SUNSET ESTATE STAGE 2 FLOOD IMPACT ASSESSMENT

FOR BINOWEE PTY LTD
1ST OCTOBER 2024

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1. INTRODUCTION

Spiire has been engaged by Binowee Pty Ltd. to undertake a Flood Impact Assessment for Sunset Estate Stage 2 ('the site'). The purpose of this report is to provide more detailed information regarding flooding associated with the site in response to the following comment received from Council (3rd April 2024):

To address the concerns regarding flooding, raised by the Department of Environment, Climate Change and Water (Biodiversity and Conservation) the planning proposal should include more detail regarding the flood analysis, such as:

- *other flood events (including PMF),*
- *the impact of the development on flood behaviour (including offsite impacts),*
- *rainfall data*
- *consideration of climate change*
- *how the flood model was developed.*

The scope of this assessment includes the following:

- Prepare hydrological model using RORB for the catchment upstream of Googong Creek which runs through the site
- Prepare inflow hydrographs for the site for the 1% AEP, 1% AEP plus Climate Change (CC), 0.5% AEP, 0.2% AEP and PMF events
- Prepare a 2D Hydraulic Model in TUFLOW to determine the impact of flows through Googong Creek on Sunset Estate Stage 2
- Prepare flood mapping including flood depth and extent, and hazard and velocity (where applicable)

2. BACKGROUND

Sunset Estate Stage 2 is located north of the Googong Township, located in Southern NSW, 8km from Queanbeyan and 15km from Canberra. The Sunset Estate site is located north of Googong Rd. The Googong Creek runs from south to north-east through the Sunset Estate Site. A draft preliminary concept layout is shown in Figure 1 below.

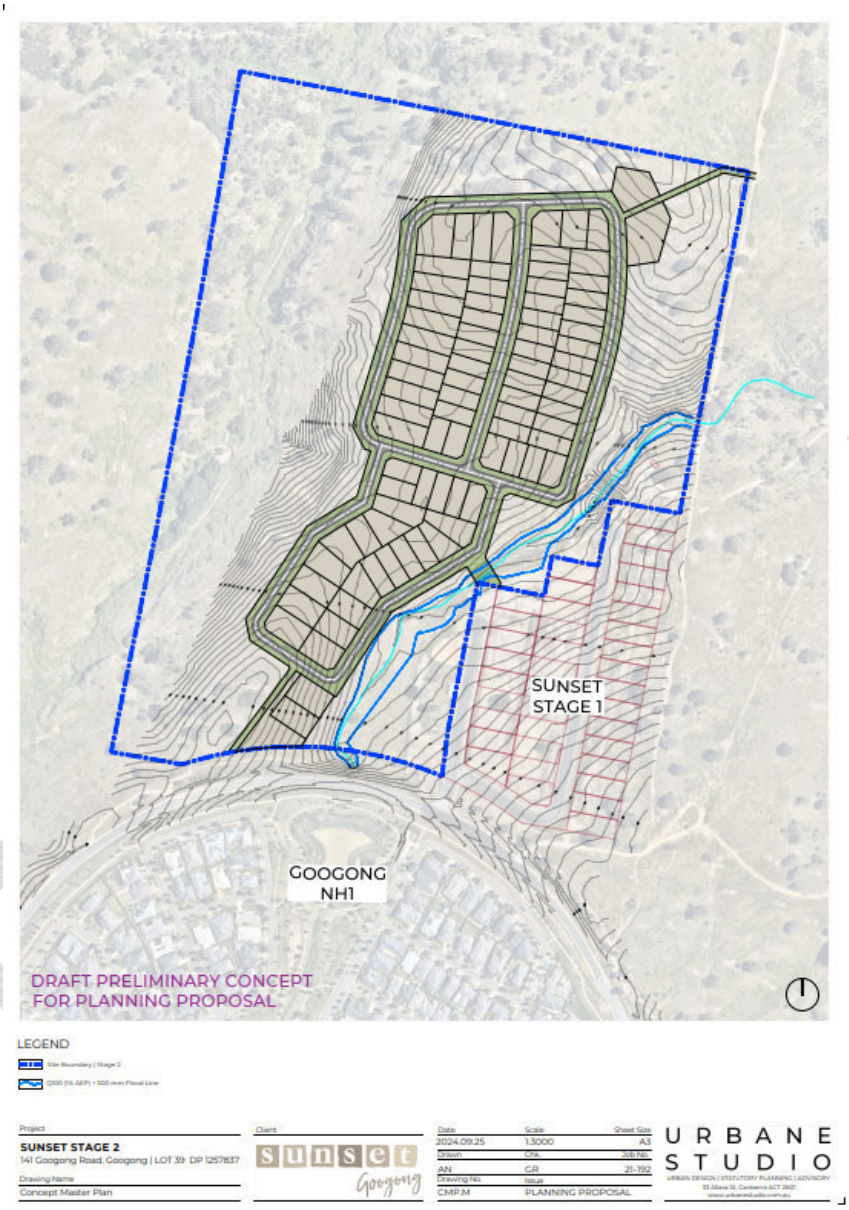

Figure 1: Draft Preliminary Concept Layout – Sunset Estate Stage 2

3. HYDROLOGICAL MODELLING

A hydrological model has been prepared using RORB to determine flows through Googong Creek, which runs through the Sunset Estate site from south to north-east.

Previous hydrological modelling using XP-RAFTS was completed as part of the *Stormwater Management and Drainage Analysis Design Report – Neighbourhood 1A Stages 1 and 2 Googong New Town (Brown Consulting 2010).* This report includes the best available comprehensive information in relation to the upstream catchment, including details of proposed basins. As such, catchment and basin details from this report have been used as inputs into the RORB model.

RORB flows have been determined for the 1% AEP, 1% AEP plus Climate Change, 0.5% AEP, 0.2% AEP and Probable Maximum Precipitation (PMP).

3.1 CATCHMENTS

The section of Googong Creek that runs through the Sunset Estate Site is downstream of a ~196 hectare developed catchment. Catchment delineation is based on catchments outlined in *Stormwater Management and Drainage Analysis Design Report – Neighbourhood 1A Stages 1 and 2 Googong New Town (Brown Consulting 2010).* Four basins have been modelled in the upstream catchment in line with the previous modelling. Refer to Appendix 1 for basin locations and details.

A fraction impervious value of 0.7 has been assumed for developed residential catchments in accordance with *Queanbeyan Palerang Regional Council Development Design Specification D5 (QPRC 2019)*. Catchments with open space and/or other land uses have been adjusted accordingly.

Catchment delineation and RORB Model Setup is shown in Figure 2.

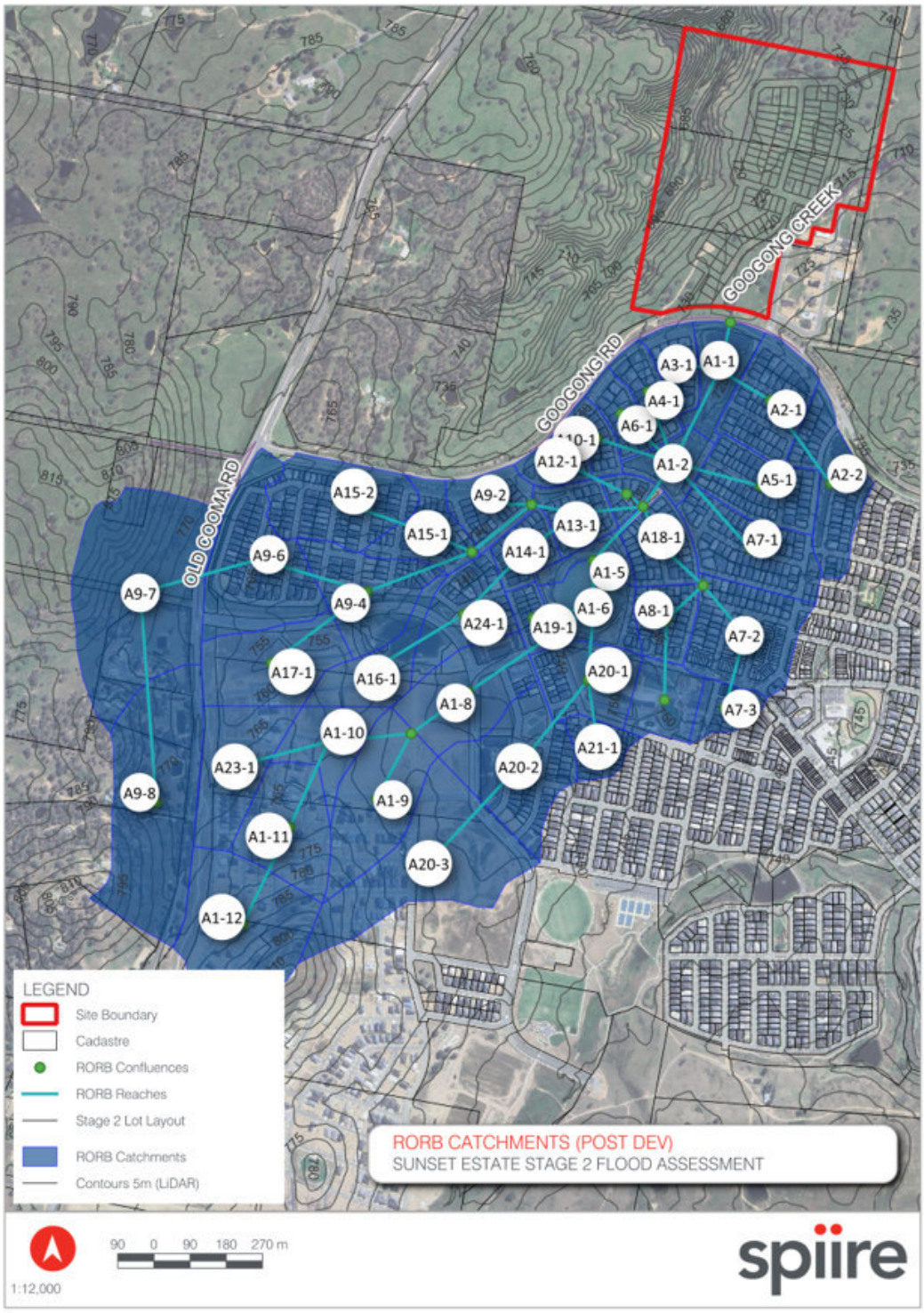

Figure 2: RORB Catchment Delineation

3.2 POST DEVELOPMENT RORB MODELLING PARAMETERS

3.2.1 1% AEP RORB INITIAL AND CONTINUING LOSS

1% AEP RORB runoff routing parameters were used in line with Googong Drainage Design Criteria (QPRC, 2011). Standard ARR Datahub loss parameters (Initial Loss (IL) 22mm, Continuing Loss (CL) 5.2mm/hr) were not used in this model as they produced lower flows that were not sufficiently close to previous modelling results. The CL parameter of 5.2mm/hr, in particular, was not considered accurate following review of ARR NSW Specific Data Information. IL and CL values were set to 10mm and 2mm/hr respectively to reflect the Googong Drainage Design Criteria (QPRC, 2011) guidelines.

3.2.2 0.5% AEP, 0.2% AEP AND PMP RORB INITIAL AND CONTINUING LOSS

IL and CL values adopted for 0.5% AEP, 0.2% AEP and PMP events have been determined using a log-log relationship method identified in AR&R, 2019 (Bk 8, Ch 4).

RORB IL and CL values are outlined in Table 1.

Table 1: RORB IL and CL Values

Parameter	Initial Loss (IL)	Continuing Loss (CL)
1% AEP	10	2
1% AEP+CC	10	2
0.5% AEP	9.3	2
0.2% AEP	8.2	2
10^{-7} AEP (PMP)	0.1	1

3.2.2.1 Kc Value

The post development 1% AEP RORB model was first run using ARR 1987 methodology and compared with previous ARR 1987 modelling (Brown Consulting 2010) in order to determine an appropriate Kc value.

Flows determined using the following Kc equations were then checked against previous modelling flows:

- Default Kc (Eqn 2.5 RORB Manual) = 3.08
- Eastern NSW (Kleemola) = 1.61

Results are shown in Table 2 below. As shown, previous modelling results (Brown Consulting 2010) estimate a post development peak flow of 11.28m^3/s (with upstream basins) at the Googong Rd crossing. The Default Kc equation (Eqn 2.5 RORB Manual) produced a flow of 8.68 m^3/s, which is considered too low. The Eastern NSW Kc equation produced a flow of 13.12m^3/s which is relatively close to that produced in previous modelling. As such, a Kc of 1.61 has been adopted for modelling of all events up to the 0.2% AEP.

Note, ARR 1987 methodology has only been used for comparison purposes to determine an appropriate Kc value. RORB modelling results presented in Section 3.5 use ARR 2019 methodology.

Table 2: Kc Flow Comparison

Method	Peak Flow Estimation	Comments
Previous results (ARR 1987) (Brown Consulting 2010) – Controlled Peak Flow with Basins	11.28 m^3/s	
RORB (ARR 1987) Default (Eqn 2.5 RORB Manual) (Kc = 3.08)	8.68 m^3/s	
RORB (ARR 1987) Eastern NSW (Kleemola) (Kc = 1.61)	13.12 m^3/s	Adopted

3.3 RAINFALL DATA

Rainfall Intensity-Frequency-Duration Data has been adopted from the Bureau of Meteorology (BoM) in accordance with ARR2019.

3.3.1 CLIMATE CHANGE FACTORS

Climate change (CC) factors have been applied to IFD data for the 1% AEP + CC event.

The methodology outlined in *Discussion Paper: Update to Climate Change Considerations chapter in Australian Rainfall and Runoff: A Guide to Flood Estimation Discussion Paper, Department of Climate Change, Energy, the Environment and Water, Canberra, CC BY 4.0 (DCCEEW 2023)* has been used to determine climate change factors.

A medium emissions socioeconomic pathway (SSP2-4.5) has been adopted, for a long-term timeframe (2081-2100).

3.3.2 PMP

The GSDM analysis was used to identify the PMP to be 1 x 10^7 AEP. The GSDM method and ARR2019 tools were used to extract the rainfall data and intensity.

3.4 RORB MODEL SET UP

The *Stormwater Management and Drainage Analysis Design Report – Neighbourhood 1A Stages 1 and 2 Googong New Town (Brown Consulting 2010)* includes four basins within the catchment upstream of Googong Rd. Basin parameters, including volumes and outlet configurations have been adopted from the strategy, in the absence of detailed design/construction plans.

3.5 RORB MODEL RESULTS

Flows for each design storm event have been obtained from the RORB modelling and input into the post developed 2D hydraulic model as inflow hydrographs. Peak flows for each storm event are detailed in Table 3 below.

Table 3: RORB Peak Flow Results

Design Event	Duration	TP	Peak Flow (m3/s)
1% AEP	1 hour	TP23	12.48
1% AEP + CC	45 min	TP21	20.21
0.5% AEP	1 hour	TP23	15.86
0.2% AEP	45 min	TP21	19.51
PMP	1 hour	N/A	181.57

4. HYDRAULIC MODELLING

Post development 2D hydraulic modelling has been undertaken using TUFLOW. The 2D hydraulic model has been used to determine the following:

- The Flood Extent within Googong Creek north of Googong Rd
- The Flood Hazard within Sunset Estate adjacent to Googong Creek

4.1 MODEL SETUP

The post development TUFLOW model has been set up with the following key elements:

4.1.1 MODEL EXTENT

The TUFLOW model set up is shown in Figure 3.

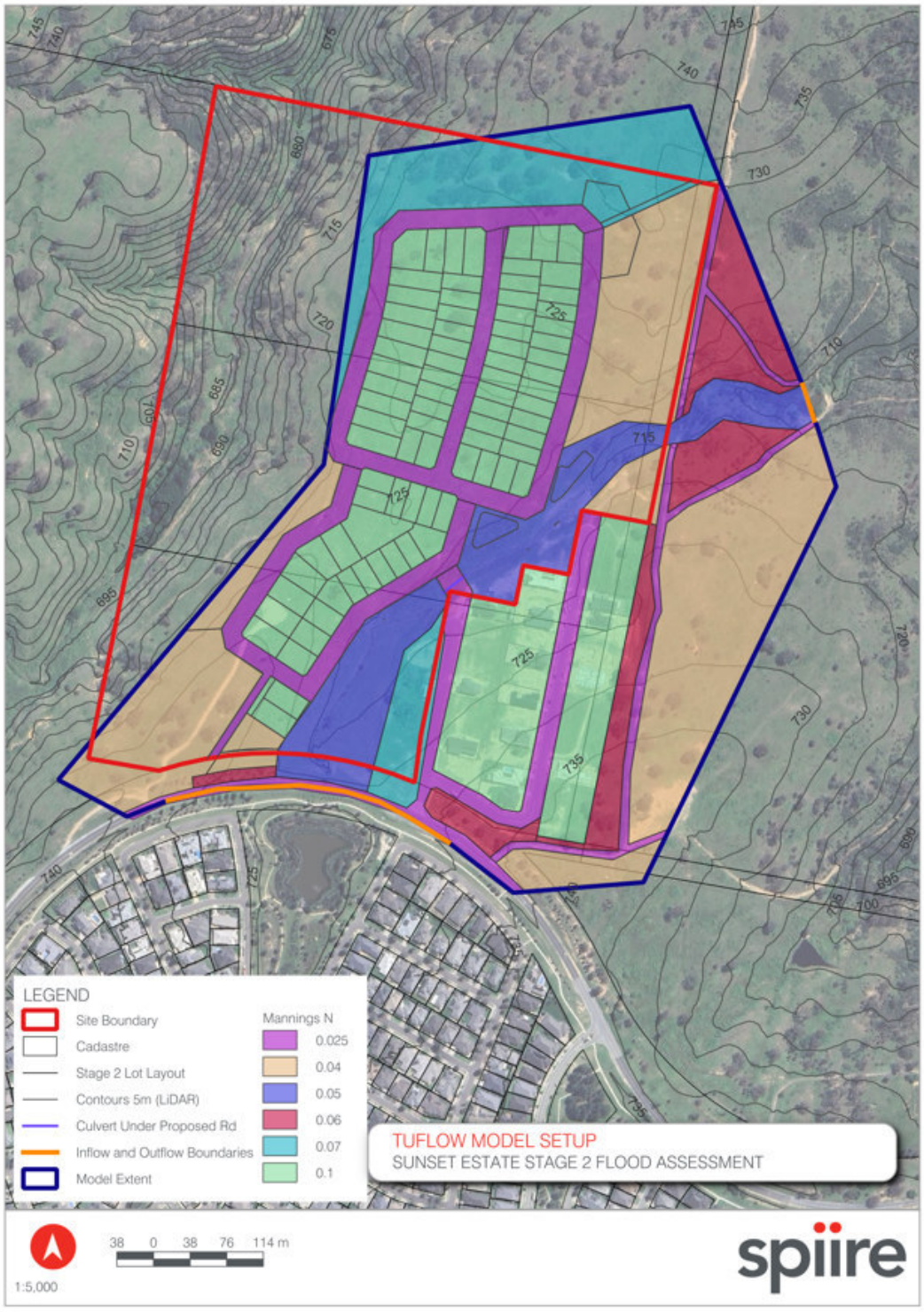

Figure 3: TUFLOW Model Setup

4.1.2 TOPOGRAPHY

The surface data adopted for the model is outlined below:

- DEM containing the following:
  - Survey of existing surface within Stage 2 development area, Googong Creek and Googong Rd
  - Stage 1 development earthworks
- LiDAR DEM for downstream section of Googong Creek (North West of development)

4.1.3 BOUNDARY CONDITIONS

4.1.3.1 Inflow Boundary

The model uses the following inflow boundaries:

- Flow Time (QT) 2d_bc inflow hydrographs for each design event.
  - 1% AEP and 1% AEP + CC boundary located directly downstream of Googong Rd
  - 0.5% AEP, 0.2% AEP and PMF boundary located on Googong Rd allow for possible overtopping from upstream catchment.

4.1.3.2 Downstream Boundary

The average slope of Googong Creek downstream of the site is ~4.5%. Given the relatively steep grade of the Creek, an HQ Slope downstream boundary has been used for the model.

4.2 BED ROUGHNESS

Bed roughness has been defined using Manning's n values. The manning's n values adopted for this assessment are based on the following:

- Existing aerial imagery where no development is proposed (including within the creek)
- The proposed development bed roughness

4.3 1D STRUCTURES

The following 1D structure has been included in the model:

- 3 x 3mW x 1.8mH Box culverts under road between Googong Stage 1 and Stage 2 (with allowance for 25% Blockage in accordance with ARR2019 Blockage Assessment Form)

4.4 1% AEP, 1% AEP+ CC, 0.5% AEP AND 0.2% AEP FLOOD RESULTS

The 1% AEP post development flood extent and water surface elevation (WSE) is shown in Figure 4. As shown, the 1% AEP flood extent is contained within the Googong Creek Corridor, and does not encroach on the Stage 2 development area. In addition, there is 0.65m

freeboard from the 1% AEP flood water surface elevation to the proposed road crossing between stages 1 and 2.

