1 Hartley Drive
(PO Box 3337)
Thornton NSW 2322
Ph (02) 4964 1811
E admin@gca.net.au
ABN 92 086 017 745
gca.net.au

Proposed Development
173 Wollombi Road, Farley

Stormwater Drainage Strategy

DBH Property Pty Ltd

Revision: 1
Version Date: 5 May 2022

GCA Ref: 22105

LAND DEVELOPMENT • BUILDINGS • INFRASTRUCTURE

CIVIL, STRUCTURAL & ENVIRONMENTAL ENGINEERING,
WATER & WASTEWATER, BUILDING DESIGN & PROJECT ADVISORY

Revision	Description	Author		Review		Approved	
1	Original Issue	TS	28/04/22	SH	02/05/22	SH	02/05/22

Table of Contents

List of Figures

List of Tables

List of Appendices

List of Acronyms

AEP	Annual Exceedance Probability
LGA	Local Government Area
MCC	Maitland City Council
MOES	Manual of Engineering Standards
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
OSD	Onsite Stormwater Detention
SQUIDS	Stormwater Quality Improvement Devices

1 Introduction

1.1 Background

This stormwater strategy is to support a proposed subdivision of Lots 1 on DP1005221 and 1 on DP 325580 into 41 lots for residential use.

Centralised stormwater management controls at the subdivision level have been designed to achieve the detention of stormwater flows that mimic natural, pre-developed flows for all storm events up to and including the 1% AEP event.

This report shows that:

- the overall post development stormwater runoff quantity will not impact on downstream flooding; and
- the retention of nominated pollutants (Total Suspended Solids, Nitrogen and Phosphorous) will meet Maitland City Councils (MCC's) current nominated targets.

1.2 Site description

The subject land is known as 173 (Lot 1 DP1005221) and 175 (Lot 1 DP 1005221) Wollombi Road, Farley. It comprises approximately 3.6 hectares of currently semi-rural / low density urban land. The Site is bound to the north by Wollombi Road, to the east by Owlpen Lane, to the south by the Castleton Close subdivision and to the west, by Ravensfield Downs. A locality plan has been provided in Figure 1.

There is a ridgeline dividing the site into two catchments running in the east – west direction approximately 150m south of Wollombi Road. The northern catchment drains via a culvert under Owlpen Lane to the head of a first order watercourse in Lot 1 on DP 1020104 (157 Wollombi Rd, Farley).

The southern catchment generally drains to the western table drain on Owlpen Lane, which in turn conveys runoff to the sag at the main culverts in the second order watercourse approximately 450m south of Wollombi Road. A residual 2100m^2 portion on the southern catchment (behind Lot 1 on DP 925327) drains via an inter allotment pit and pipe system though Lot 216 on DP 1273118, constructed as part of the Castleton Close subdivision works.

The Site is currently improved by two residential dwellings accompanied by miscellaneous structures (i.e., sheds, driveways). The Site is zoned R1 (General Residential) pursuant to Maitland Local Environmental Plan 2011. The Site is wholly situated within the Maitland City Council LGA.

1.3 Proposed development

The proposed development comprises the creation of approximately 42 residential lots within the Site boundary roughly in accordance with the draft subdivision layout shown in Figure 2.

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 to meet guidelines regarding volume rate of flow and runoff quality.

1.5 Available data

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

- A proposed subdivision layout plan from High Definition Design Pty Ltd. A copy of the subdivision plan is shown in Figure 2.
- Manual of Engineering Standards (MOES), Maitland City Council.
- Australian Rainfall and Runoff, Institution of Engineers 1998.
- Aerial Imagery (SIX Maps).
- Stormwater Drainage Strategy, GCA Engineering Solutions (Ref. 13130C), Rev 9, 30/06/2020.
- Design Drawings for Ravensfield Stage 2 (Ref. 18101C), Rev 5, 28/05/2019
- Design Drawings for Ravensfield Stage 3 (Ref. 18150C), Rev B, 30/7/2019
- Design Drawings for Castleton Close Subdivision Stage 1 (Ref. 16707C - 200), Rev 11 15/10/2021
- Design Drawings for Castleton Close Subdivision Stage 2 (Ref. 16707C - 100), Rev 7 10/12/2020
- Design Drawings for Harlington Avenue Watercourse Crossing (Ref 21332C), Rev 1 16/09/21

2 Stormwater Management Strategy

The proposed stormwater management strategy for the development is outlined below.

Runoff, up to the 1% AEP event from the northern catchment is to be piped under the crest on Owlpen Lane to the southern catchment. The combined flow from the northern and southern catchments will be directed to existing Basin 10, located immediately to the west of the sag in Owlpen Lane, approximately 450m south of Wollombi Road.

Augmentation works will be required to ensure sufficient capacity of the drainage system that directs water to Basin 10, including development approved in the Castleton Close subdivision.

It is acknowledged that Basin 10 is constrained, and no further augmentation of its capacity is feasible. However, a second basin (Basin 1) is to be constructed upstream of the proposed water crossing at Harlington Avenue.

Part of the upstream catchment that is currently served by Basin 10 will be redirected to the new Basin 1. The total catchment area to Basin 10 will remain essentially the same as in the existing situation and the remaining catchment will be served by Basin 1.

Basin 1 will be sized to cater for upstream areas as indicated in the post development catchment plan (Figure 4), including upstream catchments as previously allowed for.

Detained outflow from Basin 1 will be directed through Basin 10. The total maximum outflow rate at Basin 10 (Owlpen Lane) culverts will be shown to be less than the predevelopment (for the whole catchment) case, as determined by modelling based on the predeveloped Catchment 10 as indicated in Figure 3.

Catchment 1 will no longer discharge to the east except for very rare events (magnitude in excess of the 1% AEP event).

The existing and proposed stormwater drainage network, including those existing stormwater lines that require further investigation for augmentation is provided in Figure 5. Section 3 of this report demonstrates that the stormwater strategy will achieve the relevant target criteria for flow rates.

Water quality for the system as a whole will meet Maitland City Council targets as outlined in the MOES. This will be achieved by a treatment train approach comprising a network of Gross Pollutant Traps at strategic locations as indicated on Figure 5, a dry basin at Basin 1 and a wet basin at Basin 10. Water quality and modelling is discussed in detail at Section 4.

2.1 Catchment 1

Lot and road areas within Catchments 1B, 1C, 1D and 1E will be drained by a conventional pit and pipe drainage network located in the street or in inter-allotment drainage where required. The pipe network comprises 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.

The sag pits and pipe network currently located on the Harlington Avenue Creek Crossing (Ref 21332C) will require review to ensure it has adequate capacity and to direct flows into Basin 1.

Discharge from the Basin 1 will be controlled by a combination of low-level discharge pipes, low level outlet pipes and an increased pit inlet level.

Catchments 1A and 1F are considered to be external to the area of development interest. For the purposes of this report however, detention is provided for Catchment 1F in accordance with previously approved drainage strategies (Ref 13130). Considering the local topography, it is unlikely Catchment 1A will be developed in the future, however, should this be the case, it will be subject to its own detention.

2.2 Catchment 10

Catchment 10A and 10B will be urbanised during the proposed development. 10A is to be directed through Castleton Close, while 10B will be directed down Owlpen Lane. In both cases, the design systems (Ref 16707-200 and 16707-100 respectively) will require review to ensure they have adequate capacity to drain the proposed subdivision to Basin 10.

Catchment 10C comprises the already approved development in the catchment to Basin 10, while 10D is the watercourse and its associated riparian land and will remain undeveloped.

Basin 10 is existing and was approved pursuant to DA 14-724 to Maitland City Council. It is not proposed to modify this basin in any way.

Lot and road areas within Catchment 10 will be drained by a conventional pit and pipe drainage network located in the street or in inter-allotment drainage where required. The pipe network comprises 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.

3 Volume Rate of Flow

3.1 Criteria

Maitland City Council publishes OSD requirements for subdivision development in their Manual of Engineering Standards (MOES).

The combined discharge from the proposed development and Ravensfield Downs has been limited to the predevelopment rates for 1EY, 10% and 1% AEP events.

