to prevent any water ponding or water logging problems on sites. Steeper slopes (greater than 4%) are not recommended given potential embankment scouring and erosion problems along the swale. However, if steeper slopes cannot be avoided, the provision of dense vegetation, check banks along swales and / or drop structures may help to distribute flows evenly across the swales and to assist in slowing runoff velocities. The creation of check banks may be achieved through depressions in the grassed invert level of the channel. A porous base or infiltration trench with perforated drain is required below the check dam area.

7. A filtration trench or sub-soil drain system is required under the invert level of swales with longitudinal slopes of less 2% to prevent water ponding.

8. Swales with longitudinal slopes of 2% or less should be “V” shaped, whereas swales with slopes greater than 2% should incorporate wider parabolic shaped bases.

9. Vegetation is an integral component of swales since it promotes constant distribution and retardation of flows. Vegetation is required to cover the full width of a swale and be designed to withstand the likely design flows and velocities. The vegetation of the swale must also be of a sufficient density in order to guarantee significant contact between flows and vegetation.

10. If run-off enters a swale as distributed flow (ie perpendicular to the main flow direction), the swale batter receiving the inflows acts as a vegetated buffer and can provide an important pre-treatment function for the swale by removing coarse sediment prior to flows concentrating along the invert of the swale.

Figure 6: Examples of grassed swale (Source: Water Sensitive Urban Design of the Sydney Region)

Figure 7: (Top left) Examples of Vegetated Swale (Source: Water Sensitive Urban Design of the Sydney Region)

7.5 Buffer Strips

1. Buffer strips provide discontinuity between impervious surfaces and the drainage system. Buffer strips should be placed lower than the road surface to allow for sediment accumulation. The set down required is a trade-off between potential scouring effect and providing adequate depth to enable the sufficient build-up space for accumulated sediment.

7.6 Bio-Retention Swales

General

1. Bio-retention swales (or bio-filtration trenches) are treatment systems that are located at the downstream end of a swale (ie immediately upstream of the swale overflow pit). Bio-retention swales provide both stormwater treatment and conveyance functions. The swale component provides a stormwater pre-treatment function by removing coarse to medium sediments whilst the bio-retention system removes finer particles and associated pollutants.

2. Bio-retention swales provide efficient treatment of stormwater through fine filtration, extended detention treatment with some biological uptake. Bio-retention swales are very efficient at removing nitrogen and other soluble or fine particulate contaminants and provide a run-off conveyance function along the full length of the swale.

3. Runoff is filtered through a filter media as it percolates downwards under gravity. The filtered runoff is then collected at the base of the filter media via perforated pipes and flows to downstream watercourses or to storages for potential reuse.

4. The reduction of runoff volumes can be primarily attributed to maintaining soil moisture of the filter media and evapotranspiration losses.

5. The longitudinal slope of a bio-retention swale should be between 2% to 4%, in order to prevent any water ponding or water logging problems on sites.

Vegetation in Bio-retention Swales

1. Vegetation that grows in the filter media of bio-retention swales is an integral component of these treatment measures.

2. Bio-retention swales can use a variety of vegetation types including turf (swale component only), sedges and tufted grasses. Vegetation is required to cover the whole width of the swale and bio-retention filter media surface. The vegetation must be capable of withstanding design flows and be of sufficient density to prevent preferred flow paths and scour of deposited sediments.

3. Grassed (turf) bio-retention swales may be used in a residential or industrial subdivision where a continuous bio-retention trench approach is used. However, grassed bio-retention swales need to be mown to protect the conveyance capacity of the swale component and therefore repeated mowing of the grass over a continuous bio-retention trench can result in long term compaction of the filter media and reduce its treatment performance. Therefore, the preferred vegetation type for bio-retention swales is sedges and tufted grasses (with potential occasional tree plantings) that do not require mowing.

4. The denser and taller the vegetation planted in the bio-retention filter media, the better the treatment provided, especially during extended detention. Taller vegetation has better interaction with temporarily stored stormwater during ponding, which results in enhanced sedimentation of suspended sediments and associated pollutants. The vegetation that grows in the bio-retention filter media also acts to continuously break up the surface of the media through plant root growth and wind induced agitation, which prevents surface clogging. Vegetation also provides a substrate for bio-film growth in the upper layer of the filter media which facilitates biological transformation of pollutants (particularly nitrogen).

5. Dense vegetation planted along the swale component can also offer improved sediment retention by reducing flow velocity and providing vegetation enhanced sedimentation for deeper flows. However, densely vegetated swales have higher hydraulic roughness and therefore require a larger area and/ or more frequent use of swale field inlet pits to convey flows compared to grass swales. Densely vegetated bio-retention swales can become features of an urban landscape and once established, require minimal maintenance and are hardy enough to withstand large flows.

6. Bio-retention swales may be located within passive open space areas, car parks or along roadway corridors within road verges or centre medians. Landscape design of bio-retention swales along the road edge can assist in defining the boundary of road corridors as well as providing landscape character and amenity. It is therefore important that the landscape design of bio-retention swales addresses stormwater quality objectives whilst also being sensitive to stormwater flow requirements and as well as these other important landscape functions.

