Scenic Rim Flood Modelling

Canungra Creek and Biddaddaba Creek Flood Study Report

Scenic Rim Regional Council

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1 Introduction

1.1 Study background

Scenic Rim Regional Council (SRRC) is seeking to gain a better understanding of the Region's Natural Hazard (Flood) characteristics. Aurecon were originally commissioned by SRRC to undertake flood studies across the Scenic Rim Regional Council (SRRC) area for seven major waterway systems including Logan River, Albert River, Bremer River, Teviot Brook, Warrill Creek, Purga Creek and Upper Coomera River. These studies involved the development of catchment wide models for each of the waterways, covering the majority of creeks and tributaries.

One of the primary objectives of this modelling has been to assist Council with addressing strategic planning objectives where the 1% AEP event has been adopted as a priority event for development planning purposes. These studies have provided SRRC with flood inundation extents, peak water levels, flow velocities and hazard ratings for each waterway.

For the Albert River catchment, modelling and reporting was completed in December 2017. The completed flood modelling did not include Biddaddaba and Canungra Creeks, tributaries of the Albert River. As such, Council commissioned Aurecon to complete modelling of the Biddaddaba and Canungra Creeks to accompany the Albert River modelling for the 1% AEP plus Climate Change event.

This report presents the investigation completed for the Biddaddaba and Canungra Creeks catchment.

1.2 Study area

The Albert River is a large tributary of the Logan River which has a confluence with the Logan River some 25 km downstream of the SRRC boundary. Canungra and Biddaddaba Creeks are tributaries of the Albert River catchment which join the Albert River near Mundoolan. As with the upstream areas of Albert River catchment, the Canungra and Biddaddaba Creek catchments are elongated rural catchments that include agricultural land on floodplain areas with forested areas in their upper reaches. Both Canungra Creek and Biddaddaba Creek have several bridges and low-level crossings along their length. The township of Canungra is situated approximately halfway along the length of Canungra Creek. Both creek catchments are completely within the Scenic Rim Local Government boundary and extend as far south as O'Reilly's Rainforest Retreat and Lamington National Park at the upstream end and north to Mundoolan at the confluence with Albert River.

1.3 Study objectives

SRRC has requested a flood study that is compliant with the current State Planning Policy (and associated guidelines) and the relevant requirements of the Building Act 1975 (Act). The flood study is to provide Council with the ability to designate a flood hazard area under Section 13 of the Act.

The following tasks form the scope of this assessment:

- Adoption of hydrologic modelling from the Albert River Flood Study and extraction of flow information from sub-catchments within the Biddaddaba and Canungra Creek sub-catchment areas
- Development of hydraulic modelling of Biddaddaba creek and Canungra Creek catchments and joint calibration with the hydrologic model
- Design event modelling of the 1% AEP event plus climate change
- Preparation of 1% AEP plus climate change flood mapping presenting flood inundation extents, flood depths, flow velocities and hazard rating
- Identification of the minimum and maximum flood levels for each property inundated by the 1% AEP event plus climate change

- Review of the definition of minor, moderate and major flood events at key stream gauge locations, to enable Council to inform BOM (and to update the current flood gauges), and
- Review of the current flood gauge network to ascertain whether there are any further locations where flood gauges could/should be located.

The work undertaken to achieve the above objectives is documented in the following report.

2 Study Data

Several datasets have been collated, reviewed and adopted for use in this project as described below.

2.1 Previous studies

The Albert River Flood Study was undertaken in 2017 is the most recent study for the Albert River. The 2017 study involved the adoption and refinement of calibrated RAFTS modelling, as well as the development of a TUFLOW hydraulic model. These models were used to determine flooding characteristics in the Albert River for a suite of design events including the 1% AEP plus climate change event.

The Albert River RAFTS model was originally developed by Logan City Council (LCC) as part of a detailed Logan River system study. This model was adopted and refined as part of the 2017 Aurecon study for SRRC.

The hydrologic modelling for the Albert River Flood Study covers the entire Canungra Creek and Biddaddaba Creek catchment areas and has sub-catchments set up in model schematisation to account for flows from sub-catchments for these watercourses. The Albert River RAFTS hydrologic model was therefore adopted for the provision of inflows for the Canungra Creek and Biddaddaba Creek Flood Study.

2.2 Survey Data

2.2.1 Aerial LiDAR Survey

SRRC's 2011 Aerial LiDAR Survey (ALS) data was utilised as the basis for topographic representation within the Albert River catchment as per the 2015 study. ALS data typically produces levels within an accuracy of ±150 mm and a horizontal accuracy of ±300 mm.

As part of the Logan River Flood Study (Aurecon, 2014), the ALS data was verified against ground survey (2013) of Permanent Survey Marks (PSM). The ALS data was found to provide elevations within ±300 mm of the ground survey PSM. This is considered a reasonably accurate representation of the topography and confirmed that the LiDAR was suitable for use in the hydraulic model.

