alluvium

Northern Beaches Council

WSUD & MUSIC Modelling Guidelines

Document history

Revision:	
Revision no.	03
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Distribution:	
Revision no.	01
Issue date	June 2016
Issued to	Northern Beaches Council
Council contact	Ben Fallowfield
Description:	Final

Citation:

Alluvium, 2016. *Northern Beaches Council WSUD and MUSIC Modelling Guidelines*. Prepared by Alluvium Consulting Australia for Northern Beaches Council, Draft, June 2016.

Ref:H:\TRIM\Offline Records (7P)\Natural Environment - ~ CORPORATE MANAGEMENT - Planning - High Level Planning Documents(13)\Final Northern Beaches Council WSUD Technical Guide & Music Modelling Guidelines.DOCX

Contents

1 Introduction

Water Sensitive Urban Design (WSUD) principles seek to ameliorate the impact of urbanisation on the water cycle. WSUD Principles include:

i) Minimise the volume of stormwater run-off,

ii) reduce run-off and peak flows from urban developments by local detention basins and minimising impervious areas,

iii) treating urban stormwater to best practice standards for reuse and/or discharge to receiving waters,

iv) reducing potable water demand through water efficiency, stormwater harvesting and wastewater reuse,

v) minimising wastewater generation and treatment of wastewater so that is can be reused,

vi) integrating vegetated stormwater treatment into the landscape, so as to provide increased biodiversity, amenity and micro-climate benefits which can reduce the heat island effect, and

vii) providing green infrastructure and green links to improve habitat corridors.

This document provides guidance to Applicants in meeting the stormwater quality requirements of Warringah Council's Water Management Policy (WMP) (2015). This document must be read in conjunction with the WMP and in the event of conflict, contradiction or inconsistency, the requirements of the WMP shall prevail.

1.1 PRE-LODGEMENT MEETING

Council offers a Pre-lodgement meeting service which is strongly encouraged for large-scale, complex or controversial development applications, however is available for all development types. A fee is payable for this service with further details provided on the website link below.

Following the meeting, you will receive written advice that lists the information required for the application to be processed. It also indicates whether or not the application is likely to be accepted.

Further information can be found at http://www.warringah.nsw.gov.au/planning-and-development/application-process/submit-your-application

2 Requirements

2.1 DEVELOPMENTS REQUIRED TO MEET COUNCIL WSUD REQUIREMENTS

The following development types must meet Council's stormwater quality requirements in section 8.1 of the WMP:

- Residential Flat Buildings/Multi-residential dwelling houses – Development with a site area greater than 1000m^2
- Commercial/Mixed Use/Industrial – Development with a site area greater than 1000m^2
- Subdivision – Subdivision resulting in the creation of:
    - Two lots where the total post development impervious area of the new lots exceeds 40%
    - Three or more lots
- Increased Hard Surfaces – Development proposing an increase in impervious area of more than 50m^2

All developments must meet the Water Conservation & Reuse requirements in section 7.1 of the WMP.

2.2 WSUD REQUIREMENTS FOR DEVELOPMENT

2.2.1 Stormwater Quality

Section 8.1.1 of the WMP determines which of the two stormwater quality requirements apply to the development. The following water quality requirements apply for urban, already developed lands:

Pollutant	Performance Requirements
Total Phosphorous	65% reduction in the post development mean annual load
Total Nitrogen	45% reduction in the post development mean annual load
Total Suspended Solids	85% reduction in the post development mean annual load
Gross Pollutants	90% reduction in the post development mean annual load1 (for pollutants greater than 5mm in diameter)
pH	6.5 - 8.5
Hydrology	The post-development peak discharge must not exceed the pre-development peak discharge for flows up to the 2 year ARI

It is noted that the above targets do not require any analysis of the existing pollutant load generated at the site prior to development. The percentage reduction is assessed against the proposed development if no stormwater treatment measures are implemented.

Pollutant load requirements also apply for undeveloped land in Group A and B catchments and Land within the riparian buffer of a Coastal Upland Swamp in the Sydney Basin Bioregion Endangered Ecological Community).

Criteria	Objectives
Stormwater Quality	Stormwater quality discharging from the development shall not impact the receiving waters. Reference shall be made to local data if available, including the Warringah Creek Management Study and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC), or other widely accepted guidelines.
Sediment	Disturbance to stream and wetland sediments is to be minimised by regulated discharge of stormwater and dissipation of flows at discharge locations. Runoff from the development must be retained at natural discharge rates and sediments controlled at the source.
Hydrology	Stormwater flow is to mimic natural conditions and ensure a dispersed pattern of flow, avoiding centralised or concentrated discharge points into the wetland or waterway. Natural flow regimes must be retained. The reduction or increase in flows, alteration in seasonality of flows, changes to the frequency, duration, magnitude, timing, predictability and variability of flow events, altering surface and subsurface water levels and changing the rate of rise or fall of water levels must be avoided.

2.2.2 Water Efficiency

Buildings that are not affected by BASIX that are installing any water use fittings must demonstrate compliance with the minimum standards defined by the Water Efficiency Labelling and Standards (WELS) Scheme. Minimum WELS rated fittings include:

i. 4-star dual-flush toilets
ii. 3 star showerheads
iii. 4 star taps (for all taps other than bath outlets and garden taps)
iv. 3 star urinals
v. 3.5 star washing machines
vi. 4 star dishwashers.

Cooling towers must:

i. Connect a conductivity meter to ensure optimum circulation before discharge.
ii. Include a water meter connected to a building energy and water metering system to monitor water usage
iii. Employ alternative water sources for cooling towers where practical.

