Warrnambool City Council
MUSIC Guidelines

July 2013

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Front page: Marrakai Estate Wetland (Water Technology Site Visit 12/06/2013)

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Executive Summary

This document presents the preferred MUSIC modelling parameters to be used within the Warrnambool City Council municipality. Directions for designing Water Sensitive Urban Design (WSUD) assets in Warrnambool are also provided based on the climatic and soil conditions.

At the concept design stage, it is necessary to develop a stormwater management plan to demonstrate how the flood retardation and stormwater quality treatment will be managed to ensure that 1 in 100 year peak runoff flows are retarded back to the existing conditions flows and that stormwater quality meets the Best Practice requirements using a MUSIC model. Developers and designers should refer to the Infrastructure Design Manual (IDM) and the WCC WSUD Infrastructure Design Guidelines including the design checklists before submitting a concept design to Council.

Key recommendations for the municipality are as follows:

- **Rainfall –** For WSUD sizing a reference year has been provided from Camperdown Donalds Hill (Station 90153) from 1/10/1988 to 01/10/1989. The six minute rainfall data is appropriate for most urban applications.
- **Harvesting / Water Balance Rainfall –** If long term daily rainfall data is required for stormwater harvesting or water balance studies the period from 1962 to 1971 at Warrnambool Post Office (90082) station provides variable conditions including wet and dry years. If low rainfall years are required then 1925-1935 is a period of consistently low rainfall.
- **Evapotranspiration -** Monthly evapotranspiration values from long term average are also provided in Figure 2 of this guide.
- **Soil Types –** A range of soil types are encountered within Warrnambool City Council municipality. Guidance in the type of WSUD assets and the design considerations based on the soil type are shown in Figure 3.
- **Fraction Impervious -** Detailed fraction impervious values are presented in this guide. Commonly, normal density residential land use would have a 60% fraction impervious while industrial and commercial land use would have a 90% fraction impervious.

It is advised that before submitting a concept design to Council, the developer or designer check that the MUSIC model meets the requirements using the online MUSIC Auditor tool.

1. Introduction

The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) was developed by eWater as a conceptual tool to simulate and estimate both the quantity and quality of runoff from different land uses within a particular catchment. The software also allows the user to simultaneously assess the performance of a variety of stormwater treatment systems. The use of MUSIC ensures that stormwater runoff is managed and that receiving waterways or systems are protected.

Currently in Victoria, stormwater quality improvement technologies must adhere to the Best Practice Environmental Management Guidelines (BPEMG). This requires:

- **45%** reduction in **Total Nitrogen (TN)** from typical urban loads
- **45%** reduction in **Total Phosphorus (TP)** from typical urban loads
- **80%** reduction in **Total Suspended Solids (TSS)** from typical urban loads
- **70%** reduction in **Litter** from typical urban loads
- Maintain discharges for the 1.5 year ARI event at pre-development levels

The development of this document follows discussions with Warrnambool City Council Officers about the increasing number of Water Sensitive Urban Design (WSUD) features being constructed in Warrnambool, and the importance of using consistent MUSIC parameters to assess WSUD feature design. This MUSIC Guidelines document specific to WCC is part of a series of documents which should be consulted in conjunction when proposing and/or designing a WSUD asset in the Warrnambool region (refer **Figure 1**).

- **Infrastructure Design Manual (IDM)** - The IDM clearly documents the participating Council's requirements for the design and development of Infrastructure. Specific to Stormwater, the IDM ensures that all stormwater discharged to natural watercourses and other drainage authority's drains meet the requirements of the Environment Protection Act 1970 and the water quality performance objectives for individual drainage catchments as provided in the State Environment Protection Policies (SEPPs).
- **Sustainable Infrastructure Guidelines (IDM Group)** - These guidelines are currently under development and seek to provide guidance on alternative design considerations and materials that will deliver more sustainable infrastructure.
- **Urban Stormwater: Best Practice Environmental Management Guidelines (CSIRO, 1999)** - These guidelines assist in the development of strategies for improved environmental management of urban catchments and waterways.
- **WSUD Infrastructure Guidelines (WCC, 2013)** - This document presents information on WSUD features, principles, design considerations and requirements. The document outlines the process that needs to be taken from the design stage trough to the final handover and ongoing maintenance. Checklists and flow charts have been included to aid interpretation of this process.
- **MUSIC Guidelines (WCC, 2013)** - This document provides guidance on input parameters and modelling approaches for MUSIC specific to Warrnambool.
- **WSUD Maintenance Manual (WCC, 2013)** – Due to be developed in August 2013. This document will provide Warrnambool specific advice related to maintenance of WSUD infrastructure.

- **WSUD Engineering Procedures: Stormwater (CSIRO, 2005)** - This manual provides design and maintenance procedures, typical drawings, design checklists, landscape requirements, worked examples and case studies.
- **Water Sensitive Urban Design Guidelines (Melbourne Water, 2009)** - These guidelines set out expectations to inform developers and consultants in developing WSUD projects. The document provides information on the approvals process, design considerations, suitability of WSUD types in different conditions and considerations for construction, protection, maintenance and handover of WSUD assets.