No bathymetry data was provided for this study. The LiDAR data does not capture the river bed definition where there is standing water. However, the loss of this low flow definition is unlikely to have a significant impact on peak flood levels when considering the large event as assessed in this study.

2.2.2 Structure Data

Several crossings traverse Canungra and Biddaddaba Creeks including both low level crossings/culverts and bridges. Bridge survey was collected at five key locations, as requested by Scenic Rim Council as detailed in Table 1.

Table 1 Surveyed crossings

Crossing/Structure	Watercourse	Approximate Chainage	Survey Site Reference
Boyland Bridge	Canungra Creek	8550	Site 1
Wonglepong Bridge	Canungra Creek	14300	Site 4
Christie Street Bridge (Canungra Township)	Canungra Creek	24650	Site 3
Sarabah Bridge	Canungra Creek	37350	Site 5
Cavell Bridge	Biddaddaba Creek		Site 2

Survey of structures was prioritised based on the anticipated influence of the structure on the hydraulic regime of the catchment and proximity to areas sensitive to flood risk.

2.3 GIS data

The following GIS datasets were provided by SRRC which were utilised as per the 2015 study:

- Aerial imagery – High resolution 2013 aerial imagery
- GIS based hydraulic structures data. Details regarding refinements to the modelling of hydraulic structures is provided in Section 4.4.2.

In addition, the following dataset was provided:

- Updated DCDB (2017)

These datasets have been utilised for the generation of flood mapping and tabulated flood levels.

2.4 Calibration data

2.4.1 Stream gauge data

A review of the stream gauge data within the project extents was undertaken. There are two stream gauges within the Canungra Creek catchment, the Double Crossing Road and Benobble (Main Road Crossing) gauges, located upstream and downstream of Canungra Township respectively. Only the Benobble gauge was used for the purposes of calibration for this study, as the Double Crossing Road gauge only became operational in 2015, after the occurrence of each calibration event conisdered. Table 2 details the stream gauges and event information used from each for this study.

Table 2 Available stream gauge information

Gauge Location	Owner	Years of record	Data Available for Calibration Event			
			1974	1990	2008	2013
145107A – Double* Crossing Road	BoM/DNRM	2015 to present	x	x	x	x
145107A - Benobble (Main Road Bridge)	BoM/DNRM	1973 to present	✓	✓	✓	✓**

*Gauge not used for calibration in this study.
**Suspected gauge malfunction or poor-quality data for the 2013 event.

2.4.2 Rainfall gauge data

As per the previous Albert River study, the hydrologic modelling was completed and calibrated to cover the entire Albert River catchment including the Biddaddaba and Canungra creek catchments. The rainfall data applied in this modelling to develop flood flows for original model calibration events was therefore also adopted in this current investigation.

2.4.3 Flood level observations

Observed historical flood levels/debris marks across the catchment were provided by SRRC for the 1974 and 2008 events. For the 2008 event, peak levels were observed at 48 locations spread along the length of Canungra Creek and were therefore used as an additional measure of model calibration.

2.5 Report terminology

This report adopts the latest approach to design flood terminology as detailed in the updated *Australian Rainfall and Runoff – Book 1 Terminology* (AR&R, National Committee on Water Engineering, 2016). Therefore, all design events are discussed in terms of Annual Exceedance Probability (AEP) using percentage probability (eg 1% AEP design event).

Table 3, an extract of Figure 1.2.1 from Book 1 (AR&R, 2016), details the relationship between Annual Recurrence Interval (ARI) and AEP for a range of design events.

Table 3 Extract from Figure 1.2.1 AR&R adopted terminology

AEP (%)	AEP (1 in x)	Average recurrence interval (ARI)
10.00	10	9.49
5.00	20	20
2.00	50	50
1.00	100	100
0.50	200	200
0.20	500	500

3 Development of models

3.1 Hydrologic Model

RAFTS is a runoff routing model and an industry standard tool commonly used for hydrologic studies. The existing hydrologic RAFTS model procured from Logan City Council (LCC) for the Albert River catchment, which incorporates the Biddaddaba and Canungra Creek catchments, was adopted as the basis for review and re-use for calibrated hydrologic flows. The RAFTS hydrologic model was developed as part of a detailed study of the Logan River system by LCC.

3.1.1 Modelling extents and events

The Canungra and Biddaddaba Creek catchments fall within the Albert River portion of the broader Logan River system. The Albert River RAFTS model was previously calibrated for the 1974, 1990 and 2013 events. The 2008 event was subsequently added to the RAFTS model by Aurecon for the 2017 Albert River Flood Study.