7.7 Bio-Retention Basins

General

1. Bio-retention basins operate with the same treatment processes as bio-retention swales but do not have a conveyance function. High stormwater runoff flows are bypassed away from the bio-retention basin or are discharged into an overflow structure.

2. Bio-retention basins should be designed to provide efficient treatment of stormwater through fine filtration, extended detention treatment and some biological uptake, particularly for nitrogen and other soluble or fine particulate contaminants.

3. Bio-retention basins can be installed in a range of scales and shapes with smaller systems taking the form of planter beds in car park areas or within the verge of the footpath area. Larger bio-retention basins may be constructed at the outfall of a drainage system, to provide suitable end of pipe treatment to runoff from larger sub-catchments.

4. Bio-retention basins must be located, configured and designed to treat runoff from at least 90 per cent of the impervious area of the site (i.e. driveway, paved areas and any roof area not draining to a rainwater tank). Vegetated filter strips should be located between impervious areas and the bio-retention measure wherever possible.

5. Bio-retention basins must have temporary storage (detention) depth 150mm and a filter media depth of not less than 600mm.

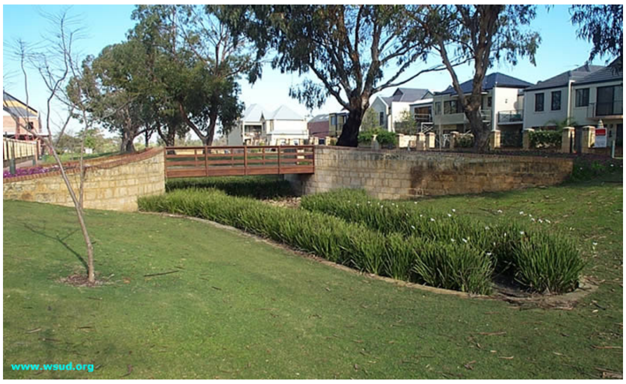

Figure 8: Examples of Bio-Retention Basins (Source: Water Sensitive Urban Design of the Sydney Region)

6. Bio-retention basins must be constructed using a loamy sand filter medium of the following characteristics:

   (a) Well graded, with no gaps in the particle size distribution.

   (b) Total silt and clay content of less than 3 per cent w/w.

   (c) Organic matter content of less than 5 per cent w/w.

   (d) Not hydrophobic and not indicate dispersive properties.

7. Bio-retention basins must incorporate an impervious liner where surrounding soils are likely to be sensitive to any exfiltration from the bio-retention measure (e.g. sodic soils, shallow groundwater or close proximity to significant structures).

8. Bio-retention basins must be planted with hardy plants that are able to withstand prolonged periods of dry and wet conditions (preferably local indigenous plants). Plants with extensive and deep root systems will provide the best water quality treatment.

Hydraulic Design of Bio-retention Basins

1. The hydraulic design of a bio-retention basin is critical in ensuring the effective stormwater treatment performance of the basin as well as protecting the hydraulic integrity and function of associated minor and major drainage systems, to minimise storm flow damage.

2. The following aspects are critical in the design of an effective bio-retention basin:

   (a) The finished surface of the bio-retention filter media must be horizontal (i.e. flat) to ensure full engagement of the filter media by stormwater flows and to prevent concentration of stormwater flows within depressions and ruts resulting in potential scour and damage to the filter media.

   (b) The temporary ponding of up to 0.3 metres depth over the surface of the bio-retention filter media (ie created through the use of raised field inlet pits (overflow pits)) can assist in managing flow velocities over the surface of the filter media as well as increase the overall volume of stormwater runoff that can be treated by the bio-retention filter media.

(c) The overflow pit or bypass channel should be located near the inflow zone to prevent high flows passing over the surface of the filter media. If this is not possible, then velocities during the minor (2-10 year ARI) and major (50-100 year ARI) floods should be maintained sufficiently low (preferably below values of 0.5 m/s and not more than 1.5 m/s for major flood) to avoid scouring of the filter media and vegetation.

(d) Where the field inlet(s) in a bio-retention system is required to convey the minor storm flow (i.e. is part of the minor drainage system), the inlet must be designed to avoid blockage, flow conveyance and public safety issues.

7.8 Sedimentation Basins

1. Sedimentation basins are designed to retain coarse sediments from run-off and are generally the first element in a treatment train. Sedimentation basins are primarily used for the trapping of sediments in runoff from construction sites and as pre-treatment measure, in order to protect downstream stormwater treatment measures (eg wetlands) from becoming overloaded with sedimentation.

2. Sedimentation basins operate by reducing flow velocities and encouraging sediments to settle out of the water column. The recommended target particle size is 0.125mm for the design of a sediment basin.

Figure 9: Examples of Bio-Retention Basins (Source: Water Sensitive Urban Design of the Sydney Region)

3. Sedimentation basins are typically constructed as ephemeral basins so that they drain during prolonged dry periods and refill only during rainfall runoff events.