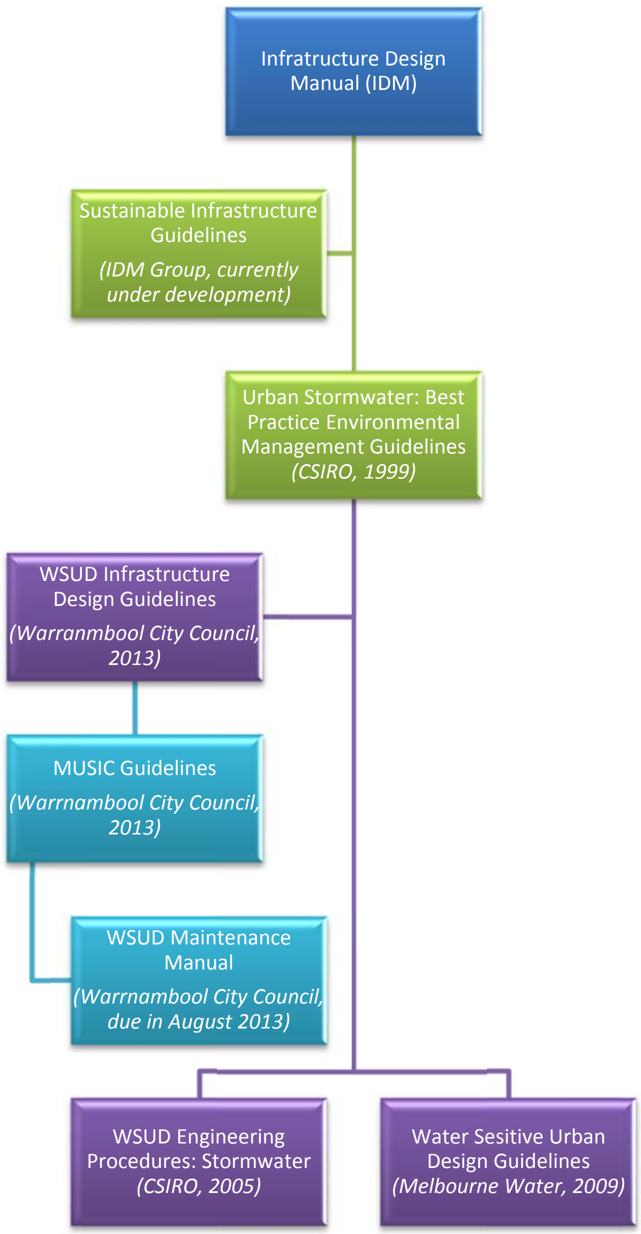

Figure 1 – Manuals and Guidelines documents for consultation

Warrnambool City Council officers require the MUSIC model output file from the designers in order to demonstrate the compliance of devices and assess the MUSIC model submissions using MUSIC audit tool as detailed in Section 6 of this document.

This document is based on the Melbourne Water MUSIC Guidelines (2010) which have been adapted to Warrnambool City Council (WCC) municipality as a supplementary document to the Infrastructure Design Manual (IDM).

1.1 Purpose of this document

This document provides guidance on input parameters and modelling approaches for MUSIC specific to WCC. They have been developed to:

- Ensure a consistent and uniform approach is applied to MUSIC models developed for stormwater management within the WCC
- Provide advice on the use of MUSIC model in the Warrnambool region; and to
- Provide guidance on region specific input parameters to be used in MUSIC models

At the time of writing this guideline the current version of the MUSIC software was Version 5.1.

Users of these guidelines are assumed to be familiar with the MUSIC software. This document should be used in conjunction with the MUSIC User's Manual (MUSIC Development Team, 2005). The document is not intended to be a design guideline and should be used in conjunction with site constraints / opportunities.

A design report and accompanying MUSIC model will need to be submitted with an application. This includes a concept design plan with appropriate landscaping and consideration of site constraints and opportunities.

2. Meteorologic Data

2.1 Rainfall – Reference Year for WSUD Sizing

The municipality of Warrnambool is covers approximately 121km^2 including the localities of Allansford, Bushfield, Dennington, Illowa, Warrnambool, Woodford and Yangery. Only one rainfall area was used to represent the local rainfall characteristics of the area due to low number of pluviometric stations in the vicinity of Warrnambool and the limited climate variability within the relatively small area.

Based on a rainfall analysis a reference year has been selected to represent the average conditions in Warrnambool. As a 6 minute interval is most commonly required, the pluviograph station at Camperdown Donalds Hill (90153) was assessed. The period from 1/10/1988 to 1/10/1989 provided the most consistent results to the long term average conditions at Warrnambool.