The previous calibration was undertaken using gauge records at Cainbable Creek, Lumeah, Nindooinbah, and Bromfleet. Figure A-1, Appendix B, presents the Albert River hydrologic model layout and extents, with the Biddaddaba and Canungra Creek catchments also clearly delineated.

The Canungra Creek catchment has additional significant historical information for each calibration event at the Benobble gauge. The Benobble gauge is situated near the middle of the Canungra Creek catchment and 4.7 km downstream of the Canungra township. The Benobble stream gauge information was used for calibration of the hydraulic model.

3.1.2 Initial RAFTS model parameters

As noted above the adopted Albert River catchment hydrologic model was calibrated to the 1974, 1990, 2008 and 2013 flood events. The RAFTS model flood routing used the Muskinghum-Cunge channel routing method. This specifies the storage constant and weighting factors (k and x) to be applied between nodes.

The RAFTS model also includes a storage coefficient multiplication factor ‘Bx’. This uniformly modifies all sub catchment Storage Time Delay Coefficient values. The previously used storage factors ‘k’, ‘x’ and ‘Bx’ were assumed appropriate and adopted for use in this study.

Table 4 LCC RAFTS model calibration event parameters

Event	Calibration parameters		
	Initial Loss (mm)	Continuing Loss (mm/hr)	Bx
1974	30	1.75	1.3
1990	50	2.7	1.3
2008	10	3.5	1.3
2013	175	3.0	1.3

The initial loss parameter is largely event specific relating to the antecedent conditions in the catchment, and as expected varies between calibration events.

3.2 Hydraulic Model

3.2.1 Software platform and modelling approach

A 2-dimensional (2D) hydraulic modelling approach was adopted for this study. Modelling has been undertaken using the TUFLOW software (version 2018-03-AB).

3.2.2 Modelling extents

The extent of the Biddaddaba and Canungra Creek systems modelled covers the majority of each catchment from the upper extents to the confluence with the Albert River, including a total area of approximately 196 km^2. The hydraulic model includes representation of select hydraulic structures and topographic features that influence flood behaviour. The adopted model extents are presented in Figure A-2, Appendix A.

3.2.3 Topography

The hydraulic model is based on topographic information sourced from the 2011 LiDAR survey provided by SRRC. The topography is represented in the hydraulic model using a 10 m grid size. This grid sizes selected allow sufficient detail for the channel and floodplain representation in the hydraulic model whilst allowing for reasonable model run times.

Model breaklines were used to represent the inverts of all significant channels in the catchment, based on region inspection of a much finer grid resolution (1m grid) representation of the 2011 ALS information.

3.2.4 Roughness assumptions

Surface roughness values used in the hydraulic model are presented in Table 5 and were based on accepted industry values. Land use types were identified for areas using the provided aerial photography.

Table 5 Surface roughness/Manning's n values

Land use type	Manning's n
Floodplains	0.060
Watercourse Channel	0.050
Riparian Zones	0.070
Medium Vegetation	0.070
Dense Vegetation	0.090
High Density Residential Areas	0.150
Low Density Residential Areas	0.090

3.2.5 Hydraulic structures

As-Constructed details were not available for existing structures, including bridges, low level crossings or culvert structures. A number of key structures were surveyed and included in the hydraulic model. Hydraulic structures were surveyed at four crossings along Canungra Creek including Boyland Bridge, Wonglepong, Christie Street Bridge (Canungra Township) and Sarabah Bridge, and Cavell Bridge on Biddaddaba Creek.

The following assumptions have been made regarding bridge structures where applying survey information to the hydraulic model:

- The bridge deck and soffit levels do not vary along the length of the given bridge structure
- The adopted deck and soffit levels applied at each structure correspond to the surveyed level in the middle of the structure approximately over the invert of the watercourse
- Losses at structures have been simulated in the hydraulic model via the layered flow constriction approach, where a blockage factor is applied at various elevations in the watercourse to represent the influence of the various crossing features on the flow, eg piers, bridge decks and bridge guard/hand rails
- A blockage factor of 10% has been assumed to allow for pier losses below bridge structures
- A blockage factor of 100% has been assumed for elevations representing bridge deck thickness, and
- A blockage factor of 50% has been assumed for guard rails on bridges.

There are a number of bridges or low-level crossings throughout the catchment that have not been included in the model due to a combination of a lack of available data and expectations that they will be significantly overtopped under the 1% AEP event ("drowned out") and therefore of limited impact on peak water levels.

3.2.6 Boundary conditions

The RAFTS model outputs were applied as inflows into the TUFLOW hydraulic model. Local flows from each RAFTS model sub catchment area were split (multiplied by a factor of 0.5) and applied to the TUFLOW bathymetry at both the mid-point and downstream edge of each RAFTS sub-catchment.