4. Sedimentation basins are also generally constructed to a maximum depth of 1.5 metres to 2 metres, in order to allow sufficient depth for sediment accumulation whilst minimising the potential for fringing aquatic macrophytes to colonise the basin.

5. Enhanced sedimentation processes allow finer particles to settle within the basin.

6. The large quantity of coarse sediment carried in stormwater will require a suitable maintenance regime, to enable regular removal of sediment from the sediment basin. In this regard, the maintenance regime should involve processes which separate the coarser sediment from the finer sediment material since the fine sediment material typically contains the higher concentration of contaminants such as hydrocarbons and / or heavy metals.

7. The batter slopes on approaches and immediately beneath the permanent water level within a sedimentation basin, must be designed to ensure public safety.

8. The public safety requirements will vary from site to site and requires careful consideration. The maximum batter slope for a sedimentation basin should be 1 in 5 (Vertical: Horizontal).

7.9 Constructed Wetlands

7.9.1 General

1, Constructed wetlands are generally shallow water bodies with extensive aquatic vegetation.

2. Constructed wetlands generally consist of:

   (a) An inlet zone (or sediment basin) regulates water flow runoff into the wetland and removes coarse sediments;

   (b) A marcophyte zone which is a shallow heavily vegetated area to remove fine particulates and uptake of soluble pollutants; and

   (c) A high flow bypass channel which is designed to protect the macrophyte zone from high velocity flood flows.

3. Wetland processes are improved by slowly passing runoff through heavily vegetated areas, allowing plants to filter sediments and pollutants from the water. Bio-films which grow on plants absorb nutrients and other contaminants.

4. Wetlands can also provide a flood protection function when used as a detention basin. Additionally, wetlands can also provide a water storage function for later reuse for spray irrigation purposes.

5. Constructed wetlands are designed to mimic the natural efficiency of these areas in treating both the quality and peak discharge flow rate of large stormwater flows.

6. Constructed wetlands are typically best suited to large scale residential or industrial subdivisions and are designed as end of line treatment devices.

7.9.2 Inlet Zone of a Constructed Wetland

1. The inlet zone of a constructed wetland is designed as a sedimentation basin and serves two functions: (1) pre-treatment of inflow to remove coarse to medium sized sediment; and (2) the hydrologic control of inflows into the macrophyte zone and bypass of floods during ‘above design’ operating conditions.

2. The inlet zone in a constructed wetland should contain the following elements:

   (a) A sedimentation basin ‘pool’ to capture coarse to medium sediment (125 μm or larger).

   (b) An inlet zone connection to the macrophyte zone consisting of an overflow pit within the inlet zone connected to one or more pipes through the embankment separating the inlet zone and the macrophyte zone.

   (c) High flow bypass weir (or ‘spillway’ outlet structure to deliver ‘above design’ flood flows to the high flow bypass channel.

   (d) The inlet zone typically must comprise a deep open water body (> 1.5m) that operates essentially as a sedimentation basin designed to capture coarse to medium sized sediment (i.e. 125 μm or larger).

(e) A Gross Pollutant Trap (GPT) may need to be installed such that litter and large debris can be captured at the interface between the incoming waterway or pipe and the open water of the inlet zone.

(f) The crest of the overflow pit must be set at the permanent pool level of the inlet zone (which is typically set 0.3 metres above the permanent water level of the macrophyte zone).

(g) The dimension of the overflow pit (control structure) should be set at the permanent pool level of the inlet zone (which is typically set 0.3 metre above the permanent water level of the macrophyte zone).

(h) The pipe that connects the sedimentation basin to the macrophyte zone needs to have sufficient capacity to convey a 1 year ARI flow, assuming the macrophyte zone is at the permanent pool level and without resulting in any flow over the high flow bypass weir.

(i) An energy dissipater is generally required at the end of the pipes to reduce velocities and distribute flows into the macrophyte zone.

(j) The inlet zone is to have a structural base (e.g. rock or concrete) to define the base when desilting and provide support for maintenance plant/ machinery when entering the basin for maintenance.

(k) The high flow bypass weir ('spillway' outlet) is to be set at the same level as the top of extended detention in the macrophyte zone.

7.9.3 Macrophyte Zone Design Considerations

1. The layout of the macrophyte zone is recommended to be designed to ensure that the hydraulic efficiency of the system is optimised and healthy vegetation is sustained over the long term.

2. The general design considerations for the layout of the macrophyte zone within a constructed wetland include (but are not necessary limited to) the following:

(a) The preferred extended detention depth is 0.5 metres. Deeper extended detention depths up to a maximum of 0.75 metres may be acceptable where the wetland hydrologic effectiveness is greater than 80% and where the botanic design uses plant species tolerant to greater depths of inundation.

(b) The bathymetry of the macrophyte zone should be designed to promote a sequence of ephemeral, shallow marsh, marsh and deep marsh zones in addition to small open water zones. The relative proportion of each zone will be dependent on the target pollutant and the wetland hydrologic effectiveness.

(c) The macrophyte zone is required to retain water permanently and therefore the base must be lined with a suitable clay material to retain water. If in-situ soils are unsuitable for water retention, a clay liner (ie compacted a minimum 300mm thick) must be used to ensure there will be permanent water for vegetation and habitat.

