MUSIC

Modelling Guidelines
November 2018

CONSULTATION DRAFT

water by design
a Healthy Land and Water initiative

ISBN xxx-x-xx-x

Version 3 2018

This publication should be cited as: Healthy Land and Water (2018) MUSIC Modelling Guidelines, Healthy Land and Water Limited, Brisbane, Queensland. ISBN xxx-xx-xxx

DISCLAIMER

The material contained in this publication is produced for general information only. It is not intended as professional advice on specific applications. It is the responsibility of the user to determine the suitability and appropriateness of the material contained in this publication to specific applications. No person should act or fail to act on the basis of any material contained in this publication without first obtaining specific independent professional advice. Healthy Land and Water expressly disclaim any and all liability to any person in respect of anything done by any such person in reliance, whether in whole or in part, on this publication. The information contained in this publication does not necessarily represent the views of Healthy Land and Water and its network.

ACKNOWLEDGEMENTS

Version 3 of the MUSIC Modelling Guidelines were developed by Healthy Land and Water and Water by Design.

Authoring Team (V2&3) Andrew O'Neill (Healthy Land and Water), Karen Toms (Healthy Land and Water), Glenn Browning (Healthy Land and Water) and Jack Mullaly (Ideanthro), with technical input from Tony Weber (Alluvium Consulting), Shaun Leinster (DesignFlow) and Alan Hoban (Bligh Tanner).

Authoring Team (V1): Tony Weber (BMT WBM), Shaun Leinster (DesignFlow), Eleanor McKeough, (DesignFlow), Paul Dubowski and Alan Hoban (Water by Design program)

HEALTHY LAND AND WATER

Healthy Land and Water is an independent organisation dedicated to improving and protecting South East Queensland's environment. As experts in research, monitoring, evaluation and project management, we deliver innovative and science-based solutions to challenges affecting our landscapes, waterways and biodiversity.

Our Water by Design initiative was established in 2005 and builds the capacity of the water and urban development sectors to help successfully implement sustainable cities through better urban water management. Find out more at www.waterbydesign.com.au

For further information about or to provide feedback on this guideline or other projects, please email info@hlw.org.au or telephone (07) 3177 9100.

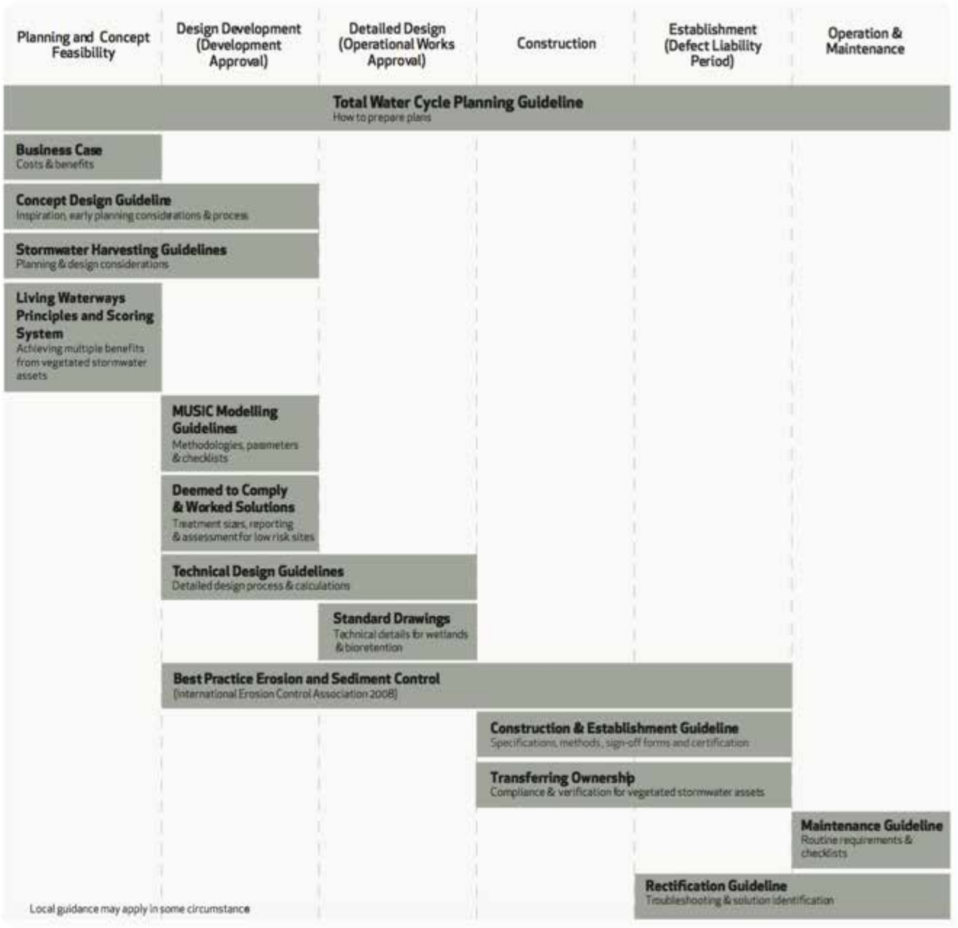
Contents

LIST OF TABLES

LIST OF FIGURES

Chapter 1 Introduction

Water by Design Tools & Resources



The above diagram illustrates the context in which the MUSIC Modelling Guidelines relate to other resources which assist in the planning, design` and implementation of water sensitive urban design.

Since Healthy Land and Water first published the MUSIC Modelling Guidelines in 2010, the management of the impacts of urban stormwater has become embedded in policy and practice for new urban developments in Queensland. MUSIC Modelling forms a key part of the compliance approach for these policies, ensuring that all new applicable development meets the Urban Stormwater Management Design Objectives set out by the Queensland and local governments. Local government and natural resource management groups also use MUSIC modelling to strategically plan future investment in catchment management.

Apart from water quality objectives, stormwater infrastructure must achieve an integrated outcome with the built landscape that contributes multiple benefits for our communities.

In this way good stormwater management makes a significant contribution to economically, socially and environmentally sustainable development by providing a range of benefits such as improved community health through increased recreation in outdoor environments, improved amenity, and protection of natural waterways.

While MUSIC modelling is an invaluable concept design tool, it is only part of the story – Healthy Land and Water has published a range of tools to help users achieve these outcomes including Living Waterways in addition to the MUSIC Modelling guidance provided in this document.

FOR MORE INFORMATION VISIT:

www.waterbydesign.com.au

Chapter 1 Introduction

The urbanisation of our cities places pressures on both our valued local waterways and receiving environments such as the Great Barrier Reef. These impacts, combined with increasing demand for urban green space, highlight the importance of managing these impacts through the provision of urban green infrastructure using a water sensitive urban design approach.

The need and approaches have been recognized internationally and in Australia through major research initiatives such as the Cooperative Research Centre for Water Sensitive Cities, through State and Local Government policies that set quantitative requirements for mitigating urban stormwater impacts caused by pollution and hydrologic change, and significant investment from industry to achieve these objectives.

The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) is a software tool that simulates the behaviour of stormwater in urban catchments and is a commonly used tool for demonstrating the performance of stormwater quality treatment systems.

It is important to emphasise that MUSIC is a conceptual design decision support tool that informs an iterative design approach. MUSIC utilizes local climate and soil information, to show how a conceptual development will alter hydrology and pollutant runoff, and allows the user to test a variety of options to first reduce these impacts, and then mitigate the residual impacts. By using this hierarchy significant cost savings can be delivered to clients and ultimately the community.

The purpose of the MUSIC Modelling Guideline is to provide consistent and uniform guidance to stormwater quality modelling and assessment. This guideline focuses on providing preferred MUSIC parameters to demonstrate compliance with stormwater management design objectives and should be read in conjunction with the MUSIC User Manual. See Section 2 for further details on stormwater management design objectives.

Assessment authorities will require that all reporting of MUSIC modelling submitted as supporting evidence with development applications is consistent with these guidelines unless locally specific guidelines are available. Before preparing a MUSIC model for a development application, the applicant should contact the relevant assessment authority to ensure use of the most current version of the guidelines and to fully appreciate locally specific reporting requirements.

In addition to modelling water quality outcomes, other aspects of the design of stormwater treatment systems should be considered such as their integration into urban landscapes, aesthetics and social benefits, protection of natural environments, and consideration of long term maintenance requirements. Healthy Land and Water have developed a tool titled 'Living Waterways' to assist with assessing these and other design components.

FOR MORE INFORMATION VISIT:
www.livingwaterways.com.au

THE GUIDELINES ARE STRUCTURED AS FOLLOWS:

CHAPTER 2: Stormwater management design objectives – discusses the stormwater management design objectives for Queensland.

CHAPTER 3: Catchment model set-up – specifies the preferred meteorological data; source node, rainfall runoff, pollutant export parameters; and the definition of MUSIC catchments (note that locally specific information can be found in Appendix A).

CHAPTER 4: Stormwater treatment nodes– provides guidance on the configuration and parameters for modelling stormwater treatment nodes.

Photo: Alan Hoban - Bligh Tanner

CHAPTER 5: Life cycle cost – summarises the method for estimating life cycle cost information with MUSIC and discusses the important cost information for reporting.

CHAPTER 6: Results – describes how to analyse model results to determine whether the treatment strategy complies with stormwater quality objectives.

CHAPTER 7: Reporting and assessment – outlines the information about MUSIC modelling required by assessment authorities for development applications.

These guidelines have been prepared for urban stormwater management professionals experienced in using MUSIC and designing and/or assessing stormwater quality treatment systems. Prior to undertaking MUSIC modelling readers should refer to the MUSIC User Manual and undertake formal training in MUSIC modelling. MUSIC training is provided by the eWater. The eWater training provides a background to the software, technical information that underpins the model, and advice on how to set up a MUSIC model. Further information about MUSIC is also available via the Catchment Modelling Toolkit ewater.org.au/products/music/

Proponents must ensure modelling is consistent with these guidelines (or other locally accepted guidelines), to demonstrate compliance with the minimum best practice, load-based, locally applicable objectives.

Refer to **hlw.org.au** for further information on planning, designing and constructing stormwater management measures.

Chapter 2 Stormwater Objectives

Photo: Dr Andrew O'Neill

Chapter 2 Stormwater Objectives Addressed By This Guideline

Stormwater management objectives may be specified in a range of planning documents (including State Planning Policies, Regional Plans, Local Government Planning Schemes etc). Please refer to the relevant authority to obtain information on the most up to date information on design objectives. For more information visit:

www.waterbydesign.com.au

Stormwater Management Design objectives in Queensland are driven by the Water Quality part of the State Planning Policy (DILGP, 2017) which set out requirements and objectives for:

- Stormwater Quality Management
- Waterway Stability

The State Planning Policy (DILGP, 2017) also sets out requirements for new development to achieve "Liveable communities" and requires that development achieves, for example "attractive, adaptable and accessible built environments…, providing attractive and accessible natural environments and public open space and facilitating vibrant places and spaces, diverse communities, and good neighbourhood planning and centres design that meets lifestyle needs." Recently updated local government planning scheme policies also reflect these principles.

By providing green stormwater infrastructure that achieves not only water quality outcomes, but also these multiple benefits, developers and local government make a substantial contribution to sustainable cities, by increasing the quality of urban places, and encouraging community interaction and participation with these systems whilst reducing construction and development costs. Healthy Land and Water has developed a range of resources to support these outcomes including Living Waterways, which is a planning tool that links with MUSIC and encourages, incentivises and communicates how integrated approaches to urban stormwater management achieve these objectives. For more information visit:

www.livingwaterways.com.au

Table 2.1 indicates the extent to which MUSIC and this guideline can be used to demonstrate compliance with the stormwater management and Liveable Communities objectives.

TABLE 2.1 SUITABILITY OF MUSIC TO ADDRESS STORMWATER MANAGEMENT OBJECTIVES

OBJECTIVE	OBJECTIVE DESCRIPTION	SUITABILITY OF MUSIC TO DEMONSTRATE COMPLIANCE	WHERE TO FIND INFORMATION
Stormwater Quality	This objective aims to protect the quality of receiving waters by limiting the quantity of stormwater pollutants that are discharged. This objective adopts best practice targets for reducing pollutant loads.	Suitable	This Guideline
Waterway Stability	This objective aims to prevent additional in-stream erosion downstream of urban areas by controlling the size and duration of sediment-transporting flows.	Not Suitable	Refer to QUDM
Frequent Flow Management	Frequent flow objectives can take a number of different forms. They aim to protect in-stream ecosystems from the effects of urbanisation, in particular the increased frequency of runoff. This approach ensures that the frequency of hydraulic disturbance to in-stream ecosystems in developed catchments is similar to pre development conditions. Note: the Frequest Flow Objective is not currently madatory under the *State Planning Policy (July 2017)*	Suitability depends on nature of objective	Consult local authority
Living Environment	The purpose of this objective is to protect and enhance natural areas ajacent to waterways	Not suitable	Living Waterways
Living Communities	The purpose of this objective is to create versatile places that enable safe, healthy, inclusive and resilient communities.	Not suitable	Living Waterways
Living Water	The purpose of this objective is to protect and enhance our water systems and their environments such as riparian zones.	Suitable for Water quality part (LW1.2)	Living Waterways
Living Local Economies	The purpose of this objective is to provide affordable, enduring solutions that are viable to build, use and maintain.	Life cycle costing module in MUSIC (Section 4)	Living Waterways and Life cycle costing in MUSIC

More work is being undertaken on the potential for the use of MUSIC to demonstrate compliance with the frequent flow management objective. In its current form (Version 6), MUSIC is not an appropriate tool for demonstrating compliance with the waterway stability objective. Local governments and other agencies should prepare more locally relevant and rigorous objectives that may be beyond what is required by the State. Proponents should check with the relevant authorities to confirm relevant stormwater management objectives.

Proponents must ensure modelling is consistent with these or other locally accepted guidelines, to demonstrate compliance.

Chapter 3 Catchment Model Set-Up

All catchment model set-up information that generally applies to all Queensland can be found in this section. Locally-specific information for catchment model set-up can be found in Appendix A including meteorological data, and rainfall run-off parameters.

3.1 Meteorological Data

MUSIC uses recorded meteorological data as the primary input for rainfall–runoff and pollutant generation at a source node. Runoff, represented as surface runoff and baseflow, is generated in MUSIC through the interaction of rainfall evapotranspiration and soil properties.

Selecting appropriate climatic data for the modelled region ensures reasonable runoff and constituent predictions are made.

This Section provides advice on appropriate meteorological data for different climatic regions. Note that meteorological data is specific to regions, please refer to Appendix A for regional climatic data. Where locally-specific data is not available, contact the local authority or Healthy Land and Water for advice.

Use the regional maps to determine the rainfall station within closest proximity to the catchment being modelled and then use the Rainfall Data and Modelling Periods Tables to determine the appropriate rainfall period and potential evapotranspiration (PET) data to construct a suitable MUSIC climate template. Rainfall and evapotranspiration data for these locations are either supplied directly with MUSIC or available from the Bureau of Meteorology. For guidance on creating a meteorological template for MUSIC, refer to the MUSIC user manual (ewater.org.au).

3.2 Modelling Period and Time-Step

For all development applications use the 10 year modelling period provided in Appendix A and adopt a six-minute time-step.

Using a 10 year climate period ensures the model captures sufficient data to represent a range of rainfall patterns over time. It allows a reasonable balance between model accuracy, computer capability and memory requirements, simulation run time, and the size of the output file. Where 10 years of suitable data is not available use the highest number of years available ensuring that a minimum of 5 years of continuous data is used. The chosen rainfall series should of good quality and be representative of the site including some wet and dry years and a comparable mean rainfall. Using time-steps greater than 6 minutes (e.g. 30 minutes), is generally only appropriate during the early development of the model to reduce run times; however, the final version of the model and final simulations must use a six-minute time-step.

> To ensure the water storages modelled in MUSIC are stable and reflective of in-situ conditions the auto warm-up option for source nodes is on by default. The auto warm-up option can be found under
> > Settings > Preferences

3.3 Catchment Properties

Defining the characteristics of the MUSIC source nodes (catchment nodes), involves:

- Defining the total area, sub-catchment areas and total catchment areas
- Splitting the catchments into similar land use or surface types (e.g. separating roofs, roads and other pervious and impervious areas, or lumping land uses together)
- Defining the percentage of impervious areas for each land use or surface type
- Selecting rainfall runoff parameters
- Selecting pollutant export parameters.

These steps are detailed in the following sections together with the MUSIC catchment (source node) parameters.

3.3.1 DEFINING SUBCATCHMENTS

Include all areas of the development in the model, including polluting any surfaces that will not receive treatment. In defining the catchment consider each of the following:

- The boundary of the proposed development site and proposed road or allotment layout
- The topography in particular the post-development earthworks, reflecting the final road levels, earthworks levels, subcatchments and proposed stormwater drainage system. (Note it is best environmental practice to minimise changes to topography, maintain native vegetation, and to integrate new development into the natural landscape along with stormwater treatment)
- The conceptual stormwater drainage design (locate point of discharge in a way that minimises hydraulic and erosion impacts on receiving waterways).
- The development layout has been designed to minimise impact e.g. reduced impervious surfaces.
- The location of stormwater treatment measures, -ensure they are not built in natural waterways and riparian zones, and consider opportunities to connect people with the landscape (see Living Waterways for more information)
- The location and extent of external catchments and how these catchments drain through the development site.
- Passive recreation areas, preserved vegetation, waterways, riparian areas and revegetation areas do not need to be included in the MUSIC model catchment source nodes as they are not considered part of the development footprint causing pollution.

Establish the catchment area for each sub-catchment from development plans, preferably in a digital format (i.e. CAD, GIS or other). Clearly depict the location and extent of the catchments and associated development contours, earthworks and drainage on a plan for reporting to the assessment authority.

3.3.2 DEFINING LAND USES AND SURFACE TYPES

SOURCE NODES

MUSIC offers five general types of land use or 'source nodes': urban, forest, agricultural, user defined, and imported data. Stormwater data collected around Australia, including that collected by Brisbane City Council and Gold Coast City Council, allows modelling of more specific source nodes to be undertaken.

This section details the characteristics of the land and surface types that can be modelled in MUSIC. The recommended imperviousness, rainfall–runoff and pollutant export parameters are provided.

Urban land uses can be lumped into residential, industrial and commercial land uses. Catchments can then be split into nodes representing different surfaces types including roofs, roads (or car parks) and ground level for split catchment modelling. Modelling of split land uses is only required when routing runoff from one surface type to a treatment node separately from the others e.g. roof to rainwater tank. **All source nodes (lumped or split), are not default nodes in MUSIC and should be reconfigured according to these guidelines.**

DEFINING SOURCE NODES (FOR SPLIT OR LUMPED CATCHMENTS)

Define the area (in hectares) for each land use type within each sub-catchment (e.g. Residential, commercial, industrial, etc.) Source nodes are then created in the MUSIC model for each land use type.

Appropriate source node parameters for each type of source node (lumped and split) are outlined in detail in this chapter.

Appendix B offers six quick reference source node parameter summaries.

When rainwater tanks are proposed to form part the stormwater treatment strategy, source nodes must be 'split' into roof, ground and roads. This will ensure the model takes into account the appropriate flow and pollutant load reduction attributable to the tanks.

LUMPED CATCHMENT APPROACH

The Lumped Catchment Approach is an appropriate method for modelling development application in MUSIC (including MCU, ROL and OPW application). It is a suitable for broad-scale master planning, conceptual planning, or catchment planning and development planning and applications where splitting catchment surface types is not required.

TABLE 3.1 LUMPED CATCHMENT APPROACH

LUMPED LANDUSE	MUSIC SOURCE NODE	ENCOMPASSING LANDUSES
Residential	Urban source node	Majority of landuse is residential dwellings, but also includes activities servicing residential needs such as roads, parks*, schools, small commercial areas etc.
Rural Residential	Urban source node	Residential uses on large lots with a high proportion of pervious area (<10% total impervious area). Activities servicing local needs such as schools, parks*, roads etc. are included. Areas of broad hectare, low-intensity farming activities (where soils are not exposed) and semi-natural broad hectare land may also be included.
Industrial	Urban source node	Includes areas of light and general industry, including activities associated with the manufacture or distribution of goods (e.g. heavy machinery). The industrial node includes building envelopes, parking. It is typified by high percentage of impervious area.
Commercial	Urban source node	Includes activities such as shops, offices and restaurants, with buildings, parking areas/driveways, adjacent roads and road reserves. Commercial source nodes can be used to model special purpose or multipurpose centres such as hospitals, major educational facilities, shopping centres and community centres. Commercial areas are typified by high percentage of impervious area.
Forest	Forest source node	Undisturbed, natural bushland areas.
Agriculture	Agricultural source node	Includes large scale cropping or grazing land.

*For park land uses, impervious areas >100m^2 should be modelled as a seperate source nodes (eg. car parks, communit centres). To account for minor park infrustructure such as paths and small shelters, adjust the fraction impreviousness of the parkland node rather than modelling these areas as separate nodes.

SPLIT CATCHMENT APPROACH

The splitting of lumped land uses into specific surface types (eg. road, ground, roof areas) is required when:

- Rainwater tanks are being considered as part of the stormwater treatment strategy
- The sub-catchment land use does not refelct the typical land use split (eg. a commerical sub-catchment with 15% road and 5% groundlevel)
- Or where a part of the sub-catchment is being diverted to a different location (eg. sub-catchment has the roof and road areas draining to a treatment system but not ground areas.

Where the above requirements are met split the MUSIC model catchments into relevant surface types using:

TABLE 3.2 SPLIT CATCHMENT APPROACH

LANDUSE	MUSIC SOURCE NODE	ENCOMPASSING LANDUSES
Roof	Urban source node	Roof of any residential, industrial and commercial building. If applying rainwater tanks split the roof area between that going to the tank and going to the stormwater drain.
Road/Carpark	Urban source node	Roads and carparks that are majority impervious. A small section of pervious area may be applied if there are vegetated areas as part of road verges or carpark landscaping.
Ground level source node	Urban source node	Applies to any remaining area within the development after roofs and roads are accounted for. These are largely pervious ie parks, backyards, landscaping etc, but can contain small impervious areas such as patios, paving, pergolas and residential driveways.

[2] Commercial and industrial driveways should be considered as part of car parking areas and modelled as "road source node"

EXAMPLE

Figure 3.1 and Table 3.3 demonstrates how the three different surface type nodes can be applied to a residential property.

FIGURE 3.1: Surface Types

TABLE 3.3 SURFACE TYPE AND APPROPRIATE NODES

SURFACE TYPE	MUSIC SURFACE TYPE NODE
House and garage roof to tank	Roof (100% impervious)
House to external drainage	Roof (100% impervious).
Ground level (driveway, shed and yard)	Included as part of ground level surface node with the percentage imperviousness adjusted accordingly
Half of road and verge	Included as part of road surface node with the percentage imperviousness adjusted accordingly. Note that 50% of the road width would generally be modelled with the property on the opposite side of the road.

MEASURING THE AREA OF SURFACE TYPES

The area of each surface type within the relevant catchment must be measured from development layout plans.

Surface-type areas within each catchment can be grouped into a single surface-type node i.e. multiples of the same surface type can be grouped together.

Where a development plan is not available, for example during conceptual design or broad master planning, adopt surface type proportions from Table 3.4 which shows the typical surface-type split for residential, industrial and commercial developments.

TABLE 3.4 TYPICAL SURFACE-TYPE SPLITS

DEVELOPMENT TYPE	MUSIC SURFACE TYPE NODE		
	ROAD	ROOF	GROUND
Residential 10 dwellings/ha	25	25 (based on 250 m2 roof area)	50
Residential 15 dwellings/ha	25	32.5 (based on 215 m2 roof area)	42.5
Residential 40 dwellings/ha	30	35	35
Residential 80+ dwellings/ha	32.5	35	32.5
Industrial	30	50	20
Commercial	30	50	20

UNDEFINED SOURCE NODES

There are two source nodes for which parameters cannot be defined in this guideline.

USER DEFINED SOURCE NODE

The user defined source node is similar to the catchment nodes in that MUSIC generates runoff based on defined rainfall–runoff and pollutant parameters. The main purpose of this node is as a visual reminder that data other than default rainfall–runoff and pollutant export data is being used. If the parameters used differ from the recommended parameters for the general source nodes, they must be referenced in the MUSIC reporting.

IMPORTED DATA NODE

The imported data node allows historical or computer-generated runoff and flow data to be used as input in the model. One possible application of this node is in combining a number of MUSIC models into one. Rather than including all the source nodes from each model (which can make the model complicated and large), the results from the smaller models are imported into one overall model, which can reduce complexity and run-time of the one larger model. Refer to the MUSIC Help for information on using the imported data node.

3.3.3 CALCULATING THE IMPERVIOUSNESS OF THE CATCHMENT

Impervious areas dominate the rainfall runoff process in urban catchments because they generate much more runoff and more frequent runoff than pervious areas. Therefore, ensure impervious areas are accurately represented in MUSIC models.

Use Table 3.5 to determine the appropriate method for determining the impervious fraction. For all development applications the impervious fraction in MUSIC models must be equal to the total impervious fraction measured from development plans.

TABLE 3.5 METHODS FOR DETERMINING THE IMPERVIOUS FRACTION OF CATCHMENTS

PURPOSE OF MODELLING	MUSIC SURFACE TYPE NODE	METHOD FOR DETERMINING IMPERVIOUS FRACTION
Development application	Split	Development plans (preferably digital i.e. ACAD or GIS)
	Lumped	Development plans (preferably digital i.e. ACAD or GIS)
Broadscale master planning and conceptual design (generally not for development applications)	Split	Table 3.4 and Table 3.6
	Lumped	Table 3.7
Existing catchment	Split	1. Aerial photography (for existing catchments) 2. Table 3.4 and Table 3.6 3. Information from similar developments
	Lumped	1. Table 3.7 2. Aerial photography (for existing catchments) 3. Information from similar developments

1 is the preferred method and 3 is the least preferred method.

TABLE 3.6 TYPICAL IMPERVIOUS FRACTION FOR SPLIT CATCHMENT LAND USE (READ WITH TABLE 3.4)

DEVELOPMENT TYPE	SURFACE TYPE IMPERVIOUS FRACTION (%)		
	ROAD RESERVE	ROOF	GROUND LEVEL
Residential 10 dwellings/ha	60	100	15
Residential 15 dwellings/ha	60	100	20
Residential 40 dwellings/ha	70	100	30
Residential 80+ dwellings/ha	80	100	50
Industrial	75	100	60
Commercial	75	100	80

Table 3.7 shows typical values, however you should ensure impervious fraction percentages chosen for your development reflect your development layout and the maximum allowable dwelling size.

TABLE 3.7 TYPICAL IMPERVIOUS FRACTION FOR LUMPED CATCHMENT LAND USE

SURFACE TYPE	IMPERVIOUS FRACTION (%)	
	RANGE	PREFERRED MINIMUM
RESIDENTIAL OR MIXED USE		
Residential 10 dwellings/ha	40–55	45
Residential 15 dwellings/ha	50–60	55
Residential 40 dwellings/ha	60–70	65
Residential 80+ dwellings/ha	70–95	85
INDUSTRIAL		
Typical industrial (warehouse, manufacturing, workshop etc.)	70–95	90
Garden and landscape suppliers	30–60	50
COMMERCIAL		
Business or town centre	70–95	90
Offices	70–95	90
Bulky goods	70–95	90
PUBLIC ZONES		
Public open space	5–50	20
Car parks	70–95	90
Library, sporting, depots	50–90	70
Schools and universities	50–80	70
INFRASTRUCTURE PROJECTS		
Highway and roads	60–90	70
Rail	50–80	65
OTHER		
Rural residential (greater than 0.4ha lots)	5–20	10
Rural residential (smaller than 0.4ha lots)	10–25	20
Rural	0–5	2
Forest or conservation	0–5	0

3.3.4 RAINFALL RUNOFF PARAMETERS

Use the rainfall runoff parameters specific to your region, presented in Appendix A, to model development applications unless:

- Alternative parameters are supported by the assessment authority
- Comprehensive calibration of the parameters has been undertaken to local stream records. See Section 3.3.6 for further discussion on calibration.

3.3.5 POLLUTANT EXPORT PARAMETERS

LUMPED LAND USE POLLUTANT EXPORT PARAMETERS

Table 3.8 provides the pollutant export parameters to use when modelling lumped catchments. These parameters have been calculated for event flows and baseflows considering the default MUSIC parameters, information provided by Brisbane City Council, and research on agricultural land uses (BMT WBM, 2009).

When modelling rural or low-intensity grazing land, the rural residential node should be used with the fraction impervious set to zero. The figures in Table 3.9 which relate to "agriculture" should only be used for active cropping or high-intensity grazing.

TABLE 3.8 POLLUTANT EXPORT PARAMETERS FOR LUMPED CATCHMENT LAND USES (LOG^{10} VALUES)

LANDUSE	FLOW TYPE	TSS LOG^{10} VALUES		TP LOG^{10} VALUES		TN LOG^{10} VALUES	
		MEAN	ST. DEV	MEAN	ST. DEV	MEAN	ST. DEV
Urban residential	Baseflow	1.00	0.34	-0.97	0.31	0.20	0.20
	Stormflow	2.18	0.39	-0.47	0.32	0.26	0.23
Industrial	Baseflow	0.78	0.45	-1.11	0.48	0.14	0.20
	Stormflow	1.92	0.44	-0.59	0.36	0.25	0.32
Commercial	Baseflow	0.78	0.39	-0.60	0.50	0.32	0.30
	Stormflow	2.16	0.38	-0.39	0.34	0.37	0.34
Rural residential	Baseflow	0.53	0.24	-1.54	0.38	-0.52	0.39
	Stormflow	2.26	0.51	-0.56	0.28	0.32	0.30
Forest	Baseflow	0.51	0.28	-1.79	0.28	-0.59	0.22
	Stormflow	1.90	0.20	-1.10	0.22	-0.075	0.24
Agriculture*	Baseflow	1.00	0.13	-1.155	0.13	-0.155	0.13
	Stormflow	2.477	0.31	-0.495	0.30	0.29	0.26

*Only use for active cropping and high-intensity grazing agricultural landuses

If alternative pollutant concentrations to those outlined in Table 3.8 are proposed by an applicant, they must provide independently peer reviewed monitoring results to the assessment authority.

These results are required to substantiate the proposed alternative parameters and demonstrate to the assessment authority that the proposed data is more scientifically robust than the monitoring results referenced in this guideline.