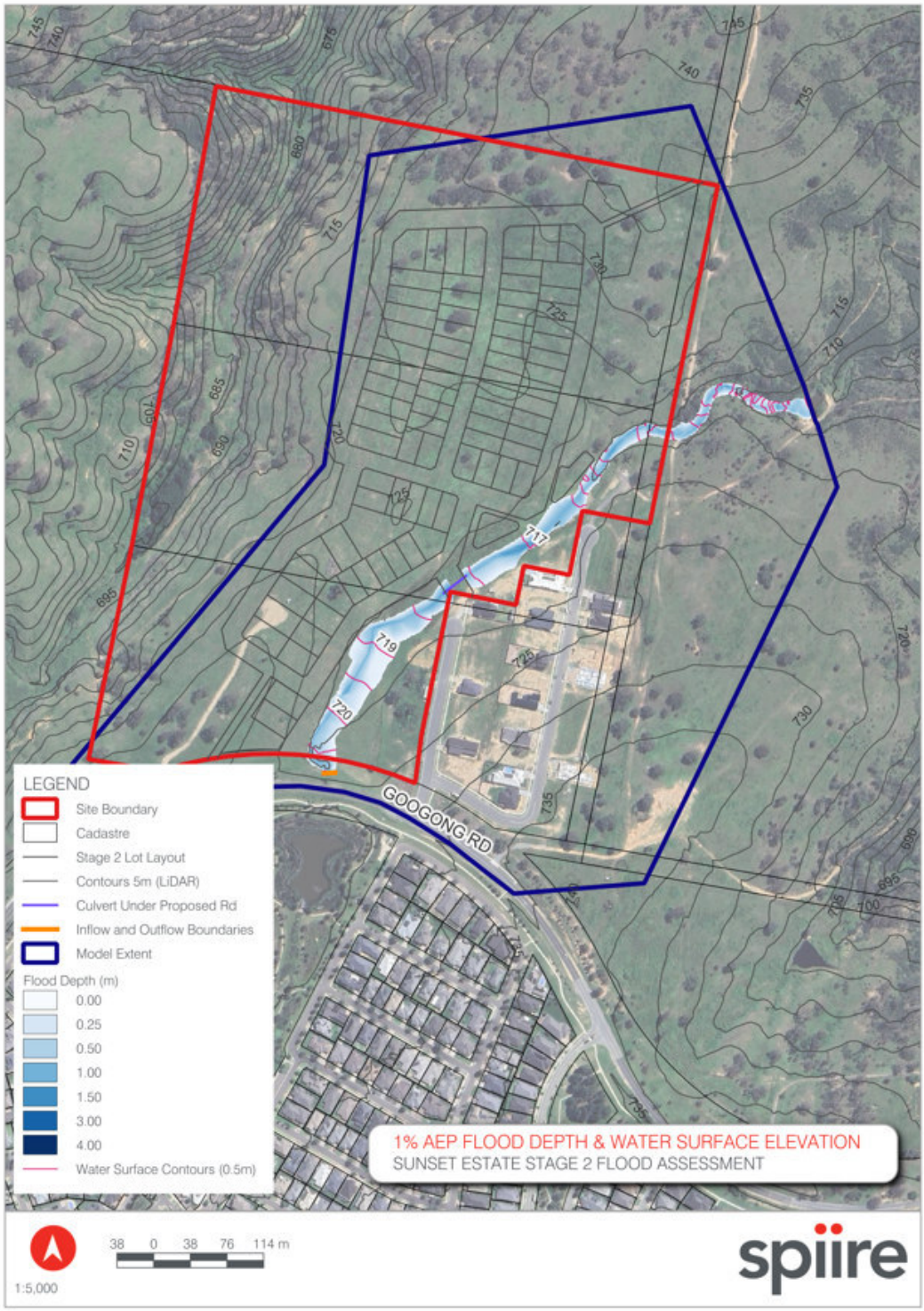

Figure 4: 1% AEP Flood Depth and Water Surface Elevation

The 1% AEP plus Climate Change post development flood extent and water surface elevation (WSE) is shown in Figure 5. As shown, the 1% AEP plus Climate Change flood extent is contained within the Googong Creek Corridor, and does not encroach on the Stage 2 development area.

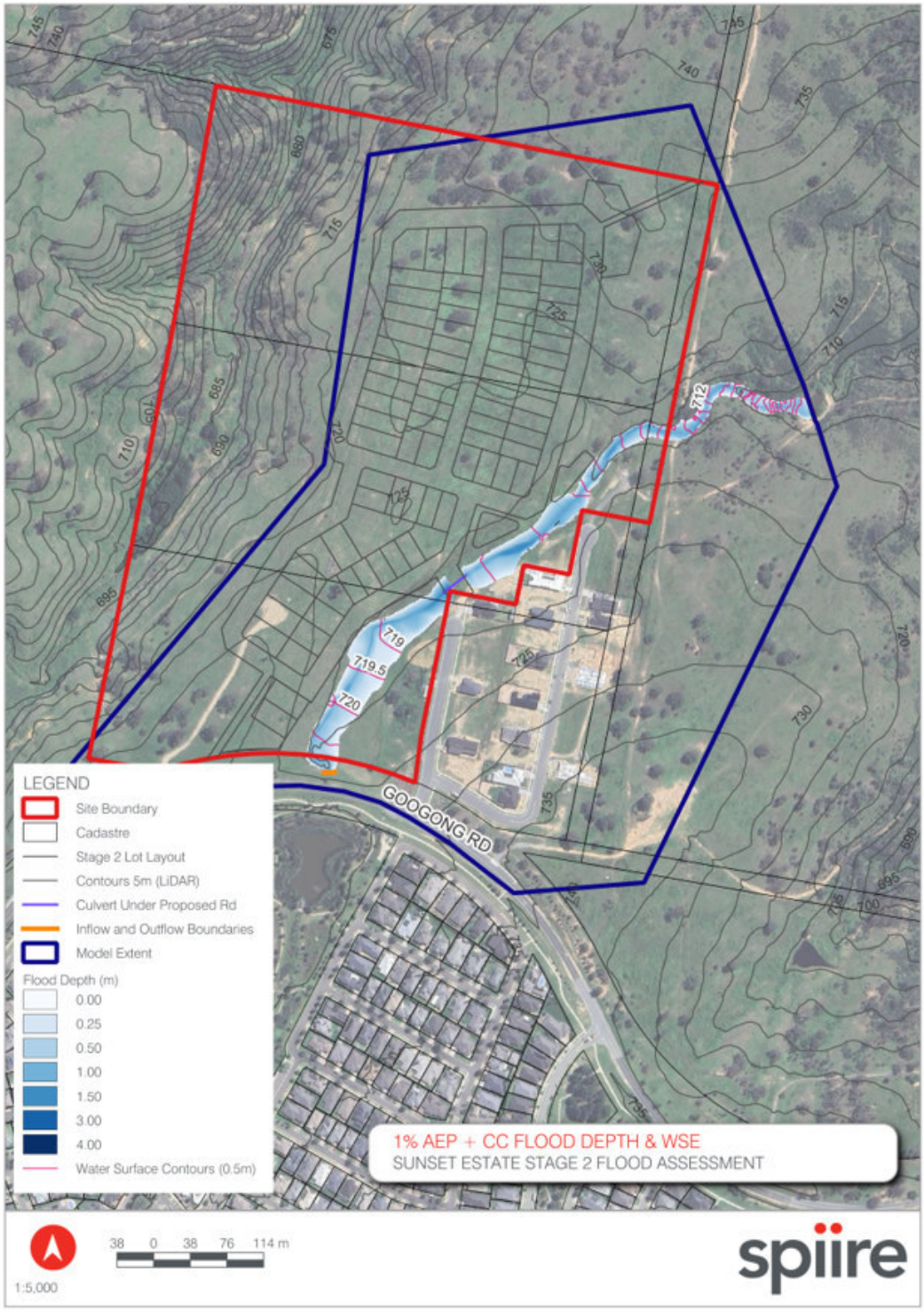

Figure 5: 1% AEP + Climate Change Flood Depth and Water Surface Elevation

The 0.5% AEP post development flood extent and water surface elevation (WSE) is shown in Figure 6. As shown, the 0.5% AEP flood extent is contained within the Googong Creek Corridor, and does not encroach on the Stage 2 development area.

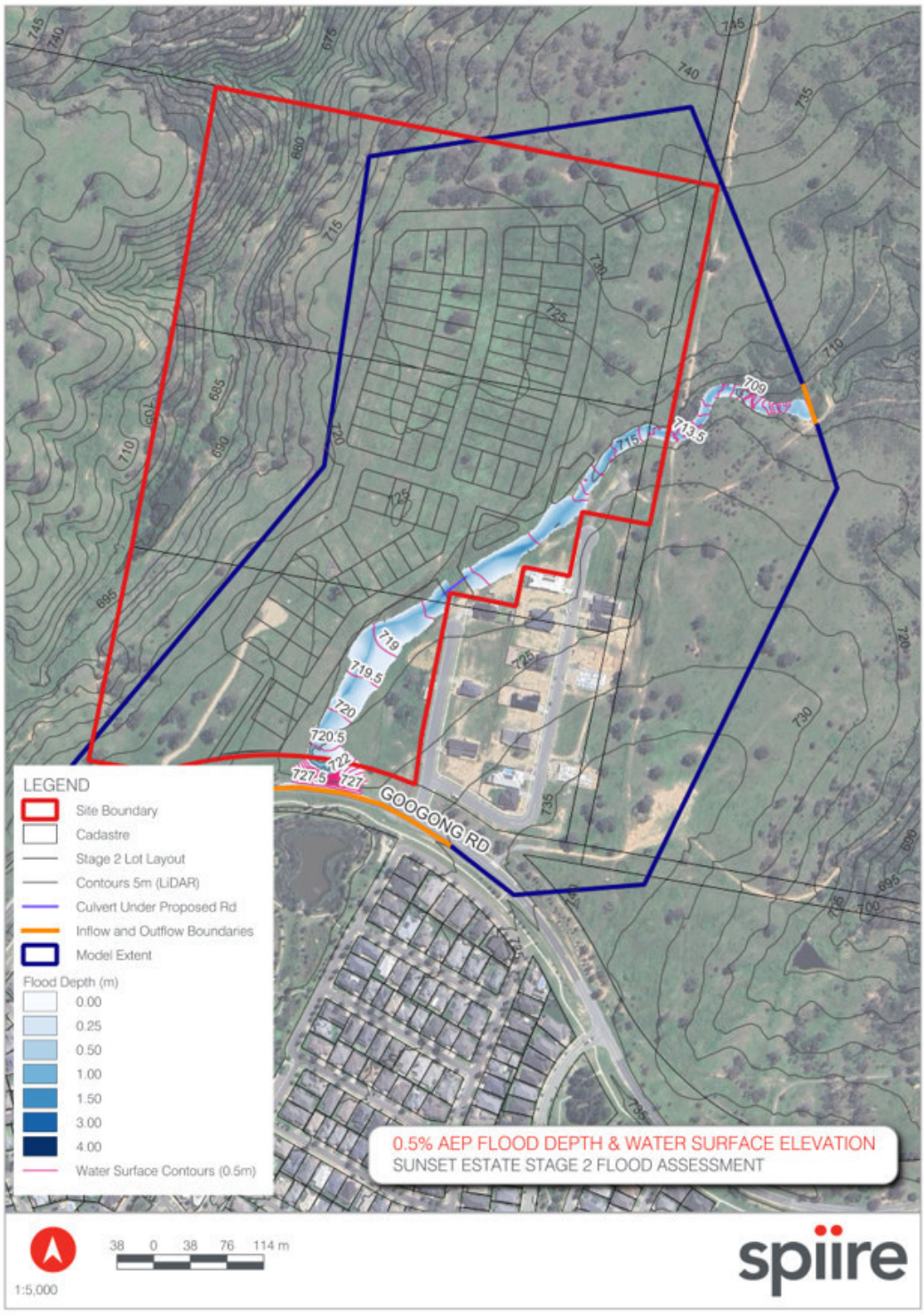

Figure 6: 0.5% AEP Flood Depth and Water Surface Elevation

The 0.2% AEP post development flood extent and water surface elevation (WSE) is shown in Figure 7. As shown, the 0.2% AEP flood extent is contained within the Googong Creek Corridor, and does not encroach on the Stage 2 development area.

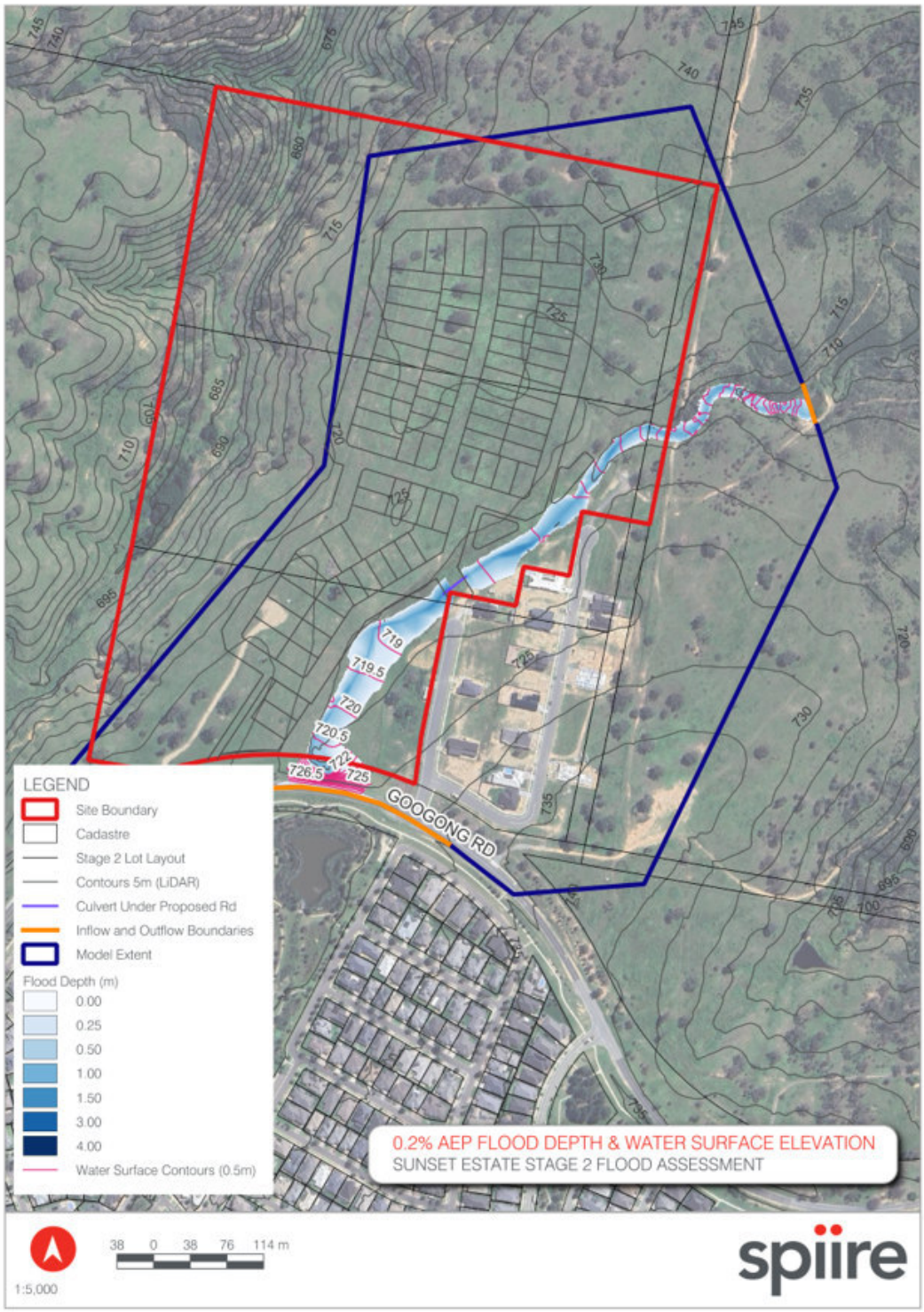

Figure 7: 0.2% AEP Flood Depth and Water Surface Elevation

4.5 PMF RESULTS

PMF flood modelling has been undertaken in relation flood egress to ensure safe evacuation routes are available for the site. The post development PMF flood extent and water surface elevation (WSE) is shown in Figure 8. As shown, the PMF flood extent encroaches on the Stage 2 road directly adjacent to the Googong Creek, and overtops the proposed road crossing between stages 1 and 2. Evacuation is, however available via Googong Rd.

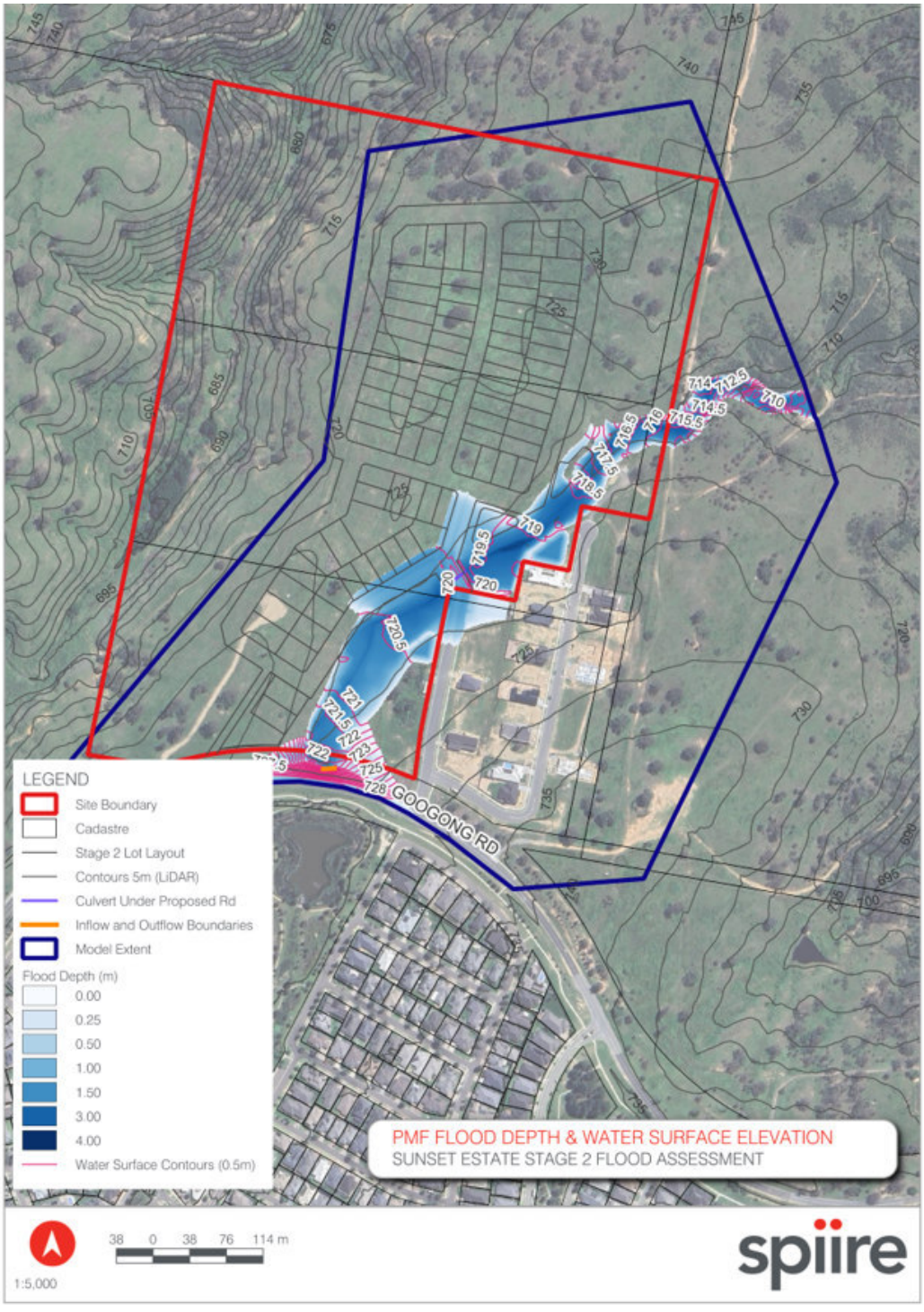

Figure 8: PMF Flood Depth and Water Surface Elevation

4.5.1 HAZARD AND VELOCITY

As the PMF flood extent inundates the development area surrounding the Googong Creek a Hazard and Velocity assessment has been undertaken. The PMF Hazard Classification level is shown in Figure 9. As shown, the hazard classification is high (H5 to H6) within Googong Creek, over the proposed road crossing from Stage 1 to Stage 2, and within surrounding Stage 1 and 2 road reserves. The hazard classification is not, however, considered high (H5 to H6) within stage 1 and 2 lot areas.