Reference Station: **Camperdown Donalds Hill (90153)**

Reference Year (6 minutes timestep): **[01/10/1988 – 01/10/1989]**

Appendix A shows the monthly pluviometric data for the selected station reference year compared to the long term monthly average rainfall from the closest weather station in Warrnambool.

It is, however, recommended that the results obtained by using the reference year be ultimately compared with the long term rainfall data as a final design check.

2.2 Rainfall – Long Term for Stormwater Harvesting

If a water balance or stormwater harvesting is modelled within MUSIC, then the entire record (or at minimum a 10 year period representing both wet and dry periods) is required. A selected 10 year period (1/01/1962 – 31/12/1971) from the weather station Warrnambool Post Office (90082) was identified to be the most variable period compared to the Warrnambool Post Office Station long term mean annual rainfall; with 1971 the wettest year and 1963 the driest year. (see **Appendix B**).

10 Year Period Station: **Warrnambool Post Office (90082)**

10 Year Period (daily timestep): **[01/01/1962 – 31/12/1971]**

The 10 year period from 1962 to 1971 has a daily timestep and should only be used for water balance analysis to estimate inflow/outflow out of a storage rather than extraction out of a pipe system.

If low rainfall years are required then 1925-1935 is a period of consistently low rainfall.

The appropriate rainfall files can be provided by WCC officers.

2.3 Evapotranspiration

The evapotranspiration distribution for the City of Warrnambool is shown in **Figure 2**. These values correspond to the average areal potential evapotranspiration maps generated by the Bureau of Meteorology (BoM) over a 30-year period from 1961 to 1990. The use of this distribution is approved for the area within the City of Warrnambool municipality.

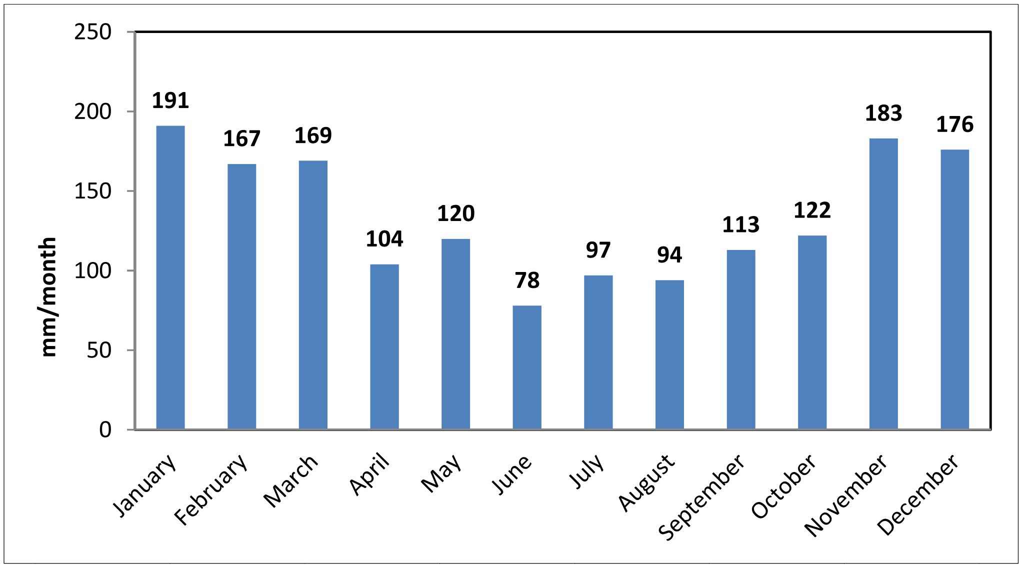

Figure 2 – Warrnambool Evapotranspiration Distribution

3. Model Setup

3.1 Timestep

The timestep must be equal to or less than:

- The Time of Concentration of the smallest Sub-Catchment; and
- The shortest detention time (under design flows) of the treatment measures being modelled.

In a situation where either of these values are less than 6 minutes, a timestep of 6 minutes should be used. Six minute data will be appropriate for most urban models.

3.2 Hydrologic Routing

Where appropriate hydrologic routing should be used to best represent the catchment's time of concentration. The user may, however, choose not to use hydrologic routing as MUSIC is not an appropriate hydrology model and the routing does not affect the nutrient reductions. In general this will return a conservative result for the treatment system.

3.3 Soils

When using MUSIC the pervious area properties will automatically default to the Brisbane properties and will need to be changed to represent Warrnambool soil properties. The Warrnambool pervious area properties are: **Soil Store Capacity = 30mm, Field Capacity = 20mm.**

Other soil parameters may be used if verified by soil testing.

3.4 Losses from the System

The exfiltration rate within a treatment node refers to the seepage rate of the surrounding soil. This should be set to 0 mm/hr in the MUSIC model unless a geotechnical report suggests otherwise.

