Water Sensitive Urban Design – MUSIC Model report

Client: Housing Plus Orange
Site Address: 10A Park Street East Maitland NSW 2323

30 April 2024

Our Reference : 40560-ER01_D

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1. INTRODUCTION

1.1 Overview

Barnson was engaged by Housing Plus Orange to undertake a stormwater management design and numerical simulation to determine stormwater runoff quality, for a development proposed at 10A Park Street East Maitland NSW 2323.

The proposed development is for a core and cluster refuge facility, which will include buildings housing administrative offices and amenities, short term residential units as well as covered and outdoor play areas and a paved parking area. In accordance with the Maitland City Council Manual of Engineering Standards (Maitland City Council, 2014), stormwater runoff from areas that may be a source of pollutants, such as roads and gardens, shall be treated to provide a means of "polishing" of the runoff prior to its discharge beyond the site. Stormwater treatment measures such as bio-retention filters, silt traps, gross pollutant traps etc, shall be employed for this purpose. Design and construction parameters for proposed stormwater treatment measures, shall be determined with recognised computer software such as MUSIC, with supporting reference made to the publication "The Constructed Wetlands Manual" (1988); Water by Design publication "Construction and Establishment Guidelines - Swales, Bioretention Systems and Wetlands"; Landcom publication "Managing Urban Stormwater – Soils & Construction" or their equivalent, where applicable.

The purpose of this report is to present the information relevant to the numerical simulation prepared, using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) software package, in support of the water sensitive design strategy and stormwater management plan for the proposed development.

2. BACKGROUND

1.2 Site Description

The site proposed for the re-development is located at Lot 2//DP 1285515, 10A Park Street, East Maitland NSW 2323. The site has an area of 1,786 m^2 and is largely unoccupied with only a drainage easement crossing the site and a single shed structure and small paved area visible. Figure 2.1 show an aerial photo of the development site. The site is bordered by residential properties to the north, east and south and fronts onto Park Street to the west.

The vacant, unpaved areas of the property is covered in lawn grass. Appendix A includes a survey plan of the development site indicating the size of the site, as well as the areas covered by the existing structures. Table 2.1 present a summary of the areas relating to the existing site.

The proposed development involves the construction of four new buildings comprising administrative offices and residential units. The building will be constructed on a concrete slab which will be formed on compacted engineered fill. Sections of the western portion of the site will be sealed to provide vehicle access and parking. The drainage easement and natural drainage channel (similar to a swale) will remain as it drains not only this portion of the site but also adjoining properties. Appendix B includes a plan presenting the layout of the proposed development. Table 2.1 includes a summary of the areas occupied by the structures, parking and landscaping/play areas as shown on the design plan.

Figure 2.1: Development Site

Table 2.1: Summary of development site land use areas.

Land Use	Area (m^2)
Lot 2//DP 1285515	1,786 (total lot area)
Existing Site	
Existing structure and paved area	100
Lawn	1,686
Proposed Development	
Structure (Roof)	680
Parking and driveway	350
Paved play areas and walkways	190
Play area/landscaping	260
Unpaved drainage easement and channel	306

3. STORMWATER QUALITY MODELING

3.1. Objectives and Targets

The objectives and targets for a WSD Strategy can differ for each development type and are to be achieved within a proposed development through the provision of appropriate water sensitive design measures.

The objectives for the proposed development are:

- *To reduce urban stormwater runoff by harvesting rainwater for use where appropriate*

Capture rainwater for re use (e.g. flushing of toilets and landscaping/garden maintenance).

- *To control the hydrological impacts of development on receiving surface and ground water systems by controlling the frequency, magnitude and duration of flows to preserve, as far as practicable, pre-development groundwater and surface water regimes and interactions.*

Ensure that post-development stormwater runoff volumes are the same or lower than pre-development volumes.

- *To safeguard the environment by maintaining or improving the quality of stormwater run-off.*

Water quality modelling was undertaken of a pre-development and the post-development (mitigated) scenario using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) software to demonstrate the mean annual load pre- and post-development as well as that load-based stormwater quality targets are achieved. A stormwater treatment train has been developed and modelled to determine the effectiveness of the proposed system in achieving the relevant water quality objectives.

The stormwater quality targets are (Maitland City Council, 2014):

- 80% reduction in Total Suspended Solids (TSS) from typical urban loads;
- 45% reduction in Total Nitrogen (TN) from typical urban loads;
- 45% reduction in Total Phosphorus (TP) from typical urban loads; and
- 70% reduction in Gross Pollutants (GP) from typical urban loads.