The model has been extended a few kilometres past the confluence with the Albert river, both up and down Albert River, to account for the inundation that occurs on the floodplain around the confluence from both the Albert River and Canungra Creek flood events. In the upstream direction, inflow boundaries have been setup to include Albert River flows flowing past the confluence.

The downstream boundary condition has been setup with a water level versus time relationship drawn from the Albert River hydraulic model.

4 Calibration

4.1 Process of calibration

Four events were used in the calibration process being 1974, 1990, 2008 and 2013. Inflow hydrographs from the RAFTS model were incorporated into the TUFLOW hydraulic model within the study area. The hydraulic model was run for each event and the resulting water levels and discharges compared to the stream gauge data and recorded flood levels.

As the LCC hydrologic model was calibrated and peer reviewed, no changes to the calibration parameters within the hydrologic model were made for the three events previously modelled (1974,1990 and 2013). The hydraulic model parameters were adjusted to achieve the best match against the available recorded historical data.

In the 2017 Albert River Flood Study, an iterative joint calibration approach was undertaken for the 2008 event with both hydrologic and hydraulic model parameters adjusted. The hydrologic model parameters from this process were adopted as a starting point when calibrating the hydraulic model for the 2008 event in this current investigation.

4.2 Calibration targets

Ideally, the tolerances indicated in Table 6 represent a guide to a good calibration:

Table 6 Calibration targets

Water level	Discharge
+/- 0.15m at stream gauges	+/- 10%

Whilst these targets are a guide, given the large flow magnitudes and variability of the floodplain in a large rural catchment such as the Canungra Creek catchment, review of the percentage change in water level in relation to depth was also considered. For example, where the overall depth of flow, recorded versus modelled was less than 5%, this was also considered to represent a good calibration outcome.

The determination of a reasonable calibration outcome, in this instance, has also considered catchment response indicators such as timing of peaks and shape of hydrographs. The response of the hydraulic model in comparison to the existing hydrology modelling was also used as verification check for quality of hydraulic model setup and performance.

4.3 Calibration data

4.3.1 Stream gauge data

A review of the stream gauge data within the project extents was undertaken. The LCC hydrologic model calibration focussed upon the Bromfleet stream gauge in an area dominated by flows from the Albert River and was therefore not considered for use in calibrating the hydraulic model for the Biddaddaba and Canungra Creek catchments. Two additional gauges were identified along Canungra Creek as potential calibration locations, including Benobble (145107A) and Double Crossing Road (145938A) approximately 4.7km downstream and 4.4km upstream of Canungra respectively.

Only the Benobble stream gauge has been used for calibration purposes based on availability of information for each of the calibration events tested. The available stream gauge information for each of the historical flood events is detailed in Table 7 with the location of each of these gauges presented in Figure A-3, Appendix A.

Table 7 Available stream gauge information

Gauge Location	Owner	Years of record	Data Available for Calibration Event			
			1974	1990	2008	2013
145107A – Double* Crossing Road	BoM/DNRM	2015 to present	x	x	x	x
145107A – Benobble (Main Road Bridge)	BoM/DNRM	1973 to present	✓	✓	✓	✓**

*Gauge not used for calibration in this study.
**Suspected gauge malfunction or poor quality data for the 2013 event.

4.3.2 Rainfall gauge data

The rainfall stations used for the calibration of each calibration event by the LCC for the Albert River hydrologic model are presented in Figure A-4a, Appendix A. Eight pluviographs were available to represent rainfall patterns across the Biddaddaba and Canungra Creek catchments.

4.3.3 Flood level observations

Observed historical flood levels/debris marks across the catchment were provided by SRRC for the 1974 and 2008 events. For the 2008 event, peak levels were observed at 48 locations spread along the length of Canungra Creek and were therefore used as an additional measure of model calibration.

4.4 Calibration runs

The approach to calibration of the hydraulic model included testing the impact of varying the hydraulic model roughness values and hydrologic model initial and continuing losses.

Given that most of the flow conveyed through the catchment passes through the channel and of the riparian zones, sensitivity of roughness values was targeted in these areas. Noting that catchments are subject to change over time and catchment roughness values may also have varied between each calibration event.

The various roughness values tested for the channel and riparian zones of the model, with Run ID, are included in Table 8.

Table 8 Calibration testing of Manning's 'n' roughness values

Calibration Run ID	Manning's n	
	Riparian	Watercourse Channel
E006	0.070	0.050
E007	0.100	0.050
E012	0.100	0.060
E013	0.070	0.070
E014	0.070	0.050
E015	0.070	0.035

The influence of varying roughness values on the calibration was followed by testing changes in the initial and continuing losses in hydrologic model for selected events. Table 9 summarises the various initial and continuing losses tested.

