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# Proposed Residential Development 259 Windermere Road, Lochinvar Stormwater Management Strategy

Newpro20 Pty Ltd

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## List of Acronyms

GP	Gross Pollutants
MCC	Maitland City Council
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
SQUIDS	Stormwater Quality Improvement Devices
TN	Total Nitrogen
TP	Total Phosphorous
TSS	Total Suspended Solids

# 1 Introduction

## 1.1 Background

This stormwater strategy is to support the proposed residential development of 259 Windermere Road, Lochinvar.

Centralised stormwater management controls at the subdivision level have been designed to limit post development peak flow rates to predevelopment conditions for 1EY, 10% and 1% AEP critical storm durations.

This report shows that the overall post development stormwater runoff quantity will not impact on downstream flooding. This report also demonstrates that the retention of nominated pollutants (Total Suspended Solids, Nitrogen, Phosphorous and Gross Pollutants) will meet Maitland City Councils (MCC's) current nominated targets.

## 1.2 Site description

The subject land is known as 259 Windermere Road, Lochinvar (Lot 1902 DP1112961; the Site). It comprises approximately 9.0 hectares of land. The Site is bound to the east by Lochinvar Creek, to the south by a previously approved residential subdivision on Lot 1 DP537313 (48 Windermere Road, Lochinvar), and to the west by Windermere Road. A locality plan has been provided in Figure 1.

The Site contains gradients varying from approximately 1.5% up to 15% and typically falls to the east, toward Lochinvar Creek. The lower areas of the Site are affected by the 1% AEP flood level of R.L. 26.00.

A catchment has been nominated based on the topography of the Site. The catchment varies between predevelopment and post development phases. These catchments are shown on Figures 2 and 3 and include the following:

- Predevelopment: Catchment 1 and 4
- Post development: Catchment 1A and 1B

In the predevelopment phase, a ridgeline divides the Site into two catchments. Both the northern (Catchment 4) and southern (Catchment 1) catchment drain to Lochinvar Creek. During the post development phase, Catchment 1A comprises the proposed development which will utilise the proposed stormwater drainage network. Catchment 1B will bypass the proposed stormwater basin and drain directly to Lochinvar Creek.

The Site's current land use is rural. There are no existing dwellings on the Site. The Site is zoned R1 (General Residential) and C3 (Environmental Management) pursuant to Maitland Local Environmental Plan 2011. The Site is wholly situated within the MCC LGA.

## 1.3 Proposed development

The proposed development includes the creation of approximately 96 residential lots within the Site boundary. The subdivision layout is shown in Figure 4.

To ensure runoff from the proposed development is in accordance with MCC's guidelines, a detention basin is to be provided in the lower reach of the Site as appropriate by enlarging the previously approved detention basin in the site to the south.

## 1.4 Objectives

The objectives of this report are to investigate the likely impacts of the interaction of the development with its stormwater and flooding environment and make recommendations for appropriate treatment to meet guidelines regarding volume rate of flow and runoff quality.

## 1.5 Available data

The following information was utilised in the preparation of this strategy:

- A proposed subdivision layout plan by GCA Engineering Solutions. A copy of the subdivision plan is shown in Figure 4.
- Maitland Engineering Standards – Stormwater Drainage.
- Australian Rainfall and Runoff, Institution of Engineers 1998.
- Land Information Centre Digital Elevation Model (LIC DEM).
- Aerial Imagery (SIX Maps).
- Stormwater Drainage Strategy, GCA Engineering Solutions (Ref. 20300C), Rev 3, 11/06/2021.
- Design Drawings for 48 Windermere Road Lochinvar Subdivision (Ref. 20300C), Rev 5, 08/09/2021.

## 2 Stormwater Management Strategy

The proposed stormwater management strategy for the development is outlined below. A general arrangement of the proposed stormwater drainage network is provided in Figure 5. Subsequent sections of this report will demonstrate that the stormwater strategy will achieve all the relevant target criteria.

### 2.1 Catchment plan

To ensure that the relevant environmental objectives are achieved in a financially sustainable manner, water quality and detention measures have been considered during the initial development stage. It is proposed to utilise the approved detention/bio-retention basin located to the south-east of the proposed development that was designed as part of the residential subdivision of Lot 1 DP537313 (48 Windermere Road, Lochinvar). The basin will be augmented as required to serve both the residential development on Lot 1 DP537313 and the proposed development.

This report will utilise the same catchment areas modelled in the Stormwater Management Strategy for Lot 1 DP537313 (GCA Engineering Solutions, Rev 3, 11/06/2021) with some adjustments to account for the proposed development (Catchment 1 was increased and Catchment 4 was added). The previous Catchment Plans have been included in Appendix A for reference.

Catchments 1 and 4 will be urbanised during the proposed development. Once developed, stormwater runoff from Catchment 1A will be redirected into the proposed detention basin.

Lot and road areas will be drained by a conventional pit and pipe network located in the street or in inter-allotment drainage where required. The pipe network will comprise the minor system subject to MCC's minor design standard of 10% AEP. The road network would form the majority of the major network standard of 1% AEP.

Discharge from the basin will be controlled by a combination of biofiltration media sub soil drainage, low-level discharge pipes, a low-level outlet pipe, inlet pit and a spillway.

Stormwater runoff from minor Catchment 1B will bypass the previously approved proposed basin due to local topography and discharge directly to Lochinvar Creek.

Water quality for the system as a whole will meet MCC's targets as outlined in the MOES. This will be achieved by a treatment train approach comprising Gross Pollutant Traps as indicated on Figure 5 and a bio-retention basin. Water quality and modelling is discussed in detail in Section 4.



## 3 Volume Rate of Flow

### 3.1 Criteria

Discharge from the proposed and previously approved development has been limited to the predevelopment rates for 1EY, 10% and 1% AEP events.

### 3.2 Methodology

For large developments utilising detention basin storages, the Time Area Hydrograph Routing method is considered to be the most appropriate tool for determining basin volumes. The DRAINS software package, published by Watercom Pty Ltd, has been used to investigate the catchments and the ameliorating effects of the proposed basin. This works by translating rainfall hyetographs into runoff hydrographs over sub catchments and subsequently adding the resulting hydrographs together to quantify design rates of flow and runoff volumes.

Modelling parameters used for the proposed residential development were taken directly from the previously approved Stormwater Management Strategy for Lot 1 DP537313 (GCA Engineering Solutions, Rev 3, 11/06/2021). The DRAINS model data is provided in Appendix B.

### 3.3 Results

#### 3.3.1 Detention basin

The previously approved basin is located to the south-east of the proposed development, above the 1% AEP flood level of R.L. 26.00. Details for the previously approved basin compared to the widened basin are provided in Table 3-1. The widening of the previously approved basin as part of the proposed development works is shown in Figure 6.

**Table 3-1: Comparison of Previously Approved and Widened Detention Basin details.**

	Previously Approved Detention Basin	Widened Detention Basin
Top of Bank	R.L. 29.00	R.L. 29.00
Q <sub>100</sub> Top Water Level	R.L. 28.50	R.L. 28.47
Detention Invert Level	R.L. 26.00	R.L. 26.00
Q <sub>100</sub> Detention Volume	7773m <sup>3</sup>	13808m <sup>3</sup>
Internal Batter Slopes	1v:6h	1v:6h
Bioretention Invert Level	R.L. 25.80	R.L. 25.80
Bioretention Media Invert Level	R.L. 25.20	R.L. 25.10
Filter Media Area	50m <sup>2</sup>	150m <sup>2</sup>
Filter Media Depth	0.4m	0.4m
Outlet Control Pit (Internal Dimensions)	1.5m x 1.2m control pit at R.L. 27.30 & I.L. 25.20	1.5m x 1.2m control pit at R.L. 27.30 & I.L. 25.10
Inlet Orifice	3x ø150mm at R.L. 26.00	2x ø150mm at R.L. 26.00
Outlet Pipe	1x ø675mm RCP at R.L. 25.20	1x ø675mm RCP at R.L. 25.10
Spillway	6.5m long at R.L. 28.15	6.5m long at R.L. 28.15

The following modifications were made to the previously approved detention basin to account for the proposed residential development:

- The volume was increased by 6035m<sup>3</sup>.
- The inlet orifice was modified from 3x ø150mm to 2x ø150mm.

### 3.3.2 Discharge rates

The DRAINS model for predevelopment, and post development scenarios for the 1EY, 10% and 1% AEP events are presented in Appendix B, and the results are shown in Appendix C.