3.2 Methodology

DRAINS is a time area hydrograph model that uses the ILSAX engine to convert rainfall hyetographs to runoff hydrographs using an initial and continuing loss model with differing parameters for impervious, supplementary and grassed areas.

Input rainfall comprises discrete storms of various durations. The average intensity is distributed according to regional Australian Rainfall and Runoff temporal patterns which are broken down to the desired time step, usually 5 minutes. In this way, the total volume of a storm is considered in lieu of just generating a peak rate of flow (as per the probabilistic rational method) and detention basins can appropriately be modelled for their efficacy.

Total durations for input rainfall range from 5 minutes to 72 or more hours, however for the small catchments modelled in urban drainage scenarios, it is unlikely that long durations will generate critical flow results. Longer durations are nonetheless modelled to confirm the tails of the hydrographs do not extend or overtop basin storages.

A predevelopment model was constructed using site contours and fully pervious catchment types with long kinematic wave flow paths according to catchment characteristics. The model was run for 1EY, 10% and 1% AEP events for the 5, 10, 15, 20, 25, 30, 45 minutes and 1, 1.5-, 2-, 3-, and 4.5-hour durations. The critical peak flow rates for the 1EY, 10% and 1% AEP events were then adopted as the maximum permissible site discharge for the study area (at existing Basin 10).

The post development DRAINS model was iteratively run to size Basin 1 so that the predevelopment outflow criteria were achieved for the outlet to Basin 10, considering full development of the catchment.

The predevelopment and post development DRAINS model data and layouts are provided in Appendix A.

Previously approved stormwater strategy's DRAINS modelling (Ref 13130C) utilised ARR 1987 rainfall data, which was superseded in 2016. Modelling for the proposed development, including the previously approved development to the existing Basin 10 has now been undertaken using 2016 rainfall data. Accordingly, there are marginally different results in predevelopment flow rates to previous reports, The criteria for matching (ARR 2016) predevelopment runoff rates is nonetheless achieved.

3.3 Modelling parameters

Maitland City Council's MOES publishes parameters to be adopted in DRAINS models as provided in Table 3-1 below.

Table 3-1: MCC's MOES modelling parameters.

Parameter	Value
Soil Type	As reported (3.5)
Antecedent Moisture Content	3
Grassed Depression Storage	5mm
Paved Depression Storage	1mm

A 0.65 fraction impervious was adopted for the developed catchments, having conservative regard for the mix of Residential lots < 1000m^2 (0.6) and road reserve (0.7).

Design rainfall as adopted from the Australian Rainfall & Runoff (ARR) Data Hub (2019) for the Farley Locality (-32.72972, 151.51632).

3.4 Results

3.4.1 Proposed Basin 1

DRAINS was iteratively run to design the detention component of the proposed basin yielding the following results as shown in Figure 6:

Top of bank	R.L 26.50
Internal Batters	1v:5h
Q100 Top Water Level	R.L 26.12
Detention Invert Level	R.L 23.70
Peak Detention Volume	2653m^3
Outlet Control Pit (Internal Dimensions)	5m x 1.2m outlet pit @ R.L 24.90
Inlet Orifice	3x Ø900mm at I.L 23.70
Outlet Pipes	3x Ø1200mm at I.L 23.70

Basin 1 is to be located on the upstream side of the Harlington Avenue creek crossing, which is to be designed to convey the 1% AEP flow without being overtopped. The final outlet design for the basin comprises a pit with 3x Φ900mm penetrations at the invert level on the upstream side, connected to 3 x Φ1200mm culverts forming the proposed Harlington Rd Crossing.

The design for the Harlington Rd Crossing (Ref 21332C) is to be reviewed for consistency.

Results for outflow at the Basin 1 outlet are summarised in Table 3-2 below.

Table 3-2: Post development model flow results (Basin 1).

AEP Event	Post development discharge rate at Basin 1 outlet (m^3/s)
1EY	3.30
10%	8.22
1%	11.9

3.4.2 Existing Basin 10

Basin 10 (approved in DA 14-724) but was re-modelled with Basin 1 located upstream. The design of Basin 10 was not modified in anyway. The results for outflow at the Basin 10 outlet are summarised below in Table 3-3.

Table 3-3: Post development model flow rate results (Basin 10 without Basin 1).

AEP Event	Predevelopment discharge rate (m^3/s)	Post development discharge rate at Basin 10 outlet and with Basin 1 (m^3/s)	Difference (%)
1EY	2.33	2.33	0
10%	10.40	8.67	-16.6
1%	23.10	18.3	-20.8

3.5 Discussion

The proposed development, with the inclusion of proposed Basin 1 and outlet pipes, will not produce an outflow larger than predevelopment flow rates during the 1EY, 10% and 1% AEP events at the Owlpen Lane outlet.

4 Runoff Quality

4.1 Criteria

Treatment targets for the proposed development were adopted from Maitland City Council'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 proposed development was modelled using MUSIC, the Model for Urban Stormwater Improvement Conceptualism, 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 study area was addressed during the design of Basin 10 (DA 14-724). A MUSIC model was constructed with a catchment comprising pavement area, roof area and landscaping to examine whether Basin 10 would still achieve the required stormwater treatment objectives considering full development of the catchment and the proposed development. Roof areas were separated so runoff could be disposed of through internal re use via rainwater tanks.

4.3 Results

The MUSIC model layout is provided in Appendix C. The achieved pollutant retention achieved by Basin 10 is provided in Table 4-2. It has not been proposed to modify Basin 10 in anyway.

Table 4-2: Achieved pollutant retention (Basin 10).

Pollutant	Average Annual Surface Generation	Average Annual Export	Achieved Reduction (Pollutants Retained)	Target Reduction (Pollutants Retained)
Total Suspended Solids (TSS; kg/year)	29200	2050	93.0%	80%
Total Phosphorous (TP; kg/year)	60	18.9	68.5%	45%
Total Nitrogen (TN; kg/year)	567	110	80.7%	45%
Gross Pollutants (GP; kg/year)	8040	0	100%	70%

4.4 Discussion

Basin 10 still achieves MCC's stormwater treatment objectives with the addition of the proposed development. Water quality modelling indicates that proposed Basin 1 need only be a detention basin, and therefore can be constructed as a dry, vegetated basin. The above results indicate the proposed stormwater drainage strategy will produce an outcome for the proposed development that complies with Council's standards for water quality control.

5 Summary and Conclusions

The proposed subdivision of Lots 1 on DP1005221 and 1 on DP 325580 into 41 lots for residential use has the potential to impact on downstream drainage.

The combined wet detention basin and water quality control basin constructed pursuant to DA 17-724 (Basin 10) can be augmented by an additional basin to be constructed upstream of Harlington Avenue (Basin 1) to achieve compliance for flow at the Owlpen Lane outlet.

The proposed development will not impact Basin 10's ability to meet regional guidelines for best practise for retention of TSS, TN and TP. Water quality modelling indicates that Basin 1 need only be a detention basin and therefore can be constructed as a dry, vegetated basin.

