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STORMWATER MANAGEMENT STRATEGY

M6937
PROPOSED RESIDENTIAL DEVELOPMENT
CEMETERY ROAD, COROWA
JULY 2021

Stormwater Quality Management Strategy	
Our Reference	M6937
Client	ENTH DEGREE ARCHITECTS
Project	Proposed Residential Development
Location	Cemetery Road, Corowa
Report Author	Matt Sammon
Checked	Kristy Tossol

Revision Table:

Version	Date	Description
1	8th April 2020	Stormwater Management Strategy
2	8th July 2020	Stormwater Management Strategy
5	27th July 2021	Stormwater Management Strategy

Distribution Table:

Version	Date	Description
1	8th April 2020	Council - Planning
2	8th July 2020	Council - Planning
5	27th July 2021	Council - Planning

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1. OBJECTIVE

The objective of this report is to investigate and provide an effective and efficient stormwater management strategy to treat and convey the stormwater runoff generated from the proposed development site to the existing Council drainage system.

This report forms part of the initial design and analysis carried out by North East Survey Design (NESD) on behalf of Enth Degree Architects (Client) to assist Federation Council (Council) with their assessment of the Planning Permit Application for the proposed development.

2. INTRODUCTION

Clause 7.3 of the LEP refers to stormwater management and aims to minimise the impacts of urban stormwater on land, adjoining properties, native bushland and receiving waters.

With Clause 7.3 in mind NESD was engaged by the client to provide an effective and efficient stormwater management strategy to treat and convey the stormwater runoff generated from the development site to various bioretention basins with an outfall to the existing Council drainage system to maintain existing flows so as to avoid any adverse impacts of stormwater runoff on adjoining properties.

3. EXISTING SITE CONDITIONS

The development is broken into two separate catchments. Catchment A = 13.50ha and Catchment B = 14.23ha. Catchment A generally falls north west to the corner of Redlands Road and Cemetery Road. Catchment B generally falls south west to Cemetery Road and an existing open drain that flows from east to west along the southern boundary of the site. There is a small area of external catchment which has been incorporated into Catchment A. The surrounding developments are drained via comprehensive underground drainage network which discharges to existing Council infrastructure.

The site is currently used as for farming and agricultural purposes, so it is cleared with minimal native vegetation on the land. Refer to Figure 3.1 below for aerial view of the development site shown in its current state.