(d) The bathymetry of the macrophyte zone should be designed so that all marsh zones are connected to a deeper open water zone to allow mosquito predators such as frogs to seek refuge in the deeper open water zones during periods of extended dry weather.

(e) The placement of the inlet and outlet structures and the length to width ratio of the macrophyte zone and flow control features are particularly critical, in order to promote a high hydraulic efficiency within the macrophyte zone.

(f) The constructed wetland should be designed to enable draining of the macrophyte zone for water level management, during the plant establishment phase.

(g) The macrophyte zone outlet structure needs to be designed to provide a notional detention time (usually 48 to 72 hours) for a wide range of flow depths. The outlet structure should also include measures to exclude debris to prevent clogging.

7.9.4 Wetlands Constructed within Retention (or Detention) Basins

1. Wetlands may in some cases be constructed at the base of retention basins, thus reducing the land required for stormwater treatment. In these situations, wetland systems may occasionally become inundated to greater depths than the extended detention depth; however, the inundation duration is generally relatively shorter (hours) and is unlikely to affect the wetland vegetation provided there is a safe pathway to drain the wetland following flood events which avoids scour of the wetland vegetation and banks.

2. When designing a wetland within a retention basin, the outlet control structure of the retention basin (typically culverts) should be placed at the end of the wetland bypass channel. This ensures flood flows 'backwater', across the wetland thus protecting the macrophyte vegetation from scour by high velocity flows.

Figure 10: Example of a constructed wetland (left) and a constructed wetland within a retention basin (Source: Water Sensitive Urban Design of the Sydney Region)

7.9.5 Vegetation Type

1. Vegetation planted in the macrophyte zone has an important functional role in treating stormwater flows as well as adding aesthetic value. Dense planting of the littoral zone will also inhibit public access to the macrophyte zone, minimising potential damage to wetland plants and reducing the safety risks posed by water bodies.

2. The plant species for the constructed wetland should be selected based on the hydrologic regime, microclimate and soil types of the locality and physiological and structural characteristics, natural distribution of the wetland plants. The planting densities should ensure that 70 - 80 % cover is achieved within two growing seasons (2 years). The distribution of the species within the wetland should relate to their structure, function, relationship and compatibility with other species.

7.9.6 Wetland Design to Reduce Mosquito Incidence

1. The following aspects should be considered in the design of a constructed wetland, in order to minimise the incidence of mosquitoes:

(a) Access for mosquito predators such as frogs, fish and predatory insects, to all parts of the water body (avoid stagnant isolated areas of water).

(b) Provision for a deep sump of permanent water (for long dry periods or for when water levels are artificially lowered) so that mosquito predators such as frogs may seek refuge and maintain a presence in the wetland.

(c) Maintaining natural water level fluctuations that disturb the breeding cycle of some mosquito species.

(d) Wave action from wind over open water will discourage mosquito egg laying and disrupt the ability of larvae to breathe.

(e) Providing a bathymetry such that regular wetting and drying is achieved and water draws down evenly so isolated pools are avoided.

(f) Providing sufficient gross pollutant control at the inlet such that human derived litter does not accumulate and provide breeding habitat.

(g) Ensuring overflow channels don't have depressions that will hold water after a storm event.

2. Each case has to be considered on its own merits. It may be possible that a well established constructed wetland will have no significant mosquito breeding associated with it; however, changes in climatic and vegetation conditions could change that situation rapidly. Maintaining awareness for mosquito problems and regular monitoring for mosquito activity should be considered as a component of the management of these sites.

7.9.7 Access into the Constructed Wetland

1. Access to all areas of a constructed wetland is required for maintenance. In particular, inlet zones and gross pollutant traps require a track suitable for heavy machinery for removal of debris and de-silting as well as an area for dewatering removed sediments. If sediment removal requires earthmoving equipment to enter the basin, then a stable ramp suitable for heavy plant will be required into the base of the inlet zone (maximum slope 1:8).

2. To aid maintenance, it is recommended that the inlet zone be constructed with a hard rock or concrete bottom. This is important if maintenance is performed by driving into the basin. It also serves an important role by allowing excavator operators to detect when they have reached the base of the inlet zone during desilting operations.

3. Macrophyte zones also require access for weeding and replanting work as well as regular inspections.

4. Maintenance access to constructed wetland needs to be considered when determining the layout of the proposed wetland system.

7.9.8 Batter Slopes to Permanent Water within a Constructed Wetland

1. The batter slopes on approaches and immediately under the permanent water level within a constructed wetland must be designed to ensure public safety.

2. The public safety requirements for individual wetlands will vary from site to site and requires careful consideration. However, a gentle slope to the waters edge and extending below the water line must be adopted. The maximum batter slope for constructed wetlands should be 1 in 8 (Vertical: Horizontal).