Results for outflow of the predevelopment and post development catchments (without modifying the previously approved detention basin) at the catchment outlet are summarised in Table 3-2.

**Table 3-2: Discharge rates – Predevelopment and Post development (no basin widening).**

Event	Predevelopment discharge rate (m <sup>3</sup> /s)	Post development discharge rate without widened detention basin (m <sup>3</sup> /s)	Difference (%)
1EY	0.207	0.72	+250
10% AEP	1.98	2.20	+11
1% AEP	5.04	6.99	+39

Results for outflow of the predevelopment and post development catchments (with modifications to the previously approved detention basin) at the catchment outlet are summarised in Table 3-3.

**Table 3-3: Discharge rates – Predevelopment and Post development (with basin modification).**

Event	Predevelopment discharge rate (m <sup>3</sup> /s)	Post development discharge rate with modified detention basin (m <sup>3</sup> /s)	Difference (%)
1EY	0.207	0.205	-1
10% AEP	1.98	1.59	-20
1% AEP	5.04	3.74	-27

### 3.4 Discussion

With modifications to the previously approved detention basin and outlet structure, the proposed residential development will not produce an outflow larger than pre-development flow rates during the 1EY, 10% and 1% AEP events.

## 4 Stormwater Runoff Quality

### 4.1 Criteria

Treatment targets for the proposed development were adopted from MCC’s MOES and are shown in Table 4-1.

**Table 4-1: Stormwater treatment objectives.**

Pollutant	Stormwater treatment objective
Total Suspended Solids (TSS)	80% retention of average annual load
Total Phosphorus (TP)	45% retention of average annual load
Total Nitrogen (TN)	45% retention of average annual load
Gross Pollutants (GP)	70% retention of average annual load

### 4.2 Methodology

The development was modelled using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) published by eWater Limited, which is the current best practice tool for estimating the ameliorating effects of proposed stormwater quality improvement devices (SQUIDS) in a treatment train approach.

MUSIC uses real historical continuous rainfall records (over several years) as input and compares the theoretical pollutant generation within the catchment to the final theoretical export rate (usually expressed in kg/year) to determine a treatment train effectiveness expressed in percentage points that are directly comparable to the guidelines in Table 4-1.

Stormwater quality for the previously approved residential development was addressed during the design of the previously approved combined basin. A MUSIC model was constructed with a catchment comprising the pavement area, roof area and landscaping of both the previously approved and proposed residential development to examine whether augmentation of the previously approved combined basin would be required to achieve the required stormwater treatment objectives.

### 4.3 Results

The MUSIC model layout is provided in Appendix D. The minimum sand filter area needs to be increased from 50m<sup>2</sup> to 150m<sup>2</sup> for the combined basin to meet MCC’s stormwater treatment objectives. The pollutant retention achieved by the combined basin with a minimum sand filter area of 150m<sup>2</sup> is provided in Table 4-2.

**Table 4-2: Stormwater Treatment Objectives**

Pollutant	Average Annual Surface Generation (kg/year)	Average Annual Export (kg/year)	Achieved Reduction (Pollutants Retained)	Target Reduction (Pollutants Retained)
Total Suspended Solids (TSS)	26000	5210	80.0%	80%
Total Phosphorus (TP)	50.4	21.2	57.9%	45%
Total Nitrogen (TN)	365	196	46.4%	45%
Gross Pollutants (GP)	5140	158	96.9%	70%

## 4.4 Discussion

MCC's stormwater treatment objectives will be met by increasing the previously approved combined basins sand filter area from 50m<sup>2</sup> to 150m<sup>2</sup>. The above results indicate the proposed stormwater drainage strategy will produce an outcome for the proposed and previously approved development that complies with Council's standards for water quality control.

## 5 Summary and Conclusions

The strategy for management of stormwater runoff for the proposed development includes:

- Capture of stormwater from lot and road areas by conventional pit and pipe networks located in the street or in inter-allotment drainage where required.
- Widening of the previously approved detention basin to the south-east of the Site. It is proposed to modify the previously approved bio-retention component of the previously approved basin by increasing the minimum sand filter area by 100m<sup>2</sup>.
- Stormwater runoff from minor Catchment 1B is to bypass the previously approved detention basin due to local topography and drain directly to Lochinvar Creek.

Post development outflows are less than or equal to predevelopment outflows for the 1EY, 10% and 1% AEP events. The development will not increase the risk or likelihood of mainstream erosion in smaller flood events or flooding in larger events.

It is proposed to modify the design of the bio-retention component of the previously approved combined basin by increasing the minimum sand filter area by 100m<sup>2</sup>. With the proposed augmentation, water quality modelling indicates that the proposed development will not impact the previously approved combined basin's ability to meet regional guidelines for best practise for retention of TSS, TN, TP and GP.

# Figures





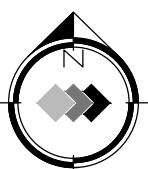
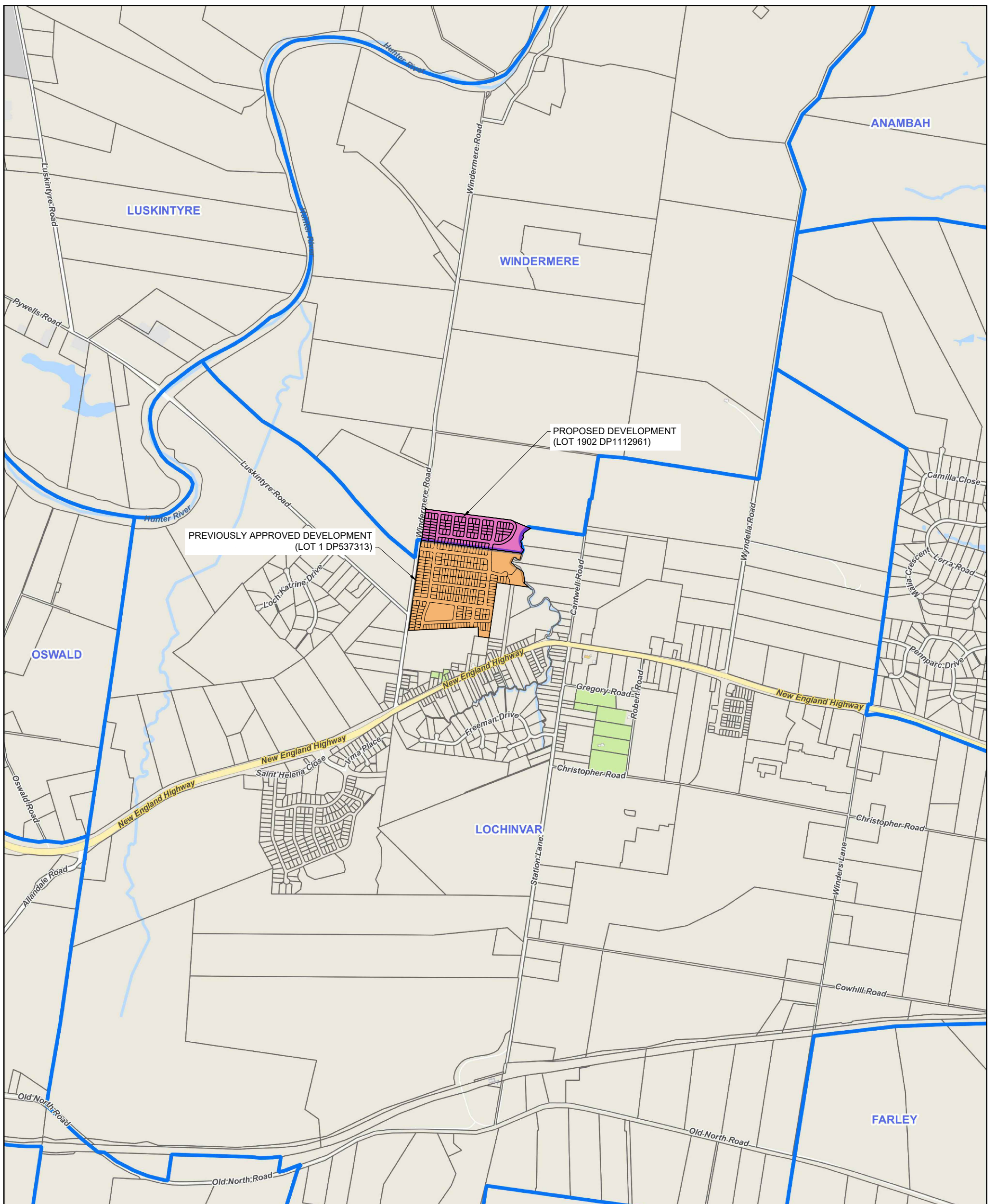