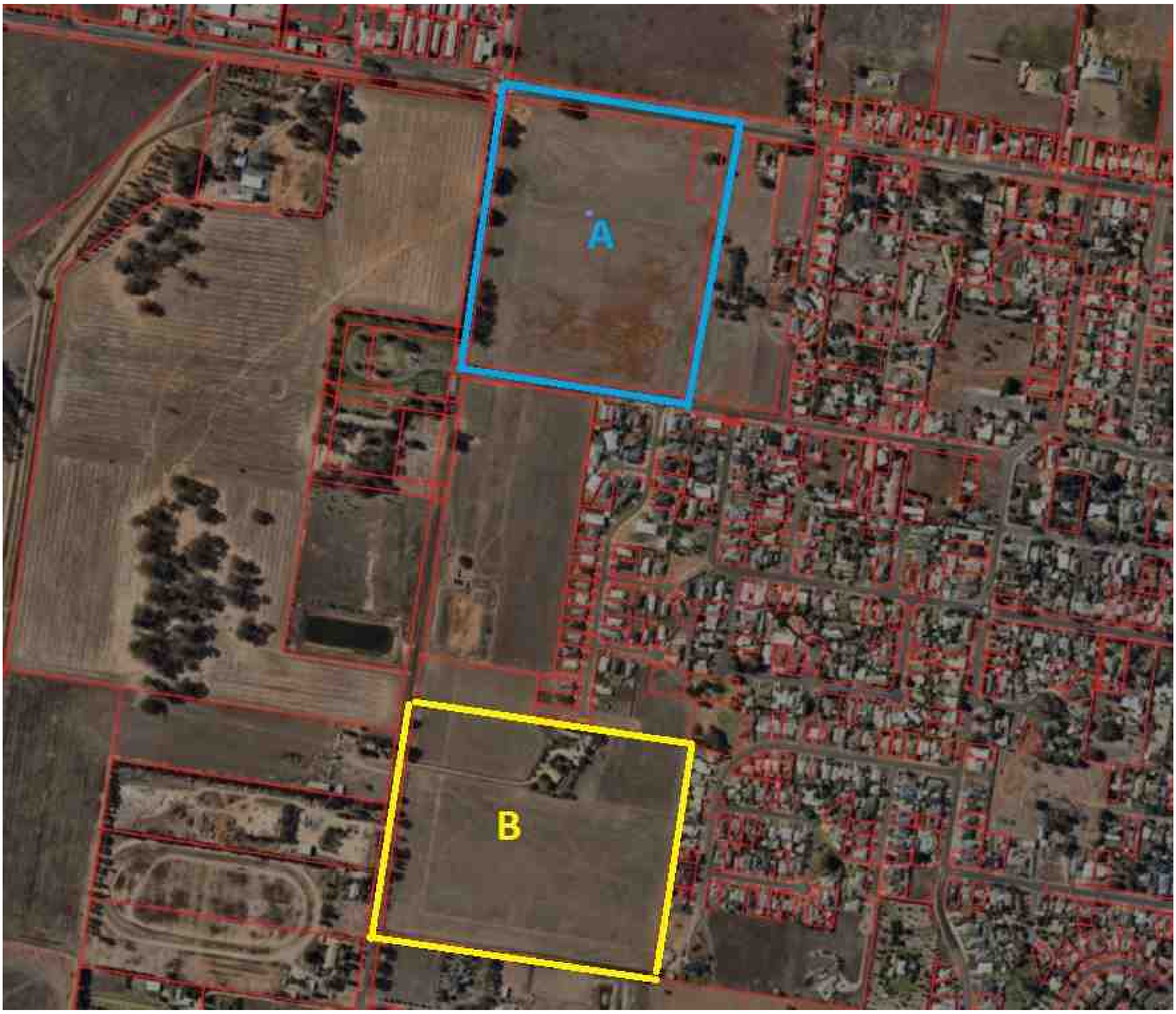


Figure 3-1 – Aerial Perspective of the Sites

4. PROPOSED STORMWATER MANAGEMENT STRATEGY

Elements of WSUD have been utilised to address the current Urban Runoff Management Objectives in order to improve stormwater quality and assist in achieving the objectives of Urban Stormwater Best Practice Environmental Management Guidelines. These elements include the use of rainwater tanks and detention storage used in conjunction with the traditional 'pits and pipes' type networks. This method was identified as the most feasible and effective stormwater treatment and conveyance system currently available.

Due to the topography of the site the catchments have been broken into two (Catchment A & Catchment B).

Figure 4-1 – Catchment Plan A

Figure 4-2 – Catchment Plan B

Stormwater from each catchment will be directed to a retarding basin. Each of the basins will be designed to store design rainfall events up to and including the 1% AEP. Discharge from this basin will be restricted to the Permissible Site Discharge (PSD) for each catchment of Catchment A = 397L/sec and Catchment B = 408L/sec.

Roof runoff from each dwelling will be directed the underground drainage network and overland flow from the garden, grassed and paved areas of each lot will be directed to the kerb and channel. Flows from the kerb and channel will be collected via the traditional ‘pits and pipes’ underground drainage system and directed to each of the retarding basin areas before discharging to Cemetery Road drainage system.

5. STORMWATER RUNOFF ANALYSIS

Preliminary stormwater runoff analysis has been carried out in accordance with the Council's Engineering Guidelines for Subdivisions and Development Standards - Part 3 "Stormwater Drainage Design Standards" (EGSDS) to determine the On-Site Detention (OSD) requirements for the site using design storms up to and including 1% AEP.

As discussed in Section 4 above the development site is proposed to be split into two catchments. Piped discharge from each of these catchments will be directed to the proposed retardation basins will be sized for the 20% AEP (4.5 year ARI) as per Table 1 - EGSDS requirements.

5.1 Rational Method

The rational method has been adopted as per section 5 of Councils EGSDS to calculate the peak catchment discharge using the following formula:

$$Q_y = \frac{C_y \times I_{tc,y} \times A}{360}$$

Where:

- Q_y = Flow rate, Q (m^3/s) for an AEP of Y years.
- C_y = Runoff Coefficient, C for an AEP of Y years.
- $I_{tc,y}$ = Average rainfall intensity, I (mm/h) for design duration of t_c (time of concentration) and AEP of Y years.
- A = Area of catchment in Ha.

5.2 Site Areas & Runoff Coefficients

Site areas were taken directly from the Stormwater Management plan. Refer Figure 4.1 above.

