PENRITH CITY COUNCIL

WSUD TECHNICAL GUIDELINES

Version 3 – June 2015

PENRITH
CITY COUNCIL

Contents

1. PURPOSE OF WSUD TECHNICAL GUIDELINES

These Guidelines must be used to prepare and submit supporting information for Development Applications and Construction Certificates. They are an adaptation of the Draft NSW MUSIC Modelling Guidelines and should be read in conjunction with the latest version of the MUSIC User Guide.

The Guidelines should also be read in conjunction with a number of other industry best practice guidelines documents including:

- Draft NSW Music Modelling Guidelines (prepared for the Sydney Metropolitan CMA)
- WSUD Conceptual Design Information (prepared by Water by Design)
- WSUD Technical Design Guidelines (prepared by Water by Design)
- Typical Drawings (prepared for the Sydney Metropolitan CMA)

The Guidelines provide guidance on the following:

- Council's requirements for the location, ownership and ongoing maintenance responsibilities of WSUD measures
- What is to be submitted with a Development Application or Construction Certificate application
- What is required to be included in a WSUD Strategy
- Parameters to be used in MUSIC modelling
- Where to get further information on the design, construction, operation and maintenance of stormwater treatment measures
- Council's expectations in relation to proposed WSUD measures, and
- Provides Deemed to Comply solutions for smaller scale residential, commercial and industrial developments.

The WSUD Technical Guidelines will be periodically reviewed and updated to reflect changes in industry best practice.

2. COUNCIL APPROVAL REQUIREMENTS FOR WSUD SYSTEMS

2.1. General Requirements

When preparing supporting documentation for a Development Application or Construction Certificate application, Council requires applicants and developers to engage appropriately qualified and experienced practitioners for the development of appropriate WSUD designs and strategies.

2.1.1. Pre-Application Consultation

Discussion with Council is encouraged at an early stage of a development proposal to agree on a general design approach before a detailed WSUD Strategy is prepared.

2.2. Deemed to Comply Provisions

To simplify the approval process a number of Deemed to Comply solutions for some developments sized less than 5,000m^2 have been developed. These solutions provide a means to comply with the WSUD requirements without the need to provide supporting information including MUSIC Modelling. The deemed to comply solutions apply to a range of development types including:

- Multiunit housing
- Industrial developments, and
- Commercial developments

In order to use the deemed to comply solution, applicants are required to adopt predefined treatment measures including a raingarden and rainwater tanks. The sizing of the raingarden is dependent on a number of parameters including percentage of bypass, depth of extended detention and whether a rainwater tank is connected to internal plumbing.

Full details on how to apply the deemed to comply options is included in Council WSUD Deemed to Comply Toolkit available in **Addendum 1**. The information includes a number of design checklists, standard drawings, a sample operation and maintenance plan as well as a series of case studies.

In cases where a proponent elects **not** to utilise the deemed to comply provisions, then the information outlined in Section 2.3 is to be provided in support of a development application.

2.3. Information at Development Application Stage

Development Applications that are required to meet the water conservation targets only are to document within their Development Application how the potable water conservation targets will be met. This can be through a BASIX Certificate for residential dwellings or a certificate of water appliances and fittings within the DA submitted.

Development types that are required to meet water conservation, stormwater quality and quantity targets must submit a Water Sensitive Urban Design Strategy with a development application. A Water Sensitive Urban Design Strategy is a written report detailing potable water savings and stormwater quality and quantity control measures to be implemented as part of a development. The strategy is to include the following detail:

- **Proposed development –** Describe the proposed development at the site, including site boundaries and proposed land uses.
- **WSUD objectives –** Identify the WSUD objectives that apply to the proposed development.
- **Water conservation –** document how the potable water conservation targets will be met. For residential developments this maybe in the form of a BASIX Certificate.
- **Stormwater quality –** demonstrate how the stormwater quality targets will be met. It should include stormwater quality modelling results and identify the location, size and configuration of stormwater treatment measures proposed for the development.
- **Stormwater quantity -** demonstrate how the stormwater quantity targets will be met. It should include modelling results and identify the location, size and configuration of measures proposed for the development.
- **Details of MUSIC Modelling** (or equivalent) **–** Modelling parameters to determine the size and configuration of WSUD elements must be undertaken in MUSIC (or equivalent) and use the parameters included in Section 4 of this document.
- **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.
- **Draft Operation and Maintenance plan –** An indicative list of inclusions in the maintenance plan is included in Checklist provided in Section 7 of this document
- **Checklist** – outlining the details of the WSUD Strategy and reference of the information source.

Development that needs to consider on-site detention are to refer to Council's *Engineering Specifications* and *Stormwater Drainage for Building Developments* documents.

2.4. Information to be provided at Construction Certificate Stage

Council may impose a consent condition requiring the submission of full details of WSUD treatment systems for Councils review prior to the issue of a Construction Certificate.

The following information must be provided with a Construction Certificate application:

- Detailed construction plans including all calculations, drawings and designs which are consistent with the design parameters used in the modelling and approved concept designs from the Development Application.
- An Erosion and Sedimentation Control Plan.
- An Operation and Maintenance Plan (OMP) outlining how operation and maintenance issues have been appropriately considered in the development of the WSUD Strategy. A Draft OMP should be provided with the Development Application and include details on the following:
    a) Site description (area, imperviousness, land use, annual rainfall, topography etc)
    b) Site access description
    c) Likely pollutant types, sources and estimated loads

d) Locations, types and descriptions of measures proposed

e) Operation and maintenance responsibility (council, developer or owner)

f) Inspection methods

g) Maintenance methods (frequency, equipment and personnel requirements);

h) Landscape and weed control requirements

i) Operation and maintenance costs;

j) Waste management and disposal options; and

k) Reporting.

- Completed Construction Certificate Checklist

2.5. Works as Executed (WAE) Drawings & Compliance Certificates

The Principal Certifying Authority must not issue an Occupation Certificate unless Works as Executed (WAE) plans have been prepared and the constructed WSUD system has been completed in accordance with the approved Construction Certificate drawings and conditions of development consent, as per Council's *Engineering Specifications* and *Councils Stormwater Drainage for Building Developments* documents.

2.6. Positive Covenant and Restriction of Use on WSUD elements

To ensure on-going future maintenance of WSUD elements applicants may be required to create a "Positive Covenant" and "Restriction on the Use of Land" under Section 88B of the *Conveyancing Act* 1919, burdening the property with the requirement to maintain the WSUD elements. The following is an example of possible restrictions:

Restriction

The proprietor of the burdened lot shall not:

(1) Erect, construct or place any building or other structure,

(2) Make alterations to the ground surface levels, grates, pipes, pits, kerbs, tanks, gutters, WSUD measure or any other structure associated with the water quality control system,

Within the land so burdened without the prior written consent of Penrith City Council

Positive Covenant

(1) The proprietor of the burdened lot from time to time shall do all things necessary to maintain, repair and replace the grates, pipes, pits, kerbs, tanks, gutters, WSUD measure or any other structures of and incidental to the water quality control system within the land so burdened to the satisfaction of Penrith City Council and in this regard must also comply with any reasonable written request of the Council within such time period nominated.

(2) Where the proprietor of the burdened lots fails to comply with any written request of the Penrith City Council referred to in (1) above the proprietor shall meet any reasonable cost incurred by the Council in completing the work

(3) Full and free right for the Penrith City Council and every person authorised by it to enter upon the burdened lot in order to inspect, maintain, cleanse, replace, repair any grates, pipes, pits, kerbs, tanks, gutters WSUD measures or any other structure or alter surface levels to ensure the on-site detention system within the land so burdened functions in accordance with the approved Construction Certificate (Council Reference: DA /).

Note: Penrith City Council must be nominated as the authority to vary or modify the above restrictions and positive covenants.

2.7. Handover of WSUD Assets to Council

Council's prefers WSUD measures to be located on private land under the maintenance of the owner or occupier. If there is a need to hand assets over to Council, arrangements will be made prior to the approval of a Development Application. In this regard, Council will not consider accepting ownership of any WSUD measures unless all of the following conditions are met:

(1) The proponent must have a Development Application pre-lodgement meeting with Council Officers to discuss Council's requirements of the proposed development

(2) 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

(3) 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

(4) 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)

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

(6) 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)

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

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

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

(10) 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)

(11) The condition of the infrastructure and associated with the land complies with the approved design specification.

(12) 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)

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

(14) Inspection and maintenance forms provided

(15) Vegetation establishment period successfully complete (3 years unless otherwise approved by Council)

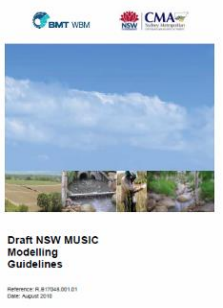
(16) Copies of all required permits (both construction and operational) have been submitted.

3. GENERAL INFORMATION ON WSUD STRATEGY PREPARATION

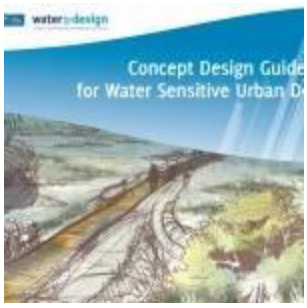
The following information should be referred to when developing a WSUD Strategy.

1. MUSIC Model – MUSIC, the Model for Urban Stormwater Improvement Conceptualisation, derives default water quality parameters for a range of pollutants generated from various land use types. As presented in Australian Runoff Quality (Engineers Australia)[1] most verified and published Australian water quality research has been synthesised into MUSIC. The latest version of MUSIC is Version 6 (2013), and is available at eWater. The MUSIC model includes a modelling guideline which should be referred to when using the MUSIC software. Parameters for the MUSIC model in Penrith are outlined in Section 4 of this document.

2. MUSIC Modelling guide – the development of a MUSIC model requires specific inputs and parameters. For proposed developments in the Penrith Council LGA key parameters for undertaking any MUSIC modelling are outlined in Section 6 of this document. Further information on MUSIC modelling is available in the *Draft NSW MUSIC Modelling Guideline*. See http://www.wsud.org/resources-examples/tools-resources/tools/draft-music-modelling-guidelines-31-08-201011/



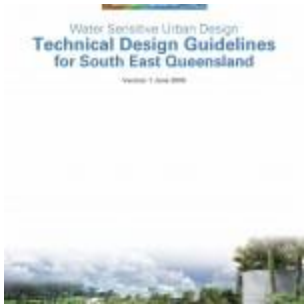
3. WSUD Conceptual Design Information – information on specific WSUD elements (such as rainwater tanks, bioretention and wetlands) and where they are appropriate is available in the South East Queensland's (SEQ) 'Water by Design' Program's Concept Design Guidelines for WSUD. This document provides an industry standard and seeks to assist multi-disciplinary teams conceptualise and develop design solutions that integrate best practice sustainable urban water management within the urban form. A Sydney based guide has been produced that replaces Queensland references with Sydney specific alternatives available. See http://www.wsud.org/resources-examples/tools-resources/reference-guidelines/wsud-reference-guidelines/



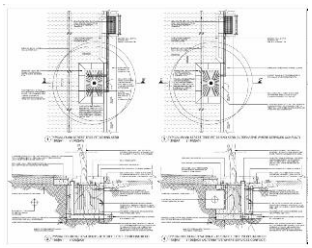
The following resources outline further information which can be used by proponents when developing detailed design / construction drawings and undertaking construction.

[1] Engineers Australia (2006), Australian Runoff Quality, Melbourne, Australia.

4. Technical Design Manual – the 'Water by Design' Program's WSUD Technical Design Guidelines for South East Queensland describe appropriate methods for the detailed design of some common structural stormwater management measures.



5. Typical Drawings – the Sydney Metropolitan CMA has released typical drawings for a series of WSUD elements, including bioretention systems at steep or flat sites, in footpaths or roadways. See http://www.wsud.org/resources-examples/tools-resources/typical-drawings/



Standard Drawings have also been incorporated in Council's WSUD Deemed to Comply Toolkit

6. Construction and Establishment for Swales, Bioretention Systems and Wetlands – the South East Queensland 'Water by Design' Program has produced Construction and Establishment Guidelines, providing guidance on common construction and establishment issues associated with the delivery of vegetated WSUD elements, assisting practitioners to avoid common faults and potential failure at the delivery and design stage. A Sydney based guide has been produced that replaces Queensland references with Sydney specific alternatives available. See http://www.wsud.org/resources-examples/tools-resources/reference-guidelines/wsud-reference-guidelines/

7. Various Public Health Requirements / Guidelines.
   All WSUD treatment measures must be designed and constructed with consideration of the Public Health Act.

   http://www.health.nsw.gov.au/PublicHealth/environment/water/wastewater.asp
   http://www.health.vic.gov.au/legionella/coolingtower/coolingtower.htm
   http://www.basix.nsw.gov.au/basixcms/basix-help-notes/water/central-systems/central-cooling.html

Table 1: Contents of a WSUD Strategy, and tools and resources available

Outline contents	Details to be provided in the WSUD Strategy	Supporting Information
Proposed Development	Summarise any background information available on the site, including previous studies, a description of the existing site conditions and details of the development – layout, size, catchments, topography, landuse, roof areas, etc.	*Proponent's development layout*
WSUD Objectives	This section should identify the WSUD objectives which apply to the development including water conservation and stormwater quality objectives.	*Penrith WSUD Policy (Section 3)*
Water Conservation	Identify how water saving fittings fixtures and appliances would be integrated into the development to meet the water conservation targets. Water balance modelling (for harvesting and reuse systems) should include: • Water demands • Other parameters and assumptions Refer to Section 4.5 for estimating the use and for modelling requirements.	
Stormwater Quality Demonstrate how the stormwater quality targets will be met. Including: • stormwater quality (MUSIC) modelling results • identify the location, size and configuration of stormwater treatment measures proposed for the development.	Establish a stormwater quality (MUSIC) model for the proposed development to predict expected stormwater pollutant loads generated from development and to develop a strategy to achieve the stormwater quality targets. The information submitted with the WSUD Strategy should include: • Location, size and configuration of stormwater treatment elements. • Details of MUSIC modelling, with the MUSIC parameters and assumptions outlined in an appendix to the WSUD Strategy. Parameters to be reported include rainfall (rain station, time step and years of rainfall) and evapotranspiration, source nodes (catchment areas, impervious fractions, soil parameters and pollutant mean and standard deviation values), and treatment nodes, with the following parameters reported: a) bioretention systems - hydraulic conductivity, extended detention depth and filter depth b) ponds and wetlands - inlet pond size, permanent pool depth, extended detention depth and notional detention time	*MUSIC modelling software* *Standard MUSIC parameters for Penrith (Section 4 of this document)* *NSW MUSIC Modelling Guide*

Outline contents	Details to be provided in the WSUD Strategy	Supporting Information
	c) swales - slope and vegetation heights • Any variation from the recommended MUSIC parameters must be reported and justified.	
Stormwater Quantity – Stream Forming Flows will be met	When determining Stream Erosion Index (SEI) Council requires the use of the methodology in the Draft NSW MUSIC Modelling Guide (Aug 2010) that is adapted from Blackham and G. Wettenhall (2010). • Parameters to be reported include: a) rainfall (rain station, time step and years of rainfall) and evapotranspiration b) source nodes (catchment areas, impervious fractions, soil parameters and pollutant mean and standard deviation values), c) generic nodes to transform modelled flows below the stream forming flow threshold of interest (i.e. 50% of 2yr ARI natural flows) to zero. The Generic Treatment Node should be configured the same for the natural and developed (with measures) models d) flood frequency analysis • Provide all calculations • Details of MUSIC modelling, with the MUSIC parameters and assumptions outlined in an appendix to the WSUD Strategy.	*Modelling Stream forming flows NSW MUSIC Modelling Guide*
Cost and Maintenance 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. Develop a maintenance plan. An indicative list of inclusions in the maintenance plan is included in Checklists provided in Section 7 of this document.	*Concept Design Guidelines for WSUD (external link Section 1.1)*
Checklist	Checklist of the WSUD aspects of the development	*Penrith WSUD Policy (Section 7)*

4. MUSIC MODELLING PARAMETERS FOR PENRITH

This section provides guidance on modelling parameters to be used when modelling WSUD elements in MUSIC. These guidelines are provided to ensure consultants, developers and Council have a consistent and uniform approach to stormwater quality and harvesting modelling within the City of Penrith.