2.2.3 Rainwater Tanks

Rainwater tanks which are connected for internal use (toilet flushing & washing machine) and external reuse (garden irrigation) are encouraged for all developments.

a) Rainwater tanks shall comply with the following:

   i. Be fitted with a first-flush device that causes initial rainwater run-off to bypass the tank and must drain to a landscaped area. The first flush device will not be permitted to connect to the stormwater system

   ii. Have a sign affixed to the tank stating the contents is rainwater

   iii. Be constructed or installed in a manner that prevents mosquitoes breeding, such as the use of mesh to protect inlets and overflows

   iv. Have its overflow connected to an existing stormwater drainage system that does not discharge to an adjoining property, or cause a nuisance to adjoining owners

   v. Pumping equipment must be housed in a soundproof enclosure

   vi. Where the rainwater tank is interconnected to a reticulated water supply, it must be installed in accordance with Plumbing Code of Australia, particularly backflow/cross connection prevention requirements.

b) If OSD is required for residential development, Council may permit the volume of rainwater reuse to be credited against the calculated OSD storage volume as determined by Council's Onsite Stormwater Detention Technical Specification, provided the rainwater tank is connected for internal reuse.

2.3 SUBMISSION REQUIREMENTS

To demonstrate compliance with Council requirements as outlined above, a WSUD must be submitted with the development application. A WSUD Strategy details the water management measures to be implemented on a proposed development site including water conservation objectives and stormwater quality control to meet Council's stormwater quality targets.

The main elements to be included within a WSUD Strategy are:

- Background Information and Site Analysis
- Proposed development description
- WSUD objectives applicable
- Stormwater quality control measures and modelling demonstrating compliance with the targets
- Costs and maintenance requirements

Table 1 outlines the detail required under each of the headings and provides links to supporting information and key resources and tools available to assist in the preparation of the WSUD Strategy. The supporting information is contained both within this document as well as in external documents which are available on the internet.

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

Outline contents	Details to be provided in the WSUD Strategy	Supporting Information
Background Information and Site Analysis	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. Identify catchments, drainage lines and receiving environments (both within and downstream of the site). Characterise the ecological values of the site and its receiving environments.	
Proposed Development	Describe the proposed development at the site, including site boundaries, proposed land uses, densities, population, infrastructure, development staging.	*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 and how the treatment measures will integrate with the development layout and the surrounding area.	*Warringah Council WMP (Sections 7.1, 8)*
Stormwater quality control measures and modelling	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. • Summary of MUSIC results demonstrating compliance with the targets • 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: – bioretention systems - hydraulic conductivity, extended detention depth and filter	*MUSIC modelling software* *Standard MUSIC parameters for Warringah (Section 3 of this document)* *NSW MUSIC Modelling Guide (external link Section 1.1)* WSUD Conceptual

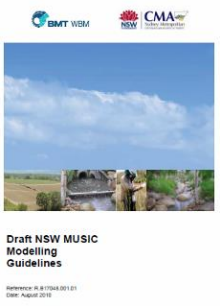
Outline contents	Details to be provided in the WSUD Strategy	Supporting Information
	depth – ponds and wetlands - inlet pond size, permanent pool depth, extended detention depth and notional detention time – swales - slope and vegetation heights • Any variation from the recommended MUSIC parameters must be reported and justified. Details of the modelling of those elements, parameters and assumptions used, and all data files must be provided.	Design *(Section 4 and external link Section 1.1)*
Cost - Operation 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.	*Concept Design Guidelines for WSUD (external link Section 1.1)*

2.4 SUPPORTING INFORMATION FOR THE PREPARATION OF A WSUD STRATEGY

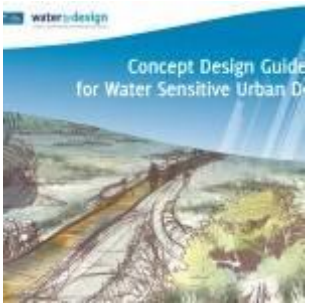
When preparing a Development Application, a proponent is required to employ the services of appropriately qualified and experienced practitioners for the development of an appropriate WSUD strategy for their site. The following information should be referred to when developing that strategy.

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) most verified and published Australian water quality research has been synthesised and incorporated into MUSIC. The latest version of MUSIC is Version 6 (2016), and is available for purchase 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 Warringah are outlined in this document.

2. MUSIC Modelling guide – the development of a MUSIC model requires specific inputs and parameters. For proposed developments in the Northern Beaches LGA key parameters for undertaking any MUSIC modelling are outlined in Section 3 of this document. Further information on MUSIC modelling is available in the *Draft NSW MUSIC Modelling Guideline*. See https://www.warringah.nsw.gov.au/sites/default/files/documents/general-information/stormwater/nsw-music-modelling-guidelines-august-2015.pdf



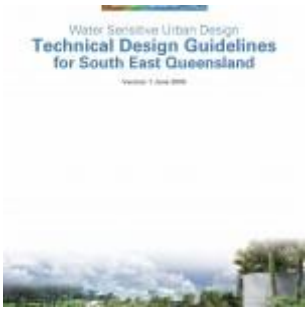
3. WSUD Conceptual Design Information – information on specific WSUD elements (such as rainwater tanks, bioretention and wetlands) and where they are appropriate is available in the South East Queensland's (SEQ) 'Water by Design' Program's Concept Design Guidelines for WSUD. This document provides an 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/



2.5 FURTHER INFORMATION BEYOND THE DEVELOPMENT APPLICATION STAGE

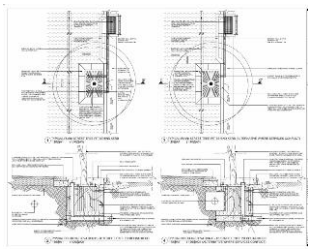
The following resources outline further information which can be used by proponents when developing detailed design / construction drawings and undertaking construction.

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. 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/

6. 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/



2.6 ENGAGING A CONSULTANT TO DEVELOP A WSUD STRATEGY

Applicants and developers are required to employ the services of appropriately qualified and experienced practitioners for the development of the Water Management Plan. The benefit of using consultants with demonstrated capacity to undertake a WSUD Strategy will generally reflect a smoother and straight forward approval process. Consultants should possess the following skills:

- Advanced MUSIC modelling training and experience
- Demonstrated experience in designing WSUD elements
- Members of the NSW Stormwater Industry Association and/or the Institution of Engineers Australia can provide a first starting point.