<u>CATCHMENT A</u>

Developed Residential Lots:	
C = 0.45	A = 10.00Ha
Road Reserves:	
C = 0.85	A = 3.50Ha
TOTAL:	A = 13.50Ha

<u>CATCHMENT B</u>

Developed Residential Lots:	
C = 0.45	A = 10.83Ha
Road Reserves:	
C = 0.85	A = 3.40Ha
TOTAL:	A = 14.23Ha

5.3 Time of Concentration & Design Rainfall Intensity

The time of Concentration was calculated for each catchment and the corresponding Rainfall Intensity information was determined using the Rainfall Intensity – Frequency – Duration (IFD) data sourced from the Bureau of Meteorology (BoM), refer to Figure 5.1 below for details.

5.4 Definition of Catchment Area

Site areas were taken directly from the existing conditions plan and the Plan of Subdivision. Allowances for flows from outside the development site (Neighbour Area) were made. Refer Figure 4.1 above.

Development Site Areas:

Catchment A	13.50 Ha
Catchment Area:	135,000 m^2 (13.5 Ha or 0.1350km^2)
Catchment B	14.23 Ha
Catchment Area:	142,300 m^2 (14.23 Ha or 0.1423km^2)

The time of concentration is calculated from:

$t_c = 0.76\ A^{0.38}$ (hrs)

Where:

A = Catchment area in km^2

5.4.1 Development Site A

$t_c = 0.76\ (0.1350)^{0.38}$

$= 0.355$ hrs $= 21.31$ minutes

Adopt 21.31minutes

Time of Concentration:	21mins
Rainfall Intensity (1% AEP):	58.9mm/hr

5.4.2 Development Site B

$t_c = 0.76\ (0.1423)^{0.38}$

$= 0.362$ hrs $= 21.73$ minutes

Adopt 21.73minutes

Time of Concentration:	22mins
Rainfall Intensity (1% AEP):	57.30mm/hr

	Annual Exceedance Probability (AEP)						
Duration	63.2%	50%#	20%*	10%	5%	2%	1%
1 min	92.9	106	148	176	203	239	266
2 min	78.3	89.4	124	148	171	199	220
3 min	71.1	81.2	113	134	155	181	200
4 min	65.6	75.0	104	124	143	167	185
5 min	61.1	69.9	97.1	115	133	156	173
10 min	46.1	52.8	73.6	87.5	101	119	132
15 min	37.6	43.0	60.0	71.3	82.3	97.0	108
20 min	31.9	36.6	51.0	60.7	70.1	82.5	92.1
21 min	31.0	35.5	49.5	58.9	68.1	80.2	89.5
25 min	27.9	32.0	44.6	53.0	61.3	72.2	80.5
30 min	24.9	28.5	39.7	47.3	54.6	64.3	71.7
45 min	19.2	21.9	30.4	36.1	41.8	49.1	54.7
1 hour	15.8	18.0	24.9	29.6	34.2	40.2	44.8
1.5 hour	11.9	13.6	18.7	22.2	25.7	30.1	33.5
2 hour	9.79	11.1	15.3	18.1	20.9	24.5	27.2
3 hour	7.39	8.36	11.4	13.5	15.6	18.3	20.4
4.5 hour	5.58	6.30	8.58	10.1	11.7	13.7	15.4
6 hour	4.58	5.16	7.02	8.29	9.54	11.3	12.6
9 hour	3.46	3.90	5.30	6.26	7.23	8.57	9.64
12 hour	2.84	3.19	4.34	5.15	5.95	7.09	8.00
18 hour	2.13	2.40	3.28	3.90	4.54	5.44	6.17
24 hour	1.73	1.95	2.68	3.21	3.75	4.51	5.13
30 hour	1.47	1.65	2.28	2.74	3.23	3.89	4.44
36 hour	1.28	1.44	2.00	2.41	2.85	3.45	3.93
48 hour	1.02	1.15	1.61	1.96	2.33	2.82	3.23
72 hour	0.737	0.833	1.17	1.43	1.72	2.09	2.40
96 hour	0.580	0.655	0.922	1.13	1.36	1.65	1.90
120 hour	0.480	0.542	0.760	0.930	1.12	1.36	1.56
144 hour	0.411	0.464	0.646	0.787	0.940	1.15	1.32
168 hour	0.361	0.406	0.562	0.680	0.806	0.982	1.13