3. Palisade (open metal type) fencing at a minimum height of 1.5 metres will be required to be erected on top of concrete or stone walls for constructed wetlands where:

   (a) There is a risk of serious injury in the event of a fall (where the batter slope of the wetland is greater than 0.5 metres high or is too steep to comfortably walk up/ down or the lower surface has sharp or jagged edges);

   (b) There is a high pedestrian or vehicular exposure (on footpaths, near bikeways, near playing/ sporting fields, near swings and playgrounds);

   (c) Where the water level (permanent or temporary) is at a depth of greater than 300mm;

   (d) Where the water is expected to contain concentrated pollutants

   (e) Where mowed grassed areas abut the asset.

4. In some cases, a dense vegetation screen around the perimeter of the wetland at least 2 metres wide and 1.2 metres high (minimum) may be suitable. However, this option will only be considered where the fencing of the wetland is physically restricted due to topographical or other constraints. Any such dense vegetation must be designed to minimise potential hiding places, particularly in areas close to any pathway / cycleway.

7.10 Infiltration Measures

1. Infiltration measures are designed to enable pre-treated stormwater runoff to infiltrate into surrounding soils and underlying groundwater. The purpose of infiltration measures is to act as a conveyance measure to facilitate infiltration of surface waters to groundwater and not as a treatment device.

2. Infiltration measures generally consist of a shallow excavated trench designed to detain a certain volume of runoff water and to subsequently allow for the infiltration of the runoff into the soil strata. Infiltration measures also assist in reducing surface runoff volumes by providing a pathway for treated stormwater runoff to recharge into the groundwater table. These measures are best suited to highly permeable soils so that water can infiltrate the soil strata at a sufficient rate and to prevent water ponding.

7.11 Porous Pavements

1. Porous pavements are suitable for use in areas with light traffic loads such as car parking spaces, private driveways and private roads within a small community title subdivision. Porous pavements allow run-off to infiltrate through the pavement's surface to the underlying soil strata, instead of overland run-off directly into a piped stormwater drainage system.

2. Porous paving provides both stormwater flow and pollution retention measures but these surfaces require regular maintenance to ensure correct operation at optimal treatment capacity.

3. Porous pavements are generally constructed with a deep layer of gravel which is bedded on a sand filter layer. This allows run-off to percolate through the porous pavement into the gravel reservoir and then into the sand filter underneath. The removal of particulates and some dissolved pollutants is achieved by filtration and absorption onto soil particles.

4. Regular pavement surface maintenance is required to ensure the optimal infiltration efficiency of the porous pavement.

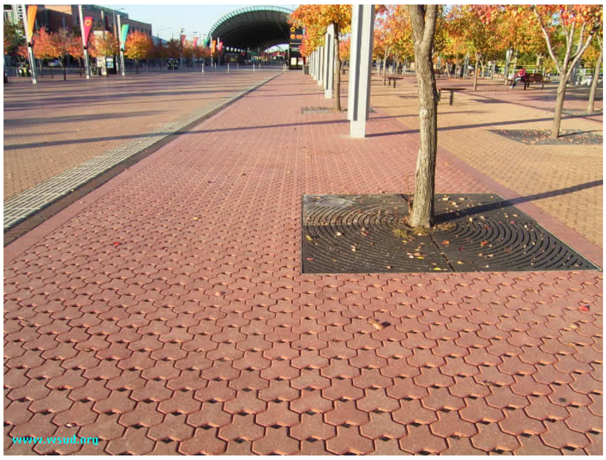

Figure 11: (Top left) Grassed infiltration area (Source: Water Sensitive Urban Design of the Sydney Region)

Figure 12: (Top right) Example of porous pavement (Source: Water Sensitive Urban Design of the Sydney Region)

Figure 13: Infiltration trench and rain garden surrounding car parks (Source: Water Sensitive Urban Design of the Sydney Region)

Figure 14: Infiltration trenches surrounding car parks prior to (left) and after (right) vegetation establishment (Source: Water Sensitive Urban Design of the Sydney Region)

8 WSUD PRINCIPLES FOR SUBDIVISION ROAD AND LOT LAYOUT DESIGN

1. The general WSUD principles for subdivision road design and lot layout include:

   (a) The subdivision layout should promote the retention of existing landforms with cut and fill land re-shaping works being minimised, wherever possible.

   (b) The retention of natural watercourses and drainage lines is recommended, wherever practicable.

   (c) The layout of roads in a subdivision should be designed to fit the existing topography and landform features of the site.

   (d) The road layout pattern should minimise road lengths running perpendicular to the slope of the site, in order to reduce run-off velocities.

   (e) Road design should take into account the cleansing of stormwater through the use of grass swales, filter (buffer) strips, infiltration trenches etc.

   (f) Road carriageways are required to be designed to minimise the amount of impermeable area through reduced road carriageway widths and / or porous pavements, in order to encourage infiltration of stormwater run-off into the soil strata.

   (g) Any trunk drainage design should be based on a system of natural watercourses and designed to mimic natural conditions and in particular natural flows.

   (h) The retention of the natural alignment and profile of watercourses, wherever possible.

