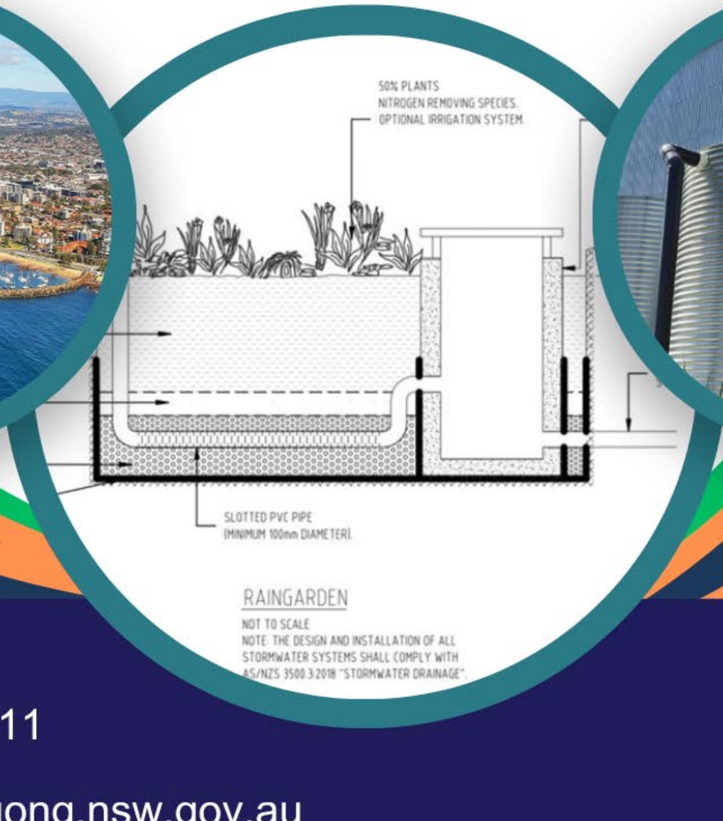
Water Sensitive Urban Design (WSUD)

Guidebook for Developers

2025

wollongong
city of innovation



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Acknowledgment of Country

Wollongong City Council acknowledges the Traditional Custodians of the land in which our city is built, the Aboriginal people of Dharawal Country. We recognise and appreciate their deep spiritual connection to this land, waters, and our greater community. Council would like to pay its respects to First Nation Elders past, present and those emerging and extend our acknowledgement to all Aboriginal and Torres Strait Islander people who call the city home. We recognise Aboriginal and Torres Strait Islander people as the first people to live in the area, we respect their living cultures and recognise the positive contribution their voices, traditions and histories make to our city.

Citation

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Acknowledgements

Wollongong City Council acknowledges that the development of this Guidebook is aligned with the strategies and legislative actions outlined in the *Lake Illawarra Coastal Management Program 2020-2030*, as well as the Lake *Illawarra Catchment – Applying the risk-based framework for improving water quality* document prepared by the NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW, 2024). This Guidebook has been informed by the Guidelines for WSUD Strategies developed in collaboration with the NSW Government, relevant resources documents and support from Blacktown City Council, Shellharbour City Council, Kiama Council, Shoalhaven City Council, Gold Coast Council, MidCoast Council, Optimal Stormwater, Stormwater NSW, Ocean Protect, eWater, Melbourne Water, and supplemented by expert recommendations from Alluvium Group.

Wollongong City Council gratefully acknowledges the contributions received from these organisations, the development industry and Wollongong City Council Staff for the invaluable support received in the preparation of this Guidebook.

Disclaimer

This Guidebook was created with consideration, based on thorough reviews and consultation. While we've made every effort to ensure the information is accurate and reliable, Wollongong City Council is not responsible for any loss, damage, or costs that may result from using or relying on this guide.

The Guidebook is reviewed and updated regularly. Please check the Wollongong City Council website to make sure you're using the latest version. If you need help during the WSUD design phase, before submitting a development application, or want more information about WSUD, contact Council's Customer Service Centre on (02) 4227 7111.

Table of contents

Table of figures

List of tables

SECTION 1 - INTRODUCTION

1.1 Who should use this Guidebook?

This Guidebook is for developers and civil engineers who are trained in designing and building Water Sensitive Urban Design (WSUD) systems, and in stormwater, floodplain and hydraulic modelling. All assessments and modelling must be done by qualified and experienced consultants. In some cases, like water conservation, you might also need advice from specialists, such as experts in irrigation or UV water treatment.

By following the guidance and checklists provided in this Guidebook, applicants can ensure their WSUD Strategy is assessed promptly and is in accordance with Council's compliance requirements

1.2 Council's expectations for sustainable development

Water is a precious and limited resource that must be carefully managed to meet the needs of current and future generations. This chapter of the Wollongong Development Control Plan (DCP) sets out requirements for incorporating Water Sensitive Urban Design (WSUD) into new developments and redevelopments across the Wollongong Local Government Area (LGA).

Wollongong's location between the escarpment and the coast creates unique climate and water conditions. In the steep escarpment areas, rainwater flows quickly, increasing runoff and reducing infiltration. On the flatter coastal floodplains, water moves more slowly and stays on the surface longer. The region's sandy and fine soils are highly erodible, making stormwater and erosion management more complex and requiring tailored solutions.

Development changes how water flows through the landscape and often introduces pollutants from hard surfaces like roads and footpaths. With the population expected to grow by nearly 70,000 people by 2045, extra development will place increasing pressure on water systems. WSUD is a planning approach that helps reduce the environmental impacts of urbanisation. It combines urban design, stormwater management, and environmental protection to:

- Reduce peak stormwater flows.
- Improve water quality.
- Reuse rainwater.
- Support water-efficient landscaping.
- Protect natural waterways and habitats.

Wollongong's waterways, and Lake Illawarra face increasing pressure from urban development. By incorporating WSUD during the design and development phases, significant environmental and community benefits can be achieved, including:

- Improved water quality, helping to protect downstream waterways, the ocean, and Lake Illawarra.
- Protection of water resources, by managing stormwater sustainably and reducing pollution at the source.
- Reduced erosion and sedimentation downstream of development.
- Minimised environmental impacts from new developments.

- Lower demand for drinking water, through harvesting and reuse.
- Cooling of the region, by mitigating the urban heat island effect.
- Enhanced biodiversity, by supporting local wildlife and expanding natural habitats.

In 2024, the NSW Government assessed the impacts of development in the Lake Illawarra catchment area. The study found that continuing with a business-as-usual approach would harm Lake Illawarra. To address this finding, this we have incorporated pollution reduction targets based on the NSW Government's Lake Illawarra Catchment – Applying a risk-based framework for improving water quality for an area identified as Zone A.

1.3 How to use this Guidebook

This Guidebook outlines the steps and assumptions developers must follow when designing WSUD systems and modelling water quality, using tools like MUSIC (Model for Urban Stormwater Improvement Conceptualisation). It should be used together with other relevant chapters of Council's Development Control Plan (DCP) 2009, including: A02, B01, B02, B03, B05, B07, D16, E06, E13, E14, E17, E19, E22, and E23. Please refer to these Chapters as needed.

SECTION 2 - WSUD COMPLIANCE PATHWAYS

WSUD must be integrated at neighbourhood, precinct planning, Development Application (DA) and Construction Certificate (CC) stages. A WSUD Strategy must accompany an applicant's Water Cycle Management Plan and demonstrate compliance with:

- Relevant Wollongong DCP Chapters (including A2, E15, E13, E14, and E23), and
- Other applicable guidelines and regulations, such as:
    - Council's WSUD Guidebook for Developers 2025 (as amended or superseded),
    - Council's WSUD Engineering Series 2025 (as amended or superseded), and
    - Any other relevant local and state legislation or technical standards.

Notes:

- It is strongly recommended that applicants arrange a pre-lodgement meeting with Council early in the application process. This meeting helps establish agreement on the overall design approach before finalising a detailed WSUD strategy. If a pre-lodgement meeting is not held, or if the submitted WSUD strategy does not align with parameters previously set by Council, the following may occur:
    - Council may require significant redesign of the WSUD elements during the development application stage, or
    - Council may decline to accept dedication of the WSUD asset.

2.1 Preparing a WSUD Strategy

As part of the Water Cycle Management Plan required for a Development Application (DA), Neighbourhood Plan application, or a Concept Development Application, applicants must include a 'WSUD Strategy' that details how they will manage stormwater sustainably and meet the pollution reduction targets. To make sure a WSUD Strategy meets Council's requirements, please refer to the table below. It outlines what needs to be included in an applicant's WSUD strategy.

Table 1. Required inclusions for a WSUD strategy for DA application.

SECTION	CONTENTS TO INCLUDE IN A WSUD STRATEGY
Cover page	Including - a) The full name and relevant contact information for the company/ consultant. b) The contact details of the individual responsible for preparing the WSUD strategy. c) The application, or project number associated with the development.
Executive summary	Provide a concise summary of the report and any conclusions.
Background information	Summarise any background information available, including - a) Any previous studies, or concurrent studies, and b) Maps and mapping data.
Site context	Identify the catchments, drainage lines and receiving environments (both within and downstream of the site) and characterise the ecological values of the site and its receiving environments. Include site diagrams, historical and current land use imagery, and other visual elements to provide comprehensive site context
Proposed development	Describe the proposed development at the site, including site boundaries, proposed land uses, population densities, infrastructure and development staging.
WSUD objectives	Identify and outline the WSUD objectives and water quality targets that apply to the proposed development. Objectives must consider not only to water quality and water flow objectives, but must also address the following - a) Ease of maintenance and access. b) Performance monitoring (i.e. designing inlets and outlets so that monitoring equipment can be easily fitted and so that reliable data can be collected). c) Large rainfall/storm event fail safes that not only protect nearby private and public assets but also protect the WSUD infrastructure (e.g. bypasses for constructed wetlands rather than spillways). d) Aesthetics (i.e. integration into urban environment such that it does not detract but improves the visual quality of the development). e) Provision of habitat for local native plant and animal species. f) Non potable water re-use opportunities, and g) Co-benefits such as habitat creation, passive cooling, walking paths, educational signage etc:
A groundwater report (if required)	In this section, identify and outline the actions that will be taken to mitigate the potential for interaction with groundwater, damage to groundwater-dependent ecosystems, where required. **Note:** For more information about Councils groundwater requirements for development, refer to WDCP Chapter E15.
Constraints and opportunities	Identify and list the key constraints and opportunities for water management on the site, including any flooding. This section must also include the identification of natural watercourses and other sensitive environments within the site that should be preserved and/or remediated by the development.

SECTION	CONTENTS TO INCLUDE IN A WSUD STRATEGY
WSUD measures	Identify and list all the WSUD Infrastructure to be installed and constructed to meet the WSUD objectives (conceptual plans are sufficient at the Development Application stage, however, future detailed designs at the Construction Certificate stage must ensure that the objectives and performance parameters for the WSUD assets are met).
Water conservation	This section should demonstrate how the potable water conservation targets will be met, and how potable water will be supplemented with roof water, treated stormwater and / or wastewater where applicable. **Note:** For more information about Council's Stormwater harvesting, reuse and efficiency requirements, refer to WDCP Chapter E15.
Stormwater management & water quality	In this section demonstrate how the WSUD measures will meet the water quality targets. It is to include stormwater quality and flow modelling results and identify the location, size and configuration of stormwater treatment measures proposed for the development. This section must also detail a methodology for validating the performance of the WSUD measures relative to the objectives identified in the WSUD strategy.
Integration with the urban design	In this section, outline how WSUD elements or design will integrate with the urban design and where space allows, the co-benefits the design. **Note:** Wollongong has a rich cultural heritage, and we strongly encourage applicants to incorporate the principles of the *Connecting with Country Framework* (2023) during the design and landscaping phases of WSUD projects within the LGA. This NSW Government framework provides guidance on embedding Aboriginal cultural values and knowledge into planning and design, promoting a Country-centred approach that respects and cares for land, water, and community. It emphasises collaboration with Aboriginal people, recognising that if we care for Country, Country will care for us.
Costs	Prepare capital and operation and maintenance cost estimates of the proposed WSUD measures. Both typical annual maintenance costs and corrective maintenance or renewal costs must be included.
Operation and maintenance plan	This section should outline the inspection and maintenance requirements to ensure proposed measures remain effective. The Operation and Maintenance Plan should account for, as a minimum, the following - a) Litter accumulation management. b) Sedimentation management. c) Structural condition (this will depend on the type of WSUD infrastructure in question, but should be included where applicable pits, pipes, ramps, erosion, bank integrity, etc). d) Access for maintenance. e) Maintaining functional and landscape vegetation to a satisfactory condition (including weed control), f) Settling or erosion of bunds/batters, g) Damage, including vandalism, to structures, and h) Inlets and outlets management to ensure flows, i) Maintenance drains operational.
References	Include a list of all source documents and modelling tools used to create the WSUD strategy.
Appendices:	
Appendix A: **Music modelling files, or Music-link report**	This section must outline the methodology for validating the performance of the WSUD, relative to the specified water quality targets for the development. Electronic versions of all modelling files are to be submitted as Appendix A to enable auditing and ensure all modelling calculations are accurate. Alternatively, attach the MUSIC-link report as Appendix A in the WSUD Strategy.

SECTION	CONTENTS TO INCLUDE IN A WSUD STRATEGY
Appendix B: Conceptual plans	For the proposed development area, provide conceptual layout plans showing the location and extent of stormwater treatment measures and the direction of flow including: a) Access for maintenance, b) the locations for water quality monitoring, c) the public safety precautions (e.g., signage, fencing, etc) d) details on the types, sizes and location of the intended WSUD measures, and e) draft operational and maintenance plan for each WSUD system. **Notes:** • Concept plans can be submitted with the development application. However detailed plans must be prepared and submitted to the Principal Certifying Authority for approval prior to the issue of the Construction Certificate, or handover of WSUD assets to Council. • See Section 26 of this Guidebook for more information about Council's handover requirements for WSUD assets.

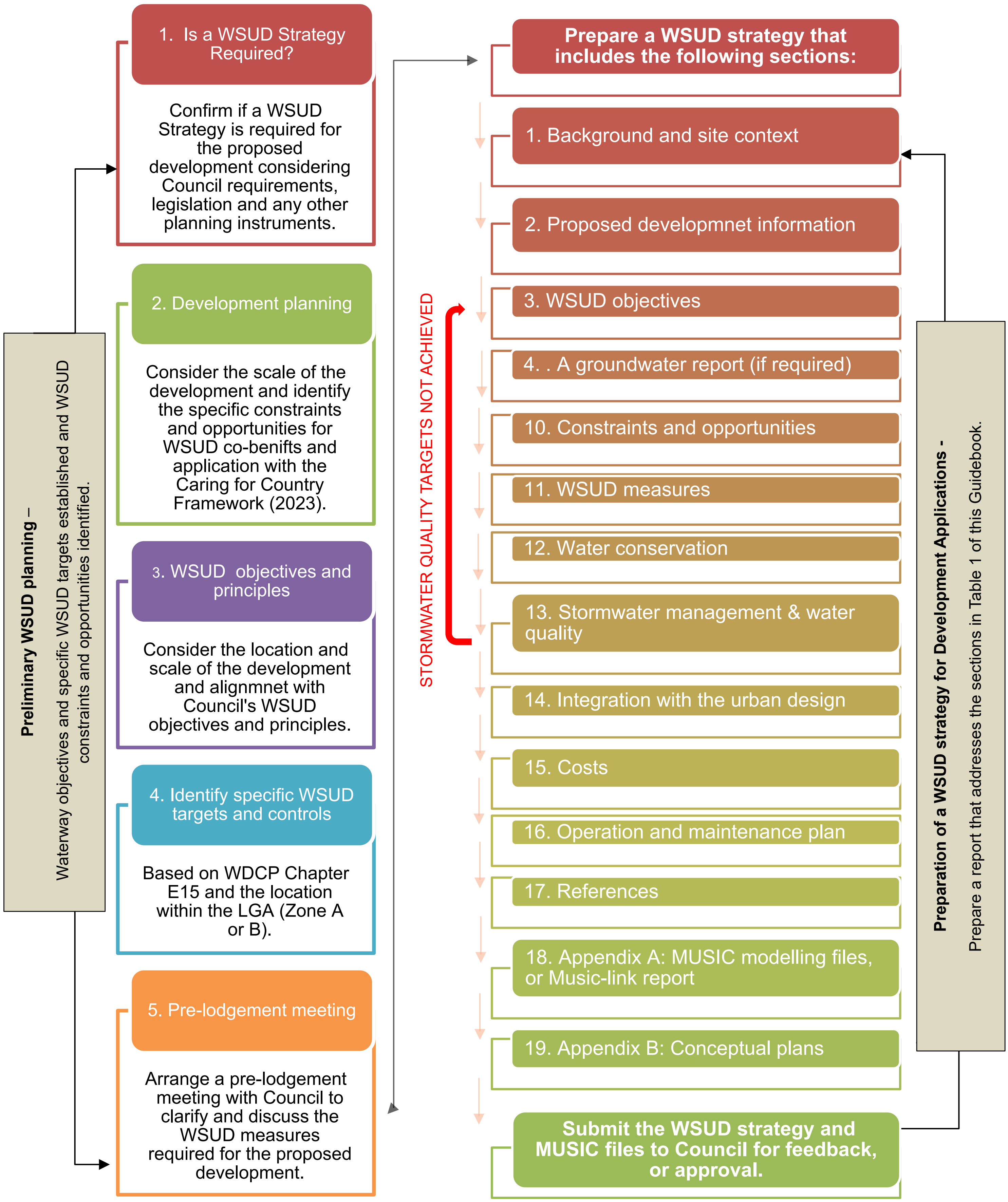


Figure 1. Steps for preparing a WSUD Strategy.

2.2 MUSIC- link

MUSIC™ (Model for Urban Stormwater Improvement Conceptualisation) is Australia's leading stormwater modelling software developed by eWater. It simulates rainfall-runoff processes and pollutant generation within urban catchments and evaluates the performance of WSUD treatment measures. MUSIC-link software streamlines both the development and assessment of MUSIC (models by incorporating the LGAs specific modelling parameters. Applicants using MUSIC-link can generate a detailed report demonstrating how well their model meets the Council's stormwater treatment requirements and regulatory frameworks. The MUSIC-link report can then be submitted along with the WSUD strategy. For more information about MUSIC-link visit: www.ewater.org.au/ewater-solutions/tools/music/.

SECTION 3 - MUSIC MODELLING

3.1 General MUSIC modelling guidance

MUSIC™ software was created in 2001 by the Cooperative Research Centre for Catchment Hydrology. The software simulates and assesses how well stormwater treatment systems work, and supports the planning and design of effective WSUD strategies.

Stormwater quality modelling for assessment in Wollongong must use MUSIC version 6 or later. Modelling must follow the latest version of the NSW MUSIC Modelling Guidelines and include any extra requirements set out in Council's supporting documents. Table 2 below gives a general overview of the key steps for running a MUSIC model to check if the WSUD design meets the water quality targets set out in the table below.

Table 2. General guide for modelling water quality using MUSIC.

STEP	ACTION / INPUT
Step 1: open MUSIC	Launch the MUSIC software.
Step 2: download data using MUSIC, or MUSIC-link	On the left-hand, drop-down menu choose 'New MUSIC-link' and click on the Wollongong Council logo. If you are unfamiliar with Counil's adopted nodes and data, click on the Wollongong City Council Default Nodes to download a model with data specific to Wollongong LGA. This will include a climate file, source nodes and the various treatment nodes.
Step 3: determine the catchment area	Identify the catchment area to be modelled, ensuring it covers the entire area draining to the proposed stormwater treatment system.
Step 4: determine the proportion of each land use source node	Assess the proportion of each land use (eg, roof, road, landscaped area) within the catchment area. This will be essential for assigning appropriate source nodes in MUSIC.
Step 5: determine and select the stormwater treatment nodes as per Council's approved treatment options	This treatment train will define how the stormwater will be managed and treated.
Step 6: allocate the source nodes to the relevant treatment node using the drainage link	Assign each source node to a corresponding treatment node in the system, ensuring that the flow from each land use is directed to the proper treatment process. Provide the relevant receiving node for the treated water.
Step 7: run the MUSIC model simulation and compare results with the water quality targets	Simulate the stormwater treatment process in MUSIC and compare the outcomes with the water quality targets provided by the Council (such as pollutant removal rates).

STEP	ACTION / INPUT
Step 8: review the modelling results	Has the model met Council's stormwater quality targets set out in Table 3? • **If Yes:** Move on to Step 10 (finalise the design). • **If No:** Review target failures and revise the treatment train design to achieve the desired water quality targets.
Step 9: finalise the design and prepare the required reports	Once the treatment system meets the necessary water quality targets, finalise the stormwater design and prepare the required documentation and reports for submission.

SECTION 4 - PRE-DEVELOPMENT LAND USES

Identifying the pre-development land use is essential for assessing the potential impacts of future development. This section provides guidance on selecting the correct land use category before undertaking hydrological modelling. For Wollongong, the adopted pre-development condition should reflect the main land use as it existed in 2017 (verified through aerial imagery), rather than the current zoning. The 5 pre-development land use categories in the LGA are:

- **Rural.**
- **Forested.**
- **Agricultural.**
- **Urban infill.**
- **Mixed use.**

4.1 Rural land use example

The rural land use category should be adopted to represent cleared land, with or without scattered trees, where pasture grasses are the dominant vegetation type. Rural land may also include single dwellings and associated farm buildings supporting rural activities, such as sheds or barns. If the site has been partially cleared and includes vehicle tracks, stormwater channels, or other significant disturbances, these areas may also be classified as 'rural' for the purpose of establishing site-specific targets. In cases where rural sites contain pockets of uncleared land with native vegetation, these areas should be delineated separately and classified as 'forest' areas for the purpose of determining management targets.