FIGURE 1  
LOCALITY PLAN

1:20000 0 400 800 1200m

DATE: 28/09/22



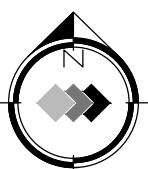
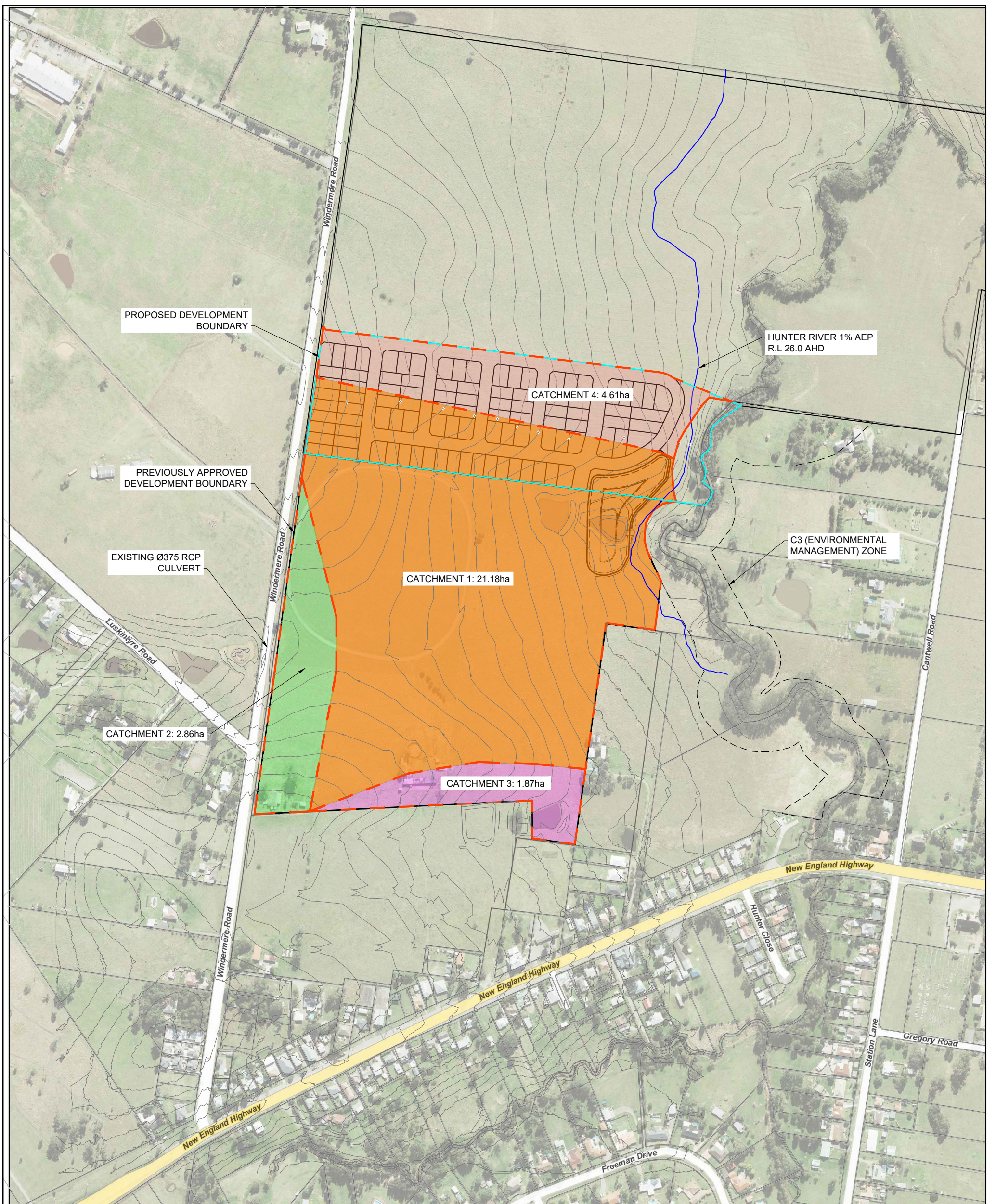


FIGURE 2  
PREDEVELOPMENT CATCHMENT PLAN

1:5000 0 100 200 300m

DATE: 28/09/22



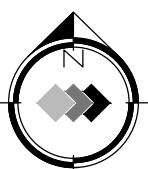
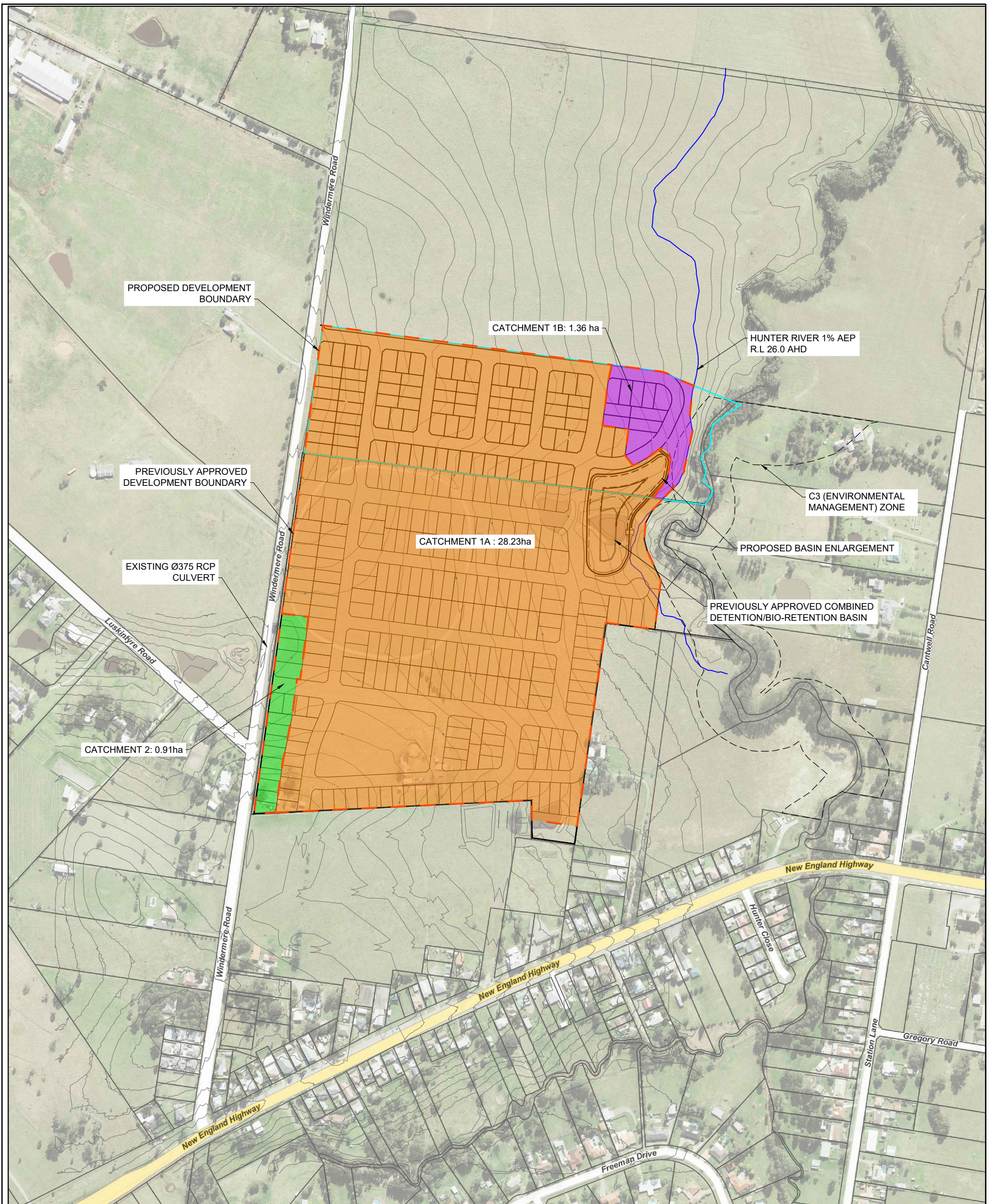