SPLIT CATCHMENT SURFACE TYPES POLLUTANT EXPORT PARAMETERS

Use the 'split' catchment pollutant export parameters provided in Table 3.9 for all climatic regions unless the assessment authority supports alternative parameters.

TABLE 3.9 POLLUTANT EXPORT PARAMETERS FOR SPLIT CATCHMENT LAND USE (LOG10 VALUES)

FLOW TYPE	SURFACE TYPE	TSS LOG10 VALUES		TP LOG10 VALUES		TN LOG10 VALUES	
		MEAN	ST. DEV	MEAN	ST. DEV	MEAN	ST. DEV
URBAN RESIDENTIAL							
Baseflow parameters	Roof	N/A	N/A	N/A	N/A	N/A	N/A
	Roads	1.00	0.34	-0.97	0.31	0.20	0.20
	Ground level	1.00	0.34	-0.97	0.31	0.20	0.20
Stormflow parameters	Roof	1.30	0.39	-0.89	0.31	0.26	0.23
	Roads	2.43	0.39	-0.30	0.31	0.26	0.23
	Ground level	2.18	0.39	-0.47	0.31	0.26	0.23
INDUSTRIAL							
Baseflow parameters	Roof	N/A	N/A	N/A	N/A	N/A	N/A
	Roads	0.78	0.45	-1.11	0.48	0.14	0.20
	Ground level	0.78	0.45	-1.11	0.48	0.14	0.20
Stormflow parameters	Roof	1.30	0.44	-0.89	0.36	0.25	0.32
	Roads	2.43	0.44	-0.30	0.36	0.25	0.32
	Ground level	1.92	0.44	-0.59	0.36	0.25	0.32
COMMERCIAL							
Baseflow parameters	Roof	N/A	N/A	N/A	N/A	N/A	N/A
	Roads	0.78	0.39	-0.60	0.50	0.32	0.30
	Ground level	0.78	0.39	-0.60	0.50	0.32	0.30
Stormflow parameters	Roof	1.30	0.38	-0.89	0.34	0.37	0.34
	Roads	2.43	0.38	-0.30	0.34	0.37	0.34
	Ground level	2.16	0.38	-0.39	0.34	0.37	0.34

STOCHASTIC POLLUTANT GENERATION

Runoff pollutant concentrations can be generated either stochastically (from a defined mean and standard deviation) or by a constant mean concentration. For development applications the stochastic option must be used for modelling stormwater runoff and treatment.

Serial correlation – The serial correlation coefficient must be used and the values included left as default in accordance with the "Editing Source Nodes" section under Creating a Stormwater Treatment Train chapter of the MUSIC Help.

The serial correlation coefficient will not have any effect on the pollutant loads generated, however it will ensure that the pollutant concentrations at any one time step are related to the previous time step. This will ensure that pollutant generation simulated by MUSIC during any one event will be more consistent with what happens in real events and may provide better estimates of the performance of devices.

3.3.6 CALIBRATION

Calibration to local data should be undertaken if good quality data sets are available. MUSIC calibration is important for models incorporating land use types that are more than 90% pervious. Most urban developments are less than 90% pervious. So, while the calibration of a MUSIC model is desirable, it is not necessary for development applications due to the dominant influence of impervious area on hydrology.

MUSIC model calibration, and calibration of hydrologic models generally, is complex and beyond the scope of the guidelines. When undertaking calibration care is needed when:

- Selecting suitable data sets
- Analysing catchment characteristics
- Determining the period of calibration
- Verifying and validating the calibrated model
- Selecting the objective functions used for assessment
- Transferring the parameters to ungauged catchments.

The impact of hydrologic calibration on the predictive capability of the water quality model must be considered. It may impact treatment sizing, event responses and compliance with mean annual pollutant load performance objectives. Where calibration is undertaken and revised source node parameters are used in development applications, a full calibration report outlining responses to these issues should be provided to assessment authorities. The assessment authority will decide if the revised parameters are suitable.

Chapter 4 Stormwater Treatment Nodes

Photo: Dr Andrew O'Neill

Chapter 4 Stormwater Treatment Nodes

MUSIC is a useful, widely used pollutant modelling tool, however it should not be the only consideration when design stormwater treatment solutions.

Treatment solutions should be designed not only to treat water quality, but in a way that encourages public acceptance and appreciation.

Living Waterways provides a formula for designing such systems in a way that considers nature, communities and economic sustainability.

When selecting treatment devices consider the guidance provided in Living Waterways, and use these principles to guide design and subsequently the modelling parameters. Also refer to the Concept Design Guidelines for Water Sensitive Urban Design and the Water Sensitive Urban Design Technical Guidelines (Water by Design).

Refer to the information in the following section when establishing the treatment nodes you have chosen for your integrated design.

4.1 General Notes

The following notes apply to all MUSIC models developed to support development applications:

4.1.1 EXFILTRATION

Long-time users of MUSIC will note that in previous versions of the MUSIC Modelling Guidelines (e.g. the 2010 version), exfiltration from the base of treatment nodes was forbidden when modelling to demonstrate compliance with water quality targets. The reason for this was that MUSIC, by default, assumed that all exfiltrated flows (i.e. those that infiltrated into the surrounding soil) were lost from the model. In the process, the model treated all pollution associated with these flows as having been removed. It included this pollution in calculations of pollutant load reductions. While groundwater flows are complex, groundwater is none the less a receiving environment and should be protected from pollution. Therefore, the previous version of the MUSIC Modelling Guidelines took the conservative approach of forbidding the use of exfiltration from treatment nodes while modelling to demonstrate compliance with water quality targets. It did however encourage the use of exfiltration for water balance modelling and assessing compliance with flow based objectives. For developments modelling both, this presented a dilemma requiring two similar, but not identical models to be developed to model each of water quality and flow based outcomes.

This version of the MUSIC Modelling Guidelines continues the approach of considering groundwater as a receiving environment. However, starting with MUSIC version 6, secondary drainage links (see Section 4.1.2) may be used to convey infiltrated flows downstream within models.

Therefore, it is now considered appropriate to include exfiltration from treatment nodes in MUSIC when modelling compliance with water quality objectives provided that appropriate secondary drainage links are used to route infiltrated flows downstream to the treatment node such that they (and their associated pollution) are accounted for in load reduction targets.

OTHER THOUGHTS REGARDING EXFILTRATION

Exfiltration of treated stormwater is encouraged to replenish groundwater and may form an important part of a treatment train aimed at meeting hydrologic management objectives.

Exfiltration rates are dependent on the soil type. Exfiltration rates should be set conservatively based on the soil type and only used for water that has passed through the full treatment zone (eg through the base of a bioretention system and not through the walls, or at the end of a wetland). The rate must be justified through in-situ soil testing. As exfiltration influences treatment area size (and therefore layout), justification must be lodged to the assessment authority as part of the planning application (i.e. prior to approval of a layout plan). The applicant must also suitably demonstrate that in-situ soils will not be compacted during earthworks or that the exfiltration rate modelled is suitably discounted to take into consideration the impacts of construction activity.

Given the depth at which exfiltration is likely to occur, the saturated hydraulic conductivity of the subsoil rather than the topsoil must be tested

4.1.2 LINKING CATCHMENT NODES TO TREATMENT NODES

Drainage links allow nodes to be connected in MUSIC. Links convey the applicable water from one node to another in line with the chosen model time-step. There are two types of link available in MUSIC:

- Primary drainage links
- Secondary drainage links

In earlier version of MUSIC, the only link available was the primary drainage link. In MUSIC v6, the secondary drainage link was introduced. The secondary drainage link increases flexibility when modelling. The following explains the use of both the primary and secondary drainage links. The MUSIC User Manual describes the parameters for links between nodes.

PRIMARY DRAINAGE LINKS

As the name suggests, primary drainage links are the predominate type of link used in MUSIC. For many modelling applications, primary drainage links will suffice.

Primary drainage links may be connected from:

- Source node to treatment
- Source node to junction node
- Source node to receiving node
- Treatment node to treatment node
- Treatment node to junction node

The routing and/or translation functions (double click on the drainage link to bring up "Properties") can be used to adjust the timing and magnitude of flow arriving at a downstream node. The default setting of '"no translation or routing"' is a conservative approach for assessing treatment performance. In this instance, the model assumes that flows and associated pollutants from all parts of a catchment arrive at a treatment node at the same time. This means that MUSIC may overestimate the
overflow volume.

For small catchments, where the time of concentration is not significantly longer than the modelling time-step (i.e. 6 min), it is not recommended to use routing in the model.

Primary drainage links can be customized to select which components of the flow they convey. For example, a primary node connecting a bioretention system to a junction node will by default convey the low flow bypass, the high flow bypass, the pipe outflows and the weir overflows to the downstream node. By double clicking on the primary drainage link, the user can edit which of these components of the flow the link conveys. For most simple modelling applications the default settings should be used. Any deviation from the default setting must be justified.

The primary drainage link does have one major limitation. It cannot be used to split the different components of the flow leaving a node. The secondary drainage link overcomes this problem.

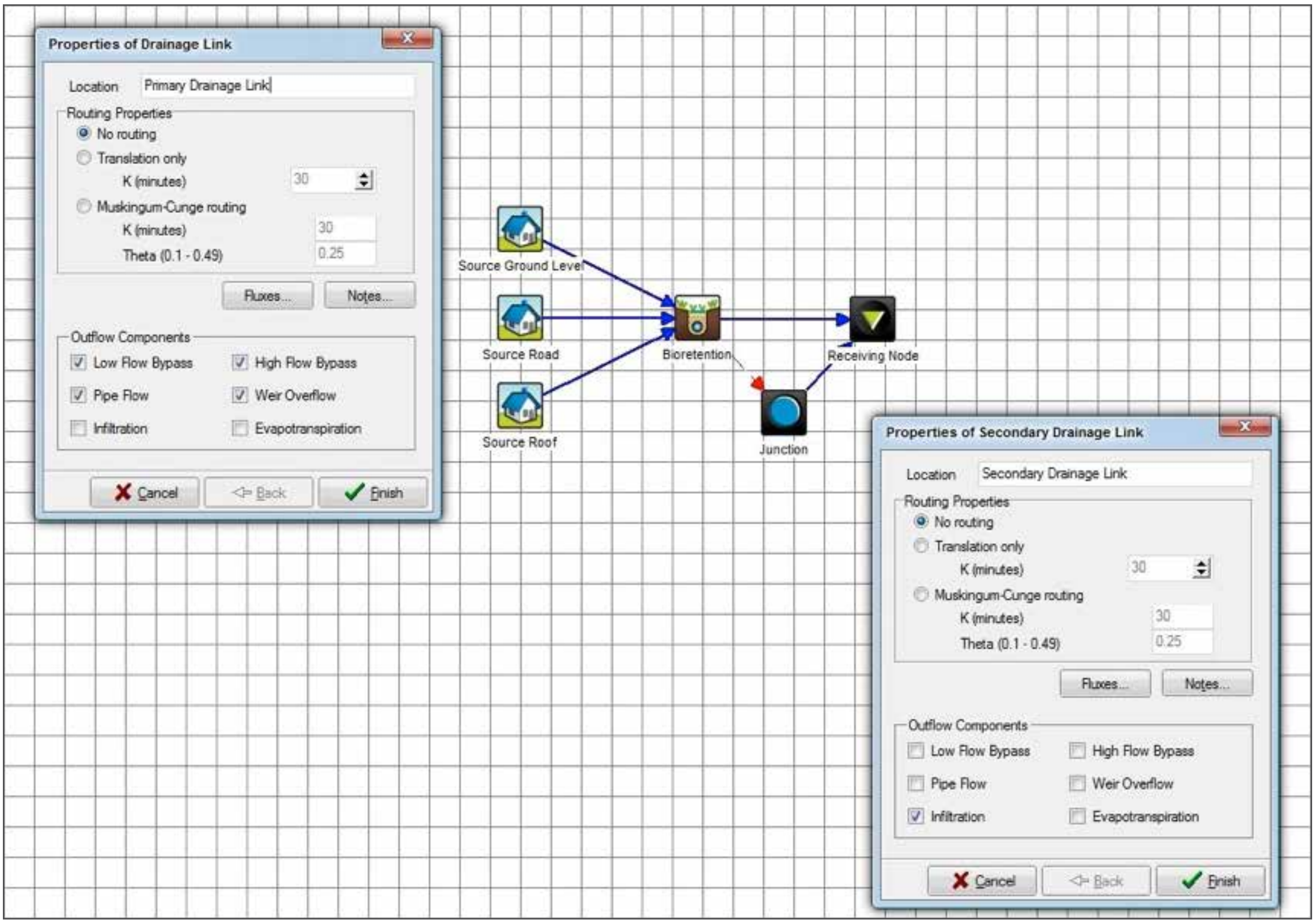


FIGURE 4.1 Secondary drainage link

SECONDARY DRAINAGE LINKS

Secondary drainage links are installed alongside primary drainage links to allow different components of the flow to be conveyed downstream separately. Secondary drainage links depart from the same node as their associated primary drainage link, but must discharge to a different downstream node. Figure 4.1 demonstrates a simple model including a secondary drainage link. In Figure 4.1, the primary drainage link routes the standard bioretention outflow components (low flow bypass, high flow bypass, piped outflow and weir overflow) downstream. The secondary drainage link conveys downstream the water that has exfiltrated from the base of the bioretention system into the surrounding soil.

Note that, if when implementing a secondary drainage link, the user assigns to the secondary drainage link a component of the flow that would by default be assigned to the associated primary drainage link, that outflow component will be automatically turned off in the primary drainage link.

4.1.3 HYDROLOGIC ROUTING

The efficiency with which water moves within a treatment system is a function of the system's shape. Systems with low length–width ratios (e.g. ponds) have high potential for turbulence and short-circuiting; systems with high length–width ratios (e.g. swales) have an approximation of plug flow. This is simulated in MUSIC by the number of 'continuously stirred tank reactors' (CSTRs). In MUSIC a number of different shapes representing the surface component of the system are available for modelling. Click on the 'More' button at the bottom of the relevant treatment node parameter dialog box to access this feature. To select the most appropriate value, click on the button with the three small dots (next to the CSTR cells entry box). A new dialog box will open allowing the user to select the CSTR configuration that most closely reflects the design – See Figure 4.2.

Users are encouraged to keep default parameters for most applications. Where proper calibration / research has been performed then values may be changed.

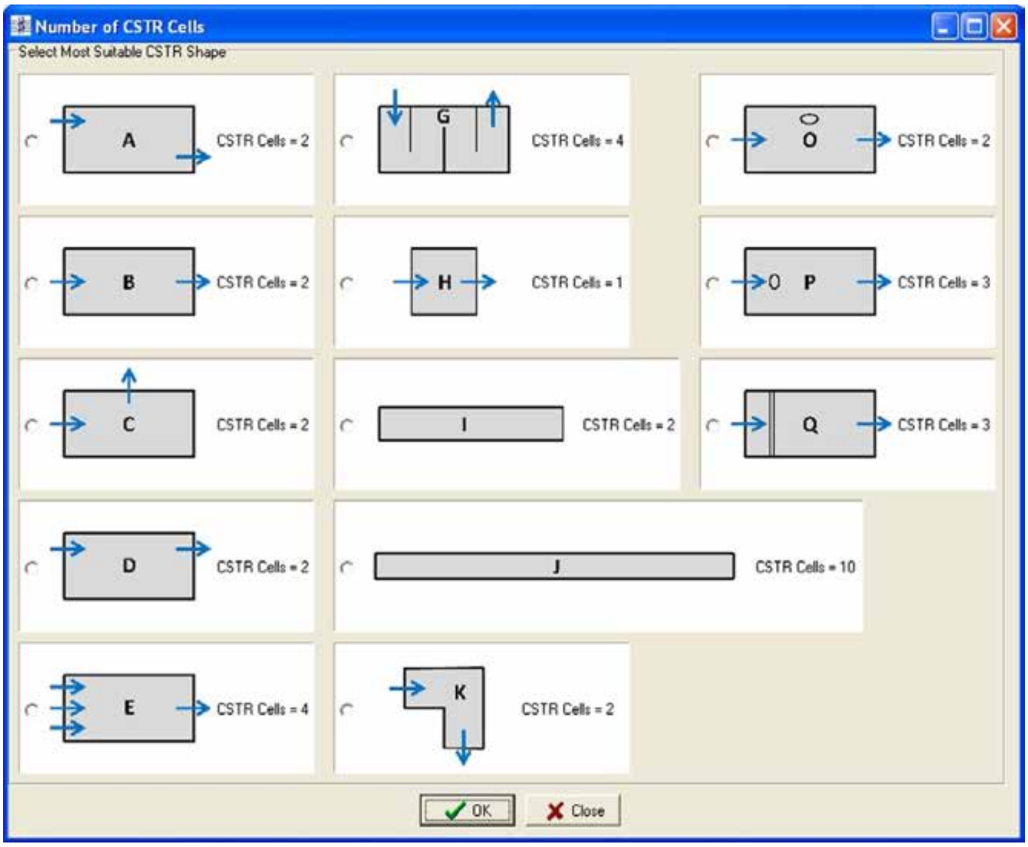


FIGURE 4.2 Example of CSTR cells

4.1.4 ADDITIONAL NOTES

The following notes apply to all MUSIC models developed to support development applications:

- Do not change the default advanced properties parameters (for example the first order decay model (k-C* model) under the 'MORE' button on a treatment node), unless recommended within a particular section of this guidline or relevant justification has been provided to and appointed by the relevant assessment authority. The only exception is selection of suitable shape factors to represent the hydrologic routing within a treatment measure in advanced modelling scenarios (further details on shape factors are provided in Section 4.1.3).
- MUSIC is generally not suitable for modelling water quality treatment in: natural waterways, natural wetlands, naturalised channel systems, environmental buffers, lake and pond systems. These are receiving environments and cannot in any case form part of the stormwater treatment train for an urban catchment.

Ponds and lakes, that is freshwater or brackish water bodies other than sediment basins that are not extensively vegetated, are receiving water bodies and are not to be modelled as treatment nodes. **Stormwater must be treated before it discharges to these bodies.** Ponds and lakes cannot be considered as contributing to stormwater quality treatment regardless of whether they are naturally occurring or constructed as part of developments. Refer to the *State Planning Policy* (DILGP, 2017) and any regional or local-specific guidelines for more information about dealing with ponds and lakes

4.2 Rainwater Tanks

Rainwater tanks are a useful way for managing stormwater. They are mandatory in some Local Government Areas in Queensland. Check with the local Council for requirements. In areas where they are not compulsory they can still be incorporated into the development design and MUSIC model, however the development application must demonstrate how the development will ensure the tanks will be installed by each new home owner. The following section explains how to incorporate them into the model.

4.2.1 RAINWATER TANK MODELLING PARAMETERS

Use the rainwater tank node for simulating water balance within tanks and estimating pollution reduction through sedimentation and reuse. Rainwater tank parameters are summarised in Table 4.1 with further details provided below.

MUSIC is not an appropriate tool for modelling the effectiveness of tanks for peak-flow mitigation or for on-site detention volume assessments. This is because MUSIC uses a continuous simulation method for modelling runoff, not an event flow method, and is therefore not suitable for estimating peak Annual Exceedance Probability (AEP) flows.

TABLE 4.1 RAINWATER TANK MODELLING PARAMETERS

INLET PROPERTIES	
High-flow bypass (cubic metres per sec)	100
Low-flow bypass (cubic metres per sec)	0
STORAGE PROPERTIES	
Volume below overflow pipe (kL)	User defined (must be greater than, or equal to, five times the maximum daily demand)
Depth above overflow (m)	User defined (0.2 m)
Surface area (m2)	User defined
OUTLET PROPERTIES	
Overflow pipe diameter (mm)	User defined (90 mm x$\sqrt{\text{no.tanks}}$)
REUSE PARAMETERS	
Annual demand (kL/day)	User defined irrigation demand (see Section 4.2.2) with Potential Evapotranspiration — Rain option selected
Daily demand (kL/day)	User defined indoor demand (see Section 4.2.2)
Monthly distribution of annual demand (kL/yr)	0
User-defined time series	Not used

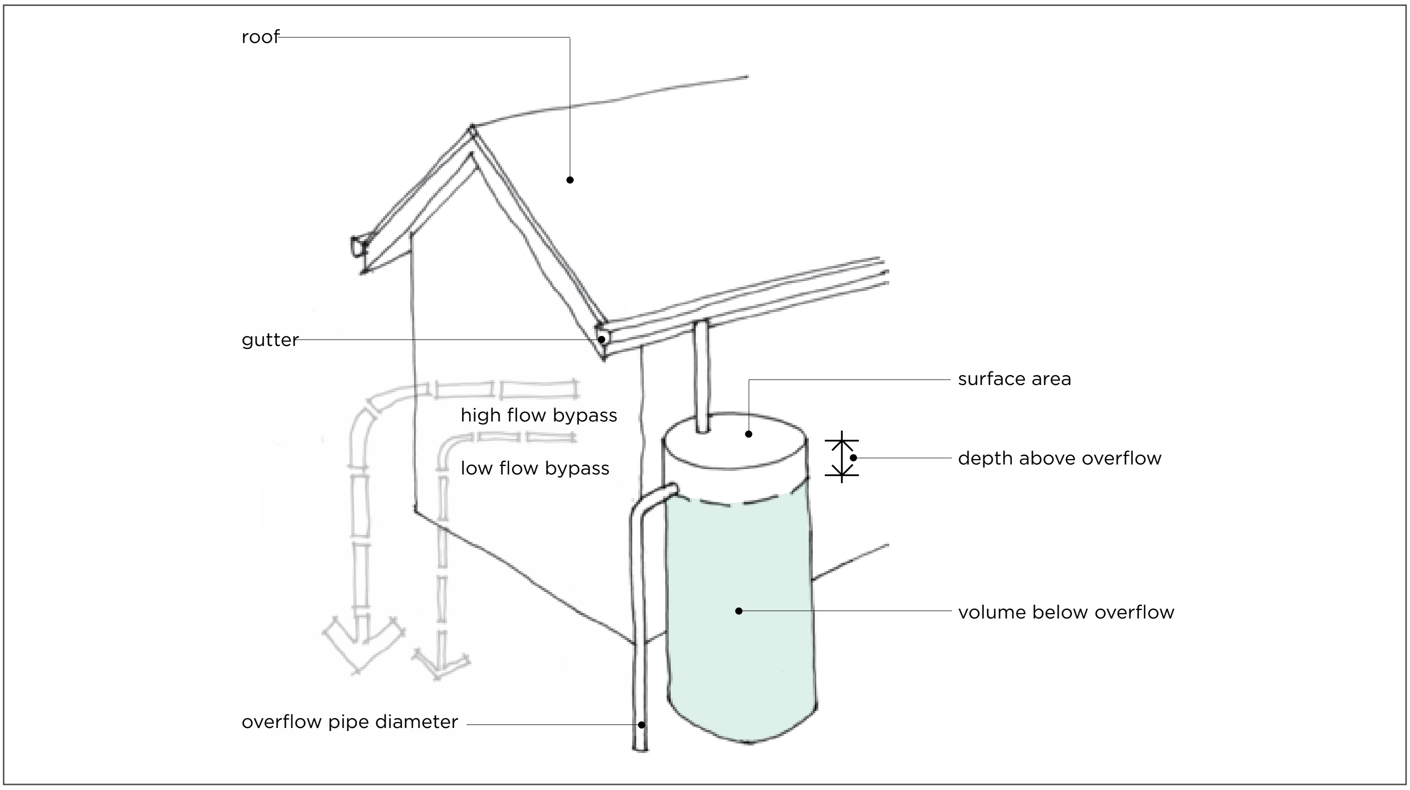


FIGURE 4.3 Rainwater tank parameters

EXAMPLE OF INCORPORATING RAINWATER TANKS INTO MUSIC

The following example models a detached dwelling with a 5 kL tank and 50% of the roof area draining to a tank. The road and verge at the front of the property is also included in this model as would be required when modelling most reconfiguration of lot applications. The model would be set up as shown in Figure 4.4 splitting the four separate surface types (road, ground level, proportion of roof draining to the rainwater tank and proportion of roof bypassing the rainwater tank), i.e. the "split surface approach". Figure 3.1 demonstrates how these split surface types relate to a residential allotment.

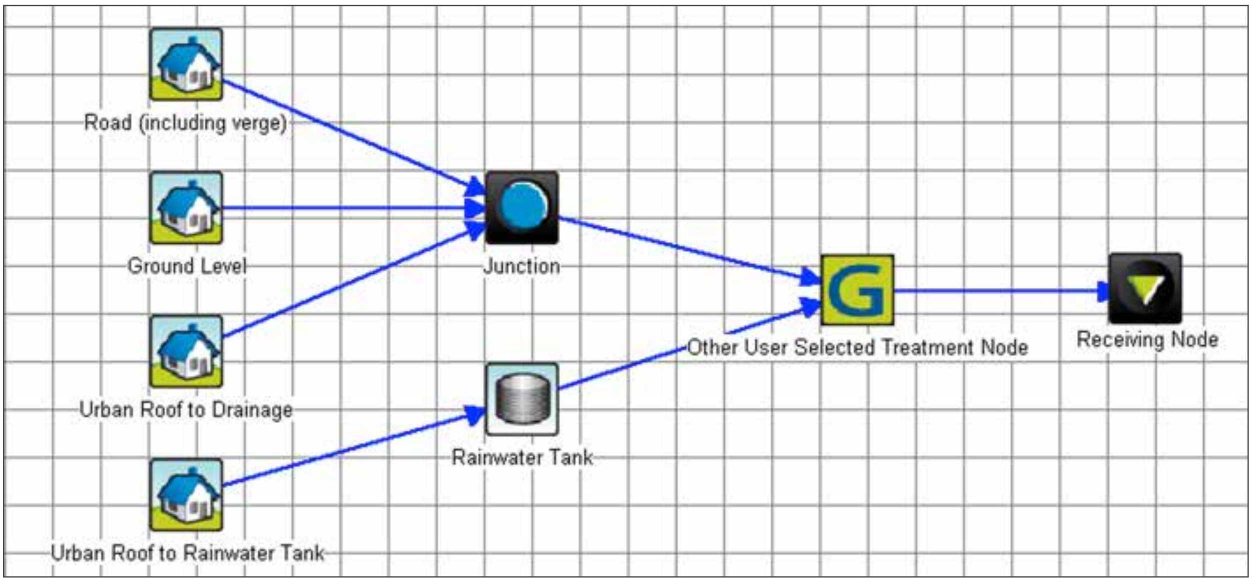


FIGURE 4.4 Example of incorporating rainwater tanks in a split-surface residential MUSIC model

4.2.2 RESIDENTIAL TANK DEMANDS

INDOOR DEMANDS

Use the information in Table 4.2 and Table 4.3 for modelling tanks unless the assessment authority has an alternative preferred approach.

Different areas will vary in demographics so occupancy rates and rainwater tank demands should be agreed with the assessment authority before development applications are lodged even if using the data in these tables.

If alternative data is used, the stormwater management plan must clearly specify and justify adopted parameters. Care needs to be taken when selecting appropriate demands. For example, if the demand for tank water is over-estimated, downstream treatment systems will potentially be undersized.

The data presented is based on monitoring undertaken by Gold Coast City Council and Griffith University and is consistent with the parameters presented in the Draft Stormwater Harvesting Guidelines (Healthy Waterways, 2009).

TABLE 4.2 RESIDENTIAL OCCUPANCY RATES

DEVELOPMENT TYPE	SIZE	OCCUPANCEY (PEOPLE PER DWELLING)		
		PERMANTENT RESIDENTIAL[4,5]	HOLIDAY ACCOMODATION[4]	
		AVERAGE	PEAK[7]	AVERAGE[8]
Detached dwelling	1 bedroom	1.6	2	0.8
	2 bedroom	1.9	4	1.1
	3 bedroom	2.5	6	1.3
	>3 bedroom	3.4	8	1.9
	Overall mixed	2.8	6.7	w.5
Townhouse	Studio/1 bedroom	1.2	2	0.8
	2 bedroom	1.6	4	1.1
	3 bedroom	2.3	6	1.3
	>3 bedroom	3.3	8	1.9
	Overall mixed	2	5.4	1.2
Unit	Studio/1 bedroom	1.2	2	0.8
	2 bedroom	1.2	2	0.8
	3 bedroom	2.2	6	1.3
	Overall mixed	1.7	4	0.8
Resort	1 bedroom		2	0.8
	2 bedroom		4	1.1
Hotel / motel	Standard room		2	0.8
	Family room		4	1.1

[4] Residential data is based on ABS census data from the 2006 Census of Population and Housing.

[5] Residential development with stable permanent population and relatively few visitors or transients.

[6] Tourist/holiday accommodation with transient populations.

[7] Assumes a peak occupancy of two people per bedroom.

[8] Assumes between 45% and 65% of rooms occupied on average (Tourism Queensland, 2008) and the average number of people per room between 35% and 40% of peak occupancy

The "kitchen", "bathroom" and "total" parameters in Table 4.3 Rainwater tank demands have been greyed out as residential rainwater tanks are typically connected for laundry and toilets uses only. The parameters in these rows should only be used where there is a planning mechanism in place to ensure these additional connections can be enforced at the building stage.

As The Queensland Development Code - Part 4.1 Sustainable Building, requires all new buildings to install water saving devices, adopt the figures in the "full water saving device" column when modelling new developments.

TABLE 4.3 RAINWATER TANK DEMANDS[9] [10]

USE	UNIT	PER CAPITA INTERNAL WATER DEMAND (LITRES PER PERSON PER DAY)[11]			
		STANDARD RESIDENTIAL12	SOME WATER SAVING DEVICES13	MOST WATER SAVING DEVICES14	FULL WATER SAVING DEVICES15
PERMANENT RESIDENTIAL					
Laundry	Per person	50	43	35	26
Toilet	Per person	38	33	26	21
Kitchen	Per person	15	15	14	13
Bathroom	Per person	82	76	69	63
Total	Per person	185	167	144	123
HOLIDAY ACCOMMODATION (HOUSES, UNITS, TOWNHOUSES)[16]					
Laundry	Per person	40	34	28	21
Toilet	Per person	46	40	32	25
Kitchen	Per person	15	15	14	13
Bathroom	Per person	98	91	82	75
Total	Per person	199	180	156	134
RESORTS, HOTELS, MOTELS[17]					
Laundry	Per person	10	9	7	5
Toilet	Per person	46	40	32	25
Kitchen	Per person	15	15	14	13
Bathroom	Per person	123	114	103	94
Total	Per person	194	178	156	137

[9] Water demands based on water end-use consumption analysis into Gold Coast dual reticulated households presented at OzWater'09 (Willis, R et al. 2009).