The PMF Flow Velocity is shown in Figure 10. As shown, velocities greater than 2m/s are generally contained within the Googong Creek Corridor, except around the proposed road crossing between stages 1 and 2.

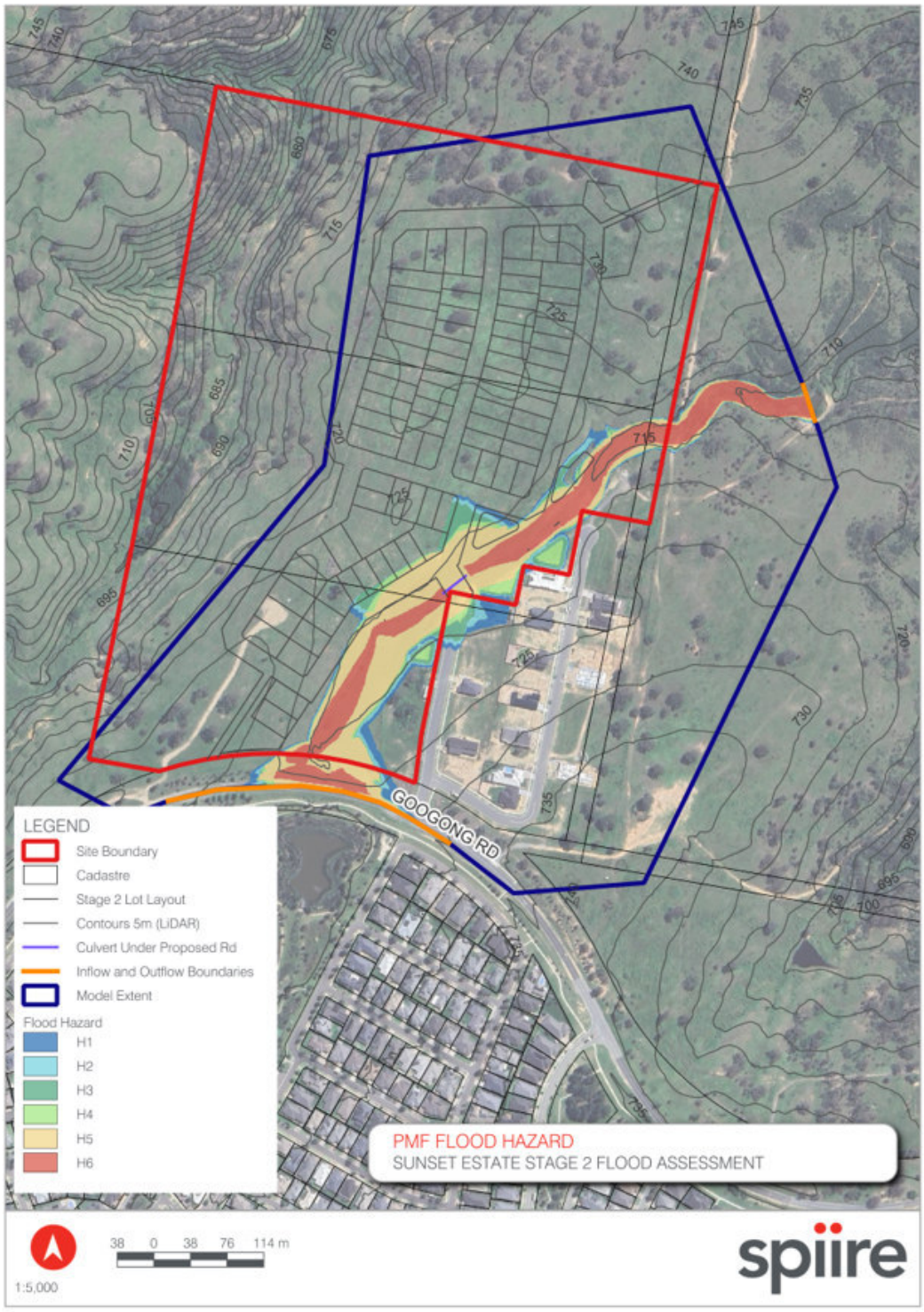

Figure 9: PMF Flood Hazard

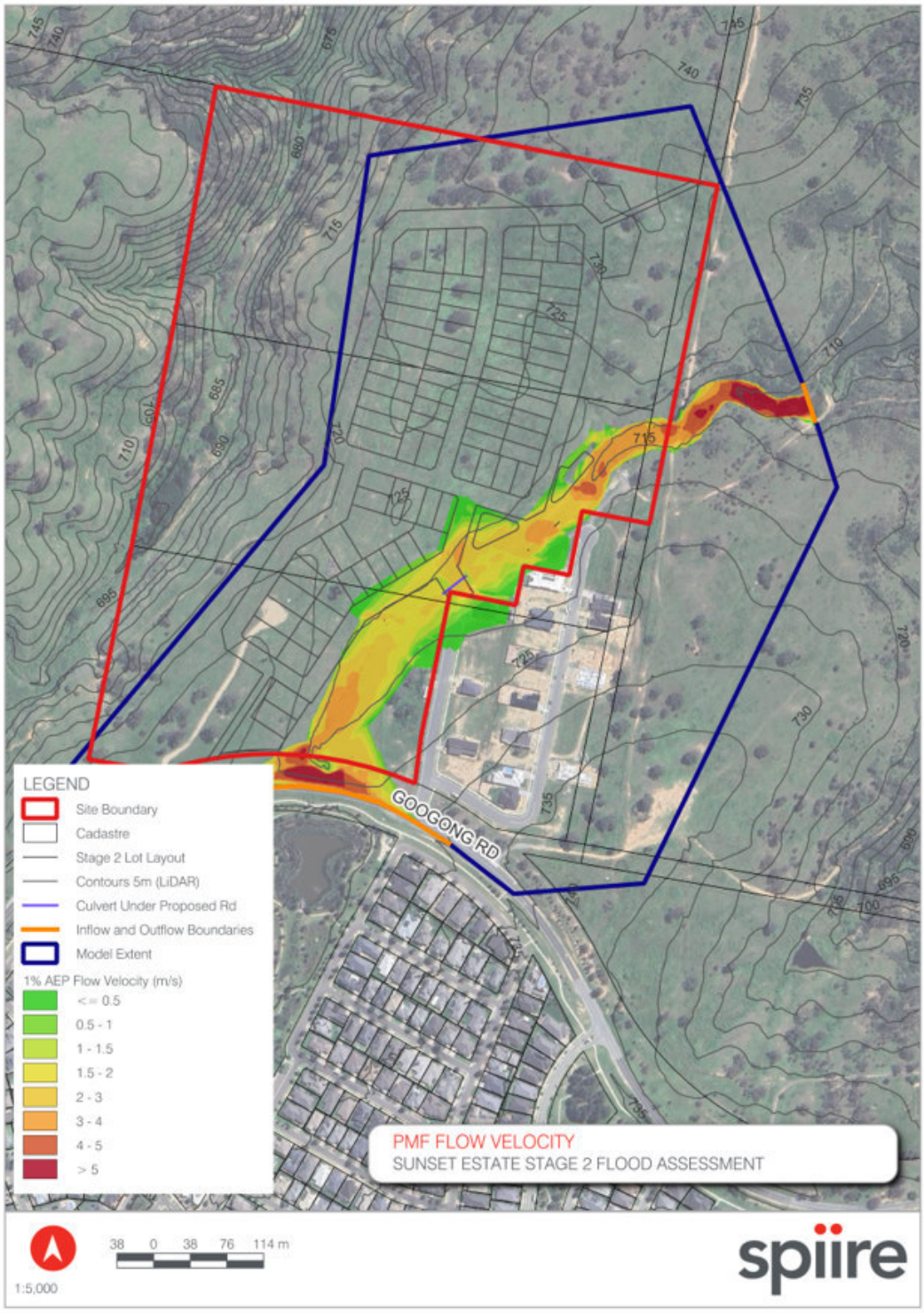

Figure 10: PMF Flow Velocity

5. SUMMARY/CONCLUSIONS

The Flood Impact Assessment completed for Sunset Estate Stage 2 provides detailed information regarding flooding associated with the site. Results outlined in this report are summarised below:

- The 1% AEP flood extent is contained within the Googong Creek, and thus does not encroach on the proposed stage 2 development area. In addition, there is sufficient freeboard (0.65m) from the 1% AEP flood water surface elevation to the proposed Googong Creek culvert crossing.
- The 1% AEP + CC, 0.5% AEP and 0.2% AEP flood extents are contained within the Googong Creek, and thus do not encroach on the proposed stage 2 development area.
- The PMF flood extent encroaches on the Stage 2 road directly adjacent to the Googong Creek, and overtops the proposed road crossing between stages 1 and 2. Evacuation is, however available via Googong Rd.
- The PMF hazard classification is considered high (H5 to H6) within Googong Creek, over the proposed road crossing from Stage 1 to Stage 2, and within surrounding stage 1 and 2 road reserves. The hazard classification is not, however, considered high (H5 to H6) within stage 1 and 2 lot areas.
- PMF velocities greater than 2m/s are generally contained within the Googong Creek Corridor, except around the proposed road crossing between stages 1 and 2.

APPENDIX 1

BROWN CONSULTING STORMWATER MANAGMENT DRAINAGE ANALYSIS (MARCH 2010)

STORMWATER MANAGEMENT AND DRAINAGE ANALYSIS

DESIGN REPORT

NEIGHBOURHOOD 1A

STAGES 1 AND 2

GOOGONG NEW TOWN

March 2010

Prepared for CIC Australia

BROWN CONSULTING

Urban Development | Structures
Roads & Traffic | Water & Environment

Engineering innovative and sustainable environments with creativity, care and value

STORMWATER MANAGEMENT AND DRAINAGE ANALYSIS

DESIGN REPORT

NEIGHBOURHOOD 1A :STAGES 1 AND 2

GOOGONG NEW TOWN

REVISION SCHEDULE

NO.	DATE	ISSUE	PREPARED BY	REVIEWED BY	AUTHORISED BY
0	16/03/2010	DRAFT	J Lepetit	T Connell	n/a
1	23/4/2010	FINAL	J Lepetit	T Connell	n/a
2	28/5/2010	FINAL FOR SUBMISSION	J Lepetit	T Connell	T Connell
3	1/6/2010	REVISION – ELTON COMMENTS	J Lepetit	T Connell	T Connell

Reference: H:\C09000\C09088\documents\de\Stormwater Management\C09088-StormwaterManagement&DrainageAnalysis_Rev3_20100601.docx

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1 INTRODUCTION

This design report for the stormwater drainage and management of Neighbourhood 1A: Stages 1 and 2 of the proposed Googong New Town has been prepared by Brown Consulting (ACT) Pty Ltd for CIC Australia to support the Development Application (DA) for Neighbourhood 1A: Stages 1 and 2 of the future Googong New Town. This study specifically addresses the issues associated with stormwater drainage and peak flow attenuation, stormwater quality control and improvement using Water Sensitive Urban Design (WSUD) principles and is built upon collaborative work with Brown Consulting (NSW) Pty Ltd and EDAW|AECOM.

Googong New Town will at ultimate development extend over three catchments: Montgomery Creek catchment, Jerrabomberra Creek catchment and an unnamed creek referred to as Googong Creek catchment.

The DA for Neighbourhood 1A: Stages 1 and 2 focuses on Googong Creek catchment. It further develops the previous investigation undertaken and presented in the Googong Creek Catchment Stormwater Strategy (Brown Consulting, January 2010, see **Appendix A**)

This report should be read in conjunction with the Development Application Drawings (the Drawing Set).

1.1 PURPOSE OF THIS REPORT

This report has been prepared to demonstrate to Queanbeyan City Council and any other determining authority that the design features of the Neighbourhood 1A: Stages 1 and 2 of Googong New Town within Googong Creek catchment are appropriate for approval. The objectives of this report are to:

- Provide a summary of the existing drainage and hydrologic environment of Googong Creek.
- Outline the design criteria and codes that apply to the development.
- Describe the features of the stormwater management system for Googong Creek.
- Provide calculation and modelling outputs demonstrating how the project complies with the planning regulations.
- Describe the management of major and minor overland flows in Googong Creek.
- Outline how the stormwater quality measures included in the design will reduce the post developed pollutant loads.
- Outline the soil and water management strategies to be employed during construction.

1.2 STORMWATER OBJECTIVES OVERVIEW

The key objectives for stormwater management include:

- Meet stormwater targets identified within the Queanbeyan Development Control Plans (DCP) for both water quality and quantity.
- Linking water infrastructure effectively to minimise the impacts of development upon the water.
- Protecting downstream receiving waters (e.g. riparian corridors) from flooding and water quality degradation.
- Protect assets and the future subdivision from flooding.

A number of design criteria have been integrated into the design of the stormwater system for Neighbourhood 1A: Stages 1 and 2 including:

- Queanbeyan City Council – *Handbook of Drainage Design Criteria*;
- Queanbeyan City Council – *Development Control Plan No. 38 – Subdivision, Part B1 – Subdivision Design Criteria*;
- Queanbeyan City Council – *Development Control Plan No. 41 – Soil, Water and Vegetation Management Plans*;
- Queanbeyan City Council – *Development Design Specification D5 Stormwater Drainage Design*;
- Queanbeyan City Council – *Development Design Specification D7 – Erosion Control and Stormwater Management*;
- Queanbeyan Local Environment Plan (1997)
- ACT Planning and Land Authority *Waterways Water Sensitive Urban Design – General Code* (2008)
- ACT Planning and Land Authority *Industrial Zones Development Code* (2008)
- Suggested Googong Development Control Plan (by Elton)

1.3 EXISTING CONDITIONS

This section presents a summary of the detailed information contained in the Googong Creek Catchment Stormwater Strategy (Brown Consulting (NSW) Pty Ltd, January 2010) (provided in **Appendix A**).

Topography and Site Drainage

Googong Creek is the second largest catchment within the future Googong New Town. Representing roughly 164 ha within the site, it drains the northern area of the site from the western boundary at Old Cooma Road in a North Easterly direction to Queanbeyan River.
Twin culverts are located on Googong Creek at the Googong Dam Road embankment representing the downstream boundary of the development area.

Waterways and major drainage lines

There are a number of minor tributaries of Googong Creek within the site. The creek has two distinct characters; upstream and downstream of the Googong Dam Road culvert.

Upper section

The main channel and tributaries in the upper section of Googong Creek consist of grassy swales and remnant chain of ponds meadows draining to a number of farm dams. Minor modifications to the drainage lines in these sections have occurred, with diversion banks constructed to increase flows to several dams. Within this upper section there are limited lengths of stream bed and bank formations. There is a small part of Googong Creek on the western side of Old Cooma Road. This site is partially cleared and is generally steeper than the section of creek within the site. This catchment is drained under Old Cooma Road via a piped culvert (600 mm diameter). Flows in excess of the capacity of this culvert would pond behind the road embankment and flow over the roadway. The size of this catchment is 28.1 hectares. A culvert consisting of twin nominal 1650 mm diameter pipes is located on Googong Creek at the Googong Dam Road embankment. The culvert, embankment and the large dam immediately upstream form a de facto detention basin at this location, providing storage for flows above the culvert capacity. It is considered extremely unlikely that the roadway would be overtopped in any storm event.

Lower section

Preliminary investigations of the section of Googong Creek downstream of the twin culvert Googong Dam Road indicate that the creek is well formed with definable beds and banks. This section can be classified as having higher riparian values and development in this area, known as "Hamlet East" will incorporate different water design measures than the upstream sections. Neighbourhood 1A: Stages 1 and 2 does not extend downstream of the Googong Dam Road. This report therefore does not include any details of the development downstream of Googong Dam Road.

Googong Creek Classification

Brown Consulting completed in November 2008 a Riparian Corridor Assessment for all catchments located at Googong New Town site. The document was presented and discussed with DWE and DPI (now Department of Climate Change and Water).

The assessment of the classification of the various reaches of the creek system has been undertaken to provide guidance on the type of riparian corridor to be provided. There are two classification systems for the creeks; the first is DWE's creek categorisation system and the second is DPI's (NSW Fisheries) creek categorisation system for aquatic habitat.

The DWE classification was developed from the riparian corridor assessment project in the Illawarra region. This system provides natural recourse outcomes for a range of environmental objectives. This system has three categories:

- Category 1 – Environmental Corridor. This maximises the natural resource outcomes sought for a watercourse. These include protection and enhancement of aquatic and terrestrial vegetation and habitat. With an emphasis on improving connectivity between habitat zones.
- Category 2 – Terrestrial and Aquatic Habitat. This has similar objectives as Category 1, but is less stringent in terms of width of the core riparian zone and connectivity requirements.
- Category 3 – Bank Stability and Water Quality. This recognises the lower values of some streams with regard to environmental functions and because of site constraints it is unlikely that an ecologically satisfactory riparian outcome can be achieved.

The DPI classification system is based on the likelihood of fish habitat being present. This system has four categories:

- Class 1- Major Fish Habitat. Major permanently or intermittently flowing waterway (e.g. river or major creek), habitat of a threatened fish species.
- Class 2 – Moderate Fish Habitat. Named permanent or intermittent stream, creek or waterway with clearly defined bed and banks with semi permanent waters in pools or in connect wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting the area.
- Class 3 – Minimal Fish Habitat. Named or unnamed waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna. Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or recognised aquatic habitats.
- Class 4 – Unlikely Fish Habitat. Named or unnamed waterway with intermittent flow following rain events only, little or no defined drainage channel, little or no flow of free standing water or pools after rainfall events.

This document has identified the following creek categorisation for Googong Creek:

Table 1 Creek Classification

Creek	DWE Category	DPI Classification
Lower Montgomery Creek	1	2
Upper Montgomery Cree	2	3
Lower Googong Creek	2	2
Upper Googong Creek	3	4
Jerrabomberra Creek	3	4
Queanbeyan River (within Site)	3	4
Queanbeyan River (hamlet area)	2	2

Creek classification for Googong Creek identifies the limited environmental and habitat value of upper Googong Creek which is proposed for partial development and modification. The

lower Googong Creek possesses environmental values that need to be protected through careful management.

2 HYDROLOGY

It is important to note that while the DA is focused on Neighbourhood 1A: Stages 1 and 2 of the Googong New Town, the hydrological and stormwater analysis was carried out for the whole of Googong Creek Catchment which extends beyond Neighbourhood 1A: Stages 1 and 2 alone to the west.

2.1 OBJECTIVES

The specific objectives of the DA with regards to stormwater quantity management include:

- Attenuate all storm flows from 1 year ARI to the 100 year ARI to existing flow levels,
- Provide a high level of safety in terms of batter slopes and ponding depths,
- Protect assets from flooding.

2.2 METHODOLOGY

The *XP-RAFTS* model was used for hydrological analysis of the existing catchment to obtain pre-development flows (referred to as the Permissible Site Discharge) from Stage 1, and to model the proposed development scenario. The model integrates the various stormwater detention basins as well as the area known as the "mini-common" as initially discussed and presented in the Googong Creek Catchment Stormwater Strategy (Brown Consulting (NSW) Pty Ltd, January 2010) (provided in **Appendix A**).

2.2.1 Hydrological Model Parameters

The *RAFTS* hydrological model was used for existing conditions and analysis of developed conditions. The following parameters from QCC Handbook of Drainage Design Criteria supplemented with the ACT Planning and Land Authorities' Water Sensitive Urban Design General Code (March, 2008) were adopted:

ARBM Rainfall losses

The Australian Representative Basins Model (ARBM) approach was used to model rainfall losses. The values adopted in the ARBM model were as per Table 1.3 of the Handbook of Drainage Design Criteria and Table 1.6 ACT Design Standards for Urban Infrastructure – Stormwater.

Initial Continuing Losses

The IC losses method was used to estimate the impervious areas of the proposed development with the following assumptions:

- Impervious Initial Loss 0.5mm
- Impervious Continuing Loss 0 mm

Manning's values and Impervious Fraction

Manning's values were assigned in accordance with the QCC Handbook of Drainage Design Criteria and the ACT Planning and Land Authorities' Water Sensitive Urban Design General Code (March, 2008).