Figure 2 - Examples of rural sites

4.2 Forested land use example

The forest land use category should be adopted for sites (or areas within a site) that are currently covered by native vegetation, with a nearly continuous canopy observable from aerial imagery. Forested land use also includes re-established vegetation that has developed a near-continuous canopy and has established habitat value.

Figure 3 - Examples of forested sites

4.3 Agricultural land example

The agricultural land use category should be adopted for sites where cropping, horticulture, or intensive agricultural activities have been conducted for at least the past five years. This includes land used for dairy farms, poultry farms, feedlots, and turf farms. Evidence from historical aerial imagery or other sources should be provided to support the pre-development agricultural land use assumption. It is recommended that sites where the pre-development condition is assessed by the consultant as agricultural be confirmed with Council before proceeding with modelling. This will help avoid rework that may be required if Council determines that an alternative pre-development land use is more appropriate.

Figure 4 - Examples of agricultural sites

4.4 Urban infill land use example

All cleared or modified land within urban areas should be considered as 'urban infill' sites. This includes sites that are adjacent to or surrounded by existing development and typically have existing road access. In cases where 'urban infill' sites contain existing built urban development and/or continuous stands of native vegetation, these areas should be delineated separately for the purpose of establishing management targets.

Figure 5 - Examples of urban infill land uses

4.5 Mixed land use example

Some sites may have mixed land use pre-development conditions. A typical example would be a partially cleared rural site that includes remnant forest areas. In these circumstances, the land uses should be mapped within the site from recent aerial imagery and proportions of each land use considered for the purpose of establishing management targets.

Figure 6 - Examples of mixed-use sites

Notes:

- In cases where the site has a mixed pre-development land use, with multiple land use types present across the development site, each land use should be mapped. The total area of each land use should then be calculated. To determine the proportion of each land use, the total area of each land use category should be compared to the total development site area.
- The applicant must provide a diagram of the site as part of a WSUD strategy and include aerial imagery and mapping the extents of the different land use categories adopted for the site.

Current site photographs should also be included to support the pre-development land use assumptions. If the pre-development condition is unclear, the consultant should contact Council prior to proceeding with the WSUD measures or preparing the MUSIC model.

SECTION 5 - GUIDANCE ON REDUCING COSTS AND LAND TAKE FOR WSUD

Implementing WSUD measures can be both cost-effective and space-efficient, especially when integrated early and designed strategically. This section provides practical guidance to help developers meet compliance requirements while reducing costs and minimising land use.

1. Early planning and collaboration are key

WSUD should be delivered through an integrated approach involving collaboration between designers, engineers, landscape architects, and ecologists. Successful outcomes depend on multidisciplinary input throughout planning, design, and implementation. WSUD should be included during the concept design stage to avoid costly redesigns. By integrating WSUD with landscaping, open space, and road design, developers can share land uses and reduce the overall footprint of stormwater infrastructure. Multi-functional features, such as floating wetlands, swales, permeable paving, and WSUD street trees, can be incorporated into shared spaces or corridors. This approach not only optimises land use but also improves stormwater treatment, enhances visual appeal, and delivers co-benefits like urban cooling and biodiversity.

2. Use modular systems and treatment trains

Modular systems and treatment trains are ideal for sites with limited space. Compact options, such as high flow bioretention units, permeable paving, and larger rainwater tanks, can be tailored to the catchment size and pollutant loads, rather than relying on generic sizing. A treatment train combines multiple WSUD elements in sequence (e.g. sediment trap → bioretention → wetland), with each component targeting a specific pollutant or hydraulic function. This staged approach improves treatment performance and reduces the need for large, single-purpose systems

3. Lot scale integration

Incorporating WSUD elements directly within private lots, such as rainwater tanks, permeable paving, and rain garden, can significantly reduce the need for large-scale public infrastructure. Treating and reusing stormwater close to its source lowers runoff volumes and reduces the size of downstream systems. For example, installing oversized rainwater tanks on individual lots can minimise the volume of stormwater entering the broader network. This approach allows developers to avoid allocating space for communal basins or detention areas, freeing up more land for housing or commercial use.

4. Co-locate with other infrastructure

Dual-purpose assets, such as detention basins that double as recreational areas when dry, can enhance community value while meeting stormwater management goals. WSUD features can be integrated into existing infrastructure to save space and reduce costs. Placing elements like rain gardens, swales, or permeable paving within road verges, car parks, or public open spaces allows stormwater treatment to occur without requiring additional land.

5. Choose smart vegetation

Choosing the right vegetation is essential for reducing long-term maintenance costs and ensuring WSUD systems perform effectively. Native, drought-tolerant species are ideal, as they require minimal irrigation and are well adapted to local conditions. Avoid high-maintenance plants that need regular watering or specialised care. Selecting resilient vegetation not only lowers upkeep costs but also supports biodiversity and improves the visual appeal of WSUD assets. See Section 25 in this Guidebook for more information about selecting the right plant species for your project.

6. Efficient layout and grading

Smart site layout and grading can significantly reduce construction costs and land disturbance. By optimising site levels, developers can minimise the need for excavation and earthworks. Keeping pipe runs short and avoiding deep pits also helps reduce material and labour costs. A well-planned layout not only saves money but also improves the functionality and maintainability of WSUD systems.

7. Maintenance considerations

Designing WSUD systems with access and maintenance in mind helps reduce long-term costs and ensures ongoing performance. Provide clear and safe access for maintenance crews, avoid steep batters and ensure vehicle access where needed. Include features like sediment forebays or trash racks to capture debris and reduce cleaning frequency. Well-planned maintenance access improves safety, lowers operational costs, and supports asset longevity. See Section 24 in this Guidebook for more information about Council's access and maintenance requirements for WSUD systems.

SECTION 6 - IMPERVIOUS AREA ASSUMPTIONS

Impervious surfaces play a key role in accurately modelling stormwater runoff in MUSIC software. It's important to distinguish between directly connected and disconnected impervious areas.

Disconnected surfaces such as driveways and footpaths, drain first onto nearby pervious areas and only contribute to runoff during heavy rainfall. This affects how much runoff is generated. Table 3 below outlines the typical development types in the LGA and the corresponding assumptions for directly connected impervious areas.

Table 3. Assumed imperviousness values based on typical development trends in the LGA

ZONING TYPE	TYPICAL DEVELOPMENT SCALES AND ASSUMPTIONS
Zone R2 - Low density residential:	• Average residential dwelling roof area = 300 m²/lot. • Average residential lot driveway and paved landscaping area = 20% of non-roof lot area. • Average residential lot pervious landscaping area = 80% of non-roof lot area.
Zone R3 - Medium density residential:	• Average residential dwelling roof area = 200 m²/lot • Average residential lot driveway and paved landscaping area = 50% of non-roof lot area. • Average residential lot pervious landscaping area = 50% of non-roof lot area.

ZONING TYPE	TYPICAL DEVELOPMENT SCALES AND ASSUMPTIONS
Zone R5 - Large lot residential:	• Average residential roof area = 350 m²/lot • Average non-roof impervious area = 150 m²/lot
Urban residential roads:	• Road reserve = 50% footway and 50% carriageway • Road carriageway and parking areas = 100% imperviousness • Footway area = 25-50% imperviousness
Commercial and industrial subdivisions:	• Lot imperviousness = minimum of 90% for lot areas and 60% for road reserve imperviousness will be adopted in the absence of specific lot details. • Commercial/Industrial Developments: If the final layout is known (from architectural or engineering drawings), use the actual imperviousness data for the model.

Note: If detailed designs aren't available at the DA stage, applicants should use the provided assumptions as estimates to make sure stormwater goals are fully accounted for.

SECTION 7 - RAINFALL RUN-OFF PARAMETERS

For MUSIC modelling, developments with more than 10% impervious area must use the rainfall-runoff parameters listed in Table 4. These parameters ensure consistency across assessments in Wollongong. Alternative parameters may be accepted if the applicant can demonstrate, with supporting evidence, that they are more appropriate for the specific site conditions.

Table 4. Rainfall run-off parameters for MUSIC modelling.

MUSIC PARAMETER	SOIL HYDROLOGIC GROUP			
	A	**B**	**C**	**D**
Impervious rainfall threshold				
Combined impervious surfaces (mm)	1.5	1.5	1.5	1.5
Roof surfaces (mm)	0.5	0.5	0.5	0.5
Paved and road surfaces & pervious area parameters (mm)				
Soil storage capacity (mm)	155	105	100	90
Initial storage (% of capacity)	25	25	25	25
Field capacity (mm)	75	75	70	65
Infiltration capacity coefficient a (mm/day)	360	250	180	135
Infiltration capacity exponent b (SCALAR)	0.5	1.3	3	4
Groundwater properties				
Initial depth (mm)	10	10	10	10
Daily recharge rate (%)	100	60	25	10
Daily baseflow rate (%)	50	45	25	10
Daily deep seepage rate (%)	0	0	0	0

SECTION 8 - SOIL HYDROLOGIC GROUP PARAMETERS

A soil's hydrologic grouping indicates how well it can absorb and transmit water. A key factor in this process depends on the soil's texture and the amount of clay, silt, and sand present. Applicants must identify the most appropriate soil hydrologic group considering geotechnical investigation data, soil landscape mapping data and/or web-based soil data.

One source of data is the NSW government's eSpade website (http://www.environment.nsw.gov.au/eSpade2WebApp) and enables a user to spatially review statewide soil mapping. The four (4) main hydrologic soil groups found in the Wollongong region are listed in Table 5. A map showing the distribution of these soil groups across the Local Government Areas (LGAs) is provided in Figure 8.

Table 5. Wollongong's main soil hydrologic groups.

SOIL CLASS	SOIL CHARACTERISTICS
Group A – low runoff potential:	• Soil Composition: >90% sand or gravel; <10% clay and silt particles. • Characteristics: Well-drained soils like sands and gravels. • Runoff Potential: Extremely low.
Group B – low to moderate runoff potential:	• Soil Composition: 50-90% sand; 10-20% clay particles. • Characteristics: Loamy sands and sandy loams. • Runoff Potential: Low to moderate.
Group C – moderate runoff potential:	• Soil Composition: <50% sand; 20-40% clay particles. • Characteristics: Loams, silty loams, silt, sandy clay loams, clay loams and silty clay loams. • Runoff Potential: Moderate.
Group D – high runoff potential:	• Soil Composition: <50% sand; >40% clay particles. • Characteristics: Clays, silty clays, and sandy clays. • Runoff Potential: Extremely high.

Notes:

- If the depth to bedrock is less than 0.5 meters from the surface, regardless of the soil texture, Group 'D' parameters must be adopted due to the limited infiltration capacity.
- In cases where the site has multiple soil types that belong to different hydrologic groups, the soil group with the highest runoff potential must be adopted.
- Runoff concentration parameters for MUSIC modelling must be based on both pre-development and post-development land uses. For post-development scenarios, these parameters should reflect the proposed land use and the stormwater management strategies being implemented, as they are essential for accurately modelling expected stormwater quality outcomes and assessing the effectiveness of WSUD measures.

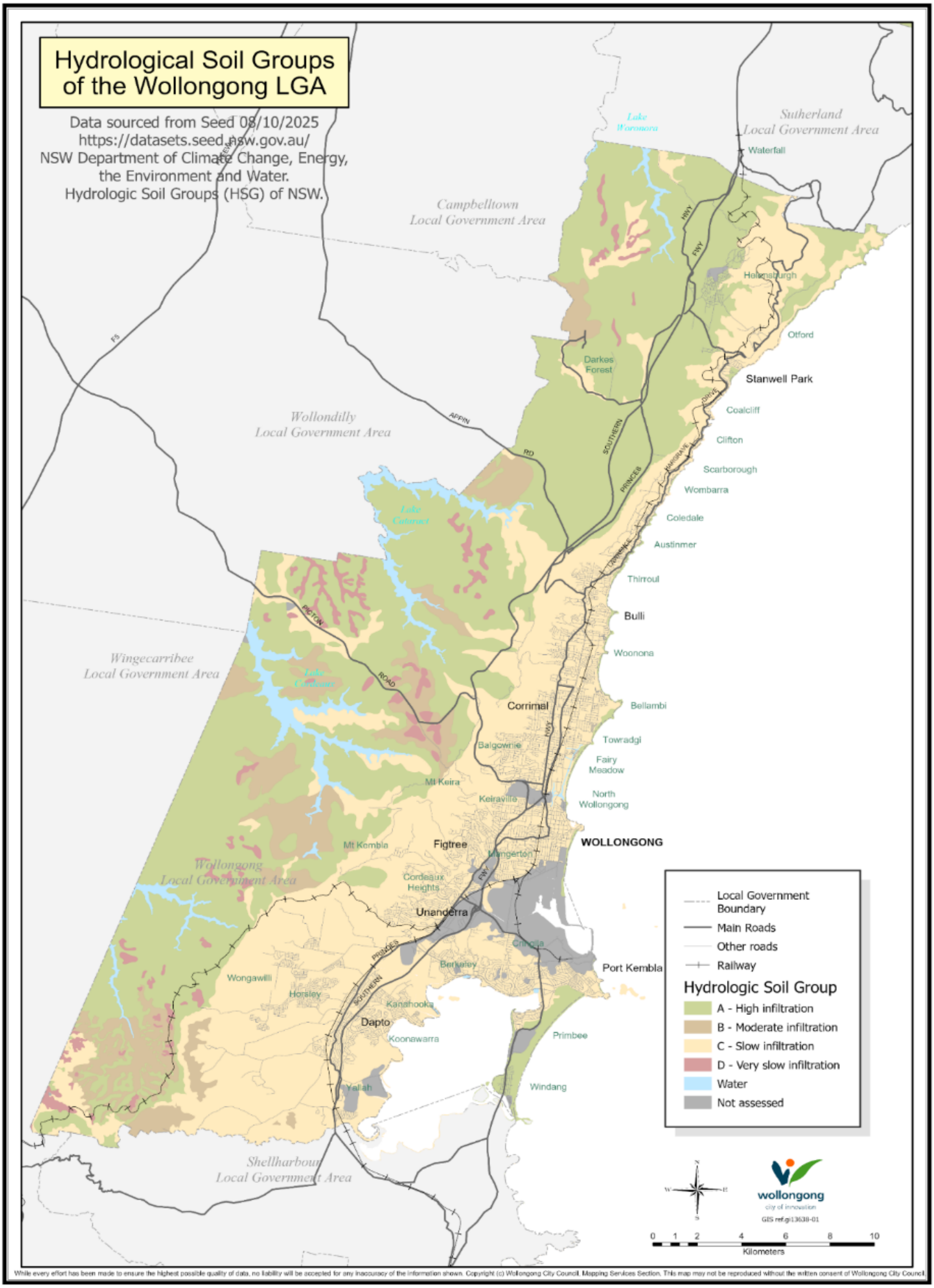


Figure 7 – Primary hydrological soil groups of the Wollongong LGA (eSpade)

SECTION 9 - RAINFALL DATA

Wollongong's location between the escarpment and the coast creates unique rainfall patterns and weather conditions. These localised events make it essential to use site specific data when designing WSUD systems to ensure they are suited to the regions climate and capable of managing stormwater effectively. Rainfall in Wollongong can be intense and unpredictable, particularly in areas near the escarpment where stormwater flows are often rapid. This is due to rainfall quickly moving from the headwaters of the catchment. In contrast, the mid to lower catchment areas are characterised by flatter, narrower and undulating terrain which experiences much slower runoff responses. These differences should be carefully considered when setting WSUD objectives for a development. To model rainfall accurately, applicants must use data from the local rainfall station below.

Table 6. Mean monthly rainfall (January 1, 1996, to December 31, 2005) Port Kembla (BSL Central Lab) Station No. 068131.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Rainfall (mm/ month)	81.79	118.99	66.31	93.41	105.59	64.11	78.37	104.26	38.05	77.46	75.21	44.07	**947.60**

Note: A continuous rainfall simulation of at least 10 years should be used for hydrologic modelling, with a minimum time-step of 6 minutes to accurately represent storm hydrographs and the movement of water through small-scale treatment measures such as vegetated swales and bioretention systems.

SECTION 10 - POTENTIAL EVAPOTRANSPIRATION (PET) DATA

PET data is required to simulate the movement of water through the landscape, particularly the loss of water through evaporation and plant transpiration. Accurate PET values are essential for estimating how much rainfall contributes to runoff versus how much is lost to the atmosphere. The monthly PET values used in MUSIC should reflect local climatic conditions to ensure realistic modelling outcomes. These values are typically based on long-term meteorological data and are specific to the region. For developments within the LGA, the recommended monthly PET values are provided in the table below.

Table 7. Daily PET data – Port Kembla (BSL Central Lab) Station No. 068131. Data includes both wet and dry period (mm/day).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PET (mm/day	5.84	4.82	3.94	2.5	1.61	1.2	1.26	1.74	2.5	4.03	5.0	5.23

SECTION 11 - MUSIC TREATMENT NODES

11.1 User defined source nodes

The user defined source node in MUSIC functions similarly to catchment nodes, generating runoff based on specified rainfall, runoff and pollutant parameters. Its main purpose is to indicate that custom data rather than default values is being used. If the parameters differ from those recommended for standard source nodes, this must be clearly referenced in the WSUD Strategy MUSIC report submitted to Council for approval.

11.2 Infiltration at the treatment node

In MUSIC, most stormwater treatment measures (except for Gross Pollutant Traps (GPTs) and rainwater tanks) allow for modelling infiltration through the base or sides of the system. How infiltration is treated depends on whether it occurs at a source node or a treatment node, and it is typically defined using a constant exfiltration rate (in mm/hr). Infiltration at a source node will contribute to baseflow, which affects both the total flow and pollutant load at the site outlet. In contrast, infiltration at a treatment node is considered lost from the system and does not contribute to outlet flow or pollutant loads. This distinction is especially important in sandy soils, where over 90% of stormwater runoff (and associated pollutants) may infiltrate through the base of a treatment node. This can significantly distort model results, as baseflow loads are included in the pre-development model, but infiltrated stormwater is excluded from the post-development node.

To address potential inaccuracies in MUSIC modelling caused by infiltration at treatment nodes, Wollongong City Council supports the use a secondary drainage link. This method routes infiltrated stormwater from the treatment node to a downstream node, ensuring it is included in flow and pollutant load calculations. In sandy soils or other cases where no underdrain is provided, the exfiltration rate must reflect the actual in-situ soil infiltration rate. This prevents overflow across the weir and ensures all stormwater is accounted for. In these situations, the secondary drainage link must always be used. This approach assumes the groundwater table is the receiving environment, and all relevant stormwater quality targets must be met at the base of the treatment measure before any water is discharged or allowed to infiltrate.

Notes:

- WSUD infiltration measures are not accepted in soil hydrologic groups 'C and D.'
- If infiltration is used as a stormwater treatment method, the water must first be treated and cleaned through a Gross Pollutant Trap (GPT), or another stormwater improvement device before being released.

11.3 Rainwater tank nodes

For industrial, business, large neighbourhood, and precinct-scale developments, rainwater tanks (RWTs) play a key role in reducing runoff volumes and pollutant loads from roof areas. In MUSIC, the rainwater tank node can be used to simulate water balance and estimate pollutant reduction through sedimentation and reuse (see Table 8).

Based on a review of BASIX data, the following maximum rainwater tank sizes are considered reasonable at the subdivision stage:

- Low-density residential: 5 kL per lot
- Medium-density residential: 3 kL per lot
- Large-lot rural residential: 10 kL per lot

Table 8. Typical rainwater tank demands (derived from Sydney Water data)

WATER USE	SINGLE DWELLINGS (L/DAY/DWELLING)				
	Number of Occupants				
	1	2	3	4	5
INDOOR USES					
• Toilets	27	34	54	107	134
• Toilets and Washing Machine	58	115	173	231	289
• Toilets, Washing machine and hot water	106	212	318	425	531
• All uses	162	325	487	649	812
OUTDOOR USES					
• All uses	151	151	151	151	151

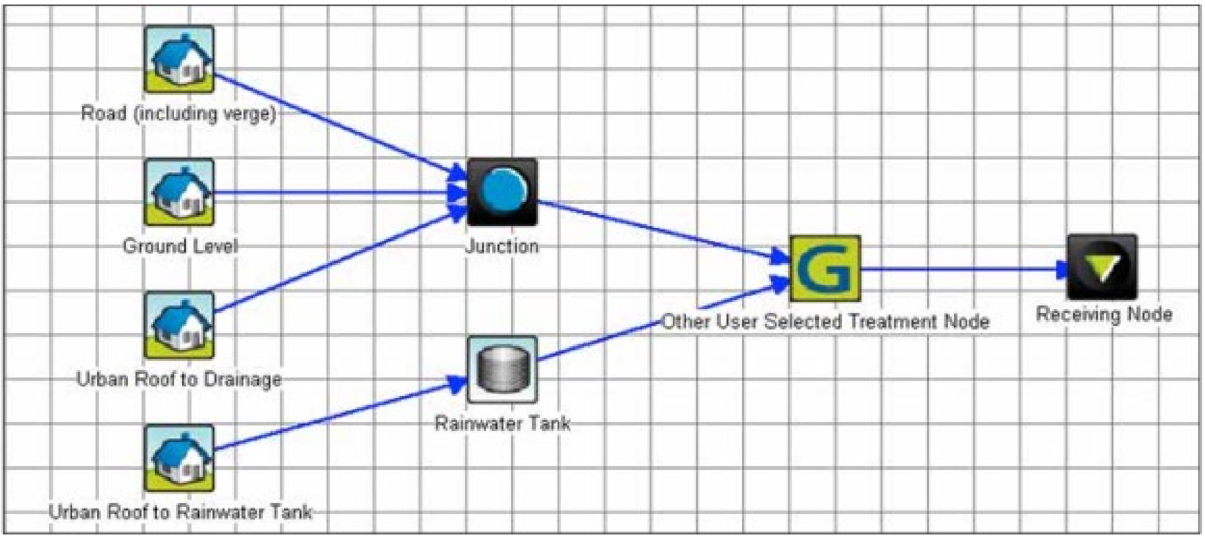


Figure 8. Example - incorporating rainwater tanks in a split surface residential MUSIC model (Blacktown- WSUD Handbook for developers)

Notes:

- For modelling purposes, 100% of the dwelling roof area can be assumed to be connected to the rainwater tank. This assumes that future dwellings in the residential subdivision will use the tank for stormwater management. Other buildings (eg, sheds or garages) must be modelled as unconnected to a rainwater tank.
- See Section 22 of this Guidebook for more information about rainwater tank modelling and other usage parameters.