3 MUSIC Modelling for Northern Beaches Council DAs

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

The approaches and parameters outlined in this section should be used at all times when developing a WSUD Strategy to meet the targets outlined in Warringah Council's WMP. Further information on MUSIC Modelling is available in the *Draft NSW MUSIC Modelling Guideline*. The information contained herein 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 (2016).

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.

3.1 MUSIC PARAMETERS

3.1.1 Rainfall & evaporation inputs

The rainfall data recommended for MUSIC modelling for the Northern Beaches LGA is shown in Table 2. Council requires all stormwater quality modelling to use the Sydney Observatory 6-minute rainfall data. A modelling period of 1/1/1981 to 31/12/1985 is recommended, as this period is representative of the long-term average annual rainfall of the Northern Beaches, and also includes a number of wet and dry years.

For hydrologic modelling used for stormwater harvesting analysis and stormwater storage design (including rainwater tank sizing), continuous simulation for 50 years should be used at a daily time step for estimating supply reliability. Sydney Observatory daily data from 1925-1974 is recommended as it is representative of the long-term average annual rainfall of Northern Beaches.

Table 2: Recommended Rainfall Data for MUSIC modelling

Purpose	Time step required	Rainfall Station	Modelling Period
Water quality	6 minutes	066062 Sydney Observatory	1981-1985
Water quantity (including rainwater tanks, stormwater storages)	Daily	066037 Sydney Observatory	1925-1974

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

Table 3: Monthly Evapotranspiration for Sydney Region

Month	J	F	M	A	M	J	J	A	S	O	N	D
PET (mm)	180	135	128	85	58	43	43	58	88	127	152	163

3.2 SOURCE NODE INPUTS

3.2.1 Rainfall runoff parameters

MUSIC rainfall-runoff parameters have been derived for NSW from model calibration studies. Table 4 outlines the soil properties recommended for adoption in MUSIC modelling for Northern Beaches. The steps for setting up the rainfall runoff parameters are described below:

Step 1: Divide site into sub-catchments based on topography and land use types – all subcatchments (to be designated as separate source nodes) should be classified as Roads, Roofs, and Other impervious and Pervious areas and entered into the model at appropriate locations.

Step 2: Estimate Fraction Impervious for each sub-catchment (source node) – A calculation of the impervious fraction for each sub-catchment (source node) should be made based on the proposed land-uses (eg road, roof, carpark, landscape area etc).

The total impervious area for the site should be consistent with Council's planning controls, including minimum landscaping area, maximum building envelopes, floor space ratios and road design guidelines. For the Northern Beaches LGA some of these controls include minimum open space requirements and minimum percentage of open space and landscaped area.

Step 3: Set Soil Properties – For all source nodes, the soil characteristics shown in Table 4 should be adopted in MUSIC. These parameters have been derived based on typical soils found in the Northern Beaches LGA and can be viewed at NSW eSPADE website. The parameters for 'sand' should be used for sites within the soil landscape areas na, ww, and np. The parameters for all other soil landscape areas (gy, ha, la, nh, so, wa, wn, xx) should use the parameters for 'sandy clay loam'. Use of different soil parameters must be justified.

Table 4: Soil properties for MUSIC Source Nodes

Parameter	Unit	Recommended values	
Impervious area parameters			
Rainfall Threshold (mm)	mm	1.5 (for roads/paths etc.) 0.3 (for roofs)	
Pervious area parameters			
		Sand	**Sandy Clay Loam**
Soil Capacity (mm)	mm	350	108
Initial Storage (%)	%	30	30
Field Capacity (mm)	mm	144	73
Infiltration Capacity Coefficient a		360	250
Infiltration Capacity Coefficient b		0.5	1.3
Groundwater Properties			
		Sand	**Sandy Clay Loam**
Initial Depth (mm)	mm	10	10
Daily Recharge Rate (%)	%	100	60
Daily Baseflow Rate (%)	%	50	45
Deep Seepage (%)	%	0	0

3.2.2 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 (BMT WBM)

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	2.15	1.20	-0.60	-0.85	0.30	0.11
Residential	Std Dev	0.32	0.17	0.25	0.19	0.19	0.12
Industrial							
Commercial							
Rural	Mean	1.95	1.15	-0.66	-1.22	0.3	-0.5
	Std Dev	0.32	0.17	0.25	0.19	0.19	0.12
Paved Road Areas	Mean	2.43	---*	-0.30	---*	0.34	---*
	Std Dev	0.32	---*	0.25	---*	0.19	---*
Roof Areas	Mean	1.30	---*	-0.89	---*	0.30	---*
	Std Dev	0.32	---*	0.25	---*	0.19	---*
Unsealed Roads	Mean	3.00	1.20	-0.30	-0.85	0.34	0.11
	Std Dev	0.32	0.17	0.25	0.19	0.19	0.12
Forest	Mean	1.60	0.78	-1.10	-1.52	-0.05	-0.52
	Std Dev	0.20	0.13	0.22	0.13	0.24	0.13
Landscape Areas	Mean	2.15	1.20	-0.60	-0.85	0.30	0.11
	Std Dev	0.32	0.17	0.25	0.19	0.19	0.12
Revegetated Areas (inc. APZs)	Mean	1.95	1.15	-0.66	-1.22	0.30	-0.05
	Std Dev	0.32	0.17	0.25	0.19	0.19	0.12

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

3.3 TREATMENT NODE INPUTS

To meet the 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.

In order to avoid any confusion relating to treatment node implementation Council provides the following advice for modelling stormwater quality treatment systems within the Northern Beaches LGA.

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 = 50-200 mm/hr Filter depth = 0.5 – 0.8m (this excludes transition and drainage layer). TN content of filter media = >600mg/kg Orthophosphate content of filter media = >30mg/kg Exfiltration rate = 0 mm/hr Overflow weir width = surface area/10m. If an overflow weir is undersized, it results in water backing up and adding additional extended detention. Note that a submerged (saturated) zone requires a specially designed outlet pit configuration.
Gross pollutant traps 	High flow bypass for the device = typically 3-month ARI peak flow. If an alternative is used it should be justified in the report. Gross pollutant removal should be obtained for the specific GPT type proposed from the supplier (independently verified). Pollutant removal should be based on Appendix C of the MUSIC User Manual and the *Draft NSW MUSIC Modelling Guideline.* GPTs should generally be used as pre-treatment measure for larger subcatchment scale sites, prior to treatment through bioretention or wetland etc. They are not usually required as pre-treatment for small, street scale systems.