- Impervious Areas Roughness n=0.015
- Pervious Areas Roughness n=0.040

Impervious fraction was assigned based on:

- QCC Handbook of Drainage Design Criteria,
- ACT Design Standards for Urban Infrastructure – Stormwater (Table 1.3 p. 1-10)
- as well as relevant project experience modelling similar conditions.

Typical impervious fractions are provided below:

Table 2 Typical Impervious Fractions

Land Use	Impervious Fraction Used	QCC Values[1]
Town Centre	90%	n/a
Commercial Area/Shopping Centre	85%	85%
Roads	80%	n/a
Residential Area (Multi Unit)	70%	70%
Residential Area (Single Residential)	60%	60%
Open Spaces	5-10%	10%

While the typical values specified above are relevant and compliant with standards, it is recommended that these impervious fraction values are refined based on more actual land use at detailed design stage.

2.2.2 Calibration

The above RAFTS parameters were applied to the model to estimate flows from the catchment for the 100 year ARI storm. For the calibration, a Probabilistic Rational Method was used to estimate the flow and the RAFTS model Bx factor adjusted accordingly to achieve a similar flow. The Rational Method was considered suitable for calibration: the catchment is a large rural catchment, which can be well approximated by this method. This process determined that the RAFTS model Bx factor required adjusting to a value of 1.5 to approximate the peak flow from the rational method.

2.2.3 Rainfall Data

Design storms obtained from Chapter 3 of *Australian Rainfall and Runoff* (Institution of Engineers, Australia, 1987) using Intensity-Frequency-Duration (IFD) data, were used for

[1] Values taken from Handbook of Drainage Design Criteria (Table 1.1)

ARI's of 2 to 100 years, which were representative of the local climatic conditions in Googong. Storm durations from 10 minutes to 24 hours were analysed.
Googong IFD table is provided in **Appendix B**.

2.2.4 Hydrological Model Catchments

The calibrated XP-RAFTS model was used to assess both pre-development hydrological conditions as well as proposed post-development conditions including proposed stormwater detention and peak flow attenuation measures. Summary results are provided below.
Detailed results are provided in **Appendix C**.

A map of the XP-RAFTS model catchment is provided as drawing no. C09088-100+ in the drawing set.

The XP-RAFTS model catchments are summarised below:

Table 3 Googong Creek Catchment RAFTS Catchments (Developed)

Developed Catchments	Total Area [ha]	Percentage Impervious [%]
A1-1	3.20	10%
A1-2	2.18	50%
A1-3J	n/a	
A1-4 Swale	0.28	100%
A1-5	1.39	20%
A1-6	3.92	20%
A1-7J	n/a	
A1-8	6.03	70%
A1-9	6.84	70%
A1-10	3.47	70%
A1-11	5.71	70%
A1-12	9.24	50%
A2-1	4.73	70%
A2-2	5.95	70%
A3-1	2.09	70%
A4-1	2.12	70%
A5-1	4.51	70%
A6-1	1.86	70%
A7-1	5.64	70%
A7-2	6.49	70%
A7-3	1.81	70%
A8-1	2.63	70%
A9-1 swale	0.22	100%

Developed Catchments	Total Area [ha]	Percentage Impervious [%]
A9-2	2.94	60%
A9-3J	0.00	100%
A9-4	5.52	50%
A9-5J	n/a	
A9-6	8.24	50%
A9-7	15.11	5%
A9-8	13.02	5%
A10-1	1.41	70%
A11-1	1.00	70%
A12-1	1.84	70%
A13-1	2.48	70%
A14-1	2.10	70%
A15-1	3.26	60%
A15-2	6.46	70%
A16-1	3.66	70%
A17-1	6.16	70%
A18-1	3.03	70%
A19-1	1.34	70%
A20-1	4.40	70%
A20-2	7.11	70%
A20-3	10.58	70%
A21-1	1.85	70%
A22-1	3.12	70%
A23-1	5.66	70%
A24-1	4.40	60%
Total	*195.00*	*107.70*

2.2.5 Existing Hydrologic Conditions

An XP-RAFTS hydrologic model has been developed for Googong Creek in the pre-development state. This model uses the parameters specified in Queanbeyan City Council *Handbook of Drainage Design Criteria* and ACT Planning and Land Authorities' *Water Sensitive Urban Design General Code* (March, 2008).

Flows were calculated for storms ranging from 15 minutes to 6 hours for the 100 year, 50 year, 20 year, 10 year, 5 year, 2 year, 18 month, 1 year, 9 month, 6 month and 3 month average recurrence intervals (ARI).

Permissible Site Discharges and existing hydrological conditions modelling were assessed at the culvert under Googong Dam Road, which corresponds to the ultimate outlet from Stages 1 and 2.

The existing hydrologic conditions and Permissible Site Discharges (PSD) are summarised below:

Table 4 Googong New Town NH1A Permissible Site Discharges (pre-development flows)

Event ARI [years]	Peak Flow [m^3/s]
100	14.86
10	7.42
5	5.78
1	2.18

2.3 IMPACT ASSESSMENT OF THE PROPOSED DEVELOPMENT

XP-RAFTS was used to determine what the impact of the proposed development of Neighbourhood 1A: Stages 1 and 2 as well as future stages of the Googong New Town would be on the hydrology of the site if no tailored stormwater management was put in place.

The table below summarises at the outlet point the peak discharge that could be expected in absence of any management measures (such detention basins or WSUD).

Table 5 Googong New Town NH1A Unmanaged Developed Site Discharges

Event ARI [years]	Peak Flow [m^3/s]	%age variation
100	35.85	+141%
10	22.21	+199%
5	19.22	+233%
1	10.90	+400%

Given the increase in peak flow, erosion and scouring conditions would be likely to occur in the absence of any management strategy and infrastructure.

3 PROPOSED STORMWATER MANAGEMENT STRATEGY

This section details the proposed strategy to manage to otherwise detrimental impacts of the development on the local waterways, receiving environment as well as the flooding analysis demonstrating the careful protection of proposed future infrastructure and assets.

3.1 STORMWATER DETENTION AND PEAK FLOW ATTENUATION

In this section are presented the elements of the strategy primarily designed to attenuate peak flows to PSD levels.

3.1.1 Overview

The stormwater detention and peak flow attenuation strategy has been developed and detailed in the Googong Creek Catchment Stormwater Strategy (Brown Consulting (NSW) Pty Ltd, January 2010) (provided in **Appendix A**).
An overall view of the stormwater detention measures is given on drawing no. C09088-101+.

Key elements of the strategy include:

- Basin 1 (Local Park 1): a complex system of swale, bioretention basins, stormwater quality control pond with stormwater detention capacity located at the outlet of the system near the Googong Dam Road culvert.
- Basin 2 (Recreation Reserve): this sporting oval/recreational reserve also represents a major stormwater detention basin which attenuates flow from a large part of the Googong Creek catchment. A low flow bypass with a capacity of 2m^3/s corresponding to approximately a 3 months ARI is provided.
- Basin 3 and 4 (subsequent development stage): located in Neighbourhood 2, basins 3 and 4 will be designed to provide significant attenuation of the peak flows generated by the northern part of the Googong Creek catchment. The conceptual design of basins 3 and 4 is included in f this report but the works are not part of the d Development Application for Stages 1 and 2 . They have however been integrated in the overall catchment analysis and stormwater strategy definition.
- A network of stormwater drainage swale providing some stormwater attenuation benefits. Key swales are located along Street 4, Street 2/3 and Street 20/21 (refer to drawing no. C09088-101+ and 102+.

The preliminary design of the proposed detention basins is detailed below:

Basin No. 1(Local Park 1)

Basin Type:	Bioretention, Stormwater Quality Control Pond and Detention Basin
Area (TWL):	14,300m^2
Volume (TWL):	23,000m^3

Outlet:	Subsoil drainage Ø150 @721.7m + spillway (8m) @ 723.45m (180mm throat)
NOL:	h=1.0m (722.9mAHD) (PWL) | A= 7,300m^2
EDD:	V=2500m^3 | h=0.52m (723.42mAHD)
Q1:	h=0.7m (723.6mAHD)
Q5:	h=1.08m (723.98mAHD)
Q20:	h=1.16m (724.06mAHD)
Q100:	h=1.39m (724.29mAHD)

Basin No: 2

Basin Type:	Detention Basin (Sports Oval)
Area (TWL):	25,700m^2
Volume (TWL):	20,363m^3
Outlet:	Low flow bypass (2m3/s)+ Ø225 @0m+Spillway (4m) @0.95m
NOL:	h=0m (738mAHD) | (A= 0m^2)
EDD:	V=0m^3 | h=0 m^3 (dry basin)
Q1:	h=0.28m (738.28mAHD)
Q5:	h=0.6m (738.6mAHD)
Q20:	h=0.85m (738.85mAHD)
Q100:	h=1.15m (739.15mAHD)

Basin No: 3

Basin Type:	Detention/Bioretention Basin
Area (TWL):	6,300m^2
Volume (TWL):	6,170m^3
Outlet:	Spillway 25m @ 0.6m
NOL:	h=0 (743.4mAHD) | A= 3,835m^2
EDD:	V=2,013m^3 | h=0.6m (744mAHD)
Q1:	h=1.22m (744.62mAHD)
Q5:	h=1.25m (744.65mAHD)
Q20:	h=1.27m (744.67mAHD)
Q100:	h=1.3m (744.7mAHD)

Basin No: 4

Basin Type:	Detention Basin
Area (TWL):	12,260m^2
Volume (TWL):	19,516m^3
Outlet:	Ø750 RCP @ 0.65m + spillway 15m @ 1.3m
NOL:	h= 0m (749mAHD) | (A=7,410m^2)
EDD:	V=5,300m^3 | h= 0.65m
Q1:	h= 1.05m (750.05mAHD)
Q5:	h=1.34m (750.34mAHD)
Q20:	h=1.69m (750.69mAHD) (1.04m above EDD)

Q100:	h=2.0m (751mAHD)

It is important to note that the design of the detention basins will need to be progressed as the project progresses to detailed design. Basin design and outlet configuration is preliminary and solely intended to demonstrate that a functional design outcome will be achievable.

Preliminary design was completed in 12D model using the following criteria:

- Maximum batter slope: 1 in 6
- Q100 Freeboard: 300mm except for key infrastructures (600mm)
- Maximum water depth (Q20) 1.2m above EDD level

3.1.2 Stormwater Attenuation Results

Stormwater attenuation performance criteria include:

- the provision of adequate extended detention storage capacity to detain and release in a controlled manner a nominal 3 month ARI storm event
- the demonstration of attenuation of peak flows for 1 year to 100 year ARI events.

These requirements are addressed below:

Extended Detention Requirements

The extended detention (EDD) requirement represents the necessary storage capacity required to capture a nominal 3 months ARI event for a controlled release over 24 to 72 hours.

Two methods were used to assess the required EDD volume for Googong Creek catchment:

- XP-RAFTS modelling of 3 months ARI storm runoff volume generated by the developed catchment
- Using the empirical approach described in the ACT Planning and Land Authorities' *Water Sensitive Urban Design General Code* (March, 2008) (1.4kL of storage per 100m^2 of impervious catchment.

The estimated EDD requirement is summarised below:

Table 6 Estimation of Extended Detention (EDD) Requirements

Estimation Method	EDD Volume Requirement (m^3)
XP-RAFTS	15,100
ACT Waterways Code	15,081
Adopted EDD Requirement	**15,100**

Proposed EDD storage measures

EDD storage measures typically include dedicated EDD storage volumes in detention basins, storage achieved in WSUD measures in the streetscape (eg, tree pits, raingardens, etc.) and rainwater tanks on properties.

For the Googong Creek catchment, the following measures are proposed:

EDD storage in basins: for most stormwater detention basins, EDD storage is proposed, except for the recreation reserve that features a low flow bypass of 2m³/s.

Decentralised WSUD measures are also proposed which will contribute to the EDD storage for the site. These include:

(i) Rainwater tanks: at this stage in the design process, it is difficult to estimate with certainty the number and capacities of future rainwater tanks on site. It is expected that rainwater tanks would be a mandatory feature of future blocks in Googong. It is also understood that compulsory tank capacity would be in the order of 4kL to 6kL per block. Based on recent development projects in the ACT where rainwater tanks are compulsory (4kL for block sizes between 500m² and 800 m² in accordance with ACT Planning and Land Authorities' Water Sensitive Urban Design General Code (March, 2008), it is expected that 25% of EDD storage may be met using rainwater tanks. This figure will need to be refined as project progresses.

(ii) Raingardens in the streets. A number of raingardens are proposed within Stage 1 (refer to DWG no. C09088-140+)

(iii) Tree pits: a number of tree pits have been proposed by landscape architects AECOM|EDAW. At this stage in the design developed, it is not possible to confirm number and location of tree pits. Nominally, each tree pit represents an EDD storage of 1.5m³ which would be added to the EDD storage for the site.

The table below demonstrates how the EDD storage requirement is met for the Googong Creek catchment:

Table 7 Proposed Extended Detention (EDD) Storage

Location	Measure	Area at EDD (m^2)	EDD height (m)	Volume (m^3)
Basin 1	Bioretention Pod 1	1,035	0.4	488
	Bioretention Pod 2	911	0.4	440
	Bioretention Pod 3	1,046	0.4	488
	Bioretention Pod 4	278	0.4	170
	Bioretention Pod 5	366	0.4	189
	Central Swale	234	0.6	141
	Pond/Wetland	5,322	0.4	2,129
Total Local Park 1 (Basin 1)				**4,044**
Basin 2	No measure			0
Basin 3	EDD Pond	3,355	0.6	**2,013**
Basin 4	EDD Pond	8,850	0.65	**5,300**
Decentralised WSUD Measures				

	Rainwater tanks	*25% of EDD requirement*		3775
	Stage 1 Raingarden Type flat grade	340	0.15	51
	Stage 1 Raingarden Type moderate grade	165	0.15	24.75
Total EDD Storage				**15,208**

While the figures estimated in the table above are preliminary and would require confirmation as design progresses, they demonstrate that meeting the EDD requirements for the site will be possible.

Modelling of Peak Discharge at Googong Dam Road Outlet

A XP-RAFTS hydrologic model was used to model the measures proposed. Detailed results are provided in **Appendix C**.

A summary table is presented below, which shows the attenuation performance of the proposed strategy and demonstrates that comes detailed design, a suitable design outcome will be possible to ensure the protection of the downstream waterways.

Table 8 Stormwater Peak Flow Attenuation Performance Assessment

Event ARI [years]	Developed Peak Flow [m^3/s]	Controlled Peak Flow [m^3/s]	%age Attenuation	Permissible Site Discharge [m^3/s]	Flow Attenuation Target Met?
100	35.85	11.28	-69%	14.86	Yes
10	22.21	4.91	-78%	7.42	Yes
5	19.22	3.82	-80%	5.78	Yes
1	10.90	1.07	-90%	2.18	Yes

3.2 STORMWATER QUALITY CONTROL AND IMPROVEMENT

3.2.1 Typical Stormwater Quality Deterioration Associated with Urbanisation of Rural Catchments

Typical impact of urban development in rural catchments water quality is a net deterioration of stormwater quality due to the introduction of a number of pollutant sources.

Stormwater pollutants originate from a number of sources including atmosphere, motor vehicles, construction activities, erosion and surface degradation, spills and leachates and miscellaneous surface deposits.

Typical stormwater quality pollutants include:

- Gross pollutants and litter
- Sediments and suspended solids
- Nutrients (particularly nitrogen and phosphorus)
- BOD and COD
- Micro-organisms
- Toxic organics and trace metals (including heavy metals)
- Oils and surfactants.

While suspended solids, gross pollutants, nutrients and BOD/COD are considered the most important factors of stormwater quality, specific design criteria for the purpose of the Development Application are :

- Gross pollutants (90% removal requirement)
- Suspended Solids (85% removal requirement)
- Total Phosphorus (65% removal requirement), and
- Total Nitrogen (65% removal requirement).

3.2.2 Management of Salinity Hazard

The project proposes to direct treated recycled water in excess of the volumes to be reused to be directed to the stormwater drainage system. The treated recycled water will be of relatively high salinity level (modelling indicates TDS of 1,100mg/L max.). Investigations have been carried confirming the suitability of soil types for application of recycled water and manageable risk that represent directing recycled water to the stormwater drainage system. These risks would likely include salt accumulation in the waterways potentially leading to detrimental impact on vegetation and soil stability.

Given the highly urbanised character of the future Googong New Town, even the smallest rainfall events (in excess of a 2mm rainfall depth) will generate stormwater runoff that will effectively flush the stormwater drainage system. It is therefore considered that recycled water while representing a non negligible salt load for the receiving environment will only have a limited impact on the environment of Googong.

It is worth noting that more detailed investigation and modelling is currently being undertaken as part of the project Environmental Assessment report for the Water Cycle under Part 3A application, to determine more precisely the likely levels of salinity and any salt accumulation on site.

3.2.3 Assessment Methodology

MUSIC Modelling

Stormwater quality control measures and overall strategy have been modelled using MUSIC.

Model Parameters

The following key MUSIC model parameters have been used:

- Rainfall – Queanbeyan Bowling Club (BOM Station no. 070072) for the period 1967 - 2007
- Evaporation – default Canberra monthly averages within MUSIC (from the Bureau of Meteorology)
- Runoff parameters and pollutant concentrations – ACT Planning and Land Authorities *Water Sensitive Urban Design General Code* Appendix B.
- Time series data on the discharge of recycled water from the WRP

3.2.4 Proposed Strategy and Measures

Minor Flow Management

The design criteria for open channels are outlined in Section D5.13 of Queanbeyan City Council – Development Design Specification D5 Stormwater Drainage Design. Runoff from the development area for storms up to the 5 year ARI will be directed to a pipe system from the lots, in accordance with Section D5.04.5 of Queanbeyan City Council – Development Design Specification D5 Stormwater Drainage Design. The pipe system will discharge into the community detention system within Googong Creek, discussed below.

The road drainage system will also be connected to the central trunk drainage system with the combined flow discharging in the stormwater control basins. Flow from these basins will discharge from the site into Googong Creek to the north via the existing culvert under Googong Dam Road.

Major Flow Management

Major flows are considered those flows in excess of the 5 year ARI for residential lots and the 10 year ARI peak flow for commercial lots. Major flows from the development will be directed by overland flow paths using the roads and swales.

A series of swales, following existing natural drainage lines will direct flow from lots and roads to detention basins and eventually to the outlet at Googong Dam Road. The base of the swales will be excavated to the design level or to underlying rock where appropriate. In accordance with Section D5.13 of Queanbeyan City Council – Development Design Specification D5 Stormwater Drainage Design, the channel is to have minimum batters of 1 in 4 and the base of the channel to have a minimum cross slope of 1 in 20. The batters will be protected by freeform rock armouring where required.

Stability of the rock armouring will be accordance with the methodology in Section D5.06.9 of Design Specification D5 and on Hydraulic Design of Flood Control Channels, Engineer Manual published by the US Army Corps of Engineers.

Gross Pollutant Traps

Gross pollutant traps are typically placed in-line with the drainage system prior to discharge into a bioretention basin to capture litter, debris, coarse sediment, oils and greases. While the pollutant capture efficiency of various traps may vary, as a conservative measure for modelling purposes the GPT is assumed that the GPT will be capable of removing of the annual load:

- Gross Pollutants 90%
- Suspended Sediments 0%
- Total Phosphorous 0%
- Total Nitrogen 0%

It is proposed to install three GPTs upstream of the Googong Local Park 1 for litter control. .Please refer to drawings C09088-145+,146+ and 147+ for locations.

Swales

A series of swales, following existing natural drainage lines will direct flow from lots and roads to detention basins and eventually to the outlet at Googong Dam Road.

Swales will be planted with Monaro grasslands wherever appropriate for hydrology and scour protection. Depending upon the longitudinal grade of the swale, it may be required to plant more robust/sturdy plants such as sedges and rushes to provide additional friction losses and velocity control.

Planting will focus on re-establishing the grassland species of the Monaro landscape within broad waterway corridor, with some trees planted beyond the waterway channel.

The design criteria used in the design of the swales are listed below:

Batter Slope:	1 in 6
Preferred Q100 Flow Velocity	1m/s
Preferred Max Q100 Flow Velocity	2m/s
Preferred Q1 Flow Velocity	0.5m/s

Where required, it is expected that small check dams could be used to control flow velocities.