FIGURE 3  
POST DEVELOPMENT CATCHMENT PLAN

1:5000 0 100 200 300m

DATE: 04/07/22



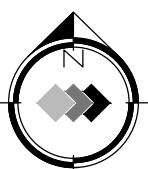
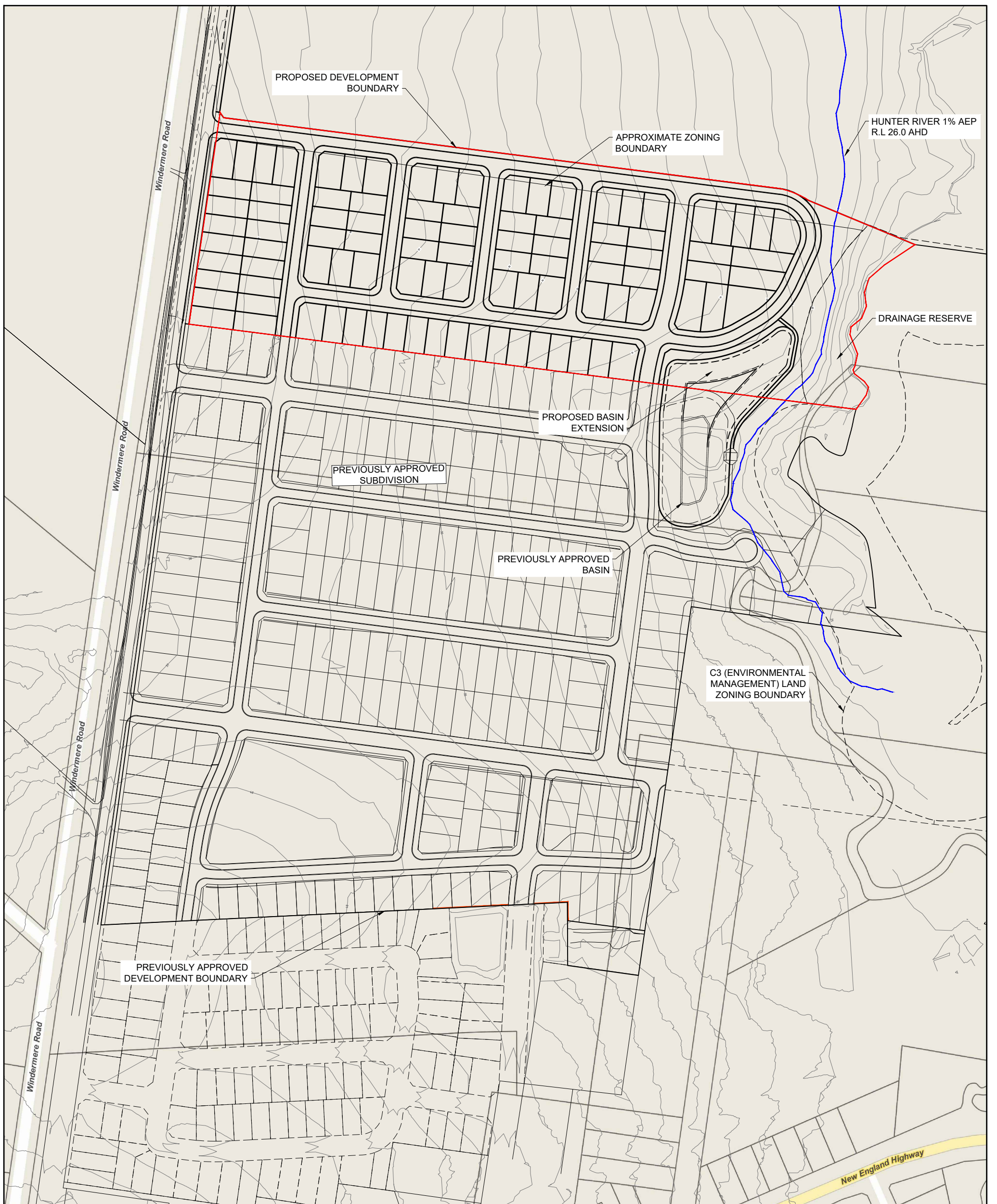


FIGURE 4  
SITE PLAN

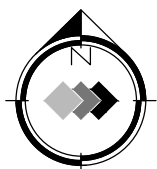
1:3000 0 60 120 180m

DATE: 28/09/22

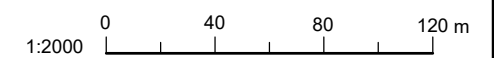


**LEGEND**

- PROPOSED STORMWATER PIPE
- PROPOSED HEADWALL
- PROPOSED EKI PIT
- PROPOSED SAG PIT
- PROPOSED IAD PIT
- NATURAL CONTOURS (0.5m INTERVAL)
- EXISTING DETENTION BASIN
- PROPOSED BASIN WIDENING

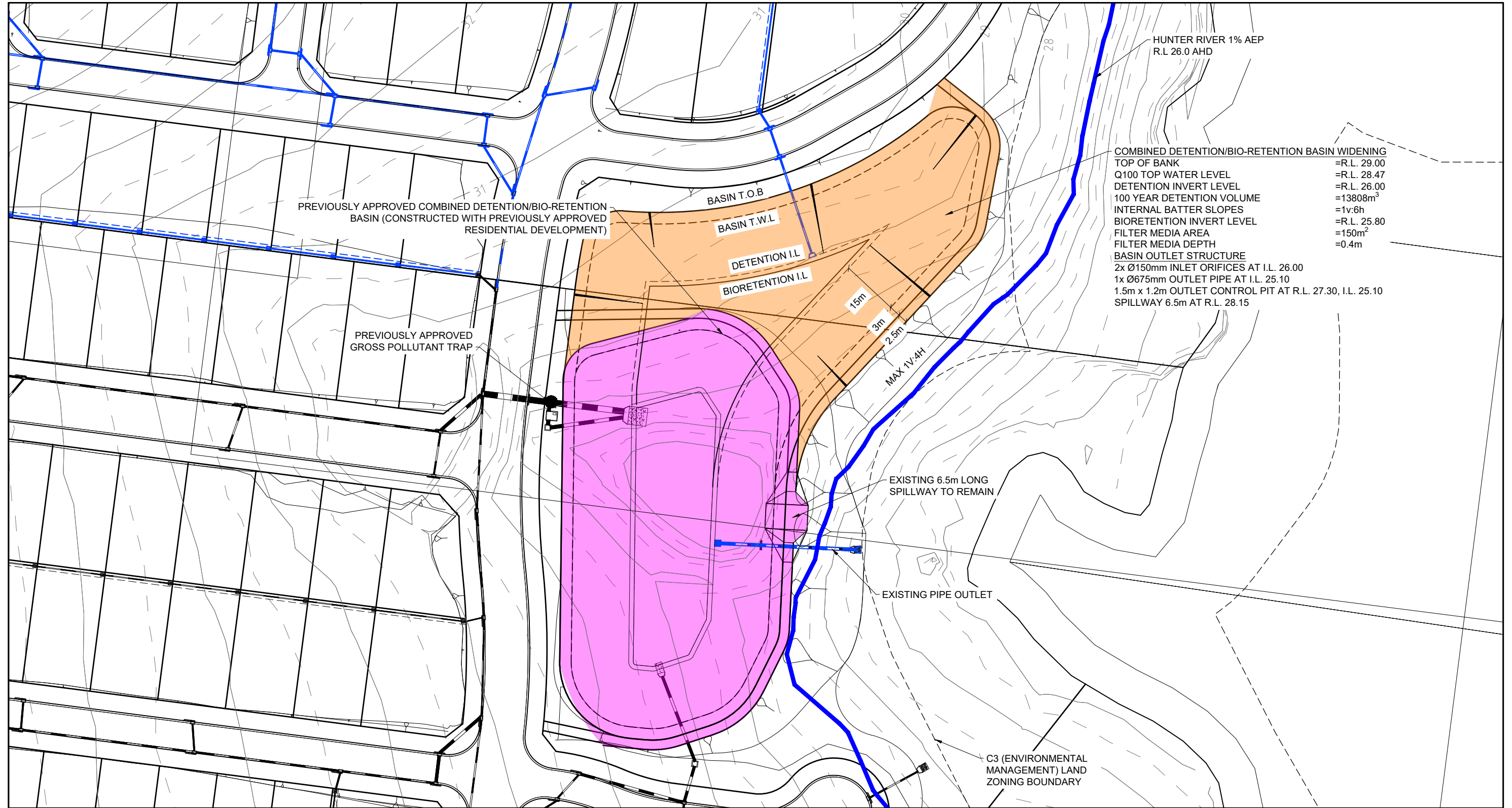


**FIGURE 5**  
STORMWATER MANAGEMENT PLAN



DATE: 06/10/22





**LEGEND**

- PROPOSED STORMWATER PIPE
- PROPOSED EKI PIT
- PROPOSED SAG PIT
- PROPOSED IAD PIT
- PROPOSED HEADWALL
- NATURAL CONTOURS (0.5m INTERVAL)
- EXISTING DETENTION BASIN
- PROPOSED BASIN WIDENING