Analysis of geological map of Warrnambool shows that the following three types of soil conditions can be encountered in Warrnambool;

- Sandy soils
- Heavy Clay soils
- Clay soils

A map showing the different soil conditions is presented in **Figure 3.**

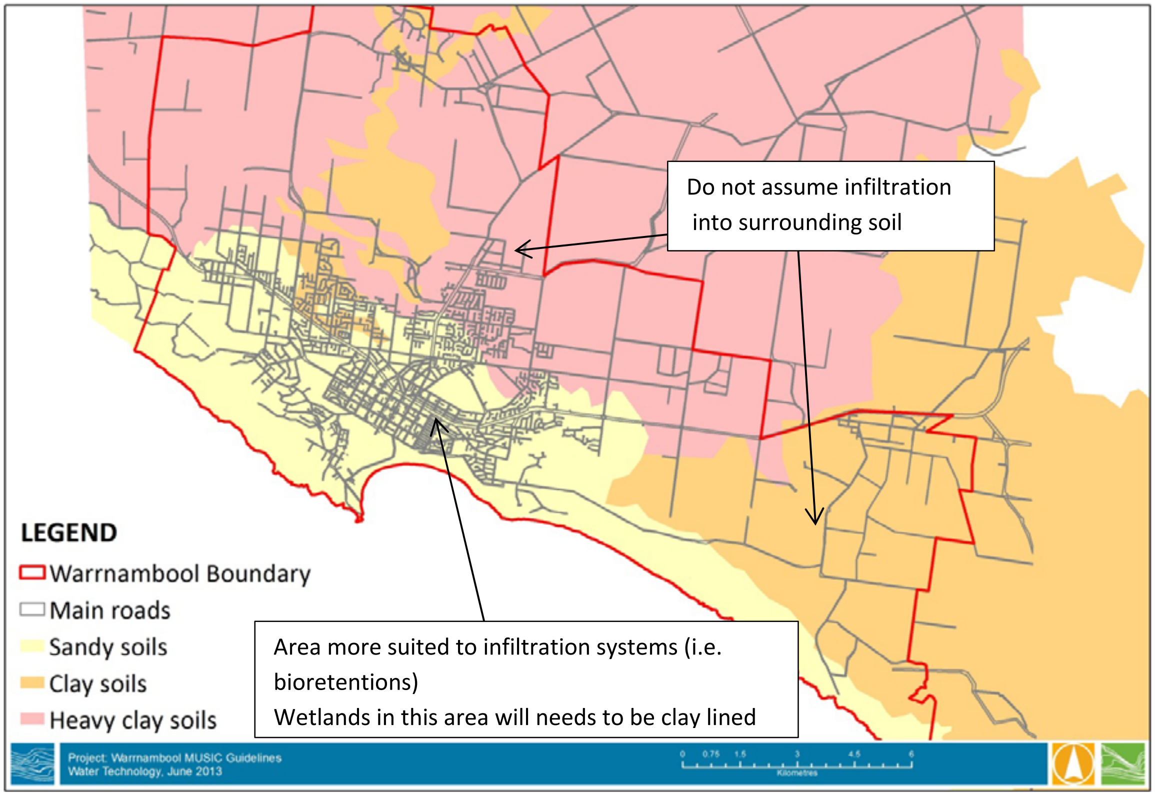

Figure 3 – Warrnambool Soil Condition Map

In <u>sandy soil conditions</u>, the following items must be considered:

- Infiltration systems such as raingardens could be potentially unlined or partially lined. This is not to occur if the system is adjacent to housing or paved surfaces such as roadways.
- Swales do not need to be lined unless adjacent to paved surfaces.
- The base of sedimentation ponds and wetlands will need to be lined with clay.
- Infiltration system such as leaky rainwater tanks could be considered in sandy regions.

In <u>clay based soil conditions</u>, the following items must be considered:

- Soil testing will need to be undertaken to ensure clay layer is appropriate for a wetland or sediment pond liner.
- Sedimentation ponds should be upsized to account for the high contents in sediments coming from the upstream catchment which would slow down the setting rate of the particles in the sedimentation pond.
- Infiltration systems are not preferred in this environment. Infiltration systems will need to be lined and raingardens with significant upstream catchments require a sedimentation pond as primary treatment. Leaky rainwater tanks are not recommended unless geotechnical investigations prove sufficient infiltration is possible.

An example of clay soil observed at Brierly Outfall Drain on June 12, 2013 is shown in **Figure 4**.

Figure 4 – Clay Soil Example at Brierly Outfall Drain in Warrnambool (Water Technology, 12/06/2013)

3.5 Pollution Concentration Data

Default concentration values for TSS, TP and TN should be used unless other data is available.

3.6 Fraction Impervious

In a situation where a model cannot be calibrated with local flow data, please refer to **Table 1** for an indication of an appropriate fraction impervious value based on the landuse.

Note: Values included in this table relate only to the average imperviousness of a land-use type. They are not runoff coefficients and should not be used as runoff coefficients. Refer to the Australian Rainfall and Runoff (Engineers Australia, 2001) for the difference between fraction impervious and runoff coefficients. If runoff coefficients are required for OSD purposes please refer to the IDM.