3.2. Rainfall and Evapotranspiration Parameters

Table 1 summarises the meteorological and rainfall-runoff data used in the MUSIC model. The meteorological data used was retrieved from the Bureau of Meteorology on-line pluviography database.

Table 3.1: Meteorological and Rainfall Runoff Data

Information	Details
Rainfall Station	061250 PATERSON (TOCAL AWS)
Time step	6 minute
Modelling period	January 1989 – Dec 1989

3.3. Catchment Parameters

Based on the existing and proposed land uses, the existing Development Site has been modelled as a single catchment which is a mixture of a roofed shed structure and hardstand areas, which make up 6% of the site. The remainder of the site is accepted as pervious.

The proposed development will consist mainly of covered (roof) structures and paved parking/driveway, with the remainder occupied by play/landscape areas. The proposed development was modelled as six catchments given that run-off from each catchment is channelled to different areas. The proposed stormwater management plan, attached as Appendix C present the different areas of the site with an indication of where water from each area drains to. The landscaping and play areas surrounding the proposed buildings were modelled as two catchments to allow for runoff draining to the two different areas. Table 3.2 present a summary of the catchment areas while in Table 3.3 present source node and pollutant generation parameters for the catchments modelled for the existing site and proposed development.

Table 3.2: Source Node Parameters

Land use / Surface Type	Sub-catchment Areas (ha)	Total Area (ha)
Pre-development		
Pervious landscape (pervious)	0.1686(85%)	0.1786
Driveway and roof (impervious)	0.01 (6%)	
Post development		
Roof A	0.03	0.068
Roof B	0.007	
Roof C	0.015	
Roof D	0.006	
Roof E	0.01	
Driveway and parking area	0.035	0.035
Concrete play areas and pathways	0.019	0.019
Drainage easement and swale at parking area	0.0306 (~ 0.031)	0.0566
Landscape	0.0090	
Play area/landscape	0.0170	

According to the eSpade hydrologic soil group mapping data (http://www.environment.nsw.gov.au/eSpade2WebApp), the development site falls in Group C, which is characterised by slow infiltration. The source node parameters used for the simulation of the runoff characteristics of the modelled catchments are as listed in Table 3.3

Table 3.3: MUSIC rainfall runoff parameters

MUSIC Parameter	Value
Impervious rainfall threshold	
Combined impervious surfaces (mm)	1.5
Roof surfaces (mm)	0.5
Pervious area parameters	

Soil Storage Capacity (mm)	100
Initial Storage (% of capacity)	25
Field Capacity (mm)	70
Infiltration Capacity Coefficient a (mm/day)	180
Infiltration Capacity Exponent b (scalar)	3
Groundwater Properties	
Initial Depth (mm)	10
Daily Recharge Rate (%)	25
Daily Baseflow Rate (%)	25
Daily Deep Seepage Rate (%)	0

The pre-development scenario was modelled as an urban residential land use.

3.4. Proposed Treatment measures for post-development case

3.4.1. General

Based on the existing stormwater management design for the proposed development, the features of the development and the range of available Stormwater Quality Improvement Devices (SQIDs), this study has developed an overall concept that will satisfy the requirements of downstream environmental protection. Figure 3.1 shows a schematic representation of the proposed treatment train elements.

The sections that follow sections describe the modelling parameters applied to MUSIC for each of the treatment nodes included as part of the water quality assessment. Annexure C is a stormwater management plan.

3.4.2. Stormwater pit inserts

Gross pollutant trap (GPT) stormwater pit insert is proposed for the stormwater pit that discharges from the development site. The treatment node used to model the GPTs, is the default available in the MUSIC model software and the performance criteria selected are in accordance with Water NSW guide, Using MUSIC in the Sydney Drinking Water Catchment (2019).

Parameters for the GPT treatment efficiency are summarised in Table 3.4.