Figures

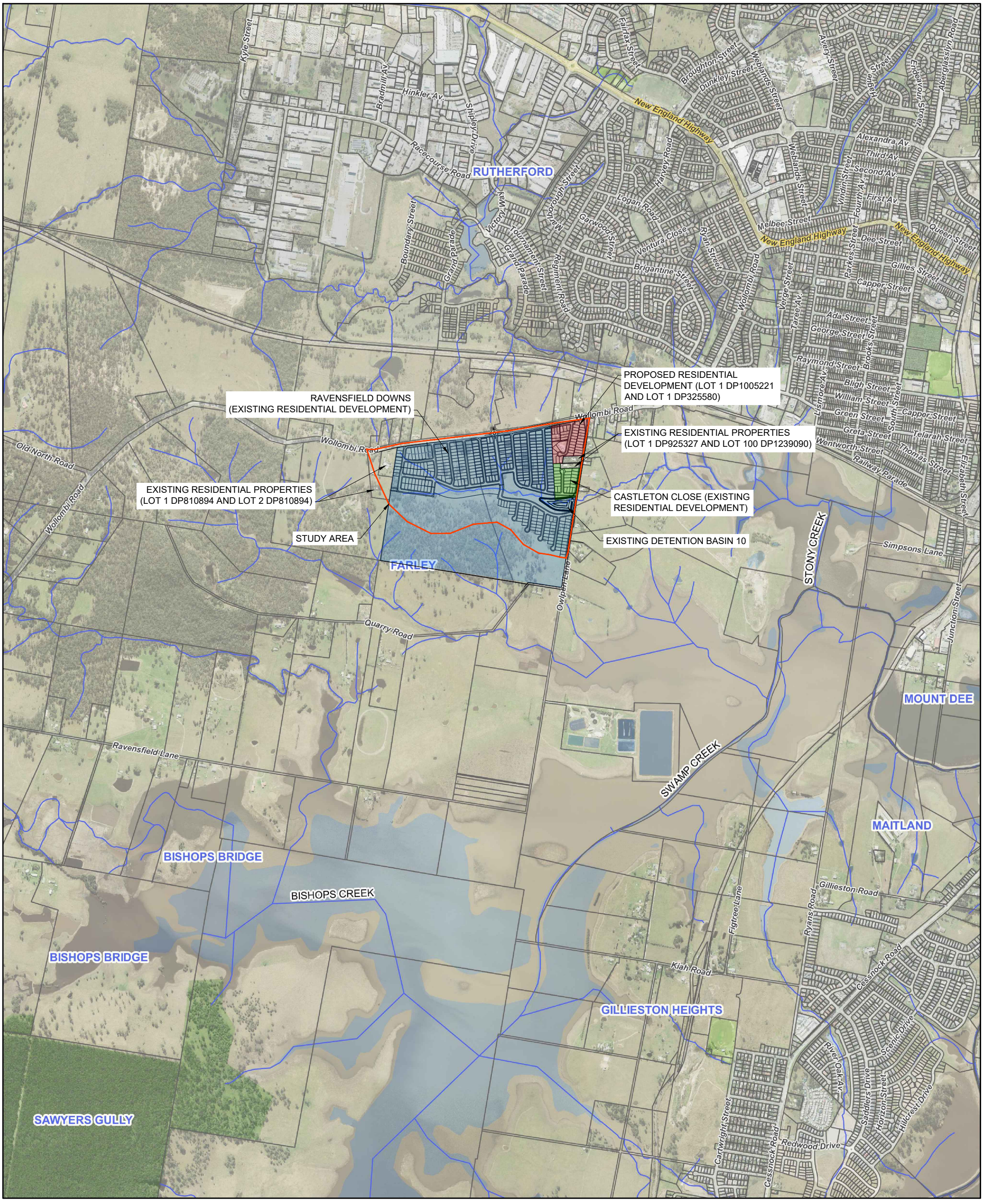


FIGURE 1
LOCALITY PLAN

1:20000 0 400 800 1200m

DATE: 29/04/22

DWG REF: 22105 F01 LOCALITY r1

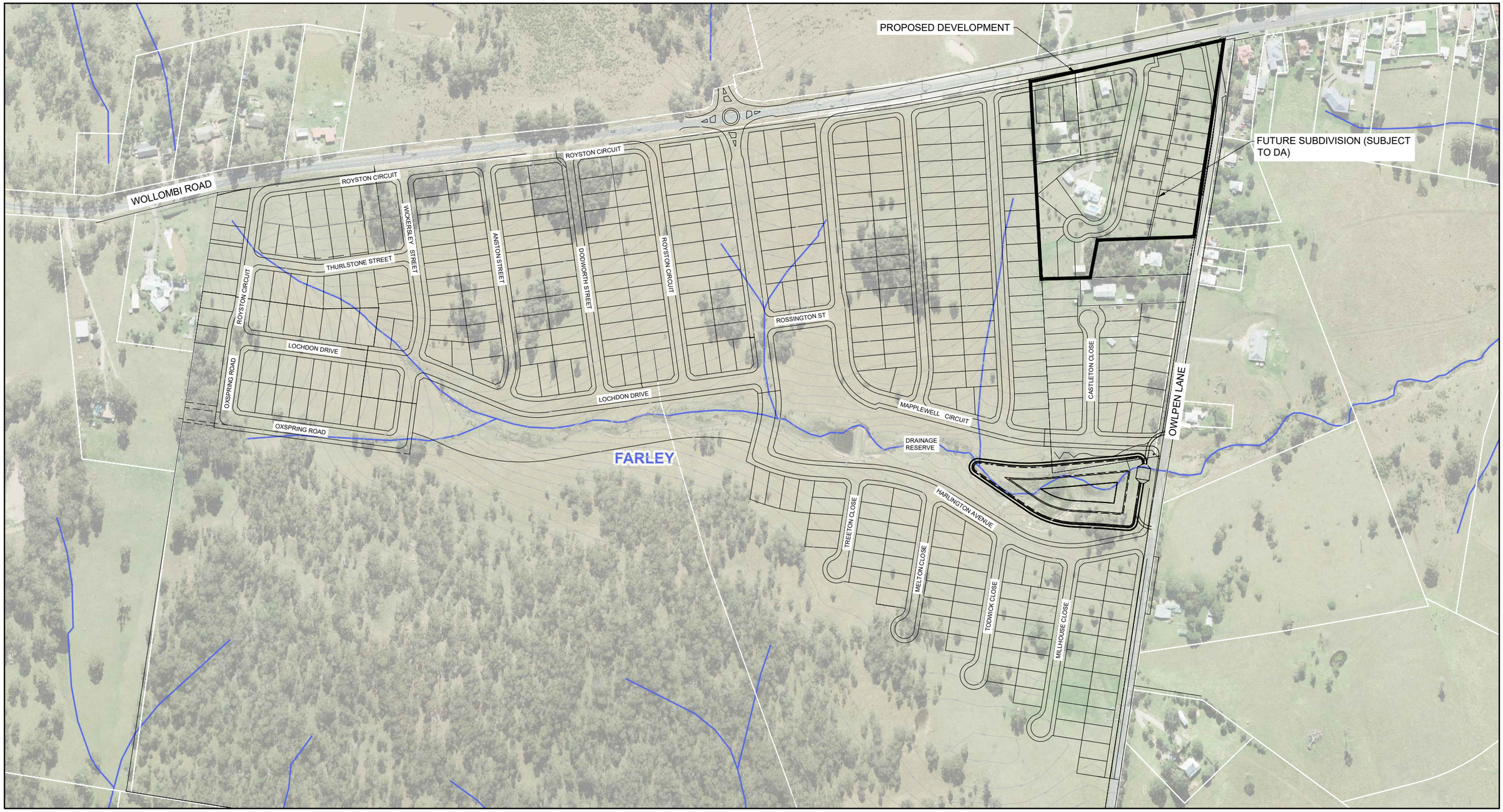


FIGURE 2
SITE PLAN