Table 1 – Fraction Impervious Guide

Zone	Zone Code	Description	Normal range	Typical Value
Residential Zones				
Residential 1 & 2 Zone	R1Z	Moderate range of densities (Lot size 800m² - 4000m²)	0.40 – 0.50	0.45
	R2Z	Normal densities (Lot size 500m² - 800m²)	0.50 – 0.70	0.60
		Medium densities (Lot size 350m² - 500m²)	0.70 – 0.80	0.75
		High Densities (Lot size < 350m²)	0.80 – 0.95	0.85
Low Density Residential Zone	LDRZ	Low densities (0.4 ha min)	0.10 – 0.30	0.20
Mixed Use Zone	MUZ	Mix of residential commercial, industrial and hospitals.	0.60 - 0.90	0.70
Township Zone	TZ	Small townships with no specific zoning structures	0.40 – 0.70	0.55
Industrial Zones				
Industrial Zone 1	IN1Z	Main zone to be applied in most industrial areas	0.70 – 0.95	0.90
Industrial Zone 2	IN2Z	Large industrial zones away from residential areas	0.70 – 0.95	0.90
Industrial Zone 3	IN3Z	Buffer between Zone 1 and Zone 3	0.70 – 0.95	0.90
		Garden supplies/nurseries	0.30 – 0.60	0.50
		Quarries	0.10 – 0.30	0.20
Business 1 Zone	B1Z	Main zone to be applied in most commercial areas	0.70 – 0.95	0.90
Business 2 Zone	B2Z	Offices an associated commercial uses	0.70 – 0.95	0.90
Business 3 Zone	B3Z	Offices, manufacturing industries and associated uses	0.70 – 0.95	0.90
Business 4 Zone	B4Z	Mix of bulky goods retailing and manufacturing industries	0.70 – 0.95	0.90
Business 4 Zone	B5Z	Mix of offices and multi-dwelling units	0.70 – 0.95	0.90

Zone	Zone Code	Description	Normal range	Typical Value
Rural Zones				
Rural Zone + Farming Zone	RUZ FZ	Main zone to be applied in most rural areas	0.05 – 0.20	0.10
Environmental Rural Zone	ERZ	Rural areas with specific environmental considerations	0.05 – 0.20	0.10
Rural Living Zone	RLZ	Predominantly residential use in rural environment	0.10 – 0.30	0.20
Public Land Zones				
Public Use Zone	**PUZ**	Use of land for public purposes		
Service and Utility	PU1Z	Power lines, pipe tracks and retarding basins	0.00 – 0.10	0.05
		Reservoir	0.40 – 0.60	0.50
Education	PU2Z	Schools and universities	0.60 – 0.80	0.70
Health and Community	PU3Z	Hospitals	0.60 – 0.80	0.70
Transport	PU4Z	Railways and Tramways	0.60 – 0.80	0.70
Cemetery / Crematorium	PU5Z	Cemeteries and Crematoriums	0.50 – 0.70	0.60
Local Government	PU6Z	Libraries, sports complexes and offices/depots	0.50 – 0.90	0.70
Other Public Use	PU7Z	Museums	0.50 – 0.80	0.60
Public Park & Recreation Zone	PPRZ	Main zone for public open space including golf courses	0.00 – 0.20	0.10
Public Conservation & Resource Zone	PCRZ	Protection of natural environment or resources	0.00 – 0.05	0.00
Road Zone – Category 1	RDZ1	Major roads and freeways	0.60 – 0.90	0.70
Road Zone – Category 2	RDZ2	Secondary and local roads	0.50 – 0.80	0.60
Commonwealth Land				
Commonwealth Land	CA	Army barracks, CSIRO	0.50 – 0.80	0.60

3.7 Stochastic or Mean Generated Data

Stochastically generated data should always be used. The only exception to this is if the user wishes to assess the system behaviour for a specific event or set of parameters.

3.8 Source Nodes

Agricultural and forest source nodes should be treated as independent subcatchments due to the uncertainties associated with the nodes being significantly higher than the uncertainties for urban nodes. For this reason it is normally preferable to use urban nodes with low fraction impervious values instead of agricultural of forest nodes. Parkland within an urban development will typically be represented by an urban node with low fraction impervious (10% recommended).

Care needs to be taken when setting up the MUSIC model to ensure that the appropriate flows are entering the WSUD features. Where flows bypass a system (such as roof water directly into the outlet pit or areas not able to drain to features) these must be replicated as different source nodes.

3.9 K, C*, C**

These parameters should not be altered unless a significant amount of relevant published data suggests otherwise.

3.10 In stream Works

Any works within receiving waters should not be included in any treatment train models. Online wetland treatment trains are acceptable permitting that they comply with WCC requirements.

3.11 Bypass

Any flows greater than the 0.25 Year ARI should be bypassed around the system. This will be included in the inlet properties for each WSUD device.