[10] Assumptions regarding effect of water saving devices based on Draft Urban Water Use Study of South East Queensland (NRM, 2005).

[11] Per capita water demand can vary with the number of people in the household.

[12] Conventional dwellings without any water saving fixtures or appliances.

[13] Conventional dwellings with some water saving devices (i.e. about 30% penetration of water efficient devices into the development).

[14] Dwellings with substantial installation of water saving devices (i.e. about 50-70% penetration of water efficient devices into the development).

[15] Dwellings with full use of all water saving devices.

[16] Assumes 20% higher bathroom and toilet use, a 20% reduction in laundry demand and otherwise equivalent to permanent residential usage.

[17] Assumes 50% increase in bathroom water demands, 20% increase in toilet demands and 80% reduction in laundry demands (i.e. off-site laundry).

OUTDOOR DEMANDS

There are a range of approaches for estimating irrigation water demands. In the absence of project-specific information use an annual irrigation application of 548-730 mm for all development applications in SEQ unless:

- The assessment authority specifies alternative rates
- The applicant can demonstrate a suitable alternative rate and the assessment authority consents to the use of the alternative rate.

Apply the lower rate (548 mm) to private gardens or to low importance parklands and the higher rate (730 mm) to highly managed sites without waterwise plants. On residential lots, assume that 75% of the landscaped area (pervious area as measured off development plans), will be irrigated. Where development plans do not suitably define landscape areas, for preliminary planning purposes the irrigated landscape area can be estimated as 70% of the non-roof area (not the total lot).

MUSIC includes an option to apply irrigation only when rainfall is less than the daily evapotranspiration value (PET-rain). Use this selection when applying outdoor demands (as shown in Figure 4.5).

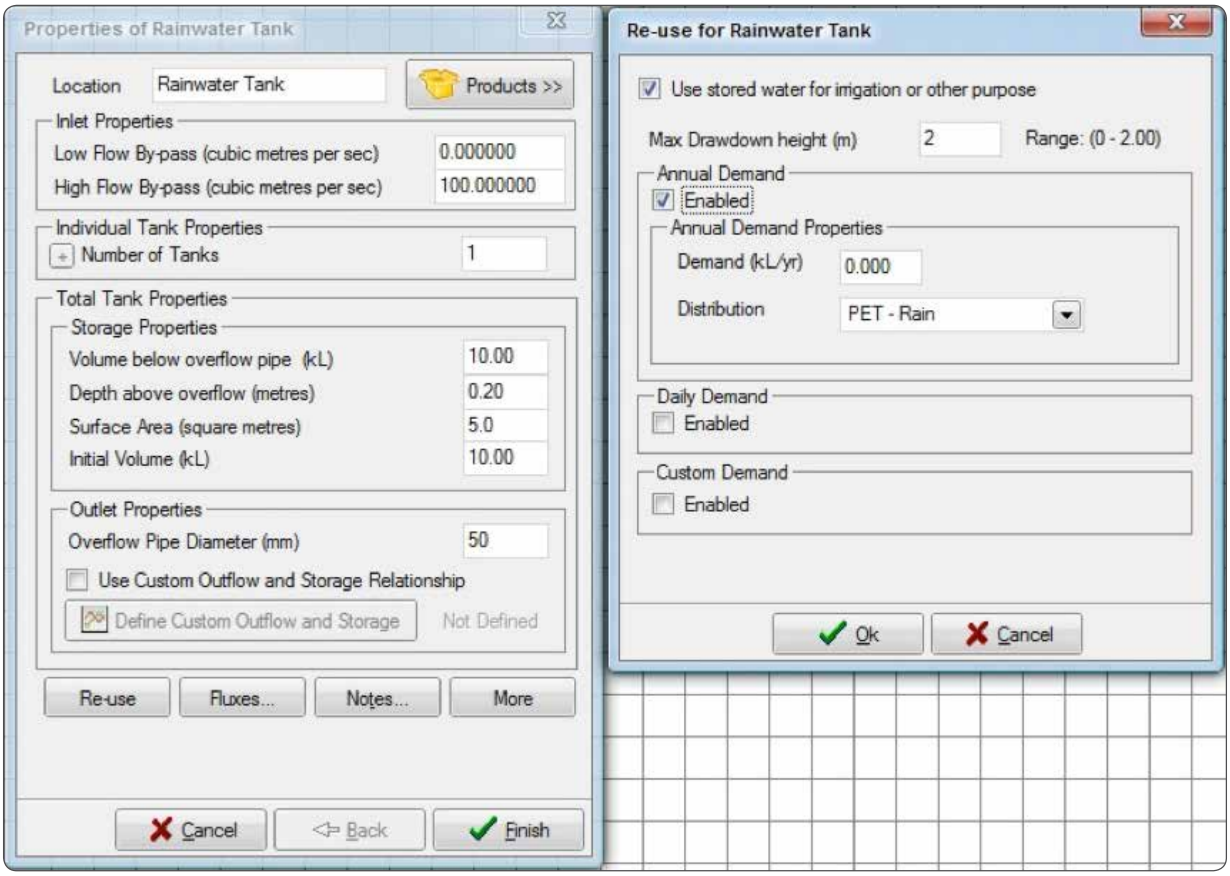


FIGURE 4.5 RAINWATER TANK INPUTS

[18] Based on an average irrigation demand of 1.5–2.0 mm per day. Source: Draft Stormwater Harvesting Guidelines (Water by Design).

Roof water can also be used to supply swimming pools, water features and fountains (for backwashing filters and to replace losses due to evaporation and leakage). These losses are project specific, so there are no pre-approved modelling methods. Any additional outdoor demands should only be modelled where the demands are justified and likely to continue throughout the expected life of the rainwater tank.

4.2.3 COMMERCIAL AND INDUSTRIAL DEMANDS

As each situation is likely to be unique for rainwater tanks in industrial and commercial scenarios, there are no standard configurations or reuse demands provided in this guideline. Any demand modelled for commercial or industrial uses is required to be justified in reporting to the assessment authority.

4.2.4 RAINWATER TANKS VOLUME

In modelling rainwater tanks for development applications, refer to local government guidelines. If none exist provide evidence in the development application to demonstrate how the installation of rainwater tanks will be enforced and guaranteed.

The tank volume modelled is the volume that is operating to retain runoff from the roof, i.e. tank volume modelled is not the total internal volume of the tank, but the total volume minus the volume below the invert of the overflow pipe and above the trickle top up volume (these two volumes do not contribute to active storage). The trickle top up volume can be up to a suggested maximum of 1,000 L and is configured in MUSIC via the Maximum drawdown height.

The storage volume quoted by most tank manufacturers and suppliers is generally the active storage volume. In effect, most tank suppliers and manufactures already subtract the volume below the invert of the overflow pipe and above the trickle top up volume when quoting tank volumes. As a result, the total volume used in modelling can for most applications be the volume quoted by the manufacturer or supplier.

4.2.5 LUMPED VERSUS INDIVIDUAL TANKS

When modelling a catchment with more than one tank, and the ratio of roof area to tank volume and reuse demand is relatively constant, the roof areas in a catchment can be lumped together as can the tank nodes. When lumping rainwater tanks in this way, the tank node size is scaled up to reflect the combined volumes of the individual tanks. When scaling up the dimensions of the tank, the depth in the tank should remain constant (i.e. depth of one tank is used in the lumped tank), with the surface area increased to make up the required volume. The diameter of the overflow pipe from the tank should be equivalent to the diameter of the overflow pipe of a single tank multiplied by the square root of the number of tanks.

WORKED EXAMPLE

Consider a greenfield site being developed as a low-density residential estate with:

- 20 lots at 550 m² with roof areas of 250 m²
- Ground level 30% impervious areas with the remainder lawn and garden beds
- Three-bedroom detached dwellings.

5 kL tanks will be provided on each lot. Above ground tanks are proposed, and 50% of the roof areas will be connected to the tanks. The remaining roof areas will discharge to the drainage system and treated by a bioretention system downstream. Overflows from the tanks will also be drained to the bioretention system to maximise on-site treatment.

Rainwater will be used for household non-potable water uses including toilet flushing, laundry uses and garden irrigation. Using the data provided in Table 4.2 and Table 4.3, the following calculations are undertaken:

- Indoor use (per person) = 21 L/day (toilet) + 26 L/day (laundry) = 47 L/day
- Indoor use (per dwelling) = 47 L/day x 2.5 people/dwelling = 117.5 L/day
- Outdoor use (per dwelling) = 210 m² (pervious ground level of lot) x 75% (portion of pervious area that is irrigated) x 0.548 m (annual

The lumped tank volumes will be modelled with the following configuration:

Catchment Area = 125 m2 (50% Of The Roof Area) X 20 (Lots) = 2,500 m2 = 0.25 Ha

- Tank Volume (Below Overflow Pipe) = 5 kL X 20 = 100 kL
- Depth Above Overflow = As Default (Or According To Tank Design) = 0.2 m
- Surface Area = 100 (Volume) / 2 (Height Of Individual Tank = 2 m) = 50 m2
- Overflow Pipe Diameter = 90 mm X$\sqrt{20}$ = 402 mm
- Annual Demand (Representing Outdoor Use) (Scaled By Daily Pet – Rain) = 86.3 kL X 20 (Lots) = 1,726 kL
- Daily Demand (Representing Indoor Use)= 1,175 L/Day X 20 (Lots) = 2,350 L/Day = 2.35 kL/Day.

4.2.6 FIRST-FLUSH DIVERTERS

In many rainwater tank installations, a diverter is put in place to capture the initial runoff from the roof, which may contain high amounts of leaf matter and other contaminants. Diverters capture a certain volume of runoff after which water bypasses the diverter and enters the tank. To simulate this in MUSIC, the roof source node is configured with the rainfall threshold value set to represent the first flush volume.

For example, if the volume of the first flush diverter is 20 L, and the connected roof area is 100 m2, then the rainfall threshold value for the roof source node is 0.2 mm. This 0.2 mm is added to the default rainfall threshold of the roof which is 1 mm. So the rainfall threshold value becomes 1.2 mm. That is, only after there has been 1.2 mm of rainfall in a day will water enter the tank.

One of the most common mistakes made in modelling rainwater tanks occurs when users forget to use the correct units. The annual demand, daily demand and monthly distribution of annual demand should be modelled and reported in kL/day

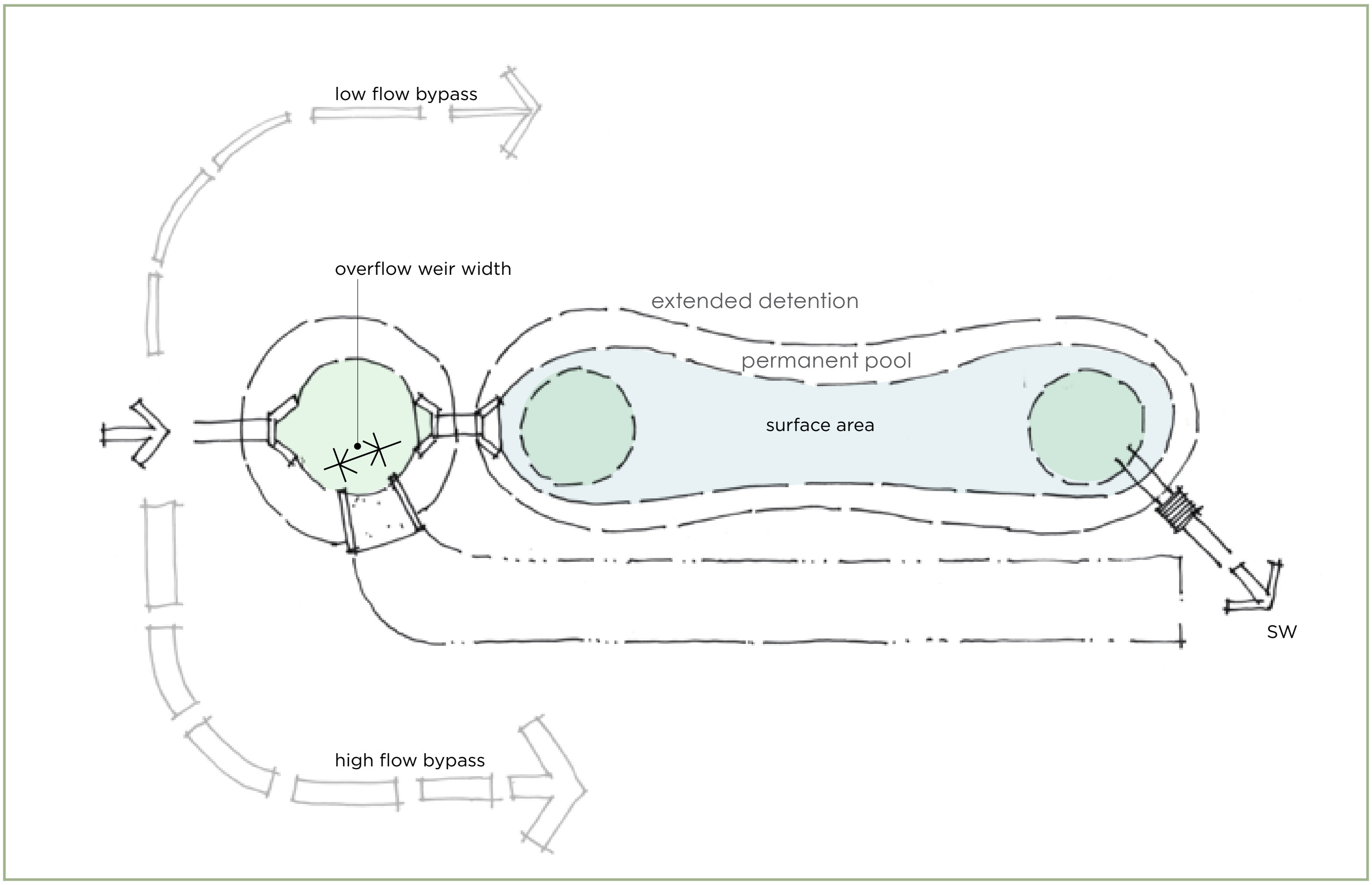
4.3 Constructed Wetlands

A summary of appropriate constructed wetland parameters is presented in Table 4.4 with further details outlined below.

For more information on modelling and designing wetlands, refer to the MUSIC User Manual, Australian Runoff Quality and The Constructed Wetlands Technical Design Guidelines (Water by Design 2016).

TABLE 4.4 CONSTRUCTED WETLAND PARAMETERS INPUT SUMMARY

INLET PROPERTIES	
Low-flow bypass (cubic metres per sec)	0
High-flow bypass (cubic metres per sec)	100 or higher see section 4.3.1
Inlet pond volume (cubic metres)	Sized to remove coarse sediment (>125 µm) during 1 year ARI storm (for conceptual design, assume 5% macrophyte area). Refer to Constructed Wetlands Technical Design Guidelines for further sizing information.
STORAGE PROPERTIES	
Surface area (square metres)	User defined
Extended detention (metres)	0.5 m maximum
Permanent pool volume (cubic metres)	Generally 0.2 m to 0.3 m x surface area
Initial Volume (cubic metres)	Equal to permanent pool volume
Exfiltration rate (mm/hr)	Typically 0 mm/hr
Evaporative loss as % of PET	125
OUTLET PROPERTIES	
Equivalent pipe diameter (mm)	Use a user defined Storage-Discharge-Height relationship (entered under the 'More' button on the Wetland node dialog box). For preliminary sizing of wetlands (at the planning stage), set the equivalent pipe diameter so that notional detention time is as close to 48 hrs as possible.
Overflow weir width (metres)	Greater of surface area (m2)/10 or weir width to convey major storm flow with 0.3 m head.
Notional detention time (hrs)	minimum 48 hrs
ADVANCED PROPERTIES	
Orifice Discharge Coefficient	Default
Weir Coefficient	Default
Number of CSTR cells	User defined (see Section 4.15) where appropriately justified
Total Suspended Solids	k (m/yr) = Default; C* (mg/L) = default
Total Phosphorus	k (m/yr) = Default; C* (mg/L) = default
Total Nitrogen	k=150-200, C*= 0.75 (DesignFlow, 2016)



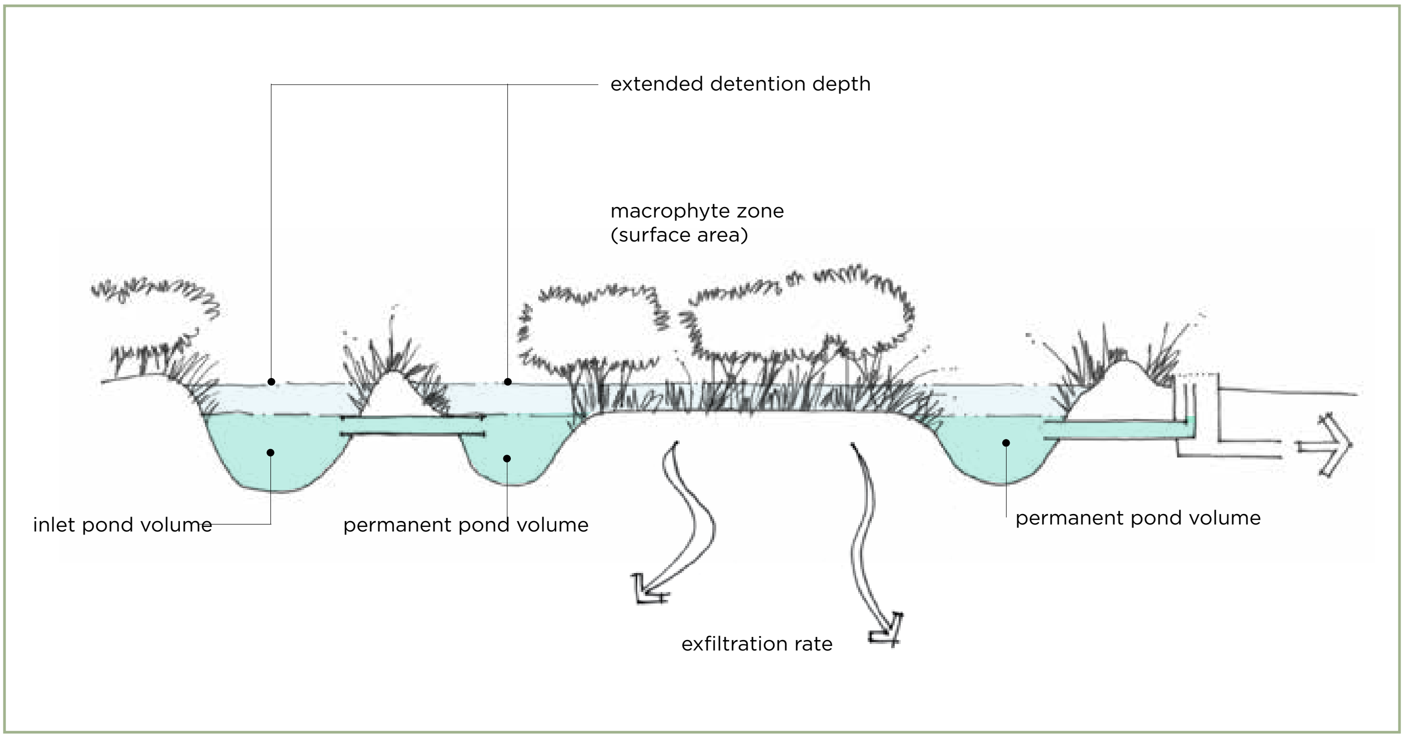


FIGURE 4.6 Constructed wetland parameters

4.3.1 INLET PROPERTIES

All constructed wetlands are different, however typical wetland design includes the macrophyte zone, an inlet pond and a high flow bypass. In simple terms, stormwater enters the inlet pond. The low flows are then directed to the macrophyte zone where they are treated, with the high flows bypassing via the high flow bypass.

The wetland node in MUSIC refers to both a 'low flow bypass' and a 'high flow bypass'. Users should be aware that both bypasses in MUSIC occur before the inlet pond. They do not represent the high flow bypass referred to above.

LOW-FLOW BYPASS (m^3/s): Unless there is a site-specific reason that low flows would be bypassed, set the low flow bypass to zero. This will result in all low flows reaching the inlet.

HIGH-FLOW BY-PASS (m^3/s): Unless there is a site-specific reason that high flows would be bypassed prior to them reaching the inlet pond, set the high flow bypass to a high value (i.e. 100 m3/s or higher) .

INLET POND VOLUME (m^3): MUSIC is not considered to be suitable for sizing wetland inlet ponds. Refer to the Constructed Wetland Technical Design Guidelines (Healthy Waterways, 2016) for the recommended sizing method. Once the inlet pond area and volume is defined using the Constructed Wetlands Technical Design Guidelines, the volume can be inserted into MUSIC. As a guide, the modelled surface area of the sediment pond is typically 5% of the macrophyte zone, assuming a minimum depth of 1.5 m and active sedimentation depth of 1 m.

When modelling an inlet pond with extended detention that receives 'feedback' from the macrophyte zone (i.e. water levels in the inlet pond are controlled by the macrophyte zone outlet), the extended detention volume located above the sediment basin could be included in the extended detention volume of the macrophyte zone node.

4.3.2 STORAGE PROPERTIES FOR MACROPHYTE ZONE

SURFACE AREA (m^2): The 'surface area' specified in the wetland node relates to the macrophyte zone of the wetland. There are two methods for defining the surface area:

1. Equal surface area method (preferred) – to use this method set the surface area equal to the normal water level (i.e. assume that the extended detention has vertical sides). This is the simplest approach and is a more conservative estimate of extended detention storage.
2. Average surface area method – to use this method average the surface area at the top of the permanent pool (commonly referred to as the 'normal water level') and the top of the extended detention (commonly referred to as the 'top water level'). This method takes account of the fact that wetlands generally have battered edges. It is noted that this approach results in an overestimation of the surface area of the permanent pool and hence the evaporation rate and draw-down between rainfall events.

EXTENDED DETENTION DEPTH (m): Set the extended detention depth to 0.35m-0.5 m (or lower to reflect actual design parameters) Deeper extended detention depths increase the risk of plant failure due to stress from extended periods of excessively deep water. The default value for the extended detention depth of 1.0 m is not acceptable.

Permanent pool volume (m^3): Calculate the average depth from the bathymetry or use an average depth of 0.2–0.3 m. MUSIC assumes the permanent pool volume is a constant depth, whereas constructed wetlands generally have a range of depths including ephemeral areas (i.e. no permanent pool).

Initial Volume (m^3): should be equal to the permanent pool volume. Doing so will ensure that model runs begin with the wetland full of water. Specifying a volume less than the permanent pool volume will lead MUSIC to overestimate treatment performance.

Exfiltration rate (mm/hr): The exfiltration rate should generally be set to zero as constructed wetlands are typically lined with impermeable material. Where a wetland is expected to exfiltrate water, a non-zero value may be entered. Where this occurs the exfiltrated water must be retained in the model using a secondary drainage link (see Sections 4.1.1 and 4.1.2).

4.3.3 OUTLET PROPERTIES

Equivalent pipe diameter (mm): Set the equivalent pipe diameter so that the notional detention time is above 48 hours. The notional detention time of the wetland is equal to the extended detention volume (surface area multiplied by the extended detention depth), divided by the flow rate through a circular hole equal to the pipe diameter, with a head equal to the extended detention depth.

Wetland outlets are rarely configured as a single orifice however and so the discharge relationship is different to that simulated in MUSIC. Additionally, the actual time taken for the wetland to draw down from the top of extended detention to the permanent pool level is greater than the notional detention time. The difference between actual draw down and notional detention time can be explained by the fact that as the water level decreases from the top of extended detention towards the permanent pool level, the head of water also decreases and therefore the discharge rate decreases.

To account for this effect in MUSIC, a user-defined stage–discharge relationship can be specified. This allows the user to construct specific outflow characteristics consistent with their outflow design by importing a text file into MUSIC. The text file can be generated using spreadsheet software. Further guidance on creating stage-discharge files is provided in the MUSIC Help.

OVERFLOW WEIR WIDTH (M): The length of the overflow weir controls the discharge rate when the water level in the wetland exceeds the top of extended detention. An undersized overflow weir results in water backing up, effectively adding more extended detention. To avoid this, as a starting point, set the overflow weir length (m) as the greater of either the surface area (m2) divided by 10 m or weir width to convey major storm flow with 0.3m head.

4.3.4 ADVANCED PROPERTIES

Where appropriate justification can be made select Advanced Properties by clicking on the "more" button.

CSTR cells

Refer to Section 4.1.3 for information on CSTR cells and hydrologic routing within wetlands.

K and C Values*

Using the default K and C* values in MUSIC V6 underestimates performance of wetlands in removing nitrogen from stormwater. New studies indicate that wetlands are more efficient than previously thought (DesignFlow, 2016). To ensure that MUSIC V6 accurately reflects nitrogen removal in wetlands, click the "More" button at the bottom of the Wetland Properties box, then adjust the k and C* values for total nitrogen as shown below. All other values must be left as default.

Total Nitrogen: K = 150-200m/y and C* = 0.75

4.3.5 REUSE

The reuse demand profile from the permanent pool of a wetland is project specific. Reuse is only possible from a wetland in MUSIC if a permanent pool volume is set within the node. Refer to Section 4.3.2 for further guidance.

4.4 Swales

A Summary of appropriate swale parameters is presented in Table 4.5 with further details outlined below.

For more specific details on designing swales, refer to the WSUD Technical Design Guidelines and for more details on modelling swales in MUSIC, refer to the MUSIC Help.

TABLE 4.5 SWALE PARAMETERS

INLET PROPERTIES	
Low-flow bypass (cubic metres per sec)	0
STORAGE PROPERTIES	
Length (metres)*	User defined
Bed slope (%)	Maximum 4%
Base width (metres)*	User defined
Top width (metres)	User defined
Depth (metres)	User defined
Vegetation height (metres)	User defined (consider vegetation species being used)
Exfiltration rate (mm/hr)	0

*Note: if the length / width ratio is low, consider lowering the CSTR and k values to account for reduced treatment effectiveness

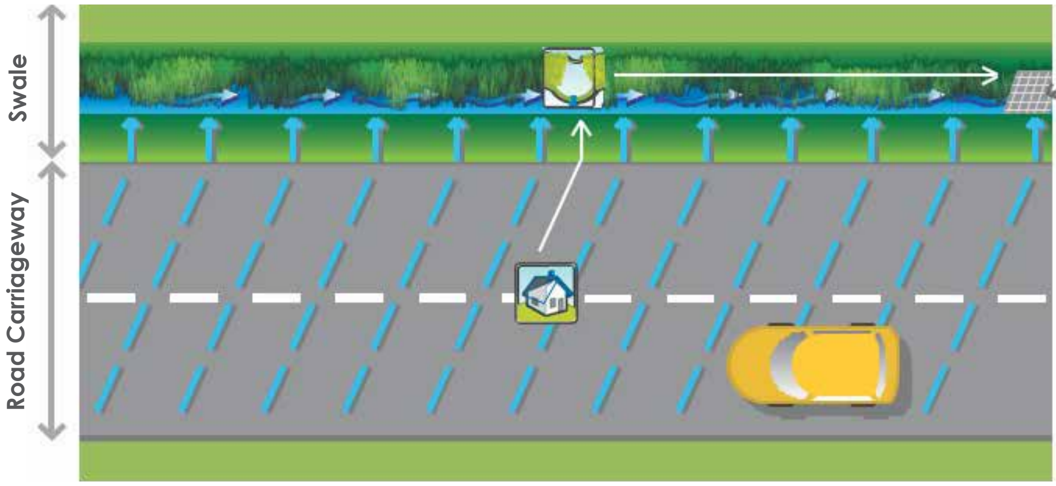
A number of issues should be noted when modelling swales:

- **OPTION A:** If a swale receives distributed lateral inflow along its length and the whole length of the swale discharges at a single point (as shown in "Option A" of Figure 4.7), then the swale length should be modelled in MUSIC as its actual length. The upstream end of the catchment is well treated and the downstream of the catchment is not treated as well therefore the overall performance is identical to the swale modelled as a series of smaller swales (Option B). In this scenario MUSIC should be set up using a single source node (or multiple nodes if splitting the catchment into surface types) and single swale node.
- **OPTION B:** If the swale is segmented, and each segment accepts stormwater at its upstream end (as opposed to continuously along its length) and discharges at its downstream end then the swale should be modelled in MUSIC (as shown in "Option B" of Figure 4.7). It can be modelled as either a single aggregated swale (by summing the total catchment areas and total swale lengths or multiple swales segments as per Option A) or as multiple short segments, each with its own discharge point. Either option will give the same output in MUSIC.
- **OPTION C:** If the swale accepts point source discharges at given locations but each segment of the swale flows into the next segment of the swale with a single outlet point at the downstream end (as shown in "Option C" of Figure 4.7), then the upstream part of the swale is well treated, and the downstream part is not treated well. The swale should be modelled as a series of swale nodes, each receiving inflows from the upstream swale segment and local catchment inflows, with swales modelled separately.