Table 9 RAFTS model parameters – Rainfall loss testing

Event	Calibration parameters		
	Initial Loss (mm)	Continuing Loss (mm/hr)	Bx
1974	50	1.75	1.3
1990	70	2.7	1.3
2008	30	3.5	1.3

4.5 Calibration results

The following sections discuss each calibration event in turn and include figures that present the comparison of recorded water levels and modelled results at the Benobble stream gauge. The rainfall patterns and approximate rainfall depths have also been shown for each of the rainfall gauges used in the catchment to indicate the performance of the model with regards to response to rainfall. It should be noted that no rainfall gauges are located within the Canungra Creek catchment for the calibration events and rainfall data is only from gauges in external catchments.

4.5.1 1974 event

Figure 1 presents the peak water levels at the Benobble stream gauge for each of the model runs and the stream gauge for the 1974 event.

Comparison between the rainfall patterns and time to peak for recorded and modelled levels for the 1974 event appear to be reasonable, meaning that the rainfall is a reasonable representation of the pattern of rain that fell on the catchment.

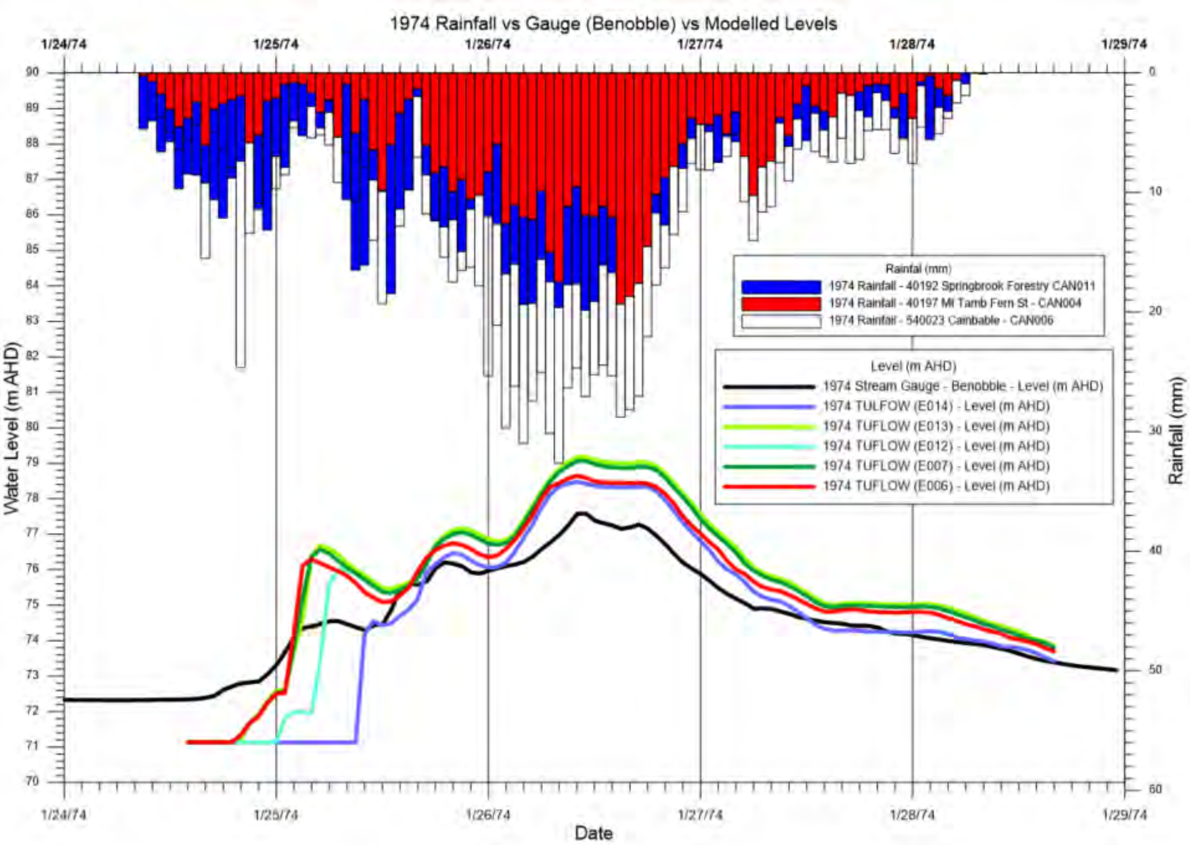

Figure 1 Main Road Bridge (Benobble) water level comparison 1974 event

Overall, the hydraulic model results appear to be consistently higher than the observed gauge readings (refer Table 10) and changing both the roughness and loss rates has a limited impact on results.