Figure 5-1 – IFD Data for Corowa

5.5 Pre-Developed Runoff Coefficient

From Table 4 - EGSDS Federation Council the runoff coefficient:
The coefficient of runoff is calculated from:

$C_Y = F_Y \times C_{10}$

Where:

Y	= ARI in years
F_Y	= Frequency factor from Table 4 EGSDS
C_{10}	= 10 year ARI runoff coefficient

$C_Y = 1.0 \times 0.05 = 0.05$

5.6 Permissible Site Discharge (PSD)

Catchment Area A: 135,000 m^2 (13.5 Ha or 0.1350km^2)

From Section 5.1 above:

Q_y	$= C_y \times I_{tc,y} \times A$
Q_{10}	$= 0.05 \times 58.90 \times 0.135$
	=0.397 m^3/s (397 L/s)
PSD	= 0.397 m^3/s

Catchment Area B: 142,300 m^2 (14.23 Ha or 0.1423km^2)

From Section 5.1 above:

Q_y	$= C_y \times I_{tc,y} \times A$
Q_{10}	$= 0.05 \times 57.30 \times 0.1423$
	=0.408 m^3/s (408 L/s)
PSD	= 0.408 m^3/s

5.7 Onsite Detention Requirements (OSD)

Developed site runoff coefficient:

<u>Catchment A</u>

Road Reserve	= 38,085 x 0.85 = 32,372	(C = 0.85, road reserve refer EGSDS)
Lots	= 89,685 x 0.45 = 40,358	(C = 0.45, lots refer EGSDS)
Reserve	= 7,230 x 0.05 = 361	(C = 0.2, lots refer EGSDS)
Total	= 73,091	

Weighted Coefficient, C = 0.53

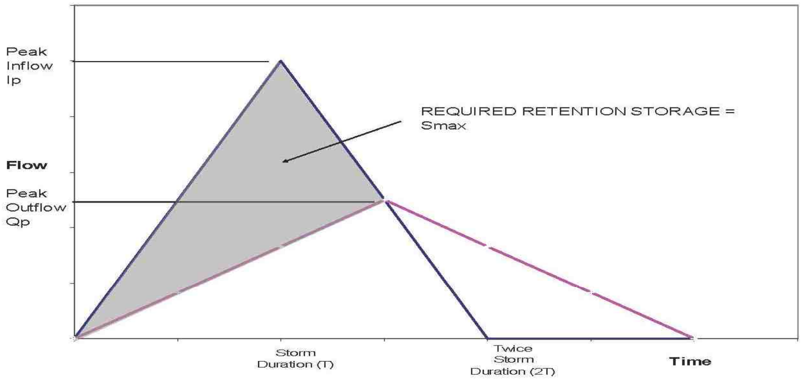
From Boyd's Method using the Corowa rainfall data, the PSD from above and the volume of OSD for the 1% AEP was determined to be 1,850m^3, refer to Figure 5.2 below.

This additional runoff will be stored onsite in the retardation basin storage area.

NORTH EAST SURVEY DESIGN

Project:	Proposed Development
Location:	Redlands Road Corowa
Client:	Enth Degree Architects
Our Ref.:	M6937
Date:	27th March 2020

Flood Storage - Site Catchment - Boyd's Formula



Boyd's Equation: $S_{max} = V_1\left(1-\frac{Q_p}{I_p}\right)$

Where:
S_{max} = Maximum Volume of Temporary Storage (m^3)
V_1 = Volume of Inflow Flood (m^3)
I_p = Peak discharge of inflow hydrograph (m^3/s)
Q_p = Peak discharge of outflow hydrograph (m^3/s)

Catchment Area (A) =	13.5	ha
Runoff Coefficient (1% AEP) =	0.53	weighted
1% AEP Effective Catchment Area = ∑CA =	7.16	ha
Restricted outflow requirement (PSD) =	0.397	m^3/s

Storage requirement is highest value of S_{max} calculated in the table below
Critical storm duration is the storm duration when S_{max} occurs

Storm Duration (min)	1% AEP Intensity (mm/hr)	I_p (m^3/s)	Q_p (m^3/s)	V_1 (m^3)	S_{max} (m^3)
5	173	3.44	0.40	1032	912
6	163	3.24	0.40	1166	1023
10	132	2.62	0.40	1574	1336
20	92.1	1.83	0.40	2197	1720
30	71.7	1.43	0.40	2565	1850
60	44.8	0.89	0.40	3205	1776
120	27.2	0.54	0.40	3892	1034
180	20.4	0.41	0.40	4379	91
360	12.6	0.25	0.40	5409	-3166
540	9.64	0.19	0.40	6208	-6655
720	8	0.16	0.40	6869	-10282