Table 9 Typical Swale Detail

						Discharge		Velocity	
Street	Type	Typical Cross Section	Width	Depth[2]	Slope	Q1	Q100	Q1	Q100
			m	*m*	*%*	*m3/s*	*m3/s*	*m/s*	*m/s*
Street 2 (top)	IV-A	DWG C009088-015+	Min 9.6	1.50	1%	0.83	2.54	0.89	1.21
Street 2 (bottom)	IV-A	DWG C009088-015+	Min 9.6	1.50	1%	2.53	7.86	1.21	1.53
Street 4 (top)	IV-B	DWG C09088-016	7.6	1	2%	2.53	7.86	0	0
Street 4 (bottom)	IV-B	DWG C09088-016	7.6	1	2%	2.99	9.49	0.9	1.2
Street 21 (top)	IV-A	DWG C009088-015+	Min 9.6	1.50	1.50%	2.06	2.75	1.34	1.44
Street21 (bottom)	IV-A	DWG C009088-015+	Min 9.6	1.50	1.50%	2.38	3.23	1.39	1.4

Bioretention Basins

Bioretention basins will be utilised to perform the majority of the water treatment from the site. Bioretention basins consist of shallow areas over most of their surface area to incorporate macrophytes for nutrient uptake.

The bioretention basins have been conceptually designed on the basis of a 0.6m deep filter medium with a maximum depth of ponding of 0.4m and a 48-72 hour drawdown.

The total bioretention area provided for the whole of Googong Creek catchment is 3,870m^2.

[2] Depth from kerb to base of swale.

A typical cross section through one of the bioretention systems is given in drawing no. C09088-142+.

Raingardens

A number of raingardens have been designed to integrate the streetscape and provide stormwater quality improvement for the road runoff. In principle very similar to bioretention basins, the raingardens have been designed to fit within the street verge and the landscaping outcomes.

Typical detail of the raingardens is provided in drawing C09088-140+ and C09088-141+.

3.2.5 Stormwater Quality Management Strategy Performance Assessment

The stormwater treatment performance has been verified using MUSIC to assess the pollution reduction achieved by the various WSUD measures proposed for the Googong Creek catchment.

Modelling in MUSIC was undertaken using the MUSIC parameters specified above. Outputs of the MUSIC model are presented and interpreted below:

Table 10 MUSIC model outputs (no recycled water)

Pollutant	Googong Ck Untreated	Googong Ck with WSUD	Reduction	Target QCC DCP	Target Googong DCP	Targets Met
Total Suspended Solids (kg/yr)	174,000.00	4,260.00	97.5%	80%	80%	Yes
Total Phosphorus (kg/yr)	153.00	36.50	76.1%	45%	65%	Yes
Total Nitrogen (kg/yr)	2,070.00	873.00	57.7%	45%	45%	Yes
Gross Pollutant (kg/yr)	25,200.00	0.00	100%	100%	90%	Yes

Table 11 MUSIC model outputs (with recycled water discharge)

Pollutant	Googong Ck Untreated	Googong Ck with WSUD	Reduction	Target QCC DCP	Target Googong DCP	Target Met
Total Suspended Solids (kg/yr)	176,000.00	4,930.00	97.2%	80%	80%	Yes
Total Phosphorus (kg/yr)	239.00	53.40	77.7%	45%	65%	Yes

Pollutant	Googong Ck Untreated	Googong Ck with WSUD	Reduction	Target QCC DCP	Target Googong DCP	Target Met
Total Nitrogen (kg/yr)	6,380.00	1,330.00	79.1%	45%	45%	Yes
Gross Pollutant (kg/yr)	25,200.00	0.00	100%	100%	90%	Yes

4 SPECIFIC DESIGN ELEMENTS

4.1 Stormwater drainage culverts under Club Googong

Located at the intersection of Street 4, Street 20/21 and Street 33, the proposed Club Googong is located close to major flow path for Googong Creek.
As a result, stormwater management and drainage in this area is particularly important to this DA.
It is a design requirement that 100 year ARI flood immunity be provided to Club Googong.

Allowing for a blockage factor of 20%, the culvert under Street 4 comprises two 2.7m x 1.2m RCBC in order to convey the 100 year ARI storm event.

Flow velocity at the culvert outlet will be relatively high (in excess of 3m/s) and will require scouring protection and energy dissipaters to be designed to limit scour issues and manage risks to the population in the Local Park 1.

For more information on the drainage around/under Club Googong, please refer to drawing no. C09088-146+.

The design and ultimate integration of drainage culverts in the design of Club Googong and the local landscaping features is pending progress on Club Googong which is being undertaken by Allen Jack +Cottier at the time this report is produced. Full integration will be done at Detail Design Stage.

4.2 Local Park 1

The Local Park 1 area is central to Stages 1 and 2 of Googong New Town. Not only is the Local Park 1 located in the heart of this part of the future development but it also achieves a number of essential functions:

- Stormwater detention basin
- Stormwater quality control and improvement site
- Urban park
- Recreational functions for residents
- Environmental and biodiversity values conservation; and
- Significant amenity value for the whole area.

Significant time and efforts have been put in the design of the proposed Local Park 1 area.
Brown Consulting and AECOM have worked closely to develop and detail the initial concept design that had been prepared at the Master Planning stage of the project.

The current design meets the multiple design criteria and functional targets in terms of stormwater detention, peak flow attenuation, flood levels and flooding behaviour, terrain batters and provision of adequate community and recreational facilities.

The Local Park 1 design integrated a number of bio-retention systems that will guarantee the long term treatment of stormwater quality to high levels.

For more information on the Local Park 1 area, please refer to drawing no. C09088-145+ and C09088-146+.

4.3 Bioretention Systems and Raingardens

The proposed stormwater quality control measures suite includes a number of bioretention systems and raingardens.

These biofiltration systems achieve advantageous results in terms of water quality treatment and clogging prevention (Bratieres *et al.*, 2008; Read *et al.* ,2008). Biofiltration systems work using a combination of physical, chemical and biological treatment processes. Biofiltration systems offer a number of benefits (FAWB, 2010) including:

- Flexible designs
- Aesthetic and biodiversity values
- Contribute to restoration of more natural flow regimes

The proposed biofiltration systems have been developed in collaboration between AECOM and Brown Consulting, in accordance with the principles described in the ACT *Waterways Code* (ACTPLA, 2005), best practice guidelines (such as from Engineers Australia) and integrating the most recent development in research from the Faculty of Advanced Water Biofiltration, the international centre of expertise in this area.

More information on typical details proposed for the site is presented in drawing no. C09088-140+, C09088-141+, C09088-142+, C09088-145+, and C09088-146+.

5 FLOODING ANALYSIS

An analysis of flooding within the major floodways of Stage 1 was undertaken to assess the flood planning levels (FPL) and road levels within the subdivision.

5.1 METHODOLOGY

- HEC-RAS for the Local Park 1 (Basin 1):
- Manning's hydraulic calculations for Swales

5.1.1 Roughness

Roughness was described in the cross sections by Manning's values. The values used for the flood estimation were those for a fully established vegetation community in the riparian corridor, with a n value of 0.035 corresponding to a minor stream on plain clean, straight with no rift or deep pools but with stones and weeds (CRC Catchment Hydrology, 2000. *Rehabilitation Manual – Australian Streams Vol. 2*)

5.1.2 Culvert Blockages

A number of culverts are proposed throughout Stage 1, particularly to drain stormwater underneath the proposed Club Googong site. A blockage factor of 20% was applied to all culvert crossings in the HEC-RAS model for the assessment of the flood planning level.

5.2 HYDRAULIC ANALYSIS RESULTS

The flood extent is shown on drawing C09088-102+. Q100 flows are satisfactorily contained within the swales and the Local Park 1 area.

The only exception is for Street 4 which will locally be flooded under 100 year ARI event. A one lane carriage way will be maintained at all times. This is acceptable under the Queanbeyan DCP and Drainage Manual design criteria.

6 SOIL EROSION CONTROL MEASURES

6.1 SOIL CONTEXT

Soil typology was confirmed by Brown Consulting (NSW) Pty Ltd in the Googong Creek Catchment Stormwater Strategy (January 2010, see **Appendix A**).

Soils present within the Googong Creek catchment were taken from the Soil Landscapes of the 1:100,000 Canberra Sheet, and are presented in **Figure 3** of **Appendix A**.

Soil constraints and sediment type for the soil classification on Figure 3 are taken from Appendix C, Table C24 of the Blue Book (*Managing Urban Stormwater: Soils and Construction.* Landcom)

- Anembo (an) – widespread seasonal waterlogging, localised permanent waterlogging of low areas (Sediment Type F/D)
- Burra (ba) – high water and wind erosion hazards, high run-on to low areas, mass movement of steeper slopes, localised shallow soils (Sediment Type F)
- Campbell (ca) – rounded, steep stony hills with rock outcrops, terracettes and vertical tuffs, shallow soils are hardsetting, infertile and erodible, localised waterlogging associated with weak impermeable soils on lower slopes (Sediment Type F/D)
- Celeys Creek (cc) – low rolling hills, granite tors, shallow, infertile permeable, coarse grained topsoils, subsoils display poor water holding and seasonal waterlogging (Sediment Type F/D)
- Paddy's River (pd) – erodible, non-cohesive coarse soils, highly susceptible to gully erosion, localised wind erosion (Sediment Type C)
- Round Hill (rh) – shallow, infertile, stony soils with low water holding capacity, rock outcrop common with steep rocky slopes susceptible to mass movement and rockfall (Sediment Type C/F)

6.2 PROPOSED LAND USE EROSION SENSITIVITY

The proposed subdivision and landuse for the Neighbourhood 1A: Stages 1 and 2 of Googong New Town includes residential lots and a number of open spaces that will be adequately landscaped and vegetated. Therefore ultimate site conditions will be stable with only very limited soil erosion to be expected.

Soil erosion control measures are required during the construction and vegetation establishment period of Neighbourhood 1A: Stages 1 and 2 in order to ensure that soil material destabilised by earthworks and land areas where vegetation will be establishing do not erode away.

6.3 PREVENTION AND MITIGATION MEASURES

It is important to note that a dedicated Soil and Water Management Plan (SWMP) will be prepared during detailed design stage and implemented prior to construction commencing to ensure minimisation of potential impacts on hydrology and water quality during the construction period. This plan will incorporate the design and installation of erosion controls in accordance with the requirements of Queanbeyan City Council *Development Design Specification D7 – Erosion Control and Stormwater Management* and the *Managing Urban Stormwater: Soils and Construction published by Landcom* ("Blue Book").

Two types of measures are proposed: preventive measures to try and control the generation of eroded material from the site (eg, mulching) and mitigation measures designed at controlling, diverting and trapping sediments and suspended solids that would be mobilised. The key soil erosion control measures are presented below.

This section of the report is to be read with reference to drawing no. C09088-155+.

6.3.1 Prevention Measures

- At the vegetation clearing stage, cleared vegetation will be mulched and spread over disturbed area to provide a natural erosion barrier
- Construction of cut-off drains to prevent clean water from upstream of the corridor flowing onto and eroding disturbed areas
- Controls outside the specific work area would be put in place including:
    - Refuelling of plant and machinery within bunded areas or off site in appropriate locations
    - Minimisation of disturbed areas so that the potential export of sediment is minimised
    - The establishment and maintenance of stabilised construction compounds to reduce the overall disturbance area for the Project.

6.3.2 Mitigation Measures

- The diversion of site discharge points to erosion control measures such as silt fences and sedimentation basins in order to control dirty water areas
- The stabilisation of exposed areas as soon as practical following the construction of each section of works
- Temporary sediment basins will be constructed to capture water and sediment before it can leave the site or enter the receiving water bodies. Conceptual design of the temporary sediment basins will be included in the SWMP and follow the methodology outlined in the "Blue Book" with the following features :
    - Sediment basins are to be located at points near where dirty water would discharge to receiving waters or leave the site

- Basins are to be designed for Type F/D soils, as outlined in Section 6.3.4 of the Blue Book, in accordance with the soil type classification.
- The minimum depth of the basins will be 0.6 metres with an average depth of 1 metre (where achievable).

6.3.3 Monitoring Program

In addition the control measures aiming at preventing soil erosion or controlling the mobility of sediments on site, a stormwater quality monitoring program will be designed and implemented in order to record the performance of the Soil and Water Management Plan and adjust it where required.

A surface water quality monitoring program for the construction period will be developed to monitor water quality upstream and downstream of the construction areas. Construction period monitoring will be carried out periodically and after rainfall events as part of the assessment of the operation of water quality mitigation measures. Monitoring during the construction phase of the project would examine the following indicators:

- pH
- Electrical conductivity
- Turbidity
- Dissolved oxygen

7 DESIGN REPORT CONCLUSIONS

The hydrological and hydraulic modelling has shown that the proposed residential subdivision and supporting roads can be constructed while meeting Queanbeyan Council, and NSW Department of Climate Change and Water (former NSW DEC and NSW DWE) requirements for stormwater quantity and quality management.

The objectives and performance targets (quantity and quality) are achieved by using a mix of water sensitive urban design (WSUD) components throughout the subdivision, not limited to bio-retention basins, wetlands ponds and detention storage.

All road levels are shown to be >100 mm above the 100 year ARI flood level and all lots meet the FPL requirement.

The only exception is Street 4 where flood extends to part of the road. Modelling however shows that a one lane carriage way of 2.5m wide will be maintained at all times, making the proposal compliant with all relevant design guidelines and requirements.

8 REFERENCES

Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000;
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NSW Roads and Traffic Authority (1998) Stormwater Management and Drainage Design, Chapter 22 – Open Channels, Draft 5.0, January 1998;
Australian/New Zealand Standard – Plumbing and Drainage Part 3: Stormwater drainage (AS/NZS 3500.3:2003)

Queanbeyan City Council – Handbook of Drainage Design Criteria;
Queanbeyan City Council – Development Control Plan No. 38 – Subdivision, Part B1 – Subdivision Design Criteria;
Queanbeyan City Council – Development Control Plan No. 41 – Soil, Water and Vegetation Management Plans;
Queanbeyan City Council – Development Design Specification D5 Stormwater Drainage Design;
Queanbeyan City Council – Development Design Specification D7 – Erosion Control and Stormwater Management;
Queanbeyan Local Environment Plan (1997)
ACT Planning and Land Authority Waterways Water Sensitive Urban Design – General Code (2008)
ACT Planning and Land Authority Industrial Zones Development Code (2008)
Proposed Googong Development Control Plan (Elton, 2010)

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Read, J., Wevill, T., Fletcher, T.D., & Deletic, A. (2008). Variation among plant species in pollutant removal from stormwater in biofiltration systems. *Water Research, 42 (4-5), 893-902.*

9 GLOSSARY OF TERMS

Afflux	The rise in water level upstream of a hydraulic structure such as a bridge or culvert, caused by losses incurred from the hydraulic structure.
Australian Height Datum	National survey datum corresponding approximately to mean sea level.
Annual Exceedance Probability	The chance of a flood of a given size or larger occurring in any one year, generally expressed as percentage probability. For example, a 100 year ARI flood is a 1% AEP flood. An important implication is that when a 1% AEP flood occurs, there is still a 1% probability that it could occur the following year.
Average Recurrence Interval	Is the long term average number of years between the occurrence of a flood as big as, or larger than the selected flood event.
Catchment	The catchment at a particular point is the area of land which drains to that point.
Design floor level	The minimum (lowest) floor level specified for a building.
Design flood	A hypothetical flood representing a specific likelihood of occurrence (for example the 100 year or 1% probability flood). The design flood may comprise two or more single source dominated floods.
Development	Existing or proposed works which may or may not impact upon flooding. Typical works are filling of land, and the construction of roads, floodways and buildings.
Discharge	The rate of flow of water measured in terms of volume over time. It is not the velocity of flow which is a measure of how fast the water is moving rather than how much is moving. Discharge and flow are interchangeable.
Digital Terrain Model	A three-dimensional model of the ground surface that can be represented as a series of grids with each cell representing an elevation (DEM) or a series of interconnected triangles with elevations (TIN).
Effective warning time	The available time that a community has from receiving a flood warning to when the flood reaches their location.
Flood	Above average river or creek flows which overtop banks and inundate floodplains.
Flood awareness	An appreciation of the likely threats and consequences of flooding and an understanding of any flood warning and evacuation procedures. Communities with a high degree of flood awareness respond to flood warnings promptly and efficiently, greatly reducing the potential for damage and loss of life and limb. Communities with a low degree of flood awareness may not fully appreciate the importance of flood warnings and flood preparedness and consequently suffer greater personal and economic losses.
Flood behaviour	The pattern / characteristics / nature of a flood.

Flooding	The State Emergency Service uses the following definitions in flood warnings: *Minor flooding:* causes inconvenience such as closing of minor roads and the submergence of low level bridges *Moderate flooding:* low-lying areas inundated requiring removal of stock and/or evacuation of some houses. Main traffic bridges may be covered. *Major flooding:* extensive rural areas are flooded with properties, villages and towns isolated and/or appreciable urban areas are flooded.
Flood frequency analysis	An analysis of historical flood records to determine estimates of design flood flows.
Flood fringe	Land which may be affected by flooding but is not designated as a floodway or flood storage.
Flood hazard	The potential threat to property or persons due to flooding.
Flood level	The height or elevation of flood waters relative to a datum (typically the Australian Height Datum). Also referred to as "stage".
Flood liable land	Land inundated up to the probable maximum flood – flood prone land.
Floodplain	Land adjacent to a river or creek which is inundated by floods up to the probable maximum flood that is designated as flood prone land.
Flood Planning Levels	Are the combinations of flood levels and freeboards selected for planning purposes to account for uncertainty in the estimate of the flood level.
Flood proofing	Measures taken to improve or modify the design, construction and alteration of buildings to minimise or eliminate flood damages and threats to life and limb.
Floodplain Management	The coordinated management of activities which occur on flood liable land.
Floodplain Management Manual	A document by the NSW Government (2001) that provides a guideline for the management of flood liable land. This document describes the process of a floodplain risk management study.
Flood source	The source of the flood waters.
Floodplain Management Standard	A set of conditions and policies which define the benchmark from which floodplain management options are compared and assessed.
Flood standard	The flood selected for planning and floodplain management activities. The flood may be an historical or design flood. It should be based on an understanding of the flood behaviour and the associated flood hazard. It should also take into account social, economic and ecological considerations.
Flood storages	Floodplain areas which are important for the temporary storage of flood waters during a flood.
Floodways	Those areas of the floodplain where a significant discharge of flow occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if they are

	partially blocked, would cause significant redistribution of flood flows, or a significant increase in flood levels.
Freeboard	A factor of safety usually expressed as a height above the flood standard. Freeboard tends to compensate for the factors such as wave action, localised hydraulic effects and uncertainties in the design flood levels.
Geographical Information System	A form of computer software developed for mapping applications and data storage. Useful for generating terrain models and processing data for input into flood estimation models.
High hazard	Danger to life and limb; evacuation difficult; potential for structural damage, high social disruption and economic losses. High hazard areas are those areas subject to a combination of flood depth and flow velocity that are deemed to cause the above issues to persons or property.
Historical flood	A flood which has actually occurred – Flood of Record.
Hydraulic	The term given to the study of water flow in rivers, estuaries with coastal systems.
Hydrograph	A graph showing how a river or creek's discharge changes with time.
Hydrology	The term given to the study of the rain-runoff process in catchments.
Low hazard	Flood depths and velocities are sufficiently low that people and their possessions can be evacuated.
Management plan	A clear and concise document, normally containing diagrams and maps, describing a series of actions that will allow an area to be managed in a coordinated manner to achieve defined objectives.
Peak flood level, flow or velocity	The maximum flood level, flow or velocity occurring during a flood event.
Probable Maximum Flood	An extreme flood deemed to be the maximum flood likely to occur at a particular location.
Probable Maximum Precipitation	The greatest depth of rainfall for a given duration meteorologically possible over a particular location. Used to estimate the probable maximum flood.
Probability	A statistical measure of the likely frequency or occurrence of flooding.
Riparian Zone	Areas that are located adjacent to watercourses. Their definition is vague and can be characterised by landform, vegetation, legislation or their function.
Runoff	The amount of rainfall from a catchment which actually ends up as flowing water in the river of creek.
Stage hydrograph	A graph of water level over time.
Velocity	The speed at which the flood waters are moving. Typically, modelled velocities in a river or creek are quoted as the depth and width averaged velocity, i.e. the average velocity across the whole river or creek section.