4. Treatment Nodes

4.1 Gross Pollutant Traps (GPT's)

Gross Pollutant Traps (GPT's) are sediment traps which screen and store litter and debris. Only stormwater treatment proven by reputable studies shall be attributed to a GPT. No nitrogen reductions will be accepted in the treatment train performance.

Before a model can be approved, copies of the product specifications, installation manual and maintenance requirements need to be provided as part of the submission. Please refer to the *WCC WSUD Infrastructure Design Guidelines (2013)* document for details.

4.2 Soak Pits

Soak Pits (also called Soakage Pits, Soak Wells, Leaky Wells or Soakers) are onsite stormwater retention system that allow for infiltration into the ground. This is an open permeable pit which can be easily accessed and maintained. Warrnambool has over 700 Council owned Soak Pits and more privately owned.

The use of soak pits should not be considered where soil types are not appropriate (refer to **Figure 3**) and other drainage treatments and features can be achieved. No stormwater treatment shall be attributed to a Soaker Pit and any nitrogen reductions due to the use of it should not be included in the treatment train overall performance.

4.3 Lakes

Lakes are open water bodies which treat stormwater by providing extended detention and allowing sedimentation. In most situations, however, alternative stormwater treatment should occur prior to entering a pond or a lake. Aside from water balance assessments using at least a 10 year period of wet and dry years, MUSIC should not be used to model nutrient reductions.

For any proposed lakes the circulation time and water balance calculations will need to be provided.

4.4 Sediment Ponds

Sediment ponds (or sediment basins) are detention systems which slow stormwater runoff and allow the sediments to settle and deposit. By keeping the stormwater in the pond for an extended period of time much of the medium and large sediment in the stormwater is removed. Sediment ponds are often temporarily used during construction activities as they assist in controlling and removing the elevated sediment levels. They are also generally incorporated into wetland designs.

Sediment Ponds should be sized using the Fair and Geyer Settling Velocity Equation, as specified in the CSIRO (2005) WSUD Engineering Procedures. Details should be supplied with submission.

4.5 Wetlands

Wetlands are shallow, vegetated WSUD assets which treat stormwater by allowing for sedimentation, filtration and biological uptake.

A minimum of 80% coverage of emergent macrophytes is required within the normal water level surface area of the wetland.

The surface area parameter of a wetland in MUSIC corresponds to the area of water at half extended detention depth. The software hydrologic routing analysis calculates the volume of water in storage (i.e. above the Normal Water Level (NWL)) during a storm event by multiplying the depth of water above the NWL by the surface area.

The extended detention depth should be within the range 0.3 – 0.5m unless approved by WCC staff. Due to the different depth zones, the permanent pool will vary between 0.3 - 1.5m depth, with an average of 0.4m.

The permanent pool volume which is the volume of water below the NWL can be estimated as the surface area times the average depth of 0.4m.

It is recommended that the detention time in the macrophyte zone is 72 hours. The minimum detention time is 48 hours. Details should be supplied with submission.

If the wetland is to be placed within the 100 Year ARI flood extent then the following evidence must be provided to ensure the system can be sustainable during floods:

- Velocity calculation in wetland to ensure v < 0.5 m/s in the wetland
- Wetland to be located outside the 10 Year ARI extent (unless approved by WCC)
- Connection to the waterway must be considered to allow free draining of the system to the creek during maintenance, and to prevent erosion of the creek/river banks
- The floodplain storage or flood level must not be impacted

Figure 5 – Marrakai Estate Wetland (Water Technology, 12/06/2013)

4.6 Swales

Swales are grassed or vegetated channels which collect and transport stormwater. They can do this with, or instead of, underground drainage. The vegetation in a swale treats stormwater and reduces pollutant loads. Swales are typically constructed with a low grade in order to reduce the velocity of stormwater flows. The suggested vegetation heights for swales are:

- 10 to 100mm for mowed grass swales
- 100 to 400mm for unmown vegetation

Note that the vegetation height selected in the MUSIC model must represent the vegetation in the base of the swale. Swales with rock lining in the base provide no water quality treatment.

It is important to note that waterways within a development cannot be deemed to be swales and should therefore not be included in the MUSIC model.

Swales are not to exceed 4% unless check banks are provided. Additional capacity and velocity checks will need to take place. The velocity must not exceed 0.5m/s for storms up to the 5 Year ARI event and 1.0m/s in the 100 year ARI event.

Swales within the nature strip of the development (as shown in **Figure 6**) are not preferred due to the reliance on residents to maintain the system. Boulevard style swales in the centre of the roadway, and swales in drainage reserves are more appropriate.

Figure 6 – Marrakai Estate Swale (Water Technology, 12/06/2013)

4.7 Bioretention Systems / Raingardens

Bioretention systems are vegetated WSUD assets with a filtration media which collect, detain, and treat stormwater. The design of bioretention systems should be in accordance with Chapter 5 and Chapter 6 of the WSUD Engineering Procedures: Stormwater Manual (CSIRO, 2005). The filter media specification should also comply with the requirements listed in the Stormwater Biofiltration Systems: Adoption Guidelines (FAWB, 2009).