The parameters must be used when developing a WSUD Strategy to meet the targets outlined in Penrith WSUD Policy. Further information on MUSIC Modelling is available in the *Draft NSW MUSIC Modelling Guideline*. The information is an adaption of the Draft NSW MUSIC Modelling Guideline and should be read in conjunction with the eWater MUSIC User Guide which is provided with the MUSIC software.

This guideline provides specific guidance on rainfall and evaporation inputs, source node parameters, rainfall runoff parameters, pollutant generation parameters and stormwater treatment nodes. Any MUSIC models that are not consistent with this guideline must justify the differences in parameters and/or assessment methods.

Using MUSIC-*link* to develop MUSIC models

In order to improve the development assessment process with regards to Water Sensitive Urban Design, Council is working with eWater to simplify the process of developing Stormwater Treatment Strategies. The use of **MUSIC-*link*** can simplify the development and assessment of MUSIC models.

As such, Council encourages proponents to utilise the **MUSIC-*link*** function when preparing MUSIC models for proposed developments within the City of Penrith.

The main benefit of **MUSIC-*link*** is that developers and consultants can design their stormwater management infrastructure and then immediately validate it (within the software) to ensure that parameters fall within the limits of Penrith City Council's requirements. On receiving a submitted design and related validation report, our Development Assessment team can immediately check for compliance with our standards.

MUSIC-*link* streamlines the process of achieving a match between the Penrith City Council's specific guidelines and urban developer's water sensitive designs. MUSIC-link allows Penrith City Council to:

- Apply a simple, robust and quicker process of WSUD assessment, helped by the compliance report that **MUSIC-*link*** provides with designs,
- Communicate clearly and directly with developers and designers, providing locally specific WSUD requirements and modelling parameters, and
- Provide increased levels of redundancy for model assessment.

In summary, the use of **MUSIC-*link*** allows a MUSIC model to be prepared using Council's preferred parameters, allowing a more streamlined assessment process. The tool also allows proponents / consultant to assess models against Council's requirements before the lodgement of a DA. As such, the use of the tool is encouraged by Council.

Instructions for the Use of MUSIC-*link*

The instructions for the use of **MUSIC-*link*** are available at the following link.
http://www.toolkit.net.au/Dropbox/music/metadata/AuthorityData/Penrith%20City%20Council/PenrithCityCouncil-UsingMUSIC-link.pdf

4.1. Rainfall & evaporation inputs

The rainfall data recommended for MUSIC modelling for Penrith is shown in Table 2. Pluviograph data from Station 67113 Penrith Lakes AWS shall be utilised for MUSIC modelling in the Penrith LGA. Data for the 1999 to 2008 period shall be adopted for MUSIC modelling. The data over this period is relatively complete with a mean annual rainfall of 712mm. Depending on the location of the development within the City an alternate rainfall data set may be used, however justification needs to be provided in the WSUD Strategy.

Table 2: Recommended Rainfall Data for MUSIC modelling

Purpose	Time step required	Rainfall Station	Modelling Period
Water quality	6 minutes	67113 Penrith Lakes AWS	1999 to 2008
Water quantity (including rainwater tanks, stormwater storages)	Daily	67113 Penrith Lakes AWS	1999 to 2008

Average Sydney potential evapotranspiration (PET) data is suitable for use in modelling water quality and hydrology. The monthly PET values for the Penrith area are shown in Table 3.

Table 3: Monthly Evapotranspiration for Penrith

Month	J	F	M	A	M	J	J	A	S	O	N	D
PET (mm)	159	122	115	77	50	39	41	57	81	122	142	152

4.2. Rainfall-Runoff Parameters

Default rainfall-runoff parameters for Penrith are shown in Table 4. The parameters must be adopted for all developments where the impervious percentage exceeds 10%.

Table 4: MUSIC Rainfall-Runoff Parameters for Penrith

Impervious Area Parameters	
Rainfall threshold (mm)	1.4mm
Pervious Area Parameters	
Soil Storage Capacity (mm)	105
Initial Storage (% of capacity)	30
Field Capacity (mm)	70
Infiltration Capacity Coefficient – a	150
Infiltration Capacity Exponent - b	3.5
Groundwater Properties	
Initial depth (mm)	10
Daily Recharge Rate (%)	25
Daily Baseflow Rate (%)	10
Daily Deep Seepage Rate (%)	0

In situations where the site being modelled has an impervious proportion less than 10% (e.g. undeveloped site), a model calibration exercise shall be undertaken to ensure that model predictions of total runoff, surface runoff and baseflow volumes are appropriate.

4.3. Pollutant Generation Parameters

The development of the MUSIC software included a comprehensive review of stormwater quality in urban catchments, which forms the basis for the default values of event mean concentrations for total suspended solids (TSS), total phosphorous (TP) and total nitrogen (TN).

Table 5 presents the recommended stormwater quality parameters for various land use categories in MUSIC. Note that for all simulations the MUSIC model must be run with pollutant export estimation method set to "stochastically generated" as opposed to the "mean" estimation method.

Table 5: Stormwater Quality Parameters for MUSIC Source Nodes

Land-use category		**Log10 TSS (mg/L)**		**Log10 TP (mg/L)**		**Log10 TN (mg/L)**	
		Storm Flow	**Base Flow**	**Storm Flow**	**Base Flow**	**Storm Flow**	**Base Flow**
General urban (incl. public open space)	Mean Std Dev	2.15 0.32	1.20 0.17	-0.60 0.25	-0.85 0.19	0.30 0.19	0.11 0.12
Residential							
Industrial							
Commercial							
Road Areas	Mean Std Dev	2.43 0.32	---* ---*	-0.30 0.25	---* ---*	0.34 0.19	---* ---*

Roof Areas	Mean Std Dev	1.30 0.32	---* ---*	-0.89 0.25	---* ---*	0.30 0.19	---* ---*

***** Base flows are only generated from pervious areas, therefore these parameters are not relevant to impervious areas

4.4. Treatment Node Inputs

To meet a site's stormwater quality objectives the development will need to incorporate an appropriate stormwater treatment process for the development, dependent on site constraints and opportunities.

The default parameters in MUSIC for the first order decay k-C* model used to define the treatment efficiency of each treatment device should be used unless local relevant treatment performance monitoring can be used as reasonable justification for modification of the default parameters. Reference should be made to the MUSIC User Manual.

Note: The following devices are not to be modelled within the MUSIC program: Natural waterways, Natural wetlands, Naturalised channel systems, Environmental buffers and Ornamental Lake/Pond systems.

4.5. Non-potable Reuse rates for Modelling Rainwater Tanks in MUSIC

The following rates are provided as a guide for MUSIC modelling purposes. **Residential development (excluding home units or multistorey dwellings)** allow for rainwater reuse per dwelling based on the area of lots as follows:

- Lots > 720 m^2 allow 0.14 kL/day internal use & 100 kL/year as PET- Rain
- Lots > 520 & < 720 m^2 allow 0.12 kL/day internal use & 75 kL/year as PET- Rain
- Lots > 320 & < 520 m^2 allow 0.10 kL/day internal use & 50 kL/year as PET- Rain
- Lots < 320 m^2 allow 0.08 kL/day internal use & 25 kL/year as PET- Rain NOTE: Consider each Villa and/or Townhouse dwelling as Lots < 320 m^2

Industrial and commercial developments, including schools, child-care centres, hotels/motels, hospitals, halls, sporting fields and aged care and places of worship (including not-for-profits), allow for rainwater reuse as follows:

For internal rainwater reuse, allow 0.1 KL/day per toilet, or urinal in industrial/commercial developments and generally ignore any disabled toilet. However where the site is only occupied say 6 days per week the daily usage rate is to be proportioned by 6 / 7. Similarly where there is an additional afternoon, or night shift using less staff, increase the rate proportionally.

Other internal usage may involve vehicle washing or other industrial usage and specific data will need to be supplied to justify these reuse rates.

For irrigation of landscaped areas only allow 0.4 kL/year/m^2 as PET-Rain for sprinkler systems and 0.3 kL/year/m^2 for subsurface irrigation. For bioretention filter areas only allow 0.4 kL/year/m^2 as PET-Rain (subsurface irrigation only). Higher rates may be required by the landscape architect for specific landscape requirements; however such rates will not be

accepted by Council in the MUSIC model. This does not stop the Landscape Architect increasing the rainwater tank size to cover such requirements.

In order to avoid any confusion relating to treatment node implementation Council provides the following advice for modelling stormwater quality treatment systems within the City of Penrith.

Table 6: Stormwater treatment parameters

Stormwater treatment measures	Selected key parameter values and design guidance
Bioretention systems (basins & swales) 	High flow bypass = generally 3-month ARI flow (to be calculated by consultant). Extended detention depth = 0.1-0.3 m (for basins) Saturated hydraulic conductivity = 125 mm/hr (maximum) Filter depth = 0.5-0.8 m TN content of filter media = 800mg/kg Orthophosphate content of filter media = 40mg/kg Exfiltration rate = 0 mm/hr Note that a submerged (saturated) zone requires a specially designed outlet pit configuration.
Gross pollutant traps 	High flow bypass for the device = 3-month ARI peak flow. Gross pollutant removal should be obtained for the specific GPT type proposed from the supplier – preferably independently verified. • TSS removal = 0 (unless a CDS-type system, when TSS removal can be up to 70% for inflow concentrations greater than 75 mg/L). • TP removal = 0 (unless a CDS-type system, when TP removal can be up to 30% for inflow concentrations greater than 0.5 mg/L). • TN removal = 0.
Wetlands 	High flow bypass = 1 year ARI flow (to be calculated by consultant). Inlet pond volume calculated using: • Inlet pond surface area = 10% of macrophyte zone (storage surface) area • Inlet pond depth = 2.0 m recommended • Extended detention depth = 0.25 - 0.75 m based on outlet design Notional detention time target = 72 hours.
Swales 	Bed slope = 1-5% Vegetation heights of 0.05-0.5 m are acceptable, however MUSIC assumes that swales are heavily vegetated when modelling their treatment performance. Mown grass swales should not be expected to provide significant stormwater treatment and should not be modelled in MUSIC.
Rainwater tanks 	Only roofs should be connected. Given constraints due to gutter and downpipe arrangement, typically a maximum of 50% of the total roof area can be connected to one tank. If using stored water for irrigation, insert annual irrigation demand (kL/yr) as per 'Water Right Tool' or provide other irrigation estimation details. For a daily demand (kL/day), refer to Section 4.5.

Stormwater treatment measures	Selected key parameter values and design guidance
Infiltration systems 	Infiltration measures encourage stormwater to infiltrate into surrounding soils. Infiltration measures are highly dependent on local soil characteristics and are best suited to sandy soils with deep groundwater. Infiltration is not recommended in areas of sodic or saline soils or soil contamination, where infiltration could mobilise salts or contaminants. Given the presence of clay throughout the LGA as well as significant areas of sodic and saline soils, infiltration will not be permitted in the Penrith LGA.
Water quality ponds (note there are separate procedures for modelling water storage ponds) 	Permanent pool = 1.0-2.0 m Extended detention depth = 0.25-1.0 m. Parameters within the MUSIC model assume that stormwater is pre-treated to remove coarse sediment upstream of the pond, therefore ponds should never be designed without pre-treatment (such as a swale or sedimentation basin).
Sedimentation basins 	Permanent pool volume based on 2 m depth (e.g. with a surface area of 50m^2 the PPV would be 100m^3) Extended detention depth = 0.25-1.0 m
Detention basins 	Refer to Council's 'Stormwater and On Site Detention Code (1999)' for details on OSD requirements (see Council's Stormwater Management for Building Developments).
Buffers 	Buffer strips are only applicable where runoff is distributed across the whole buffer strip and the buffer strip slope is ≤ 5%
Media filtration systems (e.g. sand filters) 	As per bioretention systems (without vegetation)
Generic 	For modelling a treatment device that is not a specific node within the program. This option should only be used if the user has sufficient data to model it effectively. Examples of applications include flow diversions, or sewer overflows.
ALL TREATMENT NODES	Seepage loss (exfiltration rate) should normally be zero. Evaporative loss should normally range from 75% of PET for completely open water to 125% of PET for heavily vegetated water bodies.
ALL "ADVANCED PROPERTIES" (k-C* values, orifice discharge and weir coefficients, void ratio, number of CSTR cells)	As per MUSIC default values

Any variance to the above parameters needs to be justified in the WSUD Strategy report.

4.6. Approved use of Proprietary Stormwater Treatment Devices

Council may consider approving the use of certain proprietary devices in place of bio-filtration measures, however prior to approval the following information must be provided for Council's consideration:

- The proposed reduction efficiencies need to be justified by rigorous scientific testing and results are published in a credible engineering/scientific journals
- Pollutant reduction parameters independently verified using a method to suit local or regional conditions (comparison between climate, pollutant concentrations and soluble pollutants)
- Information on the performance under dry weather flows (to account for potential pollutant leaching)
- Information on the assumed high-flow bypass rate and details about how it was determined, and
- The modelled pollutant reduction efficiency reflects the published figures.

5. DRAINAGE AND FLOODING CONSIDERATIONS

5.1. Drainage and On-site detention

The evaluation of hydrology to estimate peak design discharges for minor events is required for WSUD to assist with:

- the design of inlets and outlets for hydraulic control structures;
- sizing of WSUD measures that also have a flow conveyance function (e.g. vegetated swales); and
- evaluating hydrologic inputs to hydraulic models used to evaluate flood levels, flooding extents and other flooding characteristics

Interpretation of the drainage characteristics of a particular site is essential for locating, selecting and designing WSUD measures. An appropriate standard method for estimating the 5 year ARI flow shall be adopted for WSUD measures required to manage minor drainage flows.