Photo: Jack Mullaly - Ideanthro

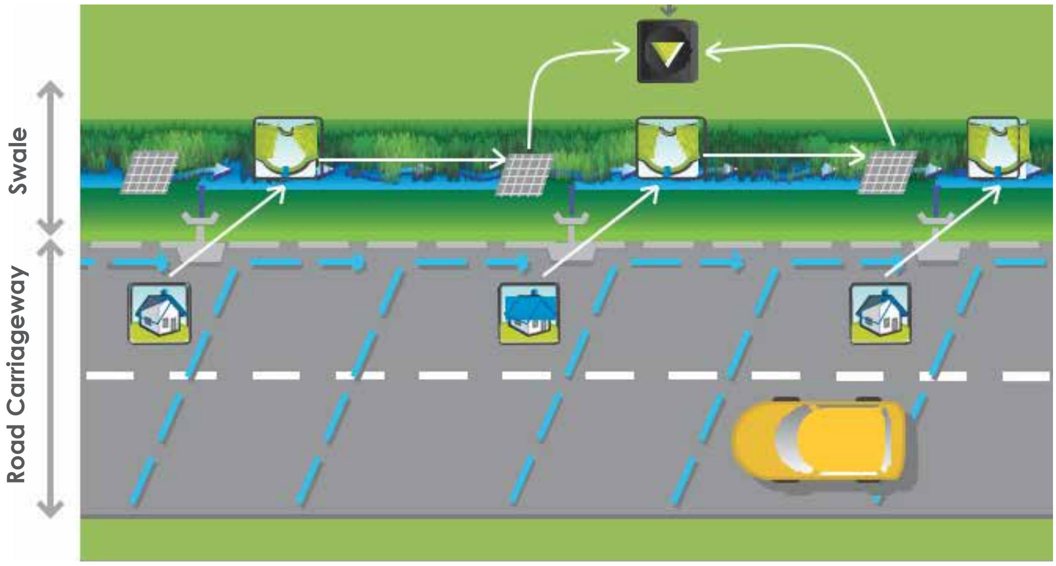
- The total length of swale should account for conveyance capacity and safety limitations selected in accordance with the WSUD Technical Design Guidelines. Proponents must ensure that the system being modelled can actually be constructed.
- If the longitudinal grade of the swale is 5% or greater, the system is primarily for conveyance and will not provide suitable treatment of stormwater. These swales should not be included in the MUSIC model as treatment nodes.
- The height of vegetation in the model depends on the landscape treatment. Turf has a vegetation height of 50 mm. Native grasses and sedges typically have a vegetation height of 300 mm or more however advice from a landscape architect or ecologist should be sought.
- The exfiltration rate should generally be set to zero. A non-zero rate may be adopted if justified through in-situ soil testing. If a non- zero value is adopted the exfiltrated water must be retained in the model using a secondary drainage link (see Section 4.1.1 and 4.1.2)

OPTION A



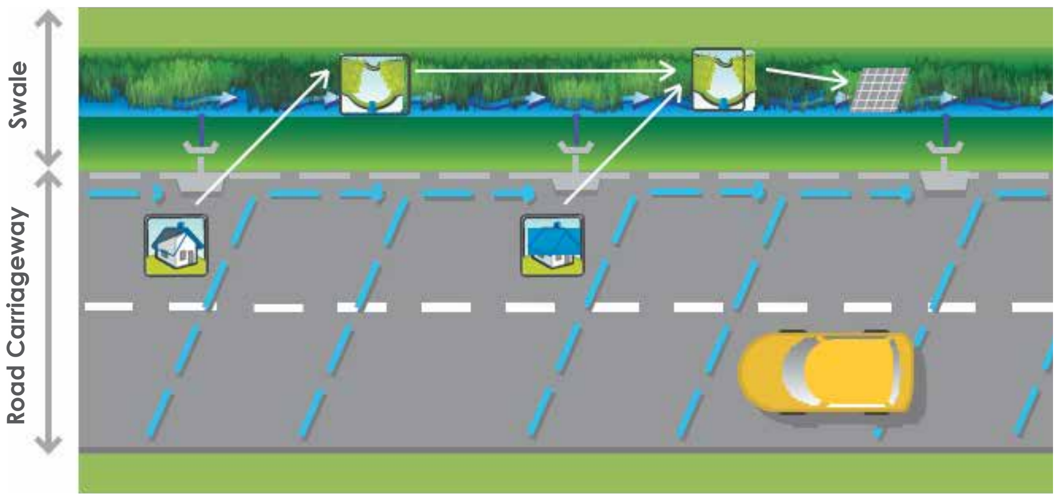
Road runoff into roadside swale as distributed inflow: the full swale length should be modelled

OPTION B



Consecutive swale segments flowing into one another with single outlets should be modelled as a series of sales using actual length

OPTION C



Option C to be modelled accounting for full swale length. May be modelled using multiple swale nodes reflecting each segment, or aggregated as a single combined catchment area and combined swale length.

FIGURE 4.7 Typical localised and distributed inflow arrangements to swale

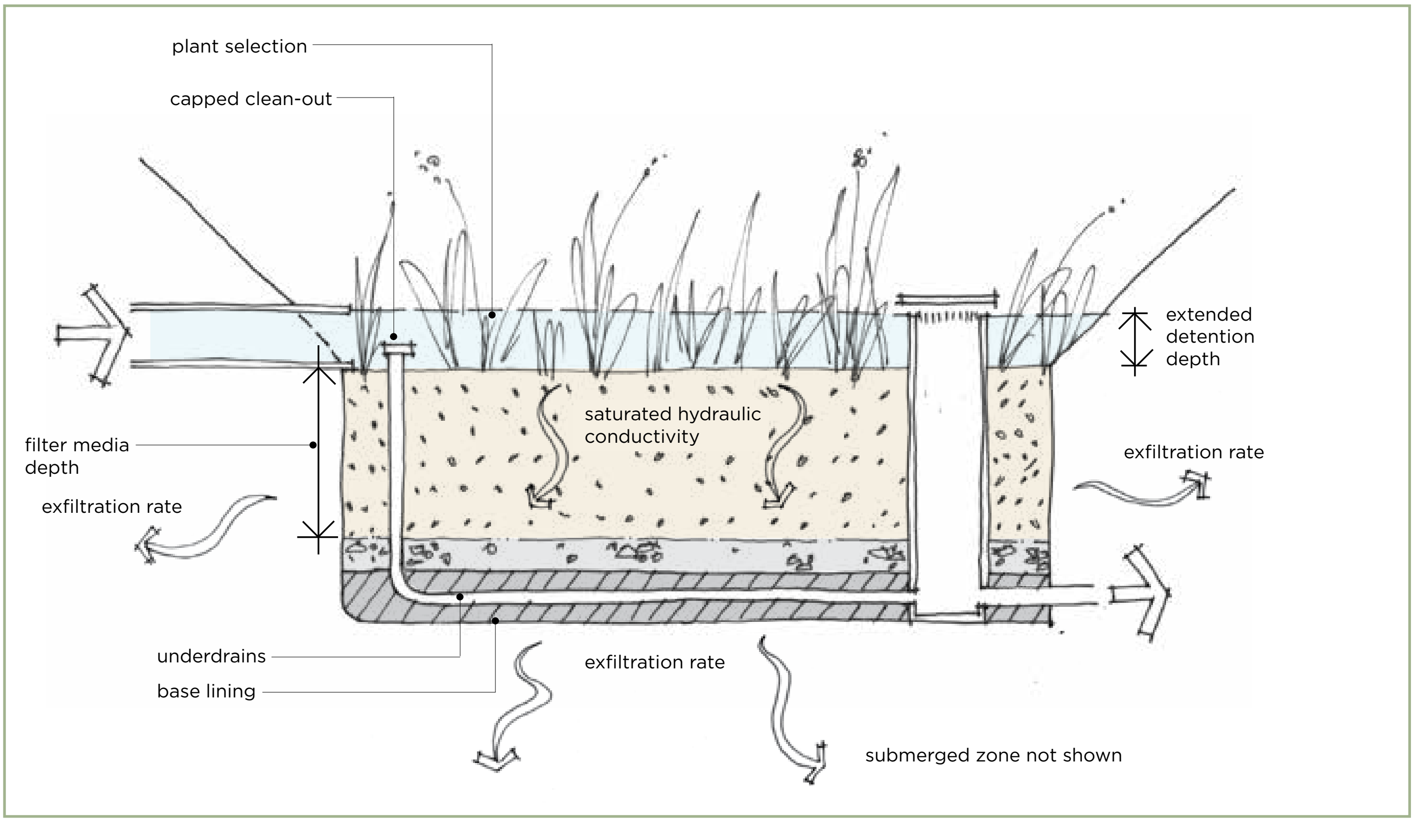
4.5 Bioretention Systems

A summary of appropriate bioretention parameters is presented in Table 4.6 with further details below.

For more specific details on modelling bioretention systems in MUSIC, refer to the information presented below and the MUSIC User Manual (www.ewater.com.au).

TABLE 4.6 BIORETENTION PARAMETERS

INLET PROPERTIES	
Low-flow bypass (cubic metres per sec)	User defined
High-flow bypass(cubic metres per sec)	User defined
STORAGE PROPERTIES	
Extended detention (metres)	0.3m
Surface area (square metres)	User defined (see section 4.5.2)
FILTER AND MEDIA PROPERTIES	
Filter area (square metres)	User defined
Unlined filter media perimeter (metres)	User defined
Saturated hydraulic conductivity (mm/hr)	200 mm/hr (but also run 50 mm/hr for sensitivity and present results)
Filter depth (meters)	0.4 m to 1.0 m (typically 0.5–0.6 m)
TN content on filter media (mg/kg)	User defined (use 400mg/kg if unknown)
Orthophosphate content in filter media (mg/kg)	User defined (use 30mg/kg if unknown)
INFILTRATION PROPERTIES	
Exfiltration Rate	User defined
LINING PROPERTIES	
Is the base lined?	User defined
VEGETATION PROPERTIES	
Plant Selection	User defined
OUTLET PROPERTIES	
Overflow weir width (metres)	Typically greater than or equal to surface area (m2)/10
Underdrain present	Typically Yes
Submerged zone with carbon present	User defined
Depth (of submerged zone)	User defined



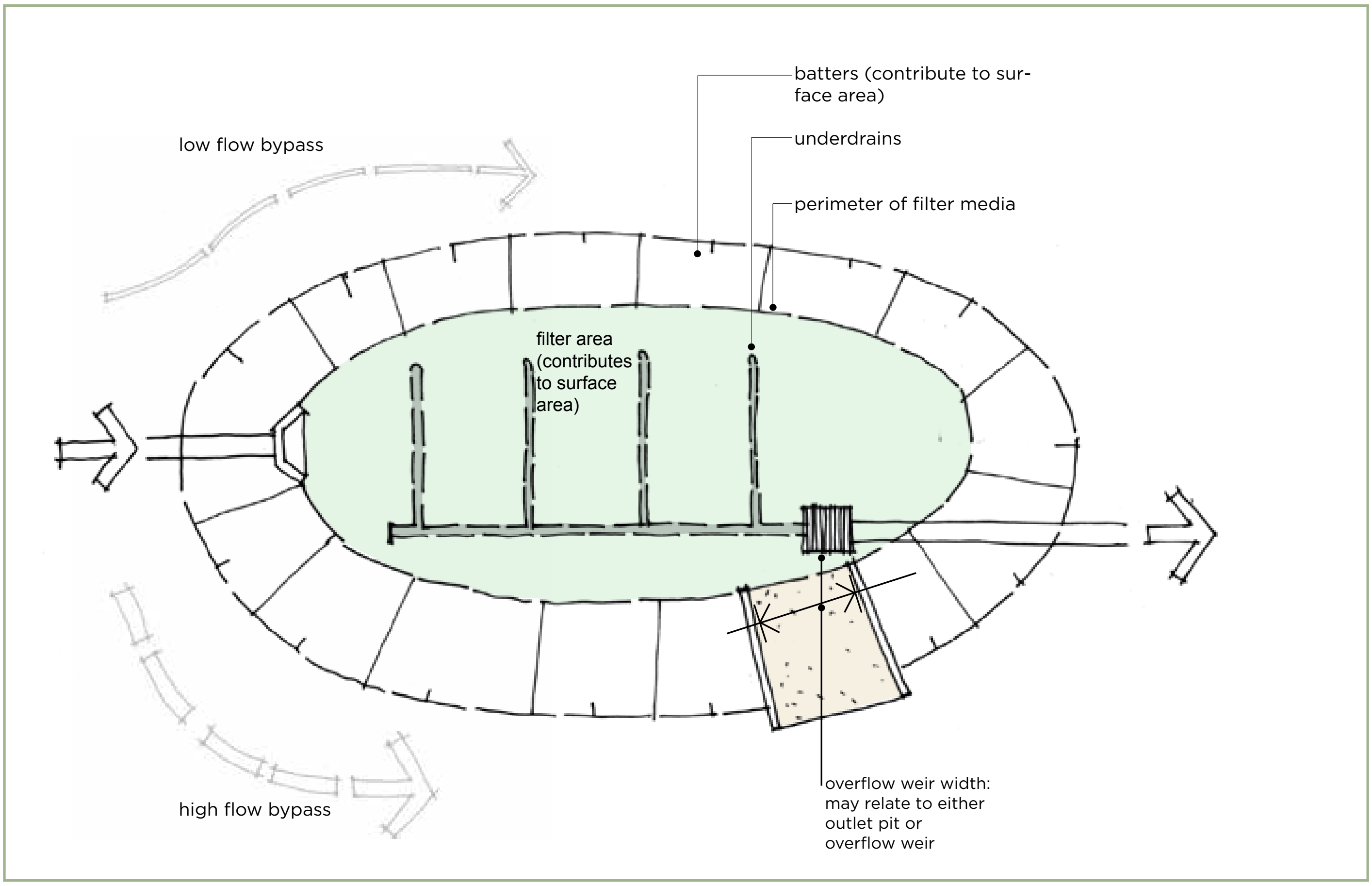


FIGURE 4.8 Bioretention parameters

4.5.1 INLET PROPERTIES

LOW-FLOW BYPASS (m^3/s): There are no standard recommendations for the low-flow bypass as the inputs are dependent on individual design scenarios.

High-flow bypass (m^3/s): There are no standard recommendations for the high-flow bypass as the inputs are dependent on individual design scenarios. High flow bypass should be sized to avoid scouring flows in the bioretention basin.

4.5.2 STORAGE PROPERTIES

SURFACE AREA (m^2): The surface area parameter in MUSIC represents the area water can pond above the filter media. There are two accepted methods for defining the surface area, which are listed below:

1. Equal surface area method – this method assumes that the surface area is equal to the filter area and that the extended detention storage has vertical sides. For systems with a trapezoidal-shaped extended detention storage this is a conservative estimate of the extended detention storage and is the preferred approach.
2. Median surface area method – many bioretention systems do not have vertical sides in the extended detention zone in which case a more accurate estimate of the median surface area can be calculated, which is based on the median depth of ponding in the extended detention area. Note that the median depth of ponding will often be less than half the extended detention depth. Calculation of the median depth of ponding requires analyses to be undertaken outside of MUSIC. The complexity of this analysis and its marginal impact on treatment sizing, especially for large systems, is the reason this is not the preferred approach

Note that bioretention systems, which have an extended detention surface area substantially larger than the filter media experience conditions which have the potential to reduce the lifespan of the system and as such are strongly discouraged. In designing a system in this manner the bioretention system will operate like a bath tub whereby large volumes of stormwater are captured and squeezed through a small filter media area like a plug hole.

> There are significant risks associated with designing systems in this manner including: overloading the filter media (with pollutants); filter media blockages – causing reduced hydraulic conductivity and placing stress on vegetation which is likely to result in plant mortality or a change in plant composition from the intended design. If there is no alternative approach, then **the filter area must not be less than 50% of the total surface area of the detention basin area.**

> When a bioretention system is incorporated into the base of a retarding basin, the volume of the retarding basin (i.e. the volume available in the basin above the top of the extended detention depth), is not to be included in the model for water quality assessment. Flood storage is not creditable as extended detention.

If the exfiltration rate is to be set to a value other than zero, set the unlined filter media perimeter to either:

- The actual unlined perimeter (if the perimeter is unlined and the perimeter is known)
- Four times the square root of the surface area (if the perimeter is unlined but the perimeter is not known)
- 0.01m (if the perimeter of the system if lined

Note the discussions in Section 4.1 with respect to exfiltration rates and modelling using the secondary drainage link.

SATURATED HYDRAULIC CONDUCTIVITY (mm/HR): Use a loamy sand as the filter media for all bioretention systems, with a hydraulic conductivity of 200 mm/hr. For sensitivity testing, simulate the bioretention system in MUSIC using a hydraulic conductivity of 50 mm/hr and present the results with the development application. Compliance with water quality objectives is only required for the actual long term expected hydraulic conductivity i.e.
200 mm/hr.

FILTER DEPTH (m²): The recommended bioretention filter depth is 0.4–1.0 m (preferably 0.5-0.6 m). The depth depends on the available depth based on the inlet and outlet levels and the species of plants being used. Do not model the depth of the drainage layer, intermediate layer or submerged zone as part of the filter media depth.

TN CONTENT IN THE FILTER MEDIA (mg/kg): Bioretention performance is sensitive to the amount of nitgren in the filter media. In Queensland, the stormwater design objectives were developed using a value of 400mg/kg. When modelling to demonstrate compliance with the objectives, adopt the larger of 400mg/kg, or the actual value of total nitrogen in the filter media as established through testing. When not modelling to demonstrate compliance with these objectives, adopt the actual value. If it's not known, adopt 400mg/kg. The amount of nitrogen available within the filter media is defined by testing consistent with the Adoption Guidelines for Stormwater Biofiltration Systems (CRC for Water Sensitive Cities, 2016)

ORTHOPHOSPHATE CONTENT OF FILTER MEDIA (mg/kg): Bioretention performance is sensitive to the value of orthophosphate in the filter media. In Queensland, the stormwater design objectives were developed using a value of 30mg/kg. When modelling to demonstrate compliance with the objectives, adopt the larger of 30mg/kg, or the actual value of orthophosphate in the filter media as established through testing. When not modelling to demonstrate compliance with these objectives, adopt the actual value. If it's not known, adopt 30mg/kg. The amount of phosphorous available within the filter media is defined by testing consistent with the Adoption Guidelines for Stormwater Biofiltration Systems (CRC for Water Sensitive Cities, 2016)

4.5.4 INFILTRATION PROPERTIES

Exfiltration rate (mm/hr): The exfiltration rate should generally be set to zero. A non-zero rate may be adopted if justified through in-situ soil testing. If a non-zero value is adopted, the exfiltrated water must be retained in the model using a secondary drainage link (see Sections 4.1.1 and 4.1.2).

4.5.5 LINING PROPERTIES

Is the base of the bioretention system lined?: Whether or not the base of the system is lined only influences the model if the exfiltration rate is set to a value other than zero. Select yes or no depending on whether or not your bioretention system is to be lined. For further information see the discussions in Section 4.1 with respect to exfiltration rates and modelling using the secondary drainage link.

Photo: Paul Dubowski - BMT WBM

4.5.6 VEGETATION PROPERTIES

Plant types have a significant impact on reducing nutrient loads. Root morphology and associated physiochemical processes being key factors in the variation in performance between species (Read et. al. 2008). Select the correct option in MUSIC in accordance with the following:

- **Vegetated with effective nutrient removal species:** use when at least 50% of the plant cover in the bioretention system will either (a) come from the plants listed in Table 19 of the Bioretention Technical Design Guidelines (Healthy Waterways, 2014) or (b) come from plants that meet the functional attributes for bioretention plants as described in Section 3.6 of the Bioretention Technical Design Guidelines (Healthy Waterways, 2014)
- **Vegetated with ineffective nutrient removal species:** use when less than 50% of the plant cover in the bioretention system will come from either of the sources listed above
- **Unvegetated:** use when the system does not contain plants

4.5.7 INFILTRATION AND OUTLET PROPERTIES

OVERFLOW WEIR WIDTH (M): The length of the overflow weir controls the discharge rate when the water level in the bioretention system exceeds the top of extended detention. An undersized overflow weir results in water backing up, effectively adding additional extended detention. To avoid this, it is recommended that, as a starting point, the overflow weir length (m) is set as the surface area (m^2) divided by 10 m.

UNDERDRAIN PRESENT: Bioretention systems are generally configured with a collection system at their base. This generally takes the form of underdrainage pipes, but can also include specially configured outlet pits. Where a collection system is located at the base of a bioretention system, tick yes. Where a collection system is not located at the based of the system, select no. Note that if no is selected, the system must be configured with exfiltration into the surrounding soils. This will require consideration of the appropriate lining and exfiltration parameters (see Sections 4.5.4, 4.5.5 and 4.1.1), as well as the use of the secondary drainage link (see Section 4.1.2).

SUBMERGED ZONE WITH CARBON PRESENT (DEPTH (M)):
To improve the potential for denitrification in bioretention systems, and to provide a moisture storage for the plants, where practicable include a zone below the underdrain.

BIORETENTION WATER LOSSES – With the inclusion of the secondary drainage link in MUSIC, modelling bioretention systems with exfiltration is increasingly practical. In recent years, a number of studies (e.g. Lucke and Nichols 2015, Parker 2010, Brisbane City Council 2009 and Hunt 2006) have investigated water losses through bioretention systems. These papers demonstrate significant volumetric water losses through bioretention systems. When modelling bioretention systems with infiltration in MUSIC, it is common to receive results that show far smaller volumes of water being lost. The cause of this discrepancy is not clear. Users must therefore be cognizant of this situation while modelling bioretention systems with exfiltration and stay abreast of developing literature.

EXFILTRATION – this parameter is used by MUSIC to calculate the amount of exfiltration that will occur through the base and sides of the system.

If an "unlined filter media perimeter" is set in MUSIC and the base is set to be unlined, then exfiltration will occur in accordance with whatever exfiltration rate is set by the user. In this case exfiltration will occur from the base and sides of the filter media according to the algorithms for side exfiltration and in accordance with the exfiltration rate for the base. Exfiltration will also occur from the sides of the surface storage area to represent loss from the batters etc.

If the exfiltration rate is set to 0 mm/hr then it does not matter whether an unlined filter media perimeter is set or the based is lined in MUSIC because MUSIC will not calculate any exfiltration. In this case the only loss calculated by MUSIC will be evapotranspiration from the filter media.However for modelling clarity we recommend where the entire system perimeter is lined with impermeable material, the "unlined filter media perimeter" should be set to 0.01

If the base is lined in MUSIC but the perimeter is unlined, exfiltration can still occur from the sides but none will be lost through the base or submerged zone. This means that moisture can be retained in a submerged zone with loss from the sides.

If the base is unlined in MUSIC and the perimeter is lined (i.e. set at 0.01 m) exfiltration will occur from the base at the exfiltration rate set by the user. This type of exfiltration is promoted as it helps to recharge groundwater and will assist in meeting hydrologic management objectives.

Table 4.7 summarises the above information providing a quick reference guide on which parameters apply to different bioretention exfiltration scenarios. This table can be used to help design teams understand which parameters need to be considered for different exfiltration scenarios and can also be used to assess whether modelling matches design plans.

TABLE 4.7 APPLICATION OF PARAMETERS TO DIFFERENT BIORETENTION EXFILTRATION SCENARIOS

EXFILTRATION SCENARIO	UNLINED FILTER MEDIA PERIMETER (M)	IS THE BASE LINED (Y/N)	EXFILTRATION RATE (MM/HR)
No exfiltration	0.01	Y[19]	0
Exfiltration from base, sides and batters	User defined	N	User defined[20]
Exfiltration from sides and batters only	User defined	Y	User defined[20]
Exfiltration from the base only	0.01[19]	N	User defined[20]

[19] If an exfiltration rate of 0 mm/hr is set these parameters become redundant but should be set as noted
[20] See Section 4.1for discussion on applying exfiltration rates

4.5.7 HYDROLOGIC ROUTING

Refer to Section 4.1.3 for guidance on hydrologic routing. The conceptual design must be developed to illustrate why a certain option is selected. If the conceptual design is not available, use the default value.

4.5.8 BIORETENTION IN SERIES

When bioretention systems are designed in series, only the stormwater that overtops the first bioretention system (either via the overflow pit or weir) should enter the second system. This requires a separate drainage system to keep the treated and untreated stormwater separate between the systems.

In earlier versions of MUSIC, the pollutant reductions through the filter media of a bioretention system were based on empirical equations to estimate the performance of the system. These equations were based on observed relationships derived from monitoring data assumed as individual bioretention systems accepting untreated stormwater. Modelling bioretention systems in series in earlier versions of MUSIC, without a bypass, results in an over-estimation of the treatment performance of the series of bioretention systems because MUSIC assumes the downstream system is receiving untreated stormwater and therefore, will assume the same level of pollutant reduction as for untreated stormwater.

In more recent versions of MUSIC, the performance of the system is less dependent on inflow concentrations and hydraulic loading is properly accounted for. However, use the prescribed methodology below to ensure good modelling practice.

To properly model bioretention in series, include a low-flow bypass in the downstream bioretention node to bypass treated flows from the upstream bioretention. Set the bypass at the maximum discharge rate of the upstream bioretention approximated by multiplying the filter media area by hydraulic conductivity. This will ensure untreated overflows from upstream enter the downstream system and treated flows are bypassed. (Some untreated stormwater will also bypass, but this volume is small in the context of the total stormwater volume). Alternatively a secondary drainage link can be used to separate treated and untreated flows

Example:

Assume a bioretention system of 150 m² is required for a catchment to meet best practice objectives. Figure 4.9 shows a MUSIC model depicting two bioretention systems, each with a 75 m² filter media area (total 150 m²). The first bioretention is modelled according to the parameters described in these guidelines. The treated outflow (low flows) from the first system bypass directly to the receiving node using a low flow bypass on the second bioretention. The saturated hydraulic conductivity of the first bioretention system is 200 mm/ hr (equating to 200 L/m²/hr, or 0.055 m³/ m²/s) and the area is 75 m², equating to a filtered flow rate of about 4.2 L/s or 0.004 m³/s. This flow rate (0.004 m³/s) is then entered as the "Low Flow By-Pass" in the second bioretention node (as shown in Figure 4.9).

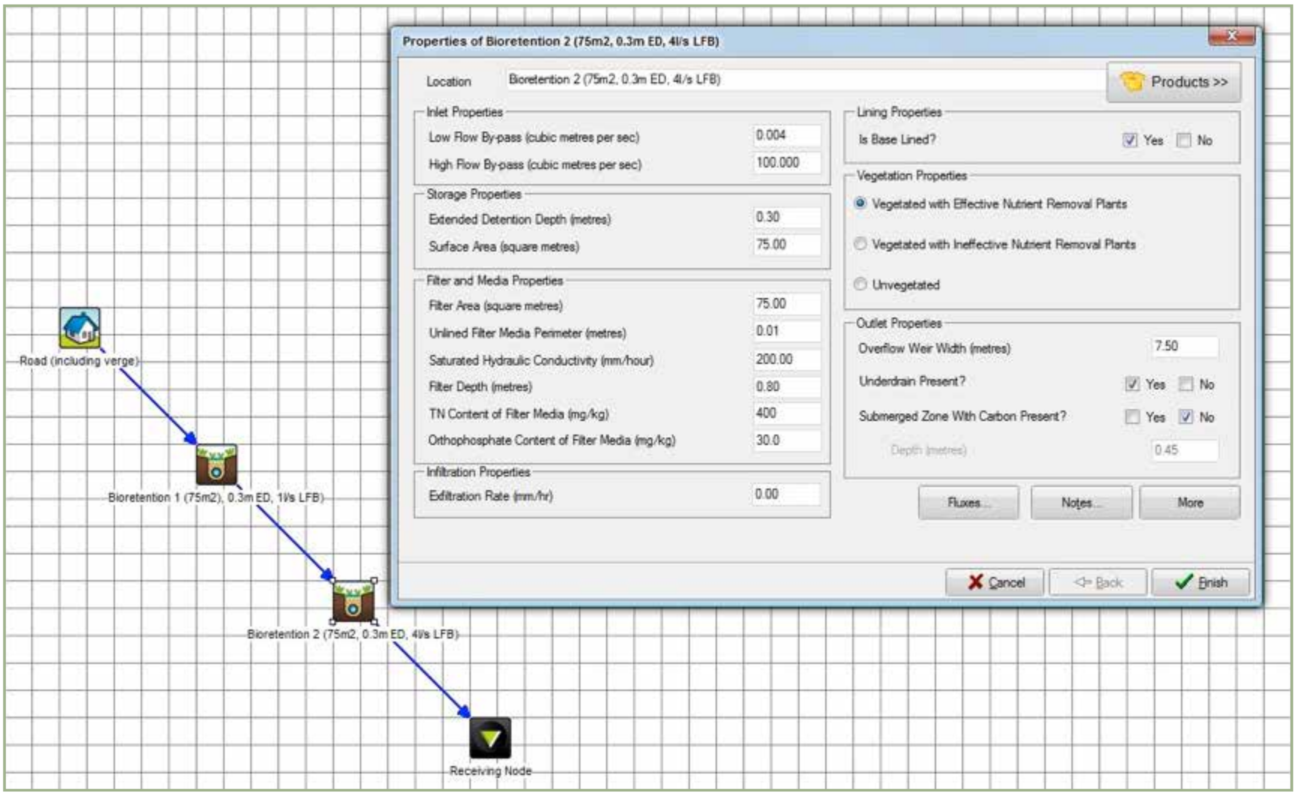


FIGURE 4.9 Modelling bioretention in series

Where smaller bioretention systems, such as street tree pods, drain into larger (precinct) bioretention systems and the systems are directly connected (i.e. the treated outflow from the smaller system flows directly into the larger one via a piped connection), as shown in Figure 4.10, the above low-flow bypass method should still be used. If, however, there are additional, untreated catchment flows entering the large bioretention, as shown in Figure 4.11, then the low-flow bypass method is not required.