1:4000 0 80 160 240 m

DATE: 29/04/22

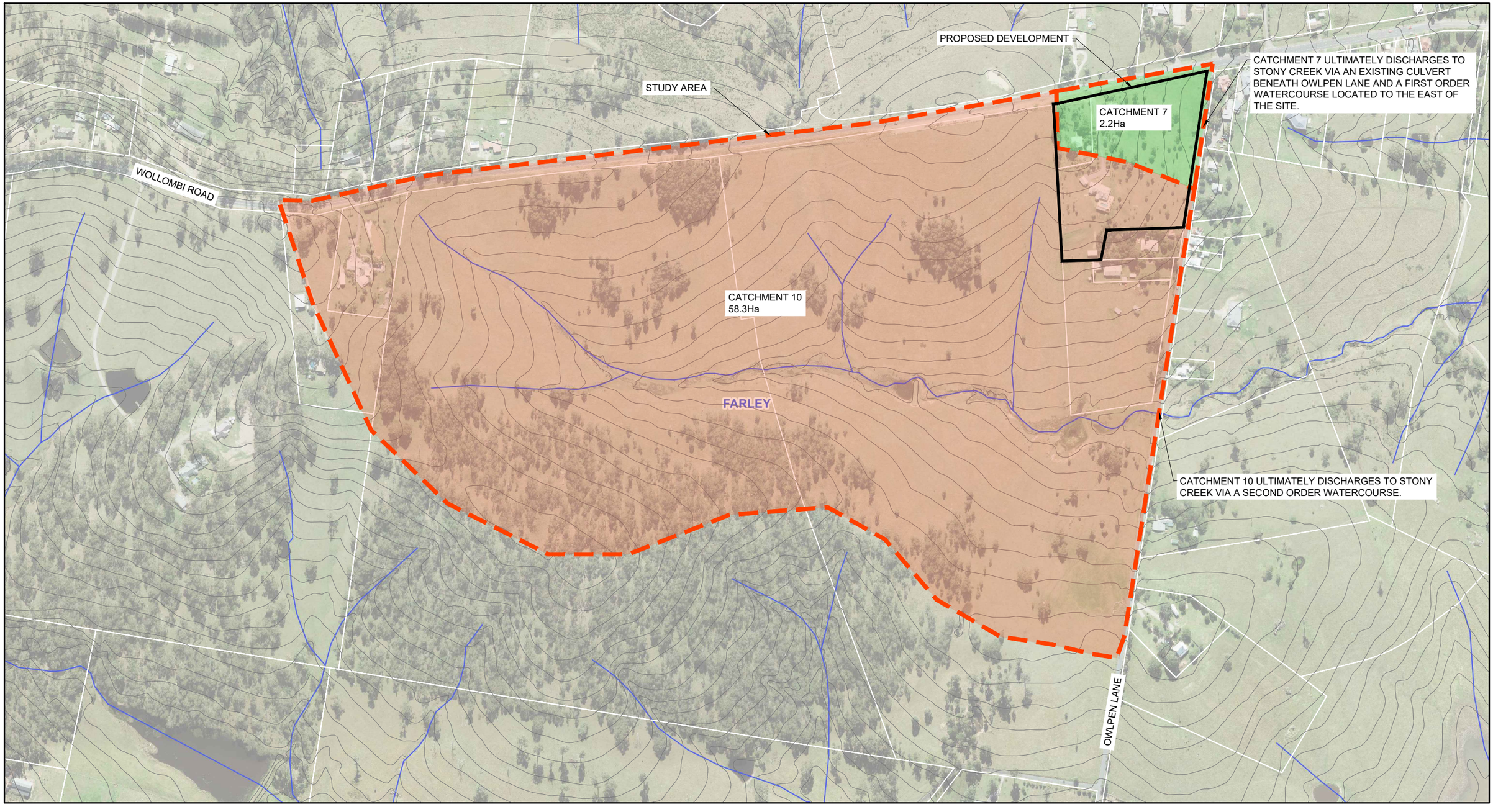
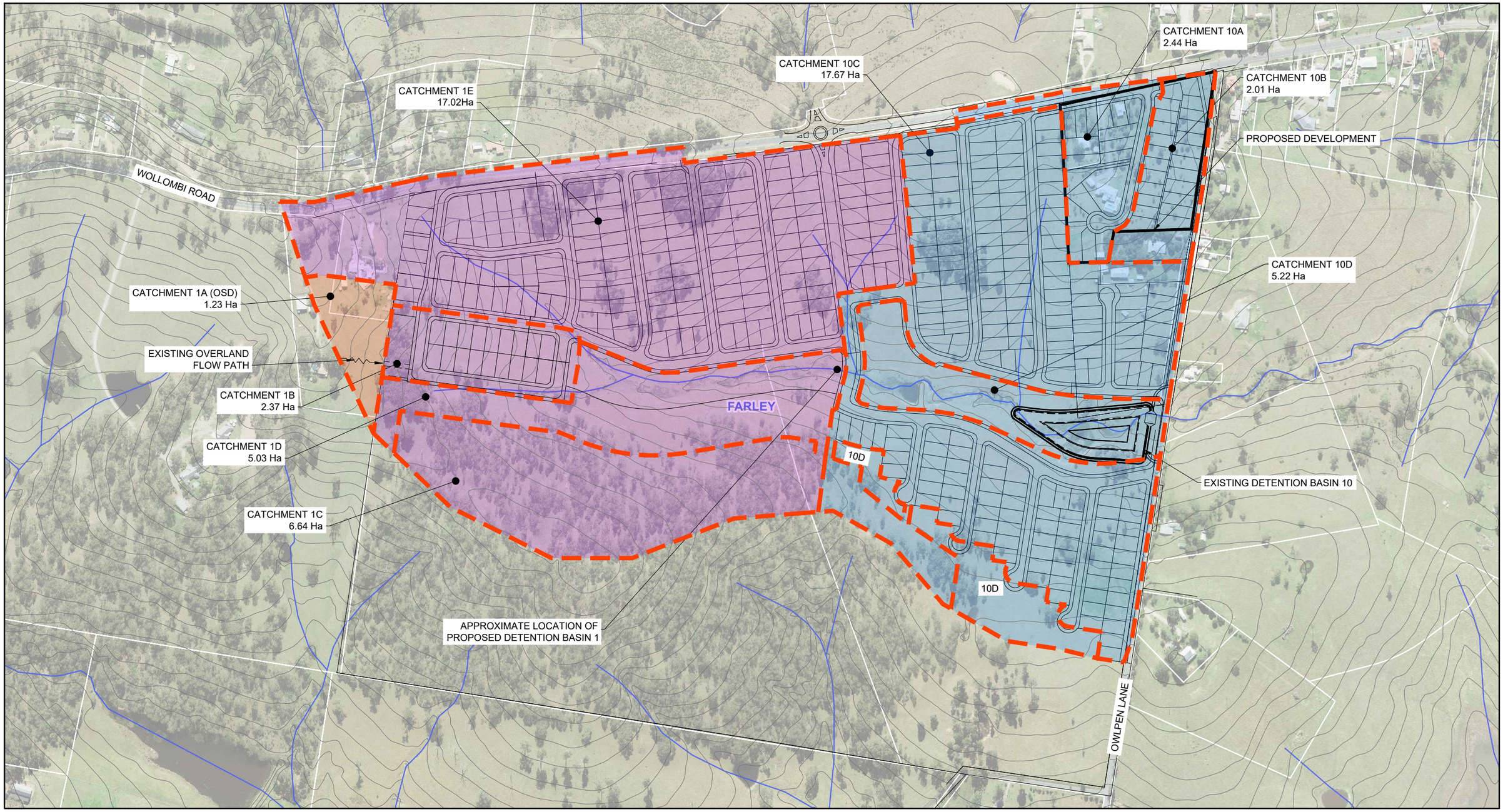


FIGURE 3
PREDEVELOPMENT CATCHMENT PLAN

1:5000 0 100 200 300m

DATE: 29/04/22



LEGEND:

CATCHMENT TO EXISTING BASIN 10

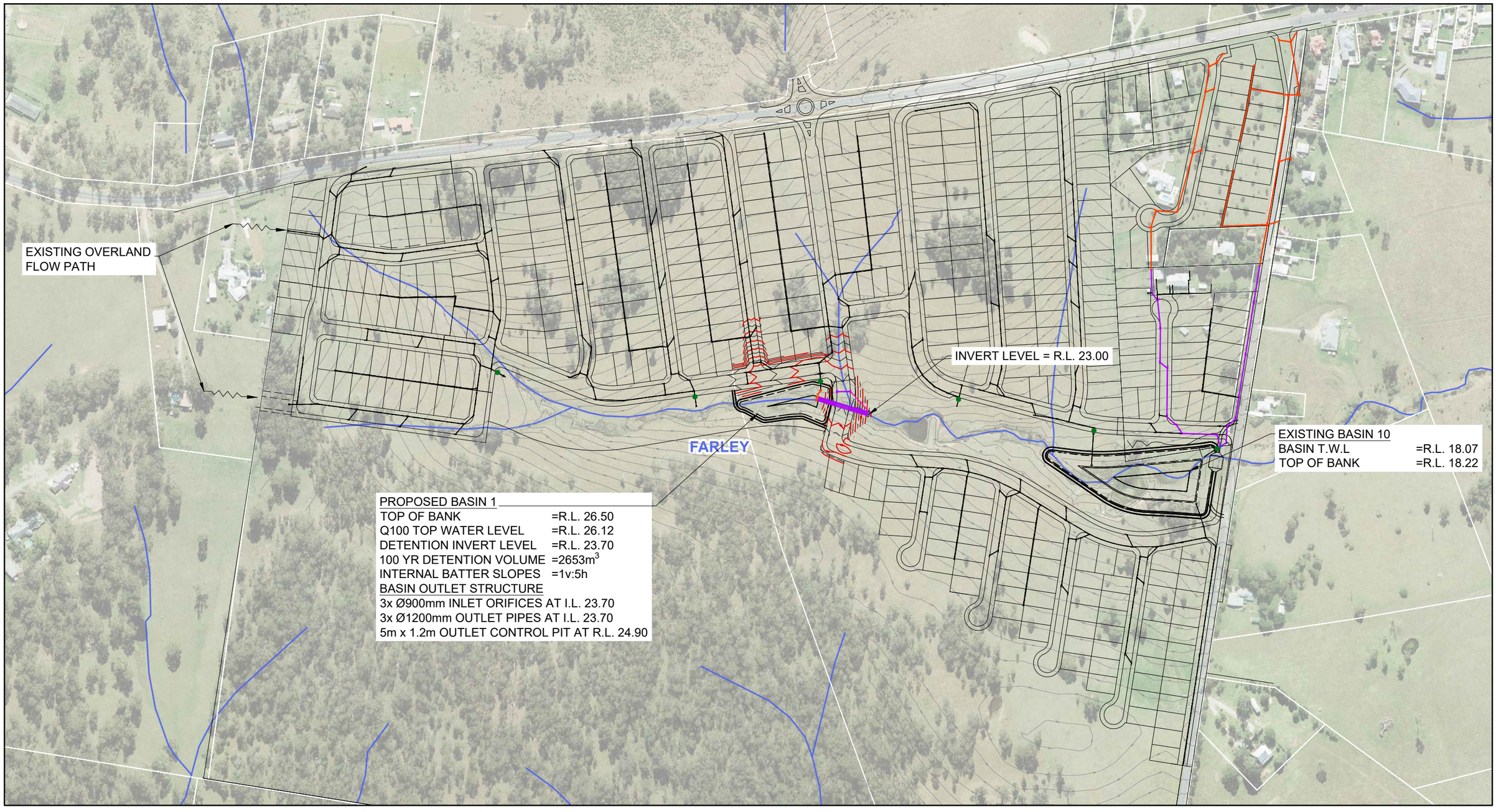
CATCHMENT WITH OSD ON OWN SITE

CATCHMENT TO PROPOSED BASIN 1

FIGURE 4
POST DEVELOPMENT CATCHMENT PLAN

1:5000 0 100 200 300m

DATE: 29/04/22



LEGEND

- STORMWATER PIPE
- EKI PIT
- SAG PIT
- IAD PIT
- HEADWALL
- EXISTING GROSS POLLUTANT TRAP
- EXISTING STORMWATER NETWORK
- PROPOSED STORMWATER NETWORK
- DESIGN STORMWATER LINES TO BE INVESTIGATED FOR AUGMENTATION
- DESIGN STORMWATER LINES TO BE REDIRECTED
- NATURAL CONTOURS (1m INTERVAL)
- DESIGN CONTOURS (EXISTING; 1m INTERVAL)

FIGURE 5
STORMWATER MANAGEMENT PLAN

1:4000 0 80 160 240 m

DATE: 29/04/22

EXISTING GPT
SURFACE LEVEL =R.L. 26.618
INVERT LEVEL =R.L. 24.199

EXISTING HEADWALL
SURFACE LEVEL =R.L. 26.150
INVERT LEVEL =R.L. 24.154

REMOVE EXISTING HEADWALL AND CONSTRUCT JUNCTION BOX

MIN ROAD LEVEL =R.L 26.473

BASIN T.O.B.

BASIN T.W.L.

1V:5H

BASIN I.L.

BASIN 1

MAX 1V:5H

CULVERT
3 / Ø1200 RCP
55m LONG
U/S I.L 23.70
D/S I.L 23.00

PROPOSED BASIN 1
TOP OF BANK =R.L. 26.50
Q100 TOP WATER LEVEL =R.L. 26.12
DETENTION INVERT LEVEL =R.L. 23.70
100 YR DETENTION VOLUME =2653m^3
INTERNAL BATTER SLOPES =1v:5h
BASIN OUTLET STRUCTURE
3x Ø900mm INLET ORIFICES AT I.L. 23.70
3x Ø1200mm OUTLET PIPES AT I.L. 23.70
5m x 1.2m OUTLET CONTROL PIT AT R.L. 24.90

LEGEND

- STORMWATER PIPE
- EKI PIT
- SAG PIT
- IAD PIT
- HEADWALL
- EXISTING GROSS POLLUTANT TRAP
- EXISTING STORMWATER NETWORK
- PROPOSED STORMWATER NETWORK
- DESIGN STORMWATER LINES TO BE INVESTIGATED FOR AUGMENTATION
- DESIGN STORMWATER LINES TO BE REDIRECTED
- NATURAL CONTOURS (1m INTERVAL)
- DESIGN CONTOURS (EXISTING; 1m INTERVAL)