SECTION 12 - DETENTION BASINS

Dry and ephemeral detention basins are designed to temporarily store stormwater runoff and release it at a controlled rate. While they do not treat water quality to a high degree, they do play a key role in managing flow volume and reducing flood risks. In Wollongong, detention basins must be constructed above ground. However, they should be seamlessly integrated into larger developments, as open spaces such as parks or recreational areas. When not in use for stormwater detention, these spaces can serve as valuable community assets. Council strongly supports and encourages this multi-functional approach, as it promotes efficient land use and aligns with the broader goals of WSUD by delivering co-benefits beyond stormwater management.

Figure 9. Example of a local detention basin (Wongawilli) designed with multiple co-benefits, including rain chains that irrigate surrounding raingardens and vegetation, educational signage, and recreational features such as a playground and walking tracks for residents to enjoy when the basin is not actively detaining stormwater.

12.1 Modelling requirements for detention basins

- In early drainage designs using MUSIC, treated flows from water quality devices, such as underdrain flows from GPTs can be directed either back into the detention basin, or to a low-flow orifice control. However, both proprietary filters and Bioretention systems rely on a pressure gradient (as described by Darcy's Law) to function effectively. When water levels rise at the outlet, as occurs in detention basins, the pressure differential decreases, reducing the flow rate through the treatment device. Once the water levels equalize, treatment stops entirely. This behaviour is not accurately represented in a MUSIC model, which assumes continuous flow through treatment devices during storm events. As a result, the model may overestimate pollutant removal, failing to meet water quality targets. Therefore, this design approach is not permitted within the LGA. To comply with Council's MUSIC modelling methodology, treated underdrain flows (e.g., from Bioretention systems or GPTs) must discharge downstream of the detention basin's discharge control pit. This prevents backflow issues and ensures continuous treatment performance across a range of storm events.
- For permanent detention basins serving larger catchments (typically greater than 5–10 hectares), the following safety measures must be incorporated:
  1) The emergency 1% AEP spillway must be set at least 200 mm above the 1% AEP storage level.
  2) The 1% AEP spillway must be capable of conveying the full 1% AEP flow assuming the control pits are blocked.
  3) The basin crest level must be at least 300 mm above the emergency spillway.

4) The top of systems berms must be a minimum of 2 metres wide.
5) Where there is a population at risk, the design must consider the requirements of NSW's Dam Safety Committee.
6) Consideration given of NSW's Dam Safety Committee requirements (where population is at risk).

Note: On-site stormwater detention (OSD) is a requirement across the LGA. For more information regarding OSD requirements in Wollongong, see *WDCP 2009 Chapter E14*.

12.2 Modelling a detention basin in MUSIC

In MUSIC, the 'Detention Basin Node' can be used to model conventional basins designed for various objectives, including improving waterway stability, enhancing water quality, or reducing flood flows. Key input parameters for modelling detention basins in the LGA are provided in *Table 9* below.

Table 9. Key MUSIC input parameters for detention basins.

STEP	ACTION / INPUT
Step 1: set the high flow or low flow bypasses:	Identify if any High Flow or Low Flow Bypasses are proposed for the treatment measure.
Step 2: determine the surface area of the basin:	For basins with battered sides, use the area at half the Extended Detention Depth (average basin area). **Note:** The Surface Area is not the actual surface area but is the area that, when multiplied by the Extended Detention Depth, will provide the volume of storage.
Step 3: ensure the correct grading of the basins base	The minimum grade along the base must be at least 1%.
Step 4: set the exfiltration rate:	For detention basins (which are be concrete or lined), Wollongong City Council requires 0 mm per hour exfiltration. **Note:** Council generally does not accept non-earth batters unless prior approval has been obtained.
Step 5: determine the low flow pipe diameter can be determined using one of the following methods:	**Method 1:** Use a simplified method by nominating only the low flow orifice diameter, typically for conventional (Version 4 UPRCT) detention systems. **Method 2:** From detention calculations using the orifice equation. **Method 3:** For multistage outlet systems, use the "Use Custom Outflow and Storage Relationship" and nominate the stage discharge relationship, or import a discharge/storage spreadsheet. **Method 4:** For water quality detention basins, select the low flow pipe option representing design outflow through the filter cartridge underdrains, calculated via the orifice equation.
Step 6: set the 'k' values	Under the 'More' tab, set the k rate to '1'.

Notes:

- Ensure the Overflow Weir width matches the actual weir length. As a weir width that is too small will lead to an overestimation of the detention basin's performance.
- For storms less than the 1% AEP (1 in 100 years) event, model a conventional detention basin based on the requirements of Council's DCP Chapter E14: Stormwater Management.
- See Section 23 of this Guidebook for more information about Council's WSUD access and maintenance requirements.

SECTION 13 - SEDIMENT FOREBAYS AND INLET BASINS

Sediment forebays and inlet basins are designed to slow stormwater runoff, allowing coarser sediments to settle out of the water column. These basins play a critical role in protecting downstream treatment zones by capturing larger particles early in the treatment train before they can enter other WSUD systems, like bio, or wetland treatment measures.

In Wollongong, sediment forebays / inlet basins are a requirement in all constructed wetlands, ponds and bio-retention / filtration systems. The design and sizing of all sediment forebays/ inlet basins must follow the guidance in this section and include the following key elements:

1) They must be sized to manage flows from the design storm event (a 1-in-100-year ARI storm).
2) The must be designed to trap particles ≥ 0.125 mm. Designs must demonstrate effective retention of these particles.
3) A weir or spillway outlet structure with a width of at least 1.8 m must be provided to safely convey flows exceeding the design event to a high flow bypass channel. The overflow pit must be in the inlet zone, connected via one or more pipes through the embankment to the macrophyte zone.
4) They must be designed to retain the collected sediment from two to five (2-5) years between maintenance cycles, ensuring that sediment buildup is manageable.
5) The crest of the overflow pit must align with the permanent pool level of the inlet zone and must be at least 0.3 m above the permanent water level of the macrophyte zone.
6) An energy dissipater (e.g., rock apron or baffles) is required at the pipe outlet to reduce flow velocity and evenly distribute water into the macrophyte zone.
7) A reinforced concrete wall, ranging from 0.4 m to 1.0 m in height, must be constructed adjacent to the sediment inlet or headwall. This allows for maintenance equipment to be safely positioned and operated against it during sediment removal.
8) The inlet zone must have a defined concrete base to support maintenance equipment (up to 20 t) and facilitate desilting operations.
9) A clearly visible depth gauge must be installed to monitor sediment build-up and assist with maintenance scheduling.
10) No rip rap or rock are to be placed within 3 metres of a concrete apron to allow for cleaning and maintenance access.
11) In Wollongong all concrete slabs for sediment forebays/ inlet basins must:
    a. Extend a minimum of 3 m length, or 1.5 times smallest dimension of culvert opening, whichever is greater,
    b. ensure the sediment forebay or inlet basin has a grading of 1(V):4(H) to maintain structural stability and allow safe, efficient maintenance
    c. be a width of at least 3 m,
    d. ensure the inlet or sediment bay is securely connected to the headwall and properly founded using concrete. The footing must extend to the batter to provide structural stability and prevent undermining,
    e. include a 'cut off wall' or similar system to prevent percolation of flows beneath culvert,
    f. be at least 200 mm thick,
    g. not interfere with the headwall and both wings continuously.

Note: For temporary sediment forebays/ inlet basins used during construction, MUSIC modelling will typically involve specifying the duration of treatment (typically around 2 years) and ensuring that the sediment basins can operate efficiently for this extended period. For more information regarding Council's access and maintenance requirements, see Section 23 of this Guidebook.

13.1 Detailed sediment forebays/ inlet basins design requirements

Table 10 below outlines the mandatory detailed design requirements that must be addressed by applicants when designing sedimentation basins within the LGA.

Table 10. Detailed design specifications and MUSIC modelling steps for sedimentation forebays and inlet basins.

DESIGN REQUIREMENT	ACTION / INPUT
Suspended sediment removal rate:	The sedimentation basin/ inlet must be designed to remove at least 90% of all suspended sediment particles down to 125 *μm* for peak design flows, with an efficiency ratio (R) of 0.95. In cases where land area is very restricted, this removal efficiency can be reduced to 85% (R = 0.85), subject to written Council approval.
Set the flow bypass parameters:	**Low Flow Bypass:** If there is a proposed bypass for low flows, input the specific value. If no bypass is specified, use the default value of 0 for low flow bypass. **High Flow Bypass:** If a high flow bypass is proposed, input the corresponding value. If none is specified, use the value of 99 for high flow bypass.
Surface area input:	Input the surface area of the basin, but this is not the actual surface area. It is the area that, when multiplied by the Extended Detention Depth, will provide the correct storage volume. For basins with battered sides, input the average surface area at half the Extended Detention Depth.
Set the extended detention depth:	In MUSIC, the Permanent Pool Volume must be set to 2/3 of the actual volume of water in the basin. This ensures that the basin has adequate capacity for sediment storage and prevents overestimating the hydraulic retention time during storm events, which would inaccurately overestimate contaminant treatment.
Set the exfiltration rate:	Council requires 0 mm per hour for sediment forebays/ inlet basins, meaning they must be lined to retain water.
Set the evaporative loss:	For open water bodies, input 75% of Potential Evapotranspiration (PET) as the evaporative loss rate in MUSIC.
Set the discharge pipe diameter:	Adjust the diameter of the discharge pipe to ensure the detention time is sufficient for sedimentation of the target particle size (typically 125 *μm*).
Set the overflow weir width:	Set the overflow weir width to the actual length of the weir (at least 2m for Wollongong LGA). A too-small weir width will overestimate the performance of the sedimentation basin, as it will under-predict the flow passing over the weir.
Option to reuse in MUSIC:	Reuse in MUSIC will not be accepted for sedimentation basins in Wollongong.
Enter the 'k' and C* rates:	Use the default MUSIC values.

SECTION 14 - GROSS POLLUTANT TRAPS (GPTS)

GPTs are engineered stormwater treatment devices designed to intercept and remove large pollutants like litter (e.g., plastic bottles, wrappers, cans), organic debris (e.g., leaves, twigs, grass clippings), coarse sediments, and floating oils and hydrocarbons (in some advanced or proprietary models) (see *Figure 10*).

Council does not permit nitrogen removal credits for wet sump Gross Pollutant Traps (GPTs) under any circumstances. This applies regardless of SQIDEP verification or any other supporting documentation. Claims for nitrogen removal from these devices will not be accepted.

In addition, in-ground GPTs and gully pit litter baskets must not be credited for the removal of pollutants smaller than 2 millimetres, dissolved pollutants, hydrocarbons, or nitrogen. These devices are designed primarily for coarse pollutant capture and are not suitable for fine particle or dissolved contaminant treatment. Performance claims for these pollutant categories will not be considered in any assessment process.

Figure 10. Examples of various GPT systems.

14.1 GPT design requirements

Table 11 outlines the key design requirements for GPTs in the LGA. These requirements will ensure effective pollutant capture, hydraulic performance, and maintainability in accordance with Council standards.

Table 11. Key design requirements for GPTs.

REQUIREMENT	ACTION / INPUT
Design parameters:	• 4 EY for GPTs that are part of a treatment train or located upstream of a Bioretention basin or wetland, and, • 2 EY for independent GPTs.
Sizing requirements:	GPTs must be sized according to the pollutant loads (including TSS, TP, and TN) in the catchment and the capacity to store at least **twice** the minimum expected pollutant loads. **Note:** All GPT devices must be designed and sized for a **minimum 6-12 monthly** cleaning cycle.
Minimum design flows:	In the absence of more detailed hydrologic data, use the following calculations for calculating minimum design flows = Q_{4EY} (m^3/s) = 0.07 x A (hectare), or Q_{2EY} (m^3/s) = 0.09 x A (hectare)

REQUIREMENT	ACTION / INPUT
Storage volume:	The GPT must have a storage volume capable of holding **twice** the minimum expected pollutant load. The storage capacity must be clearly defined to ensure it - a) Does not impede the screen area. b) Maintains the designed flow rate and capacity of the system. c) All GPT devices in the LGA must be designed and sized for a **minimum 6 monthly** cleaning cycle.
Discharge invert settings for GPTs to Bioretention 'systems	In Wollongong all discharge pipes must be a minimum of 0.3 m above any Bioretention filter media. This setup optimises flow dynamics, ensures proper drainage, and prevents potential issues with backflow or clogging in the Bioretention system. This configuration supports both the functionality of the Bioretention system and the ease of maintenance.
Manhole specifications/ access points:	All manhole covers and GPT access points must be designed to - a) Meet the requirements of the AS3996 standard for Class D, which is suitable for areas with heavy-duty vehicular traffic, such as carriageways and roads. b) Be non-corrosive. c) Be round and opened using Swift Lift, or Gatic Lifters. d) Be accessible without the need for a crane or franna. e) Incorporate best practice safety measures, for example, if someone were to injure themselves inside a GPT, the design must include features to assist them without putting the rescuer at risk. f) Be accessible and maintainable without the need for traffic control measures and minimising any disruption or risks to the public. See Section 24 of this Guidebook for more information about Council's access, maintenance and safety requirements.

Notes:

- Proprietary Gross Pollutant Trap (GPT) nodes proposed for use within a stormwater treatment train must receive prior approval from Council.
- Council may consider supplementary proprietary stormwater treatment devices if:
  - Independent, peer-reviewed research demonstrates their effectiveness, or
  - Performance claims are supported by complete and unrestricted information that enables Council to assess and, if appropriate, accept those claims.

To support the applicant's assessment, the following information must be provided to council for approval:

- Peer reviewed reports (where available).
- Performance monitoring reports from real-world installations.
- SQID sizing methodology, including any assumptions that are not validated or referenced.
- Site map showing device location, rainfall gauge, and catchment extent.
- Catchment details: area, slope, land use type, and photographs.
- Roles and responsibilities of all parties involved.
- Sampling and analysis methods used.

Maintenance records, including:

- Nature and frequency of maintenance.
- Modifications, repairs, and replacements.
- Observations from maintenance activities.

Data for all qualifying storm events, including:

- Storm sequence logs.
- Individual storm reports.
- Chain of custody documentation.
- Laboratory water quality reports.

Discussion of performance factors, such as:

- Scaling effects.
- Particle size distribution of influent and effluent.
- Any other relevant influencing factors.
- Summary of performance metrics demonstrating treatment effectiveness.
- Conflict of interest declarations for all individuals involved in sampling, analysis, and reporting.

SECTION 15 - BIORETENTION AND FILTRATION BASINS

Bioretention and filtration systems are vegetated stormwater treatment measures designed to filter runoff and improve water quality. These systems remove both particulate and dissolved contaminants by passing stormwater through various filter types (typically a mix of loamy sand, organic matter, and vegetation see Figure 11). As water infiltrates through the filter layers, pollutants are removed through a combination of physical filtration, chemical adsorption, and biological uptake by plants and microbes. In addition to improving water quality, Bioretention and filtration systems also provide flow attenuation, helping to manage stormwater volumes and reduce peak flows to downstream systems.

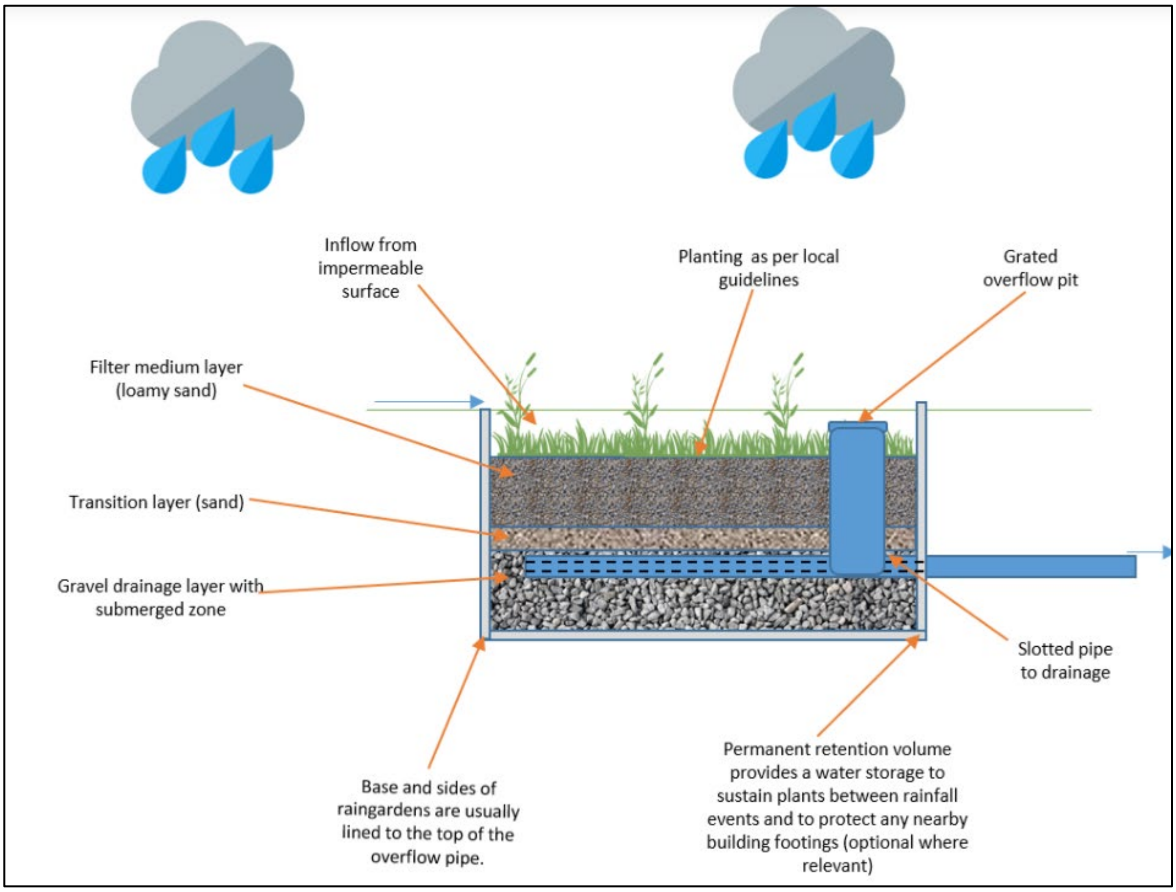


Figure 11. Example, cross sectional diagram of a Bioretention system

15.1 Bio-retention design requirements

Table 12 outlines the key design specifications that must be included when constructing Bioretention basins within the LGA. These requirements ensure effective stormwater treatment, hydraulic performance, and long-term maintainability.

Table 12. Design and MUSIC modelling specifications for Bioretention and filtration systems.

REQUIREMENT	ACTION / INPUT
High flow bypass:	The high flow bypass must be set to the 1 in 3-month flows.

REQUIREMENT	ACTION / INPUT
Sizing:	Design biofiltration systems to accommodate at least the 1:3 ARI (Average Recurrence Interval) event **Notes:** • The footprint of a biofiltration system is not limited to the treatment area. The total footprint includes the treatment area, surrounding batters, and space for maintenance access. As a rule of thumb, allow 3-3.5 times the treatment area (approximately 1.5–2 times larger than the filter zone alone). • Bio systems ≥ 3000 m^2 must have a saturated zone.
Pretreatment requirements :	Biofiltration systems with a contributing catchment area of 2-5 ha must include an upstream pre-treatment measure such as a sediment pond, GPT, swale, or inlet pond. For systems with catchment areas greater than 5 ha, an inlet pond or GPT is mandatory
Inlets into Bioretention systems:	All inlet pipes into a Bioretention systems must be installed at least 300 mm above the systems highest filter layer. This prevents backwater issues and sediment build up in the inlet area.
Bioretention outlets:	Must be above the Highest astronomical tide (HAT), Or, 300 mm above the invert to allow for free drainage.
Liner requirements:	All Bioretention systems must have a 1.5 mm HDPE liner or a minimum 300 mm compacted clay or geosynthetic clay liner (GCL). **Note:** Permanent geotextile layers are not allowed between filter media layers to avoid clogging and interference with filtration.
Perimeter and access requirements:	• For biofiltration systems ≤ 500 m^2, provide a 1 m wide access path to at least 40% of the perimeter. • For systems ≥ 500 m^2, provide a 3 m wide access path to 40% of the perimeter, with the remainder having a 1 m wide path. • Council accepts concrete, cement-treated road base, or turf as suitable finishes for access paths to biofiltration and wetland systems
Standard layout and saturated zone:	The longitudinal slope of a Bioretention swale must be between 2% to 5%, to prevent any water ponding or water logging problems on sites. **Note:** Permanent Bioretention basins ≥ 3000m^2 must include a saturated zone to store water for vegetation during dry periods. The saturated zone must be created using a thicker transition layer and drainage layer and does not include carbon materials for nutrient removal.
Biofiltration compliance measures:	Extended detention depth, edges, and slopes for biofiltration measures (particularly in public spaces such as road reserves) must comply with Austroads specifications, Australian Standards, and RMS guidance where required.
Battered slopes:	• For bio-filtration measures with maintenance access, maximum internal batter slopes must be 4(h):1(v) . • On non-accessible areas, embankments with a 3(h):1(v) slope are acceptable. **Notes:** • Council does not permit retaining walls in WSUD systems. Earth batters are preferred for accessibility and integration. Retaining walls may only be considered where site constraints make batters unfeasible, subject to Council approval. • Ensure batters are set back from biofiltration layers. Provide a physical separation so they do not abut the filter media, and prevent water from entering behind the system.
Terracing slopes and widths:	Where terracing is used: • Wall heights kept to 0.9 m or less.