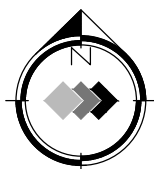
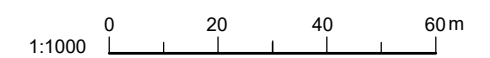


FIGURE 6  
PREVIOUSLY APPROVED COMBINED BASIN WIDENING

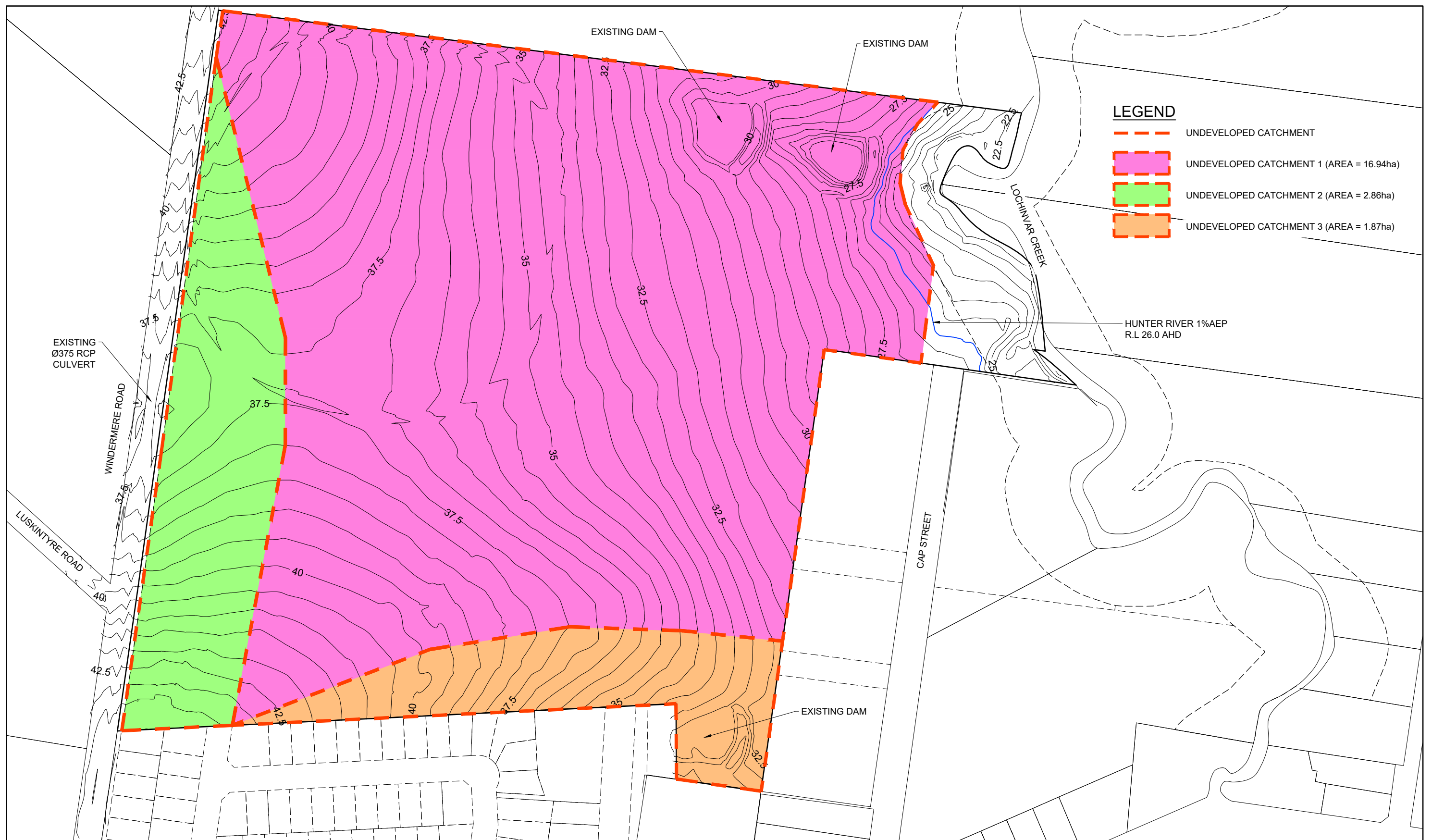


DATE: 06/10/22

# Appendix A

## Catchment Plans





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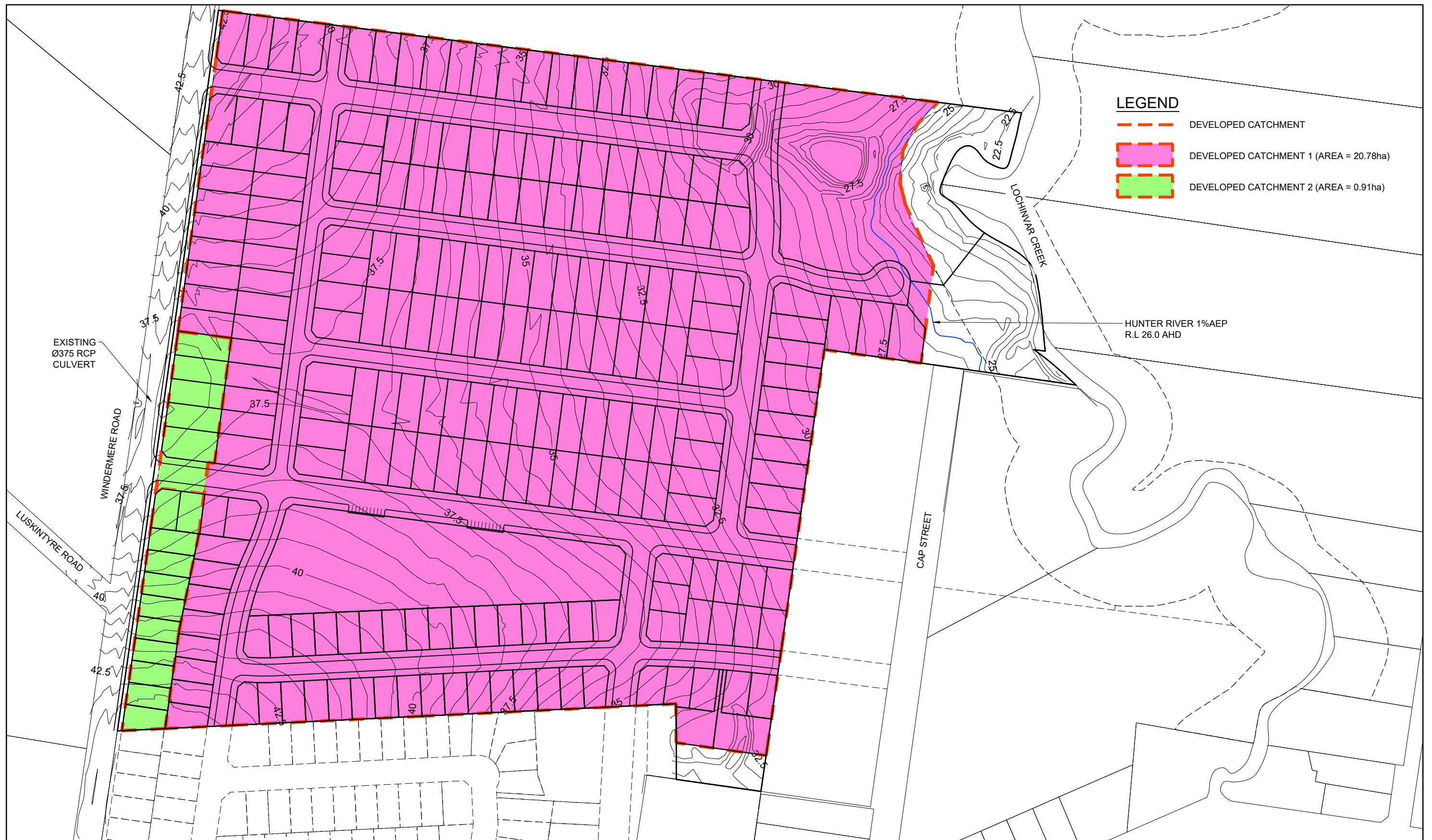
	UNDEVELOPED CATCHMENT
	UNDEVELOPED CATCHMENT 1 (AREA = 16.94ha)
	UNDEVELOPED CATCHMENT 2 (AREA = 2.86ha)
	UNDEVELOPED CATCHMENT 3 (AREA = 1.87ha)