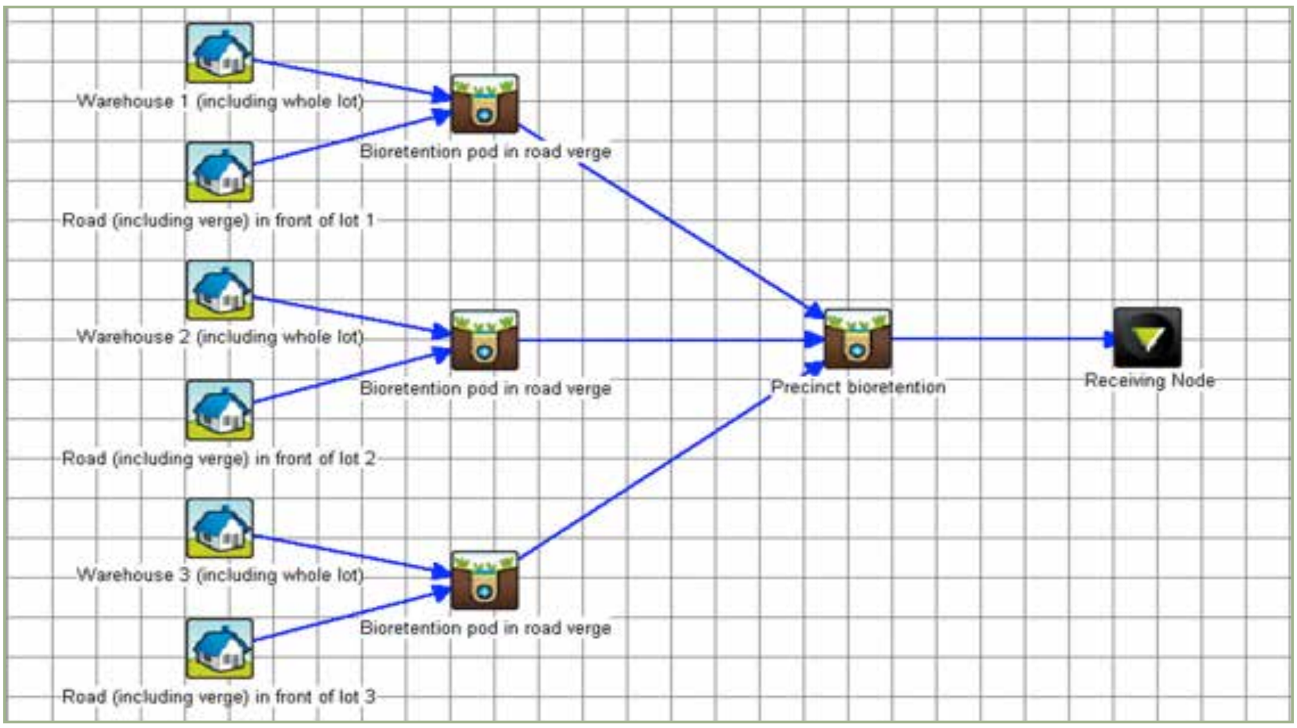


FIGURE 4.10 Directly connected bioretention systems

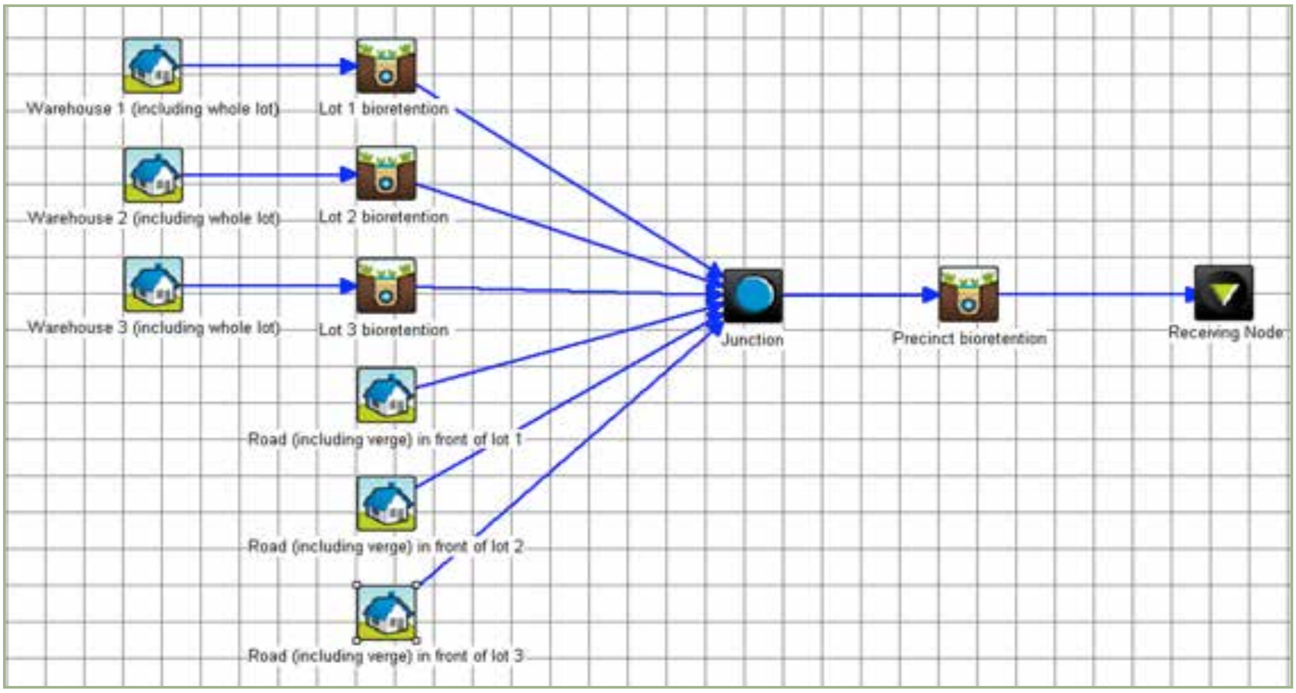


FIGURE 4.11 Bioretention in series with extra catchment area

Under drainage from upstream systems bypass the downstream system by setting an appropriate low flow bypass on the downstream cycle. No low flow bypass is set on the downstream system.

4.6 Bioretention Swales

The difference between a normal swale and a bioretention swale is that the latter has filter media and underdrainage (much like a bioretention basin). Bioretention swales must be modelled as a bioretention system with zero extended detention followed by a swale with a low-flow bypass set to the infiltration rate of the filter area. The appropriate MUSIC layout is shown in Figure 4.12 and calculation provided in below. Provide a copy of calculations to the
assessment authority.

To model pollutant reductions from bioretention swales, separate the treatment system into its various components:

- Batter slopes or buffers, this only applies where inflows reach the base of the swale through lateral inflow over a vegetated flow path (e.g. roadside swale). For further guidance on setting up the buffer node refer to Section 4.7
- Bioretention filter media components, refer to Section 4.5
- Surface swale components. For further guidance on setting up the swale node refer to Section 4.4.

The majority of the treatment node parameters should be set in accordance with the advice provided in the buffer (Section 4.7), bioretention system (Section 4.5) and swale (Section 4.4) parts of this guideline. The only two exceptions to this are:

- The bioretention node component should be modelled with no extended detention depth. This is because for the majority of rainfall events, only minimal ponding occurs above the surface of bioretention swales.
- The low flow bypass for the swale node shall be established using the following equation

$$\textit{Low flow bypass} = \frac{\textit{infiltration rate of surface (i.e.length (m) base width (m) x saturated hydraulic conductity of filter media (mm/hr)}}{3600 \times 1000}$$

If the swale is designed so that an ordinary swale (without a bioretention filter), discharges to a bioretention trench at the end of the swale, then the order of the bioretention filter node and the swale node shown in Figure 4.12 should be reversed and the low flow bypass for the swale set to 0.

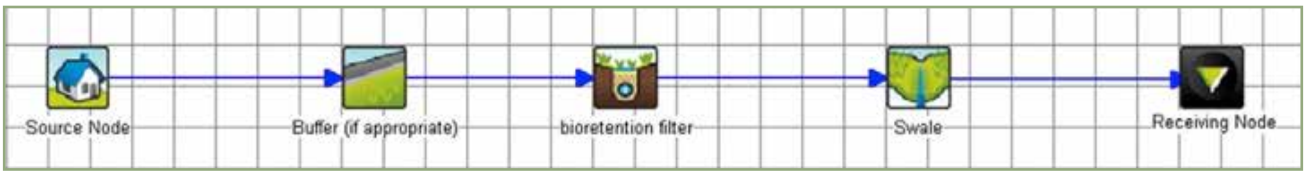


FIGURE 4.12 Standard bioretention swale model

Photo: Brad Dalrymple - BMT WBM

4.7 Buffers

The buffer node is described in the MUSIC Help Manual. Buffer nodes are generally located upstream of other stormwater treatment nodes.

The exfiltration rate should generally be set to zero (see Section 4.1). A non-zero rate may be adopted if justified through in-situ soil testing. If a value other than zero is adopted, the exfiltrated water must be retained in the model using a secondary drainage link (see Sections 4.1.1 and 4.1.2). Buffers are only appropriate for simulating situations where flow is dispersed (sheet flow). If vegetation accepts concentrated flows or pipe flows, then using the buffer node in the MUSIC model is not appropriate (i.e. minimal stormwater treatment will occur).

There may be an opportunity to model buffers as modified swale treatment nodes, however they must be clearly designed as a swale with flow dispersal across the full width of the vegetated area.

Care needs to be taken in setting up and assessing MUSIC models to ensure that source nodes can actually drain to the buffer node.

The treatment processes in a buffer strip are modelled by a set of simple transfer functions derived from a review of worldwide literature. Th transfer functions cannot be adjusted in the buffer strip node.

4.8 Proprietary and Custom Products

Proprietary and custom products such as gross pollutant traps (GPTs), trash racks and proprietary nutrient removal devices can be modelled in MUSIC. Several different nodes may be used depending on the device being modelled.

Proprietary products generally operate with a high-flow bypass. It is important to enter the correct high-flow bypass rate for the proposed unit into the gross pollutant node in MUSIC so that no pollutant reductions are attributed to bypassed flows. It is also important to note in stormwater reporting and on detailed plans that the proprietary product modelled cannot be replaced for alternative units unless the applicant can suitably demonstrate to the assessment authority that the proposed alternative unit has an equivalent high-flow bypass rate and pollutant removal capacity to the unit modelled.

4.8.1 DEMONSTRATING PERFORMANCE

Where reductions for TSS or nutrients from GPTs or other proprietary products are reported, this data must be justified. The previous version of the MUSIC Modelling Guideline provided high level advice on how to demonstrate this performance. At the time of writing, several initiatives are in development to aid in determining and demonstrating the pollutant removal efficiencies of proprietary products. In most instances, Councils will require device performance to be demonstrated using one of the following methods. Check with the relevant local authority:

- Stormwater Australia's Stormwater Quality Improvement Device Evaluation Protocol (draft at the time of writing)
- Gold Coast City Council's Stormwater Quality Improvement Device Evaluation Protocol
- In the case of small Councils, the adopted approach or policy of another local authority
- The advice shown in the following callout box (and as included in the previous version of this guideline)

Where reductions for TSS or nutrients from proprietary products are reported, this data must be accompanied by information describing:

- Pollutant reduction parameters independently verified using a method to suit local or regional conditions
- Performance under dry weather flows (to account for potential pollutant leaching)
- An assumed high-flow bypass rate and details about how it was determined
- Calculations showing that gpt storage volumes are large enough to store collected sediments and gross pollutants.

Assessment authorities should not accept models using this node unless the applicant has demonstrated that:

- The proposed reduction efficiencies are justified by rigorous scientific testing and results are published in a credible engineering/scientific journal. Copies of the supporting published paper must be lodged with the development application
- The modelled pollutant reduction efficiency reflects the published figures.

In considering whether the storage is appropriate for the proprietary product careful consideration should also be given to the:

- Expected pollutant loads
- Expected maintenance schedule

Potential risks associated with the breakdown of stored organic matter in wet sump systems (leaching of bio-available forms of nutrients).

The storage volume must be suitably sized to ensure that 90% of pollutants will be captured during inter-maintenance periods. The maintenance period used to size the storage volume must be reported to the assessment authority.

Note: whilst the GP generation has been based on significant research, recent research indicates that GP generation rates may differ to MUSIC predictions in some situations. As a result guidance may be updated in subsequent versions of this guideline.

Photo

4.8.2 THE GROSS POLLUTANT TRAP NODE

The parameters defined for the gross pollutant trap (GPT) node are described in the MUSIC User Manual. This node can also be used to model reductions in loads from other proprietary products.

4.8.3 MEDIA FILTRATION SYSTEMS

The media filtration node has been set up to account for filtration systems (both proprietary and non- proprietary) which operate in such a way that they are not properly represented by other MUSIC treatment nodes outlined in these guidelines. This node requires the user to specify the pollutant removal efficiency (under Advanced Properties), and therefore the development application will need to include information to demonstrate to the assessment authority that the proposed treatment measure operates in a manner which cannot be represented using one of the other MUSIC treatment nodes, or configured using the guidance provided for other treatment measures.

Filter media particle diameter and saturated hydraulic conductivity should be set consistent with manufacturer information. K and C* values should be retained as default values unless otherwise suitably justified (see Section 4.1).

4.9 Sediment Basins

The MUSIC User Manual describes the parameters for the sediment basin node.

Sediment basins are frequently used in construction phase erosion and sediment control to minimize sediment runoff, to capture runoff and for pre-treatment to other treatment measures such as wetlands (e.g. an inlet pond). They are sized according to the design storm discharge and the target particle size (generally 0.125 mm).

> This section does not cover construction phase sediment basins, as MUSIC is generally not suitable for modelling the pollutant removal capacity of this type of basin. Refer to the Best Practice Erosion and Sediment Control Guidelines (IECA, 2008) for guidance.

The performance of sediment basins is often simulated using the inlet pond within the wetland node. Examples of when separate sediment basins may be modelled independently include:

- Where information about sediment basin outflows needs to be obtained independently from macrophyte zone outflows
- When providing pre-treatment to bioretention basins or other treatment systems
- When splitting sediment basin outflows between different downstream nodes.

> Coarse sediment forebays are a relatively small, shallow feature sometimes included at the inlet of bioretention systems. These are designed to reduce the amount of coarse sediment entering bioretention systems. They are not specifically designed to remove TSS and the extent of any TSS removal will be dependent on how much coarse sediment has accumulated in the forebay since it was last maintained. It is therefore recommended that coarse sediment forebays are not credited with TSS removal i.e. forebays should not be modelled as sediment basins in MUSIC.

When modelling a sediment basin upstream of a wetland or bioretention system where there is no flow restriction between the sediment basin and the downstream wetland for the treatment design flow (usually ≤ 3 month ARI), the notional detention time in the sediment basin node should be set to a short period (e.g. one hour). When the sediment basin is upstream of a wetland or bioretention system and there is a flow restriction, the notional detention time should be as designed (usually for a centralised basin 8-10 hours is recommended).

Sediment basin surface area should be calculated in the same manner as for wetlands (see Section 4.3.2).

4.10 Infiltration Systems

The MUSIC User Manual describes the parameters for the infiltration node.

Infiltration is an important aspect of urban stormwater management, particularly for recharge of groundwater and compliance with frequent flow management objectives. Stormwater must be treated before infiltration. For example, this infiltration can occur from a bioretention system that has a leaky base or a swale.

Subsoils should be considered when planning infiltration systems e.g. dispersive or sodic soils.

When modelling infiltration systems within a model to be used for demonstrating compliance with water quality objectives, the exfiltrated water must be retained in the model using a secondary drainage link (see Sections 4.1.1 and 4.1.2).

4.11 Porous Pavements

A Summary of recommended porous pavement parameters are presented in Table 4.8 with further details below. Porous paving allows runoff to drain through or between paving and infiltrate the underlying media. It can provide some degree of stormwater treatment, however more importantly it increases the pervious area of the developed catchment and promotes infiltration

In MUSIC, any unvegetated filtration system with filter media is to be modelled using the media filtration node, and this applies to the modelling of porous paving. Care should be taken in setting up the node to only represent the filtration zone, not the underlying drainage layer.

The drainage layer is usually imported coarse material with little or no treatment capacity. Removing particulates and some dissolved pollutants is achieved through filtration and adsorption onto soil particles in the treatment zone or filter media (typically a base course of sand, loamy sand or other mix of finer material). Additionally, the porous pavement and associated drainage layer and filter media must be free draining (i.e. does not hold water after rainfall).

This requires the design and associated reporting (stormwater management plan) to illustrate:

- That the porous paving system incorporates an under-drainage system (slotted pipe or similar) which freely drains to downstream drainage systems
- That the in-situ soils have a suitably high saturated hydraulic conductivity to accept treated flows from the base of the porous pavement systems (i.e. in-situ permeability greater then porous pavement filter media permeability). If it cannot be illustrated the porous pavement is free draining then the porous pavement cannot be modelled in MUSIC.

TABLE 4.8 MEDIA FILTRATION NODE PARAMETERS TO REPRESENT POROUS PAVEMENTS

INLET PROPERTIES	
Low-flow bypass (cubic metres per sec)	User defined
High-flow bypass (cubic metres per sec)	User defined
STORAGE PROPERTIES	
Extended detention depth (metres)	Set to 0 m unless there is a specific design intent to allow frequent ponding above the paving
Surface area (square metres)	User defined
Exfiltration rate (mm/hr)	0
FILTRATION PROPERTIES	
Filter area (square metres)	User defined (must equal surface area where extended detention depth = 0)
Filter depth (metres)	0.4 m to 0.6 m (dependent on depth of treatment zone)
Filter median particle diameter (mm)	1 mm (or less, dependent on the filtration media)
Saturated hydraulic conductivity (mm/hr)	Equivalent to the media used (suggest 360 mm/hr for sand)
Depth below underdrain pipe (% of Filter Depth)	0.0
OUTLET PROPERTIES	
Overflow weir width (metres)	Equal to the length of the system

*Note – care should be taken when using porous pavement where dispersive subsoils are present as they may erode underground and undermine infrastructure.

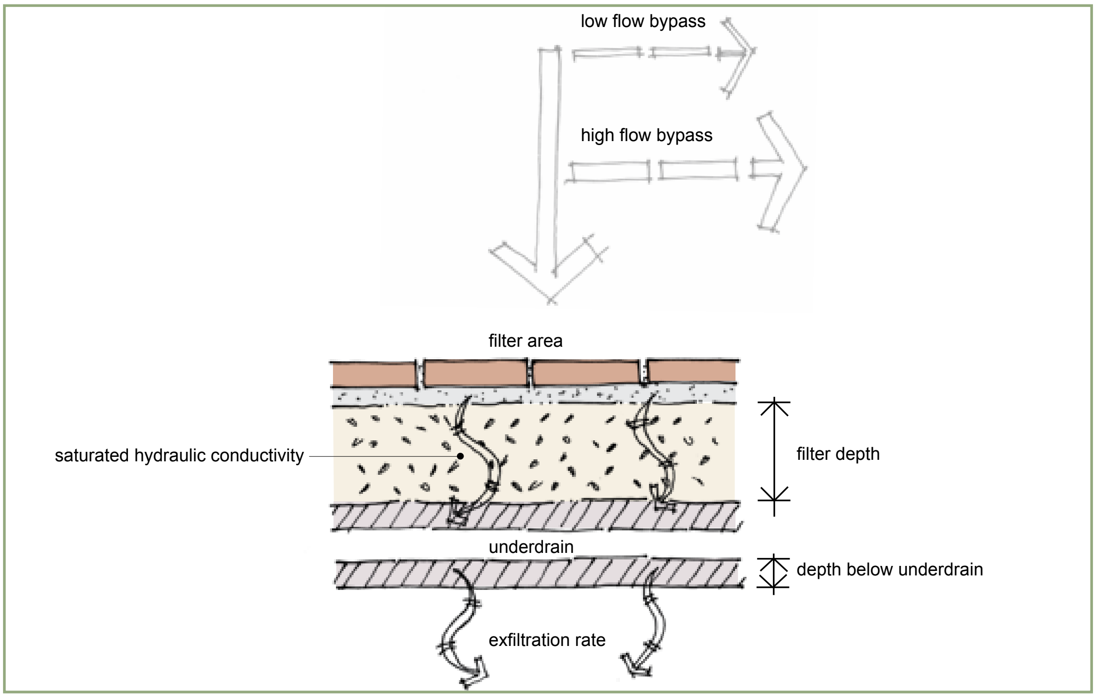


FIGURE 4.13 Porus Paving parameters diagram

SOURCE NODE SET UP: The catchment draining to the permeable paving should be separated into two or more nodes. One node should represent the surface flow to the porous area of paving and the other should represent the direct rainfall on the hard surface of the paving.

For the source node representing the porous paving area, adopt a 100% impervious fraction for that source node.

The reason that the treatment area is modelled for porous paving is generally these treatment systems do not have a large external catchment like wetlands and bioretention. The runoff from the actual area of the paving can represent a significant portion of total flow that is treated and therefore has an influence on treatment outcomes.

Figure 4.14 demonstrates how permeable paving should be set up in MUSIC.

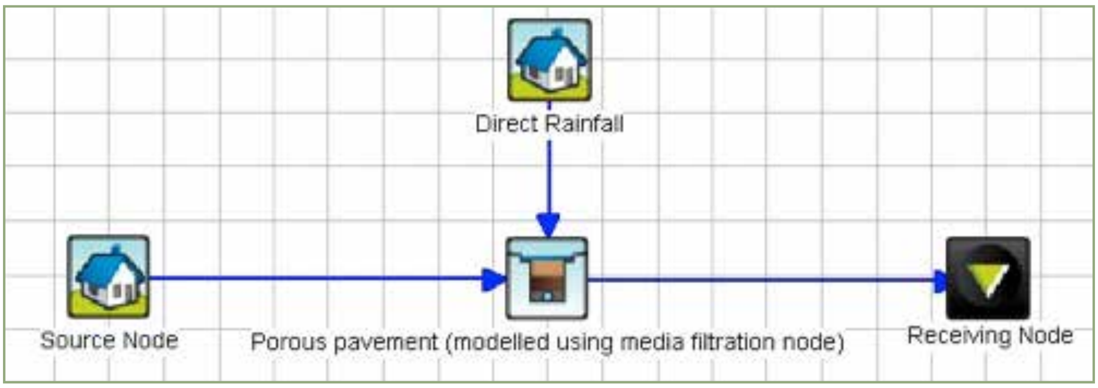


FIGURE 4.14 Example of porous paving application in MUSIC

MUSIC NODE: Model permeable paving using the media filtration node with the parameters shown in Table 4.8. For further guidance on modelling of media filtration, refer to Section 4.8.3.

EXTENDED DETENTION (m): Set extended detention to zero, unless there is a specific design intent to allow frequent ponding above the paving.

FILTER AREA (m²): Set the opening area of the permeable paving or void ratio of porous pavement (not the total surface area), as the filter area. This should be estimated from the product specifications.

FILTER DEPTH (m): Set the filter depth to represent the total depth of the treatment zone or filter media (base coarse and the sub-base coarse if applicable). Do not model the depth of the drainage layers or intermediate layers (if they are used), as part of the filter media.

SATURATED HYDRAULIC CONDUCTIVITY (mm/HR): The saturated hydraulic conductivity should be determined as representative of the smallest median aggregate (D50) in the permeable paving treatment zone or filter media (base and/or sub-base layers). This value should be factored by 0.5 to allow reduced permeability during the pavement lifecycle. Saturated hydraulic conductivity testing will need to be supplied to justify the value used.

EXFILTRATION RATE (mm/HR): It is preferable to drain the filtered runoff away from the pavement subgrade. In the model, assume that there is zero depth below and that the exfiltration rate loss is 0 mm/hr (see Section 4.1 for discussion on exfiltration). A non-zero rate may be adopted if justified through in-situ soil testing and it can be demonstrated that the pavement subgrade will not be negatively affected. If a non-zero value is adopted, the exfiltrated water must be retained in the model using a secondary drainage link (see Sections 4.1.1 and 4.1.2).

4.12 Self-Watering Street Tree

Self-watering street trees can assist with the management of water quality while providing additional benefits to tree health, amenity and cooling.

The performance of self-watering street trees should be modelled using the bioretention node. A summary of the appropriate parameters is provided in Table 4.9, with additional detail provided in the sections below.

Note: this treatment technology is undergoing further development and research and guidance may be updated in subsequent versions of this document.

TABLE 4.9 Self-watering street tree parameters

INLET PROPERTIES	
Low flow bypass (cubic metres per sec)	0m3/s
High flow bypass (cubic metres per sec)	100 m3/s (unless secondary routing defined)
Storage Properties	
Surface area (square metres)	Use same as filter area
Extended detention (metres)	0
FILTER MEDIA PROPERTIES	
Filter area (square metres)	User defined
Unlined filter media perimeter (metres)	User defined
Saturated hydraulic conductivity (mm/hr)	Typically 50-100 for trees
Filter depth (meters)	0.6 - 1.2m
TN content of filter media (mg/kg)	User defined (if unknown, use 400mg/kg)
Orthophosphate content in filter media (mg/kg)	User defined (if unknown, use 30mg/kg)
LINING PROPERTIES	
Is the base lined?	Typically Unlined
Vegetation Properties	Effective Nutrient Removal Plants should be specified
INFILTRATION AND OUTLET PROPERTIES	
Overflow weir width (metres)	Typically greater than or equal to the value of the filter area (in metres rather than square metres)
Exfiltration rate (mm/hr)	0mm/h or based on site testing with secondary route
Underdrain present	No
Submerged zone with carbon present	No

4.12.1 INLET PROPERTIES

LOW FLOW BYPASS: If the tree pit inlet is set slightly above the invert of the gutter (to manage sediment buildup) then a low flow bypass will need to be calculated. Otherwise low flow bypass can be set to zero.

HIGH FLOW BYPASS: The high flow bypass rate of the self-watering street tree is dependent upon a number of factors including the capacity of water to infiltrate from the distribution pipe into the growing media, the capacity of the distribution pipe itself and the capacity of the inlet. The high-flow bypass value should therefore be set as the lesser of:

- The infiltration capacity of the distribution pipe
- The maximum capacity of the distribution pipe
- The maximum inflow capacity of the inlet

Note: inlet design should be matched to contributing catchment, which should in turn be matched to soil moisture capacity and tree health requirement.

4.12.2 STORAGE PROPERTIES

Surface area: The surface area shall be the same as the filter area

EXTENDED DETENTION: The extended detention is the depth of ponding on the surface of the street tree pit. Where a subsurface distribution pipe is used this value can be set to zero.

4.12.3 FILTER MEDIA PROPERTIES

FILTER AREA: Where water is applied to the surface of the tree pit, the filter area is the area that is subject to ponding (usually the dimensions of the tree pit). If a subsurface distribution pipe is used (see figure 4.15) then a more conservative estimate should be used (ie. 300mm either side of the distribution pipe).

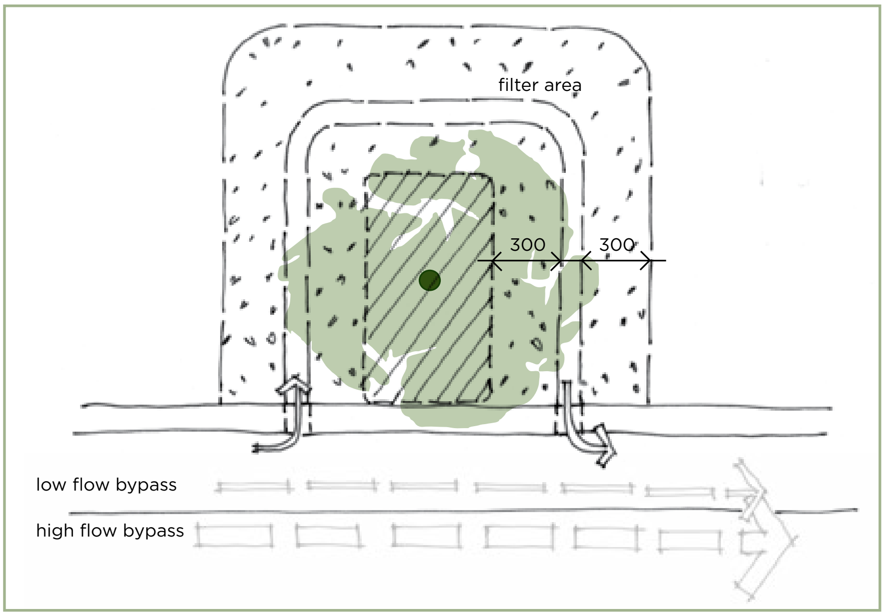


FIGURE 4.15 Self-watering street tree filter media area

UNLINED FILTER MEDIA PERIMETER: The unlined filter media perimeter shall be the lesser of:

- The length of the perimeter of the garden bed that is unlined – Where a perimeter of the garden bed is not defined, then adopted the perimeter of the interface between the growing media and the in-situ soil.
- The length of the perimeter of the filter area (see Section 4.12.3) that is unlined

SATURATED HYDRAULIC CONDUCTIVITY: Soils used in tree pits typically have a lower conductivity (50-100mm/hr).

Filter depth: The filter depth should be calculated as the depth of the growing media in the garden bed (up to a maximum of 1m) minus the depth that the invert of the distribution pipe is below the surface of the growing media.

TN CONTENT IN FILTER MEDIA: The performance of treatment systems modelled using the bioretention node in MUSIC is sensitive to the value of total nitrogen (TN) in the filter (growing) media. Where the value of TN in the growing media is known it shall be used. Where it is not known, 400mg/kg shall be used.

ORTHOPHOSPHATE CONTENT IN FILTER MEDIA: The performance of treatment systems modelled using the bioretention node in MUSIC is sensitive to the value of orthophosphate (OP) in the filter (growing) media. Where the value of OP in the growing media is known it shall be used. Where it is not known, 30mg/kg shall be used.

4.12.4 LINING PROPERTIES

IS THE BASE LINED: In most instances self-watering street trees will have an unlined base. Therefore when modelling most self-watering street trees, select 'no'. However, if the base is lined then 'yes' must be ticked.

4.12.5 VEGETATION PROPERTIES

Vegetation type:

- **Vegetated with effective nutrient removal plants:** Contains plants that are either (a) listed in Table 19 of the Bioretention Technical Design Guidelines (Water by Design, 2014); or (b) compliant with the functional requirements for plants as described in Section 3.6 of the Bioretention TDG
- **Vegetated with ineffective nutrient removal plants:** Contains plants that don't meet the above criteria
- **Unvegetated:** Contains no plants

4.12.6 INFILTRATION AND OUTLET PROPERTIES

OVERFLOW WEIR WIDTH: The length of the overflow weir controls the discharge rate when the water level in the self-watering street tree exceeds the top of the extended detention. An undersized overflow weir results in water backing up, effectively adding additional extended detention. As the extended detention within a self-watering street tree typically occurs within the distribution pipe, this is clearly not realistic. To avoid this, it is recommended that a very high value is specified for the overflow weir length. As a starting point, it is recommended that the value of the filter area (in metres rather than square metres) be used.

EXFILTRATION RATE: The exfiltration rate is the rate at which water moves from the soil within the self-watering street tree's garden and into the surrounding and underlying in-situ soil. It is not the rate at which water seeps from the distribution pipe and into the garden's soil. Self-watering street trees rely on exfiltration (and evapotranspiration) to remove water from the stormwater network. The exfiltration rate must therefore be set at the rate at which water will infiltrate into the surrounding in-situ subsoil. This must consider real world soil conditions and any compaction likely to occur during construction.

UNDERDRAIN PRESENT: Typically self-watering trees are designed without underdrainage. If this is the case then this parameter should therefore be set to no.

SUBMERGED ZONE WITH CARBON PRESENT: Submerged zones are formed in bioretention systems using an elevated underdrainage outlet. Self-watering street trees aim to infiltrate stormwater into the subsoil and typically do not contain an underdrain. In this case the street tree would not have a saturated zone. In climatic regions with extended dry periods, submerged zones or wicking storage can be utilised to improve tree health and reduce potable irrigation demand.

FIGURE Photo

4.12.7 ADDITIONAL NOTES ON SEDIMENT AND GROSS POLLUTANT REMOVAL

Self-watering street trees are not designed to treat sediment or gross pollutants. Efforts are made in design to ensure that systems bypass coarse sediment loads and gross pollutants. Some fine sediment will enter the system's distribution pipe but it is not the purpose of the system to treat sediment.