REQUIREMENT	ACTION / INPUT
	• Provide at least 0.9 m of planting width between each terrace to allow space for both plant growth, maintenance and access.
Orthophosphate content:	The starting orthophosphate content of the filter media for all models must be at least 40 mg/kg. This threshold is enforced even if soil tests show a lower concentration because soil conditions can vary, especially over time.
Subsoil drainage:	Subsoil pipes must be laid flat in a 200 mm gravel layer to ensure proper water movement and drainage within the system.
Vegetation specifications:	• Dense planting of native sedges and shrubs promotes filter media conductivity, nutrient removal, and enhances aesthetics. • No trees are to be planted in a 2 m circumference of any maintenance/ access points. **Notes:** • Approved plant species and recommended planting densities are available in Section 25 of this Guidebook. • Some trees or shrub species may be incorporated into biofiltration systems with prior Council approval. In these cases, the filter media depth must be at least 600 mm. No trees or shrubs are permitted within 2 m of any headwalls, inlet basins, culverts, access points, or maintenance tracks. Refer to Section 24 of this Guidebook for detailed requirements. • Apply 50–75 mm of sugarcane mulch over the biofiltration surface, secured with coir netting to prevent displacement. Pin the netting firmly into the ground. Do not use pine mulch or heavy jute matting
Preventing backwater:	High backwater levels are a common design issue and reduce the effectiveness of Bioretention basins by reducing or even stopping flows, which stops treatment. To reduce the impact of tailwater levels, the Saturated Water Level must be set at, or above: • The 50% AEP (1 in 2-year AEP) water level in a natural water body, such as a creek or basin, immediately downstream of the Bioretention basin, or, • the 1 EY in the immediate downstream drainage pit
Hydraulic loading rates for permanent Bioretention basins:	The biggest single rectification maintenance cost with a constructed Bioretention 'basin is partial or even total replacement of the filter media and plants once the filter media becomes clogged. Good design can extend the life of the Bioretention 'basin significantly compared to a poor design. One such design guide is the hydraulic loading rate. • Bioretention 'designs must aim to balance flow rates through the basin with a loading rate that the filter media can handle without becoming overloaded and clogged. • The 98.14% AEP flow rate serves as a benchmark for managing water volume and sediment load while promoting sustainable filtration. • Bioretention basins must have temporary storage (detention) depth of at least 300mm and a filter media depth of not less than 600 mm. • The overflow pit or bypass channel must be located near the inflow zone to prevent high flows passing over the surface of the filter media. If this is not possible, then velocities during the minor (2–10-year ARI) and major (50-100-year ARI) floods must be maintained sufficiently low (preferably below values of 0.5 m/s and not more than 1.5 m/s for major flood) to avoid scouring of the filter media and vegetation. • Ensure the Hydraulic Loading Rate (HLR) is between **40** and **80** with a desirable target between **50** and **70**. This is based on a typical residential catchment. • For industrial and business sites with higher TSS loadings the HLR should be less than **60**. For sites with detention storage above the bioretention, the HLR should be between **40** to **60** to offset the additional sediment loading and extra flow through the filter under pressure. Assuming all other items are fixed,

REQUIREMENT	ACTION / INPUT
	the lower the hydraulic loading rate, the longer before the Bioretention 'will require significant rectification. However, if it's too low there is a risk the system may not get enough water, and plants may experience significant water stress.
Enter the 'k' and C* values:	Use MUSIC's default k and C* values.

Notes:

- For combined detention basins, with Bioretention systems and filter areas greater than 500 m², set the top of the filter media to a minimum of the 50% AEP water surface level within the detention basin. Where this contradicts the Bioretention levels determined above, the higher level must apply.
-

Example: Designing and modelling bio-retention / filtration basins in MUSIC.

To model for the 98.17% AEP Flow-Based Bioretention Design In MUSIC, this would involve -

1. Setting the inflow rate for the basin based on anticipated 98.17% AEP storm events.
2. Adjusting filter media properties to balance inflow rates with filtration capacity.
3. Defining outflow control parameters, such as low-flow orifices, to manage treated water discharge effectively without inundating the filter media.

By optimising these elements in the MUSIC model, the Bioretention / filtration basin can function effectively with reduced clogging risk, allowing for better pollutant removal and increased design life.

To assess the Hydraulic Loading Rate (HLR) in a Bioretention basin and ensure it aligns with the target range for optimal performance and longevity, follow these steps using MUSIC:

Step 1: Set up the Model:

- Set the High Flow Bypass in the Gross Pollutant Trap (GPT) to the 95.02% AEP EY (3-month) flow rate.
- Ensure the 98.17% AEP flow rate is directed to the Bioretention system.
- The red dashed line in the model (Figure 11) must represent the High Flow Bypass from the GPT, indicating flows that exceed the GPT's capacity and bypass the Bioretention basin.

Step 2: Obtain Mean Annual Loads:

- Click on the Bioretention Node.
- Go to Statistics (dropdown menu), then select Mean Annual Loads.
- Record the inflow flow rate in ML/year (noting that 1 ML/year = 1,000 m³/year).

Step 3: Calculate the Hydraulic Loading Rate (HLR):

- Use the following formula: *HLR (m/yr) = Flow (ML/yr) x 1,000 / Bioretention Filter Area (m^2)*

Step 4: Check the HLR Range:

- For typical residential catchments, the HLR must be between 40 and 80 m/year.
- Desirable target for residential catchments: 50 to 70 m/year.
- For industrial and business sites with higher Total Suspended Solids (TSS) loadings, the HLR must ideally be below 60 m/year.
- For sites with detention storage above the Bioretention basin, the HLR must be between 40 to 60 m/year to offset additional sediment and flow loadings that may stress the filter media.

Step 5: Interpret Results:

- If the HLR is too high, the Bioretention system may clog more quickly, reducing its functional lifespan.
- If the HLR is too low, the system may not receive enough water, potentially causing water stress for the plants.
- For a balanced HLR that maximizes Bioretention lifespan, target the lower end of the recommended HLR range where feasible. However, avoid reducing the HLR to maintain adequate water availability for plant health and functionality.

15.2 Temporary bio systems

Where permanent water quality basins are not yet constructed, temporary Bioretention systems are required.

Designers may implement either a purpose-built temporary system, or a standard Bioretention basin, in accordance with the details in the table below.

Table 13. Temporary Bioretention filter design requirements.

REQUIREMENT	ACTION / INPUT
Filter layer:	A 400 mm filter layer is required to promote stormwater filtration and pollutant removal.
Transition layer:	Include a 100 mm transition layer beneath the filter layer, aiding in water movement and separation from the gravel layer below.
Gravel layer:	• The gravel layer thickness varies depending on basin length and is determined based on the diameter of the largest subsoil pipe plus 50 mm of cover. • A 0.5% slope must be maintained within the gravel layer to support drainage toward the subsoil pipes.

15.3 Solar access requirements for bio-retention systems

To support healthy plant growth and reduce heat stress, Council provides specific slope and terrace design guidelines that ensure adequate solar access, particularly during winter months.

Table 14. Solar access requirements for Bioretention systems.

REQUIREMENT	ACTION / INPUT
North-eastern, northern, and north-western sides:	For Bioretention basins on these sides, set slopes above 0.6 m (increasing to 0.9 m for filter media widths greater than 5 m) to a maximum gradient of 1V:1.5H. This can be achieved by incorporating battered, level planting areas (minimum 900 mm wide) that maintain structural integrity while allowing sunlight access and maintenance.
Sunlight requirements:	Ensure the Bioretention filter area receives at least 1 hour of direct sunlight at midday during mid-winter to promote healthy plant growth.
South-eastern side slope and landscaping:	To minimise heat loads and prevent reflective stress, slopes on the south-eastern side must have batters landscaped with - • A maximum gradient of 1V:3H for private developments. • A maximum gradient of 1V:4H for Council developments.
Vegetation and thermal protection:	Plant vegetation along terraced walls to reduce direct heat absorption and reflection, which helps shield Bioretention plants from thermal stress. **Note:** Tree planting is not permitted within Bioretention basins or constructed wetlands. Trees may obstruct pipework, pose flood risks due to root intrusion or windthrow, and create long-term maintenance challenges
Vegetation clearance requirements:	• For critical WSUD components that will require regular maintenance access (eg, sediment traps/ forebays, headwalls, and inlets/outlets etc), no trees or shrubs are to be planted within a 2 m radius. Council may require applicants to remove vegetation within this radius as a condition before accepting responsibility of any WSUD asset. • It is recommended that the applicant inspects vegetation at **3, 6** and **12**-month intervals to ensure that vegetation is growing appropriately. This will limit the need for mitigation measures before handover to Council occurs.

RAINGARDENS

A raingarden is a landscaped area that collects, absorbs, and filters stormwater runoff from roof tops, driveways, patios, and other hard surfaces that do not allow water to soak in. Raingardens provide numerous benefits, including filtering pollutants before they enter waterways, reducing the burden on stormwater infrastructure, and capturing and reusing water at a localised scale. Integrating disconnected downpipes into the raingardens offers another effective and visually appealing solution for managing stormwater runoff (see figure 12).

While rainwater tanks remain necessary for water storage, any overflow from the rainwater tank can be effectively directed to the raingarden, further enhancing the management of stormwater at this scale. Incorporating raingardens during the development design phase correctly is crucial, as retrofitting these systems later can become costly.

Figure 12. Various raingarden examples. ***Left****: Disconnected downpipes and rainchain system leading to a raingarden.* ***Right****: Australian native raingarden.*

15.4 Specifications for designing raingardens

Applicants planning to incorporate raingardens as part of their WSUD measures in the LGA must adhere to the specifications outlined in *Table 15*. In MUSIC Raingardens should be modelled using the 'Bio-retention' node in MUSIC to ensure compliance with local water quality and hydraulic performance standards.

Table 15. Specifications for incorporating raingardens into lot scale developments.

REQUIREMENT	ACTION / INPUT
Notifying resident requirements	Developers who incorporate raingardens as part of their WSUD measures on private lots must register the rain garden asset as a 'Deed of Agreement' under Section 88 of the Conveyancing Act 1919. This Deed must be lodged with the relevant land title to ensure that, in the event of property ownership changes, future residents are legally notified of the presence of the WSUD system and its ongoing

REQUIREMENT	ACTION / INPUT
	responsibilities. This registration will ensure that the system is recognised for perpetuity, even if ownership or tenancy changes. Developers must ensure that all relevant documentation is provided to the resident at the time of settlement. This includes, but is not limited to: • A WSUD Asset Management Plan outlining the maintenance requirements. • The WAE drawings detailing the design and operational aspects of the rain garden. • A maintenance schedule, specifying the tasks, intervals, legalities and responsible parties for ensuring the system operates effectively. • Any other information deemed necessary to ensure proper management, care, and maintenance of the raingarden system. A copy of any relevant documentation related to the design, operation, and maintenance of the raingarden should also be forwarded to Council.
Sizing:	• Ensure the design can capture at least 1 -2 % of the impervious zones of the catchment area. • Generally, 12 – 24 inches in depth. • Edging will help separate the rain garden from other surrounding landscapes and reduce encroachment of lawn into the rain garden
Location and spacing:	Sufficient spacing for the rain garden must be considers ensuring overflow can direct water safely away from the home and neighbouring properties. Developers must also ensure that raingardens are not: a) Positioned on slope sites less than 2%, or more than 10%, b) Installed within three (3) meters of a building's foundation, c) Located over utilities (pipes, electrical gas etc.:), d) In low spots of the landscape that do not drain well or retain water, e) Where there is a high ground table, or group C and D soils, f) Positioned 30 m away from slopes >10%, and, or g) Installed in areas that will disturb already established native vegetation or soils.
Shape:	For raingardens, the shape will be determined by the sites existing features such as the need to avoid structures, trees, and utilities. Generally, raingardens will be positioned so that the long dimension follows the contour of the slope, creating a natural bench. This will reduce the amount of excavation needed to keep the bottom flat, so water doesn't flow to one end and pool, leaving the rest dry. **Note:** Remember to provide additional space for the overflow containment area and plantings around the ponding area.
Sediment control:	Construction of the raingarden must occur after 95% of the lot development has been completed. A sediment pond or swale is a good temporary solution to manage sediment during the construction phase.
Ponding depths:	Between 6 – 12 inches in depth is recommended.
Outlets and overflows:	• The outlet must be located downstream of the inlet. • The overflow must direct water to a safe location (e.g. open space, storm drain or disperses into the surrounding landscape). • Do not direct overflows towards adjacent properties or structures. • At the outlet, create a berm that rises a minimum of s6 inches and twice as wide, at a maximum 2:1 slope, from the outside of the top surface of the ponding area.

REQUIREMENT	ACTION / INPUT
	Note: All berms need to hold water after heavy rainfall or frequent storms. Consider bringing in soil with higher clay or silt content that is less well-draining to construct the berm.
Protecting inlet and outlet areas:	• Where applicable, rock beaching is a simple method for managing inflow velocities. • Prevent erosion by installing scour control measures at the overflow area for a length of at least 1.5 m. • Rock beaching is a simple method for managing overflow velocities. • For both the inflow and overflow, use round rock (cobble or river rock) that is minimum two (2) inches in diameter. The rock must be free of sediment. **Note:** If the overflow is through a berm, armour the overflow with extra rock and extend the rock all the way down the slope to minimum of 1.5 metres beyond the berm to prevent erosion.
Inlet areas:	If applicable, install pipes so that they slope toward the rain garden for the most efficient water flow.
Filter media:	• At the base of the trench, use drainage scoria to a depth of at least 300 to 400 mm, with a 100 mm layer of 7 mm sized screening media to ensure sandy does not migrate into the scoria layer. • Then, place 300 mm of sand or sandy loam over the screening layer. • Add 20 mm finely crushed rock to a depth of 50 mm over the sandy layer. • After, place large flat, angular rocks into the chute area, with smaller sized rocks in between the larger rocks to fill any gaps, which will help ensure interlocking and prevent erosion. **Note:** See *Figure 20* in this Guidebook for a cross-sectional example of the filter media layers in a typical raingarden system.
Vegetation:	Rain gardens should have three planting zones - • **Zone 1** - is the bottom of the rain garden and the wettest area. Install native emergent, herbaceous perennials and deciduous shrubs in this zone. • **Zone 2** - covers the side slopes, which occasionally may become wet. This zone requires plants to help stabilise the edges. Install native herbaceous perennials, deciduous shrubs, and evergreen shrubs in this zone. • **Zone 3 -** covers the area around the perimeter of the rain garden and/or on the berm, where plants will grow in drier soil. Install native grasses, deciduous shrubs, evergreen shrubs, and Deciduous and Evergreen Trees and Large Shrubs here. **Notes:** • Locally endemic plant species must be installed (which are already adapted to the region and will use less water and require less maintenance once established. They also can provide habitat for local wildlife such as frogs. • See **Section 24** of this Guidebook, for more information about selecting the correct plant species for the LGA.
Maintenance and access tips:	• Edging around the rain garden (such as pavers, stones, etc.) can facilitate access for maintenance and provide separation from lawn and other landscaped areas. • In the short term (during the first 2 to 3 years), more frequent maintenance will be needed until the plants in your rain garden become established. • Maintain rock pads to protect the ground and prevent erosion where concentrated water flows into the rain garden from a pipe or swale. • If there is a localised area of erosion, consider stabilizing the area with rocks to spread out the flows causing erosion. If there are already rocks in this area, use larger rocks or cover a larger area with rock to spread out the flow. If erosion is occurring at the inflow and overflow locations, you may need to extend the cobble rock in these areas to disperse water flow.

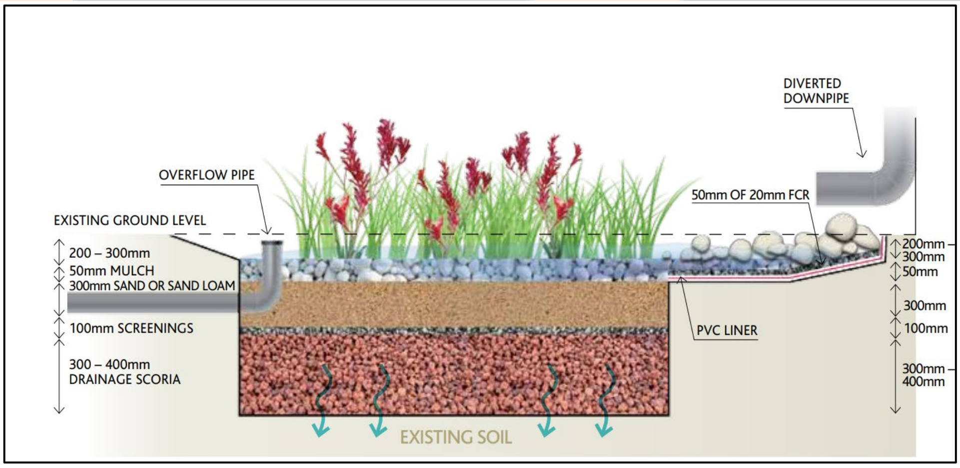


Figure 13. Cross sectional diagram of a typical raingarden system

SECTION 16 - PERMEABLE PAVEMENT

Permeable pavement systems are designed to allow stormwater to pass through the surface and into a subsurface layer (see *Figure 14*). From there, the water may infiltrate into the underlying soil, be filtered and directed to subsurface storage, or be conveyed to the drainage network through perforated pipes. These systems help reduce stormwater runoff and contribute to improved water quality outcomes. Council supports the use of permeable pavements, provided they are designed in accordance with the specifications outlined in this section.

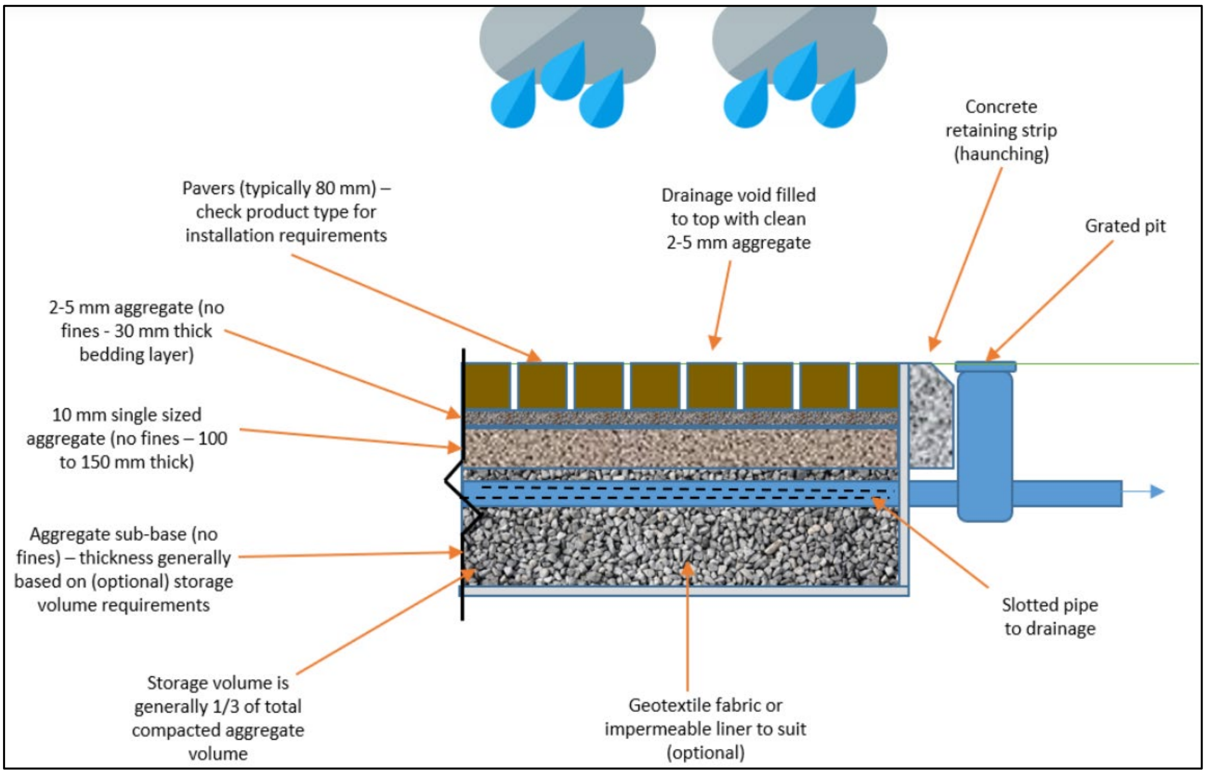


Figure 14. Cross sectional example of a permeable pavement system

16.1 Permeable pavement design and modelling requirements

To simulate flow through the filter media of permeable pavements, 40% of the design hydraulic conductivity is used. This conservative value represents the expected hydraulic conductivity at the end of the pavement's service life. Table 16 presents the recommended procedure for modelling permeable pavement in MUSIC. Although MUSIC does not include a dedicated treatment node for porous paving, it can be effectively modelled using the 'Media Filtration' node. When using this approach, the void space within the paving area should be entered as the 'filter area'. In the LGA, permeable pavements must be modelled as a filter media system in accordance with the *Water NSW MUSIC Modelling Guidelines*, using the following parameters:

1) Extended Detention Depth (m): 0.00,

2) Surface Area (m^2): Equal to the total area of pavers,

3) Exfiltration Rate (mm/hr): 0.00, and

4) Filter Media Particle Diameter (mm): Refer to *Table 17*.