FIGURE 6
DETENTION BASIN 1

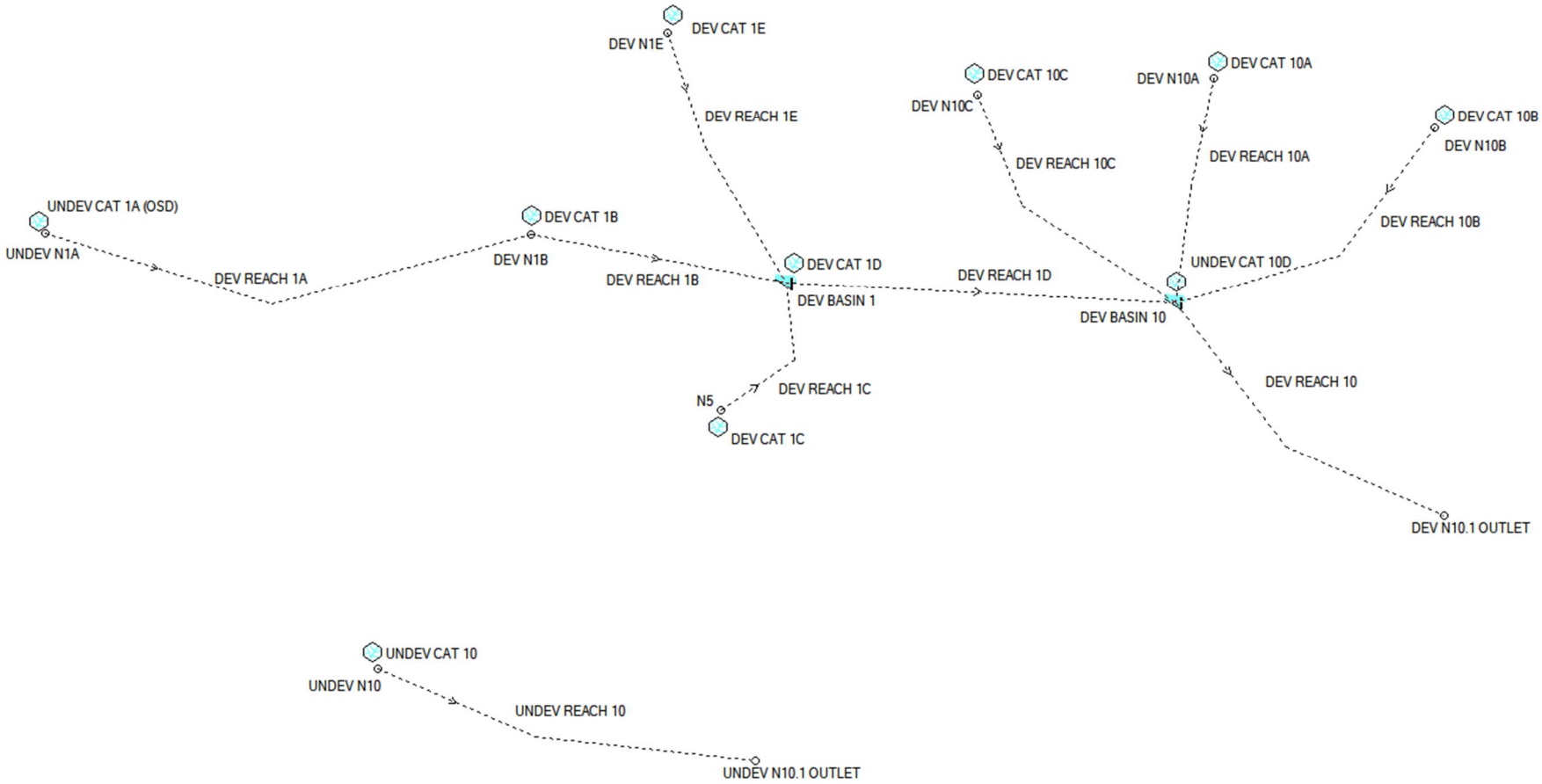
1:500 0 10 20 30 m

DATE: 29/04/22

DWG REF: 22105 F06 BASIN 1 PLAN r1

Appendix A

DRAINS Data


DEV CAT 1E
DEV N1E
DEV REACH 1E
DEV CAT 10C
DEV N10C
DEV REACH 10C
DEV CAT 10A
DEV N10A
DEV REACH 10A
DEV CAT 10B
DEV N10B
DEV REACH 10B
UNDEV CAT 1A (OSD)
UNDEV N1A
DEV REACH 1A
DEV CAT 1B
DEV N1B
DEV REACH 1B
DEV CAT 1D
DEV BASIN 1
DEV REACH 1D
UNDEV CAT 10D
DEV BASIN 10
DEV REACH 10
DEV N10.1 OUTLET
N5
DEV REACH 1C
DEV CAT 1C
UNDEV CAT 10
UNDEV N10
UNDEV REACH 10
UNDEV N10.1 OUTLET

DRAINS DATA

PIT / NODE DETAILS

Version 15

Name	Type	Family	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	id	Part Full Shock Loss	Inflow Hydrograph	Pit is	Internal Width (mm)	Inflow is Misaligned	Minor Safe Pond Dept	Major Safe Pond Depth (m)
UNDEV N1A	Node					51		0		432	-263		2		No					
DEV N1B	Node					34		0		773	-264		4		No					
DEV N1E	Node					20		0		869	-122		11		No					
N5	Node							0		906	-387		16		No					
DEV N10C	Node					20		0		1086	-165		25		No					
DEV N10A	Node					28		0		1252	-154		26		No					
DEV N10.1 OUTLET	Node					11		0		1414	-461		27		No					
UNDEV N10	Node					15		0		665	-569		37		No					
UNDEV N10.1 OUTLET	Node					11		0		930	-633		38		No					
DEV N10B	Node					30		0		1407	-189		28312		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 Length	id
DEV BASIN 10	15.4		1	None						1225	-312	No		24	
	15.8	3505													
	16	3870													
	17.92	8255													
	18.22	8908													
	18.72	8908													
DEV BASIN 1	23.7	232		None						952.083	-297.917	No		6294	
	26.5	2861													
	27	2861													

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 Time or Factor	Gutter Length (m)	Gutter Slope %	Gutter FlowFactor	Rainfall Multiplier
UNDEV CAT 1A (OSD)	UNDEV N1A	1.23	0	100	0	2	2	0	15	15	0	1	1	0	0.01	0.3	0	0				1
DEV CAT 1B	DEV N1B	2.37	65	35	0	5	5	0	15	15	0	1	1	0	0.01	0.3	0	0				1
DEV CAT 1E	DEV N1E	17.02	65	35	0	5	5	0	15	15	0	1	1	0	0.01	0.3	0	0				1
DEV CAT 1C	N5	9.57	65	35	0	5	5	0	15	15	0	1	1	0	0.01	0.3	0	0				1
UNDEV CAT 10D	DEV BASIN 10	5.22	0	100	0	0	2	0	0	15	0	0	1	0	0	0.3	0	0				1
DEV CAT 10C	DEV N10C	17.67	65	35	0	5	0	0	15	15	0	1	1	0	0.01	0.3	0	0				1
DEV CAT 10A	DEV N10A	2.44	65	35	0	5	5	0	15	15	0	1	1	0	0.01	0.3	0	0				1
UNDEV CAT 10	UNDEV N10	58.28	0	100	0	0	0	0	0	100	0	0	7	0	0	0.3	0	0				1
DEV CAT 1D	DEV BASIN 1	1.75	0	100	0	0	5	0	0	15	0	0	1	0	0	0.3	0	0				1
DEV CAT 10B	DEV N10B	2.01	65	35	0	5	5	0	15	15	0	1	1	0	0.01	0.3	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)	Rl (m)	Chg (m)	RL (m)	etc (m)

DETAILS of SERVICES CROSSING PIPES

Pipe	Chg (m)	Bottom Elev (m)	Height of S (m)	Chg (m)	Bottom Elev (m)	Height of S (m)	Chg (m)	Bottom Elev (m)	Height of S (m)	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 Depth Major Stor (m)	SafeDepth Minor Stor (m)	Safe DxV (sq.m/sec)	Bed Slope (%)	D/S Area Contributing %	id
DEV REACH 1A	UNDEV N1A	DEV N1B	0.2				Overflow	1	1	2	3	0	3
DEV REACH 1B	DEV N1B	DEV BASIN 1	0.2				Overflow	1	1	2	3	0	8
DEV REACH 1E	DEV N1E	DEV BASIN 1	0.2				Overflow	1	1	2	3	0	14
DEV REACH 1C	N5	DEV BASIN 1	0.2				Overflow	1	1	2	3	0	22
DEV REACH 10	DEV BASIN 10	DEV N10.1 OUTLET	0.3	15.5			Overflow a	1	1	2	3	0	32
DEV REACH 10C	DEV N10C	DEV BASIN 10	0.2				Overflow	1	1	2	3	0	28
DEV REACH 10A	DEV N10A	DEV BASIN 10	0.2				Overflow	1	1	2	3	0	30
UNDEV REACH 10	UNDEV N10	UNDEV N10.1 OUTLET	0.2				Overflow	1	1	2	3	0	39
DEV REACH 1D	DEV BASIN 1	DEV BASIN 10	0.2	23.7			Overflow	1	1	2	3	0	23
DEV REACH 10B	DEV N10B	DEV BASIN 10	0.2				Overflow	1	1	2	3	0	28308

PIPE COVER DETAILS

Name	Type	Dia (mm)	Safe Cover	Cover (m)

This model has no pipes with non-return valves

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

	MAIN CONTROL STRUCTURES							
Elevation	**Pipe**		**Pit**		**Check Pipe Inlet Control**		**Stage**	**Total Outflow**
RL	For H/D < 1.2 : Q=1.32D^.87H^1.63		Q=1.67LH^1.5		For H/D < 1.2 : Q=1.32D^.87H^1.63			
	For H/D > 1.2 : Q=1.62D^1.87H^.63				For H/D > 1.2 : Q=1.62D^1.87H^.63			
	Pipe Dia (D), m	0.900	Weir Length (L), m	12.4	Pipe Dia (D), m	1.200		
	Assuming Square Edged		Pit Inlet (RL), m	24.90	*Assuming Square Edged*			
Increment	Pipe Invert (RL), m	23.70			Pipe Invert (RL), m	23.70		
0.1			min	24.90				
	No. Pipes	3			No. Pipes	3		
	H (m)	Q (cumecs)	H (m)	Q (cumecs)	H (m)	Q (cumecs)		
23.70	0.00	0.00	0.00	0.00	0.00	0.00	23.70	0.00
23.80	0.10	0.08	0.00	0.00	0.10	0.11	23.80	0.08
23.90	0.20	0.26	0.00	0.00	0.20	0.34	23.90	0.26
24.00	0.30	0.51	0.00	0.00	0.30	0.65	24.00	0.51
24.10	0.40	0.81	0.00	0.00	0.40	1.04	24.10	0.81
24.20	0.50	1.17	0.00	0.00	0.50	1.50	24.20	1.17
24.30	0.60	1.57	0.00	0.00	0.60	2.02	24.30	1.57
24.40	0.70	2.02	0.00	0.00	0.70	2.59	24.40	2.02
24.50	0.80	2.51	0.00	0.00	0.80	3.23	24.50	2.51
24.60	0.90	3.04	0.00	0.00	0.90	3.91	24.60	3.04
24.70	1.00	3.61	0.00	0.00	1.00	4.64	24.70	3.61
24.80	1.10	4.24	0.00	0.00	1.10	5.42	24.80	4.24
24.90	1.20	4.48	0.00	0.00	1.20	6.25	24.90	4.48
25.00	1.30	4.71	0.10	0.65	1.30	7.12	25.00	5.36
25.10	1.40	4.93	0.20	1.85	1.40	8.03	25.10	6.79
25.20	1.50	5.15	0.30	3.40	1.50	8.82	25.20	8.56
25.30	1.60	5.37	0.40	5.24	1.60	9.19	25.30	9.19
25.40	1.70	5.58	0.50	7.32	1.70	9.55	25.40	9.55
25.50	1.80	5.78	0.60	9.62	1.80	9.90	25.50	9.90
25.60	1.90	5.98	0.70	12.13	1.90	10.24	25.60	10.24
25.70	2.00	6.18	0.80	14.82	2.00	10.58	25.70	10.58
25.80	2.10	6.37	0.90	17.68	2.10	10.91	25.80	10.91
25.90	2.20	6.56	1.00	20.71	2.20	11.23	25.90	11.23
26.00	2.30	6.74	1.10	23.89	2.30	11.55	26.00	11.55
26.10	2.40	6.93	1.20	27.22	2.40	11.86	26.10	11.86
26.20	2.50	7.11	1.30	30.69	2.50	12.17	26.20	12.17
26.30	2.60	7.29	1.40	34.30	2.60	12.48	26.30	12.48
26.40	2.70	7.46	1.50	38.04	2.70	12.78	26.40	12.78
26.50	2.80	7.63	1.60	41.91	2.80	13.07	26.50	13.07