10 APPENDICES

Appendix A	Googong Creek Catchment Stormwater Strategy
Appendix B	Intensity Frequency Duration Table for Googong
Appendix C	XP-RAFTS Results

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APPENDIX A

Googong Creek Catchment
Stormwater Strategy

SWALES					
	Q(m^3/s)	TOP WIDTH(m)	BOTTOM WIDTH (m)	DEPTH (m)	'n'
A	3.5	8.2	1.0	0.60	0.035
B	4.6	10.0	1.0	0.75	0.035
C	5.8	11.0	2.0	0.75	0.035
D	6.6	11.6	2.0	0.80	0.035
E	6.9	11.9	2.3	0.80	0.035
F	7.3	12.2	2.6	0.8	0.035
G	22.4	31.0	21.4	0.8	0.050
H	10.5	14.7	5.1	0.8	0.35

NOTES ON SWALES

- NO FREEBOARD OR COVER ALLOWED FOR (REQUIRED WATERWAY AREA)
- 1 IN 6 BATTERS
- SUB CRITICAL FLOW
- NOT HEAVILY VEGETATED (GENERALLY) MORE URBAN IN NATURE
- TYPICAL SLOPE 0.5% (ALLOW FOR DROPS)

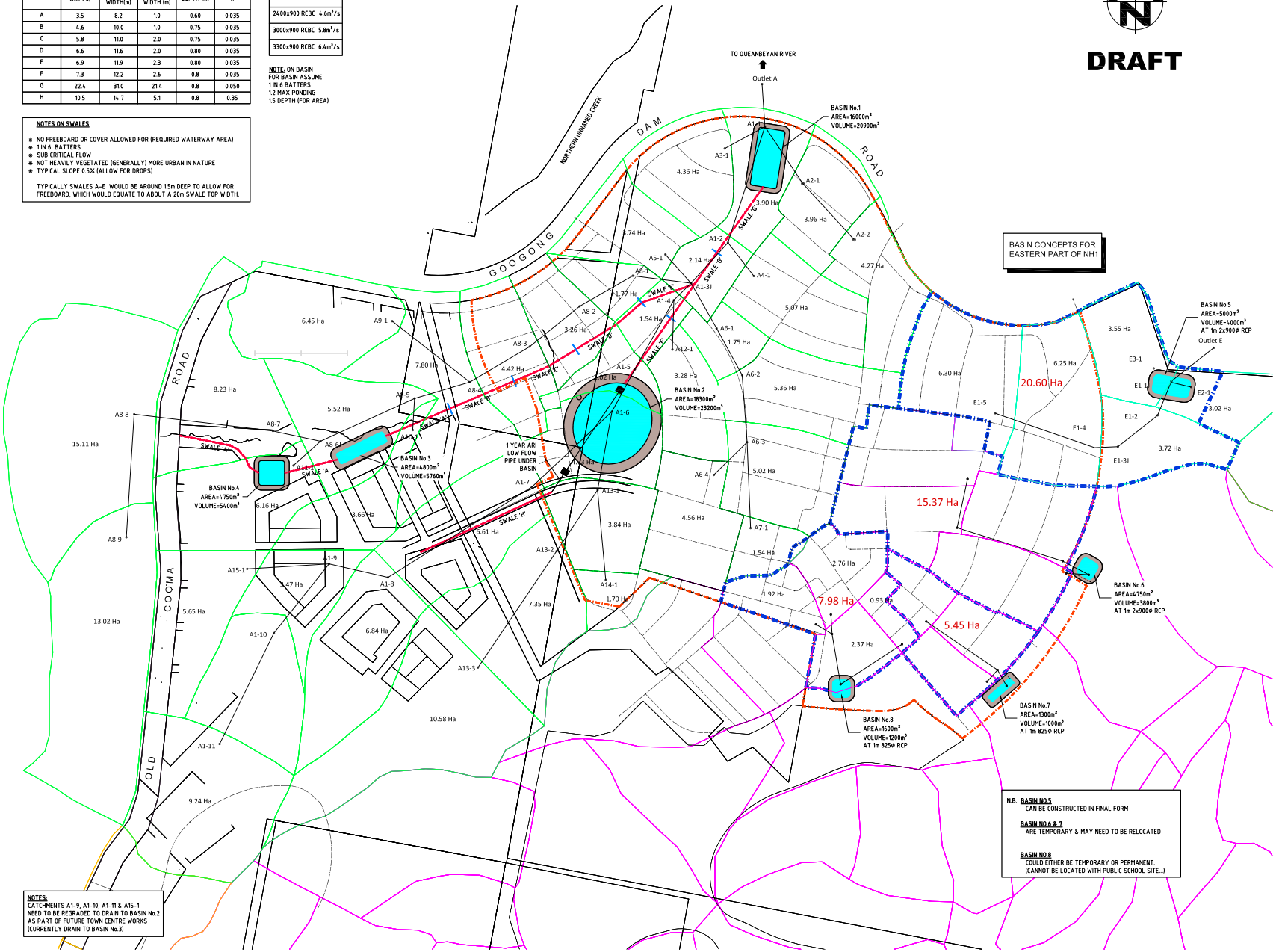
TYPICALLY SWALES A-E WOULD BE AROUND 1.5m DEEP TO ALLOW FOR FREEBOARD, WHICH WOULD EQUATE TO ABOUT A 20m SWALE TOP WIDTH.

FOR CULVERTS UNDER ROADS
(ASSUME INLET CONTROL AND 1.2m MAX PONDING)

1800x900 RCBC 3.5m^3/s
2400x900 RCBC 4.6m^3/s
3000x900 RCBC 5.8m^3/s
3300x900 RCBC 6.4m^3/s

NOTE: ON BASIN
FOR BASIN ASSUME
1 IN 6 BATTERS
1.2 MAX PONDING
1.5 DEPTH (FOR AREA)

NOTES:
CATCHMENTS A1-9, A1-10, A1-11 & A15-1
NEED TO BE REGRADED TO DRAIN TO BASIN No.2
AS PART OF FUTURE TOWN CENTRE WORKS
(CURRENTLY DRAIN TO BASIN No.3)



BASIN CONCEPTS FOR EASTERN PART OF NH1

N.B. **BASIN NO.5**
CAN BE CONSTRUCTED IN FINAL FORM

BASIN NO.6 & 7
ARE TEMPORARY & MAY NEED TO BE RELOCATED

BASIN NO.8
COULD EITHER BE TEMPORARY OR PERMANENT.
(CANNOT BE LOCATED WITH PUBLIC SCHOOL SITE...)

DRAFT

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Details

Issue	Amendment	Date
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B	DRAFT	10/11/08
C	EASTERN CATCHMENT PLAN ADDED	27/11/08

Project
GOOGONG NEW TOWN

Drawing Title
TRUNK STORMWATER DRAINAGE CONCEPT PLAN FOR NEIGHBOURHOOD 1 AND TOWN CENTRE

Scale	1:4000
Drawn	KT
Checked	RP
Job No	X07008.02
Drawing Number	SK01

Issue C

Saved: 27/12/08 By: Ian Ith
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CONSULTING

GOOGONG CREEK CATCHMENT STORMWATER STRATEGY GOOGONG NEW TOWN

January 2010

Report No. X07008-03

Prepared for CANBERRA INVESTMENT CORPORATION

BROWN CONSULTING

Engineers & Managers

PEOPLE & PROJECTS

COMMERCIAL IN CONFIDENCE

January 2010

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A	25 Jan 10	Internal Review	NWB	RP	
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GOOGONG CREEK CATCHMENT STORMWATER STRATEGY

GOOGONG NEW TOWN

FOR CANBERRA INVESTMENT CORPORATION

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LIST OF ABBREVIATIONS

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ALS	Aerial Laser Scanned
ARBM	Australian Representative Basins Model
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff
DCP	Development Control Plan
DECC	Department of Environment and Climate Change
DECCW	Department of Environment and Climate Change and Water
DEM	Digital Elevation Model
DIPNR	Department of Infrastructure, Planning and Natural Resources
DLWC	Department of Land and Water Conservation NSW
DTM	Digital Terrain Model
DWE	Department of Water and Energy
ESD	Ecologically Sustainable Development
FPDM	Floodplain Development Manual
FPL	Flood Planning Level
FPMM	Floodplain Management Manual
FPRMS	Floodplain Risk Management Study
FSL	Flood Surface Level
GIS	Geographic Information System
ha	Hectare (Area = 10,000m^2)
HEC-RAS	Hydraulic Engineering Centre – River Analysis System
LEP	Local Environmental Plan
LGA	Local Government Area
MGA	Map Grid Australia
m^3/s	Cubic meters per second
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
QCC	Queanbeyan City Council
RCP	Reinforced Concrete Pipe
RCBC	Reinforced Concrete Box Culvert
RTA	Roads and Traffic Authority of NSW
SEPP	State Environmental Planning Policy
SES	State Emergency Services
SMP	Stormwater Management Plan
TIN	Triangular Irregular Network
WSUD	Water Sensitive Urban Design

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GOOGONG CREEK CATCHMENT STORMWATER STRATEGY

GOOGONG NEW TOWN

FOR CANBERRA INVESTMENT CORPORATION

1 INTRODUCTION

Brown Consulting has been commissioned to develop a catchment stormwater strategy for the unnamed tributary of the Queanbeyan River, referred to as "Googong Creek", as part of the Googong New Town urban development. The Googong New Town project is located on a 790 hectare site eight kilometres south east of Queanbeyan that is currently grazing land. The Canberra Investment Corporation (CIC) plans to establish five new suburbs to house 16,000 inhabitants as part of the Googong New Town, to be developed over the next twenty five years.

This stormwater strategy covers stormwater quality and quantity management issues to support the Development Plan for the site. This report outlines the management of stormwater for the catchment and watercourse of Googong Creek upstream of Googong Dam Road. This report is prepared for a technical audience including engineers at determining authorities. Details of calculations, design standards, codes and modelling results are presented in the stormwater strategy reports.

1.1 DESIGN OBJECTIVES

The objective of the design, as stated in the *Googong Landscape and Open Space Strategy Report* by AECOM EDAW, Inc., is to restore the indigenous drainage habitats, including the "chain of ponds" natural drainage system in Montgomery Creek. This will be achieved by the use of Water Sensitive Urban Design (WSUD) features that will manage the quantity and quality of post-development stormwater runoff for the protection and enhancement of receiving environments.

The objectives of the Googong Creek Catchment Stormwater Strategy are to demonstrate that the design of the new town takes into consideration the requirements of the:

- Queanbeyan City Council – *Handbook of Drainage Design Criteria*;
- Queanbeyan City Council – *Development Control Plan No. 38 – Subdivision, Part B1 – Subdivision Design Criteria;*
- Queanbeyan City Council – *Development Control Plan No. 41 – Soil, Water and Vegetation Management Plans*;
- Queanbeyan City Council – *Development Design Specification D5 Stormwater Drainage Design;*
- Queanbeyan City Council – *Development Design Specification D7 – Erosion Control and Stormwater Management;*
- Queanbeyan Local Environment Plan (1997)
- ACT Planning and Land Authority *Waterways Water Sensitive Urban Design – General Code* (2008)
- ACT Planning and Land Authority *Industrial Zones Development Code* (2008)
- Googong Development Control Plan (Dated 22 July 2008)

1.2 PURPOSE OF THIS REPORT

This report has been prepared to demonstrate to determining authorities that the design features of Googong New Town within Googong Creek catchment are appropriate for approval. The objectives of this report are to:

- Provide a summary of the existing drainage and hydrologic environment of Googong Creek.
- Summarise the regulations that apply to this development.
- Outline the design criteria and codes that apply to this development.
- Discuss the management of potential climate change.
- Describe the features of the stormwater management system for Googong Creek.
- Provide calculations demonstrating how the project complies with the planning regulations.
- Describe the management of major and minor overland flows in Googong Creek.
- Outline how the stormwater quality measures in this masterplan will reduce the post-developed pollutant loads.
- Explain how stormwater management of Googong Creek sits within the integrated water management strategy for the site.
- Outline the soil and water management strategies to be employed during construction.

1.2.1 Overall Reporting Framework

The Googong Creek Catchment Stormwater Strategy for Googong New Town forms part of a series of reports outlining the proposed drainage features for the proposal.

Googong New Town Stormwater Masterplan

The Stormwater Masterplan is to be used by planners and other non-technical readers and provides a broad description of the site, the planning context, general features of the stormwater management system and the overall site water management. The Masterplan will refer to more detailed catchment strategies that include calculations and specific features. Appendices of this report include:

Riparian zone reports

Concept plans for each Creek

Catchment Stormwater Strategy: Montgomery Creek
Googong Creek
Jerrabomberra Creek

This series of reports will outline the management of stormwater on a catchment/creek basis. These reports will be prepared for a technical audience including engineers at determining authorities. Details of calculations, design standards, codes and modelling results will be presented in these reports.

Neighbourhood Concept Stormwater Plans

Reports will be prepared for each release area of the Googong New Town. These reports will outline the concept stormwater plan for individual areas in terms of the implementation of specific measures for each release and in terms of the overall site context.

2 BACKGROUND INFORMATION

This chapter provides a brief description of the locality, topography and surface water environment of Googong Creek. This is followed by an introduction to proposed Googong New Town development and outline of the masterplan.

2.1 DESCRIPTION OF STUDY AREA

2.1.1 Locality

The Googong New Town site is located in the locality of Googong, approximately 5 kilometres south of Queanbeyan in New South Wales shown in Figure 1.

The site is wholly within the Queanbeyan City Council local government area, on the border with Palerang Council local government area. The Googong New Town site is approximately 790 hectares and is located between Old Cooma Road and Googong Reservoir.

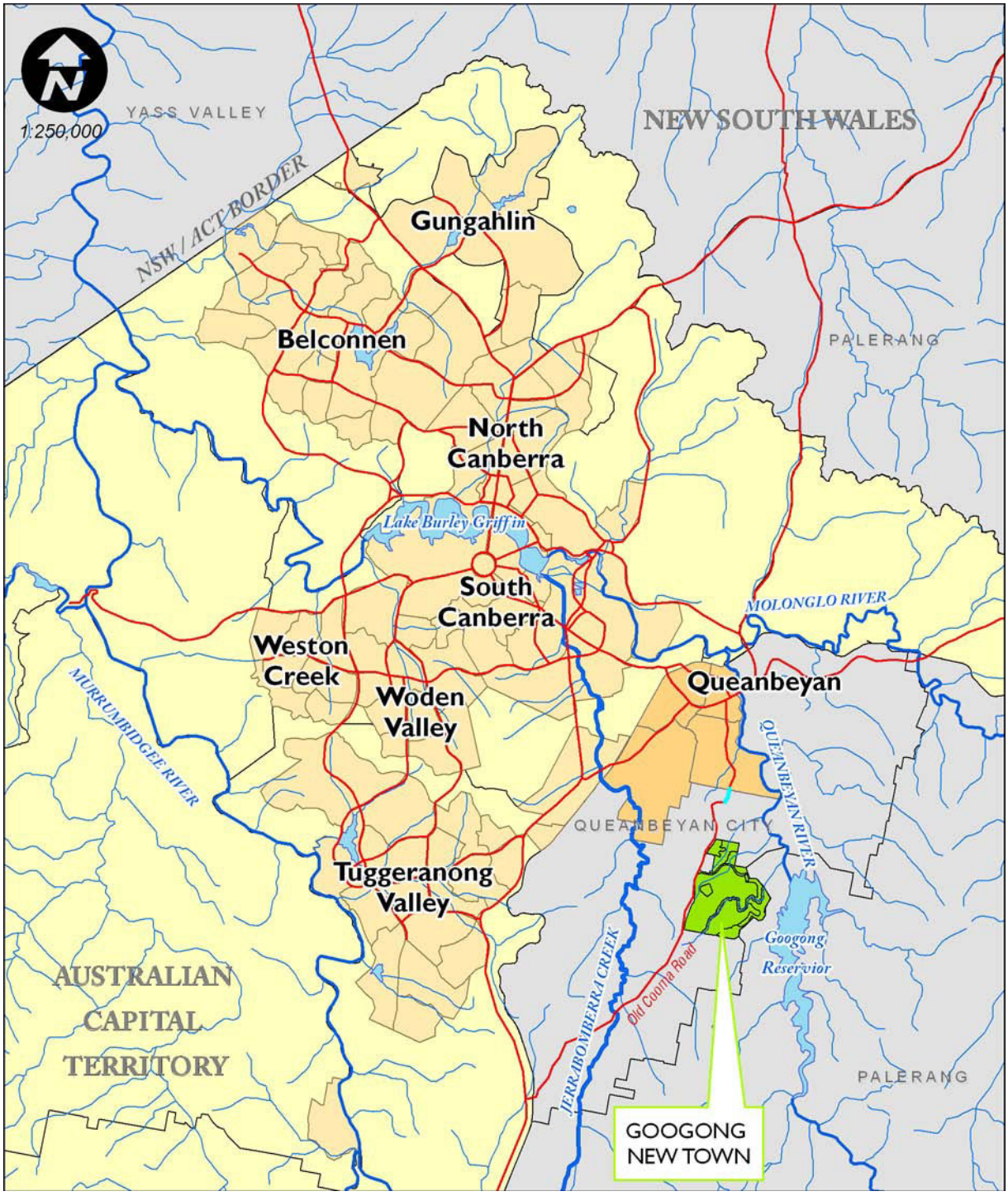


Figure 1 Locality Plan

2.1.2 Topography and Site Drainage

Googong Creek is the second largest catchment within the Googong New Town site. Googong Creek drains the northern area of the site from the western boundary at Old Cooma Road, in a north easterly direction to the Queanbeyan River, shown on Figure 2. Twin culverts are located on Googong Creek at the Googong Dam Road embankment, at the upstream and downstream boundaries of the development area. There are a number of minor tributaries of Googong Creek within the site. The creek has two distinct characters; upstream and downstream of the Googong Dam Road culvert. The area of this creek within the site is 164 hectares.

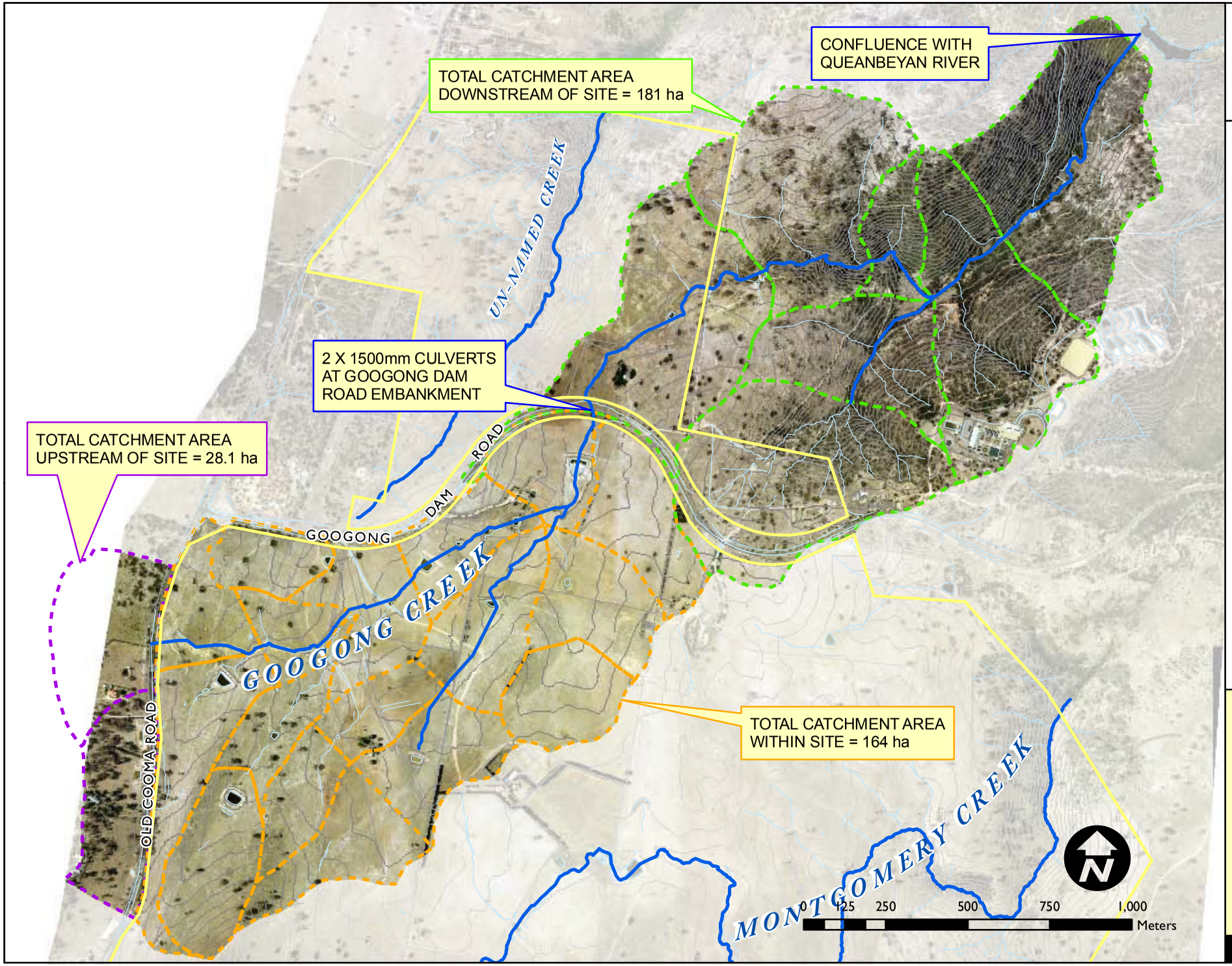
The main channel and tributaries in the upper section of Googong Creek consist of grassy swales and remnant chain of ponds meadows draining to a number of farm dams. Minor modifications to the drainage lines in these sections have occurred, with diversion banks constructed to increase flows to several dams. Within this upper section there are limited lengths of stream bed and bank formations.