Table 16. Steps for modelling permeable pavement systems in MUSIC.

STEP	ACTION / INPUT
Step 1: set the saturated hydraulic conductivity:	• To the smallest median particle diameter (D50 mm) in the pavement profile from the base or sub-base layers. • The maximum saturated hydraulic conductivity for a sand media filter in LGA is 360 mm/hr. Certification from the filter media supplier or engineer is required to confirm that the filter media meets the ASTM F1815-06 standards, with a hydraulic conductivity at least 4 times the rate specified in the MUSIC model.
Step 2: set the filter depth:	To equal the depth of the base and sub-base layers, excluding any coarse gravel layers, as these do not improve water quality and must not be included in the model. The media must be finer than 1 mm, which is the median particle diameter for a coarse sand transition layer, and this layer must not be modelled.
Step 3: set the weir length:	To equal one side of the paved area that the pavers are graded to.
Step 4: under the more tab:	Set the k values to meet the required pollution reduction targets.

Table 17. Comparative data on filter media particle size and its corresponding hydraulic conductivity.

SOIL TYPE	MEDIAN PARTICLE SIZE (μM)	SATURATED HYDRAULIC CONDUCTIVITY (mm/hr)
Coarse sand	1000	360
Medium sand	500	140
Fine sand	125	70
Medium clays	4	3.6

Notes:

- The filter area must align with the actual open area of the paving material. Paver types vary significantly, some, like solid concrete pavers, feature small hexagonal openings, while others, such as resin-bound pavers, offer larger voids. For resin-bound pavers, the open area must not exceed 40%.
- The site must be graded to ensure that only direct rainfall onto the permeable pavement is allowed to infiltrate. No runoff from adjacent impervious areas should drain into the pavers. The impervious-to-pervious drainage ratio must be 0. This design approach supports a minimum pavement lifespan of 20 years under tree canopy, and up to 40 years in open areas without overhead vegetation.

SECTION 17 - GRASS SWALES AND FILTER STRIPS

Swales or filter strips are low-impact stormwater management systems that offer effective treatment and conveyance of runoff with minimal maintenance requirements. Commonly implemented along roadsides or adjacent to impervious surfaces, these systems serve as sustainable alternatives to conventional kerb-and-gutter drainage. The primary functions of filter strips, buffers and swales include:

- Removing sediments, nutrients and hydrocarbons through filtration via vegetation.
- Reducing runoff volumes by promoting some infiltration into the subsoil.
- Delaying runoff peaks by reducing flow velocities.

With the right vegetation cover and diversity, filter strips, buffers and swales can provide multi-use habitats (e.g., wildlife corridors), and act as an effective pre-treatment step for other WSUD measures such as on-site detention basins.

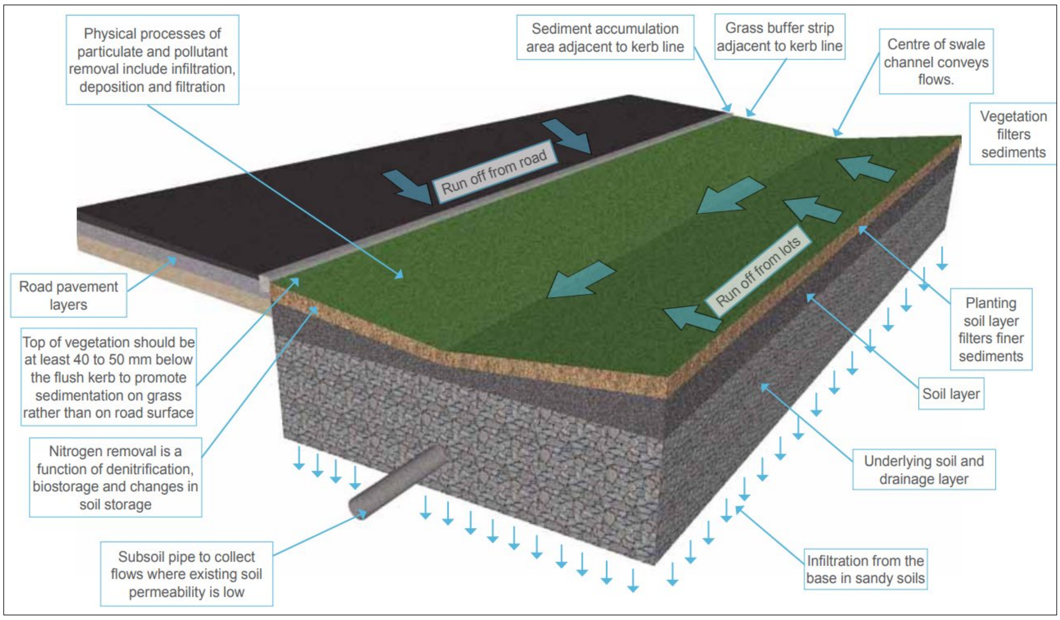


Figure 15. Cross sectional example of a grassed swale.

17.1 Swale and filter strip design requirements

Applicants must comply with the design parameters outlined in Table 18 when designing swales and filter strips within the LGA. Table 19 identifies grass species that have demonstrated superior nutrient absorption compared to commonly used varieties and approved for use in the LGA.

Table 18. Key design parameters for swales and filter strips

REQUIREMENT	ACTION
Slope:	Grassed swales must be limited to locations only where lateral gradients of 2% to 4% are achievable. Additional sub-surface drainage may be necessary at the base of grassed swales if a minimum gradient of 2% cannot be achieved along the full length of the swale.
Flow velocities:	Design the swale for a 1-year ARI peak discharge, and the design 100-year ARI peak discharge. These velocity limits are important to prevent erosion and to ensure that the swale can effectively remove pollutants. High velocities can lead to soil erosion, which compromises the swale's ability to filter and treat stormwater.
Shape:	• Grassed swales must have a trapezoidal, or curvilinear profile to avoid flow concentrations at the base. • Triangular-shaped swales must be avoided, as concentrated flow at the base can lead to scouring and sediment generation.
Maintenance:	Grassed swales that will be handed back to Council management must have a clearance width of no less than 1.8 m. **Note:** See Section 24 in this Guidebook for more information about Council's access and maintenance requirements.
Vegetation:	Mid-autumn planting is preferable to minimise watering requirements and maximise establishment time. Several grass species with demonstrated high nitrogen uptake rates are suitable for use in vegetated swale installations and are listed in the table below.

Table 19. Characteristics of lawn grasses and their corresponding nutrient removal performance in grassed swales (Li, Li, & Zhang, 2016).

SPECIES	CHARACTERISTICS	NUTRIENT REMOVAL PERFORMANCE
Kenda kikuyu	✓ Fast establishment. ✓ Good drought tolerance. ✓ Good wear tolerance. ✓ Dense and deep root system. ✓ High winter activity.	• Effective after establishment.
Santa ana couch	✓ Very deep root system. ✓ Recovers rapidly from damage. ✓ Goes dormant in winter. ✓ Short dormancy period.	• Effective (after establishment). • Maintains performance during dry periods.
Empire zoysia	✓ Comparatively slower growth than Kikuyu or Couch. ✓ Drought tolerant. ✓ May be prone to brown off in winter. ✓ Slow to establish in winter. ✓ Winter dormancy.	• Effective after establishment.

SPECIES	CHARACTERISTICS	NUTRIENT REMOVAL PERFORMANCE
Nara native zoysia	✓ Slower growing than Kikuyu and Buffalo. ✓ Faster growing than Empire Zoysia. ✓ Tends to produce a burst of seed head in early spring. ✓ Goes dormant in severe drought to survive. ✓ Some winter dormancies.	• Effective after establishment. • Not recommended in climates with frequent dry weather spells).
Palmetto soft leaf buffalo	✓ Minimal maintenance (incl. watering). ✓ Shade tolerant.	• Effective after establishment.

Notes:

- It is essential that grass is kept moist, during transport, immediately after its placement, and for the first six weeks at least after placement.
- A 3-month establishment period is generally required to ensure vegetative health. Successful establishment of a grass WSUD system requires grass to be kept moist for an extended period, especially for the first six weeks after planting. Watering is typically needed every second day unless rainfall is regular.
- Amelioration of the sand layer directly below the turf with organic matter, fertiliser and trace elements during installation is recommended to assist with grass establishment.
- The cross-sectional area and hydraulic radius are variables that the designer must determine based on the area available for the swale. These values can be trialed in MUSIC to evaluate their suitability.
- The Manning's n value is a critical variable that reflects the roughness of the channel. It varies with the flow depth, channel dimensions, and vegetation type.
- The length of the swale will be determined by whether the full flow is conveyed along the full length of the swale or equally distributed. The swale characteristics such as Bed Slope, Base Width, Top Width, and Depth are required to match the hydraulic assessment calculated earlier.

17.2 Modelling swales and filter strips in MUSIC

Once the design criteria have been satisfied, use the following approach in table 20 to model a compliant swale or filter strip with lateral inflow (i.e., inflow entering from the side, such as in a roadside swale) in MUSIC.

Table 20. Key inputs and steps to model swales and filter strips in MUSIC

STEP	ACTION / INPUT
Step 1: divide the swale into three equal segments:	Create a source node that would drain to the top segment and direct this to the second or middle swale segment.
Step 2: create a second source node:	To represent the catchment draining to the middle swale segment and direct this to the last swale segment.
Step 3: create a source node that would drain to the lowest segment:	And direct this to join the model after the swale so that it receives no treatment in the swale. This approach would treat the top catchment in the middle and lower segments, the middle catchment only in the lower segment, while the lower segment does not receive treatment.

To create the swale node, follow the steps below when inputting data into MUSIC.

Table 21. Steps to create a swale node in MUSIC.

STEP	ACTION / INPUT
Step 1: set vegetation the height:	To 0.05 – 0.10 cm
Step 2: set the exfiltration rate:	To '0' mm per hour for swales and filter strips.
Step 3: enter the 'k' and c* rates:	Use MUSIC's default values.

17.3 Protecting swales and filter strips during construction

Swales and filter strips are vulnerable during construction due to sediment laden runoff and site activity. To protect these systems:

a) If swales or filter strips will be used during site development, construct them early to allow vegetation to establish before exposure to construction impacts.

b) If installation is deferred until post-construction, protect the area with fencing and diversion measures to prevent damage from runoff and heavy machinery.

c) Use geofabric topped with shallow soil (e.g. 50 mm) and instant turf (laid perpendicular to flow) to allow temporary use as erosion and sediment control. Remove these materials and accumulated sediment post-construction, then reprofile and plant according to the final design.

SECTION 18 - VEGETATED BUFFER STRIPS

Buffer strips are commonly used as a source control measure, particularly for management of diffuse runoff. Vegetated buffer strips are only suitable for scenarios where stormwater enters as sheet flow. If the vegetation receives concentrated or piped flows, the buffer node in MUSIC should not be used, as it will provide minimal treatment. In such cases, it may be more appropriate to model the buffer as a modified swale, provided it is designed to disperse flow evenly across the full width of the vegetated area. Buffer nodes are typically positioned upstream of other stormwater treatment elements. When configuring the buffer node in MUSIC, the exfiltration rate should generally be set to zero. A non-zero value may be used if supported by in-situ soil testing, but any exfiltrated water must be retained in the model using a secondary drainage link.

Table 22 presents the recommended procedure for modelling buffer strips in MUSIC. Careful attention is required when setting up and assessing MUSIC models to ensure that source nodes can drain into the buffer node. The treatment processes within a buffer strip are represented in MUSIC using simplified transfer functions derived from international literature. Below are the steps to take when modelling vegetated buffer strips in MUSIC where they may help to meet water quality targets.

Table 22. Steps for modelling vegetated buffer strips in MUSIC.

STEP	ACTION / INPUT
Step 1: confirm the flow type:	Ensure the inflow to the buffer strip is sheet flow (i.e. dispersed overland flow). Buffer nodes are not suitable for concentrated or piped flows.
Step 2: add a buffer node in the music interface:	Insert a buffer node into your treatment train. This node should be placed upstream of other treatment elements (e.g. bioretention, wetlands).

STEP	ACTION / INPUT
Step 3: set the catchment and source nodes:	Connect the buffer node to appropriate source nodes (e.g. urban surfaces) that generate sheet flow. Ensure the layout allows for realistic drainage into the buffer.
Step 4: configure the buffers parameters:	Input the following key parameters: • Length and width of the buffer strip, • vegetation type (if applicable), • slope of the buffer area, and • the exfiltration rate set to 0 mm/hr by default. A non-zero value may be used if supported by in-situ soil testing but must be paired with a secondary drainage link to retain exfiltrated water in the mode.
Step 5: check and adjust the hydrologic routing:	Ensure that the buffer node is correctly connected to downstream treatment nodes or outlets. Music uses simplified transfer functions to simulate pollutant removal in buffer strips.
Step 6: validate the model's setup:	Check and confirm that: • The buffer node receives flow from appropriate sources • The flow path reflects actual site conditions • The model complies with local guidelines (e.g. the latest versions of Wollongong city council WSUD Guidebook and Engineering Series).
Step 7: run the model and review the results:	• Run the model and review the performance of the buffer strip in terms of pollutant load reduction and hydraulic behaviour. • Adjust parameters if necessary to meet the designs target.

SECTION 20 - CONSTRUCTED WETLANDS

Constructed wetlands are designed to replicate the functions of natural wetland systems, and can provide effective stormwater treatment under both low and high flow conditions. These systems use endemic native plant species to enhance water quality, support biodiversity, and contribute to the ecological health of the broader catchment. Wetlands must be designed to filter stormwater, retain nutrients and sediments, and support native fauna. Their design must deliver benefits at the catchment scale, not just at the site level.

In addition to their treatment function, constructed wetlands within the LGA must be designed to deliver co-benefits such as enhanced aesthetics, recreational opportunities, passive cooling, habitat provision, and cultural value. Wetlands must be integrated into the overall site design, not hidden or confined to unused corners of a development. Locating wetlands in prominent, accessible areas supports better land use outcomes and aligns with best practice in water-sensitive urban design. Maintaining connectivity between creeks, wetlands, and vegetated buffer zones is essential. These linkages improve water filtration and provide critical habitat corridors for both terrestrial and aquatic species. Where possible, existing natural corridors should be preserved and integrated into the design to enhance ecological resilience. For further guidance on development near riparian areas, refer to Council's DCP Chapter E23.

Figure 16. Example of a local wetland system with co-benefits such as shaded seating areas, educational signage and walking paths at Wongawilli.

20.1 Constructed wetlands design requirements

The table below outlines the key design parameters for constructed wetlands within the LGA, and ensures consistency with local WSUD objectives and performance standards.

Table 23. Key design requirements for constructed wetlands

REQUIREMENT	ACTION / INPUT
An upstream GPT:	An upstream GPT must be included, with a minimum capacity appropriate to the contributing catchment and a have minimum cleaning frequency of at least six (6) months.
A high-flow bypass channel:	Is required from the GPT to a location downstream of the wetland.
Permanent pool volume:	Minimum, 0.2 m to 0.3 m x surface area.
Overflow weir width:	Greater off surface area (m^2)/10 or weir width to convey major storm flow with a 0.3 m head.

REQUIREMENT	ACTION / INPUT
Equivalent pipe diameter:	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. **Note:** Any pipe(s) that connect the sedimentation basin to the macrophyte zone needs to have sufficient capacity to convey a 1-year ARI flow, assuming the macrophyte zone is at the permanent pool level and without resulting in any flow over the high flow bypass weir.
Evaporative loss as % of pet:	Set to 125% of PET.
Exfiltration rate:	0 mm/hr.
Inlet basins:	Must be included, but are considered as a separate sedimentation basin in MUSIC. This must be sized to remove coarse sediment (>125 μm) during a 1-year ARI storm (for conceptual design, assume 5% macrophyte area). **Note:** See Section 13 in this Guidebook for more information about inlet and sedimentation basin requirements.
A macrophyte zone:	Up to 400mm with heavily (80%) vegetated area to remove fine particulates of varying shallow depths and uptake of soluble pollutants.
Perimeter access:	• For wetlands < 100 m², provide a 3 m wide access path to at least 40% of the wetland perimeter and all hydraulic controls. • For wetlands ≥ 1,000 m² and < 5,000 m², provide a 3 m wide access path to 40% of the perimeter, with the remainder having a 1 m wide path. • For wetlands > 5,000 m², provide a 3 m wide access path around 100% of the perimeter and all hydraulic controls. Council accepts concrete, cement-treated road base, or turf as suitable finishes for access paths to biofiltration and wetland systems
Maintenance and access:	• A minimum 3 m wide heavy-duty ramp at a 10% max gradient, extending 2 m into the macrophyte zone for boat access. • A concrete pathway (at least 4 m wide and resistant to rust) that allows access to at least 50% of the deepwater zone and any overflow pits/ pipes not accessible from the wetland's perimeter. **Note:** See Section 24 in this Guidebook for more information about Council's access and maintenance requirements.
Sizing and storage:	• If surface area is limited, additional pre-treatment or downstream treatment (eg, bio-retention) is needed. A typical wetland must cover at least 2% of the catchment area, with some cases requiring higher percentages. • Wetlands must be designed for the 95.02 % AEP (3-month) storm event. • Where treated water is discharged into receiving waters, the outfall invert must be above the 50% AEP level in the adjacent watercourse, avoiding backwater intrusion. • Floating Wetlands can significantly enhance pollutant removal. When modelling in MUSIC, treat them as ponds, assuming the floating wetland covers at least 10% of the pond area. • An energy dissipater may be required at the end of the pipes to reduce velocities and distribute flows into the macrophyte zone. • The preferred extended detention depth is up to 0.40 m. Deeper extended detention depths up to a maximum of 0.75 metres may be acceptable where the wetland hydrologic effectiveness is higher, but requires approval from Council. Note that depths greater than 400 mm are not conducive to plant growth.

REQUIREMENT	ACTION / INPUT
Co-benefits guidance:	• Constructed wetlands within the LGA must be designed to deliver co-benefits such as enhanced aesthetics, recreational opportunities, passive cooling, habitat provision, and cultural value. • Wetlands must be integrated into the overall site design, not hidden or confined to unused corners of a development. Locating wetlands in prominent, accessible areas supports better land use outcomes and aligns with best practice in delivering water-sensitive urban design co-benefits.
Set the k and C* values:	Use MUSICs default k and C* values (m/yr)

20.2 Constructed wetland macrophyte zone design requirements

The macrophyte zone must be designed to maximise hydraulic efficiency while supporting the long-term health and sustainability of wetland vegetation. The layout should promote uniform flow distribution, minimise short circuiting, and ensure adequate contact time for treatment processes. Design specifications for macrophyte zones in constructed wetlands within the LGA are provided in Table 24 below.

Table 24. Macrophyte design requirements for constructed wetlands.

REQUIREMENT	ACTION/ INPUT
Maximum depth:	1,000 mm (including macrophyte EDD) when combined with a detention basin.
Permanent pool volume:	Total volume ÷ surface area at PWL (must be < 0.40 m).
Macrophyte health:	Avoid dieback by keeping the deep marsh zone depth ≤ 300 mm. Install plants into at least 300 mm of wet or muddy soil.
Flow path:	Create a sinuous path within the wetland to increase residence time, avoiding short circuiting.
Macrophyte zone length:	Typically, ≥ 4 times the average width.
Flow velocities:	• ≤ 0.05 m/s at the EDD during 4 EY (98.17% AEP) inflow events. • ≤ 0.5 m/s during peak 1% AEP flow
Edge depth:	• Maintain a minimum 100 mm depth at the edge of the macrophyte zone using concrete, rock, or a hard edge to prevent mosquito breeding. • Install a water level marker installed near the outlet, avoiding liner damage.