Stormwater treatment measures	Selected key parameter values and design guidance
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. Seepage loss should be modelled as 0mm/hr unless it can be shown that infiltrated flows will re-contribute to observable downstream flows Evaporative loss shall be left as default at 125% of PET
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. Set low flow bypass to $0m^3/s$ unless low flows draining to the swale would bypass in low flow events (e.g. low flow pipe under the swale) Swale depths should be between 0.15 and 0.3m in road reserves and can be deeper in other areas (e.g. open space areas) Model seepage loss as 0mm/hr unless it can be proven that infiltrated runoff would not contribute to observed flows downstream.
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 for retrofits. An assumption of no more 75% connection is feasible for greenfields developments. If using stored water for irrigation, insert annual irrigation demand (kL/yr) and provide other irrigation estimation details. For a daily demand (kL/day), make estimation based on proposed building design with calculations of proposed demands to be connected (e.g. toilet flushing and/or washing machines). Water demands must be justifiable.
Infiltration systems 	Infiltration is not a stormwater treatment measure and stormwater treatment should be provided upstream of infiltration basins. MUSIC pollutant removal parameters assume that the basin is vegetated and that stormwater is pre-treated to remove coarse sediment upstream of the retention/infiltration basin. If these assumptions are not true, then the basin should not be expected to meet the pollutant removal performance estimated in MUSIC.
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).

Stormwater treatment measures	Selected key parameter values and design guidance
Sedimentation basins 	Permanent pool volume (PPV) 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 A maximum notional detention time of 8 hours should be adopted for modelling a sedimentation basin (assuming average settling zone depth of 1m). If a longer period is desired, an alternative treatment measure incorporating vegetation should be adopted as well.
Detention basins 	Detention tanks/basins are not valid treatment systems and are not to be included within a site stormwater quality treatment strategy. Refer to Council's 'Stormwater and On Site Detention Code (1999)' for details on OSD requirements.
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. Examples of applications include proprietary treatment devices, flow diversions, or sewer overflows. This option should only be used if the user has sufficient data to model it effectively. For proprietary SQID's verified water quality studies must be appended to the stormwater report clearly demonstrating that the proposed SQID achieves the pollutant reductions adopted in the MUSIC node.
ALL TREATMENT NODES	If infiltration is allowable based on a site specific investigation, seepage loss (exfiltration rate) should be as follows: - 36 mm/hr for sandy sites (within soil landscape zone tu) - 3.6 mm/hr for sandy clay loam (within soil landscape zones gy, ha, dc) If site specific hydraulic conductivity tests are carried out these can be used to set an alternative exfiltration rate. 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. If advanced properties are changed, justification is required.

4 Bioretention Systems as WSUD Treatment

Bioretention systems are commonly used in Sydney 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.

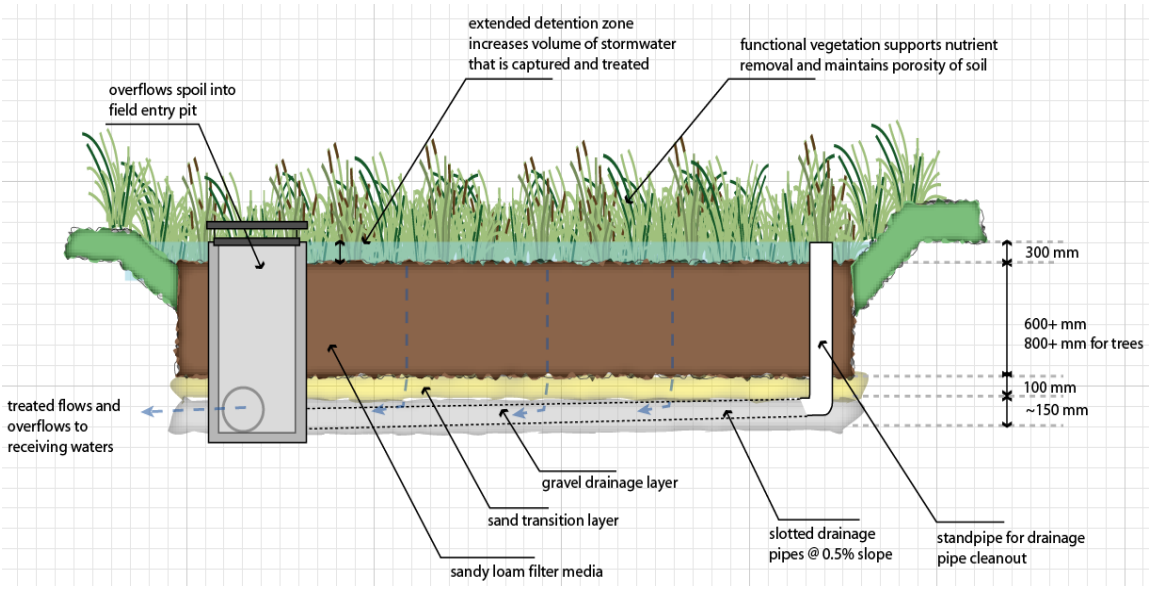


Figure 1: Bioretention system typical arrangement (Water by Design 2009)

Bioretention systems can be implemented in almost any size/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 meet the stormwater treatment targets identified in Council's WMP 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.

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. Examples of rain-gardens are shown in Figure 2.