Boyd Method -A
M6937- NESD Drainage Calculator
NORTH EAST SURVEY DESIGN (NESD)
PAGE 1 OF 1

Figure 5-2 – 1% AEP Onsite Detention Requirements Catchment A (OSD)

Catchment B

Road Reserve	= 38,359 x 0.85	= 32,605	(C = 0.85, road reserve refer EGSDS)
Lots	= 99,193 x 0.45	= 44,637	(C = 0.45, lots refer EGSDS)
Reserve	= 4,748 x 0.05	= 237	(C = 0.2, lots refer EGSDS)
Total	= 77,479		

Weighted Coefficient, C = 0.54

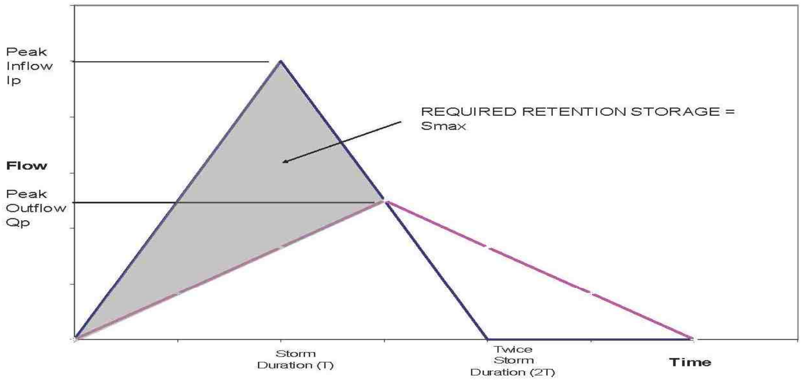
From Boyd's Method using the Corowa rainfall data, the PSD from above and the volume of OSD for the 1% AEP was determined to be 2,020m^3, refer to Figure 5.2 below.

This additional runoff will be stored onsite in the bioretention basin storage area.

NORTH EAST SURVEY DESIGN

Project:	Proposed Development
Location:	Redlands Road Corowa
Client:	Enth Degree Architects
Our Ref.:	M6937
Date:	27th March 2020

Flood Storage - Site Catchment - Boyd's Formula



Boyd's Equation: $S_{max} = V_1\left(1 - \frac{Q_p}{I_p}\right)$

Where: S_{max} = Maximum Volume of Temporary Storage (m^3)
V_1 = Volume of Inflow Flood (m^3)
I_p = Peak discharge of inflow hydrograph (m^3/s)
Q_p = Peak discharge of outflow hydrograph (m^3/s)

Catchment Area (A) =	14.23	ha
Runoff Coefficient (1% AEP) =	0.54	weighted
1% AEP Effective Catchment Area = ∑CA =	7.68	ha
Restricted outflow requirement (PSD) =	0.408	m^3/s

Storage requirement is highest value of S_{max} calculated in the table below
Critical storm duration is the storm duration when S_{max} occurs

Storm Duration (min)	1% AEP Intensity (mm/hr)	I_p (m^3/s)	Q_p (m^3/s)	V_1 (m^3)	S_{max} (m^3)
5	173	3.69	0.41	1108	985
6	163	3.48	0.41	1253	1106
10	132	2.82	0.41	1691	1446
20	92.1	1.97	0.41	2359	1869
30	71.7	1.53	0.41	2755	2020
60	44.8	0.96	0.41	3443	1974
120	27.2	0.58	0.41	4180	1243
180	20.4	0.44	0.41	4703	296
360	12.6	0.27	0.41	5809	-3004
540	9.64	0.21	0.41	6667	-6552
720	8	0.17	0.41	7377	-10249

Boyd Method - B
M6937- NESD Drainage Calculator
NORTH EAST SURVEY DESIGN (NESD)
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Figure 5-3 – 1% AEP Onsite Detention Requirements Catchment B (OSD)

6. STORMWATER QUALITY MODELLING

In order to address the Water Sensitive Urban Design (WSUD) Objectives for newly created lots, stormwater quality modelling and design for the revised development area was carried out in accordance with the current water quality performance objectives set out in the Urban Stormwater BPEMG. The objectives for environmental management of stormwater are presented in Table 6.1 below.