REQUIREMENT	ACTION/ INPUT
Grading between zones:	Provide a slope between 1:200 and 1:400 to allow for free drainage, with balance pipes to manage water levels for maintenance.
Drainage and recirculation:	• Independent drainage pipe to the downstream discharge, controlled by a gate valve for cleaning. • Include a recirculation system to maintain wetland during dry periods, enhancing aeration and reducing stagnation.
Water level control:	• Outlet control must include and adjustable water level mechanism with staggered pipes for plant establishment. • Replaceable litter screens are to be installed over 50 mm pipes and outlets to prevent blockages.
Safety:	• No public access to water without safety benching for areas with depths >300 mm. • Public safety measures must be considered and implemented around deepwater zones, high velocities, and steep batters.
Ecological features:	Install at least 8 permanent habitat features per 1,000 m², such as logs or rocks, to support wildlife (eg, turtles, frogs, birds).
Depth distribution:	Ensure equal amounts of shallow marsh (100-200 mm) and deep marsh (200-400 mm) which are required for effective function.
Vegetation:	• There must be a minimum eighty percent (80%) cover of native emergent macrophytes across shallow and deep marsh zones. • Maximum twenty percent (20%) open water area, which must include submerged marsh vegetation. • Reed species such as Lesser Bulrush (Typha angustifolia) and Bulrush (Typha latifolia) not to be used in in WSUD systems in Wollongong due to the associated maintenance requirements. WSUD assets that will be handed back to Council must remain Lesser Bullrush and Bulrush free for six (6) months prior to handover.
Invasive species management:	• Reed species such as Lesser Bulrush (Typha angustifolia) and Bulrush (Typha latifolia) not to be used in in WSUD systems in Wollongong due to the associated maintenance requirements. WSUD assets that will be handed back to Council must remain Lesser Bullrush and Bulrush free for six (6) months prior to the hand over. Other exotic species must be excluded from the wetland area before they flower, set seed, or produce other propagules. They must be treated before reaching a height of 25 cm. • Council will not accept responsibility for wetland assets where invasive species coverage exceeds fifteen percent per metre square (15% m²). **Notes:** • Tree planting is not permitted within Bioretention basins or constructed wetlands. Trees can obstruct pipework, pose flood risks due to root intrusion or windthrow, and create long-term maintenance challenges. • See Section 25 of this Guidebook for more information about exotic species management.

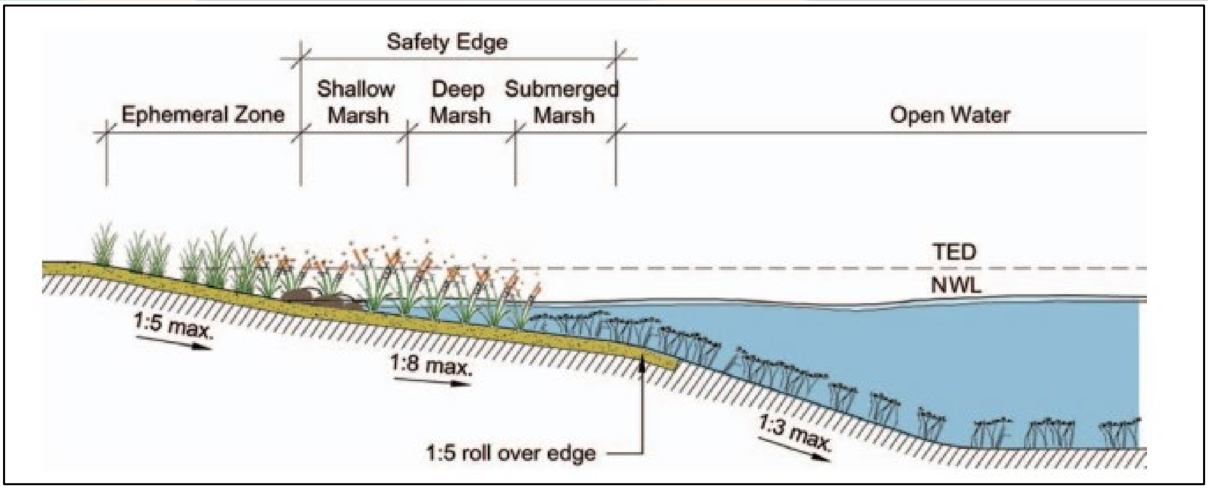


Figure 17. Example of a wetland's marsh zones and wetlands with a soft edge (source WSUD Engineering Procedures 2005).

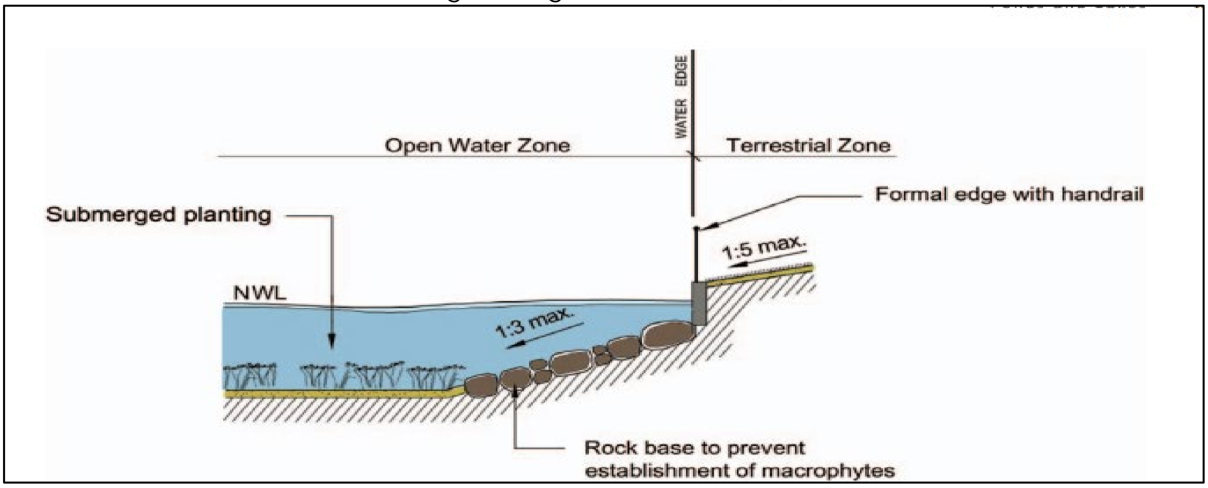


Figure 18. Wetland zoning example with hard edges (source WSUD Engineering Procedures 2005)

Table 25. Planting zones and depth guide for macrophyte species

ID	PLANTING ZONE	DEPTH RANGE
TE	Terrestrial	>+EDD
EB	Ephemeral batter	PWL to + EDD
SM	Shallow marsh	PWL to -0.2 m
DM	Deep marsh	-0.2 m to -0.4 m
SU	Submerged marsh	-0.4 to -0.7 m

20.3 Modelling constructed wetlands in MUSIC

Table 26 presents the key input parameters for configuring a compliant constructed wetland node in both the MUSIC modelling software and in accordance with LGA design standards.

Table 26. Key steps and inputs to model constructed wetlands in MUSIC.

STEP	ACTION / INPUT
Step 1: provide a GPT node with a high flow:	Set to the <4 EY (98.17% AEP) flows to direct low flows to the inlet pond (sediment basin), And,

STEP	ACTION / INPUT
	the > 4 EY (98.17% AEP) high flow bypass downstream of the 'Wetland Node' via a secondary link.
Step 2: provide a separate sedimentation basin node:	To represent the inlet pond with characteristics based on the empirical modelling requirements and details outlined for the inlet pond. **Note:** For guidance on designing compliant sediment basins, and Council's access and maintenance requirements refer to Sections 12 and 23 of this Guidebook.
Step 3: (optional). Provide a rainwater tank node:	To represent any reuse storage independent from the wetland, provide a link representing the treated pipe flow from the wetland to the tank with a secondary flow representing the high flow bypass to the next node down. **Note** that the reuse option in the wetland node is generally unacceptable and requires prior approval from Council.
Once the model is set up, enter the following parameters:	
Low flow bypass:	Set to 0.0 (as there is no low flow bypass in a wetland).
High flow bypass:	Set to 99 (is considered as part of the GPT Node).
Inlet pond volume:	Sized to remove coarse sediment (>125 μm) for a 1-year ARI storm (for conceptual design, assume 5% macrophyte area).
Surface area of wetland:	Input the surface area of the macrophyte zone, which is used to calculate storage volume (area at half the Extended Detention Depth if basin sides are battered).
Extended detention depth:	Set between 0.25 m and 0.4 m. **Note:** Do not include stormwater detention storage above this depth. Deeper extended detention depths up to a maximum of 0.75 metres may be acceptable where the wetland hydrologic effectiveness is greater than 80% and where the botanic design uses plant species tolerant to greater depths of inundation.
Permanent pool volume:	Set to 90% of the actual volume to account for sediment storage over time.
Initial volume:	Set to match the Permanent Pool Volume.
Exfiltration:	Set to 0 mm per hour for lined wetlands.
Equivalent pipe diameter:	Adjust to achieve a 'Notional Detention Time' of 24 to 72 hours, assuming the overflow pipe is set to the permanent water level.
Overflow weir width:	Matched to the actual weir length to avoid overestimating wetland performance.
Custom outflow and storage relationship:	Use if an overflow pit is employed with an orifice set lower than the permanent water level. Add the Stage/Discharge/Storage details.
Reuse:	Do not use the reuse option in the Wetland Node. A separate Rainwater Tank Node must represent storage areas like ponds or tanks if required.
Music 'k' and C* values:	Use MUSIC's default k and C* values.

20.4 Guidance to reduce mosquito occurrences in wetlands

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

- Access for mosquito predators such as frogs, fish and predatory insects, to all parts of the water body (avoid stagnant isolated areas of water).
- Provision for a deep sump of permanent water (for long dry periods or for when water levels are artificially lowered) so that mosquito predators such as frogs may seek refuge and maintain a presence in the wetland.
- Maintaining natural water level fluctuations that disturb the breeding cycle of some mosquito

species.

- Wave action from wind over open water will discourage mosquito egg laying and disrupt the ability of larvae to breathe.
- Providing a bathymetry such that regular wetting and drying is achieved, and water draws down evenly, so isolated pools are avoided.
- Providing sufficient gross pollutant control at the inlet such that human derived litter does not accumulate and provide breeding habitat.
- Ensuring overflow channels don't have depressions that will hold water after a storm event.

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

SECTION 21 - CONSTRUCTED PONDS

Constructed ponds can be sized for different purposes, which include pollutant removal and water filtration, stormwater storage for reuse, ornamental/aesthetics, enhancing aquatic biodiversity, and creating habitat and harbor for flora and fauna. Regarding WSUD, constructed ponds perform two primary functions:

1) **Water quality ponds** - Water quality ponds treat runoff by settling suspended solids. Pre-treatment is essential, typically through sedimentation basins or GPTs, as MUSIC assumes pre-treatment before the pond. While submerged macrophytes can help with nutrient removal, their role isn't directly modelled in MUSIC, though at least 10 percent (10%) fringing macrophyte coverage is required. The pond's primary function is sedimentation, which reduces TSS and other sediment-bound pollutants. Proper pre-treatment upstream is crucial for the pond to perform effectively in the MUSIC model.

2) **Storage ponds** - Storage ponds used for treated stormwater reuse can be modelled in MUSIC to assess their performance in balancing supply and demand. The permanent pool is the volume available for reuse, which may fluctuate based on supply and demand. If the permanent pool is below the reuse volume, it can either be ignored or modelled separately, with the Extended Detention Depth (EDD) represented only in the water quality pond node.

21.1 Modelling constructed ponds in MUSIC

Table 27 outlines the required steps and input parameters for designing water quality treatment ponds in the Wollongong region using MUSIC software.

Table 27. Steps and inputs for modelling constructed ponds in MUSIC.

STEP	ACTION / INPUT
Step 1: set and enter the ponds bypass levels:	Define any High Flow or Low Flow Bypasses, with default values of 0 for Low Flow and 99 for High Flow.
Step 2: determine and enter the ponds surface area:	The surface area used must be the area that, when multiplied by the Extended Detention Depth (EDD), gives the extended storage volume. For basins with batter slopes, this is the average area at half the EDD.
Step 3: determine and enter the ponds extended detention depth:	This is done by calculating the depth between the top of the permanent pool and the lip of the overflow weir.
Step 4: enter the ponds permanent pool volume:	Set as 90% of the actual water volume to account for sediment storage, ensuring hydraulic retention time isn't overestimated. For reuse, the volume cannot exceed the available reuse volume.
Step 5: set the ponds exfiltration rate:	Set to 0 mm per hour for lined ponds, as required by Council.
Step 6: enter the ponds expected evaporative losses:	Set at 75% of potential evapotranspiration (PET) for open water bodies with little to no vegetation.
Step 7: enter the details of the ponds discharge pipe:	Adjust the pipe diameter to ensure a minimum detention time of 24 hours for settling of target particles. For complex outflow conditions, enable custom outflow and storage relationships.
Step 8: set the overflow weir width:	Ensure the weir width matches the actual length to avoid overestimating performance (minimum weir withs in Wollongong are 2m).
Step 9: enter the ponds k and C* rates:	Use MUSIC's default k and C* values.
Step 10: enter any stormwater reuse rates (if applicable):	Use the Reuse tab to enter details for irrigation or other uses, reflecting the demand on water from the storage pond.

SECTION 22 - LEVEL SPREADERS

Level spreaders are erosion control devices designed to reduce water pollution by managing the impact of high-velocity stormwater runoff on receiving environments. They function by dissipating the energy of concentrated flow, converting it into sheet flow, which helps to evenly distribute water and reduce erosive forces. Level spreaders can be used in both temporary (construction phase) and permanent applications. They are often integrated with other stormwater management systems and infiltration trenches to enhance runoff infiltration and minimise downstream erosion.

Table 28 below provides the design requirements for implementing level spreaders in the LGA. Additional information and design examples can also be found in WCC's WSUD Engineering Series.

Table 28. Design parameters for level spreaders.

DETAIL	ACTION
Catchment size:	Drainage area for the level spreaders must not exceed five (5) acres is size.
Length and flow rates:	The length of the system will be determined by catchment area, but flows must not exceed 1.5 litres per second, based on the peak rate of flow from the contributing erosion control practice.
Width and depth:	• Level spreader systems must be at least 1.8 metres in width, or should be determined by the resultant post development flow and matching or replicating the natural (pre- development) overland flow such that it doesn't create a concentration of flows resulting in downslope impacts. • The depth of the spreader as measured from the lip, shall be at least six (6) inches and it should be uniform across the entire length.
Discharge:	Where level spreaders are released into a waterway, the flows, must be non-erosive and be treated/cleaned to Council' water quality targets prior to release.
Slopes and grading:	• The grade of the channel entering the level spreader should be no steeper than one percent (1%). • The level spreader should be flat (0 percent grade) to ensure uniform spreading of storm runoff.
Protecting the level lip:	The level lip may be protected with an erosion stop and jute or excelsior matting. The erosion stop should be placed vertically a minimum of six (6) inches deep in a slit trench one foot back from the crest of the level lip and parallel to the lip. The erosion stop should extend the entire length of the

DETAIL	ACTION
	level lip. Two strips of jute or excelsior matting can be placed along the lip. Each strip should overlap the erosion stop by at least six inches.
Maintenance and access:	• The level spreader should be checked periodically and after every major storm. • Any detrimental sediment accumulation must be removed to maintain flow. • If riling has taken place on the lip, the damage should be repaired and re-vegetated as soon as possible to prevent scouring. • Grass should be mowed occasionally to control weeds and encroachment of woody vegetation. Clippings should be removed and disposed of outside the spreader and away from the outlet area. • Fertilisation should be done as necessary to keep the vegetation healthy and dense. • The spreader should be inspected after every runoff event to ensure that it is functioning correctly.

SECTION 23 - RAINWATER TANKS

Rainwater tanks (RWTs) are an effective tool for managing stormwater runoff. In addition to capturing and storing rainwater, they can help reduce the volume of stormwater entering downstream treatment systems and contribute to meeting overall stormwater quantity targets for a development. In MUSIC, the rainwater tank node should be used to simulate water balance within the tank and to estimate pollutant reduction through processes such as sedimentation and reuse. Tables 29 and 30 summarise typical residential occupancy rates and rainwater tank demand patterns across NSW.

Table 29. Typical residential occupancy rates in NSW (Australian Bureau of Statistics, 2021).

Development Type	Size	Occupancy (People per Dwelling)		
		Permanent Residential	Holiday Accommodation	
		Average	Peak	Average
Detached dwelling or townhouse	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

	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
Units	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
Hotels / motels	Standard room		2	0.8
	Family room		4	1.1

Table 30. Typical rainwater tank demands in NSW (Sydney Water).

Use	**Unit**	**Per Capita Internal Water Demand (Litres per person per day*)**			
		Standard Residential	Some Water Saving Devices	Most Water Saving Devices	Full Water Saving Devices
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, AND TOWNHOUSES					
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					

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

SECTION 24 - WSUD SAFETY, ACCESS, AND MAINTENANCE REQUIREMENTS

When designing a WSUD asset(s) intended to be handed over to Council, applicants must ensure that the specifications outlined in the following sections are incorporated into the WSUD designs.

24.1 Developer maintenance period and inspections

- All constructed assets that will be transferred to Council shall be maintained for a period of no less than three (**3**) years post practical completion. The developer shall be responsible for the maintenance and functionality of the WSUD measures for a period of three (**3**) years from the issue of the Subdivision Certificate, or once **80%** of the dwellings have been completed. This includes any constructed items and vegetation installed as part of the WSUD measures. This ensures that the WSUD treatment measures are not commissioned until most of the development's infrastructure is completed, and the landform is stabilised. If the development is staged, sacrificial zones must be included in the design and rectified upon completion of development within the catchment.
- Inspections by Council Officers may be held at any point during the construction and 3-year maintenance period of WSUD assets.
- An inspection will also be held on completion of the 3-year maintenance period and prior to the transfer of ownership. If the asset is not of an acceptable standard or does not comply with Council's planning policies, the asset shall be rectified at the owner's cost. This may also include the extension of the required maintenance period.

24.2 WSUD Safety requirements

- Handrails or other approved fall protection measures shall be included into areas accessible to foot traffic, where a potential fall height greater than 900 mm exists, or where water is frequently retained to a depth greater than 100 mm. Any handrails, or other fall protection measures must not conflict with plant movements required for maintenance.
- Appropriate signage is required to identify risks (for example deep water, use of recycled water, confined spaces etc.) Warning signs should be easily understood by children. Water depth markers can be used to inform people of the depth of water that could be expected to occur at that location during rainfall or flood events. This is particularly useful in locations where sudden drops along the waterway or embankment areas occur. Other hazards associated with stormwater inlets, such as confined spaces and fall from heights, should be considered for signage as they can also lead to injury or drowning at those locations. See Council's latest version of the WSUD Engineering Series for more information about safety signage design.
- No formal access to water will be permitted unless appropriate safety benching is provided. At a minimum safety edging must be installed where ponded water depths exceed 300 mm deep.
- As swales are typically accessible to the public, the combined depth and velocities need to be from a public risk perspective. To avoid people being swept away by flows along swales, a velocity–depth product checks must be performed for design flow rates (see Institution of Engineers 2001, Book VIII Section 1.10.4 – Note: 0.35 m2 /s is used in the Melbourne Water region).
- Exclusion bars preventing entry into drainage systems must be installed where the headwall pipe is ≠ 125mm (i.e., child's head size), or where advised by Council. The effective area of exclusion

bars should be a multiple of the culvert area needed to pass the design flood and as large as reasonably practical (see example in Figure 22). The multiple should be a minimum of four (4x) for exclusion bars with a 125 mm bar spacing, and larger if debris load could be heavy or the screen could block before operatives are able to mobilise and remove material. Where practical, inlet exclusion bars should be located and designed such that flow velocities through the 'clean' exclusion bars will be low enough (typically equal to or less than 1 m/s) to allow a person to egress from the structure. All materials must be constructed to be sufficiently robust to withstand routine debris cleaning and possible vandalism, although narrow bars are preferable due to the less impact on hydraulic performance.

- If fences are considered for a safer design measure, residual risk posed because of blockage and subsequent flooding should be assessed as a separate risk assessment. For guidance on assessing blockage, refer to the Australian Rainfall and Runoff – A guide to flood estimation Book 6, Chapter 6 (Ball, et al. 2019). The location and type of fencing needs to consider all potential overland flow paths it may intercept. Any fence across a flow path will act like a trash rack, so either design it to handle the debris, or put pollution removal treatment works in front of it. In Wollongong, safety fences must be designed as a minimum to the standard specified in AS 1926.1 Swimming Pool Safety: Part 1 Safety Barriers for Swimming pools. These standards are designed to avoid pool related drownings by restricting entry by young children and is considered applicable for the management of injury or drowning because of entry to a stormwater inlet or approach flows. Deliberate access and vandalism should also be considered.

Figure 19.Example of outlet exclusion bar design (Powell, 2020).

Notes:

- Handrails or other approved fall protection measures shall be included in areas accessible to foot traffic and where a potential fall height greater than 900mm exists, or where water is frequently retained to a depth greater than 100mm. Removable handrails, gates etc. are not Acceptable unless subject of a specific approval from Council.
- Individually fixed exclusion bars are not considered safe and must be avoided.