   (i) Water and stormwater quality improvement devices (SQIDs) such as detention basins, constructed wetlands, gross pollutant traps (GPTs), litter traps and sedimentation ponds should be designed as off-line systems, in order to maintain the physical integiry and aesthetics of the natural watercourse.

   (k) Any stormwater outlets and discharge points are to be provided with energy dissipation devices, in order to minimise any potential scouring or erosion problems.

   (l) The replanting of indigenous vegetation within the subdivision, including any watercourse is recommended.

2. All proposed WSUD treatment measures are to be considered upfront in the planning process and are to be incorporated into the proposed subdivision plan for the site at the time of lodgement of the Development Application. This is necessary to ensure all relevant WSUD treatment options are considered upfront for water quality and quantity objectives.

9 STORMWATER QUALITY PERFORMANCE TARGETS

9.1 Development Control

1. The following minimum stormwater quality performance targets (prescribed in Table 2 below) are required to be achieved in the required WSUD strategy for the development:

Table 2: WSUD Stormwater Quality Performance Targets

Performance target reduction loads*	Development Type	
	Residential Subdivisions greater than 20 lots **Industrial Subdivision** **Business Parks**	**Multi-dwelling housing development** **Residential Flat Buildings** **Mixed Use Developments** **Minor Residential subdivisions (up to 20 lots)** **Commercial Office Development** **Industrial Development**
Gross Pollutants	90%	90%
Total Suspended Solids	85%	80%
Total Phosphorus	60%	55%
Total Nitrogen	45%	40%

* Reduction in loads are relative to the pollution generated from the development without treatment

Note: The stormwater quality performance targets set in Table 1 may be adjusted by Council, at its discretion, as part of the WSUD Strategy development. This is particularly applicable to developments located in sensitive catchments (e.g. Lake Illawarra catchment and the Hacking River upper catchment). Further, Council may require proponents to add other analytes and related performance criteria to WSUD Strategies for specific developments (eg. Development upon land affected by soil strata or groundwater contamination).

10 PRE-LODGEMENT CONSULTATION OF PROPOSED WSUD STRATEGY

1. Pre-lodgement discussions with Council are highly recommended at an early stage in the application process to discuss and agree on the overall design approach before a detailed WSUD Strategy is completed.

2. The aim of the consultation process is to provide direction and guidelines to the applicant and to provide advice on Council's requirements.

3. The level of consultation required will largely depend on the size and the complexity of the development.

4. Where WSUD assets are proposed to be ultimately handed over to Council following the completion of the subdivision or development, a formal pre-lodgement meeting with Council staff is required to consider the draft WSUD strategy. The pre-lodgement meeting will enable Council staff to be fully briefed of the proposed WSUD strategy treatment measures by the applicant's consultant(s) and enable Council staff to provide specific advice on the parameters to be included in the final WSUD strategy, especially as to the performance and maintenance requirements for any WSUD assets proposed to be dedicated / handed over to Council.

5. In cases where a pre-lodgement meeting is not held upfront on a proposed WSUD Strategy or the parameters determined by Council are not met in the WSUD Strategy, Council may either require a major redesign of the WSUD Strategy at the Development Application stage or may decline to accept the dedication of the WSUD asset to Council.

11 PREPARATION OF WSUD STRATEGY

11.1 General

1. The preparation of the WSUD Strategy must be undertaken by a suitably qualified and experienced consultant and must take into account any Council requirements discussed at a formal pre-lodgement meeting with Council.

2. The preparation of the WSUD Strategy will require baseline and construction phase water quality monitoring and / or suitable computer simulation modelling of stormwater quality and peak stormwater flow discharges upfront.

3. The WSUD Strategy should define the specific stormwater treatment and management measures for both the construction and operational phases of the development.

4. The WSUD Strategy shall also provide comprehensive details of proposed WSUD measures to be incorporated into the proposed development.

5. The stormwater quality objectives for each development must provide specific information on both the temporary and permanent measures to be used in order to ensure the quantity of pollutants and the peak discharge flow rates from the site will meet the 'no net' increase objective, where applicable. The objectives should also include details on the stormwater control measures proposed for both the construction and operational phases of the development.

6. All WSUD elements should not contribute to any increased flooding risk and must be designed to take into account the requirements of the Stormwater Management and Floodplain Management chapters contained in Part B to this DCP.

7. The WSUD Strategy is to be submitted with the Development Application.

11.2 Key Issues / Chapters to be included in a WSUD Strategy

1. The WSUD Strategy shall include (but is not necessarily limited to) the following information:

   (a) *Background information* **-** Summarise any background information available, including previous studies, concurrent studies, mapping data.

   (b) *Site context* – identify catchments, drainage lines and receiving environments (both within and downstream of the site). Characterise the ecological values of the site and its receiving environments.

   (c) *Proposed development* **-** Describe the proposed development at the site, including site boundaries, proposed land uses, densities, population, infrastructure, development staging.

   (d) *WSUD objectives* **-** Identify the WSUD objectives and targets that apply to the proposed development. Objectives should give consideration not only to water quality and water flow objectives, but should also consider the following;

      (i) Ease of maintenance.