Table 6-1 – Best Practice Environmental Management Guidelines

Pollutant	Current 'Best Practice' Objective
Suspended Solids (SS)	80% reduction of typical urban annual suspended solids load
Total Phosphorus (TP)	45% reduction of typical urban annual total phosphorus load
Total nitrogen (TN)	45% reduction of typical urban annual total nitrogen load
Litter	70% reduction of typical urban annual litter load

In order to determine the reductions in these pollutants are in line with the 'Best Practice' objectives, the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) analysis of the stormwater quality was carried out for the revised development site.

6.1 MUSIC Model Layout

The following figures, Figure 6.1 & 6.2, below shows the MUSIC layouts used to model the Entire Catchment A & B of the development site.

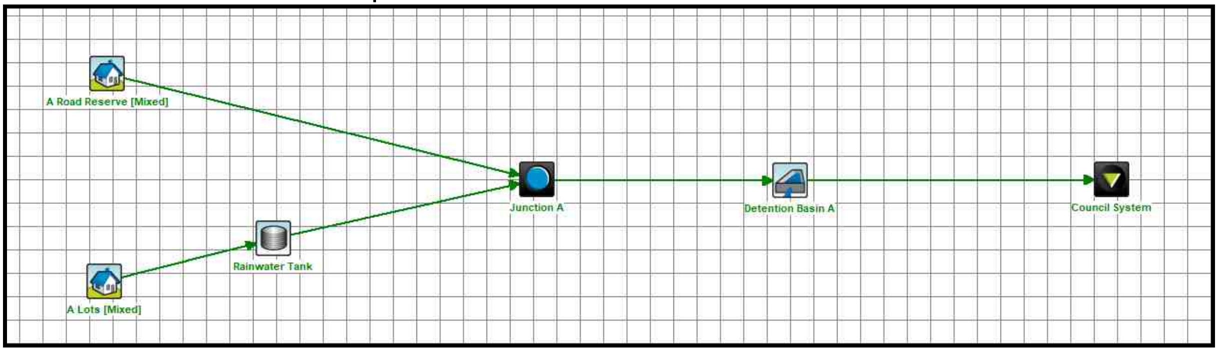

Figure 6-1– MUSIC Model Layout – Entire Catchment A

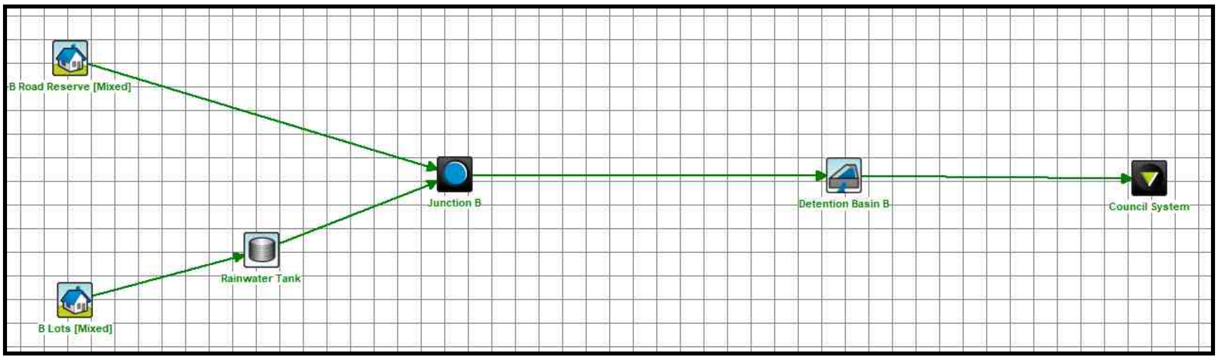

Figure 6-2– MUSIC Model Layout – Entire Catchment B

6.2 MUSIC Model Inputs

6.2.1 Meteorological Data

The Meteorological Template used for the analysis was generated by using the Pluviograph rainfall data from Cobram for the period from 1 January 1987 to 1 January 1992 inclusive using a six (6) minute time step. The Potential Evapo-transpiration (PET) data was derived using the monthly Average Areal Potential Evapotranspiration maps from the Climate Atlas compiled by the Bureau of Meteorology (BoM). The rainfall data for Cobram was obtained from the Bureau of Meteorology (BoM) through the MUSIC BoM Rainfall Data Tool.