Appendix B

DRAINS Results

DRAINS 1EY RESULTS

DRAINS results prepared from Version 2020.036

PIT / NODE DETAILS Version 8

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

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
UNDEV CAT 1A (OSD)	0.075	0	0.075	4.31	19.76	0	1EY AEP, 45 min burst, Storm 8
DEV CAT 1B	0.303	0.292	0.022	6.67	17.84	0	1EY AEP, 10 min burst, Storm 3
DEV CAT 1E	2.175	2.098	0.157	6.67	17.84	0	1EY AEP, 10 min burst, Storm 3
DEV CAT 1C	1.223	1.18	0.088	6.67	17.84	0	1EY AEP, 10 min burst, Storm 3
UNDEV CAT 10D	0.319	0	0.319	0	19.76	0	1EY AEP, 45 min burst, Storm 8
DEV CAT 10C	2.303	2.076	0.226	6.67	12.84	0	1EY AEP, 10 min burst, Storm 8
DEV CAT 10A	0.312	0.301	0.023	6.67	17.84	0	1EY AEP, 10 min burst, Storm 3
UNDEV CAT 10	2.334	0	2.334	0	30.93	0	1EY AEP, 45 min burst, Storm 3
DEV CAT 1D	0.094	0	0.094	0	22.76	0	1EY AEP, 45 min burst, Storm 8
DEV CAT 10B	0.257	0.248	0.019	6.67	17.84	0	1EY AEP, 10 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

CHANNEL DETAILS

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

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
DEV REACH 1A	0.075	0.075	24.007	0.011	0.01	12	0.56	1EY AEP, 45 min burst, Storm 8
DEV REACH 1B	0.336	0.336	24.007	0.027	0.03	12.01	1.04	1EY AEP, 10 min burst, Storm 8
DEV REACH 1E	2.175	2.175	24.007	0.083	0.18	12.02	2.17	1EY AEP, 10 min burst, Storm 3
DEV REACH 1C	1.223	1.223	24.007	0.059	0.1	12.01	1.72	1EY AEP, 10 min burst, Storm 3
DEV REACH 10	2.334	2.334	45.877	0.102	0.21	16.89	2.06	1EY AEP, 45 min burst, Storm 9
DEV REACH 10C	2.303	2.303	24.007	0.086	0.19	12.02	2.22	1EY AEP, 10 min burst, Storm 8
DEV REACH 10A	0.312	0.312	24.007	0.026	0.03	12.01	1	1EY AEP, 10 min burst, Storm 3
UNDEV REACH 10	2.334	2.334	24.007	0.086	0.19	12.02	2.25	1EY AEP, 45 min burst, Storm 3
DEV REACH 1D	3.299	3.299	24.007	0.107	0.27	12.02	2.57	1EY AEP, 10 min burst, Storm 8
DEV REACH 10B	0.257	0.257	24.007	0.023	0.02	12	0.93	1EY AEP, 10 min burst, Storm 3

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level
DEV BASIN 10	16.92	5633	2.334	0	2.334
DEV BASIN 1	24.65	457.8	3.299	0	3.299

Run Log for 22105 DEVELOPED r1 20220502 run at 13:06:12 on 3/5/2022 using version 2020.036

Flows were safe in all overflow routes.

DRAINS 10% RESULTS
DRAINS results prepared from Version 2020.036

PIT / NODE DETAILS Version 8

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

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
UNDEV CAT 1A (OSD)	0.28	0	0.28	3.37	12.56	0	10% AEP, 15 min burst, Storm 5
DEV CAT 1B	0.681	0.571	0.152	6.37	15.56	0	10% AEP, 15 min burst, Storm 4
DEV CAT 1E	4.892	4.103	1.095	6.37	15.56	0	10% AEP, 15 min burst, Storm 4
DEV CAT 1C	2.751	2.307	0.615	6.37	15.56	0	10% AEP, 15 min burst, Storm 4
UNDEV CAT 10D	1.187	0	1.187	0	12.56	0	10% AEP, 15 min burst, Storm 7
DEV CAT 10C	5.461	4.568	1.439	6.37	10.56	0	10% AEP, 15 min burst, Storm 3
DEV CAT 10A	0.701	0.588	0.157	6.37	15.56	0	10% AEP, 15 min burst, Storm 4
UNDEV CAT 10	10.422	0	10.422	0	20.54	0	10% AEP, 25 min burst, Storm 3
DEV CAT 1D	0.358	0	0.358	0	16.22	0	10% AEP, 20 min burst, Storm 7
DEV CAT 10B	0.578	0.485	0.129	6.37	15.56	0	10% AEP, 15 min burst, Storm 4

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

CHANNEL DETAILS

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

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
DEV REACH 1A	0.28	0.28	24.007	0.024	0.02	12	0.97	10% AEP, 15 min burst, Storm 5
DEV REACH 1B	0.879	0.879	24.007	0.048	0.07	12.01	1.51	10% AEP, 10 min burst, Storm 7
DEV REACH 1E	4.892	4.892	24.007	0.135	0.41	12.03	3.01	10% AEP, 15 min burst, Storm 4
DEV REACH 1C	2.751	2.751	24.007	0.096	0.23	12.02	2.38	10% AEP, 15 min burst, Storm 4
DEV REACH 10	8.673	8.673	45.877	0.186	0.57	23.16	3.05	10% AEP, 1 hour burst, Storm 6
DEV REACH 10C	5.461	5.461	24.007	0.145	0.45	12.03	3.13	10% AEP, 15 min burst, Storm 3
DEV REACH 10A	0.701	0.701	24.007	0.042	0.06	12.01	1.38	10% AEP, 15 min burst, Storm 4
UNDEV REACH 10	10.422	10.422	24.007	0.214	0.87	12.04	4.04	10% AEP, 25 min burst, Storm 3
DEV REACH 1D	8.221	8.221	24.007	0.186	0.68	12.04	3.68	10% AEP, 15 min burst, Storm 5
DEV REACH 10B	0.578	0.578	24.007	0.038	0.05	12.01	1.28	10% AEP, 15 min burst, Storm 4

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level
DEV BASIN 10	17.64	10408.1	8.673	0	8.673
DEV BASIN 1	25.18	1001.9	8.221	0	8.221

Run Log for 22105 DEVELOPED r1 20220502 run at 13:08:00 on 3/5/2022 using version 2020.036

Flows were safe in all overflow routes.