Table 10 1974 Calibration results

Results	Recorded	E006	E007	E012	E013	E014
Peak water level (m AHD)	77.58	78.65 (+1.07m)	79.07 (+1.49m)	79.07 (+1.49m)	79.17 (+1.59m)	78.48 (+0.90m)
Peak discharge (m^3/s)	326	405 (+24%)	397 (+22%)	397 (+22%)	397 (+22%)	380 (+16.5%)

4.5.2 1990 event

Figure 2 presents the peak water levels at the Benobble stream gauge for each of the model runs and the stream gauge for the 1990 event.

Comparison between the rainfall patterns and time to peak for recorded and modelled levels for the 1990 event shows that the rainfall is potentially not representative of what actually fell in the catchment. There are three rainfall datasets used and each vary in distribution and where the peak rainfall occurs. Therefore, matching the peak levels recorded by the stream gauge is challenging.

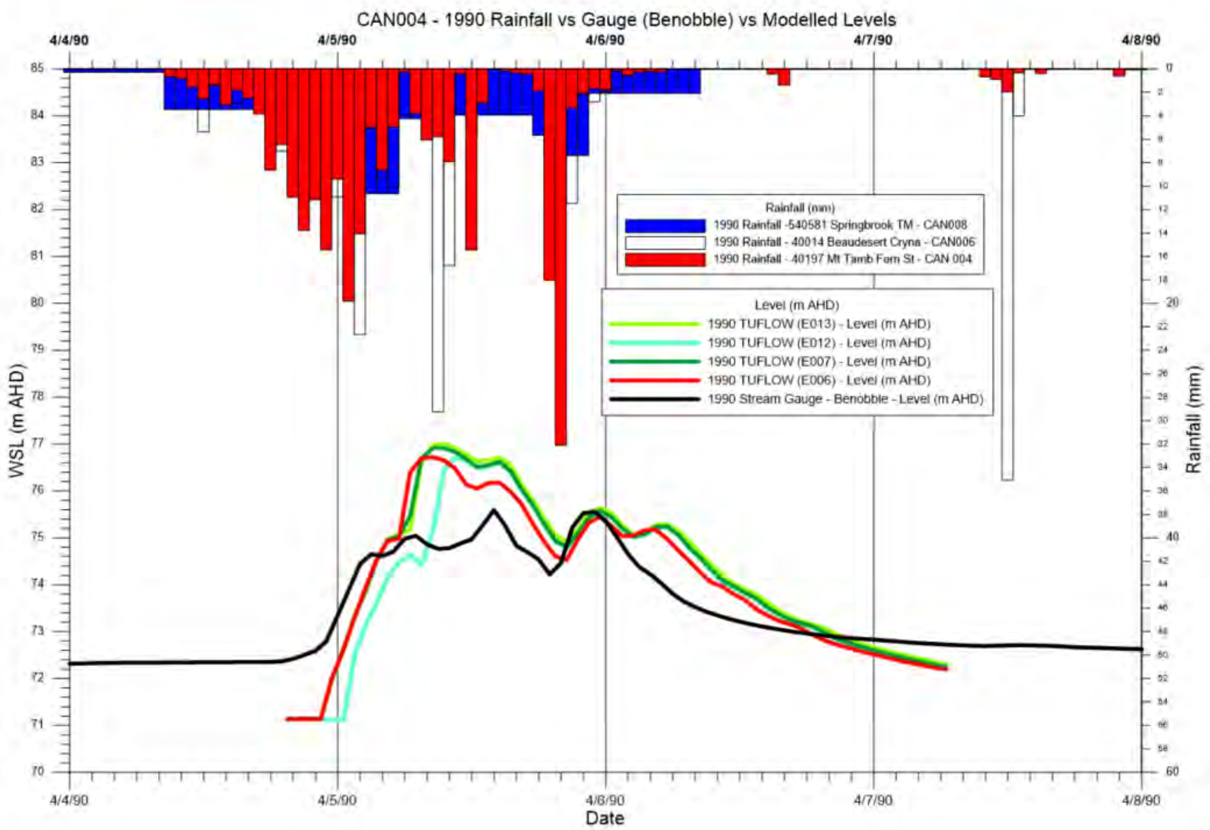

Figure 2 Main Road Bridge (Benobble) water level comparison 1990 event

Overall, the hydraulic model results appear to be consistently higher than the observed gauge readings (refer Table 10) and changing both the roughness and loss rates has a limited impact on results.

The hydraulic model results overestimate the first peak in the 1990 event. This is likely to do with the distribution of the various rainfall gauge patterns adopted for application across hydrology sub-catchments. The rainfall data applied to the catchment does not match the pattern recorded at the stream gauge and no improvement has been achieved in the sensitivity runs.