For small developments/catchments the urban Rational Method approach outlined in Australian Rainfall and Runoff (ARR) (Engineers Australia, 2001) may be applied. For large developments/catchments, the event-based hydrology should be estimated using rainfall-runoff routing software.

On-Site Detention (OSD) is required in particular areas within the LGA and for particular development types. If Council's OSD requirements are relevant for the site, undertake OSD calculations and design in accordance with Council's OSD requirements.

For more information, refer to the latest version of Australian Rainfall & Runoff Guidelines, Penrith City Council's Stormwater Drainage for Building Developments Policy, Engineering Design Guidelines and Engineering Construction Specification for Civil Works (Working Draft).

5.2. Flooding

WSUD measures should be positioned outside the main stream flooding extents. Main stream flooding from constructed trunk drainage systems and watercourses should be assessed separately and guidance on completing that assessment is beyond the scope of these WSUD guidelines.

WSUD measures shall be designed to incorporate consideration of local overland flow flooding that exceeds the capacity of the minor drainage system (i.e. >5yr ARI). An acceptable approach to assessing local overland flow is outlined below.

- An appropriate standard method for estimating the local catchment 100 year ARI flow shall be adopted. For small developments/catchments the urban Rational Method approach outlined in Australian Rainfall and Runoff (ARR) (Engineers Australia, 2001) may be applied. For large developments/catchments, the event-based hydrology is best analysed using rainfall-runoff routing software.

- For WSUD measures located within the street, the measures shall be designed to convey the overland flow during a 100yr ARI event. The overland flow during a 100yr event is typically the difference between the 100yr ARI and 5yr ARI flow where a below-ground minor drainage system is provided. In situations where no below ground drainage system is provided, the overland flow would be the entire 100yr ARI flow. In addition to having sufficient capacity to convey the overland flow (in conjunction with the remaining road reserve), the WSUD measures shall be designed to reduce scouring potential.
- For a WSUD measure located at the downstream reaches of a sub-catchment or development designed primarily for water quality management, the measure shall be configured to divert flows in excess of the 50% of 1yr ARI flow around the measure. In circumstances where the measure is also being utilised to achieve stream erosion protection or detention objectives, the measure shall be designed with high flow outlets (e.g. weirs, spillways, culverts) to manage these infrequent flows.

6. BIORETENTION SYSTEMS AS WSUD TREATMENT

Bioretention systems are commonly used in many water sensitive cities within Australia to meet stormwater quality targets, and are further described in this section. Bioretention systems are vegetated soil media filters, which treat stormwater by allowing it to pond on the vegetated surface, then slowly infiltrate through the soil media. Treated water is captured at the base of the system and discharged via outlet pipes. A typical cross-section of a bioretention system is shown in Figure 1.

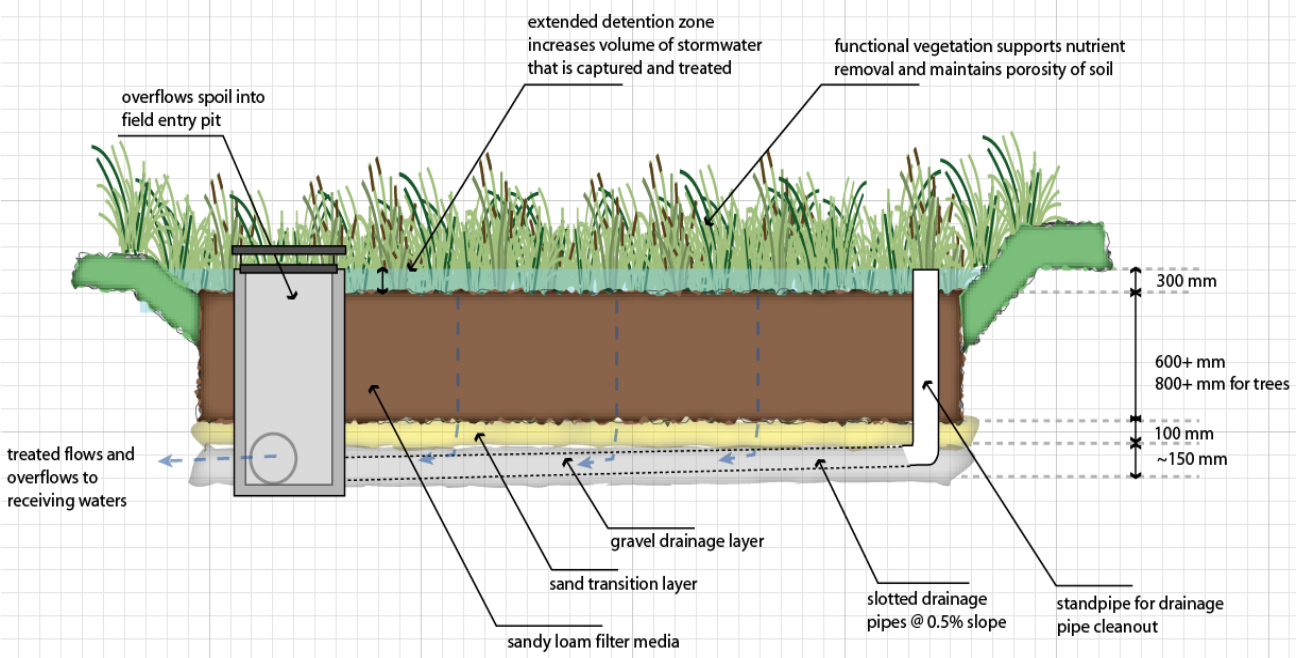


Figure 1: Bioretention system typical arrangement (Water by Design 2009)

Bioretention systems can be implemented in almost any size and shape, in many different locations including street trees in the footpath, or road or traffic calming devices within streetscapes. It is important to have sufficient depth (normally at least 0.8 m) between the inlet and outlet of a bioretention system, therefore they may not be suitable at sites with shallow bedrock or other depth constraints, however they are otherwise a very flexible and effective treatment measure for both suspended and dissolved pollutants.

Bioretention systems are able to meet the stormwater treatment targets identified in Council's WSUD Policy and are typically sized to have a filter area of approximately 1.5% of the catchment draining to the treatment element. This size will vary based on the imperviousness of the development and elements of the bioretention system such as extended detention depth and filter depth.

Street Trees

Street tree bioretention systems are small systems that are incorporated into street tree plantings. These systems can be integrated into high-density urban environments and can take on a variety of forms. The filter media should be at least 0.8 m deep to allow for root growth of the tree, therefore substantial depth is required between the inlet and outlet. Examples of street tree bioretention systems are shown in Figure 2.

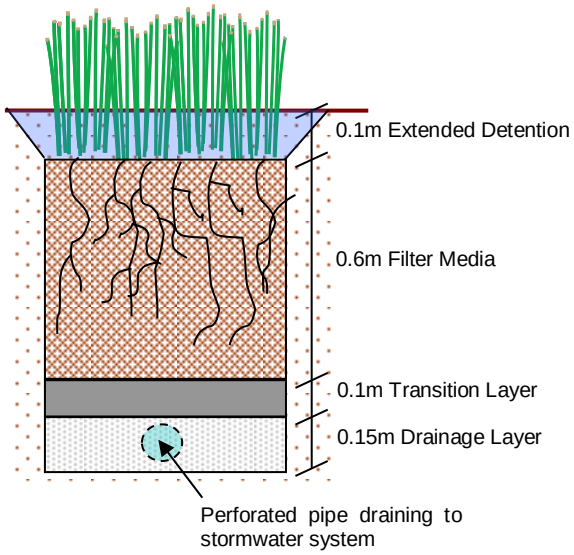
Bioretention Rain-gardens

Rain-gardens can be incorporated in a range of locations, as they can be any shape and size. They are essentially small bioretention basin systems, with typical locations including pocket parks, traffic calming measures and between parking bays.

Figure 2: WSUD bioretention (Raingardens) basin in Carparks / Streets in Penrith LGA

6.1. Elements of a Bioretention System

A bioretention system includes the following components:

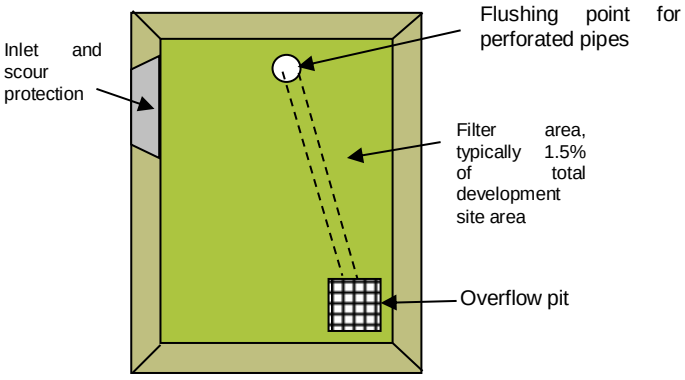


- **Vegetation** minimises surface clogging and assists in pollutant removal via biological processes. Some plant species that can be used include:
  - *Imperata cylindrica* (Blady Grass),
  - *Ficinia nodosa* (Syn. *Isolepis nodosa*) (Knobby Club Rush),
  - *Juncus usitatus* (Common Rush),
  - *Lomandra longifolia (Matrush),*
  - *Poa siebreiana (Grey Tussock grass),*
  - *Themeda australis* (Kangaroo Grass)
  - *Dianella caerulea* (Blue flax-lily)
  - *Carex appressa* (Tussock Sedge)

  A minimum of 8 plants per square metre is recommended. Shrubs or trees may also be included.

- **Extended detention** (or ponding depth) stores stormwater temporarily on the surface to buffer flows so that a greater volume can be treated.
- The **filter media** is the principal treatment zone. As stormwater passes through the filter media, pollutants are removed by filtration, adsorption and biological processes. The filter media should normally be 0.6 m deep, and 0.3 m is the minimum acceptable depth where the site is constrained. The filter media should be a loamy sand with a permeability of 100-300 mm/hr under compaction and should be clean and free of weeds. The filter media should contain some organic matter (less than 5%) but be low in nutrient content. No fertiliser is to be added.

  Media shall be used which meets the specifications defined in FAWB 2008 *'Guidelines for Soild Filter Media in Bioretention Systems.*
- A **transition layer** of clean well graded sand/coarse sand prevents the filter media from washing out of the system.
- The **drainage layer** of clean fine gravel (2-5 mm) collects treated water at the base of the system and contains 90-100 mm perforated pipes to convey treated water out of the system.
- An **impervious liner** may be required to prevent infiltration into surrounding soils, particularly if the treatment system is immediately adjacent to roads or buildings where infiltration may cause structural issues. Note that geotextile filters should not be used within the bioretention system, as they are prone to clogging. If perforated pipes come with a geotextile sock, this should be discarded before installation.



- An **inlet** for stormwater runoff. The inlet should be designed to protect the surface of the bioretention system from scour and erosion.
- An **overflow pit** (or other controlled overflow point) to allow high flows, beyond the capacity of the treatment system, to escape to the stormwater drainage system in a controlled manner.
- A **flushing point** connected to the perforated pipes, so they can be cleaned in the event of blockage.
- **Edge treatment** (e.g. a raised kerb or series of bollards) may be required to protect the bioretention system from traffic.
- **Pre-treatment** is recommended when sediment loads are likely to be high, or if there is a risk of spills. The simplest option is to incorporate a pit with a sump immediately upstream of the bioretention system.

6.2. Detailed design guidance

Design guidance in the form of typical drawings for bioretention systems at steep or flat sites, in footpaths or roadways, has been developed by the WSUD in Sydney program and is available at the following link - http://www.wsud.org/wp-content/uploads/SMCMA-WSUD-Standard-Drawings-Final.pdf.

6.3. Construction and Maintenance

During the construction phase, bioretention systems should be protected from high sediment loads associated with construction on site (erosion and sediment control measures should be in place to manage stormwater during this phase).

The commission of bioretention / raingardens systems should not proceed or be brought on line until the civil works are completed and the catchment is stable (i.e. at least 80% of the housing construction is finished). Prior to this it should be used as a sedimentation device to manage the unstable upstream catchment.

Regular maintenance is important to ensure the ongoing performance of bioretention systems. Maintenance requirements of bioretention systems include:

- Monitoring for scour and erosion, and sediment or litter build-up
- Weed removal and plant re-establishment
- Monitoring overflow pits for structural integrity and blockage

Further information is available in the Construction and Establishment for Swales, Bioretention Systems and Wetlands guidelines, as outlined above in Section 3.

7. CHECKLISTS

7.1. Development Application Checklist (lodged with DA)

Water Sensitive Urban Design
Development Application Checklist

Site/ Project Name			
Lot and DP Number:		**DA Number:**	

	Information Required with DA Submission:	**Y**	**N**
1	Has a Water Sensitive Urban Design Strategy been submitted as part of the development application?		
2	Is a BASIX Certificate required? If so, Yes - Attach certificate with DA		
3	Has the digital version of MUSIC and report on the MUSIC model using data prescribed outlined in Council's Technical Guideline been attached? Have stormwater quality retention criteria (TSS 85%, TP 60%, and TN 45%) and water quantity / drainage requirements been met and documented in the WSUD Strategy? If relevant, have the Water Conservation, Quantity and quantity targets been achieved?		
4	Does WSUD Strategy contain the following information? • Review of the **WSUD principles** and ensure that these are considered throughout development of the WSUD strategy. • Confirmation of the **WSUD objectives** that are relevant to the development application. • Confirmation of the **WSUD targets** for potable water conservation, stormwater quality management and stormwater quality management that are relevant to the development application. • Complete a **site analysis** to evaluate the site characteristics that potentially will impact on the feasibility of WSUD for the site. • **WSUD measures** that would be appropriate for the development considering the development scale, site characteristics, stormwater quality management function and stormwater quantity management function. • A **preliminary WSUD strategy** that positions the selected WSUD measures in appropriate locations and arranges the measures in an appropriate series. • **Numerical modelling** utilising MUSIC software to evaluate appropriate sizes of the WSUD measures. • C**oncept designs** of the WSUD measures. • **WSUD strategy report** that summarises the methodology and WSUD outcomes, and provide this with the development application for the site.		
5	Have the conceptual plans of the proposed stormwater treatment measures been included on the plans? (Detailed engineering plans will be required for the construction certificate)		

6	Has a Draft Operation and Maintenance Plan which includes details on the following been provided? • Site description (area, imperviousness, land use, annual rainfall, topography etc) • Site access description • Likely pollutant types, sources and estimated loads • Locations, types and descriptions of measures proposed • Operation and maintenance responsibility (council, developer or owner) • Inspection methods • Maintenance methods (frequency, equipment and personnel requirements including Work Health and Safety requirements) • Landscape and weed control requirements • Operation and maintenance costs • Waste management and disposal options, and • Reporting.		