Cobram rainfall data was used as Cobram has a similar mean annual rainfall to Corowa. The mean annual rainfall for Cobram is 461.5mm, based on 52 years of data, whilst Corowa has a mean annual rainfall of 541.0mm, based on 130 years of data.

In terms of the MUSIC Meteorological Template generated and used for the analysis, the mean annual rainfall for the selected period of from 1 January 1987 to 1 January 1992 is 484mm. This is slightly lower than the Corowa mean annual rainfall of 574.0mm.

A graphical representation of the meteorological data used is presented in Figure 6.3 below.

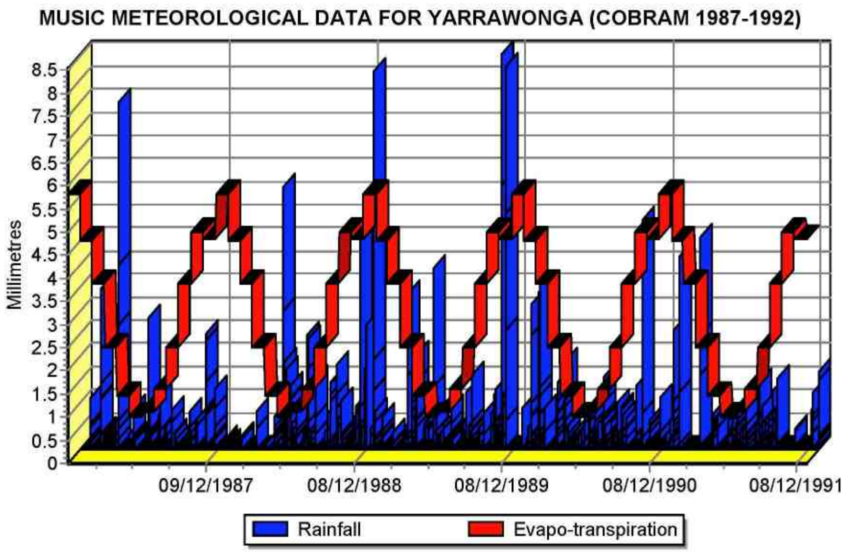

Figure 6-3 – Meteorological Data Template for Yarrawonga– Cobram Data 1987 - 1992

6.2.2 Stormwater Modelling Catchment (Source Nodes)

As part of the modelling of the stormwater quality discharged from the development site a Catchment Plan for each of the 2 catchments was prepared. Figures 4.1 & 4.2 above show the Catchment Plan used in the MUSIC analysis.

As can be seen from the Catchment Plans above the site has been broken down into sub-catchments. These sub-catchments were further broken down into areas applicable to MUSIC, Source Nodes. The percent impervious for each of the MUSIC Source Nodes was based on coefficients of runoff from Council's Design Guidelines.

Table 6.2 below summarises the percent impervious used for each of the MUSIC Source Nodes and Table 6.3 summarises the sub-catchment areas for each of the MUSIC Source Nodes used in the MUSIC modelling.

Table 6-2 – MUSIC Source Node Percent Impervious Summary

Source Node	Impervious (%)
Road Reserve A/B	85
Lots A/B	45

Table 6-3 – Sub-Catchment Summary

Source Node	Area (Ha)	Source Node	Area (Ha)
A Lots	10.40	A Road Reserve	3.10
B Lots	10.83	B Road Reserve	3.40

6.2.3 Stormwater Treatment Modelling (Treatment Nodes)

From the Stormwater Management Strategy developed and outlined above in Section 4, the following WSUD treatment nodes have been utilised in the modelling:

- 5kL Rainwater Tanks with Reuse
- 10kL Rainwater Tanks with Reuse
- Detention Basin – Entire Catchment

Tables 6.4 to 6.7 below summarises the WSUD elements utilised in the MUSIC modelling.