Table 11 1990 Calibration results

Results	Recorded	E006	E007	E012	E013
Peak water level (m AHD)	75.59	76.72 (+1.13m)	76.91 (+1.32m)	76.72 (+1.13m)	77.01 (+1.42m)
Peak discharge (m^3/s)	152	181 (+19.1%)	175 (+15.1%)	160 (+5.2%)	174 (+14.5%)

4.5.3 2008 event

Figure 3 presents the peak water levels at the Benobble stream gauge for each of the model runs and the stream gauge for the 2008 event.

Comparison between the rainfall patterns and time to peak for recorded and modelled levels for the 2008 event show a slight difference in the time of the peak. There are no rainfall stations within the actual catchment and rainfall data from surrounding catchments is being applied. This influences the shape and timing of the model results however a reasonable representation of the hydrograph shape is achieved.

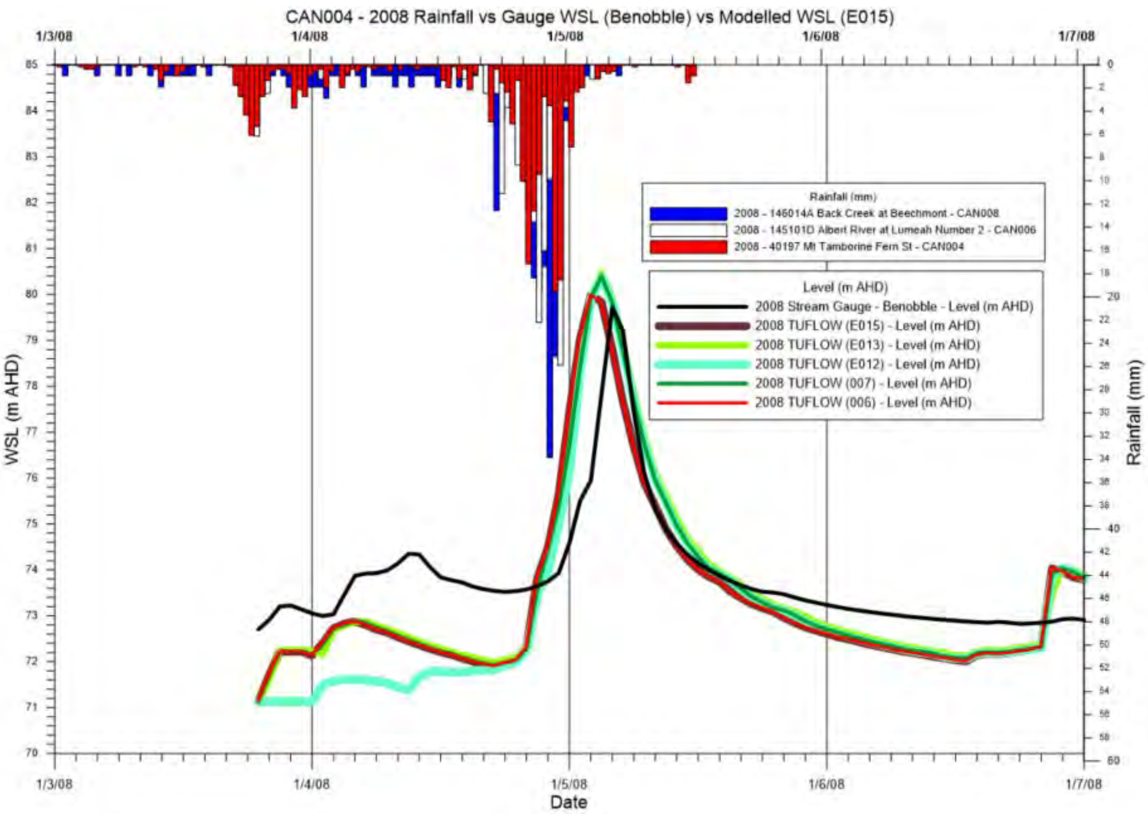

Figure 3 Main Road Bridge (Benobble) water level comparison 2008 event

Of the calibration events modelled, the 2008 event has achieved the best peak flood level match (refer Table 11) at the Benobble stream gauge, where the modelled flood depth was within 5% of the recorded depth. Similarly, for many of the historical flood level markers along the watercourse, the hydraulic model achieved a match to within 5% of the recorded flood depths. Refer to Attachment A for a long section and Attachment B in Appendix B for a tabulated comparison of 2008 event modelled peak flood levels against historical flood marker levels.

Table 12 2008 Calibration results

Results	Recorded	E006	E007	E012	E013	E015
Peak water level (m AHD)	79.71	79.99 (+0.28m)	80.40 (+0.69m)	80.40 (+0.69m)	80.49 (+0.78m)	79.99 (+0.28m)
Peak discharge (m^3/s)	480	678 (+41%)	646 (+35%)	646 (+35%)	645 (+34%)	678 (+41%)

4.5.4 2013 event

Figure 4 presents the peak water levels at the Benobble stream gauge for each of the model runs and the stream gauge for the 2013 event.