There is a small part of Googong Creek on the western side of Old Cooma Road. This site is partially cleared and is generally steeper than the section of creek within the site. This catchment is drained under Old Cooma Road via a small piped culvert (approximately 375 – 450 mm diameter). Flows in excess of the capacity of this culvert would pond behind the road embankment and flow over the roadway. The size of this catchment is 28.1 hectares.

A culvert consisting of twin 1500 mm diameter pipes is located on Googong Creek at the Googong Dam Road embankment. The culvert, embankment and the large dam immediately upstream form a de facto detention basin at this location, providing storage for flows above the culvert capacity. It is considered extremely unlikely that the roadway would be overtopped in any storm event.

Preliminary investigations of the section of Googong Creek downstream of the twin culvert Googong Dam Road indicate that the creek is well formed with definable beds and banks. This section can be classified as having higher riparian values and development in this area, known as "Hamlet East" will incorporate different water design measures than the upstream sections. This report does not include details of the development downstream of Googong Dam Road.

Hydrologic and hydraulic modelling of Googong Creek and catchments is described in the Section 4. The riparian corridor of Googong Creek has been assessed in a separate report titled *Riparian Corridor Assessment Googong Township,* prepared by Brown Consulting in June 2007 (ref: X07008.01-01A).



BROWN CONSULTING

LEGEND

- CADASTRE
- CONTOUR 5m
- CREEK
- WATERCOURSES
- SITE BOUNDARY

SUBCACHMENTS - Googong

Location to Site

- DOWNSTREAM
- WITHIN SITE
- UPSTREAM

Project

GOOGONG CREEK CATCHMENT STORMWATER

Drawing Title

SITE DRAINAGE AND TOPOGRAPHY

Scale	1:15000 @ A4
Drawn	TWC
Checked	TWC
Job No.	X07008
Drawing No.	FIGURE 2

FIGURE 2

2.1.3 Soil Type

Soils present within the Googong Creek catchment were taken from the Soil Landscapes of the 1:100,000 Canberra Sheet, and are presented in Figure 3.

Soil constraints and sediment type for the soil classifications on Figure 3 are taken from Appendix C, Table C24 of the Blue Book:

Anembo (an) – widespread seasonal waterlogging, localised permanent waterlogging of low areas (Sediment Type F/D)

Burra (ba) – high water and wind erosion hazards, high run-on to low areas, mass movement of steeper slopes, localised shallow soils (Sediment Type F)

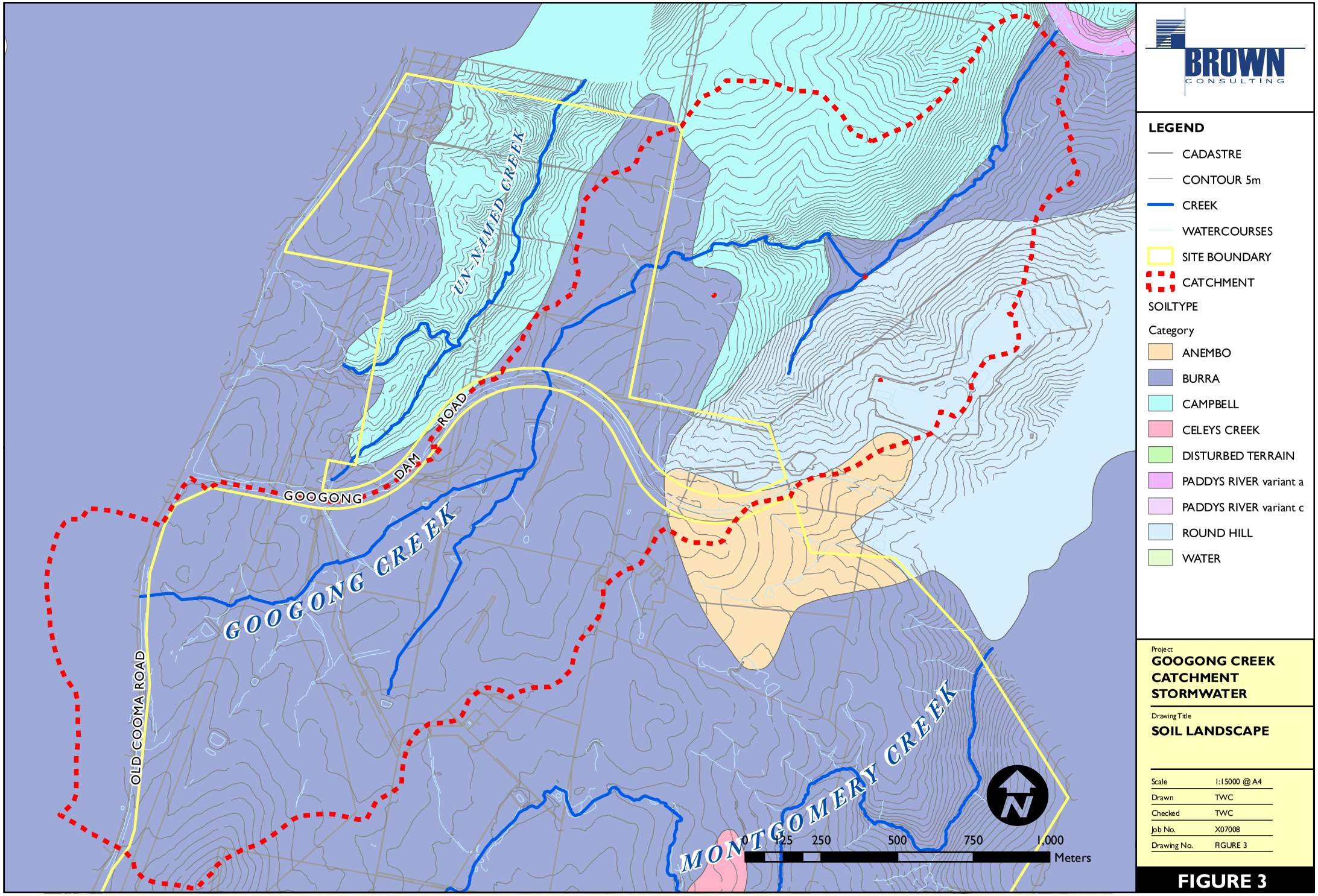
Campbell (ca) – rounded, steep stony hills with rock outcrops, terracettes and vertical tuffs, shallo soils are hardsetting, infertile and erodible, localised waterlogging associated with weak impermeable soils on lower slopes (Sediment Type F/D)

Celeys Creek (cc) – low rolling hills, granite tors, shallow, infertile permeable, coarse grained topsoils, subsoils display poor water holding and seasonal waterlogging (Sediment Type F/D)

Paddy's River (pd) – erodible, non-cohesive coarse soils, highly susceptible to gully erosion, localised wind erosion (Sediment Type C)

Round Hill (rh) – shallow, infertile, stony soils with low water holding capacity, rock outcrop common with steep rocky slopes susceptible to mass movement and rockfall (Sediment Type C/F)

Management of soils during construction is discussed in Section 9.



BROWN CONSULTING

LEGEND

- CADASTRE
- CONTOUR 5m
- CREEK
- WATERCOURSES
- SITE BOUNDARY
- CATCHMENT

SOILTYPE

Category

- ANEMBO
- BURRA
- CAMPBELL
- CELEYS CREEK
- DISTURBED TERRAIN
- PADDYS RIVER variant a
- PADDYS RIVER variant c
- ROUND HILL
- WATER

Project

GOOGONG CREEK CATCHMENT STORMWATER

Drawing Title

SOIL LANDSCAPE

Scale	1:15000 @ A4
Drawn	TWC
Checked	TWC
Job No.	X07008
Drawing No.	FIGURE 3

FIGURE 3

2.2 PROPOSED DEVELOPMENT

The Googong New Town project is located on a 790 hectare site eight kilometres south east of Queanbeyan that is currently used as grazing land. The Canberra Investment Corporation (CIC) plans to establish five new suburbs to house 16,000 inhabitants as part of the Googong New Town, to be developed over the next twenty five years.

The Googong New Town project will be developed in several stages shown on Figure 4. Googong Creek catchment contains the development areas known as Neighbourhood 2, incorporating the town centre, Neighbourhood 1A and the Hamlets East and West. Stages 1 and 2 of these developments incorporate works within the catchment of Googong Creek upstream of Googong Dam Road. These stages of the proposed development application include:

- The subdivision to create new lots and bulk earthworks on the site to facilitate future development.
- Provision of approximately 700 lots within the Googong Creek catchment
- Provision of utility services to facilitate future development (detailed separately to this report).
- Construction of site drainage works required to service the future development including detention basins and swales and Googong mini-common
- Construction of recreational features such as the sports oval and Googong mini-common

Copies of relevant drawings provided by other consultants involved in the masterplanning process of Googong New Town are provided in Appendix A.

GOOGONG CREEK CATCHMENT STORMWATER STRATEGY
GOOGONG NEW TOWN

Prepared for Canberra Investment Corporation

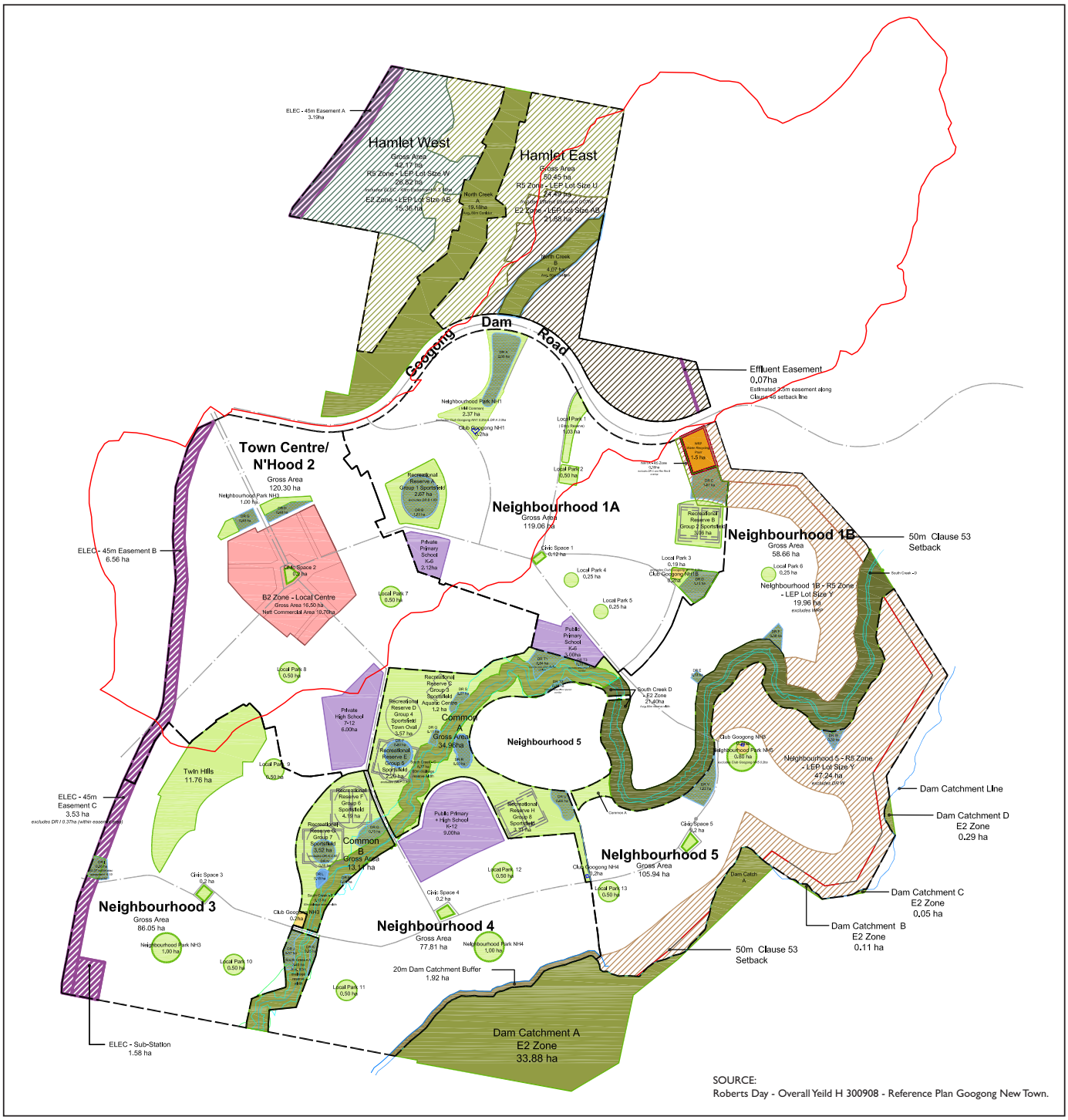


FIGURE 4 - GOOGONG NEW TOWN LAYOUT PLAN

LEGEND

- NEIGHBOURHOOD BOUNDARY
- INDICATIVE ROAD LAYOUT
- UNENCUMBERED PUBLIC OPEN SPACE
- ENCUMBERED PUBLIC OPEN SPACE
- MIXED USE URBAN CORE
- 45 METRE POWERLINE EASEMENT
- E2 Zone - LEP LOT SIZE AB (10 HA MIN.)
- Club Googong (Private)
- R5 Zone - LEP LOT SIZE Y (1.5 HA MIN.)
- R5 Zone - LEP LOT SIZE U (1000m2 MIN.)
- R5 Zone - LEP LOT SIZE W (3000m2 MIN.)
- SCHOOLS
- STORMWATER DETENTION / WETLANDS
- 20 METRE DAM CATCHMENT BUFFER
- SEWERAGE TREATMENT PLANT
- CATCHMENT BOUNDARY

BROWN CONSULTING

2.2.1 Stormwater Detention

Detention basins will be used to manage the changes to the natural hydrology of the catchment that result from urbanisation. The erosive effects of high flow events will be mitigated by attenuating peak flows. The design will incorporate stable design features of bed and banks of watercourses and associated vegetation in order to form a stable riparian landscape. The open space strategy incorporates areas that have both ecological and hydrologic function within the landscape whilst providing amenity and serving an aesthetic function.

2.2.2 Water Sensitive Urban Design

The WSUD elements proposed within Googong Creek Catchment are designed to improve stormwater quality, provide stabile waterways as well as supplying passive irrigation of vegetation. Bioretention systems will be used to treat stormwater. Detention areas and stormwater harvesting will be used to limit post-development changes in flow rate and flow duration for the protection of receiving environments. This is critical for the protection of the terrestrial and aquatic environments of the Googong Creek floodplain, particularly in limiting the impacts of urban development on channel bed and bank erosion.

WSUD elements are integrated into both the urban and landscape form within the streetscapes and within the open space areas. Development within the Googong Creek catchment will incorporate WSUD design features within roadways. The following streetscape WUSD features will be used:

- Flush or castellated kerbs on roads at open space to allow road runoff to remain as overland flow
- Road runoff directed to blisters at intersections set below road surface, planted with trees
- Rain gardens in centres of street
- Indented parking bays at urban centres
- Major roads such as Googong Ave to have castellated kerb

Stormwater quality will be addressed through bioretention systems at the urban/open space interface. Where grade, cost or available treatment area is limited, wetlands or bioretention systems can be integrated with end of catchment detention areas.

Landscaped areas will be configured to optimise passive irrigation (allowing for breaks in kerbs, appropriate set down of the planted surface, paths graded to drain to landscaped areas, scour protection at the edge of the landscaped bed).

The required bioretention treatment area is approximately 3% of the impervious catchment area. The required treatment area is reduced where rainwater tanks on individual houses and premises are used. Bioretention systems (configured as street trees or rain gardens) will treat road runoff and runoff from lots. The lot drainage will be directed to the kerb or to bioretention systems and not directly to the stormwater drainage.

Detention systems will be predominantly integrated within open space areas. Detention includes management of 1 year ARI peak flows and flow duration targets for waterway protection as well as providing 100 year ARI flood protection. A total of four, on-line detention basins are proposed for Googong Creek catchment.

3 REGULATORY FRAMEWORK

The objectives of the Stormwater Management Plan for Googong New Town take into consideration the legislative requirements and design criteria. This chapter outlines:

- the legislative framework within which the proposal has been developed;
- policies and guidelines applicable to the development; and
- design criteria that the development must comply with.

3.1 LEGISLATIVE FRAMEWORK

This section outlines the water resources legislation relevant to the development of Googong New Town.

Water Act 1912 / Water Management Act 2000

The objects of the Acts aim to provide for the sustainable and integrated management of the water sources and to apply the principles of ecologically sustainable development. The Acts set guides for the preparation of water management plans and direct the NSW Office of Water in decision making. The NSW Office of Water is a separate office within the NSW Department of Environment, Climate Change and Water. It is responsible for the management of the State's surface water and groundwater resources. The Office reports to the Minister for Water for water policy and the administration of key water management legislation, including the *Water Act 1912* and *Water Management Act 2000*.

Water Management Amendment (Controlled Activities) Regulation 2008

This Regulation of the *Water Management Act 2000* replaces the *Rivers and Foreshores Improvement Act 1948* from 4 Feb 2008. Under this Regulation a controlled activity permit is required from the NSW Office of Water for works within 40m of top of bank. This permit application will be developed at the detailed design stage of these proposals and needs to outline:

- A map of the area depicting the site to be affected by the works in relation to Googong Creek
- Plans indicating works to be undertaken including elevations
- Existing condition and values of the aquatic environment
- Recent photographs of the development area
- Details of excavations, earthworks and/or filling, including the type of materials to be affected, ie. soil, rock, etc
- The potential for disturbance of acid sulfate soils

- The potential for disturbance of contaminated material
- Stability assessment
- Location of existing drainage and any alteration to drainage
- A description of the construction methods to be used (including plant and equipment) and methods to be used to access the site
- Vegetation and landscape plans (including: details of vegetation to be retained, removed and/or planted; numbers of each species to be planted; general indication of the location of plantings)
- Methods to be employed to manage potential environmental impacts such as erosion and sediment control plans, remedial action plans, etc

NSW Seat of Government Acceptance Act 1909 / NSW Seat of Government Surrender Act 1909

Provides the Commonwealth with paramount rights to the use and control of waters of the Queanbeyan and Molonglo Rivers and their tributaries which lie in NSW, for the purposes of the ACT. The rights of NSW and it's residents to the waters of these rivers are subject to and secondary to this paramount right.

Fisheries Management Act 1994

Deals with matters related to the dredging of waterways and the reclamation of land and provides guidelines for assessing barriers to aquatic fauna movement.

Catchment Management Authorities Act 2003 / Catchment Management Act 1989

Established catchment management authorities and committees to achieve coordinated, sustainable management of natural resources on a water catchment basis.

Local Government Act 1993

Creates local governments and grants them the power necessary to perform their functions, among which are the management, development, protection, restoration, enhancement and conservation of the environment of the area the local government is responsible for, in a manner that is consistent with and promotes the principles of ecologically sustainable development. The *Local Government (Ecologically Sustainable Development) Act 1997* amended the *Local Government Act* so that ecologically sustainable development, including the sustainable use of resources, is now a guiding operational principle.

The NSW *Floodplain Development Manual: the management of flood liable land* relates to the management of flood liable land in accordance with Section 733 of the *Local Government Act*.

Queanbeyan Local Environmental Plan 1998

LEPs are prepared in accordance with the requirements of the Environmental Planning and Assessment Act 1979. The LEPs sets out zoning for land within the local government area and identifies planning objectives and development controls for each zone. A new LEP covering the whole of the Queanbeyan City Council area is being prepared.

NSW Environmental Planning and Assessment Act 1979

This Act is the primary piece of land use and planning legislation in New South Wales. It allows for the creation, at various levels of government, of environmental planning instruments to control land use and planning. State environmental planning policies, regional environmental plans, LEPs, development control plans (DCPs), and council codes and policies can all be established under the Act.