In clay and heavy clay soil types (Refer to **Figure 3**) in the City of Warrnambool, a sediment pond must be included upstream of all bioretention systems. This can be sized based on the Fair & Geyer settling velocity calculation (CSIRO, 2005) using the lower setting velocity of clay.

Other design components include:

- Extended detention to not exceed 500mm (300mm preferred)
- Assume a maximum grade of 1:5 into the bioretention
- Lining of the bioretention with geotextile to be considered in areas with significant clay content in soils
- Saturated hydraulic conductivity to be specified as 180mm/hr in design reports and plans, however modelled as 100mm/hr within MUSIC.
- Filter depth is 600mm (sandy loam), with sand and gravel layers required with the underdrainage (see FAWB specifications)
- TN content 800mg/kg and Orthophosphate content 60mg/kg unless soil tests of filter media prove otherwise
- Under drainage and planting is required for all bioretentions.

If the design is to vary from these parameters, the reasons should be stated in the report.

Figure 7 –Bioretention System/Raingarden in Estate on Aberline Road (Water Technology, 12/06/2013)

4.8 Rainwater Tanks

A rainwater tank in MUSIC achieves nutrient reductions as a result of removing the rooftop flows from the stormwater system and reusing the water onsite. They are often also used for stormwater retention purposes in order to mitigate part of the flows running off the site. It is best to assume the rainwater tank is 50% full in order to account for the variability of storage available before a rainfall event comes through unless a leaky rainwater tank is planned to be used.

When reuse is included in a treatment train, it must have reliable demands (e.g. toilet flushing) associated with it. Residential irrigation should not be included as a demand due to the high variability of its usage. For seasonal demands, a monthly distribution of the demand can be set using percentage of the annual demand for each month.

There should be an understanding and agreement between relevant stakeholders before reuse is accepted for the MUSIC model. The usage of reuse should be in accordance with the *Meteorologic Data* and *Timestep* section within these guidelines.

4.9 Permeable Pavements

Permeable pavements are paved surfaces which allow for the infiltration of stormwater and therefore reduce runoff flows. Permeable pavement should be modelled as per the manufacturer's guidelines. In order to gain approval for the use of permeable pavement supporting documents should be included.

4.10 Imported Data Nodes

Where imported data nodes are used detailed supporting documentation should be included.

4.11 Generic Treatment Nodes

Generic treatment nodes should be used as a last resort and should be supported by additional models and information.

5. Staged Development

Where works are intended to be staged, a separate MUSIC model needs to be developed to show how water quality requirements will be achieved in the temporary conditions and how the ultimate outcome will be implemented.

6. MUSIC Auditor

WCC requires all MUSIC models to be uploaded to the MUSIC Auditor found at http://www.musicauditor.com.au/. The MUSIC output report file (.mrt) must be submitted with the stormwater management plan at concept stage (example in **Figure 8**). Where any values are outside the accepted range the reasoning for these variations to the design must be provided.

Melbourne Water

Date Completed: 14-06-13
MUSIC Version Audited: v5
Filename is example.mrt
PDF Download

Source Nodes				
Parameter	User Input	Check	Guideline	Comments
Node urban does not have any errors. (Node 1)				
Node urban does not have any errors. (Node 4)				

Treatment Nodes				
Parameter	User Input	Check	Guideline	Comments
wetland (Node 3) **Music Help**				
Extended detention depth (m)	0.5	>	0.4	Deep average depth. A depth of no more than 0.4 is recommended to support healthy plant growth. Wetland Design Guidelines set a 0.5m limit, check meets Wetland Design Guidelines. Designer to confirm vegetation design consistent with expected inundation frequency if depth exceeds 0.4 m. FAQ
Overflow weir width (m)	3	<	10	Warning - check is large enough to ensure wetland can overflow freely, if not may result in system filling to unrealistic depths. FAQ
Sedimentation Basin (Node 5) **Music Help**				
Permanent pool volume (m3)	1500	<	1 * 2000 = 2000	Shallow permanent pool depth given area, wind action may result in sediment being re-entrained. Check sediment storage volume (50% of permanent pool, is sufficient). FAQ
Overflow weir width (m)	2	<	10	Warning - check is large enough to ensure sediment basin can overflow freely, if not may result in system filling to unrealistic depths. FAQ

Figure 8 –Example Output from MUSIC Auditor

7. Conclusion

The modelling guidelines provided within this document are intended to provide a local context for the MUSIC models. Values outside the provided ranges may be accepted; however Council will need to be consulted. Designs will need to take into account site constraints and opportunities wherever possible, including but not limited to:

- Location of underground services
- Surrounding soil type
- Development drainage outlet pipe level
- Flow velocities
- Consideration of safety and appropriate batter slopes
- Maintenance access

8. References

- CSIRO (2005). *WSUD Engineering Procedures: Stormwater*. Collingwood, Victoria: CSIRO Publishing.
- Facility for Advancing Water Biofiltration (FAWB) (2008) – Raingardens and Bioretention Tree Pits Maintenance Plan

Appendix A

Table 2 shows the monthly pluviometric data for the selected station reference year compared to the Warrnambool Post Office (Station 90082) Weather Station long term monthly average rainfall.