When modelling self-watering street trees as described in this document, MUSIC will report that the system is removing sediment and gross pollutants. If modelling standalone self-watering street trees, the sediment and gross pollutant removal reported shall be ignored. It shall be treated as if it were 0%.

Modelling self-watering street trees in conjunction with other treatment systems is more challenging. In this instance, the model must be built including the self-watering street trees and other treatment systems. It shall then be run and the pollutant removal rates for flow, TN and TP obtained. The model shall then be adjusted to remove the self-watering street trees and re-run to obtain pollutant removal rates for TSS and GP.

4.13 Generic Nodes

The MUSIC User Manual describes the parameters that can be defined for the generic node.

This node requires the user to specify the pollutant reduction rates (under 'Transfer Functions'). As these rates are different for each device, you must properly demonstrate the system's capacity to remove pollution in the development application. The development application must include information that clearly demonstrates that:

- The proposed treatment measure operates in a manner which cannot be represented using one of the other MUSIC treatment nodes
- The proposed reduction efficiencies are justified by rigorous scientific testing and results are published in a credible engineering/ scientific journal
- The modelled pollutant reduction efficiency reflects the published figures.

SPLITTING FLOWS USING THE GENERIC NODE

A common and accepted use of generic nodes is to represent a flow split, where low flows are directed to one downstream treatment node (e.g. a wetland) and high flows are directed to another (e.g. a swale representing a bypass channel). One generic node can only generate one of the split streams (e.g. it can only model either the low-flow or the high-flow stream). To model multiple streams in the same model (i.e. to ensure the total flows (combined low-flows and high-flows) are modelled), replicate the nodes upstream of the generic node.

Set one generic node to allow all low-flows up to the maximum treatable flow to pass through. Flows above the threshold are removed from the model at this point. The mirrored catchment using the second generic node (with an identical configuration upstream of the node), is then set to only pass the high-flows (high-flow minus the low-flows).

WORKED EXAMPLE

This example demonstrates how to set up a model which uses two generic treatment nodes to split a wetland's maximum treatable flow rate from flow that is bypassed to the wetland's high-flow bypass channel. The advantage of splitting the flows in this example is that the model takes account of the high-flow bypass channel's pollutant removal capacity which is modelled using the swale node.

Figure 4.16 shows a system that has a maximum treatable flow rate of 2 m3/s. The overall MUSIC layout is shown, and the configuration of each generic node is also shown. All flows up to the treatable flow pass through the treatment node using a 1:1 transformation. Any flows above 2 m3/s stay at 2 m3/s (i.e. when the inflow is 3 m3/s, the flows that pass through system are still a maximum of 2 m3/s and the extra 1 m3/s is removed from the model). For the high flow generic node (i.e. flows greater than 2 m3/s), when inflow is less than, or equal to, 2 m3/s, no flow is passed. Flows above 2 m3/s pass through on a 1:1 line, (remembering to subtract 2 m3/s). The combined flow downstream of the two generic nodes should be equal to the inflow to one of the generic nodes.

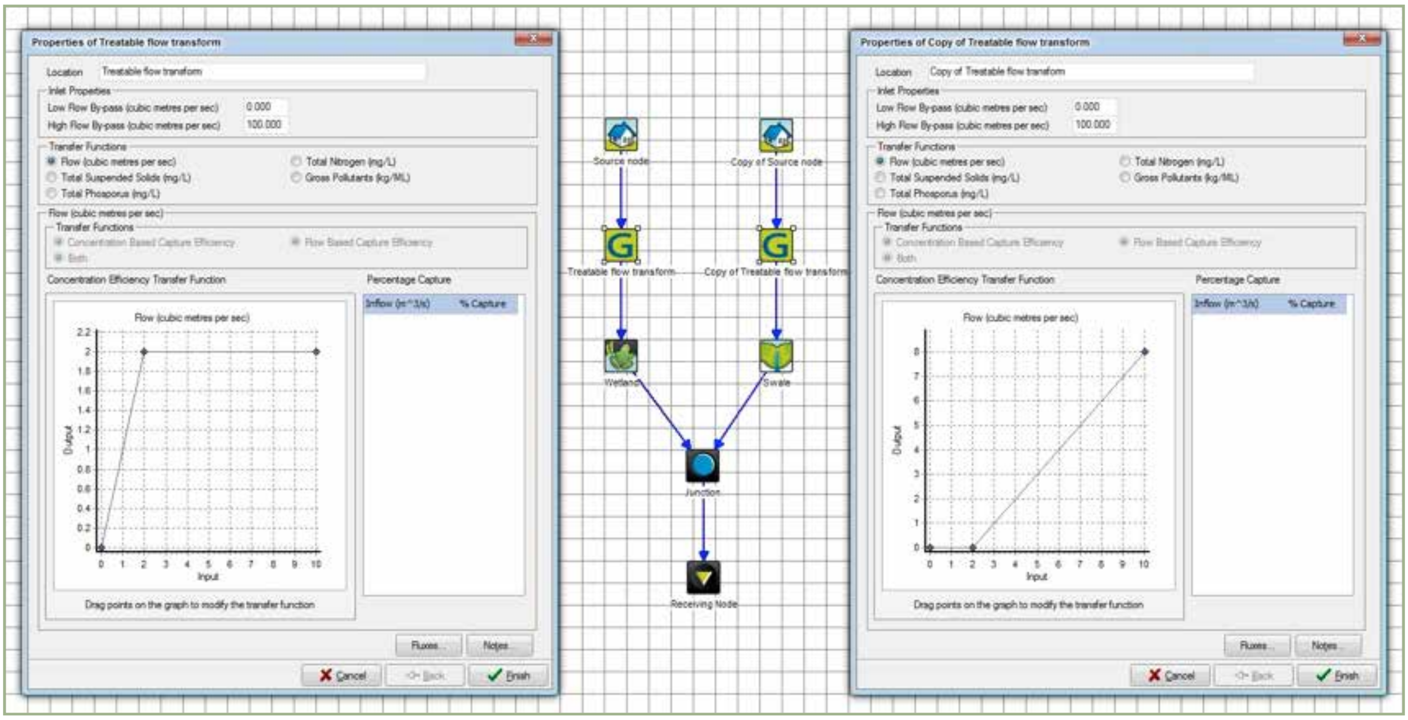


FIGURE 4.16 MUSIC generic node configuration for flow splitting

When there is a flow split in the model, care needs to be taken when assessing the treatment train effectiveness. In the above example, the catchment area above the generic nodes has been doubled, so at the receiving node the treatment train calculation of input flows and loads will also be doubled. The treatment train effectiveness should therefore be calculated manually, using the inputs from the actual (not doubled) catchment area i.e. the actual load-based reduction should be calculated by taking the source load and subtracting the load reductions in each of the split streams.

Photo: Alan Hoban - Bligh Tanner

4.14 Stormwater Harvesting

Stormwater harvesting refers to the capture, treatment, storage and reuse of runoff from any impervious areas in a catchment. Detailed information on designing stormwater harvesting systems can be found in the Draft Stormwater Harvesting Guidelines for South East Queensland (Water by Design). This section details how stormwater harvesting systems should be modelled in MUSIC.

Stormwater can be stored in tanks (above- and below-ground), wet and dry ponds and aquifers. Above- and below-ground enclosed storages can be modelled using the rainwater tank node. Open, above-ground storages should be modelled with the pond node to account for evaporation losses from the storage.

Storages are generally designed so only treated flows enter the storage–the untreated flow from upstream should bypass the storage. To model this, use either the generic node flow split (refer to Section 4.13 for details on how to split flows), or set a high-flow bypass on the storage to ensure untreated flows from upstream also bypass the storage.

The chosen option will be dependent on what happens to the flow downstream of the storage. Usually, the storage is the last point in a treatment train and, if so, the high-flow bypass option is appropriate.

The size of storage and the yield is sensitive to the modelling time-step when the volume of the storage is relatively small compared to the demand. However, using the six-minute time-step for modelling, as recommended in Section 3.2, will avoid this issue. Note also that if the tank volume is less than four or five times the average daily demand, then MUSIC may overestimate the yield.

For residential and irrigation demands, refer to Section 4.2.2. Commercial and industrial demands will be project-specific.

Chapter 5 Life Cycle Cost Assessment

Chapter 5 Life Cycle Cost Assessment

Life cycle costing is described in the Australian Standard AS/NZS 4536:1999 Life Cycle Costing – An Application Guide as a process to determine the sum of all expenses associated with a product or project, including acquisition, installation, operation, maintenance, refurbishment, discarding and disposal costs. Life cycle costing is one element in a decision-making processes and can assist in determining the relative merits of one treatment train over another.

Living Waterways sets out some information requirements (living local economies section) on life cycle costs and maintenance.

MUSIC has a life cycle costing function embedded within each of the treatment nodes (right click on treatment node, select Life Cycle Costings from the menu). The receiving node allows calculation of the total life cycle costs of the elements in a treatment train and an equivalent annual payment (once the model has been run right click on receiving node, select Life Cycle Costings from the menu).

An outline of the information required for using the life cycle costing function in MUSIC is detailed below. To set the individual costing elements of each treatment device, MUSIC provides expected, upper- and lower-cost estimates to choose from. The expected cost estimate should be selected unless justification for other cost estimates is provided. For more details, consult the life cycle costing chapter in the MUSIC User Manual.

5.1 Global Costing Properties

REAL DISCOUNT RATE (%): Up-to-date figures for the real discount rate to use should be sourced from experienced local stormwater asset managers or the Queensland Competition Authority (QCA). The rate used can significantly affect life cycle costing results. The sensitivity analysis, which is automatically undertaken in the costing module, should be reviewed. The current default in MUSIC is 5.5% (based on 2005 data).

ANNUAL INFLATION RATE (%): Current inflation rate figures should be sourced from experienced local stormwater asset managers or the QCA. The current MUSIC default inflation rate is 2%; however, Reserve Bank of Australia uses a long-term annual inflation rate of about 2.5%.

BASE YEAR FOR COSTING: The base year for costing determines the year the costings are reported in. This is generally the year the development application is submitted.

SPAN OF ANALYSIS (YEARS): The span of analysis is relevant when assessing the life cycle cost of the treatment train, rather than the cost of an individual element. The span of analysis should be set to reflect the longest expected life cycle of all of the elements in the treatment train and is typically set at 50 years.

5.2 Individual Node Costing Properties

MUSIC costing was obtained through surveys across the public and private sectors. This data is scaled according to inflation rate to the current year of analysis. While some of the data is now dated, it is still of use to provide indicative costing requirements to asset managers and should be provided for each individual node. In most cases, the default costing properties can be used for acquisition cost, annual maintenance cost, annualised renewal/adaption cost and decommissioning cost. Where costing data for particular elements are known, they should be used to replace the default costing values provided in MUSIC, as default costing values in MUSIC are somewhat out of date. For more up-to-date information refer to:

- Healthy Waterways' Guide to the Cost of Maintaining Bioretention Systems
- Healthy Waterways' OffSite Stormwater Quality Solutions Discussion Paper
- Melbourne Water's Water Sensitive Urban Design Lifecycle Costing Data

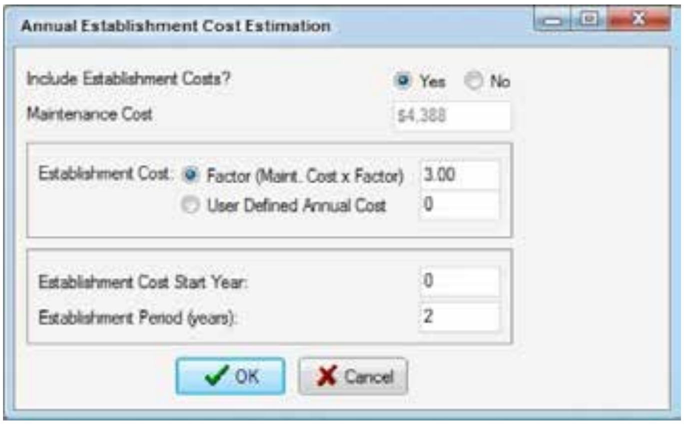


FIGURE 5.1 User defined establishment cost entry

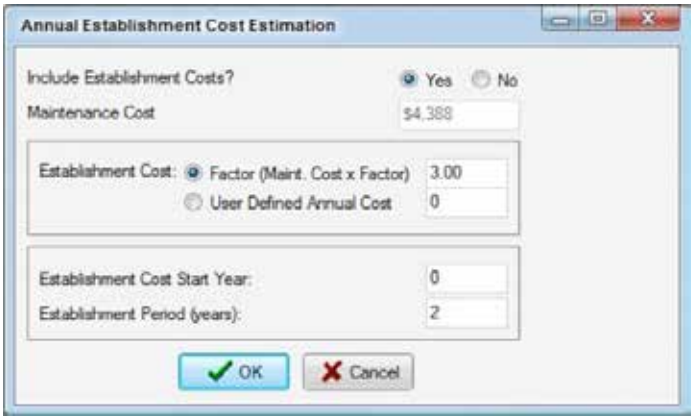


FIGURE 5.2 Maintenance factor establishment cost entry

Where the costs are not known, set the establishment cost at twice the maintenance cost using the same dialog box (see Figure 5.2).

In MUSIC an allowance is made for establishment costs (right click on treatment node, select Life Cycle Costing – This Node – Annual Establishment Costs). These costs can be important when constructing vegetated treatment systems and allowances should be made where these costs are known. If the costs of establishment (including routine inspections, weeding, watering, plant replacement etc.), are known, enter the costs directly into the establishment cost manual entry dialog as shown in Figure 5.1 User defined establishment cost entry.

Once all costs are defined, the results can then be obtained and reported either at an individual node or for the entire treatment train. Further reporting requirements are provided in Section 6.

Photo: Dr Andrew O'Neill

Chapter 6 Results

Chapter 6 Results

MUSIC offers a number of options for generating and interrogating outputs from MUSIC models. Only the outputs required for proving compliance with the stormwater quality management objectives are described here. For more information refer to the MUSIC User Manual.

6.1 Load Analysis

The MUSIC User Manual describes the statistics functions. Statistics are useful to obtain a numerical Summary of the inputs and outputs of various nodes.

To demonstrate compliance with the stormwater quality management objective, use the 'mean annual loads' and 'treatment train effectiveness' statistic functions as shown in Figure 6.1.

The mean annual load reports the input, outputs and percentage reduction of flows (ML/yr), suspended solids (kg/yr), TP (kg/yr) and TN (kg/yr) across a single node.

In comparison, the treatment train effectiveness reports the inputs, output and reductions across the node being interrogated and all upstream nodes.

6.2 Pollutant Concentration Analysis

In some instances, assessment authorities may require pollutant concentrations to be assessed. When interrogating the pollutant concentration results in MUSIC, remove any time-steps with zero flow from the analysis. Set the 'flow-based sub-sample threshold' within the assessment options to zero.

The 'flow-based sub-sample threshold' is found by right-clicking on the treatment, junction or receiving node once the model has run as shown in Figure 6.1. The statistical analysis then only counts time-steps in which outflows greater than zero are occurring. Refer to Section 2.1 of Developing Design Objectives for SEQ (Water by Design), for further information on concentration-based objectives.

For models that include a generic node which adjusts inflow–outflow at a point in the model (i.e. removes or adds flow or pollutants at a point in the model), the 'treatment train effectiveness' reporting shows differences in annual pollutant loads due to this reduction or increase in flow, as well as any actual treatment within upstream nodes. In these cases, calculate the mean annual loads by comparing the pollutant load generated at the source nodes to the pollutant load arriving at the receiving node. Refer to Section 4.13 for further discussion of generic nodes.

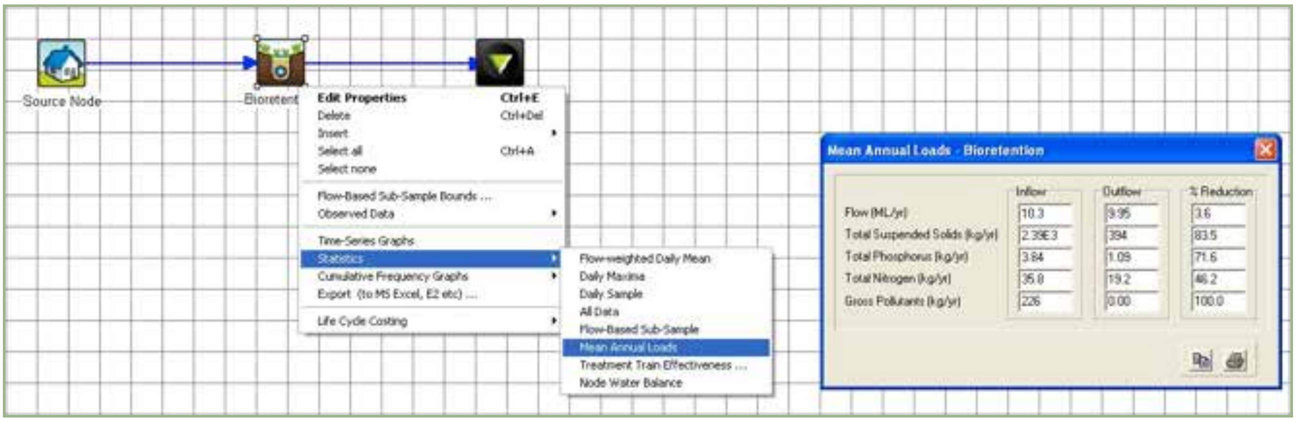


FIGURE 6.1 Example mean annual load results

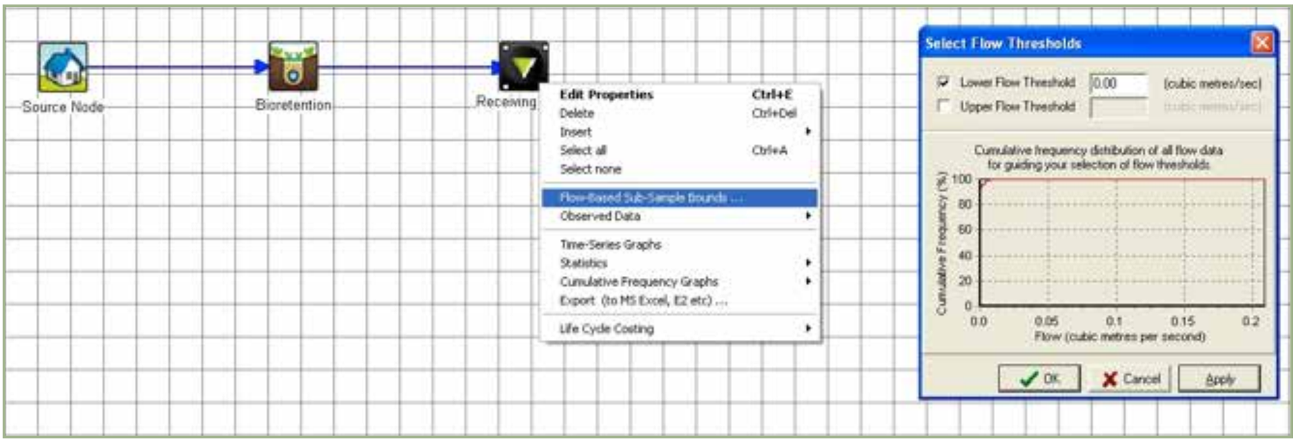


FIGURE 6.2 Setting the low-flow using the flow-based sub-sample option

6.3 Life Cycle Costing

Life cycle costing information in MUSIC is able to be extracted when setting up the life cycle costing properties at each node. While these costs are indicative, they can be of assistance to asset managers in planning maintenance resources and expenditure for future contributed assets.

To extract this information, first establish the individual node costing elements and run the MUSIC model. Then select the "results" button on the life cycle costing entry dialog as shown in Figure 6.3. While some of the individual costing elements are shown in this entry dialog, the results screen (Figure 6.4), summarises the costings and accounts for any renewal adaption period to present total costs for this element.

For each node, costing results should be extracted from the results screen as shown in Figure 6.4 for an example. Provide these details to the assessment authority.

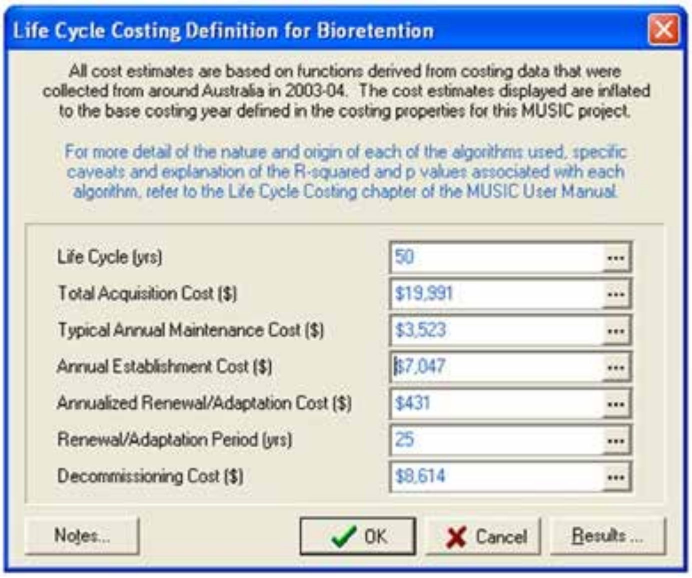


FIGURE 6.3 Life cycle costing entry dialog

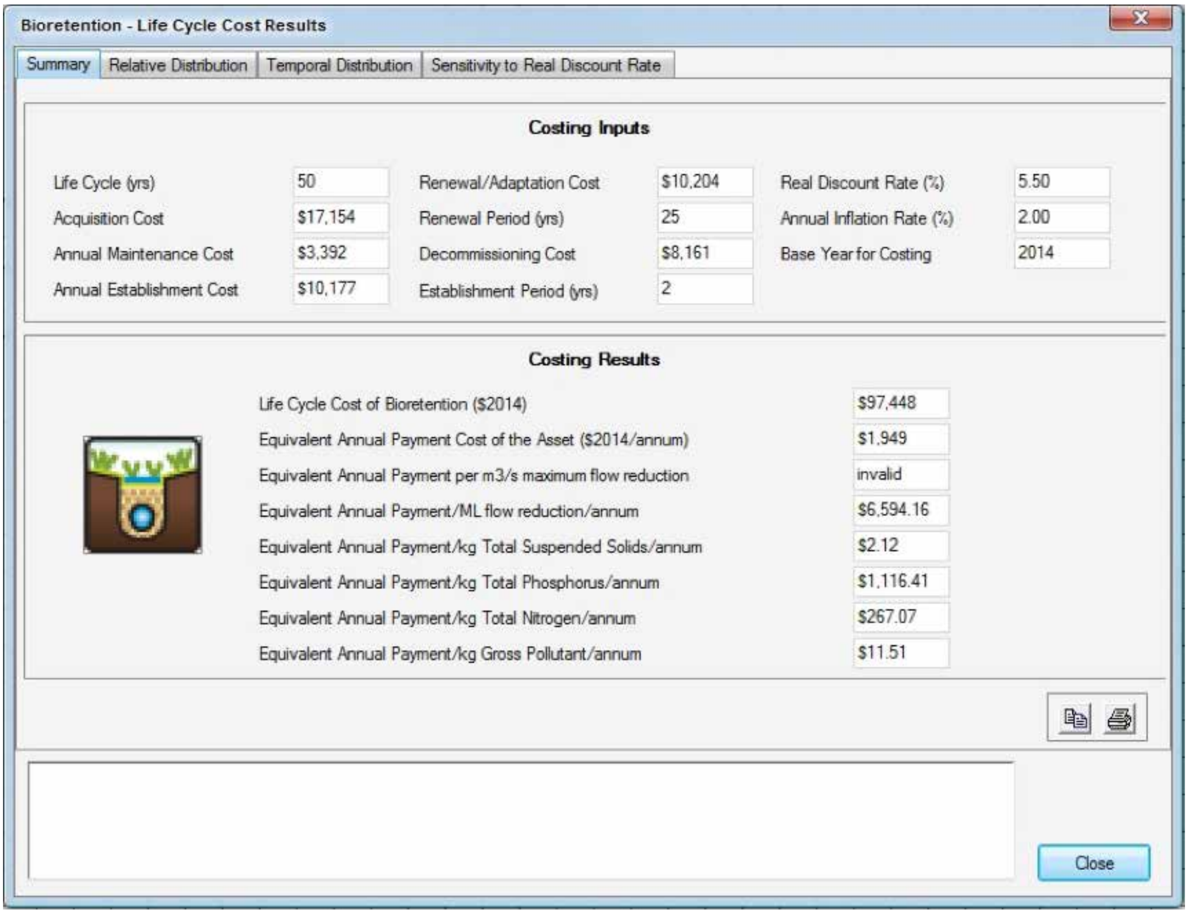


FIGURE 6.4 Life cycle costing results screen

Chapter 7 Lodgement, Reporting & Assessment

Chapter 7 Lodgement, Reporting and Assessment

7.1 Lodgement Requirements

This section provides a description of the information which should be lodged as part of MUSIC reporting associated with development applications. The assessment authority may request that the MUSIC model (sqz. file and mrt. file), is submitted concurrent with the lodgement of a development application. The reporting of the modelling methodologies and assumptions should always accompany a MUSIC model submitted for assessment.

Depending on the scale and/or complexity of the modelling undertaken and specific requirements of the assessment authority, the reporting of modelling methodologies and assumptions may:

- Form part of an integrated water management plan or total water cycle management plan
- Form part of a stormwater management plan
- Be a stand-alone music modelling report
- Consist of stand-alone completed copies of the reporting tables outlined in this guideline.

Appendix C of this guideline provides a set of reporting tables. Prior to lodging a development application the proponent should check with the assessment authority the level of reporting required for each application. In all cases, completed copies of the reporting tables provided in Appendix C should form part of any MUSIC reporting requirements to allow rapid assessment. The assessment authority may require information in addition to that outlined in this guideline.

MUSIC reporting should also be accompanied by plans which demonstrate that proposed treatment strategies can be readily constructed and maintained within the area allocated on the proposed site and that treatment measures will be free draining. This will require some detailed information (e.g. invert levels), to be lodged at the planning stage and proponents should be aware that some assessment authorities may require the lodgement of fully detailed plans as part of planning applications. For further guidance on conceptual and detailed design refer to the Concept Design Guidelines for Water Sensitive Urban Design and the Water Sensitive Urban Design Technical Design Guidelines.

For further guidance on stormwater reporting proponents should also refer to local and state policies and guidelines.

7.2 Reporting Requirements

7.2.1 INTRODUCTION

The introduction should contain at least:

- A description of the site location (including lot and plan number/s and latitude and longitude)
- A reference to relevant documents e.g. Conceptual or detailed drawings, site plans etc.
- An outline of the stormwater management objectives.

[21] Editable, electronic versions of these checklists are available from www.waterbydesign.com.au

7.2.2 SITE AND DRAINAGE CHARACTERISTICS

The following site and drainage information must be presented:

- Specify the current and proposed land use of development site
- Define sub-catchments for the developed scenario demonstrating how drainage on the site is to be managed (i.e. Flow directions). This should include a description of both the existing contours or topography and how future drainage is to be configured (including final site topography as a result of any earth works)
- Outline the location of proposed treatment measures modelled in music
- Show where the site discharge point/s is/are located
- Illustrate that modelled total catchment area is equal to that shown on site plans and catchment layouts.

7.2.3 STORMWATER MANAGEMENT STRATEGY

Describe the site opportunities and constraints for stormwater controls, for example, if steep topography prevents the use of devices such as swales. This section should include a description of the stormwater management options selected for the site during the operational phase of the development. A brief explanation should demonstrate that the proposed stormwater management measures:

- Are appropriate for the specific site and development scale
- Have adequate area for implementation (including all associated requirements such as (batters, high flow bypass, maintenance access etc.), And that they are appropriately placed within the development
- Will be free-draining
- Are hydraulically sound by safely conveying the design events, and their detention times are appropriate for the performance required
- Have appropriate maintenance access

Further guidance on how to address these details is provided in the WSUD Technical Design Guidelines.

7.2.4 MUSIC MODELLING SUMMARY

In a Summary of the MUSIC modelling, describe the modelling methodology, including information on modelling parameters and assumptions. Include information on the meteorological data, time step, source nodes and treatment nodes consistent with the guidelines. Where the modelling approach varies from the approach outlined in this guideline, justify the use of alternative values. Review the MUSIC assessment checklists provided in this guideline when preparing the report to ensure all matters have been suitably addressed.

Appendix C provides the recommended format and the minimum information required for presenting the model inputs.

Where other treatment nodes are used report all parameters adopted. Reporting is required to include justification of all parameters used as stated in the relevant section of these guidelines.

7.2.5 PERFORMANCE REPORTING

Appendix C also provides a table for reporting the performance of the proposed treatment train (Table C16). This should be lodged with all development applications and be accompanied by a statement confirming modelling and performance. This statement should be provided in addition to the information outlined in Table C16.

Sample statement:

"I __________ hereby state that the proposed stormwater treatment strategy is: feasible; can be accommodated within the proposed development layout with free draining treatment measures; achieves the stormwater management objectives of %TSS, ______%TP, %TN; and has been modelled as described in this report."

7.2.6 LIFE CYCLE COSTS

When lodging development applications provide the life cycle costing analysis results from MUSIC to the assessment authority using Table C17. Reporting is to include individual costing elements (acquisition cost, annual maintenance cost etc.), total life cycle cost, analysis period and any assumptions or details on user-defined costs.

For development applications include total acquisition costs, establishment costs and maintenance costs as undiscounted costs.

Applicants should also provide interpretation of the maintenance and renewal costs to show that the proposed treatment measures will not impose an unmanageable maintenance burden to the asset manager. Where multiple treatment options are considered as concept designs, present life cycle costing information for each scenario and discuss the preferred option. The preferred option may not always be the one that has the lowest construction and maintenance costs e.g. where there is a desire to provide additional high-value structures for amenity such as boardwalks through a wetland.

The design may also have other beneficial outcomes, for example enhancing community interaction with the natural environments. Refer to Living Waterways (specifically Living Local Economies section) for ideas on how to weigh-up and present on a variety of beneficial outcomes that a design may have.

7.2.7 AUDITING TOOLS

A web-based auditor tool has been developed by eWater to assist assessment authorities in reviewing MUSIC models. This tool requires the export of the MUSIC Summary file (*.mrt) which can then be uploaded to the web-based auditor. The auditor will highlight any discrepancies between the model and pre-defined local parameters. It is expected most assessment authorities will base their local parameters on these guidelines.

Development proponents should use the auditor to self-assess their models against local parameters prior to lodging a development application. This will allow the proponent to understand whether any aspect of their modelling is inconsistent with local parameters and if necessary amend modelling practice or provide suitable justification for using alternative parameters when lodging development applications.