3.2 POLICIES AND GUIDELINES

An indicative list of Policies and Guidelines that will require review as part of the drainage design and water management is included below:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000;
- Department of Environment and Conservation (now Department of Environment and Climate Change and Water) (2006c) *Waste Avoidance and Resource Recovery Strategy 2006;*
- Department of Primary Industries (previously the Department of Natural Resources) 2005, *Floodplain Development Manual – the management of flood liable land;*
- Department of Natural Resources (2005) *Floodplain Development Manual Glossary;*
- Department of Natural Resources (2005) *NSW Groundwater Database;*
- Ecologically Sustainable Development Steering Committee (1992) *National Strategy for Ecologically Sustainable Development;*
- Institute of Engineers (1997) *Australian Rainfall and Runoff – A Guide to Flood Estimation*
- Institute of Engineers (2006) *Australian Rainfall Quality – A Guide to Water Sensitive Urban Design*
- Landcom (2006) *Managing Urban Stormwater: Soils and Construction;*
- NSW Government (1998) *Environmental Management Systems Guidelines;*
- NSW Roads and Traffic Authority *Code of Practice for Water Management – Road Development and Management;*
- NSW Roads and Traffic Authority (1998) Roads and Traffic Design Guide, Section 7;
- NSW Roads and Traffic Authority (1998) Stormwater Management and Drainage Design, Chapter 22 – Open Channels, Draft 5.0, January 1998;
- Australian/New Zealand Standard – Plumbing and Drainage Part 3: Stormwater drainage (AS/NZS 3500.3:2003)

4 DESIGN CRITERIA

This section outlines the design criteria relevant to Googong New Town. The section provides a brief description of relevant Queanbeyan City Council publications and concludes with a table that summarises the applicable design criteria.

Queanbeyan City Council – Development Control Plan No. 38 – Subdivision, Part B1 – Subdivision Design Criteria

Section 5.4 of DCP 38, Part B1 deals with the management of soil, water and vegetation. The objectives of Section 5.4 are to manage soil erosion and minimise impacts on off-site water quality.

Section 5.5 concerns stormwater management and drainage. The objectives of Section 5.5 are to ensure that stormwater and drainage systems for subdivisions or new allotments have sufficient capacity to cater for peak demand and to ensure that subdivisions in new release areas have stormwater and drainage systems that maintain or improve predevelopment flows in terms of quality and volumes.

Queanbeyan City Council – Development Control Plan No. 41 – Soil, Water and Vegetation Management Plans

This plan sets out the legal requirements for the submission of Soil, Water and Vegetation Management Plans, along with checklists of details to be submitted with applications.

Queanbeyan City Council – Handbook of Drainage Design Criteria

This contains technical design data for the calculation of flows, flood elevations and velocities along with technical standards for the design of drainage structures. The hydrologic parameters include rainfall intensity charts and runoff parameters for flow estimation. The handbook also outlines hydraulic parameters and design requirements for pits, culverts and pipes.

The handbook is prepared to be read in conjunction with DCP 38 Part B1. Where further construction standards or specifications are required that are not provided, this handbook refers to the ACT Urban Services: Design Standards for Urban Infrastructure, Part 1 Stormwater.

Queanbeyan City Council – Development Design Specification D5 Stormwater Drainage Design;

This specification outlines requirements for hydrology, hydraulics, detention and documentation for subdivisions, buildings, structures and surrounds, along with roadworks, car parks, site works, landscaping, earthworks, damns and lakes.

In accordance with Section D5.04.5 of runoff from the development area for storms up to the 10 year ARI will be directed to a pipe system from the lots. The pipe system will discharge into Googong Creek, via a community detention system.

The design criteria for open channels are outlined in Section D5.13. Flows within Googong Creek up to and including the 2 year event will be contained within the banks of the channel, with flows above this level spilling into the riparian zone. In accordance with Section D5.13, the channel is to have minimum batters of 1 in 4 and the base of the channel to have a minimum cross slope of 1 in 20.

The design criteria for major flow structures are outlined in Section D5.14. All major structures in urban areas are to be designed for the 100 year ARI storm event without increasing flooding upstream or downstream. Stability of the rock armouring within the channel will be determined according to the methodology in Section D5.06.9 and from *Hydraulic Design of Flood Control Channels, Engineer Manual* published by the US Army Corps of Engineers.

Performance Targets as required for storm water quantity are as outlined in Table D5.3. The design objective for the site is to provide detention in addition to storm water quality treatment, such that flows can be attenuated to meet the objectives outlined in the code.

Queanbeyan City Council Development Design Specification D7 – Erosion Control and Stormwater Management

This specification is in two parts and covers erosion control and stormwater management during construction along with the design of stormwater treatment measures.

The Erosion Control section of Specification D7 outlines requirements for the management of erosion from construction sites. These measures are presented in detail, along with a concept plan in Section 9 of this report. This section also presents the along with the requirements for the preparation of a Soil and Water Management Plan.

The Stormwater Management section of Specification D7 introduces stormwater treatment device options and sets water quality objectives based on receiving environment characteristics and the risk development poses to the environment. Subdivision developments are classified as a high risk development according to D7.21.6. Reduction of pollutant export loads are subject to the requirements outlined in Table D7.2. These requirements are listed in this report in Table 1.

The Stormwater Quality Improvement Device section of Specification D7 provides a framework for the selection of water quality improvement devices and outlines design guidelines for treatment devices.

ACT Design Criteria

Where further construction standards or specifications are required that are not provided in Queanbeyan Council criteria, QCC documentation refers to the ACT criteria. Relevant codes and design standards for the ACT are:

- ACT Planning and Land Authority Waterways Water Sensitive Urban Design – General Code (2008)
- ACT Planning and Land Authority Industrial Zones Development Code (2008)
- ACT Urban Services: Design Standards for Urban Infrastructure, Part 1 Stormwater

Hydrologic parameters used in modelling, including Australian Representative Basins Model (ARBM) parameters are utilised from these ACT codes.

Table 1 summarises the design criteria applicable to development of Googong New Town, the source of the criteria and any comments or departures from the criteria.

Table 1 Stormwater Design Criteria for Googong New Town

Description	*Criteria*	*Source*	*Comments/Departures*
Rainfall Data		Queanbeyan Bowling Club 1967-2007	1967-2007 data set used for all modelling for project , including integrated water cycle management
Evaporation Data		Canberra monthly averages within MUSIC (from the Bureau of Meteorology)	
Design Rainfall	Methodology outlined in Volume 2 of ARR	D5.04.2	
Average Recurrence Interval (ARI)	Minor Urban: • 10 years for commercial/industrial • 5 years for residential • 1 year for parks and recreation areas Reduction of Peak flows to pre-development levels • 5 year and 100 year Major Structures: • 100 year, with 0.3 m freeboard	D5.04.5 Table D5.3 D5.14	
XP-RAFTS Roughness Parameters	Impervious areas 0.015 Pervious areas 0.04	ACT Planning and Land Authorities Water Sensitive Urban Design General Code (March, 2008)	

Description	Criteria			Source	Comments/Departures
XP-RAFTS ARBM loss parameters	Storage Capacities	Impervious (IMP)	0.50	ACT Planning and Land Authorities Water Sensitive Urban Design General Code (March, 2008)	
		Interception (ISC)	1.00		
		Depression (DSC)	1.00		
		Upper Soil (USC)	25.00		
		Lower Soil (LSC)	50.00		
	Infiltration	Dry soil sorptivity (SO)	3.00		
		Hydraulic conductivity (KO)	0.33		
		Lower soil drainage Factor (LDF)	0.05		
		Groundwater recession;			
		Constant rate (KG)	0.94		
		Variable rate (GN)	1.00		
		Dry soil sorptivity (SO)	3.00		
	Evapo-Transpiration	Proportion of rainfall intercepted by vegetation (IAR)	0.70		
		Max potential evapo-transpiration (EV):			
		Upper soil (UH)	10.00		
		Lower soil (LH)	10.00		
		Proportion of EV from upper soil zone (ER)	0.70		
		Ratio of potential evaporation to A class pan (ECOR)	0.90		

Description	*Criteria*		*Source*	*Comments/Departures*
Pollutant Removal targets	Suspended Solids (SS)	80% retention of average annual load	Table D7.2	Total Phosphorous (TP) and Total Nitrogen (TN) target set at 65% retention of average annual load
	Sediment	100% retention of sediment greater than 0.125 mm for flows up to the 3 month ARI peak flow		
	Oil and Grease	No visible oils for flows up to the 3 month ARI peak flow		
	Litter	100% retention of litter greater than 5 mm for flows up to the 3 month ARI peak flow		
	Total Phosphorous (TP)	45% retention of average annual load		
	Total Nitrogen (TN)	45% retention of average annual load		

Description	*Criteria*			*Source*	*Comments/Departures*
Channel Design Criteria	maximum batter slope		1 in 4	D5.13	
	base of the channel minimum cross slope		1 in 20		
Basin Design Criteria	Maximum batter slope		1 in 6	D5.15	
	Maximum water depth (20 year ARI)		1.2 m		
Vegetated Swale Design Criteria	1 year ARI velocity	< 0.5 m/s		D7.29	
	100 year ARI velocity	< 1.0 m/s			
	Longitudinal grade	> 1%			
		< 4%			
	Maximum base width	2.5 m (unless measures to ensure uniform spread of flow)			

5 SURFACE WATER ENVIRONMENT

This chapter describes in detail the:

- Existing surface water conditions within the development area and wider Googong Creek catchment, providing flows and flood extents;
- How the conditions within the catchment and Googong Creek will be affected by development of Googong New Town.; and
- How potential changes to extreme rainfall events brought about by climate change will impact on Googong Creek and the development of Googong New Town.

Modelling of the existing and developed conditions using the *XP-RAFTS* hydrological modelling package has been undertaken for Googong Creek, using the parameters outlined in Table 1. Flows were calculated at points along the creek relevant to both the existing site drainage and to the locations of developed features. This approach is appropriate for Googong Creek as design elements are proposed in the locations of existing features in order to restore the indigenous drainage habitats. The use of Water Sensitive Urban Design (WSUD) measures will manage the quantity and quality of post-development stormwater runoff for the protection and enhancement of receiving environments and is discussed in Section 6.

Hydraulic modelling using SOBEK software has been used to map flood extents for existing conditions. Models were developed from Digital Elevation Models (DEM) of the existing creek and from earthworks models of proposed drainage, landscape and development features generated in the 12D modelling package.

5.1 EXISTING CONDITIONS

A brief description of the existing layout and condition of Googong Creek is provided in Section 2.1. This section describes the existing flood conditions for Googong Creek in the location of Googong New Town, providing descriptions of the hydrologic and hydraulic calculations used to develop the flood extents maps.

5.1.1 Existing Conditions Hydrologic Modelling

An *XP-RAFTS* hydrologic model has been developed for Googong Creek in the pre-development state. This model uses the parameters specified in ACT Planning and Land Authorities' *Water Sensitive Urban Design General Code* (March, 2008) outlined in Table 1. The layout of the model is presented in Figure 5, with data input into the models and results provided in Appendix B.

Flows were calculated for storms ranging from 15 minutes to 6 hours for the 100 year, 50 year, 20 year, 10 year, 5 year, 2 year, 18 month, 1 year, 9 month, 6 month and 3 month average recurrence intervals (ARI). Peak flows for selected ARIs relevant to those in guidelines and criteria (from Table 1), are presented in Table 2.

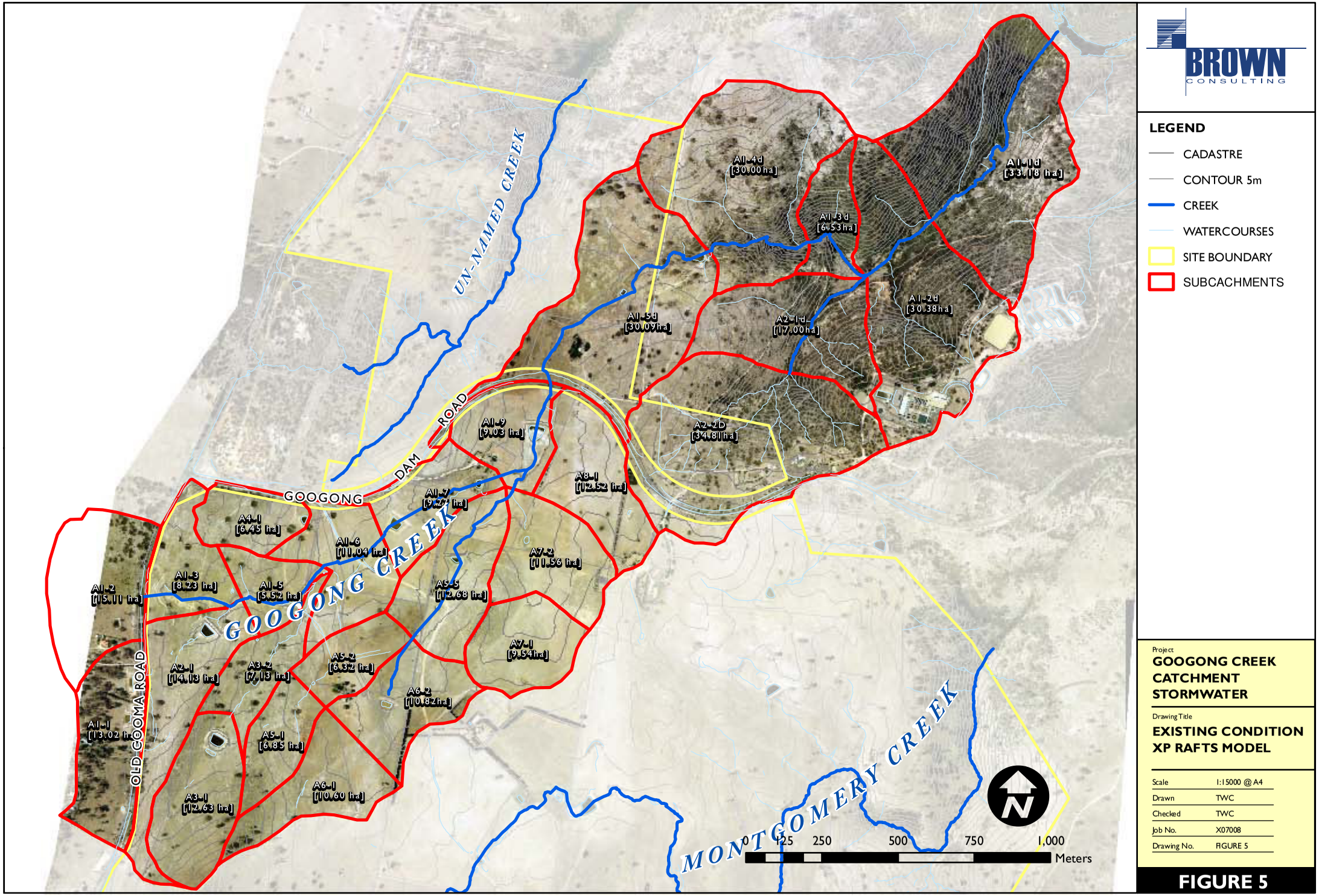
Table 2 Existing Condition Peak Flows

Node	*Peak Flow (m^3/s)*				
	100 year	*10 year*	*5 year*	*1 year*	*3 month*
Old Cooma Road (A1-2)	2.41	1.12	0.84	0.33	0.17
Basin 4 location (A1-5)	7.35	3.36	2.64	0.89	0.29
Mini Common (A1-8J)	14.18	6.85	5.35	1.96	0.52
Outlet	14.86	7.42	5.78	2.18	0.57

The results in Table 2 indicate that only a very small fraction of the flows at the Googong Road Dam are from upstream of the development site. The 3 month flows, used for development of treatment measures are three orders of magnitude smaller than the 100 year flows, used for major structural design.

5.1.2 Existing Conditions Flood Mapping

Hydraulic modelling using *SOBEK* software has been used to map flood extents for existing catchment conditions. Models were developed from Digital Elevation Models (DEM) of the existing creek from earthworks models in the *12D* modelling package. The flood extent for the 100 year peak storm for existing catchment conditions is presented in Figure 6.



BROWN CONSULTING

LEGEND

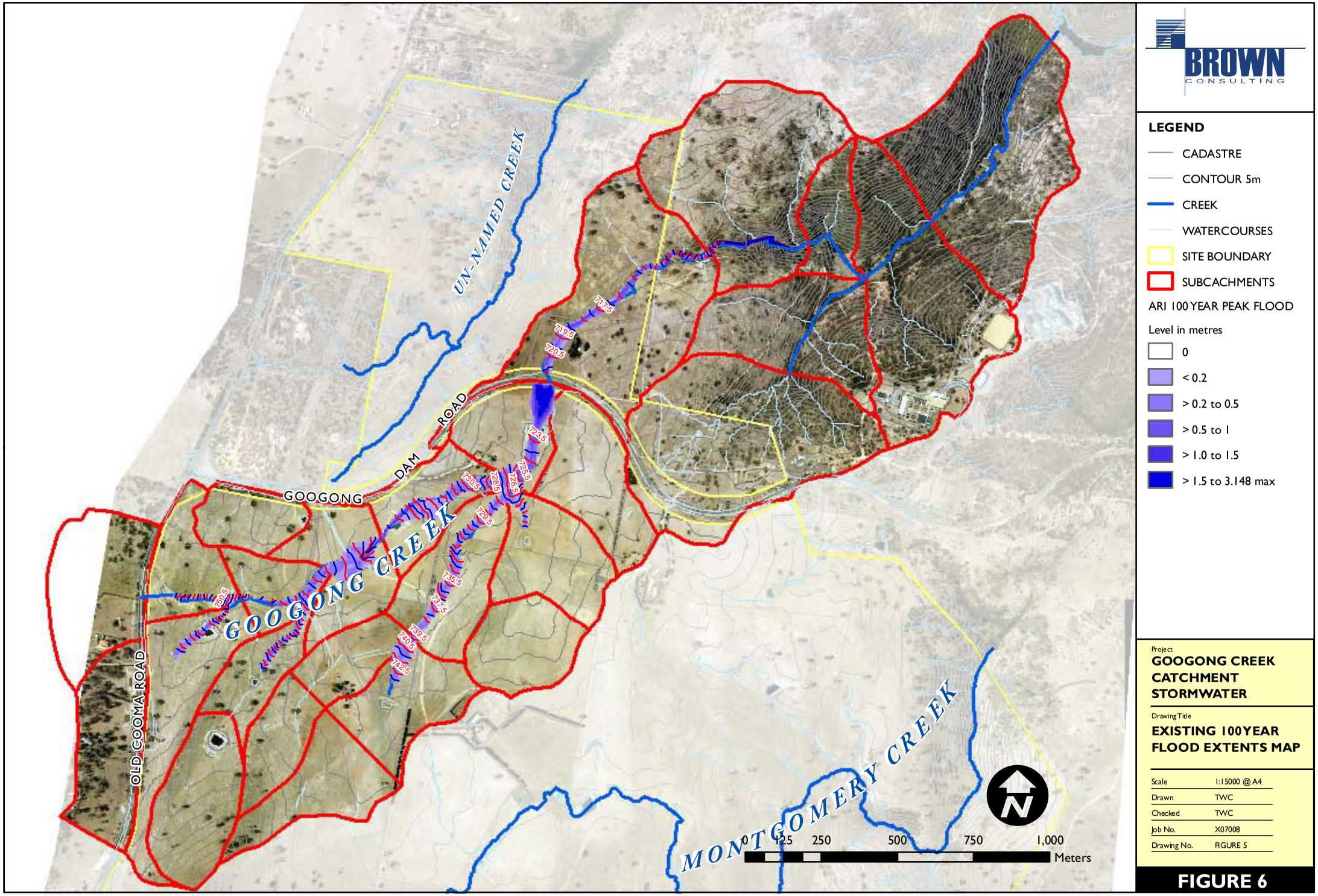
- CADASTRE
- CONTOUR 5m
- CREEK
- WATERCOURSES
- SITE BOUNDARY
- SUBCACHMENTS

Project
GOOGONG CREEK CATCHMENT STORMWATER

Drawing Title
EXISTING CONDITION XP RAFTS MODEL

Scale	1:15000 @ A4
Drawn	TWC
Checked	TWC
Job No.	X07008
Drawing No.	FIGURE 5

FIGURE 5



BROWN CONSULTING

LEGEND

- CADASTRE
- CONTOUR 5m
- CREEK
- WATERCOURSES
- SITE BOUNDARY
- SUBCACHMENTS

ARI 100 YEAR PEAK FLOOD

Level in metres

- 0
- < 0.2
- > 0.2 to 0.5
- > 0.5 to 1
- > 1.0 to 1.5
- > 1.5 to 3.148 max

Project

GOOGONG CREEK CATCHMENT STORMWATER

Drawing Title

EXISTING 100YEAR FLOOD EXTENTS MAP

Scale	1:15000 @ A4
Drawn	TWC
Checked	TWC
Job No.	X07008
Drawing No.	FIGURE 5

FIGURE 6