FIGURE 1  
UNDEVELOPED CATCHMENT PLAN

1:2500 0 50 100 150 m

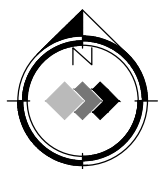
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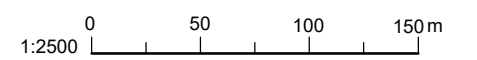


**LEGEND**

- DEVELOPED CATCHMENT
- DEVELOPED CATCHMENT 1 (AREA = 20.78ha)
- DEVELOPED CATCHMENT 2 (AREA = 0.91ha)



**FIGURE 2**  
**DEVELOPED CATCHMENT PLAN**



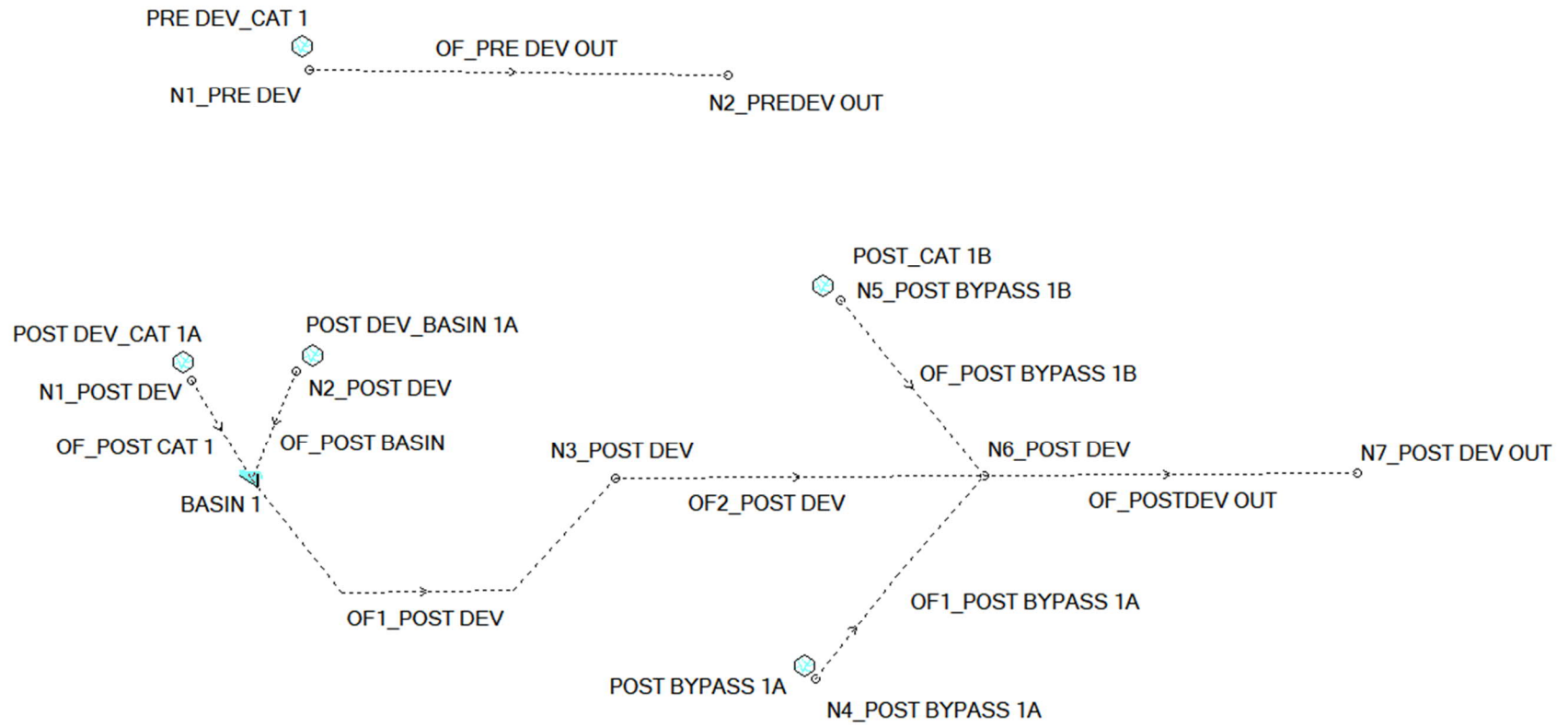
DATE: 11.06.21



# Appendix B

## DRAINS Data





DRAINS Data

PIT / NODE DETAILS

Name	Type	Family	Version 15 Size	Ponding Volume (cu.m)	Pressure Change Coeff. Ku	Surface Elev (m)	Max Pond Depth (m)	Base Inflow (cu.m/s)	Blocking Factor	x	y	Bolt-down lid	Part Full Shock Loss	Inflow Hydrograph	Pit is	Internal Width (mm)	Inflow is Misaligned	Minor Safe Pond Depth (m)	Major Safe Pond Depth (m)	
N1_PRE DEV	Node					25		0		600	-152		4	No						
N2_PREDEV OUT	Node					24.5		0		920	-156		13	No						
N3_POST DEV	Node					26		0		834	-465		1802	No						
N7_POST DEV OUT	Node					24.5		0		1401	-461		1803	No						
N4_POST BYPASS 1A	Node					26.5		0		987	-618		61050	No						
N6_POST DEV	Node					25		0		1116	-463		61195	No						
N1_POST DEV	Node					29		0		510	-390		162946	No						
N2_POST DEV	Node					29		0		590	-383		162947	No						
N5_POST BYPASS 1B	Node					28		0		1006	-329		162998	No						

DETENTION BASIN DETAILS

Name	Elev	Surf. Area	Not Used	Outlet Type	K	Dia(mm)	Centre RL	Pit Family	Pit Type	x	y	HED	Crest RL	Crest Leng id	1733
BASIN 1	26	2905		None								-466	No		
	26.5	3898													
	27	4970													
	27.5	6131													
	28	7380													
	28.5	8714													
	29	10066													

SUB-CATCHMENT DETAILS

Name	Pit or Node	Total Area (ha)	Paved Area %	Grass Area %	Supp Area %	Paved Time (min)	Grass Time (min)	Supp Time (min)	Paved Length (m)	Grass Length (m)	Supp Length (m)	Paved Slope (%)	Grass Slope (%)	Supp Slope (%)	Paved Rough	Grass Rough	Supp Rough	Lag or Factor	Cutter Length (m)	Cutter Slope %	Gutter Flow Factor	Rainfall Multiplier
PRE_DEV_CAT 1	N1_PRE DEV	21.18	0	100	0	1	5	0	0	475	0	0	5	0	0	0.1	0	0	0	0	0	1
POST BYPASS 1A	N4_POST BYPASS 1A	0.38	65	35	0	1	5	0	50	70	0	4	4	0	0.01	0.1	0	0	0	0	0	1
POST_DEV_CAT 1A	N1_POST DEV	27.23	56	44	0	1	5	0	800	100	0	2	2	0	0.01	0.1	0	0	0	0	0	1
POST_DEV_BASIN 1A	N2_POST DEV	1	0	100	0	0	0	0	0	5	-1	0	0.1	-1	0	0.1	-1	0	0	0	0	1
POST_DEV_CAT 1B	N5_POST BYPASS 1B	1.36	47	53	0	0	5	0	15	20	0	5	4	0	0.01	0.1	0	0	0	0	0	1

PIPE DETAILS

Name	From	To	Length (m)	U/S IL (m)	D/S IL (m)	Slope (%)	Type	Dia (mm)	I.D. (mm)	Rough	Pipe Is	No. Pipes	Chg From	At Chg	Chg (m)	RI (m)	Chg (m)	RL (m)	etc (m)
------	------	----	------------	------------	------------	-----------	------	----------	-----------	-------	---------	-----------	----------	--------	---------	--------	---------	--------	---------

DETAILS OF SERVICES CROSSING PIPES

Pipe	Chg (m)	Bottom Elev (m)	Height of SChg (m)	Bottom Elev (m)	Height of SChg (m)	Bottom Elev (m)	Height of Setc etc
------	---------	-----------------	--------------------	-----------------	--------------------	-----------------	--------------------