Table 6-4 - WSUD Input Summary – 151 x 5kL Rainwater Tanks – Catchment A

	Rainwater Tank
Low Flow Bypass (m3/s)	0.0
High Flow Bypass (m3/s)	100.0
No of Tanks	151
Vol below o/flow pipe (kL)	528.50
Depth above overflow (m)	0.20
Surface Area (m^2)	437.90
Initial Volume (kL)	0.00
Overflow pipe dia. (mm)	614
Max Drawdown Height (m)	1.21
Ann. Demand PET (kL/yr)	10,630

Table 6-5 - WSUD Input Summary – 184 x 7kL Rainwater Tanks – Catchment B

	Rainwater Tank
Low Flow Bypass (m3/s)	0.0
High Flow Bypass (m3/s)	100.0
No of Tanks	184
Vol below o/flow pipe (kL)	1,288
Depth above overflow (m)	0.20
Surface Area (m^2)	607.2
Initial Volume (kL)	0.00
Overflow pipe dia. (mm)	678
Max Drawdown Height (m)	2.12
Ann. Demand PET (kL/yr)	12,954

Table 6-6 – WSUD Input Summary – Detention Basin – Catchment A

	Detention Basin
Low Flow Bypass (m^3/s)	0.0
High Flow Bypass (m^3/s)	100.0
Surface Area (m^2)	1,614.0
Extended Detention Depth (m)	1.00
Exfiltration Rate (mm/hr)	0.36
Evaporative Loss as % of PET	100
Low Flow Pipe Diameter (mm)	450
Overflow Weir Width (m)	20
Notional Detention Time (hrs)	0.95

Table 6-7 – WSUD Input Summary – Detention Basin – Catchment B

	Detention Basin
Low Flow Bypass (m^3/s)	0.0
High Flow Bypass (m^3/s)	100.0
Surface Area (m^2)	792.0
Extended Detention Depth (m)	2.50
Exfiltration Rate (mm/hr)	0.36
Evaporative Loss as % of PET	100
Low Flow Pipe Diameter (mm)	300
Overflow Weir Width (m)	20
Notional Detention Time (hrs)	1.66

6.2.4 MUSIC Model Output

Using the above MUSIC model and inputs the pollutant reductions presented in Tables 6.8 & 6.9 were obtained at the Outlet Node.

Table 6-8 – Treatment Train Effectiveness Summary (% Reduction) – Catchment A

	Overall Catchment
Flow (ML/yr)	21.7
Total Suspended Solids (kg/yr)	89.7
Total Phosphorus (kg/yr)	70.3
Total Nitrogen (kg/yr)	46.1
Gross Pollutants (kg/yr)	100

Table 6-9 – Treatment Train Effectiveness Summary (% Reduction) – Catchment B

	Overall Catchment
Flow (ML/yr)	25.7
Total Suspended Solids (kg/yr)	36
Total Phosphorus (kg/yr)	70.1
Total Nitrogen (kg/yr)	45
Gross Pollutants (kg/yr)	100

Based on the figures above, the stormwater water quality performance objectives for environmental management of stormwater as defined in Urban Stormwater BPEMG can be achieved for each catchment of the development site.

7. DESIGN PARAMETERS (ASSUMPTIONS AND EXCLUSIONS)

As part of the stormwater quantity and quality analysis the following assumptions and exclusions were made:

7.1 Source Nodes

7.1.1 Roof Areas

A roof area of $350m^2$ has been assumed for each lot.

7.2 Meteorological Template

The Meteorological Template used for the analysis was generated by using the Pluviograph rainfall data from Cobram for the period from 1 January 1987 to 1 January 1992 inclusive using a six (6) minute time step. The Potential Evapo-transpiration (PET) data was derived using the monthly Average Areal Potential Evapotranspiration maps from the Climate Atlas compiled by the Bureau of Meteorology (BoM). The rainfall data for Cobram was obtained from the Bureau of Meteorology (BoM) through the MUSIC BoM Rainfall Data Tool.

7.3 Exfiltration Rate

An Exfiltration Rate of 0.36mm/hr has been adopted based on the assumption of ground conditions consisting of heavy clay materials.

7.4 Rainwater Tank Reuse

Stormwater re-use properties have been used as part of the analysis. The re-use properties in MUSIC used were 32kL/person/year scaled by PET for outdoor use (gardens, etc...), as specified in *WSUD Engineering Procedures: Stormwater*[1]. It was also presumed that the average household is made up of 2.2 persons, according to current Census data for Corowa.

8. CONCLUSION

[1] CSIRO, WSUD Engineering Procedures: Stormwater, 2006, pg 238

This report has identified an effective Stormwater Management Strategy for the proposed residential development. Through the use of the traditional ‘pits and pipes’ type system augmented with the WSUD features onsite treatment of the stormwater generated from the proposed development site can be provided. The stormwater water quality objectives defined as ‘Best Practice’ can be achieved with pollutant loads of suspended solids, phosphorus, nitrogen and gross pollutants all being reduced.

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