7.2. Construction Certificate Application Checklist (lodged with CC)

Water Sensitive Urban Design
Construction Certificate Checklist

Site/ Project Name			
Lot and DP Number:		**DA Number:**	

	Information Required with CC Application:	**Y**	**N**
1	Have detailed construction plans (including all calculations, drawings and designs) been submitted?		
2	Are detailed design drawings generally in accordance with the development applications conditions of consent, approved concept plans, MUSIC modelling?		
3	Has an Erosion and Sedimentation Control Plan been submitted for approval?		
4	Has a final Operation and Maintenance Plan which includes details on the following been provided? • Site description (area, imperviousness, land use, annual rainfall, topography etc) • Site access description • Likely pollutant types, sources and estimated loads • Locations, types and descriptions of measures proposed • Operation and maintenance responsibility (council, developer or owner) • Inspection methods • Maintenance methods (frequency, equipment and personnel requirements including Work Health and Safety requirements) • Landscape and weed control requirements • Operation and maintenance costs • Waste management and disposal options, and • Reporting.		

8. TABLE OF AMENDMENTS

Amendment Number	Amendment Date	Summary of Amendment
1	July 2014	Inclusion of MUSIC*link* details
2	June 2015	Inclusion of Deemed to Comply Solutions

This page left blank intentionally

9. ADDENDUM 1 – DEEMED TO COMPLY SOLUTIONS TOOLKIT

PENRITH CITY COUNCIL
WSUD TECHNICAL GUIDELINES

Addendum 1 – Deemed to Comply Toolkit for Residential, Industrial & Commercial Developments

June 2015 (Version 1)

PENRITH
CITY COUNCIL

TABLE OF CONTENTS

APPENDICES

APPENDIX A

WSUD Design Checklists

APPENDIX B

Sample Operation and Maintenance Plan

APPENDIX C

Case Studies 1, 2, 3 – Residential, Industrial and Commercial Development

APPENDIX D

WSUD Standard Drawings

1.0 INTRODUCTION

Council engaged Storm Consulting Pty Ltd to prepare a set of deemed to comply options for smaller scale development.

This Deemed to Comply (DTCP) toolkit has been developed for the purpose of assisting developers and their consultants to meet Council's Water Sensitive Urban Design (WSUD) Policy.

The DTCP toolkit provides tailored WSUD solutions which account for a range of parameters such as the development site type, bypass proportion, soils, and stormwater system. A number of standard drawings and case studies utilising specific WSUD devices have been developed to demonstrate how typical developments can comply with Council's WSUD requirements.

This document should be read and applied in conjunction with Part C3 of the DCP (2010), Stormwater Drainage for Building Developments (2013) and with the latest version of Council's WSUD Technical Guidelines.

2.0 SUBMISSION REQUIREMENTS

2.1. DA Stage

Reference should be made to Council's document "Stormwater Drainage for Building Developments (2013)" for information required at DA submission. The following additional information must be submitted as part of a Development Application to fulfil Council's water quality and OSD Controls:

- The location, type, size and configuration of WSUD treatment measures selected from Section 3.0 of this toolkit. These may be prepared from standard drawings provided in Appendix D.
- The area of ground or roof areas directing stormwater runoff to each treatment measure. Areas bypassing treatment shall also be shown.
- Calculations demonstrating how Council's OSD and water quality requirements have been satisfied. Case studies of typical residential, industrial and commercial developments have been provided in Appendix C.
- The relevant treatment measure design checklist filled out as provided in Appendix A.
- A draft Operation and Maintenance Plan shall be submitted as shown in Appendix B.

2.2. CC Stage

A site specific Operation and Maintenance Plan for water quality and OSD features must be submitted with the CC. Examples of such plans can be found in Appendix B.

3.0 DEEMED TO COMPLY TOOLS

This section provides a hierarchy of water management controls for use in selected developments within the Penrith LGA. WSUD devices have been selected based on the effectiveness with removing site pollutants from residential and industrial/commercial developments.

The deemed-to-comply provisions apply to sites with a total area of less than 5,000m^2, and where basement car parking is not proposed. Applicants are required to adopt treatment measures from 3.1.1 and 3.2.1. Where sites are constrained and there are no alternatives i.e. flat sites with no public drainage system in the street, the following treatment measures from 3.1.2 and 3.2.2 can be adopted as a last resort.

Design guidelines of preferred WSUD devices can be found in section 4.0 while standard drawings of the WSUD devices can be found in Appendix D. Case studies have also been provided in Appendix C demonstrating how typical multi-unit housing, industrial and commercial developments can implement the WSUD measures.

3.1. Residential Development

3.1.1. Standard Treatment Measures

Roof and ground surfaces can be treated together or separately to comply with Council's water quality targets. Table 1 presents the preferred treatment options for residential developments. Compliance with Council's water quality targets is based on selecting the appropriate size of the treatment measure as a percentage of the impervious site area.

Table 1 – Standard Treatment Measure Options for Residential Developments

Option No.	Pollutant Source	Treatment Measure	Sizing
1a	Roof & Ground	Standard Raingarden	See Figure 3.1
1b	Roof & Ground	Standard Raingarden & 2000L Rainwater Tank (for each dwelling) connected to toilet	See Figure 3.2

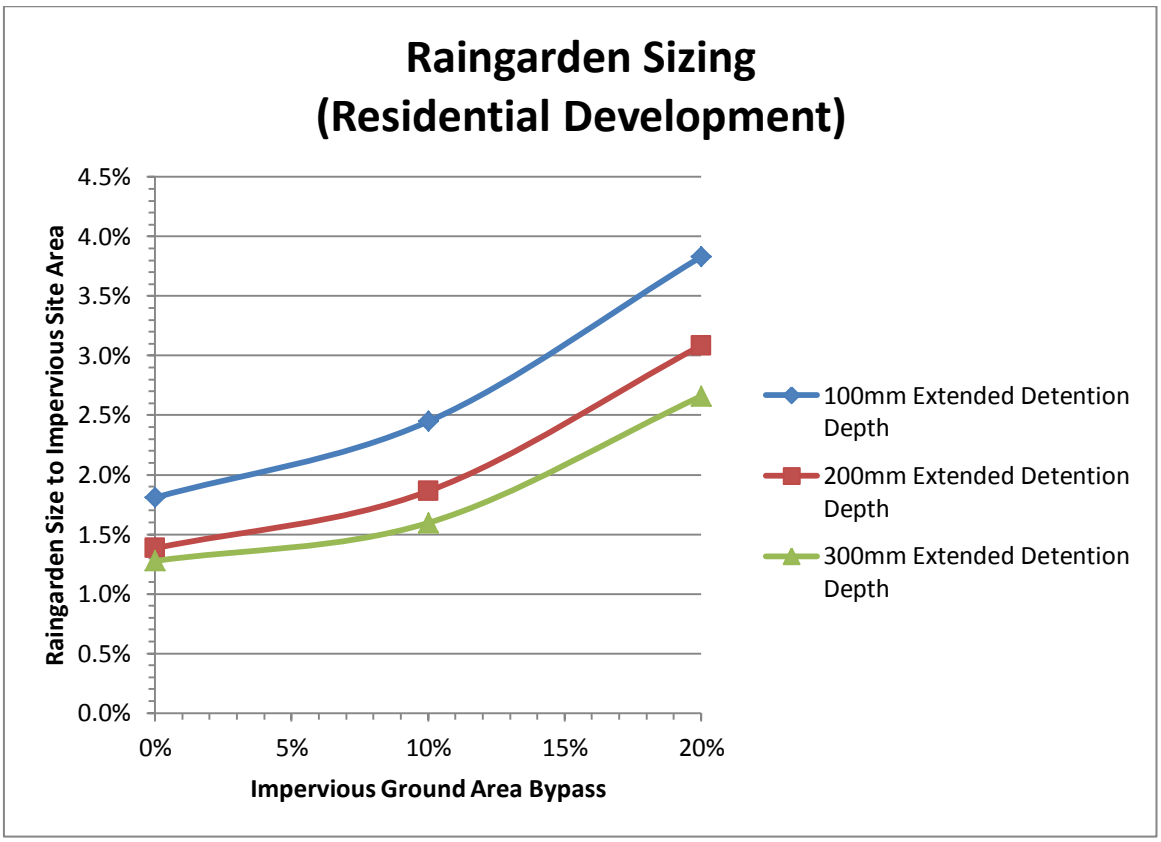


Figure 3.1 –Raingarden Filter Area Sizing for Residential Developments

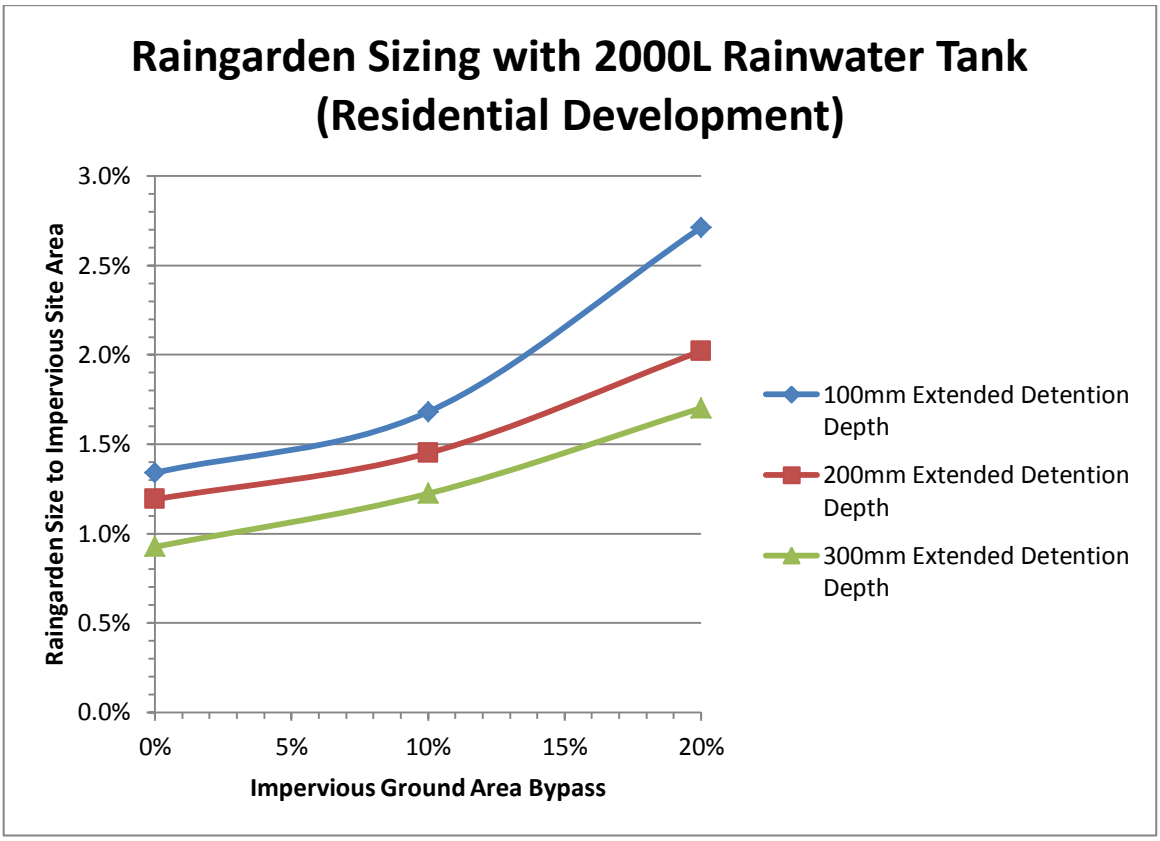


Figure 3.2 – Raingarden Filter Area Sizing with 2000L Rainwater Tank for Residential Developments

3.1.2. Constrained Sites

Where there are limitations with achieving the required grade to drain the site via a standard raingarden, a raingarden with submerged zone may be used as to achieve the required drainage levels. Table 2 presents the treatment options for a constrained residential development. Refer to section 4.3 and 4.4 for further details.

Buffer strips may be used for reducing the effective impervious area used to calculate raingarden sizes.

Table 2 – Treatment Measure Options for Constrained Residential Developments

Option No.	Pollutant Source	Treatment Measure	Sizing
1c	Roof & Ground	Raingarden with Submerged Zone	See Figure 3.1
1d	Roof & Ground	Raingarden with Submerged Zone & 2000L Rainwater Tank connected to toilet	See Figure 3.2

3.2. Industrial/Commercial development

3.2.1. Standard Treatment Measure

Table 3 presents the preferred treatment measure for treating both roof and ground areas in industrial/commercial developments. Compliance with Council's water quality targets is based on selecting the appropriate size of the treatment measure as a percentage of the impervious ground area.

Table 3 – Standard Treatment Measure for Industrial/Commercial Developments

Option No.	Pollutant Source	Treatment Measure	Sizing
2a	Roof & Ground	Standard Raingarden	See Figure 3.3

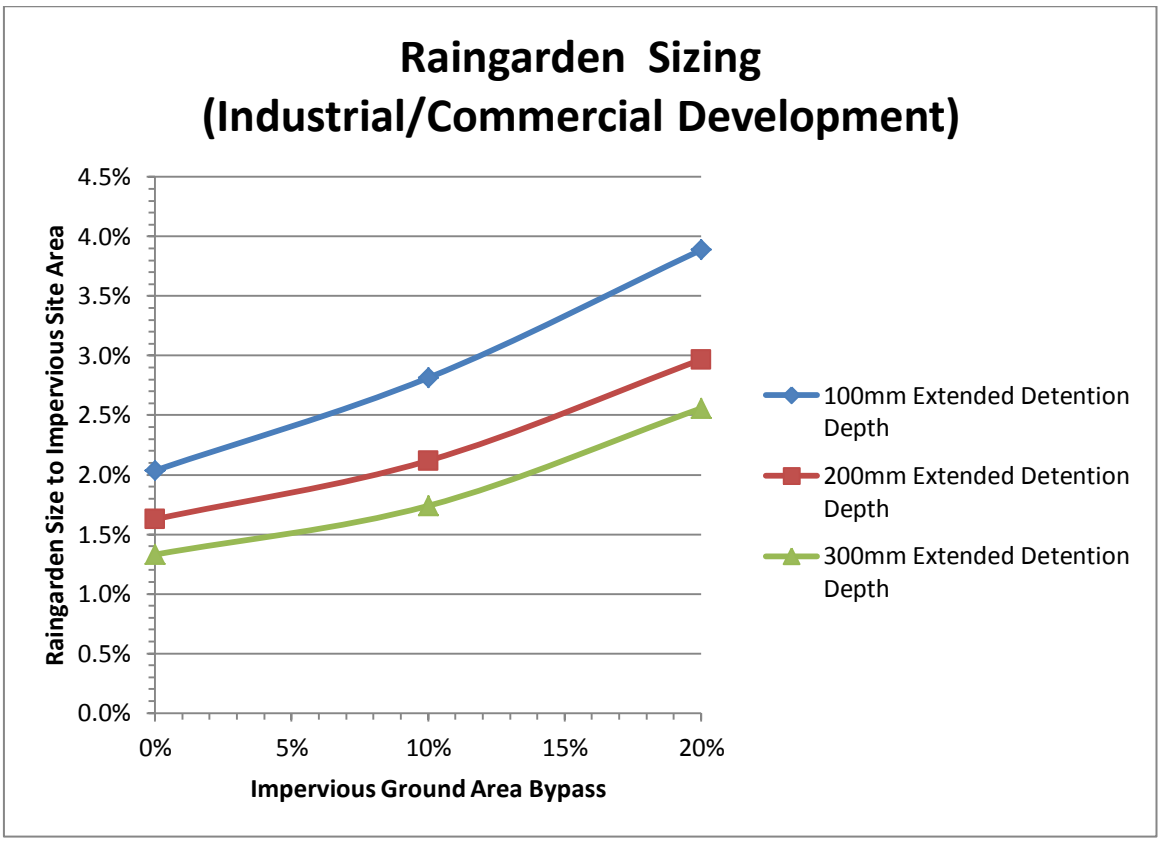


Figure 3.3 – Raingarden Filter Area Sizing for Industrial/Commercial Developments

3.2.2. Constrained Sites

Where there are limitations with achieving the required grade to drain the site via a standard raingarden, a raingarden with submerged zone may be used as to achieve the required drainage levels. Table 4 presents the alternative treatment measure for a constrained industrial/commercial development.