Figure 2: WSUD rain-gardens in Beach Rd Collaroy (left), Richmond Ave, Dee Why (right) (Photos: Ben Fallowfield)

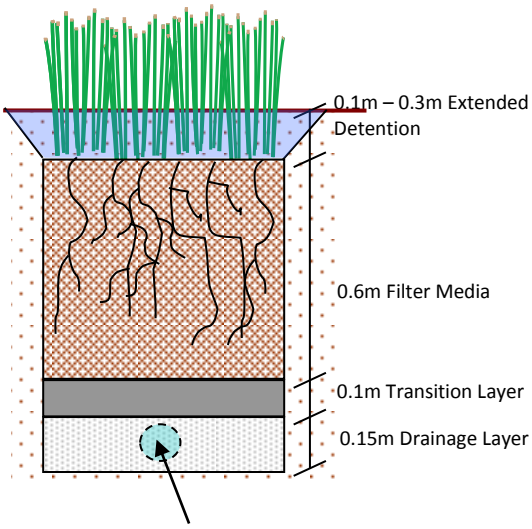
Street trees

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 3.

Figure 3: WSUD in Street Tree pits - Hornsby (left), Meadowbank shops, Ryde (centre left), Sydney University (centre right) (Photos: Alluvium).

4.1 ELEMENTS OF A BIORETENTION SYSTEM

A bioretention system includes the following components:

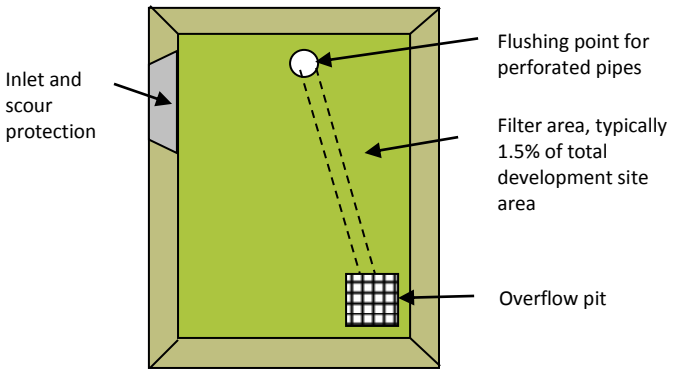


- **Vegetation** prevents surface clogging and assists in pollutant removal via biological processes. Some plant species that can be used include:
    - *Imperata cylindrica* (Blady Grass),
    - *Fincia nodosa* (Syn. Isolepis nodosa) (Knobby Club Rush),
    - *Juncus usitatus* (Common Rush),
    - *Lomandra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

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.
- 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.

4.1.1 Detailed design guidance

All stormwater quality devices must be designed in accordance with the Water by Design Technical Guidelines. Additional guidance in the form of typical drawings for bioretention systems at steep or flat sites, in footpaths or roadways, has been developed is available at the following link - http://www.wsud.org/resources-examples/tools-resources/.

4.1.2 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 bioretention system should be connected at the end of the construction phase.

- 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 in Section 0.

5 Requirement for Detailed Design and Management Plan for Issue of a Construction Certificate

5.1 DETAILED DESIGN

As part of the conditions of consent required for the issuing of a Construction Certificate, a proponent is required to prepare detailed designs of the stormwater quality treatment system. The system must be designed in accordance with the Water by Design Technical Guidelines and meet any requirements of Council's Water Management Policy. The details designs must be prepared by a suitably qualified practicing professional.

The detailed designs must be prepared to make provision for the following:

- The stormwater quality treatment Design and Management Plan must be generally in accordance with the Water Sensitive Urban Design (WSUD) Strategy in Report titled [REPORT TITLE] and Drawing No [DRAWING No] prepared by [CONSULTANT NAME] and dated [DATE] and [DATE] respectively.
- The Design must address stormwater pollutant loads generated within the property. The applicable water quality targets provided in Section 8 of Council's WMP (2015) must be shown on the Plan together with each physical component of the stormwater treatment train.

5.2 MANAGEMENT PLAN

The Management Plan must outline how all elements of the water quality treatment facility will be maintained and renewed, including estimates of capital, operation, and maintenance costs. The Management Plan must provide a summary timeline of maintenance actions together with a pictorial/diagrammatic rendering of the water quality treatment facility. The Plan must also contain the following:

a) Inspection and maintenance schedule of all stormwater quality treatment devices

b) Record keeping and reporting requirements

c) Funding arrangements for the maintenance of all stormwater quality treatment devices

d) Waste management and disposal

e) Traffic control measures (if required)

f) Relevant contact information

g) Renewal and replacement requirements of all stormwater quality treatment devices

h) Work Health and Safety requirements

6 During Construction Requirements

6.1 PROTECTION OF WATER QUALITY DEVICES

Unless being part of the sediment and erosion strategy for the development, all water quality devices must be protected until the site is fully stabilised to the satisfaction of the certifying Civil Engineer. This is to ensure that excess sedimentation resulting from the development does not detrimentally impact on the water quality device prior to commissioning.

The primary form of asset protection should be through building controls, for example to prevent sediment from washing off site in stormwater runoff. At source building controls may include:

- silt fences/straw bales
- fences/bollards around WSUD treatment systems
- sacrificial layers in treatment systems
- temporary planting during construction for sediment control (e.g. with turf), which can then be removed and the area planted out with long term vegetation
- temporary sedimentation basins
- temporary diversions of stormwater around WSUD asset during construction

7 Post Construction

7.1 CERTIFICATIONS OF WORKS AND WORKS AS EXECUTED DRAWINGS

Upon completion of the Works, the system must be certified by a suitably qualified and experienced Civil Engineer, who has membership to the Institution of Engineers Australia and National Professional Engineers Register (NPER), with Works-as-Executed drawings supplied to Council in respect of:

1. Compliance with the development application.
2. The Works have been constructed in accordance with the approved drawings. Where 'approved drawings' are those that bear Council's approval stamp. The Certification shall be signed and dated, and read

   *"I have carried out all inspections necessary to declare that the work nominated in drawing No.*******, have been carried out in accordance with the approved plans and specifications, and the conditions of development consent".*
3. The Works-as-Executed drawings are to be prepared by a Registered Surveyor and submitted to Council, to include all relevant levels, reduced to Australian Height Datum and locations including:
   - invert levels,
   - surface or pavement levels,
   - floor levels including adjacent property floor levels, if required,
   - maximum water surface level for 100 year ARI storm,
   - dimensions of basin(s), tank(s), pit(s), etc.,
   - locations of basins and distances from building and boundaries,
   - storage volume(s) provided
   - Size of the Orifice.