CHANNEL DETAILS

Name	From	To	Type	Length (m)	U/S IL (m)	D/S IL (m)	Slope (%)	Base Width (m)	L.B. Slope (1:?)	R.B. Slope (1:?)	Manning n	Depth (m)	Roofed
------	------	----	------	------------	------------	------------	-----------	----------------	------------------	------------------	-----------	-----------	--------

OVERFLOW ROUTE DETAILS

Name	From	To	Travel Time (min)	Spill Level (m)	Crest Length (m)	Weir Coeff. C	Cross Section	Safe Major Stor (m)	Depth Stor (m)	Safe Minor Stor (m)	Safe Div (m)	Bed Slope (sq.m/sec) (%)	D/S Area Contributing %	id
OF_PRE DEV OUT	N1_PRE DEV	N2_PREDEV OUT	0.1				overflow	0.3	0.3	0.4	1	100	18	5
OF1_POST DEV	BASIN 1	N3_POST DEV	0.1	26			overflow	0.3	0.3	0.4	1	100	1804	5
OF2_POST DEV	N3_POST DEV	N6_POST DEV	0.1				overflow	0.3	0.3	0.4	1	100	1805	5
OF1_POST BYPASS 1A	N4_POST BYPASS 1A	N6_POST DEV	0.1				overflow	0.3	0.3	0.4	1	100	61127	5
OF_POSTDEV OUT	N6_POST DEV	N7_POST DEV OUT	0.1				overflow	0.3	0.3	0.4	1	100	61201	1
OF_POST CAT 1	N1_POST DEV	BASIN 1	0.1				overflow	0.3	0.3	0.4	1	100	162959	5
OF_POST BASIN	N2_POST DEV	BASIN 1	0.1				overflow	0.3	0.3	0.4	1	100	162960	5
OF_POST BYPASS 1B	N5_POST BYPASS 1B	N6_POST DEV	0.1				overflow	0.3	0.3	0.4	1	100	163002	5

PIPE COVER DETAILS

Name	Type	Dia (mm)	Safe Cover Cover (m)
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This model has no pipes with non-return valves

**BASIN 1 - STAGE / DISCHARGE RELATIONSHIP FOR BASIN WITH STAGED CONTROL STRUCTURE**

Elevation	MAIN CONTROL STRUCTURES				OVERFLOW STRUCTURES				Stage	Total Outflow
	Pipe		Pit		Spillway		Check Pipe Inlet Control			
RL	For H/D < 1.2 : $Q=1.32D^{1.87}H^{1.63}$ For H/D > 1.2 : $Q=1.62D^{1.87}H^{1.63}$ Pipe Dia (D), m <b>0.150</b> <i>Assuming Square Edged</i>		Q=1.67LH <sup>1.5</sup> Weir Length (L), m <b>5.4</b> Pit Inlet (RL), m <b>27.30</b>		Q=1.67LH <sup>1.5</sup> Weir Length (L), m <b>6.5</b> Weir Invert (RL), m <b>28.15</b>		For H/D < 1.2 : $Q=1.32D^{1.87}H^{1.63}$ For H/D > 1.2 : $Q=1.62D^{1.87}H^{1.63}$ Pipe Dia (D), m <b>0.675</b> <i>Assuming Square Edged</i>			
Increment <b>0.05</b>	Pipe Invert (RL), m <b>26.00</b>						Pipe Invert (RL), m <b>25.10</b>			
	No. Pipes <b>2</b>						No. Pipes <b>1</b>			
	H (m)	Q (cumecs)	H (m)	Q (cumecs)	H (m)	Q (cumecs)	H (m)	Q (cumecs)		
26.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.73	26.00	0.000
26.05	0.05	0.00	0.00	0.00	0.00	0.00	0.95	0.75	26.05	0.004
26.10	0.10	0.01	0.00	0.00	0.00	0.00	1.00	0.78	26.10	0.012
26.15	0.15	0.02	0.00	0.00	0.00	0.00	1.05	0.80	26.15	0.023
26.20	0.20	0.03	0.00	0.00	0.00	0.00	1.10	0.82	26.20	0.034
26.25	0.25	0.04	0.00	0.00	0.00	0.00	1.15	0.85	26.25	0.039
26.30	0.30	0.04	0.00	0.00	0.00	0.00	1.20	0.87	26.30	0.044
26.35	0.35	0.05	0.00	0.00	0.00	0.00	1.25	0.89	26.35	0.048
26.40	0.40	0.05	0.00	0.00	0.00	0.00	1.30	0.92	26.40	0.052
26.45	0.45	0.06	0.00	0.00	0.00	0.00	1.35	0.94	26.45	0.056
26.50	0.50	0.06	0.00	0.00	0.00	0.00	1.40	0.96	26.50	0.060
26.55	0.55	0.06	0.00	0.00	0.00	0.00	1.45	0.98	26.55	0.064
26.60	0.60	0.07	0.00	0.00	0.00	0.00	1.50	1.00	26.60	0.068
26.65	0.65	0.07	0.00	0.00	0.00	0.00	1.55	1.02	26.65	0.071
26.70	0.70	0.07	0.00	0.00	0.00	0.00	1.60	1.04	26.70	0.075
26.75	0.75	0.08	0.00	0.00	0.00	0.00	1.65	1.06	26.75	0.078
26.80	0.80	0.08	0.00	0.00	0.00	0.00	1.70	1.09	26.80	0.081
26.85	0.85	0.08	0.00	0.00	0.00	0.00	1.75	1.11	26.85	0.084
26.90	0.90	0.09	0.00	0.00	0.00	0.00	1.80	1.12	26.90	0.087
26.95	0.95	0.09	0.00	0.00	0.00	0.00	1.85	1.14	26.95	0.090
27.00	1.00	0.09	0.00	0.00	0.00	0.00	1.90	1.16	27.00	0.093
27.05	1.05	0.10	0.00	0.00	0.00	0.00	1.95	1.18	27.05	0.096
27.10	1.10	0.10	0.00	0.00	0.00	0.00	2.00	1.20	27.10	0.099
27.15	1.15	0.10	0.00	0.00	0.00	0.00	2.05	1.22	27.15	0.102
27.20	1.20	0.10	0.00	0.00	0.00	0.00	2.10	1.24	27.20	0.105
27.25	1.25	0.11	0.00	0.00	0.00	0.00	2.15	1.26	27.25	0.107
27.30	1.30	0.11	0.00	0.00	0.00	0.00	2.20	1.28	27.30	0.110
27.35	1.35	0.11	0.05	0.10	0.00	0.00	2.25	1.29	27.35	0.214
27.40	1.40	0.12	0.10	0.29	0.00	0.00	2.30	1.31	27.40	0.400
27.45	1.45	0.12	0.15	0.52	0.00	0.00	2.35	1.33	27.45	0.642
27.50	1.50	0.12	0.20	0.81	0.00	0.00	2.40	1.35	27.50	0.927
27.55	1.55	0.12	0.25	1.13	0.00	0.00	2.45	1.37	27.55	1.250
27.60	1.60	0.13	0.30	1.48	0.00	0.00	2.50	1.38	27.60	1.384
27.65	1.65	0.13	0.35	1.87	0.00	0.00	2.55	1.40	27.65	1.401
27.70	1.70	0.13	0.40	2.28	0.00	0.00	2.60	1.42	27.70	1.418
27.75	1.75	0.13	0.45	2.72	0.00	0.00	2.65	1.44	27.75	1.435
27.80	1.80	0.14	0.50	3.19	0.00	0.00	2.70	1.45	27.80	1.452
27.85	1.85	0.14	0.55	3.68	0.00	0.00	2.75	1.47	27.85	1.469
27.90	1.90	0.14	0.60	4.19	0.00	0.00	2.80	1.49	27.90	1.486
27.95	1.95	0.14	0.65	4.73	0.00	0.00	2.85	1.50	27.95	1.503
28.00	2.00	0.14	0.70	5.28	0.00	0.00	2.90	1.52	28.00	1.519
28.05	2.05	0.15	0.75	5.86	0.00	0.00	2.95	1.54	28.05	1.536
28.10	2.10	0.15	0.80	6.45	0.00	0.00	3.00	1.55	28.10	1.552
28.15	2.15	0.15	0.85	7.07	0.00	0.00	3.05	1.57	28.15	1.568
28.20	2.20	0.15	0.90	7.70	0.05	0.12	3.10	1.58	28.20	1.706
28.25	2.25	0.16	0.95	8.35	0.10	0.34	3.15	1.60	28.25	1.944
28.30	2.30	0.16	1.00	9.02	0.15	0.63	3.20	1.62	28.30	2.247
28.35	2.35	0.16	1.05	9.70	0.20	0.97	3.25	1.63	28.35	2.603
28.40	2.40	0.16	1.10	10.40	0.25	1.36	3.30	1.65	28.40	3.005
28.45	2.45	0.16	1.15	11.12	0.30	1.78	3.35	1.66	28.45	3.447
28.50	2.50	0.17	1.20	11.85	0.35	2.25	3.40	1.68	28.50	3.927
28.55	2.55	0.17	1.25	12.60	0.40	2.75	3.45	1.69	28.55	4.441
28.60	2.60	0.17	1.30	13.37	0.45	3.28	3.50	1.71	28.60	4.987
28.65	2.65	0.17	1.35	14.15	0.50	3.84	3.55	1.73	28.65	5.563
28.70	2.70	0.17	1.40	14.94	0.55	4.43	3.60	1.74	28.70	6.169
28.75	2.75	0.18	1.45	15.75	0.60	5.04	3.65	1.76	28.75	6.801
28.80	2.80	0.18	1.50	16.57	0.65	5.69	3.70	1.77	28.80	7.460
28.85	2.85	0.18	1.55	17.40	0.70	6.36	3.75	1.79	28.85	8.144
28.90	2.90	0.18	1.60	18.25	0.75	7.05	3.80	1.80	28.90	8.852
28.95	2.95	0.18	1.65	19.11	0.80	7.77	3.85	1.82	28.95	9.583
29.00	3.00	0.19	1.70	19.99	0.85	8.51	3.90	1.83	29.00	10.338