Buffer strips may be used for reducing the effective impervious area used to calculate raingarden sizes for commercial developments.

Table 4 – Treatment Measure for Constrained Industrial/Commercial Developments

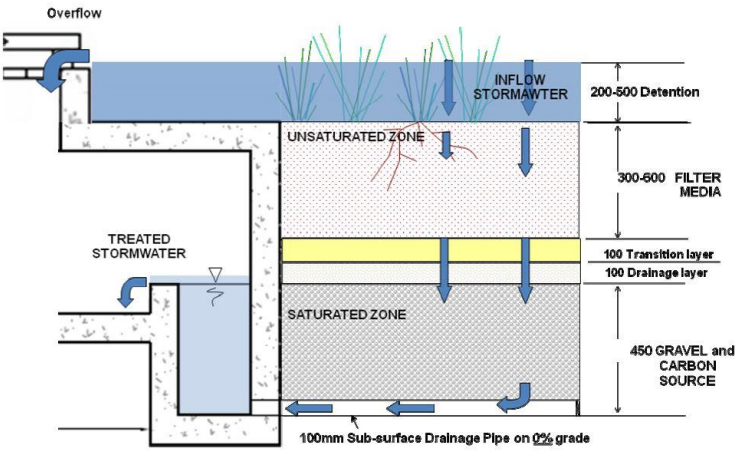
Option No.	Pollutant Source	Treatment Measure	Sizing
2b	Roof & Ground	Raingarden with Submerged Zone	See Figure 3.3

4.0 WSUD DESIGN GUIDELINES

4.1. Raingardens

Raingardens must fulfil the following requirements to be claimed as a treatment measure:

- The entire roof area and at least 80% of the impervious ground area is treated by one or more raingardens sized using the charts in Section 3.
- Raingardens should be located upstream of OSD systems, and all treated and bypass water from the raingardens shall be directed to the OSD.
- The inflow system has rock protection to prevent surface scouring
- The top water level is at least 50mm below surrounding area
- The extended detention depth does not exceed 300mm.
- The mulch layer depth ranges from 50-75mm. The mulch layer is comprised of non-floatable stone aggregate mulch sized 20mm or similiar.
- The filter media depth ranges from 450-1000mm in the standard raingarden and from 300-1000mm for raingarden with submerged zone.
- The filter media is comprised of loamy sand with a permeability of 100-300 mm/hr under compaction and a minimum orthophosphate content of 40mg/kg.
- The transition layer depth is at least 100mm. The transition layer is comprised of clean well graded sand/coarse sand.
- The drainage layer depth is at least 150mm in the standard raingarden and at least 350mm in the raingarden with submerged zone.
- The drainage layer is comprised of clean fine gravel sized 2-5 mm with 90-100 mm perforated pipes over the base of the filter.
- Flushing point(s) and an overflow pit have been installed
- The liner selected is impermeable
- Plant species have been selected in accordance with Section 6.1 of Council's WSUD Technical Guidelines and planted at a density of 8 plants/m^2

Raingarden Types	
Standard raingardens consist of an engineering filter media profile planted with drought tolerant species. They collect stormwater from impervious areas, trapping smaller sediments and removing nutrients in stormwater runoff prior to returning treated stormwater to the stormwater system through a slotted pipe in the base of the garden bed profile. The treated stormwater is discharged to the stormwater system by gravity.	 Typical raingarden (source: www.esf.edu)
Where there is insufficient difference in levels to drain the treated water from the raingarden to the stormwater system by gravity a raingarden with submerged zone may be adopted. This arrangement retains water in the lower section of the raingarden and provides for treated stormwater to drain from the raingarden at a higher level. This type of raingarden is suitable for constrained sites.	 Raingarden with submerged zone (source: www.monash.edu.au/fawb)

4.2. Rainwater Tanks

Rainwater tanks collect and store stormwater runoff from the roofs of the proposed buildings for reuse purposes such as toilet flushing and outdoor irrigation. Once rainwater tanks are filled with stormwater runoff, overflows from the tanks are directed to the downstream drainage system. Rainwater tanks must fulfil the following requirements to be claimed as a treatment measure:

- At least 50% of the roof area is connected to the rainwater tank of each dwelling
- Rainwater harvested is re-used internally for toilet flushing. Rainwater harvested may be used for other approved purposes such as laundry.
- All bypass water from rainwater tanks shall be directed to the OSD.
- An appropriate connection to mains water has been installed to supply water to tank when empty.
- Rainwater tank has been designed in accordance with the provisions of Section C3.8 Water Management in Council's DCP 2010, and SEPP (Exempt and Complying Development) 2008including installation of safety signs and pipe labelling.
- Rainwater tank volume cannot be claimed as an offset for On-Site Stormwater Detention volume.

Figure 4.1: Rainwater tank (source: www.savewater.com.au)

4.3. Buffer Strips

Buffer strips are areas of vegetation designed to slow stormwater runoff as it travels from impervious surfaces to a discharge point. They reduce and retain sediment loads as runoff passes through the vegetation. Buffer strips rely on shallow, uniform flows to treat runoff and will be well suited for treating impervious surfaces such as driveway and foot paving areas. A set down of an adequate depth is often required to retain the build-up of accumulated sediment and prevent potential scouring. Buffer strips may be used to claim a discount in site impervious area for the purpose of calculating raingarden areas under section 3. A 50% discount can be claimed for impervious areas draining to a buffer strip subject to the following conditions:

- Filter rolls are to be placed every 5-10 metres across buffer strip during establishment
- Runoff is collected from the adjacent driveways only.
- Buffer strips should be located upstream of OSD systems, and all treated and bypass water from the buffer strips shall be directed to the OSD. The inlet flows are uniformly distributed into the swale. Alternatively, wheelstrips may be used along the driveway.
- Longitudinal slope ranging from 1 - 3 %.
- Buffer strip vegetation is set down of at least 50mm below edge of driveway
- Where used, mulch must be non-floatable 20mm gravel or similar
- Batter grades are less than 1:6 for turf and less than 1:4 for landscape areas
- Collection pits drain 100m^2 of catchment every 20m of buffer strip
- Top soils are a minimum depth of 300mm for plants and 100mm for turf

Figure 4.2: Buffer Strips (source: www.lindenlandgroup.com)

4.4. Permeable Pavement

Permeable pavements are porous surfaces which overlay an aggregate layer of crushed stone or gravel. Stormwater runoff passes through the permeable pavement to the aggregate layer before it is discharged to a piped drainage system. This process reduces the peak flow site runoff by delaying time for water to enter drainage system and improves the quality of stormwater runoff by removing site pollutants.

Permeable paving may be used subject to the following conditions:

- Permeable paving is only used within areas of carparking or pedestrian pathways. This does not include driveway and OSD areas.
- Permeable paving is graded towards a piped drainage system so that runoff is controlled where a rainfall event exceeds the infiltration rate of the pavement.
- Where permeable paving is located upstream of OSD systems, all treated and bypass water from the permeable paving shall be directed to the OSD.
- The permeable pavement provided must be a hard stand material or bonded asphaltic material such as pervious concrete. Council does not permit loose aggregate style permeable pavement such as road base or gravel type material.
- Certification and standard drawings of the permeable paving must be provided. The certification shall demonstrate that the permeable paving is suitable for its intended use (i.e withstands the loads from cars, etc)

Figure 4.3: Permeable pavement (source: www.blogs.scientificamerican.com)

5.0 OPERATION & MAINTENANCE

Operation and maintenance of treatment systems are straightforward, being similar to maintenance of standard gardens and drainage infrastructure.

Following the construction of treatment measures, they should be inspected every 1 to 3 months and inspected after each major rainfall event for the initial establishment period to determine whether immediate maintenance is needed. Residents will need to be aware of the functions and benefits associated with the treatment measures so that it is looked after and not damaged or misused.

Initial establishment periods are typically:

- 1 month for rainwater tanks
- 1 to 2 years for raingardens
- 1 to 2 years for buffer strips

After the initial establishment period, inspection of the treatment measures may be extended to the frequencies shown in sample operation and maintenance plans in Appendix B.

6.0 GLOSSARY OF TERMS

(Adapted from Queensland Urban Drainage Manual, 2008)

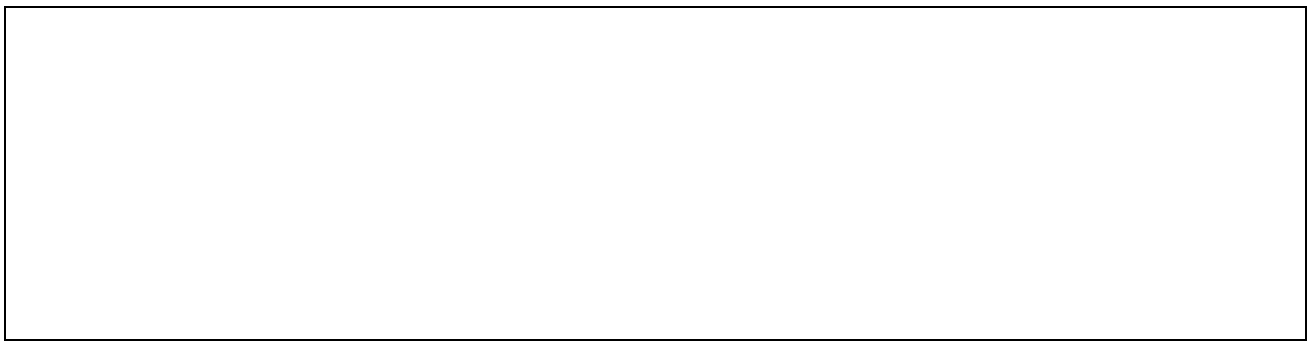
Raingarden	A well-vegetated retention cell or pond designed to enhance water filtration through a specially prepared sub-surface sand filter. The system incorporates vegetation with medium-term stormwater retention and sub-surface filtration/infiltration.
Bypass Flow	The portion of flow from a site which drains to Council's drainage system without first going through OSD or water quality treatment.
Drainage System	A system of inlet pits, pipes, overland flow paths, open channels, culverts and detention basins used to convey runoff to its receiving waters.
Detention	The process of holding water in a control structure for a limited period of time and releasing it at a reduced rate over long period of time.
Overland Flow Path	Where a piped drainage system exists: it is the path where storm flows in excess of the capacity of the underground drainage system would flow. Where no piped drainage system or other form of defined watercourse exists: it is the path taken by surface runoff from higher parts of the catchment to a watercourse, channel or gully. It does not include a watercourse, channel or gully with well defined bed and banks.
Stormwater	Rainfall that collectively runs off all urban surfaces such as roofs, pavements, car park areas, roads, gardens and vegetated open space.
Water Sensitive Urban Design (WSUD)	A set of design elements and on-ground solutions that aim to minimise impacts on the water cycle from the built urban environment. It offers a simplified and integrated approach to land and water planning by dealing with the urban water cycle in a decentralised manner consistent with natural hydrological and ecological processes.

APPENDIX A

WSUD Design Checklists

WSUD DEVELOPMENT ASSESSMENT CHECKLIST			
1. SITE INFORMATION			
Address:			
Development Type			
DA No:		Total Site Area (m^2):	
Impervious Ground Area (m^2):		Roof Area (m^2):	
Reduction in Impervious area (m^2):		Net Impervious Area (m^2):	
2. WATER MANAGEMENT CONTROLS			
a) Proposed treatment measures: ☐ Raingarden ☐ Rainwater Tank ☐ Buffer Strip ☐ Permeable paving ☐ Other			
b) Proposed treatment measures shown on plan?			Y / N
3. TREATMENT OPTIONS			
Proposed Treatment Measure	**Catchment (%)**	**Catchment Size (m^2)**	**Treatment Measure Size (m^2)**
a)			
b)			
c)			
d)			
3. DOCUMENTATION			
a) Design checklist submitted for each treatment measure?			Y / N
b) Operation and Maintenance Plan submitted for each treatment measure?			Y / N
COMMENTS			

RAINGARDEN DESIGN CHECKLIST	
Location:	DA No:
Catchment Area (ha):	Filter Media Area (m^2):
1. INFLOW SYSTEM	
a) Roof area and at least 80% of the impervious ground area treated by the standard raingarden or raingarden with submerged zone at the front setback?	Y / N
b) Inlet scour protection provided at inflow locations?	Y / N
2. RAINGARDEN CONFIGURATION	
a) Top water level ≥50mm below surrounding area?	Y / N
b) Extended detention depth ≤300mm for standard raingarden or raingarden with submerged zone?	Y / N
c) Mulch layer depth ranges from 50-75mm comprised of non-floatable stone aggregate mulch sized 10-20mm?	Y / N
d) Filter media depth ranges from 450-1000mm for standard raingarden, from 300-1000mm for raingarden with submerged zone?	Y / N
e) Filter media is comprised of loamy sand with a permeability of 100-300 mm/hr under compaction and a minimum orthophosphate content of 40mg/kg?	Y / N
f) Transition layer depth ≥100mm and comprised of clean well graded sand/coarse sand?	Y / N
g) Slotted 90-100mm dia pipes provided within drainage layer?	Y / N
h) Drainage layer ≥ 350mm for raingarden with submerged zone or ≥ 150mm for standard raingarden?	Y / N
i) Liner type selected is impermeable?	Y / N
j) Flushing point provided?	Y / N
k) Overflow pit provided?	Y / N
3. VEGETATION DESIGN	
a) Species selected in accordance with Section 6.1 of Council's WSUD Technical Guidelines?	Y / N
b) Planting density ≥ 8 plants / m^2? (Shrubs or trees may be included)	Y / N
COMMENTS	