(ii) Performance monitoring (i.e. designing inlets and outlets so that monitoring equipment can be easily fitted and so that reliable data can be collected).

(iii) Large rainfall/storm event fail safes that not only protect nearby private and public assets, but also protect the WSUD infrastructure (e.g. bypasses for constructed wetlands rather than spillways).

(iv) Aesthetics (i.e. integration into urban environment such that it does not detract but improves the visual quality of the development).

(v) Provision of habitat for local native plant and animal species.

(vi) Non potable water re-use opportunities.

(e) *Constraints and opportunities* **-** Identify the key constraints and opportunities for water management on the site, including flooding. This should include the identification of natural watercourses and other sensitive environments within the site that should be preserved and/or remediated by the development.

(f) *WSUD Measures* – identify the WSUD Infrastructure to be installed and constructed to meet the WSUD objectives (conceptual plans are sufficient at the Development Application stage. However, future detailed designs at the Construction Certificate stage must ensure that the objectives and performance parameters for the WSUD asset are met.

(g) *Best planning practice* **–** the capital and life-cycle costs of infrastructure required to meet WSUD targets can be minimised by considering site planning opportunities early in the planning process.

(h) *Water conservation* **-** This section should demonstrate how the potable water conservation targets will be met, and how potable water will be supplemented with roofwater, treated stormwater and/or wastewater.

(i) *Stormwater management* **-** This section is to demonstrate how the WSUD stormwater quality targets will be met. It is to include stormwater quality and flow modeling results and identify the location, size and configuration of stormwater treatment measures proposed for the development. This section must also detail a methodology for validating the performance of the WSUD relative to the objectives identified in this WSUD Strategy.

(j) *Integration with the urban design* - The WSUD Strategy should outline how WSUD elements will integrate with the urban design.

(k) *Costs* - Prepare capital and operation and maintenance cost estimates of proposed water cycle management measures. Both typical annual maintenance costs and corrective maintenance or renewal/adaptation costs should be included.

(l) *Operation and Maintenance Plan* – should outline inspection and maintenance requirements to ensure proposed measures remain effective. The Operation and Maintenance Plan should account for, as a minimum, the following;

(i) Litter accumulation management,

(ii) Sedimentation management,

(iii) Structural condition (this will depend on the type of WSUD infrastructure in question, but should included where applicable pits, pipes, ramps, erosion, bank integrity, etc),

(iv) Evidence of dumping,

(v) Maintaining functional and landscape vegetation to a satisfactory condition (including weed control),

(vi) Settling or erosion of bunds/batters,

(vii) Damage, including vandalism, to structures,

(viii) Inlets and outlets management to ensure flows,

(ix) Maintenance drain operational (check).

11.3 Modeling Tools for determining the size and configuration of WSUD Treatment Measures

1. Suitable modeling tools must be used to determine the size and configuration of WSUD treatment elements required to meet applicable WSUD targets.

2. The Cooperative Research Centre for Catchment Hydrology has developed the Model for Urban Stormwater Improvement Conceptualisation *25 or MUSIC stormwater management evaluation software package. This software package is a planning and decision support system which deals with the performance of stormwater treatment measures into an easily used tool. MUSIC is designed to operate at a range of temporal and spatial scales, so it is suitable for modelling stormwater quality treatment systems for individual lots up to regional scales.

   Importantly, MUSIC allows a first estimate on expected pollutant load from catchments following development in the absence of stormwater treatment initiatives, setting a baseline. From this figure, alternative stormwater treatment strategies can be compared, for compliance to state and local government stormwater quality objectives.

   The MUSIC model is the most widely used model in Australia. As with all such models, however, the accuracy of the model predictions is based on the validity of the inputs to the model. Therefore MUSIC modeling must be undertaken in accordance with the recommendations contained in the MUSIC Modeling Guidelines for NSW (available at www.toolkit.net.au), unless alternative modeling parameters are justified on the basis of local studies.

   Therefore, Council highly recommends that applicants employ the services of appropriately qualified and experienced practitioner(s) for the development of appropriate WSUD Strategy and associated modeling.

12 POST DEVELOPMENT CONSENT PHASE

12.1 Construction Phase – Inspection of WSUD Assets

1. The developer must permit adequate access for the accredited certifier(s) access during the construction of WSUD measures (as required) and prior to filling to check the general locations and sizing of associated piping, protection systems (e.g. overflows, backflow, first flush), storage, and any other hidden elements.

2. Connection to Council’s pipelines and underground infrastructure shall be inspected by a Council inspector.

3. Works for Council owned infrastructure or infrastructure that will revert to Council ownership shall be inspected by a Council inspector, prior to pipe backfilling and following surface restoration.

4. Final inspection shall be carried out by the accredited certifier, prior to issuing the relevant Compliance Certificate and shall include checking that:

   (a) Pits, pipes, basins, filtration systems etc are clean and are free draining,

   (b) Where filtration systems are present (e.g. permeable pavement, biofiltration measures), infiltration rates are within 10% of the design parameters and that filtration medium are not clogged and are free from detritus.

   (c) Orifices are secure and correctly sized and located.

   (d) All design details are according to plan.