If the Applicant chooses to have an Accredited Certifier prepare the Construction Certificate, then certification of the Works must be provided by the Accredited Certifier including the submission of Works-as-Executed drawings in respect of the above points.

A copy of the Works-as-Executed drawings must be lodged for Council's records.

Works as Executed Drawings must be prepared in accordance with Council's Guideline for Preparing Works as Executed Data for Council Stormwater Assets.

7.2 POSITIVE COVENANT

All stormwater quality systems shall require the creation of a Positive Covenant and Restriction on the Use of Land in favour of Warringah Council on the Title, under Section 88E of the *Conveyancing Act 1919* for newly created lots. For existing Titles, a Positive Covenant is to be created by an application to the NSW Department of Lands using Form 13PC. The Restriction on the Use of Land is to be created using Form 13RPA.

The purpose of the Covenant is to ensure that the registered proprietor takes care, control and maintenance obligations for all water sensitive urban design measures. The Restriction on the Use of Land is to ensure that the system is not altered in any manner, shape or form.

The terms of the instrument must be approved by Council. However, standard terms to be included in the Positive Covenant and the Restriction on the Use of Land are given in Council's On-site Stormwater Detention Technical Specification.

All drainage easements are to be acquired prior to the issue of the Development Consent and Positive Covenants and Restriction on the Use of Land are to be finalised prior to the issue of the Occupation Certificate.

7.3 MONITORING

On-going monitoring of WSUD systems is recommended to check the functionality of WSUD assets. A monitoring regime needs to be developed to effectively monitor the system, to ensure monitoring results accurately represent the functionality of the system. Regimes should include regular monitoring of the WSUD systems, rather than irregular spot samples that won't always accurately represent the system functionality. The monitoring method should be outlined in the maintenance plan and should clearly state the required monitoring frequency. Monitoring results should be reported back to council.

8 Applicant Lodgement Checklist for WSUD Strategy

This lodgement checklist is to be used by Applicants who are required to complete a WSUD Strategy Report to meet the requirements of Warringah Council's WMP.

Detail	Location of Information (eg p2 of WSUD Report, drawing3a.dwg)	Information Supplied Yes / No
Proposed development – Information on the development site, including existing site conditions, site boundaries, proposed land uses, densities, population, infrastructure, development staging. This component must include: • Catchment plan, showing clearly the extents of each subcatchment draining to each treatment system. • Stormwater drainage plan, showing clearly the configuration of the drainage infrastructure including all pits, pipes and treatment systems.		
WSUD objectives		
Stormwater quality - demonstrate how the stormwater quality targets will be met. The WSUD Strategy should include stormwater quality modelling results and identify the location, size and configuration of stormwater treatment measures.		
Costs - capital and operation and maintenance cost estimates of proposed WSUD measures.		
Maintenance Plan – A maintenance plan should outline how the WSUD elements will be maintained.		
Appendix A – MUSIC Model, including: • Screenshot of the MUSIC model. • Sqn or Sqz model of catchment with treatment measures. (to be supplied electronically) • Sqn or Sqz model of catchment without treatment measures. (to be supplied electronically) • Electronic / hard copy of the catchment and subcatchment from MapInfo or other approved format. Modelling Assumptions and inputs, including: • Description of rainfall/ET data used • Catchment details and a description of the approach taken. • Description of how fraction impervious was calculated (what figures were used for different zonings). • Description of and documentation for any departure from the "MUSIC Inputs" outlined in Section 3.1 • Modelling Results, including: • Mean annual load reduction for TSS, TP and TN • % reduction of each treatment system • % reduction of total treatment system • Describe the function and intent of the treatment system.		

9 Case Study - Industrial

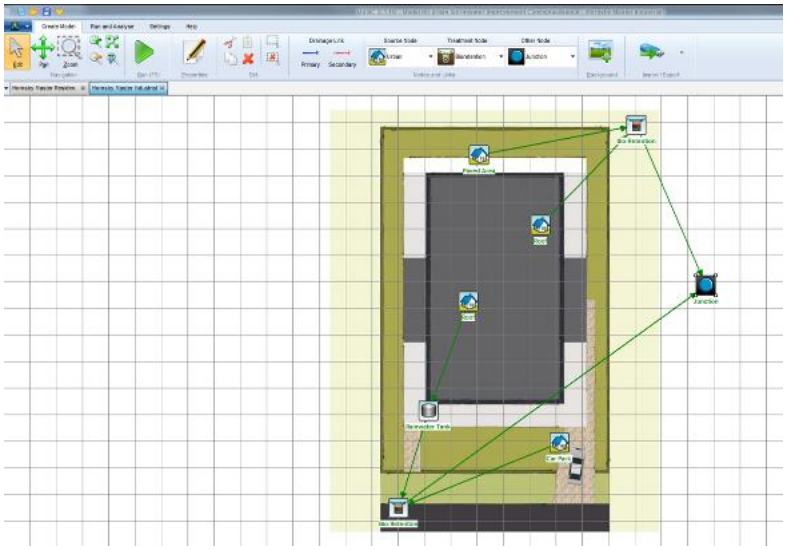
To demonstrate how WSUD can be applied to an industrial site in the Northern Beaches, the following case study has been developed. The case study presents a generic industrial development layout and highlights steps undertaken in identifying WSUD options for the site. The site is 45m x 60m and has the following dimensions:

- Total Area – 2700m^2
- Roof – 1,600m^2 (60% site)
- Car Park – 400m^2 (15%)
- Driveway – 360m^2 (14%)
- Front Veg – 250m^2 (9%)
- Back Veg – 45m^2 (2.5%)
- Back Paved – 45m^2 (2.5%)

The roof drains both to the front and the back of the property, with approximately 60% of the roof draining to the front, and 40% to the rear. The development is two storeys and includes a central toilet block in the middle of the building. The non-potable water usage for both toilet flushing and irrigation has been estimated at 1kL/day.