RAINWATER TANK DESIGN CHECKLIST	
Location:	DA No:
Catchment Area (ha):	Rainwater Tank Capacity (L):
1. RAINWATER TANK CONFIGURATION	
a) Rainwater tank capacity specified?	Y / N
b) At least 50% of the roof area diverts runoff to rainwater tank?	Y / N
c) Connected to the following for internal re-use: □ No of toilets: _____ □ Laundry □ Other: _____	Y / N
d) Fitted with a first-flush device?	Y / N
e) Connection to mains water has been installed to supply water to tank when empty?	Y / N
e) Will not exceed 3 metres in height above ground level (including stand)?	Y / N
f) Will not rest on a footing of any building or other structure on the property including retaining wall?	Y / N
COMMENTS	

BUFFER STRIP DESIGN CHECKLIST	
Location:	DA No:
Catchment Area (ha):	Buffer Strip Area (m^2):
1. INFLOW SYSTEM	
a) Inlet flows uniformly distributed?	Y / N
b) Buffer strip vegetation set down of at least 50mm below driveway edge?	Y / N
2. BUFFER STRIP CONFIGURATION	
a) Batter grades <1:6 for turf or <1:4 for landscape areas?	Y / N
b) Longitudinal slope ranges from 1-3%?	Y / N
c) Collection pit provided to drain 100m^2 of catchment every 20m?	Y / N
3. LANDSCAPE	
a) Top soils are a minimum depth of 300mm for plants and 100mm for turf?	Y / N
b) Plant species selected can tolerate periodic inundation and design velocity?	Y / N
COMMENTS	

APPENDIX B

Sample Operation and Maintenance Plan

SAMPLE RAINGARDEN MAINTENANCE PLAN		
Location:		DA No:
INSPECTION ITEMS	**FREQUENCY**	**ACTION REQUIRED**
Mulch	3 months	Replace mulch as needed with a material that will not float away
Surface vegetation	6 months	▪ Inspect health of plants and trim where necessary ▪ Remove and replace diseased/dead plants with same species ▪ Remove weeds
Debris/sediment	6 months	Inspect and clean debris/sediment build-up from surface, inlet area and overflow.
Ponding	6 months	If ponding occurs for more than 3 days after storms, check whether underdrain or filter media is blocked
Outlet/overflow pit	Yearly	Repair where cracking or spalling of concrete surfaces is identified
Underdrainage	5 years	Flush underdrainage
Filter media	~30 years	Replace filter media
COMMENTS		

SAMPLE RAINWATER TANK MAINTENANCE PLAN		
Location:		DA No:
INSPECTION ITEMS	**FREQUENCY**	**ACTION REQUIRED**
First flush device	1-3 months	Inspect and clean first flush device from debris
Contamination (Mosquito/vermin breeding or algae growth)	1-3 months	Disinfection of tank
Inlet/Outlet screen	6 months	Remove leaves and debris on surface
Roof gutters	6 months	Remove leaves and debris in gutters
Pump/strainer	6 months	Inspect and clean pump/strainer from debris
Tank structure	2 years	Check footings and fittings for signs of corrosion
Depth of sediment within tank	5 years	Desludge tank by engaging a professional tank cleaner
COMMENTS		

SAMPLE BUFFER STRIP MAINTENANCE PLAN		
Location:		DA No:
INSPECTION ITEMS	**FREQUENCY**	**ACTION REQUIRED**
Inlet/outlet drainage points	6 months	Remove accumulated sediment deposits, debris and litter
Surface vegetation	6 months	▪ Inspect health of vegetation and trim where necessary ▪ Remove and replace diseased/dead vegetation ▪ Remove weeds ▪ Mow if grassed
Excessive shading	6 months	Prune and remove brushy vegetation on adjacent slopes
Erosion/scouring	6 months	For bare areas less than 300mm wide, repair the damaged area by filling with crushed gravel. If bare areas are large, generally greater than 300mm wide, the buffer strip should be re-graded and re-seeded.
Ponding	6 months	Remove sediment or trash blockages
COMMENTS		

PERMEABLE PAVEMENT MAINTENANCE CHECKLIST		
Location:		DA No:
INSPECTION ITEMS	**FREQUENCY**	**ACTION REQUIRED**
Pavement surface	3 months	▪ Clean debris and sediment build-up by sweeping/vacuum sweep
Nuisance vegetation growth	3 months	Remove weeds from pavement and replace missing sand or gravel between pavers as needed.
Ponding	3 months	▪ Inspect subdrain outlets (if applicable) to verify they are not blocked. ▪ Replace clogged pavement
Pavement surface	5 years	▪ Repair pavement where potholes or cracking of pavement exist ▪ Rectify pavement levels where pavement deflection is identified
COMMENTS		

APPENDIX C

Case Studies 1, 2, 3 – Residential, Industrial and Commercial Development

PENRITH CITY COUNCIL

Water Cycle Management
Case Study 1
Multi-Unit Residential Development

Introduction

Council's DCP and associated policies require developments to comply with water quality and On-site Stormwater Detention (OSD) controls. To simplify this process for smaller developments, Council has developed a "deemed-to-comply" procedure which allows developers to select from a hierarchy of water management measures to satisfy the controls.

This case study guides you through the application of this "deemed-to-comply" approach to a typical Multi-Unit Residential Development within Penrith.

Site Layout

The site has an area of 1050m^2 and is currently occupied by a single dwelling towards the street frontage, and a large backyard. The site falls from the rear towards the street frontage at approximately 0.8% grade.

Five new housing units have been proposed on the site, each with an attached single garage and second open carparking space. A common driveway will run along one side boundary.

The key areas in the proposed development are:

Total site area = 1050m^2

- Roof = 386m^2 (36.8% of site)
- Driveway = 310m^2 (29.5% of site)
- Carpark = 80m^2 (7.6% of site)
- Footpath = 70m^2 (6.7% of site)
- Garden = 24m^2 (2.3% of site)
- Turf = 180m^2 (17.1% of site)

The overall site layout is given in Figure C.1.

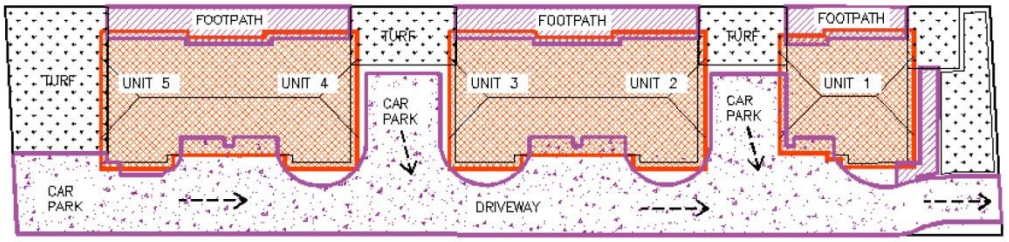


Figure C.1 - Overall Site Layout

Potential treatment measures

Under Council's deemed-to-comply toolkit, roof and ground surfaces (such as driveways) can be treated together or separately in residential developments. The deemed-to-comply toolkit provides a hierarchy of treatment measure options based on whether the site is categorised as standard or constrained. For the purpose of this case study, an excerpt is shown below for an unconstrained site treating roof and ground surfaces separately.

Treatment Measure	Pollutant Source	Sizing
Standard Raingarden (100mm extended detention depth - EDD) & 2000L Rainwater Tank connected to toilet	Roof & Ground	See Figure 3.2

Adopted solution

It was found the most effective solution for treating the roof surface was to install rainwater tanks to each unit, connected to the toilets for internal re-use. Overflows will be directed to an OSD system in the front setback. 2000L rainwater tanks have been allocated to each unit to collect runoff from the site roof area of 386m^2.

The driveway of 310m^2 was graded to the front setback to direct runoff to the raingarden prior to draining into the OSD. The site drainage system has been designed to bypass the low flows along a kerb on the edge of the driveway so these flows preferentially enter the raingarden. The pits in the driveway are set off from the kerb so that in higher flows water will begin to flow into the piped system, bypassing the raingarden.

An above ground OSD has been provided at the front setback to capture a majority of the site runoff. Under Council's OSD guidelines the site needs to provide 29m^3 of OSD storage - this includes an additional of 15% OSD volume for landscaped storage areas greater than 25m^3. The following treatment measures satisfy this requirement:

a) Driveway bypass = 22m^2 (4.8% of impervious ground area, see Figure C.1)
b) Impervious site area = 460 + 386 = 846m^2
c) Raingarden size to impervious site area = 1.45% (100mm EDD and 4.8% bypass)
d) Standard raingarden size = 12.3m^2
e) Above ground OSD area = 60m^2
f) Above ground OSD storage = 30m^3 (detention depth of 500mm)

OSD storage provided = 30m^3 > 29m^3

By using the combination of 2000L rainwater tanks and a standard raingarden to treat the multi-unit development, Council's water quality and On-Site Detention controls have been satisfied.

The new site layout is shown in Figure C.2. Key areas of the proposed development are now:

Total site area = 1050m^2

- Roof = 386m^2 (36.8% of site)
- Driveway = 310m^2 (29.5% of site)
  - Driveway to OSD = 288m^2
  - Bypass = 22m^2
- Carpark = 80m^2 (7.6% of site)
- Remaining footpath = 61m^2 (5.8% of site)
- Remaining garden = 20.7m^2 (2.0% of site)
- Raingarden = 12.3 m^2 (1.1% of site)
  - Footpath converted to RG = 9m^2
  - Garden converted to RG = 3.3m^2
- Remaining turf = 120m^2 (11.5% of site)
  - Turf converted to OSD = 60m^2
- Above ground OSD = 60m^2 (5.7% of site)

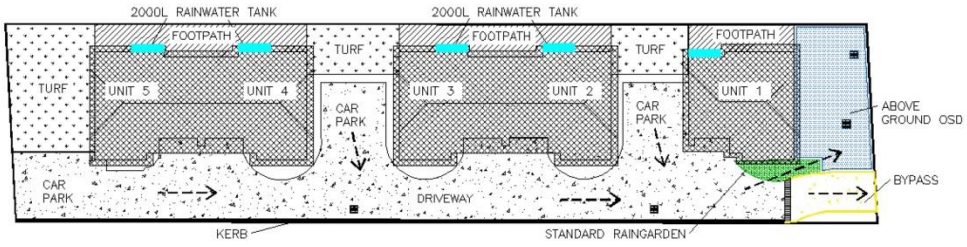


Figure C.2 – Overall Site Layout with OSD and Water Quality Controls

PENRITH CITY COUNCIL

Water Cycle Management
Case Study 2
Industrial Development

Introduction

Council's DCP and associated policies require developments to comply with water quality and On-site Stormwater Detention (OSD) controls. To simplify this process for smaller developments, Council has developed a number of "deemed-to-comply" options which allow developers to select from a specific list of water management measures that satisfy the controls.

This case study guides you through the application of this "deemed-to-comply" approach to a typical Industrial Development within Penrith.

Site Layout

The site has an area of 4000m^2 and is currently categorised as Greenfield land. The site falls from the rear towards the street frontage at approximately 2.5% grade.

Four new warehouse units have been proposed on the site with 8 carparking spaces allocated to each unit. A common hardstand area will run along the entire frontage, permitting vehicle access from two separate entry points.

The key areas in the proposed development are:

Total site area = 4000m^2

- Roof = 2160m^2 (54% of site)
- Hardstand = 924m^2 (23.1% of site)
- Carpark = 580m^2 (14.5% of site)
- Turf = 336 m^2 (8.4% of site)

The overall site layout is given in Figure C.3.

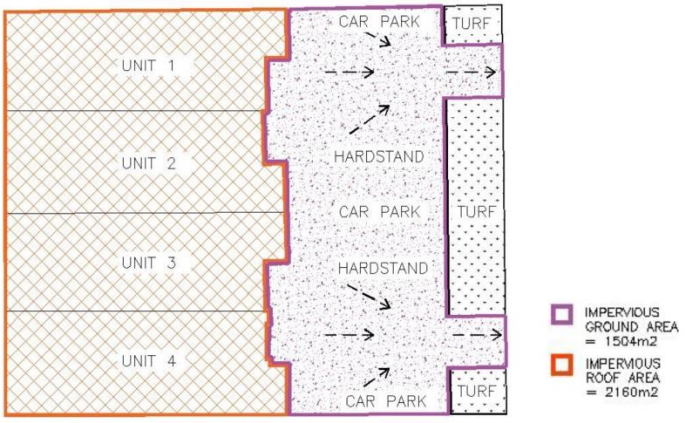


Figure C.3 - Overall Site Layout

Potential treatment measures

Under Council's deemed-to-comply toolkit, roof areas and ground surfaces (such as driveways) are to be treated together in industrial developments. The deemed-to-comply toolkit provides a hierarchy of treatment measure options based on whether the site is categorised as standard or constrained. For the purpose of this case study, an excerpt is shown below for a constrained site treating roof and ground surfaces together.

Treatment Measure	Pollutant Source	Sizing
Raingarden with Submerged Zone (200mm extended detention depth - EDD)	Roof & ground	See Figure 3.3

Adopted solution

The driveway of 1504m^2 was graded to the front setback to direct runoff to the raingarden prior to draining into the OSD. The site drainage system has been designed to bypass the low flows along a broken kerb line so these flows preferentially enter the raingarden. The pits along the hardstand are set off at low points away from the kerb so that a majority of hardstand runoff can be captured and directed into the raingarden. The roof surface, totally 2160m^2, directs runoff into the same pits along the hardstand connecting to the raingarden.

An above ground OSD has been provided at the front setback to capture all site runoff. Under Council's OSD guidelines the site needs to provide 128.8m^3 of OSD storage - this includes an additional of 15% OSD volume for landscaped storage areas greater than 25m^3. The following treatment measure satisfies this requirement:

a) Driveway bypass = 128m^2 (8.5% of impervious ground area, see Figure C.3)
b) Impervious site area = 1504 + 2160 = 3664m^2
c) Raingarden size to impervious site area = 2.0% (200mm EDD and 8.5% bypass)
d) Raingarden with submerged zone size = 73.3m^2
e) Above ground OSD area = 170m^2
f) Above ground OSD storage = 129.2m^3 (detention depth of 760mm)

OSD storage provided = 129.2m^3 > 128.8m^3

By using a raingarden with submerged zone to treat the industrial development, Council's water quality and On-Site Detention controls have been satisfied.