# Appendix C

## DRAINS Results



DRAINS Results - 1EY AEP

DRAINS results prepared from Version 2022.012

PIT / NODE DETAILS

Name	Max HGL	Max Pond HGL	Version 8			Overflow (cu.m/s)	Constraint
			Max Surfac Flow (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)		

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
PRE_DEV_CAT 1	0.207	0	0.207	1	63.43		0 1EY AEP, 2 hour burst, Storm 6
POST BYPASS 1A	0.056	0.056	0	3.06	15.05		0 1EY AEP, 5 min burst, Storm 1
POST_DEV_CAT 1A	2.077	1.926	0.151	16.75	23.01		0 1EY AEP, 15 min burst, Storm 9
POST_DEV_BASIN 1A	0.049	0	0.049	0	10.18		0 1EY AEP, 1 hour burst, Storm 8
POST_CAT 1B	0.146	0.146	0	0.94	9.74		0 1EY AEP, 5 min burst, Storm 1

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
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CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Due to Storm
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OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF_PRE DEV OUT	0.207	0.207	4.801	0.028	0.02	12.01	0.62	1EY AEP, 2 hour burst, Storm 6
OF1_POST DEV	0.098	0.098	4.801	0.018	0.01	12	0.45	1EY AEP, 2 hour burst, Storm 6
OF2_POST DEV	0.098	0.098	4.801	0.018	0.01	12	0.45	1EY AEP, 2 hour burst, Storm 6
OF1_POST BYPASS 1A	0.056	0.056	4.801	0.013	0	12	0.36	1EY AEP, 5 min burst, Storm 1
OF_POSTDEV OUT	0.205	0.205	4.801	0.028	0.02	12.01	0.61	1EY AEP, 5 min burst, Storm 1
OF_POST CAT 1	2.077	2.077	4.801	0.113	0.17	12.02	1.53	1EY AEP, 15 min burst, Storm 9
OF_POST BASIN	0.049	0.049	4.801	0.012	0	12	0.34	1EY AEP, 1 hour burst, Storm 8
OF_POST BYPASS 1B	0.146	0.146	4.801	0.023	0.01	12	0.53	1EY AEP, 5 min burst, Storm 1

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level
BASIN 1	27.08	4301	0.098	0	0.098

Run Log for 21460C DRAINS CATCHMENT 1 r2 2016 ARR 20220929.drn run at 09:53:22 on 6/10/2022 using version 2022.012

DRAINS Results - 10% AEP  
DRAINS results prepared from Version 2022.012

PIT / NODE DETAILS

Version 8

Name	Max HGL	Max Pond HGL	Max Surface Flow (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
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SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
PRE_DEV_CAT 1	1.976	0	1.976	1	42.15		0 10% AEP, 1 hour burst, Storm 9
POST BYPASS 1A	0.119	0.11	0.01	2.58	12.7		0 10% AEP, 5 min burst, Storm 1
POST_DEV_CAT 1A	6.053	4.628	1.547	13.08	18.81		0 10% AEP, 15 min burst, Storm 6
POST_DEV_BASIN 1A	0.291	0	0.291	0	5.62		0 10% AEP, 15 min burst, Storm 5
POST_CAT 1B	0.391	0.305	0.15	0.84	9.27		0 10% AEP, 15 min burst, Storm 3

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
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CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Due to Storm
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OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF_PRE DEV OUT	1.976	1.976	4.801	0.109	0.16	12.02	1.51	10% AEP, 1 hour burst, Storm 9
OF1_POST DEV	1.447	1.447	4.801	0.09	0.12	12.02	1.33	10% AEP, 2 hour burst, Storm 7
OF2_POST DEV	1.447	1.447	4.801	0.09	0.12	12.02	1.33	10% AEP, 2 hour burst, Storm 7
OF1_POST BYPASS 1A	0.119	0.119	4.801	0.02	0.01	12	0.5	10% AEP, 5 min burst, Storm 1
OF_POSTDEV OUT	1.591	1.591	4.801	0.096	0.13	12.02	1.38	10% AEP, 2 hour burst, Storm 9
OF_POST CAT 1	6.053	6.053	4.801	0.215	0.5	12.04	2.34	10% AEP, 15 min burst, Storm 6
OF_POST BASIN	0.291	0.291	4.801	0.035	0.02	12.01	0.7	10% AEP, 15 min burst, Storm 5
OF_POST BYPASS 1B	0.391	0.391	4.801	0.041	0.03	12.01	0.78	10% AEP, 15 min burst, Storm 3

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level
BASIN 1	27.79	8526.7	1.447	0	1.447

Run Log for 21460C DRAINS CATCHMENT 1 r2 2016 ARR 20220929.drn run at 09:57:02 on 6/10/2022 using version 2022.012

DRAINS Results - 1% AEP

DRAINS results prepared from Version 2022.012

PIT / NODE DETAILS

Name	Max HGL	Max Pond HGL	Version 8			Overflow (cu.m/s)	Constraint
			Max Surfac Flow (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)		

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
PRE_DEV_CAT 1	5.038	0	5.038	1	30.42		0 1% AEP, 30 min burst, Storm 7
POST BYPASS 1A	0.207	0.179	0.028	2.3	11.32		0 1% AEP, 5 min burst, Storm 1
POST_DEV_CAT 1A	11.883	8.602	3.281	10.16	15.48		0 1% AEP, 10 min burst, Storm 2
POST_DEV_BASIN 1A	0.59	0	0.59	0	3.92		0 1% AEP, 5 min burst, Storm 1
POST_CAT 1B	0.749	0.381	0.368	0.64	8.24		0 1% AEP, 10 min burst, Storm 7

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
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CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Due to Storm
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OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF_PRE DEV OUT	5.038	5.038	4.801	0.193	0.42	12.04	2.17	1% AEP, 30 min burst, Storm 7
OF1_POST DEV	3.639	3.639	4.801	0.158	0.3	12.03	1.92	1% AEP, 2 hour burst, Storm 6
OF2_POST DEV	3.639	3.639	4.801	0.158	0.3	12.03	1.92	1% AEP, 2 hour burst, Storm 6
OF1_POST BYPASS 1A	0.207	0.207	4.801	0.028	0.02	12.01	0.62	1% AEP, 5 min burst, Storm 1
OF_POSTDEV OUT	3.698	3.698	4.801	0.16	0.31	12.03	1.93	1% AEP, 2 hour burst, Storm 6
OF_POST CAT 1	11.883	11.883	4.801	0.325	0.99	12.06	3.04	1% AEP, 10 min burst, Storm 2
OF_POST BASIN	0.59	0.59	4.801	0.053	0.05	12.01	0.92	1% AEP, 5 min burst, Storm 1
OF_POST BYPASS 1B	0.749	0.749	4.801	0.061	0.06	12.01	1.02	1% AEP, 10 min burst, Storm 7

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level
BASIN 1	28.47	13808.2	3.639	0	3.639

Run Log for 21460C DRAINS CATCHMENT 1 r2 2016 ARR 20220929.drn run at 09:57:12 on 6/10/2022 using version 2022.012



# Appendix D

## MUSIC Model