7.3 MUSIC Assessment Checklist

Appendix D provides assessment tables to assist assessment officers review the major components of a MUSIC model. Proponents may also find these tables useful as a means to cross check their reporting tables and also as a pre-lodgement check to confirm the modelling approach with the assessment authority.

Chapter 8 References

Photo: Alan Hoban - Bligh Tanner

Chapter 8 References

Australian Bureau of Statistics (2006). *2006 Census of Population and Housing.*

Australian Standard (1999). AS/NZS 4536: *1999 Life Cycle Costing – An Application Guide.*

BMT WBM (2005). *Estimation of MUSIC Parameters for use in Brisbane City*. Report prepared for Brisbane City Council.

BMT WBM and SMCMA (2008). *MUSIC Modelling Guidelines for NSW Final Draft*. November.

BMT WBM (2009). *Modelling of Rural Runoff using MUSIC – report and course notes*. DEEDI.

Brisbane City Council (2000). *Stormwater Monitoring Program 1999/2000*. City Design, Brisbane, November 2000.

Brisbane City Council (2003). *Draft Guidelines for Pollutant Export Modelling in Brisbane Version 8.*

Chiew, F. H. S., & McMahon, T. A. (1999). *Modelling Runoff and Diffuse Pollution Loads in Urban Areas.* Water Science and Technology, 39(12), 241-248.

CRC for Catchment Hydrology (2005). *MUSIC Version 3.01 User Manual.* Monash University, Melbourne.

CRC for Water Sensitive Cities (2016) *Adoption Guidelines for Stormwater Biofiltration Systems*

DesignFlow (2016) *MUSIC Modelling – Review of Total Nitrogen KC* for Wetlands.* Brisbane

DesignFlow and Mackay Regional Council (2008). *Mackay MUSIC Modelling Guidelines Version 1.1 September 2008.* Mackay.

Department of Environmental and Resource Management (2009). *Draft State Planning Policy for Healthy Waters.* Brisbane.

Department of Environmental and Resource Management (2009). *Draft Urban Stormwater – Queensland Best Practice Environmental Management Guideline.* Brisbane.

Department of Infrastructure and Planning (2009). *Implementation Guideline No. 7 WSUD: Design Objectives for Urban Stormwater Management of the SEQ Regional Plan.* Brisbane.

Natural Resources and Mines (2005). *Draft Urban Water Use Study of South East Queensland.* Brisbane, QLD.

Duncan H.P. (1999). *Urban Stormwater Quality: A Statistical Overview (Report 99/3). Melbourne, Australia: Coordinated Research Centre for Catchment Hydrology Monash University.*

IECA (2008) *Best Practice Erosion and Sediment Control Guidelines*

Facility for Advancing Water Biofiltration (2008). *Guidelines for Soil Filter Media in Bioretention Systems (Version 2.01).* Monash University, Melbourne, March.

Fletcher T.D., H. Duncan, P. Poelsma and S. Lloyd (2004). *Stormwater Flow and Quality, and the Effectiveness of Non-Proprietary Stormwater Treatment Measures: A Review and Gap Analysis.* CRC for Catchment Hydrology Technical Report 04/08, Monash University, Melbourne.

Fletcher T.D. (2007). B*ackground Study for the Revision of Melbourne Water's MUSIC Input Parameter Guidelines.* Benchmark Environmental Consulting, Ballarat.

Healthy Waterways (2016) *Constructed Wetland Technical Design Guidelines*

Healthy Waterways (2015) *Living Waterways*

National Committee for Water Engineering (2005). *Australian Runoff Quality – A National Guide to Water Sensitive Urban Design.* Institute of Engineers Australia, Australia.

Read, J., T. Wevill, T. D. Fletcher and A. Deletic (2008). Variation among plant species in pollutant removal from stormwater in biofiltration systems. *Water Research*
42(4-5): 893-902.

Water by Design (2006). *Water Sensitive Urban Design Technical Design Guidelines for South East Queensland Version 1.* Moreton Bay and Waterways Catchments Partnership, Brisbane.

Water by Design (2007a). *Water Sensitive Urban Design in Industrial Areas - Fact Sheet.* South East Queensland Healthy Waterways Partnership, Brisbane.

Water by Design (2007b). *Developing Design Objectives for Urban Development in SEQ*. South East Queensland Healthy Waterways Partnership, Brisbane.

Water by Design (2009a). *Concept Design Guidelines for Water Sensitive Urban Design.* South East Queensland Healthy Waterways Partnership, Brisbane.

Water by Design (2009b). *Draft Stormwater Harvesting Guidelines.* South East Queensland Healthy Waterways Partnership, Brisbane.

Water by Design (2009c). *Water Sensitive Urban Design Deemed to Comply Solutions for South East Queensland*

– *Stormwater Quality.* South East Queensland Healthy Waterways Partnership, Brisbane

Water by Design (2009d). *Meeting the Proposed Stormwater Management Objectives in Queensland: A Business Case (Version 1 Draft).* South East Queensland Healthy Waterways Partnership, Brisbane, Queensland

Water by Design (2014) *Bioretention Technical Design Guideline*

Tourism Queensland (2008). *Tourist accommodation data sheet: year ended June 2008. Retrieved January 5, 2009, from* http://businessgc.com.au/uploads/Tourist%20Accommodation%20Data%20Sheet.pdf

Willis, R. Stewart, R.A. Chen, L. & Rutherford, L (2009). *Water end use consumption analysis into Gold Coast dual reticulated households: Pilot. Australia's National Water Conference and Exhibition: OzWater'09, Melbourne* Convention & Exhibition Centre, Melbourne, March 16-18, 2009. Melbourne (Submitted for Publication December 2008).

A.1 - South East Queensland Region

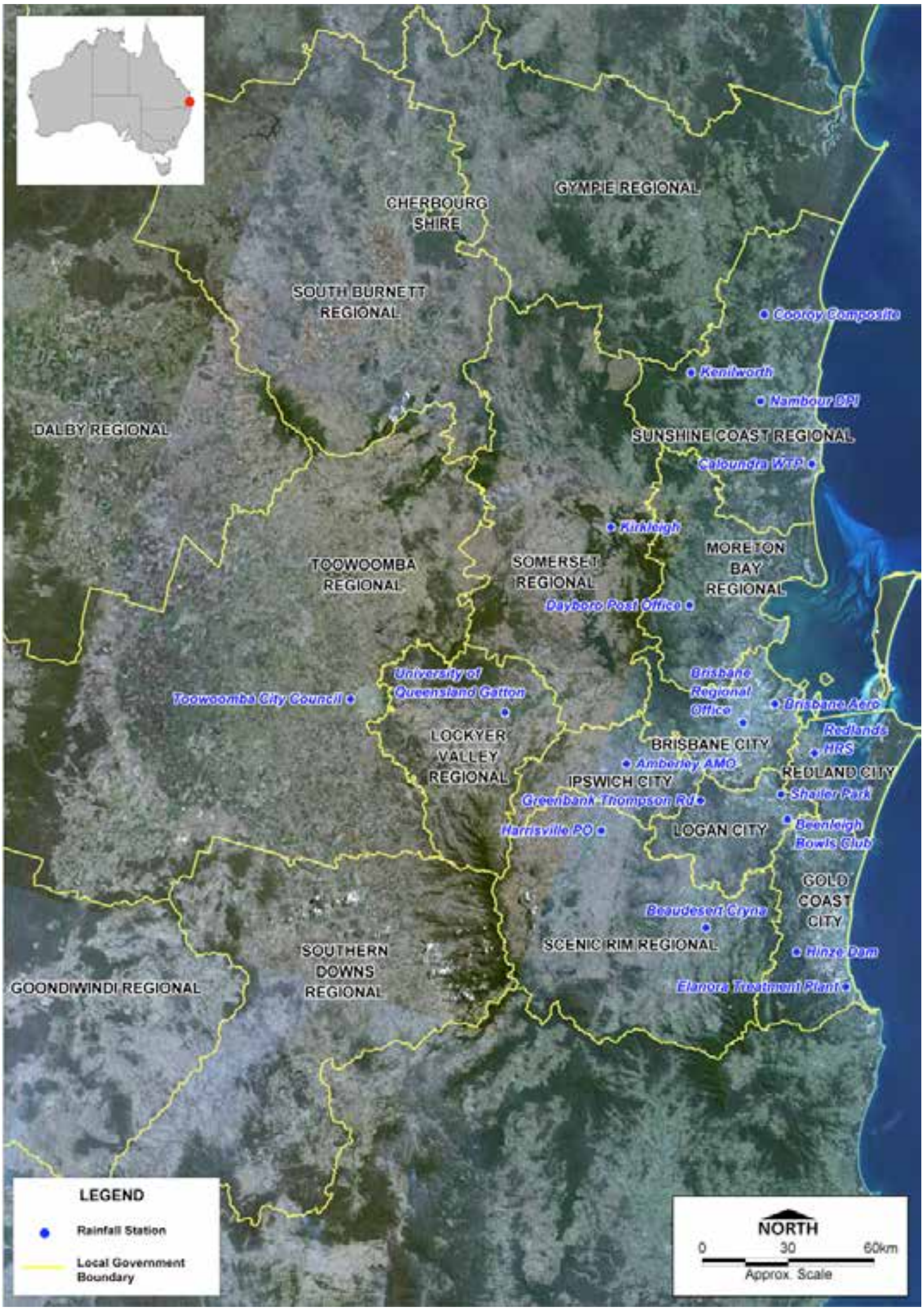


FIGURE A1.1 Rainfall station locations across SEQ (BMT WBM, 2009)

TABLE A1.1 RAINFALL DATA AND MODELLING PERIODS FOR REGIONS WITHIN SOUTH EAST QUEENSLAND

COUNCIL	STATION ID	STATION NAME	CLIMATE PERIOD FOR MUSIC	MEAN ANNUAL RAINFALL OVER PERIOD (MM)	MEAN PET (MM) (CLIMATE ATLAS OF AUSTRALIA)											
					JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Brisbane City Council (east)	40223	Brisbane Aero	1/1/1980– 31/12/1989	1149	193	151	150	109	75	63	65	84	112	148	175	199
Brisbane City Council (west)	40659	Greenbank Thompson Rd	1/1/1980- 31/12/1989	784	181	139	137	102	72	62	63	81	108	138	159	184
Brisbane City Council (central)	40214	Brisbane Regional Office	1/1/1980-31/12/1989	1178	188	146	146	107	74	63	65	84	111	144	171	192
Moreton Bay Regional Council	40063	Dayboro Post Office	1/1/1980– 31/12/1989	1256	189	145	147	109	77	67	68	86	112	146	166	188
Gold Coast City Council (north)	40406	Beenleigh Bowls Club	1/1/1990– 31/12/1999	1152	192	151	147	106	73	61	62	79	108	147	170	195
Gold Coast City Council (south)	40609	Elanora Treatment Plant	1/1/1989– 31/12/1998	1436	160	134	133	101	72	57	58	72	95	132	145	163
Gold Coast City Council (central)	40584	Hinze Dam	1/1/1976– 31/12/1985	1371	176	143	137	140	72	59	60	75	102	141	158	180
Ipswich City Council (east)	40659	Greenbank Thompson Rd	1/1/1980– 31/12/1989	784	181	139	137	102	72	62	63	81	108	138	159	184
Ipswich City Council (west)	40004	Amberley AMO	1/1/1990– 31/12/1999	781	172	133	131	101	73	63	64	82	106	136	153	178
Sunshine Coast Regional Council (north)	40059	Cooroy Composite	1/1/1973– 31/12/1983	1600	198	159	161	121	89	76	77	93	118	162	182	193
Sunshine Coast Regional Council (east)	40496	Caloundra WTP	1/1/1997– 31/12/2006	1348	198	155	160	121	86	73	74	91	118	160	180	201
Sunshine Coast Regional Council (west)	40106	Kenilworth	1/1/1988– 31/12/1997	1075	195	158	160	119	87	76	77	92	117	161	179	190
Sunshine Coast Regional Council (central)	40282	Nambour DPI	1/1/1989 – 31/12/1998	1527	204	166	169	125	89	76	78	93	121	168	187	199
Lockyer Valley Regional Council	40082	University of Queensland Gatton	1/1/1980– 31/12/1989	756	179	138	140	104	74	63	66	82	108	142	160	181
Logan City Council (east)	40715	Shailer Park	1/1/1990– 31/12/1999	1119	195	153	149	107	74	61	63	80	110	148	173	199
Logan City Council (west)	40659	Greenbank Thompson Rd	1/1/1980– 31/12/1989	784	181	139	137	102	72	62	63	81	108	138	159	184
Redland City Council	40265	Redlands HRS	1/1/1997– 31/12/2006	1088	202	160	156	111	75	62	64	81	112	155	181	209
Scenic Rim Regional Council (east)	40014	Beaudesert Cryna	1/1/1968– 31/12/1977	829	175	138	136	101	70	60	61	77	104	138	156	176
Scenic Rim Regional Council (west)	40094	Harrisville PO	1/1/1997– 31/12/2006	579	176	136	134	101	71	62	63	80	106	138	155	180
Somerset Regional Council	40318	Kirkleigh	1/1/1980– 31/12/1989	910	189	149	151	112	80	70	71	87	114	153	170	186
Toowoomba Regional Council	41467	Toowoomba City Council	1/1/1961– 31/12/1970	898	173	133	137	100	74	63	66	81	104	139	158	173

Table A1.1 shows the rainfall stations and modelling periods to be used for SEQ. This data has been compiled from existing local government MUSIC modelling guidelines and assessment of additional rainfall data. The rainfall stations and modelling periods have been selected as they most closely characterise the mean annual rainfall for the surrounding region and have a minimal amount of missing and/or accumulated data. Table A1.1 also provides the monthly mean potential evapotranspiration data to be used for each location.

Note that the Toowoomba station specified should not be used any further west then the urban areas surrounding Clifton, Toowoomba and Crows Nest.

TABLE A1.2 RECOMMENDED MUSIC RAINFALL-RUNOFF PARAMETERS SEQ

PARAMETER	LAND USE			
	URBAN RESIDENTIAL	COMMERCIAL AND INDUSTRIAL	RURAL RESIDENTIAL	FORESTED
RAINFALL THRESHOLD (MM)	1	1	1	1
SOIL STORAGE CAPACITY (MM)	500*	18	98	120
INITIAL STORAGE (% CAPACITY)	10	10	10	10
FIELD CAPACITY (MM)	200	80	80	80
INFILTRATION CAPACITY COEFFICIENT A	211	243	84	200
INFILTRATION CAPACITY COEFFICIENT B	5.0	0.6	3.3	1.0
INITIAL DEPTH (MM)	50	50	50	50
DAILY RECHARGE RATE (%)	28	0	100	25
DAILY BASEFLOW RATE (%)	27	31	22	3
DAILY DEEP SEEPAGE RATE (%)	0	0	0	0

Source: Data derived from the calibration of data from Brisbane City Council's Stormwater Monitoring Program (BMT WBM, 2005).

The pervious area and soil parameters can significantly affect model results when modelling an area with <10% impervious areas, such as rural residential development. In the absence of calibrated values specific to the location being modelled, the values in the table above are provided as a guide.

*MUSIC will warn that the normal range is between 10 and 400 mm. 500 mm is generally appropriate in SEQ.

A.2 - Whitsunday Region

TABLE A1.1 RAINFALL DATA AND MODELLING PERIODS FOR REGIONS WITHIN SOUTH EAST QUEENSLAND

STATION NUMBER	STATION NAME	CLIMATE PERIOD FOR MUSIC	MEAN ANNUAL RAINFALL OVER PERIOD (MM)	MEAN PET (MM) (CLIMATE ATLAS OF AUSTRALIA)											
				JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
33247	Proserpine Airport	1992-2001	1388	191	164	187	139	113	97	99	116	139	184	200	192
33257	Bowen Airport	1990-1999	893	196	170	193	142	115	100	101	119	144	188	206	198
33013	Collinsville Airport	1986-1995	702	184	158	178	132	107	93	94	111	134	177	193	187

Table A2.1 shows the rainfall stations and modelling periods to be used for the Whitsunday Regional Council area. The rainfall stations and modelling periods have been selected as they most closely characterise the mean annual rainfall for the surrounding region and have a minimal amount of missing and/or accumulated data. Table A2.1 also provides the monthly mean potential evapotranspiration data to be used for each location.

TABLE A2.2: RAINFALL RUNOFF PARAMETERS

MUSIC PARAMETER	
Rainfall Threshold (mm)	1
Soil Capacity (mm)	100
Initial Storage (%)	30
Field Capacity	100
Infiltration Capacity Coef. A	200
Infiltration Capacity Coef. B	1
Initial Depth (mm)	10
Daily Recharge Rate (%)	4
Daily Baseflow Rate (%)	2
Deep Seepage (%)	0.4

Source: Mackay MUSIC Guidelines with Soil Capacity adjusted for Whitsunday area (based on the calibration of rainfall and flow gauge data from the Gregory River flow gauge station (Gregory River at Lower Gregory, Station No 122004A, Lat: 20°18'01.6"S, Long: 148°32'54.2"E, catchment area: 47 sq. km, data period: 2004-2013)

B.1 - Residential Urban Source Node Summary

TABLE B1.1 TYPICAL BREAKDOWN OF SURFACE TYPES AND IMPERVIOUS FRACTION FOR SPLIT AND LUMPED RESIDENTIAL URBAN SOURCE NODES[34] (EXTRACTED FROM TABLE 3 .4, TABLE 3 .6 AND TABLE 3 .7)

SURFACE TYPE	SPLIT						LUMPED IMPERVIOUS FRACTION (%)	
	ROAD RESERVE		ROOF		GROUND LEVEL			
DEVELOPMENT TYPE	BREAKDOWN OF SURFACE TYPES (%)	IMPERVIOUS FRACTION (%)	BREAKDOWN OF SURFACE TYPES (%)	IMPERVIOUS FRACTION (%)	BREAKDOWN OF SURFACE TYPES (%)	IMPERVIOUS FRACTION (%)	RANGE	PREFERRED
Residential 10 dwellings/ha	25	60	25 (based on 250m² roof area)	100	50	15	40–55	45
Residential 10 dwellings/ha	25	60	32.5 (based on 215m² roof area)	100	42.5	20	50–60	55
Residential 10 dwellings/ha	30	70	35	100	35	30	60–70	65
Residential 10 dwellings/ha	32.5	80	Residential 80+ dwellings/ha	32.5	80	Residential 80+ dwellings/ha	32.5	80

[34] To be used for conceptual design and broad planning only. Development applications require measurement of areas from development plans.

TABLE B1.2 RAINFALL-RUNOFF PARAMETERS FOR RESIDENTIAL URBAN SOURCE NODES (INSERT RELEVANT REGIONAL DATA FROM APPENDIX A)

PARAMETER	URBAN RESIDENTIAL
Rainfall Threshold (mm)	
Soil storage capacity (mm)	
Initial storage (% capacity)	
Field capacity (mm)	
Infiltration capacity coefficient a	
Infiltration capacity exponent b	
Initial depth (m)	
Daily recharge rate (%)	
Daily baseflow rate (%)	
Daily deep seepage rate (%)	

TABLE B1.3 POLLUTANT EXPORT PARAMETERS FOR RESIDENTIAL URBAN SOURCE NODES (LOG10 VALUES) (EXTRACTED FROM TABLE 3 .8 & 3.9)

	FLOW TYPE	POLLUTANT SOURCE	TSS LOG10 VALUES		TP LOG10 VALUES		TN LOG10 VALUES	
			MEAN	ST. DEV.	MEAN	ST. DEV.	MEAN	ST. DEV.
Lumped	Baseflow	Urban Lumped	1.00	0.34	-0.97	0.31	0.31	0.20
	Stormflow		2.18	0.39	-0.47	0.32	0.32	0.23
Split	Baseflow	Roof	N/A	N/A	N/A	N/A	N/A	N/A
		Roads	1.00	0.34	-0.97	0.31	0.20	0.20
		Ground Level	1.00	0.34	-0.97	0.31	0.20	0.20
	Stormflow	Roof	1.30	0.39	-0.89	0.31	0.26	0.23
		Roads	2.43	0.39	-0.30	0.31	0.26	0.23
		Ground Level	2.18	0.39	-0.47	0.31	0.26	0.23

B.2 - Rural Residential Urban Source Node Summary

B.2.1 RESIDENTIAL URBAN SOURCE NODE SUMMARY TYPICAL IMPERVIOUS FRACTION FOR LUMPED RURAL RESIDENTIAL URBAN SOURCE NODES[36] (EXTRACTED FROM TABLE 3.7)

DEVELOPMENT LAND USE OR SURFACE TYPE	IMPERVIOUS FRACTION (%)	
	RANGE (%)	PREFERRED (%)
RURAL USES		
Rural residential (greater than 0.4 ha lots)	5–20	10
Rural residential (smaller than 0.4 ha lots)	10–25	20
Rural	0–5	2
PUBLIC ZONES		
Public open space	5–50	20
Car parks	70–95	90
Library, sporting, depots	50–90	70
Schools and university	50–80	70

[36] To be used for conceptual design and broad planning only. Development applications require measurement of areas from development plans.

TABLE B2.2 RAINFALL-RUNOFF PARAMETERS FOR LUMPED RURAL RESIDENTIAL URBAN SOURCE NODES (INSERT RELEVANT REGIONAL DATA FROM APPENDIX A)

PARAMETER	RURAL RESIDENTIAL
Rainfall threshold (mm)	
Soil storage capacity (mm)	
Initial storage (% capacity)	
Field capacity (mm)	
Infiltration capacity coefficient a	
Infiltration capacity exponent b	
Initial depth (mm)	
Daily recharge rate (%)	
Daily baseflow rate (%)	
Daily deep seepage rate (%)	

TABLE B2.3 POLLUTANT EXPORT PARAMETERS FOR LUMPED RURAL RESIDENTIAL URBAN SOURCE NODES (LOG^{10} VALUES) (EXTRACTED FROM TABLE 3.8)

FLOW TYPE	TSS LOG^{10} VALUES		TP LOG^{10} VALUES		TN LOG^{10} VALUES	
	MEAN	ST. DEV.	MEAN	ST. DEV.	MEAN	ST. DEV.
Baseflow	0.53	0.24	-1.54	0.38	-0.52	0.39
Stormflow	2.26	0.51	-0.56	0.28	0.32	0.30

B.3 - Industrial Urban Source Node Summary

TABLE B3.1 TYPICAL BREAKDOWN OF SURFACE TYPES AND IMPERVIOUS FRACTION FOR SPLIT AND LUMPED INDUSTRIAL URBAN SOURCE NODES (EXTRACTED FROM TABLE 3.4, TABLE 3 .6 AND TABLE 3.7)[37]

SURFACE TYPE	SPLIT				LUMPED			
	ROAD RESERVE		ROOF		GROUND LEVEL		IMPERVIOUS FRACTION	
DEVELOPMENT TYPE	BREAKDOWN OF SURFACE TYPES (%)	IMPERVIOUS FRACTION (%)	BREAKDOWN OF SURFACE TYPES (%)	IMPERVIOUS FRACTION (%)	BREAKDOWN OF SURFACE TYPES (%)	IMPERVIOUS FRACTION (%)	RANGE (%)	PREFERRED (%)
Typical industrial (warehouse, manufacturing, workshop etc.)	30	75	50	100	20	60	70–95	90

[37] To be used for conceptual design and broad planning only. Development applications require measurement of areas from development plans.

TABLE B3.2 RAINFALL-RUNOFF PARAMETERS FOR SPLIT AND LUMPED INDUSTRIAL URBAN SOURCE NODES (INSERT RELEVANT REGIONAL DATA FROM APPENDIX A)

PARAMETER	INDUSTRIAL
Rainfall threshold (mm)	
Soil storage capacity (mm)	
Initial storage (% capacity)	
Field capacity (mm)	
Infiltration capacity coefficient a	
Infiltration capacity exponent b	
Initial depth (mm)	
Daily recharge rate (%)	
Daily baseflow rate (%)	
Daily deep seepage rate (%)	

TABLE B3.3 POLLUTANT EXPORT PARAMETERS FOR INDUSTRIAL URBAN SOURCE NODES (LOG^{10} VALUES) (EXTRACTED FROM TABLE 3.8 & 3.9)

	FLOW TYPE	POLLUTANT SOURCE	TSS LOG^{10} VALUES		TP LOG^{10} VALUES		TN LOG^{10} VALUES	
			MEAN	ST. DEV.	MEAN	ST. DEV.	MEAN	ST. DEV.
Lumped	Baseflow	Industrial Lumped	0.78	0.45	-1.11	0.48	0.14	0.20
	Stormflow		1.92	0.44	-0.59	0.36	0.25	0.32
Split	Baseflow	Roof	N/A	N/A	N/A	N/A	N/A	N/A
		Roads	0.78	0.45	-1.11	0.48	0.14	0.20
		Ground Level	0.78	0.45	-1.11	0.48	0.14	0.20
	Stormflow	Roof	1.30	0.44	-0.89	0.36	0.25	0.32
		Roads	2.43	0.44	-0.30	0.36	0.25	0.32
		Ground Level	1.92	0.44	-0.59	0.36	0.25	0.32

B.4 - Commercial Urban Source Node Summary

TABLE B4 .1 TYPICAL BREAKDOWN OF SURFACE TYPES AND IMPERVIOUS FRACTION FOR SPLIT AND LUMPED COMMERCIAL URBAN SOURCE NODES[38] (EXTRACTED FROM TABLE 3.4, TABLE 3 .6 AND TABLE 3.7)

SURFACE TYPE	SPLIT				LUMPED			
	ROAD RESERVE		ROOF		GROUND LEVEL		IMPERVIOUS FRACTION	
DEVELOPMENT TYPE	BREAKDOWN OF SURFACE TYPES (%)	IMPERVIOUS FRACTION (%)	BREAKDOWN OF SURFACE TYPES (%)	IMPERVIOUS FRACTION (%)	BREAKDOWN OF SURFACE TYPES (%)	IMPERVIOUS FRACTION (%)	RANGE (%)	PREFERRED (%)
Business or town centre, offices and bulky goods	30	75	50	100	20	80	70–95	90
Garden and landscape suppliers							30–60	50

[38] To be used for conceptual design and broad planning only. Development applications require measurement of areas from development plans.

TABLE B4.2 RAINFALL-RUNOFF PARAMETERS FOR LUMPED COMMERCIAL URBAN SOURCE NODES (INSERT RELEVANT REGIONAL DATA FROM APPENDIX A)

PARAMETER	COMMERCIAL
Rainfall threshold (mm)	
Soil storage capacity (mm)	
Initial storage (% capacity)	
Field capacity (mm)	
Infiltration capacity coefficient a	
Infiltration capacity exponent b	
Initial depth (mm)	
Daily recharge rate (%)	
Daily baseflow rate (%)	
Daily deep seepage rate (%)	

TABLE B4.3 POLLUTANT EXPORT PARAMETERS FOR COMMERCIAL URBAN SOURCE NODES (LOG^{10} VALUES) (EXTRACTED FROM TABLE 3.8 & 3.9)

	E FLOW TYPE	POLLUTANT SOURCE	TSS LOG^{10} VALUES		TP LOG^{10} VALUES		TN LOG^{10} VALUES	
			MEAN	ST. DEV.	MEAN	ST. DEV.	MEAN	ST. DEV.
Lumped	Baseflow	Commercial Lumped	0.78	0.39	-0.60	0.50	0.32	0.30
	Stormflow		2.16	0.38	-0.39	0.34	0.37	0.34
Split	Baseflow	Roof	N/A	N/A	N/A	N/A	N/A	N/A
		Roads	0.78	0.39	-0.60	0.50	0.32	0.30
		Ground Level	0.78	0.39	-0.60	0.50	0.32	0.30
	Stormflow	Roof	1.30	0.38	-0.89	0.34	0.37	0.34
		Roads	2.43	0.38	-0.30	0.34	0.37	0.34
		Ground Level	2.16	0.38	-0.39	0.34	0.37	0.34

B.5 - Forest Source Node Summary

TABLE B5.1 TYPICAL IMPERVIOUS FRACTION FOR LUMPED FOREST SOURCE NODES (EXTRACTED FROM TABLE 3.7)

DEVELOPMENT LAND USE OR SURFACE TYPE	IMPERVIOUS FRACTION (%)	
	RANGE	PREFERRED
Forest or conservation	0–5	0

TABLE B5.2 RAINFALL-RUNOFF PARAMETERS FOR LUMPED FOREST SOURCE NODES (INSERT RELEVANT REGIONAL DATA FROM APPENDIX A)

PARAMETER	COMMERCIAL
Rainfall threshold (mm)	
Soil storage capacity (mm)	
Initial storage (% capacity)	
Field capacity (mm)	
Infiltration capacity coefficient a	
Infiltration capacity exponent b	
Initial depth (mm)	
Daily recharge rate (%)	
Daily baseflow rate (%)	
Daily deep seepage rate (%)	

TABLE B5.3 POLLUTANT EXPORT PARAMETERS FOR LUMPED FOREST SOURCE NODES (LOG^{10} VALUES) (EXTRACTED FROM TABLE 3.8)

FLOW TYPE	TSS LOG^{10} VALUES		TP LOG^{10} VALUES		TN LOG^{10} VALUES	
	MEAN	ST. DEV.	MEAN	ST. DEV.	MEAN	ST. DEV.
Baseflow	0.51	0.28	-1.79	0.28	-0.59	0.22
Stormflow	1.90	0.20	-1.10	0.22	0.075	0.24

B.6 - Agricultural Source Node Summary

TABLE B6.1 TYPICAL IMPERVIOUS FRACTION FOR LUMPED AGRICULTURAL SOURCE NODES (EXTRACTED FROM TABLE 3.7)

DEVELOPMENT LAND USE OR SURFACE TYPE	IMPERVIOUS FRACTION (%)	
	RANGE	PREFERRED
Rural	0–5	2

TABLE B6.2 RAINFALL-RUNOFF PARAMETERS FOR LUMPED AGRICULTURAL SOURCE NODES (INSERT RELEVANT REGIONAL DATA FROM APPENDIX A)

PARAMETER	COMMERCIAL
Rainfall threshold (mm)	
Soil storage capacity (mm)	
Initial storage (% capacity)	
Field capacity (mm)	
Infiltration capacity coefficient a	
Infiltration capacity exponent b	
Initial depth (mm)	
Daily recharge rate (%)	
Daily baseflow rate (%)	
Daily deep seepage rate (%)	

TABLE B6.3 POLLUTANT EXPORT PARAMETERS FOR LUMPED AGRICULTURAL SOURCE NODES (LOG^{10} VALUES) (EXTRACTED FROM TABLE 3.8)

FLOW TYPE	TSS LOG^{10} VALUES		TP LOG^{10} VALUES		TN LOG^{10} VALUES	
	MEAN	ST. DEV.	MEAN	ST. DEV.	MEAN	ST. DEV.
Baseflow	1.0	0.13	-1.155	0.13	-0.155	0.13
Stormflow	2.477	0.31	-0.495	0.30	0.29	0.26

Prior to lodging checklists, designers should cross check their work against the assessment tables in Appendix D. By taking this step, designers increase their understanding of how their reporting tables are likely to be assessed thereby minimizing the likelihood of information requests. Benefits of avoided information requests include reduced design and assessments costs and timeframes.