9.1 SIZING STORMWATER TREATMENT SYSTEMS

A MUSIC model (v6) was developed to determine the size of the stormwater treatment measures to meet the water quality targets. As outlined above the development drains both to the front and the rear of the property. To ensure that the whole site is treated, two discrete catchments were modelled.



The roof and paved area draining the back of the property were treated in a bioretention system. The total area draining the back of the property is 685m^2 (roof 640m^2 and paved area 45m^2). An approximate size of the bioretention system would be 1.5% of the area, or 10m^2. A bioretention of 15m^2 was modelled and found to meet the pollution loads from the catchment.

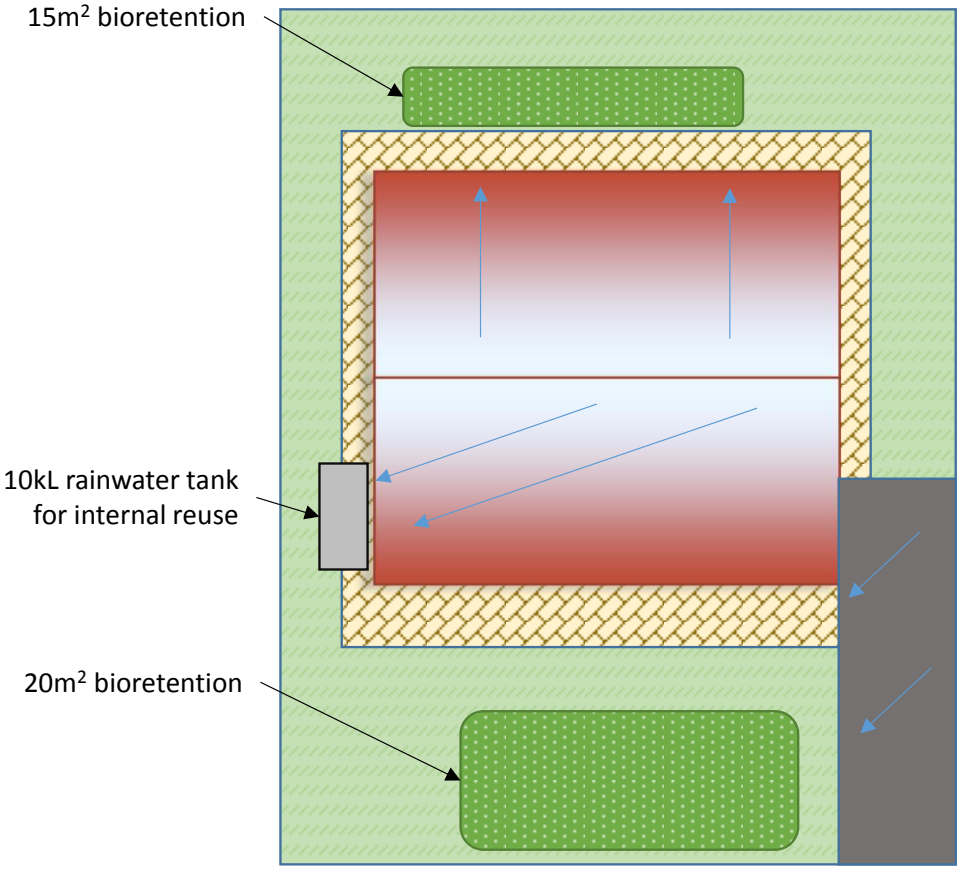
In the front of the property the roof drains to a 10kL tank which is used for internal uses (1kL/day), with the overflows and the carpark / driveways areas draining to a bioretention system. The areas to be treated by the bioretention system are 1,720m^2, including the roof overflows (960m^2), carpark and driveway (760m^2). An approximate size of the bioretention system would be 1.5% of the area, or 25m^2. A bioretention of 20m^2, coupled with reuse from the rainwater tank was found to meet the pollution loads from the catchment.

Both of the catchments attained the stormwater treatment targets as identified in Section 8.1 of Council's WMP, with the pollution reduction shown in the following table.

Parameter	Inflow	Outflow	% Reduction	Target
Flow (ML/yr)	1.0	0.8	20.3%	
Total Suspended Solids (kg/yr)	137.0	18.4	86.5%	85%
Total Phosphorus (kg/yr)	0.3	0.1	74.3%	65%
Total Nitrogen (kg/yr)	2.2	1.0	54.9%	45%
Gross Pollutants (kg/yr)	25.1	0.0	100.0%	90%

The MUSIC model used the default parameters identified in Section 2. The bioretention system has an extended detention depth of 0.2m and a filter depth of 0.6m.

The WSUD solution for the site is shown in the attached schematic with two bioretention systems and a rainwater tank. The bioretention systems can be integrated into the vegetated areas in both the front and back of the property.



10 Case Study – High Density Residential

To demonstrate how WSUD can be applied to a residential site in the Northern Beaches, the following case study was developed. The case study presents a generic high density development and identifies WSUD options for the site. The site is 60m x 45 m and has the following area:

- Total – 2,400m^2
- Roof – 1,200m^2 (50% of site)
- Driveway – 180m^2 (7.5%)
- Landscape Areas – 640m^2 (26.7%)
- Internal Courtyard – 380m^2 (15.8%)

10.1 WATER CONSERVATION MEASURES

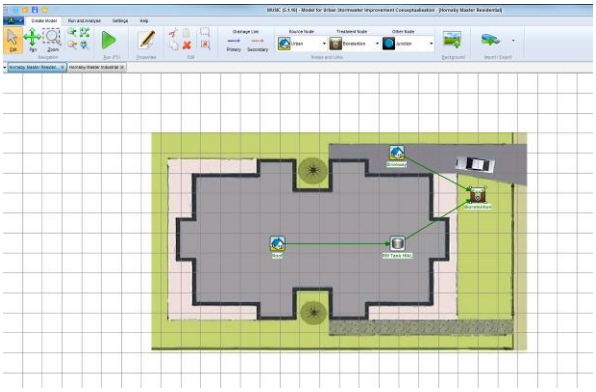
As this is a residential development, water conservation targets must meet the BASIX Scheme, which requires a 40% reduction in potable mains water consumption. More information is available at BASIX http://www.basix.nsw.gov.au. The BASIX Tool can be used to determine the size of a rainwater tank or other non-potable supply to meet the irrigation demands as required.