24.3 WSUD access and maintenance requirements

When designing a WSUD system intended for transfer to Council ownership following the three-year establishment, maintenance, and water validation period, applicants must ensure the system complies with Council's access and maintenance requirements outlined below:

- Any WSUD structure proposed for dedication to Council must be free from legal, practical, physical, or structural impediments that could hinder future access and maintenance.
- All areas to be trafficked by maintenance plant shall have subgrade bearing condition greater than 75kPa at the time when maintenance is likely to occur, noting that in cases of reactive maintenance this is generally during or shortly after rainfall and high creek flows. Where natural subgrade is proposed to be retained, design must demonstrate soil moisture controls adequate to ensure the required bearing condition will be achieved during periods of wet weather and high creek flows.
- All areas to be trafficked by maintenance plant shall have a surface treatment suitable to resist maintenance plant loads for a design life of not less than twenty years. Vertical point loads from plant shall be considered as well as slewing, turning and skid steer forces on pavement surfaces. In most cases areas which will be subjected to frequent turning, traction on grade, collection of materials for loading, or other destructive forces, will need to be concrete for durability considerations. In other areas compacted rock pavement surfacing or approved alternative may be suitable.
- In addition to vehicle and service loads, any areas to be paved for maintenance access shall be designed to resist hydraulic forces and small-scale geomorphology. In most cases this consideration will apply to ramps and tracks below top of bank and would most efficiently be addressed by consideration of where to locate such structures with respect to anticipated flood behaviours, and by provision of ancillary features such as scour protection and energy dissipation.
- Where it is not possible to design a structure to suit maintenance by a 4 to 10-ton excavator, the largest permissible excavator to be assumed for maintenance shall be a 13.5-ton to 20-ton excavator. WSUD designers shall determine the suitable maintenance plant from those identified above with reference to anticipated debris loading. Note that all anticipated debris loading shall be determined by analysis of a reference reach, application of the ARR&R debris estimation procedure, or other approved methodology such as a depth marker.
- If a structure is proposed which cannot be maintained by the plant nominated above (such as Long Reach Excavators, Combo Unit Sucker Truck or a Grab Truck), this shall not be acceptable unless subject of a specific approval from Council with demonstrated reach and access requirements.
- In areas where longitudinal gradients are steeper than 1v in 10h, the width of access track shall be at least 3.5 - 4 meters.
- In areas where it is reasonable to anticipate slippery surface conditions during maintenance, the track width must be four metres. As a minimum this shall include all areas to be used for transport of wet materials including access tracks between collection areas and dewatering areas. Structural grassed cells may also be an option for maintenance with Council approval.
- In areas where longitudinal gradients are steeper than 1v in 10h, a permanent and durable tractive surface shall be provided. The tractive surface shall be designed to facilitate plant movements and promote traction in wet and muddy conditions (see Figure 201). In most cases

slab rebating (like a boat ramp) is suitable. Any tractive surface detailing must be designed to drain freely towards creek. Alternative tractive treatments such as stencilling, exposed aggregate, or post fixed surface features shall not be acceptable unless subject of a specific approval from Council.

- All access tracks and surround shall be graded to drain towards the creek, waterway or basin area.
- Where maintenance by an excavator or backhoe is proposed, the designer must allow for the plant to be located no closer than 1 metre from the top of any embankment or retaining structure. The designer shall assess visibility from the operator's point of view, the area to be excavated must be clearly visible from the position of the plant operator. Provision of sloping or raked retaining walls rather than vertical can improve visibility in some cases.
- Where sediment material is proposed to be collected by a bobcat or backhoe loader, a concrete wall shall be provided for the operator to push material against. This wall shall be appropriately designed to withstand impact forces and surface damage associated with the proposed maintenance actions.
- Any elements of proposed structures, or supplementary features in the vicinity of areas to be used for maintenance shall be considered in SiD risk assessments to determine the likelihood and consequence of impact loads from plant operating in slippery and unevenly graded conditions. Control measures must be developed to secure these features against damage during future maintenance and provided to Council.
- Safe entry, exit, manoeuvring and parking areas must be located and configured in such a manner that traffic control is not required for planned maintenance / rectification activities. All entry, exit, manoeuvring and parking areas into a WSUD system shall include provisions to deter unauthorised access, or interruptions to the public and include safety signage.

Figure 20. Example of local complaint tactile slab surfacing for lower gradients including turning area at the top of the bank.

24.4 Dewatering and stockpiling area requirements

- Where the removal of spoil such as deposited sediment or woody debris is likely to occur during maintenance, a dewatering area must be provided . Council will accept a grassed area at least 30 m2, though the base of dewatering areas should be concrete or other approved material suitable to withstand plant manoeuvring and loading of dewatered materials for a design life of not less than twenty years (See Figure 21 for a compliant example).
- Any dewatering location must be above the highest top of bank of the low flow channel and away from any surface depressions or overland flow paths.
- The dewatering area shall drain freely toward creek and include permanent provisions designed to allow easy fitting, maintenance, and removal of water quality controls such as filters and bunding. Such condition can be achieved by provision of a concrete mass block cordon on the downslope side of dewatering areas with gaps between blocks allowing a geofabric bund to be easily deployed over blocks. Alternative arrangement for specific sites shall be discussed with Council referencing information about maintenance frequency and spoil volumes.
- Dewatering areas shall be located immediately adjacent to truck parking areas to allow ease of loading. Where it is not possible to locate dewatering areas adjacent to truck parking the site shall be designed to minimise the distance spoil is to be transported during loading.
- All manoeuvring and access shall be detailed in accordance with design criteria identified in this Guidebook and Council's WSUD Engineering Drawings 2025.
- Any turns or grade changes shall be designed to suit Council's plant requirements.
- Dewatering areas must be situated where they are within easy reach of the assumed maintenance plant conducting spoil removal. For instance,
    - Where an excavator is proposed, dewatering area shall be immediately adjacent to excavator maintenance parking so that an excavator can remove spoil from the waterway and deposit spoil into the dewatering area without moving the excavator, or,
    - Where bed level access by bobcat or backhoe is proposed the dewatering area must be located as close as possible to bed level areas to be maintained and to minimise the requirement for the loader to travel up and down ramps. In most cases a configuration allowing the loader to place materials in a dewatering area which can be reached by an excavator for loading into a truck is most advantageous.

Figure 21. Example of a compliant stockpiling area (JJ Kelly Park – Wollongong).

24.5 Bed slab and inlet design requirements

- Any culvert installation must include concrete slabs at bed level.
- No rip rap or rocks are to be placed within 3 metres of a concrete apron to allow for cleaning.
- In Wollongong, all concrete slabs/ inlet areas must:
  - Extend a minimum of 3m length, or 1.5 times smallest dimension of culvert opening, whichever is greater.
  - Be structurally connected to headwall and appropriately founded.
  - Include a 'cut off wall' or similar system to prevent percolation of flows beneath culvert.
  - Be at least 200 mm thick.
  - Not interface with headwall and both wings continuously.

24.6 Guidance on provision of debris control structures

A permanent debris control structure (DCS) shall be provided on the upstream side of culvert or bridge crossings where the following conditions apply -

- Where the culvert/bridge is proposed to replace an existing crossing where substantial blockage has occurred in the past. Developer shall consult with Council for advice on site history and suitable debris control regime.
- Assessment and approval will be required for DCS installations in key fish habitat areas.

Notes:

- In cases where the above is not applicable the developer shall undertake and document a debris control assessment in accordance with the AR&R procedures before consulting with Council to determine a suitable debris control regime. The final determination as to whether debris control is needed for a particular site shall rest with Council.
- Assessment and approval may be required for DCS installations in key fish habitat areas.

24.7 Guidance on provision of 'contingency lands'

In cases where a debris control device is proposed to be excluded, the developer shall retain public land to allow for future construction of debris control or maintenance support facilities this land shall:

- Extend in length at least 10 meter upstream and 6 meter downstream of the proposed culvert/bridge measured from the outer edge of bridge deck or culvert headwall.
- Include a 3.5 - 4-metre-wide strip from each highest top of bank (design top of bank).
- Not include land outside the provisions above, unless expressly approved by Council.
- Be continuously connected to the road reserve and free from legal or practical constraints which could impede future provision of maintenance support infrastructure.

Note: Acceptance of 'contingency lands' for the purpose of bridges / culverts shall remain at Council's discretion.

24.8 Abutment protection and training works

Abutment protection and training works are required for all bridge approaches and culvert approaches unless otherwise expressly approved by Council. If approved, they must -

- Be designed and certified by appropriately qualified civil engineer.
- Constructed in accordance with Council subdivision code.
- Are not constructed using gabion systems.

Notes:

- All outlet pipes into wetlands and ponds must be securely integrated with concrete into the system up to the headwall or outlet, rather than being placed on riprap. This approach prevents settling issues and ensures greater structural stability for the outlet system.
- For minor outlets discharging into wetlands, the design must include provisions to prevent future backwater problems. All outlets must be installed at elevations higher than the anticipated water level, with riprap used as an energy dissipater downstream. This configuration minimises the risk of blockages or backflow, particularly in hard-to-access piping, ensuring optimal performance and longevity of the system.

SECTION 25 - LANDSCAPING

Wollongong has a rich cultural heritage, and we strongly encourage applicants to incorporate the principles of the Connecting with Country framework (2023) during the design and landscaping phases of WSUD projects within the LGA. This NSW Government framework provides guidance on embedding Aboriginal cultural values and knowledge into planning and design, promoting a Country-centred approach that respects and cares for land, water, and community. It emphasises collaboration with Aboriginal people, recognising that if we care for Country, Country will care for us. The following sections outline the recommended approach for the landscaping phase of a WSUD system. For detailed landscaping requirements specific to Wollongong, refer to Council's DCP *Chapter E6: Landscaping*.

25.1 Equitable access design principles for WSUD infrastructure

- Ensure all WSUD elements (e.g. swales, wetlands, rain gardens) are connected via uninterrupted paths that comply with AS 1428.1 standards.
- Paths should be firm, stable, slip-resistant, and wide enough for mobility aids.
- Avoid abrupt level changes; use ramps with compliant gradients and landings.
- Provide clear, legible signage with tactile and braille elements where appropriate. Signage should be positioned at accessible heights and include wayfinding to key WSUD features and amenities.
- Install seating with backs and armrests at regular intervals along accessible paths. Ensure seating is in shaded areas and near WSUD features to encourage rest and engagement. Design safety benches or barriers around water bodies to prevent falls, especially for people with vision or mobility impairments. These should be visually contrasting and detectable by cane or tactile indicators.
- Provide accessible platforms or edges for viewing water features, educational signage, or interactive elements. Ensure these areas are safe and allow for wheelchair turning space.
- Design WSUD elements to avoid entrapment zones or steep drop-offs.

- Align WSUD infrastructure with Council's Disability Inclusion Action Plan and Positive Ageing Plans to ensure consistency across public spaces. For further guidance on equitable and inclusive design, refer to Chapter E1 – Access for People with Disability in Council's Development Control Plan (DCP).

25.2 Soils

- For landscaping, soil preparation and installation must follow best environmental practices. This includes preparing soil survey reports with maps and test results during the design phase, stripping and stockpiling topsoil for reuse, and evaluating the quality of local topsoil to ensure its suitability for plant growth.
- Subsoils must be deep ripped using a non-inversion plough, and stockpiled topsoil's must be reapplied. If needed, remedial works must be conducted to improve the soil's capacity to support plant growth.
- Certified imported topsoil's (certified to AS 4419-2003 – Soils for Landscaping and Garden Use) may be added as required, and the soils must be free of significant weed seed banks. For certain sites, where topsoil is absent, material may need to be imported.

25.3 Vegetation and timing for planting

- Construction planning must aim to align with the appropriate planting months (February to November for our region).
- Select Wollongong riparian and wetland species (planted at a minimum of eight (plants per square metre (8p/m2)) which are suited to our local conditions that help maintain media conductivity and nutrient uptake.
- Only approved local plant species may be used with the recommended planting species and densities are available in table 31in this Guidebook.
- No trees or shrub species are to be planted within a 2 m circumference of a WSUD assets, culvert, access or maintenance area. This ensures that roots and trees to not cause damage to the infrastructure, cause flow issues and or, block maintenance and vehicle access.

Note: Appropriate riparian, macrophyte, wetland and swale plant species lists are available in table 31 in this Guidebook. The applicant must confirm the selected species list with Council well before the planting occurs.

25.4 Exotic species management

- To prevent exotic weed invasion and reduce maintenance costs, high planting density should be used.
- Biodegradable erosion control matting or seedless hydro mulch can be applied to swale batters for short-term erosion and weed control.
- Developers must be aware that wild deer have been a longstanding pest species in Wollongong, particularly in the suburbs near the escarpment. Deer cause damage to natural areas, habitats and both public and private properties, including fences, waterways and livestock. They also pose a risk to vehicles and trains. Developers are advised to take precautions to prevent deer damage to vegetated areas
- Conventional surface mulching with organic material must be avoided in swale or filter strip systems, as organic mulch can float and wash away, potentially causing drain blockages. A simple yet effective method to combat weed invasion and reduce costly maintenance is to use high planting density rates. This Strategy helps create dense vegetation that outcompetes weeds for resources, reducing the need for frequent weed removal.

25.5 Preferred Planting list for WSUD

It is essential that developers installing vegetation as part of a WSUD system use plant species that are endemic to the local area. Table 39 provides guidance on selecting appropriate species and locations for installation within a WSUD system.

Table 31. Guidance on selecting the right local plant species for WSUD systems

Common name	Species	Type of vegetation	Recommended plant density (per m^2)	Location
Kenda and village green	*Kikuyu*	Spreading grass h 0.15	5-8 sods	Swales & batters
Santa anna	*Couch*	Spreading grass h 0.15	5-8 sods	Swales and batters
Empire and nara native	*Zoysia*	Spreading grass h 0.15	5-8 sods	Swales & batters
Palmetto and sapphire	*Soft leaf buffalo*	Spreading grass h 0.15	5-8 sods	Swales & batters
Blue fax-lily	*Dianella caerulea*	Spreading grass h 0.60	6-8	Batters
Carex	*Carex appressa*	Tussock grass h 1.0	6-8	Bioretention basins, wetlands & batters
Grey tussock grass	*Poa sieberiana*	Tufted perennial h 1.0	6-8	Batters, Bioretention basins & wetlands
Kangaroo grass	*Themeda australis*	Tufted grass h 1.2	6-8	Batters & Bioretention basins
Mat rush	*Lomandra longifolia*	Tufted perennial h 1.5	6-8	Bioretention basins, batters & wetlands
Stout bamboo grass	*Austrostipa ramosissima (stipa ramosissima)*	Upright branching grass h 1.5	6-8	Batters
Tussock grass	*Poa labillardierei var. Labillardierei*	Tufted perennial H 1.2	6-8	Bioretention basins, batters & wetlands
Fairy fan flower	*Scaevola aemula*	Sprawling herb H 0.50	6-8	Batters
Native violet	*Viola hederaccea*	Dense mat H 0.10	10-12	Batters
Warrigal spinach	*Tetragonia tetragonioides*	Spreading plant H 0.20	8-10	Basins & batters
Weeping grass	*Microlaena stipoides*	Spreading grass H 0.30	10-12	Batters
Coastal saltbush	*Rhagodia candolleana*	Low spreading shrub H 1.0	1-2	Batters
Toothed daisy bush	*Olearia tomentosa*	Low shrub H 0.60	1-2	Bioretention basins & batters

Common name	Species	Type of vegetation	Recommended plant density (per m²)	Location
Coastal rosemary	*Westringia fruticosa*	Rounded shrub H 1.5	1-2	Batters
Striped wallaby grass	*Austrodanthonia racemosa var racemosa*	Tufted perennial H 0.60	8-10	Batters
Australian indigo	*Indigofera australis*	Spreading shrub H 1.5	1-3	Batters
Hop goodenia	*Goodenia ovata*	Upright prostrated shrub H 1.5	1-3	Batters
Tassel sedge	*Carex fascicularis*	Tufted sedge H 1.0	8-10	Bioretention basins & wetlands
Slender knotweed	*Persicaria decipiens*	Trailing plant H .30	8-10	Bioretention basins & wetlands
Common rush	*Juncus usitatus*	Short clumping perennial H 1.0	8-10	Bioretention basins & wetlands
Club rush	*Ficinia nodosa*	Clumping perennial H 1.0	8-10	Bioretention basins & wetlands
Swamp hibiscus	*Hibiscus diversifolius*	Prickly shrub H 2.0	1	Batters
Blue flax-lilly	*Dianella caerulea*	Clumping perennial H .75	6-8	Batters
Swamp lilly	*Crinum pedunculatum*	Bulbous perennial H 2.0	1	Batters & bioretention basins
Dune fan flower	*Scaevola calendulacea*	Prostrate shrub H 0.40	6-8	Batters
Crimson bottlebrush	*Callistemon citrinus*	Bushy shrub H 3.0	1	Batters
Native broom	*Viminaria juncea*	Slender shrub H 3.0	1	Batters
Red flowered paperbark	*Melaleuca hypericifolia*	Dense shrub H 3.0	1	Batters
Blady grass	*Imperata cylindrica*	Clumping perennial H 1.0	8-10	Wetlands, bioretention basins & batters
Barb wire grass	*Cymbopogon refractus*	Clumping perennial H 1.0	8-10	Bioretention basins & batters
Marine couch	*Sporobolus virginicus*	Creeping perennial H 0.70	6-8	Bioretention basins & batters

Common name	Species	Type of vegetation	Recommended plant density (per m²)	Location
Marsh club-rush	*Bolboschoenus fluviatalis*	Aquatic perennial H 2.0	6-8	Wetlands & bioretention basins
Floating primrose-willow	*Ludwigia peploides*	Aquatic perennial H 0.60	5-10	Wetlands
Bog bulrush	*Schoenoplectus mucronatus*	Aquatic clumping perennial H 1.0	5-10	Wetlands
Red water milfoil	*Myriophyllum verrucosum*	Aquatic herb H 0.20	5-10	Wetlands
Narrow-leaved brown sedge	*Carex brunnea*	Clumping sedge H 0.60	5-10	Bioretention basins & batters
Sandfly zieria	*Zieria smithii*	Spindly shrub H 2.0	1-5	Batters
Longhair plumegrass	*Dichelachne crinita*	Tufted perennial H 0.80	8-10	Batters
Soft twig rush	*Baumea rubiginosa*	Tufted perennial H 2.0	8-10	Wetlands
Indian weed	*Sigesbeckia orientalis*	Annual herb H 1.0	8-10	Batters
Bacopa	*Bacopa monnieri*	Sprawling groundcover H 0.10	8-10	Batters & wetlands
Common sedge	*Carex longebrachiata*	Clumping sedge H 0.40	8-10	Bioretention basins, batters & wetlands
Starfruit	*Damasonium minus*	Patchy aquatic 0.60	1-5	Wetlands
Spotted knotweed	*Persicaria strigosa*	Creeping aquatic herb H 0.50	8-10	Wetlands & bioretention basins
Frogsmouth	*Philydrum lanuginosum*	Strappy aquatic H 0.50	1-5	Wetlands

- 'H' refers to the plants mature height (m).
- The plants in this list have been selected specifically for the Wollongong LGA.
- Alternative local species may be considered, subject to Council approval.

SECTION 26 - VALIDATING WSUD ASSETS

26.1 Construction and inspection of WSUD assets

- Council Officers may inspect connections to Council's pipelines and underground infrastructure at any stage of the development.
- Council and its authorised representatives have full and unrestricted rights to enter the burdened lot to inspect, maintain, clean, replace, or repair any grates, pipes, pits, kerbs, tanks, gutters, or other structures, and to alter surface levels as necessary to ensure the WSUD system operates in accordance with the approved Construction Certificate.
- Works for Council owned infrastructure, or infrastructure that will revert to Council ownership must be inspected by a Council inspector, prior to pipe backfilling and following surface restoration.
- A final inspection of the WSUD system(s) shall be conducted by the accredited certifier, prior to issuing the relevant Compliance certificate and must comply with the requirements in Section 23 of this Guidebook.

Note: Council has developed a range of resources such as design, construction, and hold point checklists and maintenance schedules to support developers and ensure compliance which are available upon request.

26.2 Compliance certificate requirements

Certification of WSUD compliance must be prepared and signed by the original design consultant, and must include the Works-As-Executed drawings and final handover inspection. This certification is required prior to the release of any security deposits.

At a minimum, the Compliance Certificate shall include -

- Certification that the built WSUD management measures will function in accordance with the approved design.
- Identification of any variations from the approved design and their impact on the WSUD systems performance.
- Certifications that all wastewater, rainwater and stormwater re-use systems comply with relevant legislation and guidelines (where applicable).

26.3 Water quality validation

The purpose of validating WSUD measures is to confirm that the implemented actions are achieving their intended design objectives, as outlined in the approved WSUD Strategy.

At a minimum, validation of WSUD systems must include the following -

- To ensure a WSUD measure performs effectively and meets the required pollution reduction targets, its nutrient removal performance must be validated over a **two-year** period. This water sampling period should commence after the system is activated, either one year following the completion of 80% dwellings, or the issuance of the Subdivision Certificate, allowing sufficient time for vegetation to be established.
- Water quality testing will involve sampling both the **inflow** (at the inlet or upstream) and **outflow** (at the outlet, stormwater system, or downstream waterway).
- At the conclusion of the **two-year** water monitoring phase, and prior to Council handover, applicants must submit a monitoring report that includes, at a minimum, the following:

a) A summary of technical findings in simple terms and whether the WSUD measures meet the water quality targets listed in the consent conditions.

b) Detailed results, with any exceedances of the water quality targets listed in the consent conditions highlighted.

c) Discussion of results, conclusions, and recommendations for future work.

d) Appendices with laboratory reports, data tables, and any other related information.