Table 3.4: GPT Treatment Node Parameters

Parameter	Value in MUSIC Model	Capture Efficiency
High Flow by-pass (m^3/s)	100	-
Low Flow by-pass (m^3/s)	0.0	-
TSS Input (mg/L) Output (mg/L)	1000 350	65%
TN Input (mg/L) Output (mg/L)	5.0 4.3	14%
TP Input (mg/L) Output (mg/L)	1.0 0.85	15%
Gross Pollutants Input (mg/L) Output (mg/L)	15 1.5	90%

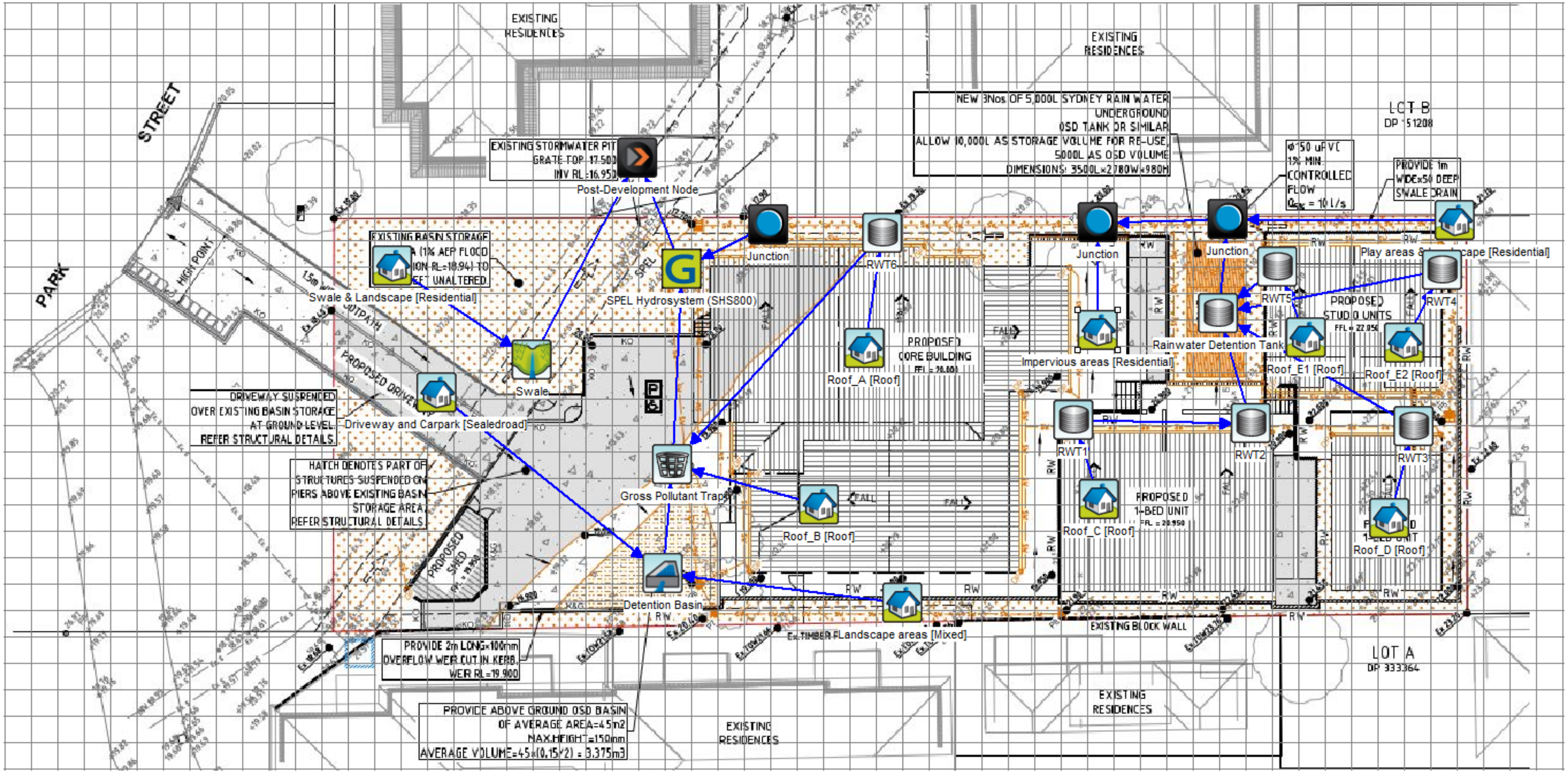

Figure 3.1: Treatment train concept.

3.4.3. Swale

An existing overland vegetated drainage reserve and drainage channel (swale) will be retained on site. The swale is included in the stormwater management plan to capture flow from the unpaved drainage reserve areas included inside the site boundary. The swale is modelled using default MUSIC parameters and the storage properties as listed in Table 3.5.