   (e) Any required warning signs are installed with the correct information.

12.2 Monitoring and Validation of WSUD Measures

1. The purpose of validating WSUD measures is to ensure that the measures implemented are achieving their design objectives as per the WSUD Strategy. As a minimum, validation must involve the following:

   (a) The performance of a WSUD measure must be validated by measuring the load reduction performance of the measure. This will necessarily require the monitoring of inflow water immediately prior to entry into the WSUD measure (i.e. at the inlet) and at the point of final discharge into receiving waters (i.e. at the outlet).

   (b) As a minimum, load reduction needs to be determined for suspended solids, total phosphorus and total dissolved nitrogen.

   (c) In cases where land has been identified as containing soil strata or groundwater contamination, the contamination must also be appropriately monitored and load reductions determined, in order to ensure the design criteria identified for the contaminant is being met, as per the approved WSUD Strategy.

   (d) Water quality monitoring must continue for at least 12 months (ie with at least 80% of the proposed development within the treatment catchment of the WSUD measure being complete).

   (e) All water quality data generated by the monitoring of WSUD measures must be subjected to statistical regression analysis and monitoring reports. This must include all laboratory certificates and chain of custody forms.

   (f) All water quality analysis must be undertaken by a NATA accredited and registered laboratory.

2. Council may add or remove items from this list in consultation with proponents for specific development should local conditions, the nature of the development, or particular WSUD measures require it. This will be done at the DA stage, and will need to be identified in the WSUD Strategy for the development concerned.

3. If monitoring results indicate that the system is not performing according to the performance targets set in the WSUD Strategy for the development, Council reserves the right to not accept ownership of the WSUD measure concerned. In such circumstances, the WSUD measure will remain under the ownership and responsibility of the proponent until such time as performance targets can be adequately met.

4. It is highly recommended that a qualified consultant be engaged by the proponent to undertake the validation of WSUD measures.

5. It is recommended that proponents meet with Council shortly after monitoring has begun (e.g. after the first measurable rain event) to ensure monitoring methods are consistent with Council requirements, and that the correct analytes are being monitored. This will help to ensure the validation process is completed in a timely and cost-effective manner.

12.3 Works as Executed (WAE) Drawings & Compliance Certificates

1. Works as executed drawings are required for all WSUD measures. Such drawings must include storage capacities and finished and invert levels of the constructed system. Where built systems vary significantly from approved design plans, a suitably qualified engineer shall certify that the constructed system satisfies Council's requirements and shall submit all supporting calculations leading to this assertion.

2. All works as executed drawings must be submitted as per Wollongong City Council's most recent issue Design and Technical Services Drafting Standards (Ref 513).

3. A Certification of WSUD Compliance shall be prepared and certified by the original design consultant in conjunction with the works as executed drawings and the final inspection prior to refund of any security deposits. The Compliance Certificate shall include:

   (a) Certification that the built management measures will function in accordance with the approved design.

   (b) Identification of any variation from the approved design and their impact on performance.

   (c) Certifications that all waste water, rainwater and stormwater re-use systems comply with relevant legislation and guidelines.

12.4 Handover of WSUD Assets

1. This section applies to developments where WSUD measures will ultimately be handed over to Council. In this regard, Council will not consider accepting ownership of any WSUD measures unless all of the following conditions are met:

   (a) The WSUD assets / measures are constructed and operate in accordance with the approved design specifications / parameters and any other specific design agreements previously entered into with Council.

   (b) The performance of the WSUD measure(s) has been validated, which must include the provision of a Performance Validation Report supporting the performance of the WSUD measure.

   (c) Where applicable, the build up of sediment has resulted in no more than a 10% reduction of operational volume (e.g. of the pond, settling basin, constructed wetland).

   (d) Asset inspections for defects has been completed and, if any defects are found, rectified to the satisfaction of Council.

   (e) The WSUD infrastructure is to the satisfaction of Council, structurally and geotechnically sound (this will require the submission of documents demonstrating that such infrastructure has been certified by suitably qualified persons).

   (f) Design drawings have been supplied in a format acceptable to Council.

(g) Works as Executed (WAE) drawings have been supplied for all infrastructure in a format and level of accuracy acceptable to Council.

(h) Other relevant digital files have been provided (e.g. design drawings, surveys, bathymetry, models etc).

(i) Landscape designs have been supplied, particularly those detailing the distribution of functional vegetation, i.e. vegetation that plays a role in water quality improvement (clearance certificates from the landscape architect will need to be supplied).

(j) The condition of the infrastructure and associated land is generally to the satisfaction of Council (this includes well maintained open space, boardworks, viewing platforms, etc).

(k) Where applicable, filter media infiltration rates are within 10% of the rates of the design parameters for the filtration system concerned (e.g. bio-retention system, permeable pavement).

(l) Comprehensive operation and maintenance manuals (including indicative costs) have been provided.

(m) Inspection and maintenance forms provided.

(n) Vegetation establishment period successfully complete (2 years unless otherwise approved by Council).

(o) Copies of all required permits (both construction and operational) have been submitted.

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