Editable, electronic versions of these checklists are available from **www.waterbydesign.com.au.**

C.1 - Meteorological and Rainfall Runoff Data Reporting Table

INPUT	DATA USED IN MODELLING
Rainfall station	Station name and number
Time step	6 minute time step required
Modelling period	Period modelled and total number of modelled years
Mean annual rainfall (mm)	
Evapotranspiration (mm)	
Rainfall runoff parameters	Note which land use parameters were used e.g. "residential". Any deviation from information recommended in these guidelines requires justification using Table B4.
Pollutant export parameters	Note which land use parameters were used e.g. "residential". Any deviation from information recommended in these guidelines requires justification using Table B5.

C.2 - Catchment Definition Reporting Table

CATCHMENT ID	AREA (HA)	LAND USE	TOTAL IMPERVIOUS (%)
1 (reference to catchment plan)	Total area of sub-catchment	Residential, commercial, industrial etc.	Total impervious portion of catchment as measured off development plans
2 (etc.)			
TOTAL			

C.3 - Catchment Split Reporting Table

CATCHMENT ID	AREA (HA)	LAND USE	TOTAL IMPERVIOUS (%)
1 (reference to catchment plan)	Area of surface type	Roof to tank	Impervious portion of each surface type or lumped land use as measured from development plans
	Area of surface type	Roof to ground	
	Area of surface type	Road reserve	
	Area of lumped land use	Ground level or Lumped	
2 (etc.)	Area of surface type	Roof to tank	Impervious portion of each surface type or lumped land use as measured off development plans
	Area of surface type	Roof to ground	
	Area of surface type	Road reserve	
	Area of lumped land use	Ground level or Lumped	
TOTAL			

C.4 - Rainfall Runoff Parameter Reporting Table[39]

PARAMETER	SOURCE NODE 1	SOURCE NODE 2 (ETC)
Land Use		
Rainfall threshold (mm)		
Soil storage capacity (mm)		
Initial storage (% capacity)		
Field capacity (mm)		
Infiltration capacity coefficient a		
Infiltration capacity exponent b		
Initial depth (mm)		
Daily recharge rate (%)		
Daily baseflow rate (%)		
Daily deep seepage rate (%)		

[37] This table only to be used where there have been any deviation from parameters recommended in these guidelines.

C.3 - Catchment Split Reporting Table

CATCHMENT ID	LAND USE	FLOW TYPE	LUMPED CATCHMENT LAND USE					
			TSS LOG10 VALUES		TP LOG10 VALUES		TN LOG10 VALUES	
			MEAN	ST. DEV.	MEAN	ST. DEV.	MEAN	ST. DEV.
Catchment 1		Baseflow						
		Stormflow						
		Baseflow						
		Stormflow						
		Baseflow						
		Stormflow						
Catchment 2 (etc.)		Baseflow						
		Stormflow						
		Baseflow						
		Stormflow						
		Baseflow						
		Stormflow						

C.5 - Pollutant Export Parameter Reporting Table[40]

CATCHMENT ID	LAND USE	FLOW TYPE	LUMPED CATCHMENT LAND USE					
			TSS LOG^{10} VALUES		TP LOG^{10}VALUES		TN LOG^{10} VALUES	
			MEAN	ST. DEV.	MEAN	ST. DEV.	MEAN	ST. DEV.
Catchment 1		Baseflow						
		Stormflow						
		Baseflow						
		Stormflow						
		Baseflow						
		Stormflow						
Catchment 2 (etc.)		Baseflow						
		Stormflow						
		Baseflow						
		Stormflow						
		Baseflow						
		Stormflow						

[40] This table only to be used where there have been any deviation from parameters recommended in these guidelines.

CATCHMENT ID	LAND USE	FLOW TYPE	LUMPED CATCHMENT LAND USE					
			TSS LOG^{10} VALUES		TP LOG^{10}VALUES		TN LOG^{10} VALUES	
			MEAN	ST. DEV.	MEAN	ST. DEV.	MEAN	ST. DEV.
Catchment 1		Baseflow						
		Stormflow						
Catchment 2 (etc.)		Baseflow						
		Stormflow						

[41] This table only to be used where there have been any deviation from parameters recommended in these guidelines.

C.6 - Rainwater Tank Node Reporting Table

RAINWATER TANKS (SECTION 4.2)		
CATCHMENT ID	**TREATMENT NODE 1**	**TREATMENT NODE 2 (ETC.)**
Volume below overflow pipe (kL). If greater than 1 tank specify number of tanks, volume per tank and total e.g. 10 tanks x 5 kL = 50 kL		
Depth above overflow (m)		
If tanks are lumped, is depth below overflow the same as a single tank and overflow pipe scaled accordingly (Section 4.2.5)?		
Surface area (m2). For lumped tanks the surface area must be adjusted in accordance with Section 4.2.5.		
Overflow pipe diameter (mm). For lumped tanks this must be equivalent to the diameter of the overflow pipe of a single tank multiplied by the square root of the number of tanks (Section 4.2.5).		
Stored water used for irrigation and other purposes (Y/N)		
PET		
PET – Rain		
Indoor connections e.g. toilet, laundry etc.		
Indoor demand (kL/day)		
Outdoor demand (kL/day)		
Daily demand (kL/day)		
Monthly distribution of annual demand (kL/day)		
Confirmation that K and C* remain default? (Y/N)		

C.7 - Wetland Node Reporting Table

CONSTRUCTED WETLANDS (SECTION 4.3)		
CATCHMENT ID	**TREATMENT NODE 1**	**TREATMENT NODE 2 (ETC.)**
Inlet pond volume (m^3). (Cannot be sized in MUSIC)		
Macrophyte zone surface area (m^2)		
Has the surface area been calculated appropriately (Section 4.3.2)? (Y/N)		
Extended detention depth (m) (Section 4.3.2). This must be less than 0.5 m		
Overflow pipe diameter (mm). For lumped tanks this must be equivalent to the diameter of the overflow pipe of a single tank multiplied by the square root of the number of tanks (Section 4.2.5).		
Permanent pool volume (m^3)		
Exfiltration rate (mm/hr) (Section 4.3.2)		
If an exfiltration rate greater than zero has been used, has the secondary drainage link been used to return the exfiltrated flows to the model? (Section 4.1) (Y / N / N/A)		
Evaporative loss as % of PET		
Equivalent pipe diameter (m). Should set so that notional detention time is as close to 48 hours as possible. Where appropriate storage-discharge-height table for be attached. Refer to Section 4.3.3 for advice on accounting for user-defined stage–discharge relationship.		
Overflow weir width (m)		
Notional detention time (hrs). Should be as close to 48 hours as possible.		
Monthly distribution of annual demand (kL/day)		
Confirmation that K and C* remain default? (Y/N)		

C.8 - Swale Node Reporting Table

SWALES (SECTION 4.4) AND SURFACE COMPONENT OF BIORETENTION SWALES (SECTION 4.6) FOR BIORETENTION FILTER COMPONENT USE TABLE C9		
CATCHMENT ID	**TREATMENT NODE 1**	**TREATMENT NODE 2 (ETC.)**
Low-flow bypass (m^3/s) Provide calculation separately in report.		
Length (m) – length must account for conveyance capacity and safety limitations selected in accordance with the WSUD Technical Design Guidelines for SEQ.		
Bed slope (%) – maximum 4%		
Base width (m)		
Top width (m)		
Depth (m)		
Vegetation height (m) – must reflect landscape design		
Exfiltration rate (mm/hr) (Section 4.4)		
If an exfiltration rate greater than zero has been used, has the secondary drainage link been used to return the exfiltrated flows to the model? (Section 4.1) (Y / N / N/A)		
If the swale accepts point source discharges at given locations, is it split into separate lengths? (Y/N/NA)		
Confirmation that K and C* remain default? (Y/N)		
ADDITIONAL ITEMS FOR BIORETENTION SWALES (SECTION 4.6)		
Is the swale node located in the model downstream of bioretention swale surface component? (Y/N)		
Is the low-flow bypass of the swale node set to the infiltration rate of the bioretention filter media? (Y/N)		

C.9 - Bioretention Node Reporting Table

BIORETENTION (SECTION 4.5)		
CATCHMENT ID	**TREATMENT NODE 1**	**TREATMENT NODE 2 (ETC.)**
Surface area (m^2)		
Has the filter area been calculated appropriately? (Y / N / N/A)		
Extended detention depth (m)		
Filter area (m^2)		
Unlined filter media perimeter (m)		
Saturated hydraulic conductivity (mm/hour). This should be modelled once at 50 mm/hr and once at 200 mm/hr. Report as "50/200"		
Filter depth (m)		
TN content of filter media (%)		
Orthophosphate content of filter media (mg/kg)		
Is the base lined? (Y/N)		
Effectiveness of plant TN removal (effective/ineffective/ unvegetated)		
Overflow weir width (m)		
Exfiltration rate (mm/hr)		
If an exfiltration rate greater than zero has been used, has the secondary drainage link been used to return the exfiltrated flows to the model? (Section 4.1) (Y / N / N/A)		
If exfiltration rate has been used, is the exfiltration rate justified? (Y / N / N/A)		
Underdrain present? (Y/N)		
Submerged zone with carbon present?		
Depth of submerged zone (m)		
Confirmation that K and C* remain default? (Y/N)		
If bioretention systems are modelled in series, is there a low-flow bypass modelled in the downstream bioretention system/s? (Note: separate drainage systems are required if a low-flow bypass is modelled).	Y N N/A	

C.10 - Buffer Node Reporting Table

BIORETENTION (SECTION 4.5)		
CATCHMENT ID	**TREATMENT NODE 1**	**TREATMENT NODE 2 (ETC.)**
Does the treatment node reflect the vegetated area receiving sheet flow only?		
UNLESS "YES" HAS BEEN ANSWERED TO THE ABOVE QUESTIONS THIS NODE CANNOT BE USED.		
Percentage of upstream area? (% as shown on the development plans)?		
Buffer area (% of impervious area as shown on the development plans)?		
Is the exfiltration rate set to zero?		
If an exfiltration rate greater than zero has been used, has the secondary drainage link been used to return the exfiltrated flows to the model? (Section 4.1) (Y / N / N/A)		

C.11 - Proprietary & Custom Products (Inc Gross Pollutant Traps) Node Reporting Table

PROPRIETARY & CUSTOM PRODUCTS (SECTION 4.8)		
CATCHMENT ID	**TREATMENT NODE 1**	**TREATMENT NODE 2 (ETC.)**
Are the proposed pollutant reduction efficiencies independently verified using a method to suited to local conditions?		
Does the data provided include performance results under dry weather flows (to account for potential pollutant leeching)? (Y/N). Copies of the supporting data must be lodged with the development application.		
Is the assumed high-flow bypass rate consistent with manufacturer specifications? (Y/N) Provide copies of relevant specification with development application.		
UNLESS "YES" HAS BEEN ANSWERED TO ALL THREE QUESTIONS ABOVE THE PROPOSED POLLUTANT REDUCTION RATES CANNOT BE RELIED UPON AS BEING REASONABLE ASSUMPTIONS OF THE UNIT'S PERFORMANCE.		
Storage volume of GPT? (m^3)		
Expected maintenance frequency? (months)		
Check that the storage volume is large enough to contain all sediments and gross pollutants received by unit during inter-maintenance periods? (Y/N)		

C.12 - Sediment Basin Node Reporting Table

SEDIMENT BASIN (SECTION 4.9)		
CATCHMENT ID	TREATMENT NODE 1	TREATMENT NODE 2 (ETC.)
Surface area (m^2)		
Has the surface area been calculated appropriately (Section 4.3.2)? (Y/N)		
Extended detention depth (m)		
Permanent pool volume (m3)		
Exfiltration rate (mm/hr)		
If an exfiltration rate greater than zero has been used, has the secondary drainage link been used to return the exfiltrated flows to the model? (Section 4.1) (Y / N / N/A)		
Evaporative loss as % of PET		
Equivalent pipe diameter (m) (Where appropriate refer to Section 4.3.3 for advice on accounting for user-defined stage– discharge relationship)?		
Overflow weir width (m)		
Notional detention time? This should be set to account for potential flow restriction.		
Number of CSTR cells		
Confirmation that K and C* remain default? (Y/N)		

C.13 - Infiltration Node Reporting Table

INFILTRATION SYSTEM (SECTION 4.10)		
CATCHMENT ID	**TREATMENT NODE 1**	**TREATMENT NODE 2 (ETC.)**
Is the exfiltration rate justified (Section 4.1)?		
Can the hydraulic conductivity of the in-situ soils be guaranteed even during earthworks?		
IF "NO" WAS ANSWERED TO ANY OF THE ABOVE QUESTIONS THIS NODE CANNOT BE USED.		
Pond surface area (m²)		
Extended detention depth (m)		
Filter area (m²)		
Unlined filter media perimeter (m)		
Depth of infiltration media (m)		
Exfiltration rate (mm/hr)		
Has the secondary drainage link been used to return the exfiltrated flows to the model? (Section 4.1) (Y / N / N/A) If the secondary drainage link is not used, WQO's must be achieved prior to stormwater entering an infiltration system.		
Overflow weir width (m)		
Evaporative loss as % of PET		
Confirmation that K and C* remain default? (Y/N)		

C.14 - Porous Pavement Node Reporting Table

POROUS PAVEMENTS (SECTION 4.11)		
CATCHMENT ID	**TREATMENT NODE 1**	**TREATMENT NODE 2 (ETC.)**
Is direct rainfall modelled as a separate source node with a 100% impervious fraction? (Y/N)?		
Is the biofilter filter area set to represent the opening area of the permeable paving or void ratio of porous pavement (not the total surface area)? (Y/N). This should be estimated from the product specifications.		
Is the extended detention depth set to 0 m?		
Is the filter depth set to represent the treatment area only		
(should not include the depth of the drainage layer)		
NB: Report all other parameters for the porous pavement using Table B16.		

C.15 - Media Filtration Node Reporting Table

MEDIA FILTRATION (SECTION 4.8.3)		
CATCHMENT ID	**TREATMENT NODE 1**	**TREATMENT NODE 2 (ETC.)**
Extended detention depth (m)		
Surface area (m^2)		
Exfiltration rate (mm/hr)		
If an exfiltration rate greater than zero has been used, has the secondary drainage link been used to return the exfiltrated flows to the model? (Section 4.1) (Y / N / N/A)		
Filter area (m^2)		
Filter depth (m)		
Filter media particle diameter (mm)		
Saturated hydraulic conductivity (mm/hr)		
Depth below underdrain (% of filter depth)		
Have the K and C* values been retained as default values or otherwise justified?		
Is the filter media particle diameter and saturated hydraulic conductivity consistent with manufacturer specifications?		

C.16 - Stormwater Quality Modelling Results Reporting Table[42]

CATCHMENT ID	POLLUTANT	INFLOWS (KG/YR)	OUTFLOWS (KG/YR)	REDUCTION (KG/YR)	REDUCTION ACHIEVED (%)	WATER QUALITY OBJ. (%)
1	TSS					
	TP					
	TN					
2 (ETC.)	TSS					
	TP					
	TN					
Total	TSS					
	TP					
	TN					

[42] Where bioretention is used as a treatment node, report results using hydraulic conductivity of 50 mm/hr and 200 mm/hr in accordance with Section 4.5.3 e.g. for TSS reduction "70% (Ksat 50 mm/hr) / 85% (Ksat 200 mm/hr)"

C.17 - Life Cycle Cost Reporting Table

GLOBAL PROPERTIES			
Real discount rate (%)			
Annual inflation rate (%)			
Base year for costing			
Costing Element	**Treatment 1**	**Treatment 2 (etc.)**	**Total**
Acquisition cost ($)			
Annual maintenance cost ($)			
Annual establishment cost ($)			
Establishment period (yrs)			
Renewal/adaption cost ($)			
Renewal/adaption period (yrs)			
Decommissioning cost ($)			

TABLE D.1 GENERAL APPLICATION INFORMATION

APPLICATION INFORMATION			
Site or Project Name		DA No.	
Lot and Plan No.			
Location			

TABLE D.2 CLIMATE AND TIME STEP ASSESSMENT CHECKLIST (REFER TO SECTION 3 & APPENDIX A)

CLIMATE & TIME-STEP (CHECK REPORTING TABLE C1)	Y	N	COMMENTS/ISSUES TO FOLLOW UP
Has the correct rainfall station been used?			
Has a 6-minute time-step been used for assessment against stormwater quality management objectives?			
Has the correct modelling period been selected?			
Has the correct potential evapotranspiration been selected?			

TABLE D.3 CATCHMENT AND SOURCE NODE ASSESSMENT CHECKLIST (REFER TO SECTION 3.3)

CLIMATE & TIME-STEP (CHECK REPORTING TABLE C1)	Y	N	COMMENTS/ISSUES TO FOLLOW UP
Are the source node areas reported appropriate with respect to catchment areas shown on the plan?			
Does the total area reported reflect the total catchment relative to the development application?			
Does the land use reported reflect the proposed land use?			
Is the total imperviousness percentage for each land type appropriate (for development applications this must be measured direct from plans)?			

CATCHMENT SPLIT (CHECK REPORTING TABLE C3)	Y	N	COMMENTS/ISSUES TO FOLLOW UP
Has a 'split catchment' approach been used?			
Does the area of each land use/surface type reported reflect the areas shown on the plan?			
Does the total area reported reflect the total catchment?			
Do the land uses or surface types reported reflect the proposed development i.e. have correct source nodes been used?			
Is the fraction imperviousness for each land uses or surface type appropriate? Nb: for development applications this must be measured direct from plan, otherwise refer Section 3.3.3.			
For split catchment modelling where rainwater tanks are proposed as treatment nodes, is the percentage of connected roof area appropriate (Section 4.2)?			

TABLE D.4 RAINFALL AND RUNOFF ASSESSMENT CHECKLIST (REFER TO SECTION 3.3 AND APPENDIX A)

RAINFALL RUN-OFF AND POLLUTANT EXPORT PARAMETER (CHECK REPORTING TABLE B4 AND TABLE)	Y	N	COMMENTS/ISSUES TO FOLLOW UP
Have the correct rainfall runoff parameters been used?			
Are appropriate pollutant export parameters used?			
Has stochastic generation been used for all pollutants?			

TABLE D.5 ALL TREATMENT NODES ASSESSMENT CHECKLIST

ALL TREATMENT NODES	Y	N	COMMENTS/ISSUES TO FOLLOW UP
Will treatment nodes modelled be free draining? Compare the total depth of the treatment measures modelled against development plan levels.			
Have any receiving environments been modelled as treatment systems? These include natural waterways, natural wetlands, naturalised channel systems, environmental buffers, freshwater and brackish lake and pond systems (existing or constructed). Stormwater must be treated before it discharges to these systems.			

TABLE D.6 RAINWATER TANK NODES ASSESSMENT CHECKLIST (REFER TO SECTION 4.2)

RAINWATER TANKS (CHECK REPORTING TABLE B6)	Y	N	COMMENTS/ISSUES TO FOLLOW UP
Has the volume below overflow pipe (kL) been calculated appropriately?			
Has the depth above the overflow been calculated appropriately?			
If tanks are lumped, is depth below overflow the same as a single tank and overflow pipe scaled accordingly (Section 4.2.5?)			
Has the total tank surface area been calculated appropriately? For lumped tanks refer to Section 4.2.5.			
Has the overflow pipe diameter been calculated appropriately? For lumped tanks this must be equivalent to the diameter of the overflow pipe of a single tank multiplied by the square root of the number of tanks (Section 4.2.5).			
Has stormwater reuse been calculated appropriately? PET PET – Rain			
Have appropriate indoor connections been selected?			
Has the indoor demand been calculated appropriately?			
Has the outdoor demand been calculated appropriately?			
Has the daily demand been calculated appropriately?			
Has the monthly distribution of annual demand been calculated appropriately?			
Have K and C* been retained as default values? (Y/N)			

TABLE D.7 WETLAND NODE ASSESSMENT CHECKLIST (REFER TO SECTION 4.3)

RAINWATER TANKS (CHECK REPORTING TABLE B6)	Y	N	COMMENTS/ISSUES TO FOLLOW UP
Has the inlet pond volume sized appropriately to capture coarse sediment?			
Has the macrophyte zone surface area been calculated appropriately?			
Is the extended detention depth less than, or equal to, 0.5 m?			
Has the permanent pool volume been calculated appropriately?			
Is the exfiltration rate set to 0 mm/hr?			
If an exfiltration rate has been used, has the secondary drainage link been used to return the exfiltrated flows to the model? (Section 4.1)			
Has the evaporative loss as % of PET been set to 125% or less?			
Has the equivalent pipe diameter been set so that the notional detention time is about 48 hours?			
Has the overflow weir width been calculated appropriately?			
Is the notional detention time (hrs) approximately 48 hours?			
Are the number of CSTRs appropriate for the shape of the system?			
Have K and C* been retained as default values for all parameters except nitrogen which has been adjusted to reflect Section 4.3.4? (Y/N)			

TABLE D.8 SWALE NODE ASSESSMENT CHECKLIST (REFER TO SECTION 4.4)

SWALES (CHECK REPORTING TABLE C8)	Y	N	COMMENTS/ISSUES TO FOLLOW UP
Is the length equivalent to the length shown on the development plans and does it account for conveyance capacity and safety limitations selected in accordance with the WSUD Technical Design Guidelines for SEQ?			
Is the bed slope less than or equal to 4%?			
Are the base width, top width and depth equivalent to the length shown on the development plans?			
Is the set vegetation height appropriate for the selected species (Section 4.4)?			
Is the exfiltration rate set to 0 mm/hr?			
If an exfiltration rate has been used, has the secondary drainage link been used to return the exfiltrated flows to the model? (Section 4.1)			
If the swale accepts point source discharges at given locations, is it split into separate lengths?			
Have K and C* been retained as default values?			
BIORETENTION SWALE CHECKS			
Is the swale node located in the model downstream of bioretention swale surface component? (Y/N)			
Is the low-flow bypass of the swale node set to the infiltration rate of the filter? (Y/N)			

TABLE D.9 BIORETENTION AND BIORETENTION SWALE NODES ASSESSMENT CHECKLIST (REFER TO SECTION 4.5)

BIORETENTION AND BIORETENTION SWALE FILTER COMPONENTS (CHECK REPORTING TABLE C8 AND TABLE C9)	Y	N	COMMENTS/ISSUES TO FOLLOW UP
Has the filter surface area been calculated appropriately?			
Is the extended detention depth consistent with the depth shown on the development plans and between 0-0.4 m?			
Is the filter media area consistent with the area shown on the development plans?			
Has an appropriate unlined filter media perimeter been set?			
Has an appropriate saturated hydraulic conductivity been set? This should be modelled once at 50 mm/hr, once at 200 mm/hr and both scenarios reported.			
Is the filter media depth modelled equivalent to the depth of media shown on the plans? This depth should not include the intermediate layer, drainage layers, or submerged zone.			
Is the TN content in the filter media set to either 400 mg/kg or another suitably justified value?			
Is the orthophosphate content in the filter media set to 30 mg/kg or another suitably justified value?			
Is the base lined?			
Has the system been modelled to reflect the nutrient removal properties of the plants to be used on site?			
Is the overflow weir width appropriate?			
Is the exfiltration rate set to zero?			
If an exfiltration rate has been used, has the secondary drainage link been used to return the exfiltrated flows to the model? (Section 4.1)			
If exfiltration rate has been used, is the exfiltration rate justified?			
Has the system been modelled with underdrains present?			
Is a submerged zone with carbon present?			
Is the depth of submerged zone consistent with plans?			
If bioretention systems are modelled in series, is there a low-flow bypass modelled in the downstream bioretention system/s? (Note: separate drainage systems are required if a low-flow bypass is modelled)			
Have K and C* been retained as default values? (Y/N)			
BIORETENTION SWALE COMPONENT ONLY (CHECK TABLE C8)			
Has an extended detention depth of 0 m been used? (Y/N)			
Has the low flow bypass been calculated? The calculation should be provided by the applicant separately.			

TABLE D.10 BUFFER NODE ASSESSMENT CHECKLIST (REFER TO SECTION 4.7)

BUFFERS (CHECK REPORTING TABLE C10)	Y	N	COMMENTS/ISSUES TO FOLLOW UP
Does the treatment node reflect the vegetated area receiving sheet flow only?			
Is the percentage of upstream area buffered consistent with catchment plans?			
Does the buffer area accurately reflect the percentage impervious area as shown on the development plans?			
Is the exfiltration rate set to zero?			
If an exfiltration rate has been used, has the secondary drainage link been used to return the exfiltrated flows to the model? (Section 4.1)			

TABLE D.11 PROPRIETARY & CUSTOM PRODUCTS (INC GROSS POLLUTANT TRAPS) NODE ASSESSMENT CHECKLIST (REFER TO SECTION 4.8)

PROPRIETARY & CUSTOM PRODUCTS (CHECK REPORTING TABLE C11)	Y	N	COMMENTS/ISSUES TO FOLLOW UP
Are the proposed pollutant reduction efficiencies independently verified using a method suited to local conditions (Section 4.8)?			
Does the data provided include performance results under dry weather flows (to account for potential pollutant leeching)? (Y/N).			
Is the assumed high-flow bypass rate consistent with manufacturer specifications? (Y/N)			
UNLESS "YES" HAS BEEN ANSWERED TO ALL THREE QUESTIONS ABOVE THE PROPOSED POLLUTANT REDUCTION RATES CANNOT BE RELIED UPON AS BEING REASONABLE ASSUMPTIONS OF THE UNIT'S PERFORMANCE.			
Is the storage volume modelled consistent with the proposed unit?			
Is the expected maintenance frequency a reasonable assumption?			
Is the storage volume large enough to contain all sediments and gross pollutants received by unit during inter-maintenance periods?			

TABLE D.12 SEDIMENT BASIN NODE ASSESSMENT CHECKLIST (SECTION 4.9)

SEDIMENT BASTINS (CHECK REPORTING TABLE C12)	Y	N	COMMENTS/ISSUES TO FOLLOW UP
Has the surface area been calculated appropriately (Section 4.3.2)?			
Is the extended detention depth consistent with the development plans?			
Is the permanent pool volume consistent with the development plans?			
Is the exfiltration rate set to 0 mm/hr?			
If an exfiltration rate has been used, has the secondary drainage link been used to return the exfiltrated flows to the model? (Section 4.1)			
Is the evaporative loss as % of PET reasonable?			
Has the equivalent pipe diameter been set appropriately? (Where appropriate refer to Section 4.3.3 for advice on accounting for user-defined stage–discharge relationship)?			
Is the overflow weir width consistent with the development plans?			
Is the notional detention time set to account for potential flow restriction?			
Are the number of CSTRs appropriate for the shape of the system?			
Have the K and C* values been retained as default values? (Y/N)			

TABLE D.13 INFILTRATION NODE ASSESSMENT CHECKLIST (REFER TO SECTION 4.10)

INFILTRATION (CHECK REPORTING TABLE C13)	Y	N	COMMENTS/ISSUES TO FOLLOW UP
Is the exfiltration rate justified?			
Has the secondary drainage link been used to return the exfiltrated flows to the model? (Section 4.1). If the secondary drainage link is not used, WQO's must be achieved prior to stormwater entering an infiltration system.			
Can the hydraulic conductivity of the in-situ soils be guaranteed even during earthworks?			
IF "NO" WAS ANSWERED TO ANY OF THE ABOVE QUESTIONS THIS NODE CANNOT BE USED.			
Is the pond surface area consistent with the plans?			
Is the extended detention depth consistent with the plans?			
Is the filter area consistent with the plans?			
Is the unlined filter media perimeter appropriate?			
Is the depth of infiltration media consistent with the plans?			
Is the exfiltration rate justified?			
Is the overflow weir width consistent with the plans?			
Is the evaporative loss as % of PET reasonable?			
Have the K and C* values been retained as default values?			

TABLE D.14 POROUS PAVEMENT NODE ASSESSMENT CHECKLIST (REFER TO SECTION 4.11)

POROUS PAVEMENTS (CHECK REPORTING TABLE C14)	Y	N	COMMENTS/ISSUES TO FOLLOW UP
Has the applicant answered "Y" to all questions in the reporting table?			

NB: Check all other parameters for the porous pavement using Table C9.

TABLE D.15 MEDIA FILTRATION NODE ASSESSMENT CHECKLIST (REFER TO SECTION 4.8.3)

MEDIA FILTRATION SYSTEM (CHECK REPORTING TABLE C15)	Y	N	COMMENTS/ISSUES TO FOLLOW UP
Is the extended detention depth consistent with plans?			
Is the surface area consistent with plans?			
Is the exfiltration rate set to zero?			
If an exfiltration rate has been used, has the secondary drainage link been used to return the exfiltrated flows to the model? (Section 4.1)			
Is the filter area consistent with plans?			
Is the filter depth consistent with plans?			
Is the filter media particle diameter consistent with manufacturer information?			
Is the saturated hydraulic conductivity consistent with manufacturer information?			
Is the depth below underdrain consistent with plans?			
Have the K and C* values been retained as default values or otherwise justified?			

TABLE D.16 OVERALL APPROVAL ASSESSMENT CHECKLIST

DESIGN OBJECTIVES (CHECK REPORTING TABLE C16)	Y	N	COMMENTS/ISSUES TO FOLLOW UP
Have all water quality objectives been met?			
Is the MUSIC model approved?			

Healthy land & water
Solutions Protecting Your World

waterbydesign
a Healthy Land and Water initiative

Healthy Land and Water

Level 19, 160 Ann St, Brisbane QLD 4000

PO Box 13204, George St, Brisbane QLD 4003

Ph: (07) 3177 9100

Fax: (07) 3177 9190

Email: info@hlw.org.au

www.hlw.org.au