Table 3.5: Swale Treatment Node Parameters

Storage Parameter	Value in MUSIC Model
Length (m)	30
Bed Slope (%)	3
Base Width (m)	2.5
Top Width (m)	5.0
Depth (m)	0.25
Vegetation height (m)	0.25
Exfiltration rate	20

3.4.4. Rainwater Tanks

Both an underground rainwater detention tank as well as 6 rainwater tanks on surface are included in the design to capture roof run-off for on-site detention purposes. The storage parameters used for the model.

Table 3.6: Underground Rainwater Detention Tank Treatment Node Parameters

Parameter	Value in MUSIC Model
High Flow by-pass (m^3/s)	100
Low Flow by-pass (m^3/s)	0.0
Number of tanks	2
Total volume of tanks (kL)	10
Demand (kL/year)	0

Table 3.7: Surface Rainwater Tank Treatment Node Parameters

Parameter	Value in MUSIC Model	
Tank designation	RWT1 to RWT5	RWT6
High Flow by-pass (m^3/s)	100	100
Low Flow by-pass (m^3/s)	0.0	0.0
Number of tanks	5 (2kL each)	1
Total volume of tanks (kL)	10	3
Demand (kL/year)	0.25	0.25

Water from the underground detention tank is released as a staged outflow via a restricted low and high level outflows. No rainwater is re-used form the underground detention tank.

Rainwater collected in the surface rainwater tanks is available for re- use in:

- Outdoor landscaping
- Flushing toilets

A small quantity of re- use is assumed in the model for each tank (1kL/year). This is a very conservative assumption as in reality all of the water in the tanks would be available for re-use. Only a small quantity (one quarter the available volume per tank per year) is assumed so as not to overemphasise the effect of the re-use on the overall stormwater quality. Overflow from the surface tanks 1, 2, 3, 4, and 5 is assumed to discharge to the underground detention tank. Overflow from surface tank 6 is released directly to the stormwater discharge.

3.4.5. Detention Basin

A detention structure is proposed for the collection, detention and controlled release of stormwater from the driveway, parking and a small portion of the landscaping along the southern-eastern boundary of the site. Roof water from the south eastern portion of the structures will also be discharged to the basin. Table 3.8 present a summary of the storage properties used in the simulation of the system.

Table 3.8: Bio-retention Treatment Node Parameters

Parameter	Value in MUSIC Model
High Flow by-pass (m^3/s)	100
Low Flow by-pass (m^3/s)	0.0
Extended detention depth (m)	0.2
Surface Area (m^2)	50
Exfiltration rate (mm/hour)	0
Evaporative Loss as % of PET	100

3.4.6. SPEL Hydrosystem

A generic node has been utilized in MUSIC, for the purpose of simulating treatment efficacy of the SPEL Hydrosystem and the transform function in the node has been modified based on SPEL Environmental's 2nd and 3rd Party field testing product data. These test results and papers are available upon request from SPEL Environmental. The SPEL Hydrosystem parameters utilised within MUSIC are summarised in Table 3.9.

Table 3.9: SPEL Hydrosystem Treatment Node Parameters

Parameter	Value in MUSIC Model	Capture Efficiency
High Flow by-pass (m^3/s)	100.00	-
Low Flow by-pass (m^3/s)	0.0	-
TSS Input (mg/L) Output (mg/L)	1000 350	65%
TN Input (mg/L) Output (mg/L)	50 40	20%

TP Input (mg/L) Output (mg/L)	5.0 3.5	30%
Gross Pollutants Input (mg/L) Output (mg/L)	15 0	100%

3.5. Results

The mean annual pollutant loads for the pre- and post-development scenarios are summarised in Table 3.10.

Table 3.10: Pre- and Post-development residual loads

Parameter	Annual Pollutant Loading (kg/yr)			
	TSS	TP	TN	GP
Pre development	42.9	8.94E-02	0.694	3.91
Post development with measures	14.6	3.33E-02	0.922	0
Difference	28.3	0.0561	-0.228	3.91
% Improvement	66%	63%	-33%	100%

The pollutant reduction targets achieved (as modelled in MUSIC) are summarised in Table 3.11. The reduction targets listed are the percentage improvement required in accordance with the Maitland City Council Manual of Engineering Standards (Maitland City Council, 2014). The results show that the modelled percentage reduction in the residual loads following treatment of the stormwater runoff are well over the reduction targets.