The new site layout is shown in Figure C.4. Key areas of the proposed development are now:

Total site area = 4000m^2

- Roof = 2160m^2 (54% of site)
- Hardstand = 924m^2 (23.1% of site)
  - Hardstand to OSD = 796m^2
  - Bypass = 128m^2
- Carpark = 580m^2 (14.5% of site)
- Remaining turf = 92.7m^2 (2.3% of site)
  - Turf converted to OSD = 170m^2
  - Turf converted to RG =73.3m^2
- Raingarden = 73.3m^2 (1.8% of site)
- OSD = 170m^2 (4.3% of site)

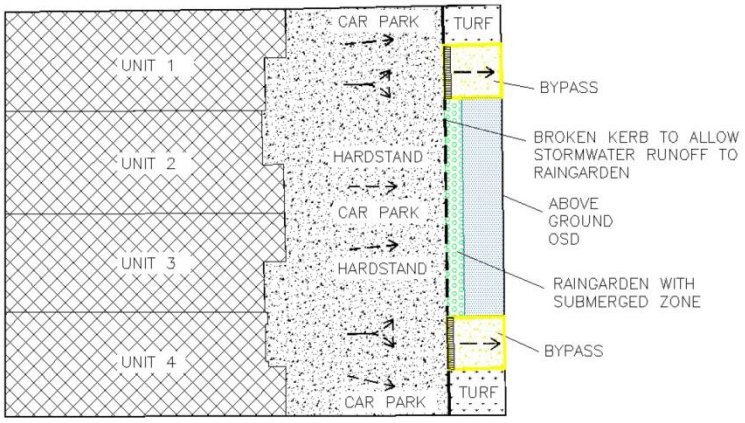


Figure C.4 – Overall Site Layout with Water Quality Controls

Introduction

Council's DCP and associated policies require developments to comply with water quality and On-site Stormwater Detention (OSD) controls. To simplify this process for smaller developments, Council has developed a "deemed-to-comply" procedure which allows developers to select from a hierarchy of water management measures to satisfy the controls.

This case study guides you through the application of this "deemed-to-comply" approach to a typical Commercial Development within Penrith.

Site Layout

This site has an area of 1290m^2.and is currently occupied by a single office building towards the street frontage, and a large backyard. The site falls from the rear towards the street frontage at approximately 1.5% grade.

A new office building has been proposed towards the rear of the site with 14 new carparking spaces to facilitate both office buildings on the site. A common hardstand area will run along the majority of the site, permitting vehicle access from a separate entry and exit point.

The key areas in the proposed development are:

Total site area = 1290m^2

- Roof = 480m^2 (37.2% of site)
- Hardstand = 476m^2 (36.9% of site)
- Carpark = 264m^2 (20.5% of site)
- Turf = 14m^2 (1.1% of site)
- Garden = 56m^2 (4.3% of site)

The overall site layout is shown in Figure C.5.

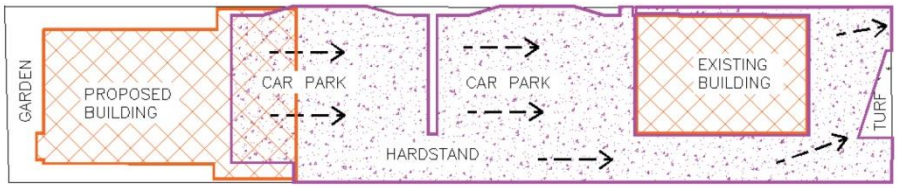


Figure C.5 - Overall Site Layout

Potential treatment measures

Under Council's deemed-to-comply toolkit, roof areas and ground surfaces (such as driveways) are to be treated together in commercial developments. The deemed-to-comply toolkit provides a hierarchy of treatment measure options based on whether the site is categorised as standard or constrained. For the purpose of this case study, an excerpt is shown below for a standard site treating roof and ground surfaces together.

Treatment Measure	Pollutant Source	Sizing
Standard Raingarden (300mm extended detention depth - EDD)	Ground	See Figure 3.5

Adopted solution

The hardstand area of 740 m^2 was divided into two sections, grading to separate raingardens prior to draining into the OSD. The site drainage system has been designed to bypass the low flows along a kerb on the edge of the driveway so these flows preferentially enter the raingarden. The pits in the driveway are set off from the kerb so that in higher flows water will begin to flow into the piped system, bypassing the raingarden.

Permeable paving has been installed across two sections of the hardstand area, approximately 58m^2 each. These sections will be used for carparking only.

A below ground OSD has been provided at the front setback to capture site runoff. Under Council's OSD guidelines the site needs to provide 36.2m^3 of underground OSD storage. The following treatment measures satisfy this requirement:

a) Driveway bypass = 44.5m^2 (6% of impervious ground area, see Figure C.5)
b) Impervious site area = 740 + 480 = 1220m^2
c) Raingarden size to impervious site area = 1.55% (300mm EDD and 6% bypass)
d) Standard raingarden size = 18.9m^2
e) Below ground OSD area = 38m^2
f) Below ground OSD storage = 36.8m^3 (based on a detention depth of 920mm)

OSD storage provided= 36.8m^3 > 36.2m^3

By combining 2000L rainwater tanks and a standard raingarden to treat the commercial development, Council's water quality and On-Site Detention controls have been satisfied.

The new site layout is shown in Figure C.6. Key areas of the proposed development are now:

Total site area = 1290m^2

- Roof = 480m^2 (37.2% of site)
- Hardstand = 476m^2 (36.9% of site)
  - Hardstand to OSD = 431.5m^2
  - Bypass = 44.5m^2
- Carpark = 264m^2 (20.5% of site)
  - Carpark to OSD = 148m^2
  - Permeable Paving = 116m^2
- Remaining turf = 0m^2
- Remaining garden = 51.1m^2 (3.9% of site)
- Raingarden = 18.9m^2 (1.5% of site)
  - Turf converted to RG = 14.0m^2
  - Garden converted to RG = 4.9m^2
- Underground OSD = 38m^2 (2.9% of site)

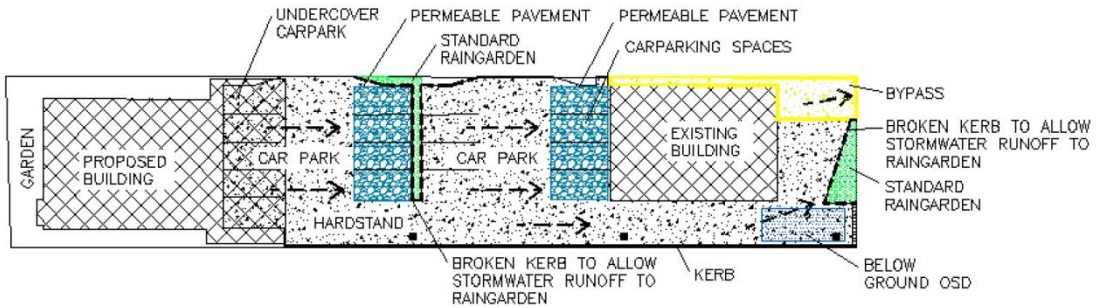
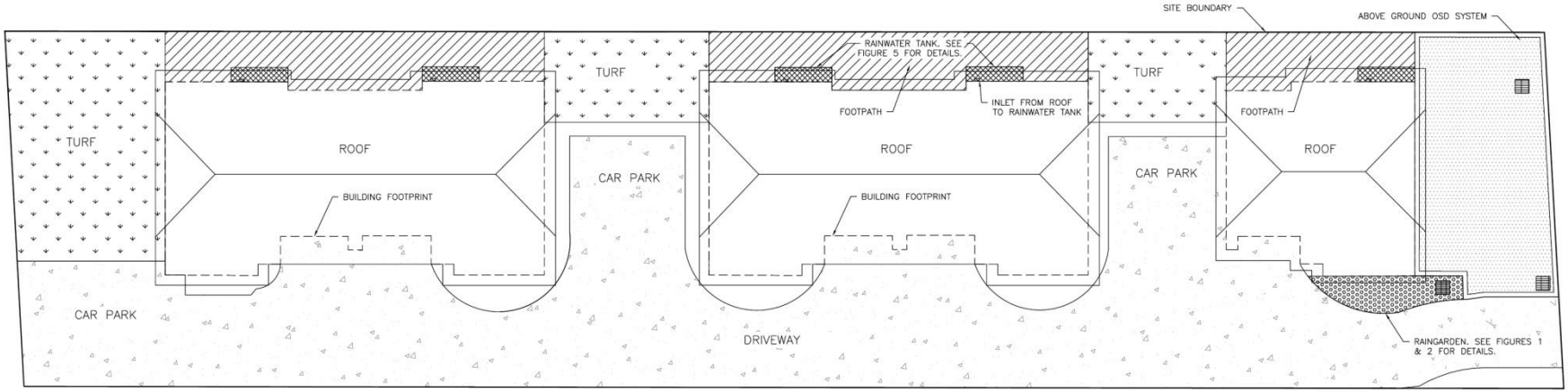


Figure C.6 – Overall Site Layout with Water Quality Controls

APPENDIX D

WSUD Standard Drawings



TYPICAL SITE LAYOUT

SCALE 1:250

PRE–DEVELOPMENT SITE AREA MATRIX

- ROOF = 386m2 (36.8% OF SITE)
- DRIVEWAY = 310m2 (29.5% OF SITE)
- CARPARK = 80m2 (7.6% OF SITE)
- FOOTPATH = 70m2 (6.7% OF SITE)
- GARDEN = 24m2 (2.3% OF SITE)
- TURF = 180m2 (17.1% OF SITE)

TOTAL IMPERVIOUS AREA = 846m2 (80.6% OF SITE)
TOTAL PERVIOUS AREA = 204m2 (19.4% OF SITE)

TOTAL SITE AREA = 1050m3

STORMWATER TREATMENT CALCULATIONS

DRIVEWAY BYPASS = 22m2 / 1050m2 = 4.8%
2000L RAINWATER TANK PROVIDED TO EACH DWELLING

RAINGARDEN SIZE TO IMPERVIOUS SITE AREA = 1.45%
(100mm EDD AND 4.8% BYPASS – FIGURE 3.2)
STANDARD RAINGARDEN SIZE = 846m2 * 1.45% = 12.3m2

TOTAL RAINGARDEN SIZE = 12.3m2

ON–SITE DETENTION CALCULATIONS

SSR REQUIRED = 240m3/ha (MULTI–UNIT HOUSING)

OSD REQUIRED = 1050m2 * (240/10000) * 1.15 = 29m3
(ABOVE GROUND STORAGE SYSTEM)
OSD PROVIDED = 60m2 x 500mm = 30m3

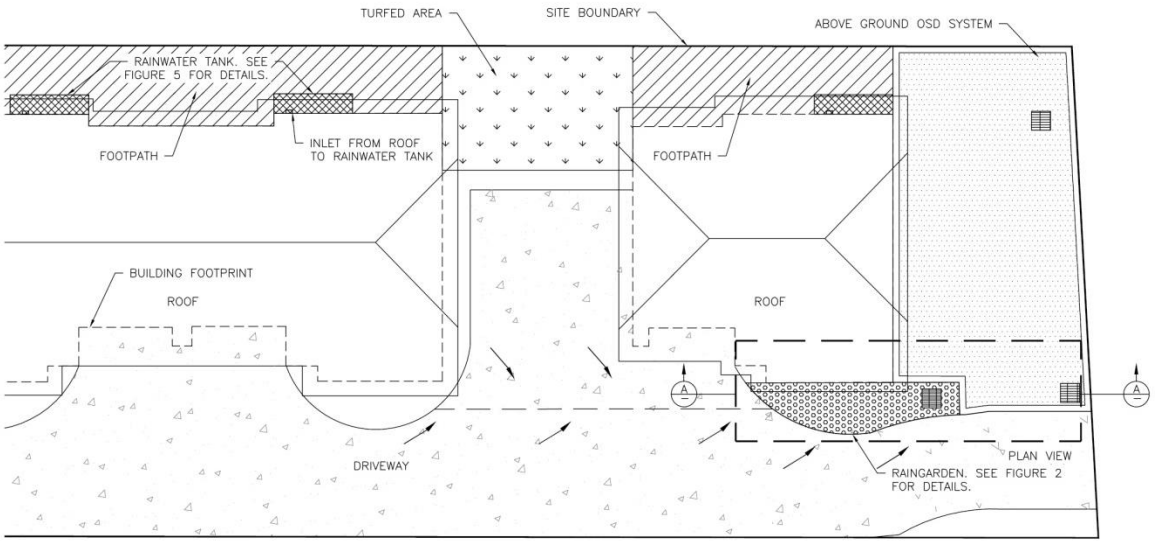
TOTAL ABOVE GROUND OSD VOLUME = 30m3

POST–DEVELOPMENT SITE AREA MATRIX

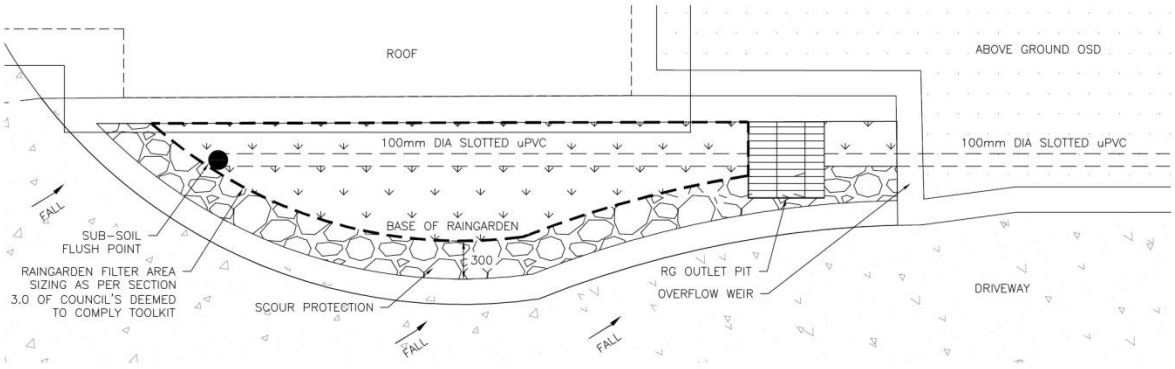
- ROOF = 386m2 (36.8% OF SITE)
- DRIVEWAY = 310m2 (29.5% OF SITE)
  - DRIVEWAY TO OSD = 288m2
  - BYPASS = 22m2
- CARPARK = 80m2 (7.6% OF SITE)
- REMAINING FOOTPATH = 61m2 (5.8% OF SITE)
- REMAINING GARDEN = 20.7m2 (2.0% OF SITE)
- RAINGARDEN = 12.3m2 (1.1% OF SITE)
  - FOOTPATH CONVERTED TO RG = 9m2
  - GARDEN CONVERTED TO RG = 3.3m2
- REMAINING TURF = 120m2 (11.5% OF SITE)
  - TURF CONVERTED TO OSD = 60m2
- ABOVE GROUND OSD = 60m2 (5.7% OF SITE)

TOTAL IMPERVIOUS AREA = 837m2 (79.7% OF SITE)
TOTAL PERVIOUS AREA = 213m2 (20.3% OF SITE)