Table 2 – Weather Station(s), Rainfall values and Reference Year

	Rainfall values (mm)												
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Annual**
Warrnambool Post Office (90082) *	32.9	34.3	47.6	60.3	77.5	76.9	88.3	85.6	73.7	66.7	54.8	44.4	**743.1**
Camperdown Donalds Hill (90153) **	39.6	11.6	43.0	61.4	70.2	78.4	78.2	98.4	69.8	60.0	78.0	55.8	**744.4**

*Long term mean monthly and annual values from November 1897 to April 1983

**Monthly and annual values from 01/10/1988 to 1/10/1989

Appendix B

A selected 10 year period (1/01/1958 – 31/12/1967) from the Warrnambool Post Office (90082) weather station was identified to be the most variable period compared to the long term mean annual rainfall; with 1967 the wettest year and 1959 the driest year (see **Table 3** in Appendices). This period will provide information about both very wet and very dry years, while maintaining a consistent record.

Table 3 – Weather Station(s) and 10 year period with wet and dry years

		Rainfall values (mm)												
Station		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Annual**
Warrnambool Post Office (90082) *		32.9	34.3	47.6	60.3	77.5	76.9	88.3	85.6	73.7	66.7	54.8	44.4	**743.1**
Warrnambool Post Office (90082) **	1962	11.3	31.3	45.2	32.5	119	118	56.8	83.7	55.5	106	25.3	32.6	**716.7**
	1963	67	10.7	33.2	7.4	80.1	50.2	118	46	59.6	22.5	21.2	8.2	**523.9**
	1964	22.3	75.3	43.2	63.1	77.9	84.9	150	103	90.5	88.6	72.1	69.8	**939.7**
	1965	6.4	3.3	39.9	66.7	96.3	41.2	100	60.1	70.2	29.5	82.7	40.3	**636.9**
	1966	26.8	24.2	32.2	66.1	40.8	53.3	130	131	55.5	44.6	46.4	137	**788.3**
	1967	37.5	44.7	32	21.4	34.2	21.5	116	121	48.3	18.2	29.9	61.7	**586.4**
	1968	12	21	57.6	70.5	207	146	104	139	70.3	131	117	23.8	**1099**
	1969	32.8	76	42.8	67.2	76.2	30.9	108	91.3	149	96.1	65.3	62.9	**897.7**
	1970	58	19.9	62.6	109	87.5	85.4	159	218	116	47.9	85.9	86.4	**1136**
	1971	46.2	40.4	52.6	146	174	117	60.9	114	103	127	125	75.2	**1181**

*Long term mean monthly and annual values from November 1897 to April 1983

**Monthly and annual values from 1958 to 1967

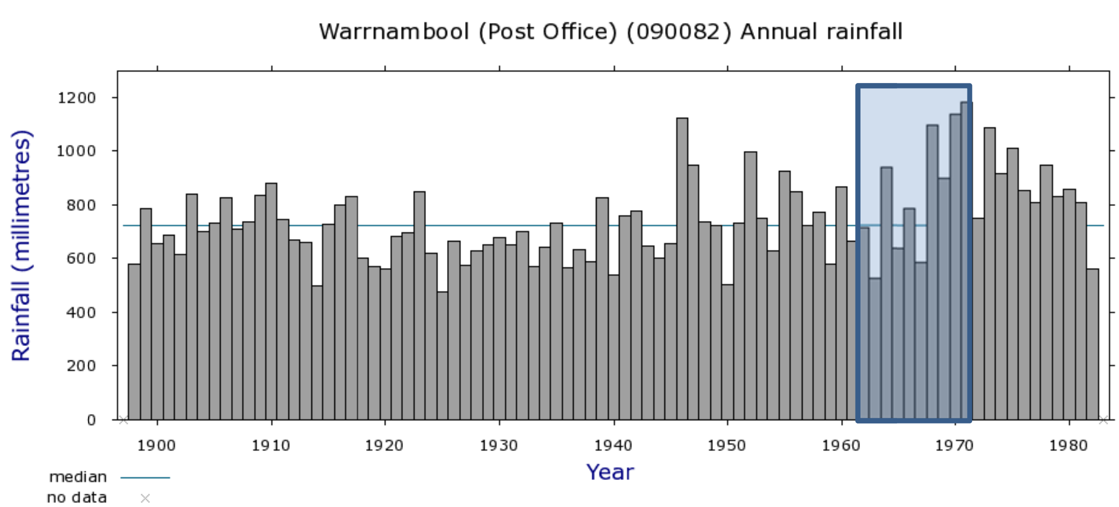

Figure 9 – 10 Year Rainfall Period for Warrnambool Post Office