Table 3.11: Treatment Train Effectiveness

Parrameter	Sources	Residual Load	% Reduction	Reduction target %
Flow (ML/yr)	1.16	1.1	5.17	-
Total Suspended Solids (kg/yr)	160	14.6	90.9	80
Total Phosphorus (kg/yr)	0.334	3.33E-02	90	45
Total Nitrogen (kg/yr)	2.57	0.922	64.1	45
Gross Pollutants (kg/yr)	28.2	0	100	70

4. OPERATION AND MAINTENANCE

4.1. General

Future operation and maintenance of the proposed WSD measures is considered important to the efficient and sustainable operation of the stormwater management system.

The following aspects are noted:

- The WSD measures proposed will all be located inside the development site and will be maintained by the site owner/operator.
- All WSD measures will be installed at the time the stormwater management pits and pipes are installed. No special scheduling of construction is foreseen. Construction stage sediment and erosion control measures fall outside the scope of this WSD strategy
- The proposed measures are designed to be easily accessed and maintained by personnel responsible for landscaping and general site maintenance.
- The proposed WSD measures, aside from the rainwater harvesting, contain no mechanical or electrical components that would require maintenance.
- In regards maintenance access the following is considered:
    - All-weather site access will be available;
    - Acceptable clearances to obstacles including power lines, trees, fences and parked cars will be available for maintenance access;
    - Steep gradients would not restrict access/egress for maintenance vehicles;
    - Access road pavement would have sufficient strength for maintenance vehicles;
    - The risk of conflict between traffic and maintenance personnel will be low; and
    - Parked vehicles would not prevent access.

4.2. Operational and Maintenance Recommendations:

- Check GPT and SPELL Hydrosystem units once a fortnight and after a significant rain event. Clean out trap basket if retained gross pollutants are present.
- Maintain vegetation in swale to ensure efficient trapping of pollutants. Check swale fortnightly and after a significant rain event and remove any gross pollutants or accumulated debris.
- Ensure that height of vegetation is swales are maintained to the top edge of the swale (approx. 0.1m in height).
- Maintain roof water gutters by installing protection measures to prevent debris (i.e. leaves, windblown debris) from entering charged lines.
- Clean out gutters and rainwater tank inlet screen at least once a quarter.
- Check rainwater collection tank annually for accumulated sediment and flush tank if sediment is occupying more than 10% of storage capacity.
- Maintain detention basin capacity and check after a significant rain event to remove any gross pollutants or accumulated debris and sediment.

4.3. Considerations for Re-use of Harvested Rainwater.

- Spraying with stormwater may transmit pathogens through aerosols and mists from the spray water. Where stormwater has been treated, public health risks associated with irrigation sprays are low.
- All spray irrigation systems should be designed to minimise off-site spray drift, as this may present a nuisance to neighbours.
- Where a lower level of treatment is provided, greater management of irrigation water to reduce public exposure is required. This can be achieved either by using subsurface irrigation or by having buffer zones between the irrigation scheme's wetted perimeter and the nearest point of public access (e.g. road or private property).
- The width of a buffer zone depends on the type of irrigation equipment used, slope, wind direction and vegetation. The preferred approach is to carry out a site-specific study to determine a suitable width.
- In public access areas, facilities such as drinking water fountains, swimming pools and picnic tables should be placed outside the area irrigated by treated stormwater or be protected from drift and direct spraying.
- Signage should be provided at all public access points to stormwater irrigation areas, warning not to drink the water. Additional signage will be needed to warn the public where access controls apply.

5. CONCLUSION

The proposed WSD strategy was demonstrated to meet all three the objectives listed in Section 3.1. These are:

- *To reduce urban stormwater runoff by harvesting rainwater for use where appropriate*

The proposed stormwater management plan includes rainwater harvesting from the roof of the proposed development. The runoff will be captured in six rainwater tanks (total capacity 13,000L).

- *To control the hydrological impacts of development on receiving surface and ground water systems by controlling the frequency, magnitude and duration of flows to preserve, as far as practicable, pre-development groundwater and surface water regimes and interactions.*

The proposed stormwater management plan includes on-site detention to ensure that post-development stormwater runoff volumes are the same or lower than pre-development volumes.

- *To safeguard the environment by maintaining or improving the quality of stormwater run-off.*

A simulation of runoff water quality for both the pre-development and post-development scenario has demonstrated that the SQUIDs proposed for water quality treatment will meet the listed reduction targets.

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APPENDIX A

Existing Site Survey Plan

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APPENDIX B

Proposed Development Layout

APPENDIX C

Stormwater Management Plan