10.2 SIZING STORMWATER TREATMENT SYSTEMS

A MUSIC model was developed to determine the size of the stormwater treatment measures to meet the water quality targets. As determined in the site assessment the development drains to one point and only one catchment was therefore modelled.

In this scenario the roof area drains to a rainwater tank. The irrigation demands for the 640m^2 landscaped area were estimated as 250kL/year. A 10kL tank was found to meet 82% of the reliability of the demand and is seen as the optimal size.

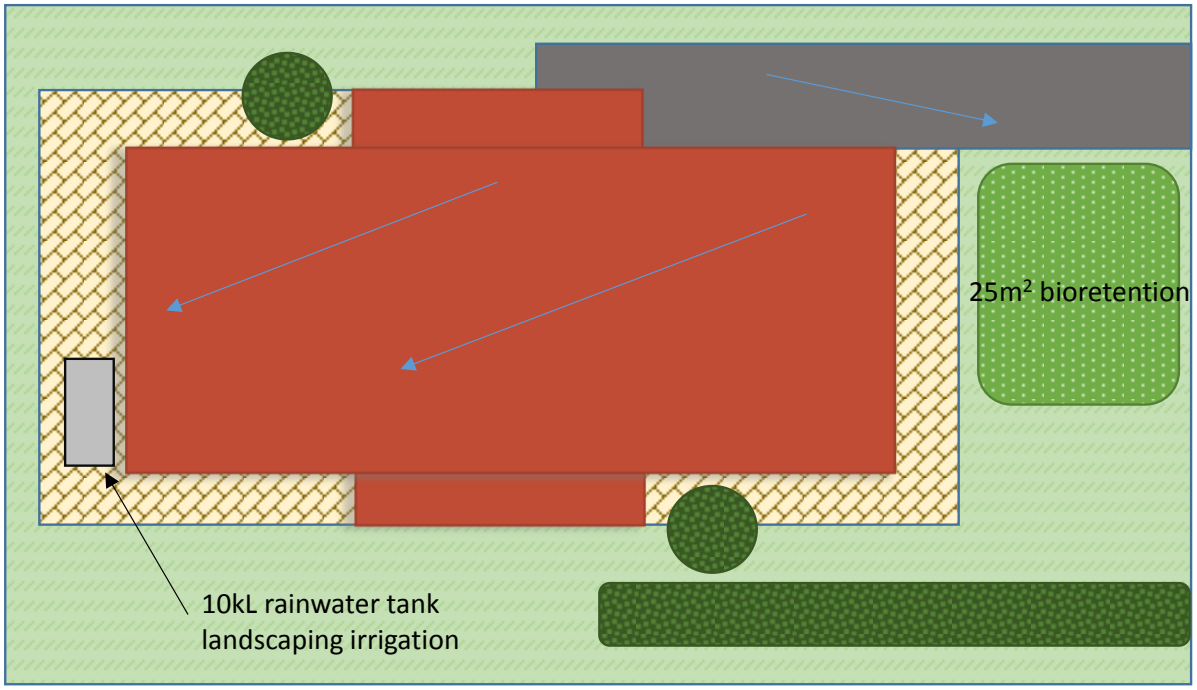
The model set-up is shown in the schematic and includes the roof draining to a 10kL tank irrigation, with the overflows and the driveway draining to the bioretention system. The area to be treated by the bioretention system is 1380m^2, including the rainwater tank overflows (from roof area of 1,200^2) and the driveway (180m^2). An approximate size of the bioretention system would be 1.5% of the area, or approximately 20m^2. A bioretention of 25m^2, coupled with reuse from the rainwater tank was found to meet



the pollution loads from the catchment. The bioretention system has an extended detention depth of 0.2m and a filter depth of 0.6m. The MUSIC modelling results are shown in the following table.

Parameter	Inflow	Outflow	% Reduction	Target
Flow (ML/yr)	1.3	1.0	20.0%	
Total Suspended Solids (kg/yr)	87.6	10.0	88.6%	85%
Total Phosphorus (kg/yr)	0.3	0.1	53.6%	65%
Total Nitrogen (kg/yr)	2.8	1.1	62.0%	45%
Gross Pollutants (kg/yr)	32.4	0.0	100.0%	90%

The WSUD solution for the site is shown in the schematic diagram below with one bioretention system and the rainwater tank. The bioretention systems can be integrated into the vegetated areas in the front of the property.



11 References

Full web addresses are provided for the weblinks throughout this document:

WSUD.org Typical WSUD Drawings;
http://www.wsud.org/resources-examples/tools-resources/

Sydney CMA Draft NSW MUSIC Modelling Guideline
http://www.wsud.org/resources-examples/tools-resources/
http://www.wsud.org/wp-content/uploads/2012/07/Draft-MUSIC-Modelling-Guidelines-31-08-201011.pdf

eWater – MUSIC software
http://www.ewater.com.au/products/ewater-toolkit/urban-tools/music/

South East Queensland's (SEQ) 'Water by Design' Program's WSUD Technical Design Guidelines for South East Queensland. http://waterbydesign.com.au/TechGuide/

South East Queensland's (SEQ) 'Water by Design' Program's Concept Design Guidelines for WSUD.
http://waterbydesign.com.au/conceptguide/

Sydney Metropolitan CMA Concept Design Interim Reference Guideline.
http://www.wsud.org/resources-examples/tools-resources/
http://www.wsud.org/wp-content/uploads/2012/07/WSUD-Interim-Reference-Guideline-Concept-Design-Guidelines-FINAL1.pdf

South East Queensland 'Water by Design' Program Construction and Establishment Guidelines,
http://waterbydesign.com.au/CEguide/

Sydney Metropolitan CMA Construction and Establishment Interim Reference Guideline.
http://www.wsud.org/resources-examples/tools-resources/

Warringah Council Water Management Policy
http://www.warringah.nsw.gov.au/sites/default/files/documents/policies-register/environment/water-management-policy/2016-011845-water-management-policy-current.pdf