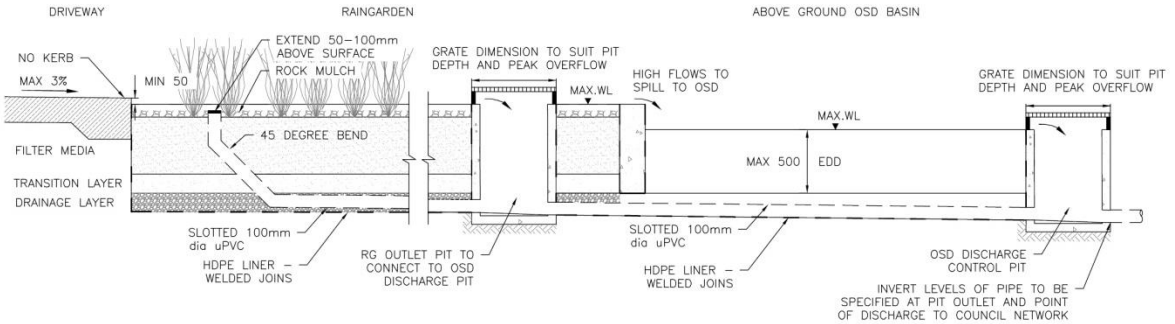
TOTAL SITE AREA = 1050m3



TYPICAL SITE LAYOUT
SCALE 1:200



PLAN VIEW
SCALE 1:50



SECTION A
SCALE 1:50

2 1 0 2 4 1:200
0.5 0.25 0 0.5 1 1:50
Original sheet size A4

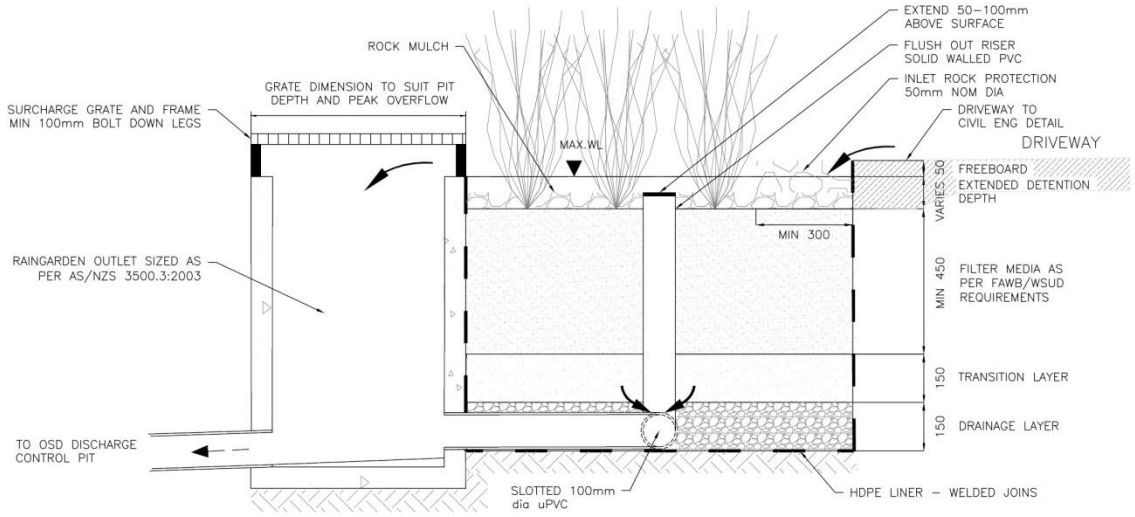
North

PENRITH CITY COUNCIL

WSUD DRAWINGS - SITE LAYOUT

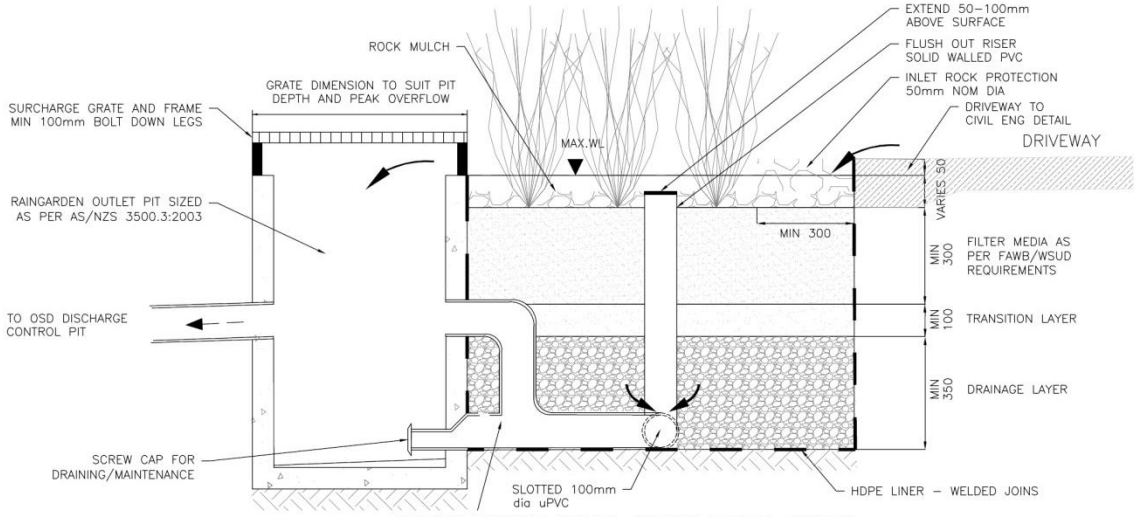
Date 30.04.15

DEEMED TO COMPLY TOOLKIT - Figure 2



STANDARD RAINGARDEN

SCALE 1:20



RAINGARDEN WITH SUBMERGED ZONE

SCALE 1:20

0.2 0.1 0 0.2 0.4 1:20

Original sheet size A4

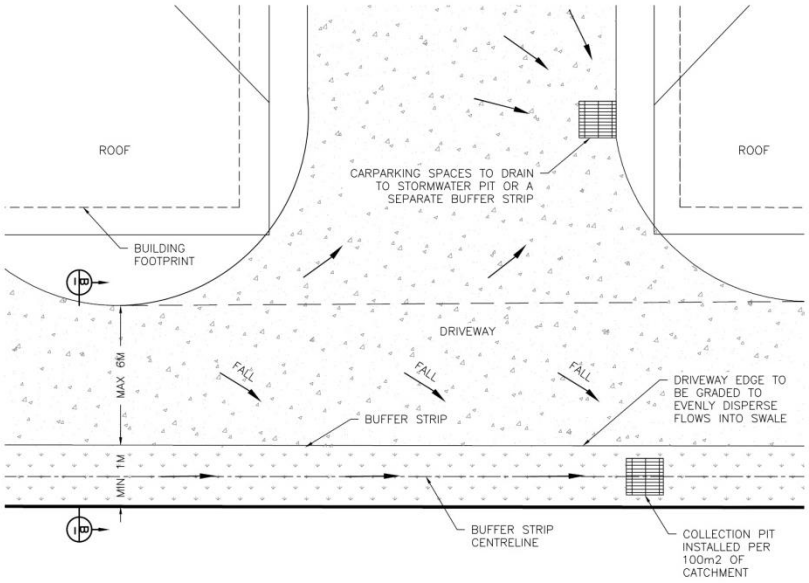
North

PENRITH CITY COUNCIL

WSUD DRAWINGS - RAINGARDENS

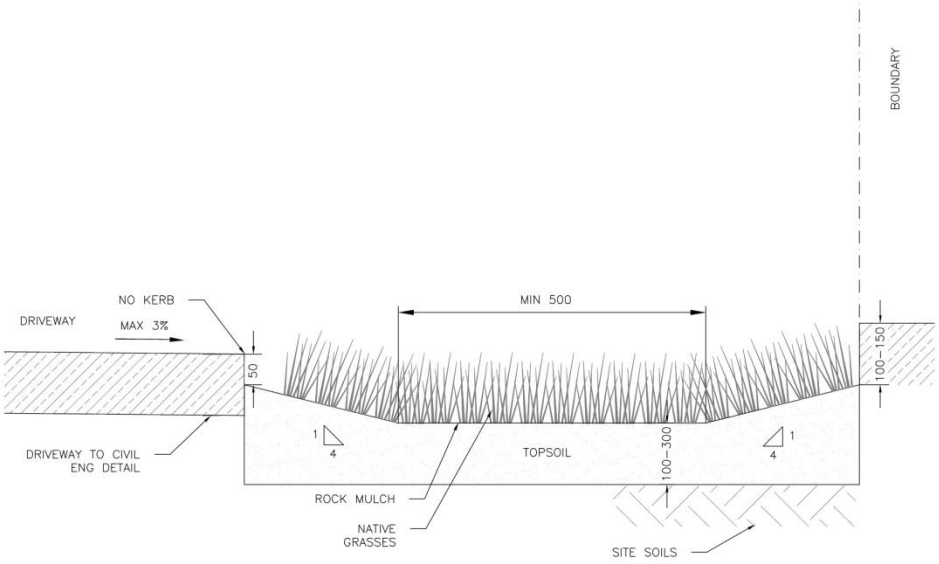
Date 30.04.15

DEEMED TO COMPLY TOOLKIT - Figure 3



TYPICAL BUFFER STRIP

SCALE 1:100



SECTION B

SCALE 1:10

1 0.5 0 1 2 1:100

0.1 0.05 0 0.1 0.2 1:10

Original sheet size A4

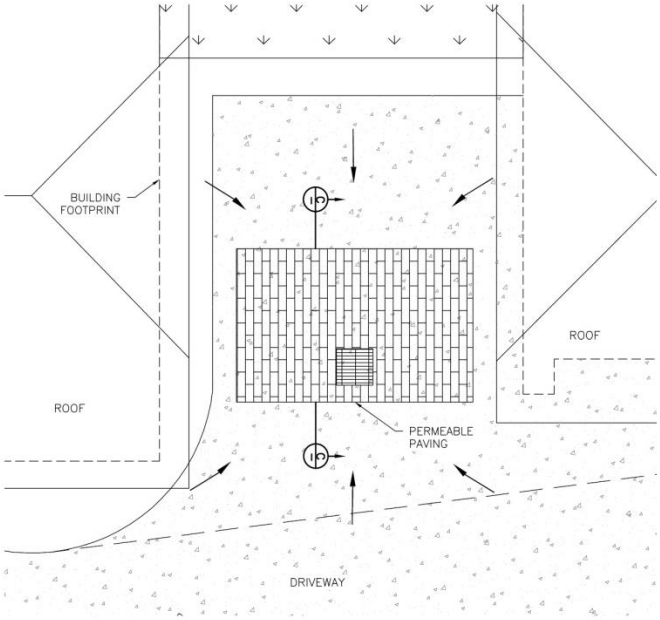
North

PENRITH CITY COUNCIL

WSUD DRAWINGS - BUFFER STRIP

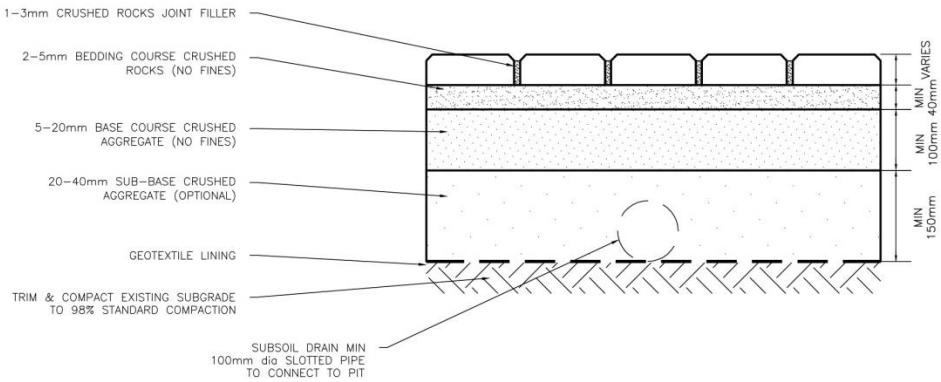
Date 30.04.15

DEEMED TO COMPLY TOOLKIT - Figure 4



TYPICAL PERMEABLE PAVEMENT

SCALE 1:100



SECTION C

SCALE 1:10

NOTE: BEDDING LAYER DEPTHS VARY FROM PRODUCT TO PRODUCT AND SHOULD BE ADJUSTED TO SUIT MANUFACTURERS SPECS AND TRAFFIC LOADING.

1 0.5 0 1 2 1:100
0.1 0.05 0 0.1 0.2 1:10
Original sheet size A4

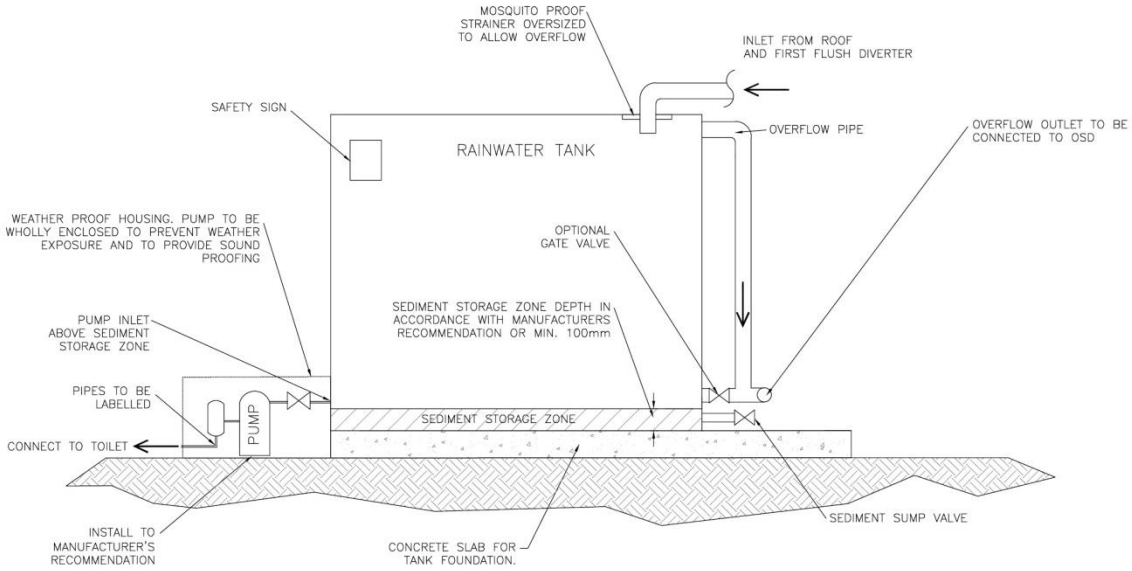
North

PENRITH CITY COUNCIL

WSUD DRAWINGS - PERMEABLE PAVING

Date 30.04.15

DEEMED TO COMPLY TOOLKIT - Figure 5



RAINWATER TANK

SCALE 1:200

NOTE: AN APPROPRIATE CONNECTION TO MAINS WATER SHALL BE INSTALLED TO SUPPLY WATER TO TANK WHEN EMPTY.

2 1 0 2 4 1:200

North

Original sheet size A4

PENRITH CITY COUNCIL

WSUD DRAWINGS - RAINWATER TANK

Date 30.04.15

DEEMED TO COMPLY TOOLKIT - Figure 6