DRAINS 1% RESULTS (DEVELOPED)
DRAINS results prepared from Version 2020.036

PIT / NODE DETAILS Version 8

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

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
UNDEV CAT 1A (OSD)	0.572	0	0.572	3.12	10.62	0	1% AEP, 15 min burst, Storm 2
DEV CAT 1B	1.192	1.004	0.285	6.04	13.02	0	1% AEP, 10 min burst, Storm 1
DEV CAT 1E	8.562	7.21	2.049	6.04	13.02	0	1% AEP, 10 min burst, Storm 1
DEV CAT 1C	4.814	4.054	1.152	6.04	13.02	0	1% AEP, 10 min burst, Storm 1
UNDEV CAT 10D	2.428	0	2.428	0	10.62	0	1% AEP, 15 min burst, Storm 2
DEV CAT 10C	10.06	6.743	3.318	6.04	8.02	0	1% AEP, 10 min burst, Storm 7
DEV CAT 10A	1.227	1.034	0.294	6.04	13.02	0	1% AEP, 10 min burst, Storm 1
UNDEV CAT 10	23.065	0	23.065	0	15.93	0	1% AEP, 20 min burst, Storm 10
DEV CAT 1D	0.739	0	0.739	0	13.62	0	1% AEP, 15 min burst, Storm 9
DEV CAT 10B	1.011	0.851	0.242	6.04	13.02	0	1% AEP, 10 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

CHANNEL DETAILS

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

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
DEV REACH 1A	0.572	0.572	24.007	0.038	0.05	12.01	1.27	1% AEP, 15 min burst, Storm 2
DEV REACH 1B	1.718	1.718	24.007	0.072	0.14	12.01	1.99	1% AEP, 10 min burst, Storm 7
DEV REACH 1E	8.562	8.562	24.007	0.19	0.71	12.04	3.75	1% AEP, 10 min burst, Storm 1
DEV REACH 1C	4.814	4.814	24.007	0.134	0.4	12.03	2.98	1% AEP, 10 min burst, Storm 1
DEV REACH 10	18.283	18.283	45.877	0.262	1	27.69	3.84	1% AEP, 25 min burst, Storm 1
DEV REACH 10C	10.06	10.06	24.007	0.209	0.84	12.04	4	1% AEP, 10 min burst, Storm 7
DEV REACH 10A	1.227	1.227	24.007	0.059	0.1	12.01	1.73	1% AEP, 10 min burst, Storm 1
UNDEV REACH 10	23.065	23.065	24.007	0.348	1.92	12.07	5.51	1% AEP, 20 min burst, Storm 10
DEV REACH 1D	11.91	11.91	24.007	0.233	0.99	12.05	4.25	1% AEP, 15 min burst, Storm 8
DEV REACH 10B	1.011	1.011	24.007	0.052	0.08	12.01	1.61	1% AEP, 10 min burst, Storm 1

DETENTION BASIN DETAILS

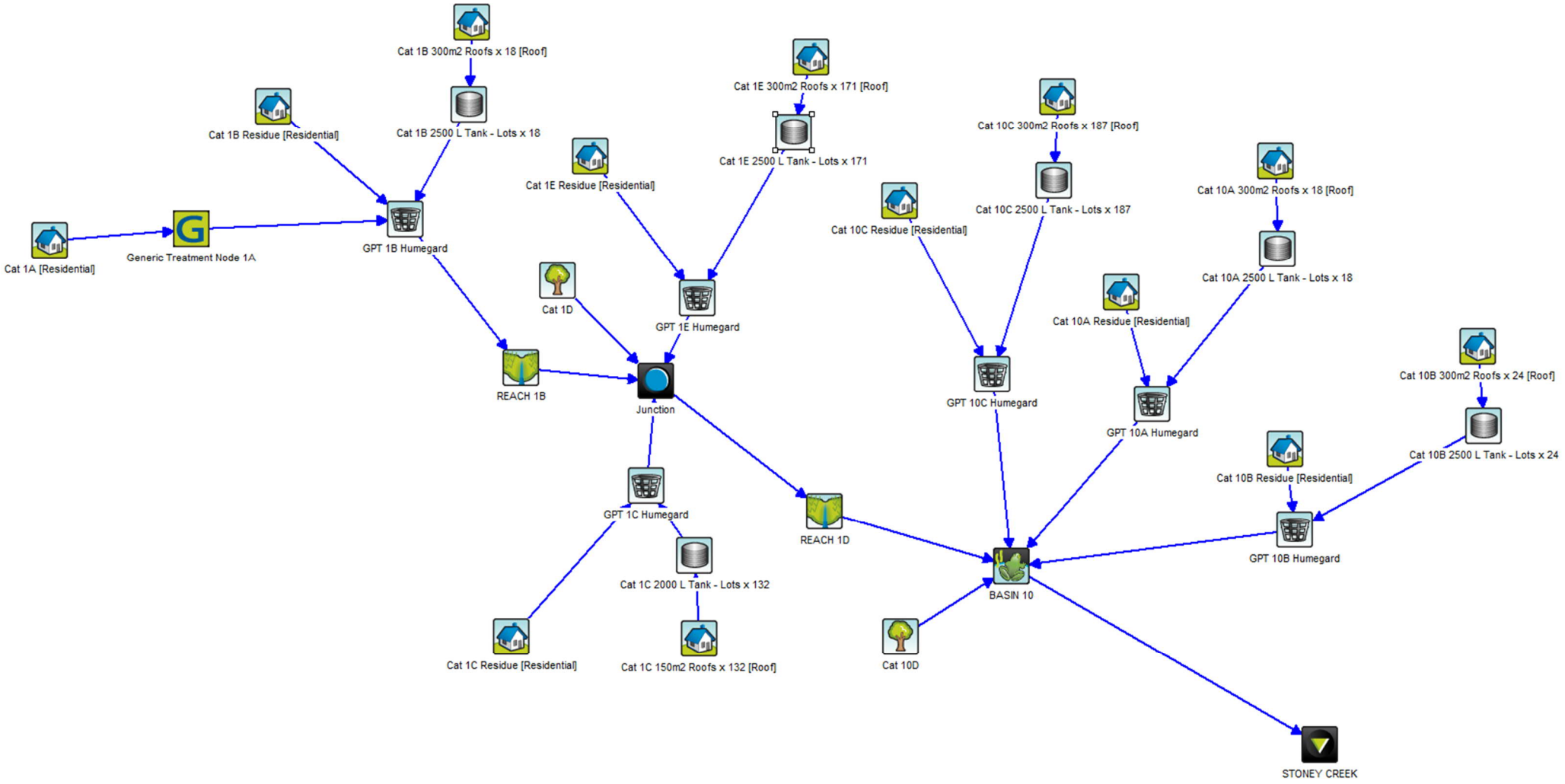
Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level
DEV BASIN 10	18.07	13870.8	18.283	0	18.283
DEV BASIN 1	26.12	2652.7	11.91	0	11.91

Run Log for 22105 DEVELOPED r1 20220502 run at 13:08:21 on 3/5/2022 using version 2020.036

Flows were safe in all overflow routes.

Appendix C

MUSIC Model Layout


Cat 1B 300m2 Roofs x 18 [Roof]
Cat 1B Residue [Residential]
Cat 1B 2500 L Tank - Lots x 18
Cat 1E 300m2 Roofs x 171 [Roof]
Cat 1E 2500 L Tank - Lots x 171
Cat 1E Residue [Residential]
Cat 10C 300m2 Roofs x 187 [Roof]
Cat 10C 2500 L Tank - Lots x 187
Cat 10C Residue [Residential]
Cat 10A 300m2 Roofs x 18 [Roof]
Cat 10A 2500 L Tank - Lots x 18
Cat 10A Residue [Residential]
Cat 1A [Residential]
Generic Treatment Node 1A
GPT 1B Humegard
Cat 1D
GPT 1E Humegard
REACH 1B
Junction
GPT 10C Humegard
GPT 10A Humegard
Cat 10B 300m2 Roofs x 24 [Roof]
Cat 10B 2500 L Tank - Lots x 24
Cat 10B Residue [Residential]
GPT 1C Humegard
REACH 1D
GPT 10B Humegard
Cat 1C 2000 L Tank - Lots x 132
BASIN 10
Cat 1C Residue [Residential]
Cat 1C 150m2 Roofs x 132 [Roof]
Cat 10D
STONEY CREEK