Notes:

- At the conclusion of the 3-year maintenance and 2-year water quality monitoring period, the lot must be dedicated to Council prior to any bond being released.
- It is recommended that proponents meet with Council shortly after water monitoring has begun (e.g., after the first measurable rain event >10 mm) to ensure their monitoring methods are consistent with Council's requirements, and that the monitoring locations and analytes are being monitored are acceptable. This will help to ensure the validation process is completed in a timely and cost-effective manner for the applicant.
- The inflow and, or outflow of WSUD elements (pits, pipes, culverts, channels, weirs) must be designed to facilitate monitoring. For example -
  - Where inflow and outflow areas are piped, pit lids that are large enough to enable access for monitoring should be installed, and
  - Inflow and outflow channels should be designed with safe access and exit points for water sampling.
- The WSUD design should consider all water sources that will potentially influence the WSUD element, such as surface water runoff, piped inflow, and groundwater. For example -
  - Where possible, consolidate multiple piped inflows and outflows into a single piped flow to simplify monitoring requirements.
  - Where automatic samplers are installed, the inflow and outflow design should consider the incorporation of pits to accommodate the monitoring equipment and minimise vandalism.

SECTION 27 - HANDOVER OF WSUD ASSETS

This section applies to WSUD assets that are intended to be transferred to Council following the completion of the establishment and maintenance periods. Wollongong City Council will not accept transfer of land containing WSUD infrastructure or assume responsibility for any WSUD assets unless all the following conditions are met:

1. Before the issue of any subdivision certificate, occupation certificate or upon completion of work, any related or relevant certificates and plans must be lodged in accordance with Council's requirements and in formats acceptable to Council.

2. All WSUD measures are constructed and operate in full compliance with the approved design specifications, parameters, and any other design agreements previously entered with Council.

3. The performance of the WSUD measures has been validated through the submission of a water quality validation report confirming their operational effectiveness.

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

5. A comprehensive handover inspection has been carried out to identify defects, and any such defects have been rectified to the satisfaction of Council.

6. The WSUD infrastructure is structurally, or geotechnically sound, supported by documentation certifying such from suitably qualified professionals.

7. Works as Executed (WAE) drawings for all WSUD infrastructure have been submitted, in a format and level of accuracy deemed acceptable by Council. Works as executed drawings are required for all WSUD measures. Such drawings must include storage capacities and finished and invert levels of the constructed system. All works as executed drawings must be submitted as per Wollongong City Council's most recent issue Design and Technical Services Drafting Standards (Ref 513).

8. Where built systems vary significantly from approved design plans, a suitably qualified engineer shall certify that the constructed system satisfies Council's requirements as per the WSUD Strategy, WSUD Guidebook for Developers and WSUD Engineering Series 2025 and shall submit all supporting calculations leading to this assertion.

9. Relevant digital files, including design drawings, surveys, bathymetry, models, and other pertinent documentation, have been provided in formats acceptable to Council.

10. Landscape designs, particularly those detailing the distribution of functional vegetation (i.e., vegetation that contributes to water quality improvement), have been submitted.

11. Where applicable, the condition of the infrastructure and the associated land is satisfactory to Council, which includes well-maintained open space, boardwalks, viewing platforms, and other related features.

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

13. The vegetation establishment period specified in the development consent has been successfully completed (typically three years).

14. Vegetation associated with the WSUD system has been installed in accordance with Council's requirements.

15. The presence of exotic vegetation does not exceed more than 15 per cent, per square metre (15% p/m^2) in bio-retention/filtration, vegetated swales, wetlands and other vegetated WSUD elements.

16. No trees or shrubs have been installed or have naturally been established within a two-metre radius of a WSUD access/maintenance area, pipe inlets and/or outlets.

17. Must meet Council's maintenance and access requirements as outlined in the latest versions of Council's WSUD Guidebook for Developers and the WSUD Engineering Drawing Series.

18. A finalised operation and maintenance manual must be provided for each WSUD measure

prior to handover. The operation and maintenance manual must include all the controls necessary to ensure future maintenance activities do not require discrete approvals processes (e.g., a review of environmental factors) under the codes and legislation at the time of design. At a minimum, the provided operations and maintenance manual shall address the following:

i) access from road,

ii) traffic and pedestrian management requirements,

iii) the measures taken to ensure public safety (including any signage and the type and locations of any fall protection measures),

iv) a Safety in Design (SiD) risk assessment for all maintenance activities,

v) unauthorised access prevention,

vi) environmental constraints,

vii) vehicle movements plan for maintenance (plan to show all dimensions, levels, grades, pavement type and surface treatments of areas to be subject to vehicle movements), and

viii) past maintenance measures (including cleaning frequency, kilograms of sediment materials removed from the site, costings to maintain and manage the WSUD measures over the three (3) year maintenance period).

19. All-development conditions relating to the WSUD measure have been complied with.

20. There are no ponding, pooling or backflow issues.

SECTION 28 - GLOSSARY AND ACRONYMS

ARI – Annual recurrence interval

Detention is the temporary storage of stormwater generated within an allotment. This restricts the discharge from the site to a predetermined rate to reduce flooding both in the local drainage system immediately downstream of the site and along the creeks and watercourses further downstream.

Dry or ephemeral detention basins are depressions that temporarily hold stormwater and release it at a slower rate than it comes in. They reduce flow velocities and so help prevent downstream erosion. They also reduce downstream flow rates. Dry or ephemeral detention areas improve stormwater quality primarily by allowing sedimentation of particle-based contaminants. They are termed 'dry or ephemeral' as their lowest point is located above the maximum groundwater level. They drain after each storm event to provide the full storage volume for the next one.

Erosion means the process by which the detachment, entrainment, suspension, and transport of soil occurs by wind, water, or gravitational effects. Erosion leads to sedimentation.

Erosion and sediment control plan means a plan as described in 'Managing Urban Stormwater: Soils and Construction' prepared by Landcom (the Blue Book) (as amended from time to time).

Gross pollutants include for example: trash, litter, and vegetation.

Gross pollutant trap (GPT) is a device that traps and removes litter and sediments greater than five (5) millimetres in size from stormwater runoff. By removing large pollutants, downstream treatment of stormwater can occur more effectively.

Groundwater management system means the processes or practices used to control groundwater.

Impervious areas mean areas which have no or extremely limited ability to transmit fluids from the surface through to the subsurface. Impervious areas occur where the soil surface is sealed, eliminating rainwater infiltration and natural groundwater recharge. They consist of artificial structures such as pavements, rooftops, sidewalks, roads, and parking lots covered by materials such as asphalt, concrete, brick, and stone. Soils compacted by urban development are also highly impervious.

Impervious surfaces are the hard surfaces (for example roofs and pavement) within a catchment.

Managing Urban Stormwater: Soils and Construction (the Blue Book) refers to the document dated 2004 and developed by Landcom. This is commonly referred to as the Blue Book as amended or superseded.

Model for urban stormwater improvement conceptualisation (MUSIC) is a modelling tool for both simple and overly complex urban stormwater systems using WSUD.

Non-potable water means water that is not fit or suitable for drinking and consumption purposes but may be used for purposes such as laundry, toilet flushing and air conditioning cooling towers. Non-potable water can be sourced from rainwater, stormwater, and recycled sewage. The source determines appropriate uses, with rainwater having more fit-for-purpose uses than the other two sources, subject to treatment methods.

Potable water refers to water that is safe for human consumption and can be used for drinking, cooking, and personal hygiene. Potable water must meet strict safety standards set out by the Australian Government.

Rainwater tank means a reservoir or container that is used to collect and store (harvest) rain that runs off impervious surfaces such as roofs, via gutters and downpipes.

RWT – Rainwater tank.

Sediment means material of varying size, both mineral and organic, that is being or has been moved from its site of origin by the action or wind, water or gravity and comes to rest.

Sediment forebay is an impoundment, basin or other storage structure designed to dissipate the energy of incoming runoff and allow for initial settling of coarse sediments. Forebays are used for pretreatment of runoff prior to discharge into the primary water quality treatment structure.

Sedimentation means the deposition of sediment, usually in locations such as a channel, along a fence line, in an area of low slope, depression, watercourse or sediment trap.

Soil means a natural material consisting of layers, amalgamates or individual particles or mineral and/or organic constituents, of variable thickness. It differs from its parent material in morphological, physical, chemical, and mineralogical properties and biological characteristics.

Stormwater harvesting and reuse scheme means a process of collection, treatment, storage, and use of stormwater.

Stormwater management means the processes or practices used to control stormwater.

Stormwater treatment measure means both hard and soft engineering practices that treat and improve the quality and quantity of stormwater.

Subsoil drainage means drainage of the layer of soil under the surface of the ground.

TSS – Total suspended solids

Total nitrogen (TN) is the sum of the nitrogen present in all nitrogen-containing components in the water column. This includes large and small phytoplankton and zooplankton, suspended microphytobenthos, dissolved inorganic nitrogen (nitrate and ammonia), dissolved organic nitrogen, labile detritus (both at the Redfield ratio and the Atkinson ratio) and refractory detritus. Total nitrogen concentration is determined by a balance between inputs (diffuse catchment loads, point source loads) and loss terms (export from the site to a watercourse and within the sediments).

Total phosphorous (TP) is the sum of the phosphorus present in all phosphorus-containing components in the water column. This includes large and small phytoplankton and zooplankton, suspended microphytobenthos, dissolved inorganic phosphorus (both absorbed and desorbed), dissolved organic phosphorus, labile detritus (both at the Redfield ratio and the Atkinson ratio) and refractory detritus. Total phosphorus concentration is determined by a balance between inputs (diffuse catchment loads and point source loads) and loss terms (export from the site to a watercourse and within the sediments).

Total suspended solids (TSS) are a measure of the mass of solid material (organic and inorganic) suspended in the water column. Suspended solids can include a range of inorganic and organic particles suspended in the water column which can be defined as the filterable residue retained on a 2.0-micron pore size filter dried at 105oC.

Water sensitive urban design (WSUD) is a philosophy which aims to mitigate environmental impacts particularly on water quantity, water quality and receiving waterways, conventionally associated with urbanisation. WSUD incorporates holistic management measures that consider urban planning and design, social. cultural and environmental amenity of the urban landscape and stormwater management which are integrated with stormwater conveyance by reducing peak flows, protection of natural systems and water quality, stormwater reuse and water conserving landscaping. This can be achieved through a design approach that strives to maintain or replicate the natural water cycle through an incremental "treatment train" approach, through the optimisation the use of rainwater on-site whilst minimising the amount of water transported from the catchment.

WSUD measure, device, or system refers to any, or all the components of a stormwater management system, as outlined in this Guidebook under the framework of WSUD. These components can include, but are not limited to, devices, infrastructure assets, technologies, or strategies designed to manage the quantity and quality of stormwater. this may encompass techniques such as rainwater harvesting systems, permeable surfaces, wetlands, bi-retention systems, swales, and other infrastructure that work together to reduce runoff, enhance water quality, and promote sustainable water management practices with urban environments.

Water sensitive urban design (WSUD) Guidebook for Developers refers to the technical document developed by Wollongong City Council as amended or superseded, available on Council's website.

APPENDIX 1 - WSUD STRATEGY CHECKLIST

Table 32. WSUD DA Checklist for a WSUD Strategy Submission. Applicants must ensure the following sections are included in their WSUD Strategy:

Checklist Section	Details	Complete (y/n)?	Notes
Cover Page	Company/consultant name and contact details; Responsible individual's contact details; Project or application number		
Executive Summary	Concise summary of the report and conclusions		
Background Information	Previous or concurrent studies; Relevant maps and data		
Site Context	Catchments, drainage lines, receiving environments; Ecological values of the site and downstream areas		
Proposed Development	Site boundaries, land uses, densities, population, infrastructure, staging		
WSUD Objectives	Water quality and flow targets; Maintenance, monitoring, fail-safes, aesthetics, habitat, reuse, co-benefits		
Groundwater Report (if required)	Mitigation actions for groundwater interaction		
Constraints and Opportunities	Flooding, sensitive environments, natural watercourses		
WSUD Measures	Conceptual plans of proposed infrastructure		
Water Conservation	Potable water targets and reuse strategies		
Stormwater Management & Water Quality	Modelling results, treatment locations, retention, validation methodology		
Integration with Urban Design	Co-benefits and cultural considerations (Connecting with Country Framework)		
Costs	Capital and maintenance cost estimates		
Operation and Maintenance Plan	Inspection and maintenance requirements		
References	Source documents and modelling tools		
Appendix A	MUSIC modelling files or MUSIC-link report		
Appendix B	Conceptual layout plans, access, monitoring, safety, WSUD details		

APPENDIX 2 -WSUD HANDOVER CHECKLIST

Table 33. WSUD Handover checklist:

Checklist Item	Details	Checked (y/n)?	Notes	Hold Point / Timing
Certificates and Plans	All relevant certificates and plans lodged before subdivision or occupation certificate issuance.			Prior to subdivision certificate
Construction Compliance	WSUD measures constructed and operating in full compliance with approved design.			Post-construction inspection
Validation Report	Water quality validation report submitted confirming operational effectiveness.			End of 2-year monitoring
Sediment Build-up	Sediment build-up does not exceed 10% reduction in operational volume.			Final inspection
Handover Inspection	Comprehensive handover inspection completed, and defects rectified.			Final inspection
Structural Integrity	Infrastructure certified as structurally and geotechnically sound.			Prior to handover
WAE Drawings	Works as Executed drawings submitted with required accuracy and details.			Prior to handover
Design Variations	Significant design variations certified with supporting calculations.			Prior to handover
Digital Files	Design drawings, surveys, models, and bathymetry provided in acceptable formats.			Prior to handover
Landscape Plans	Functional vegetation distribution documented in landscape designs.			Prior to handover
Land Condition	Associated land and infrastructure in satisfactory condition.			Final inspection
Filter Media Performance	Bio-filter media infiltration rates within 10% of design parameters.			Performance testing
Vegetation Establishment	Vegetation establishment period completed (typically 3 years).			End of maintenance period
Vegetation Compliance	Vegetation installed per Council requirements.			Final inspection
Exotic Vegetation	Exotic vegetation does not exceed 15% per square metre.			Final inspection
Tree Clearance	No trees/shrubs within 2m of WSUD access/maintenance areas, culverts or stormwater inlets/outlets.			Final inspection
Maintenance Access	System meets Council's maintenance and access requirements.			Final inspection
O&M Manual	Finalised operation and maintenance manual provided with all required details.			Prior to handover
Consent Conditions	All development consent conditions related to WSUD measures complied with.			Final inspection
Water Issues	No ponding, pooling, or backflow issues present.			Final inspection

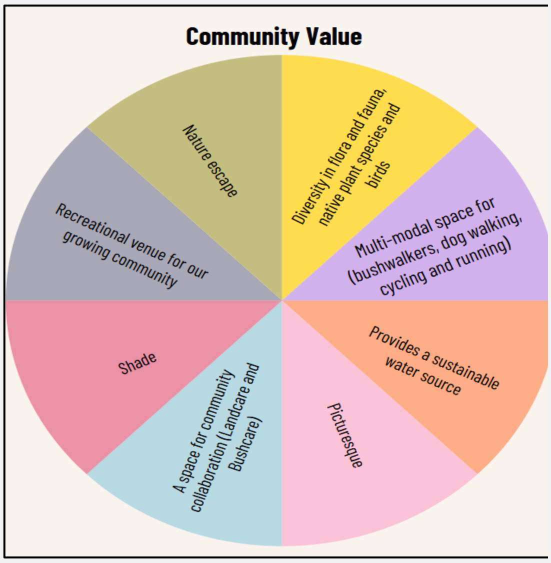
APPENDIX 3 - EXPLORING THE CO-BENEFITS OF WATER SENSITIVE URBAN DESIGN (WSUD) AT NYRANG PARK, WOLLONGONG

Nyrang Park, Keiraville.

Nyrang Park is a 4.2-hectare site highly valued by the local community. It is bounded by Gipps Road, Akuna Street, and Nyrang Street in Keiraville, NSW 2500.

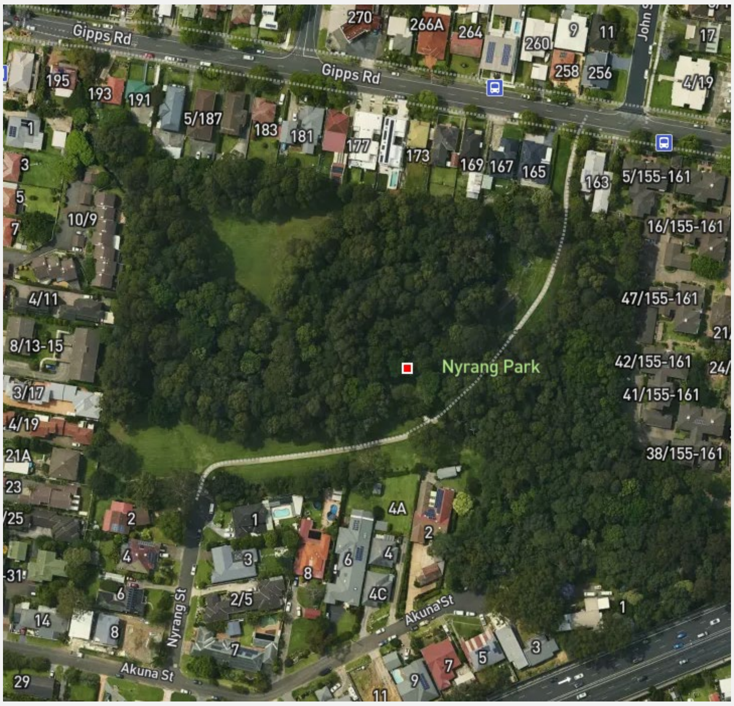
Historically, the site and its surroundings were used by First Nations Australians for sustainable living, resource gathering, and cultural practices. Later, early European settlers used the area as a rifle range and for logging and agriculture. As early as 1910, the site was known as "Dobing's Bush," renamed "Wiseman Park" in 1913, and later became known as Nyrang Park. Throughout these changes, the site has remained a place for public recreation and leisure.

The Storage Basin Project was initiated as a direct outcome of the 1991 *Fairy Cabbage Tree Creek Catchment Flood Mitigation Study*. Its purpose was to protect downstream properties from flooding during various rainfall events, particularly frequent ones. The basin includes a 3.5-metre-high embankment across the watercourse and a three-tier outlet configuration. It is designed to manage a Probable Maximum Flood (PMF), with a total storage capacity of approximately 48,000 m³, serving a catchment area of around 1.5 hectares.



Besides reducing stormwater issues, the WSUD approach at Nyrang Park offers many other co-benefits like better water quality, more biodiversity, and improved recreational areas. It's important that WSUD projects in the LGA do more than just manage stormwater. This approach supports Council's strategy for sustainable and resilient urban development.

Nyrang Park 1948



Nyrang Park 2024

CO-BENEFITS OF THE WSUD APPROACH AT NYRANG PARK

Hydrological co-benefits:

- The basin regularly detains and slows large volumes of stormwater, reducing downstream flow, erosion, and damage during major storm events.
- It supports the recharge of the local water table and groundwater systems.

Environmental co-benefits:

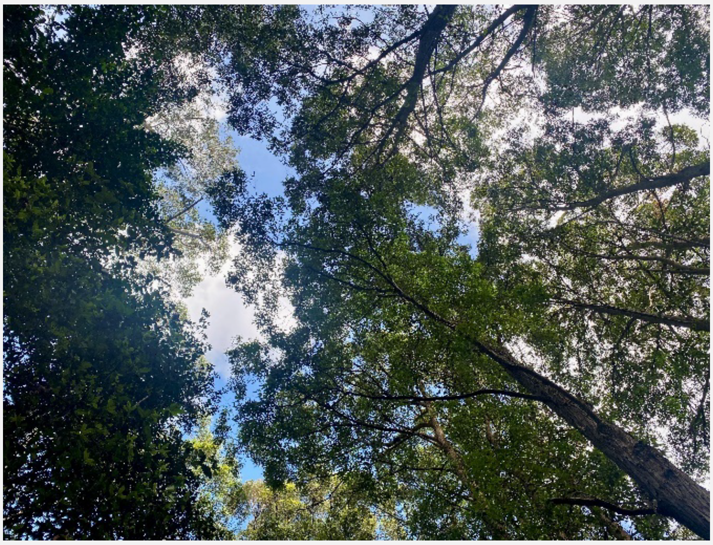
- Vegetation attracts diverse bird species and insects, while leaf litter and decomposing wood improve soil health.
- The basin floor now features rich, dark, fertile soil with improved aeration and infiltration. Native species are outcompeting most weeds, reducing maintenance needs.
- The system helps reduce air pollution and the urban heat island effect.
- It promotes biodiversity and contributes to carbon sequestration.
- Supports groundwater-dependent ecosystems

Cultural co-benefits:

- The natural waterway holds cultural significance, having served as a vital resource and gathering place for Aboriginal people. It includes elements of Dreaming Tracks that connect the escarpment to the ocean.
- The park provides cultural and aesthetic value, offering beautiful spaces for recreation and community connection, which support mental and physical well-being.
- The local Landcare group actively engages the community, educating residents about environmental stewardship.

Socio-Economic co-benefits:

- The project has increased nearby property values and reduced maintenance costs, including mowing, infrastructure upkeep, and general park maintenance. Council involvement, such as tree planting, has also decreased.
- Natural regeneration and the establishment of a tree canopy and understory have significantly reduced the need for mowing and weeding.
- The community benefits from improved health and well-being through access to walking and cycling tracks within the park.



Established trees with canopy cover help cool the area and provide essential habitat for native wildlife in urban environments

Green spaces allow the community to connect with the environment.

With thanks to dedicated volunteer efforts and Council support, this site is a rare urban example of habitat and refuge for native species like insects, birds, and lizards.

For more information:

Please contact Council's Environmental Officers on (02) 4227 7111, or send an email to council@wollongong.nsw.gov.au

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We foster a diverse economy, and we value innovation, culture and creativity
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