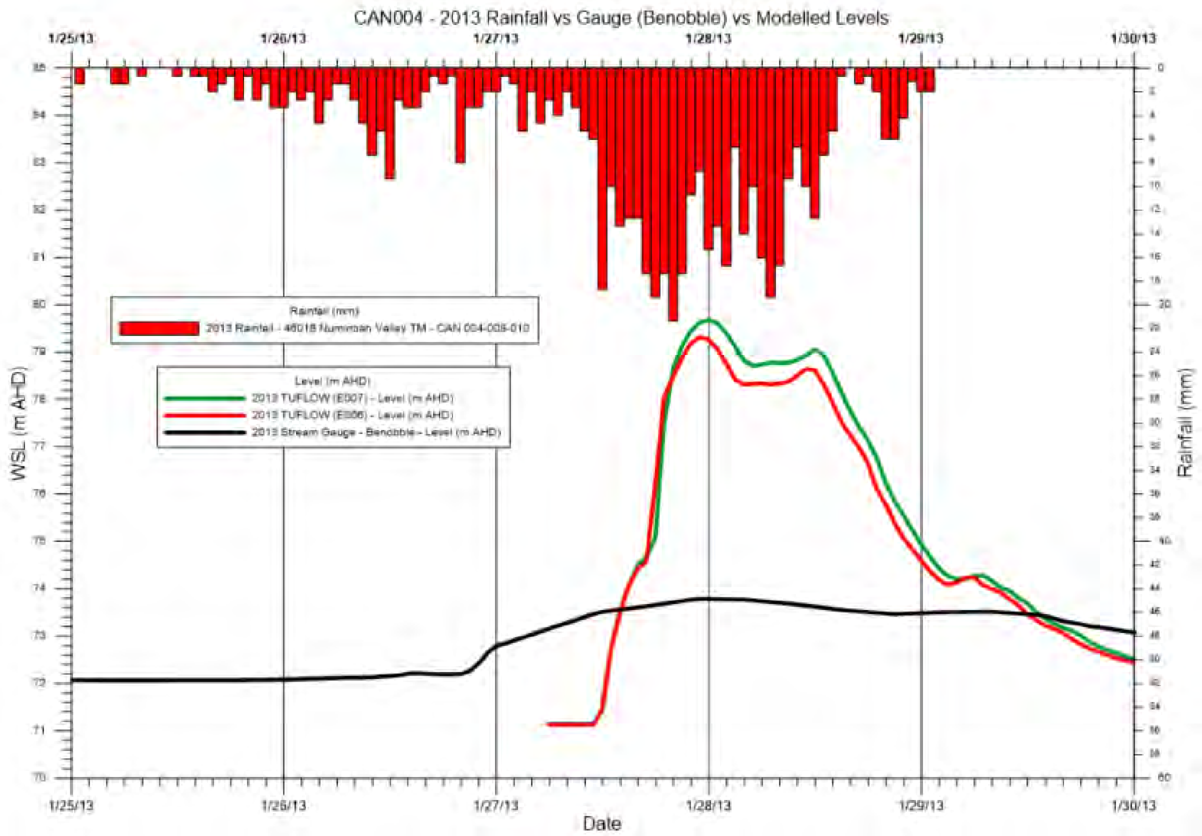

Figure 4 Main Road Bridge (Benobble) water level comparison 2013 event

Review of the rainfall and recorded stream gauge data, as well as the hydraulic model results, shows that is it likely that the stream gauge failed during the 2013 event. Therefore the 2013 event has not been considered in this instance for testing the performance of the hydraulic model. Sufficient doubt over the quality of the gauge readings exists for the following reasons:

- The magnitude of rainfall observed in rainfall gauges around the catchment, and hence volume of runoff through modelling is comparable to the 1990 event and the predicted model flows in the 1990 event match the stream gauge data for that event reasonably well.
- The observed 2013 event peak levels for the next downstream gauge (Bromfleet stream gauge) on the Albert River support the prediction of larger flows through the Canungra catchment.

4.6 Calibration outcomes

Testing of roughness and rainfall loss rates has demonstrated that they have a limited impact on the hydraulic model results. The fact that there is no rainfall gauge within the Canungra Creek catchment area to provide clear details on rainfall patterns has hindered the calibration of the hydraulic model. This is exacerbated by the elongated shape of the catchment area.

The 2008 event has a significant amount of additional anecdotal data along the length of the creek. A good match to this dataset has been achieved with modelled results within 5% of the peak recorded flow depth at the Benobble gauge and at many flood markers along the watercourse. Of the historical events modelled, the 2008 hydraulic model was therefore considered to be the best event to consider for calibration.

Overall, a reasonable calibration has been achieved based on the available information and the objectives of this study. An iterative calibration process was followed with the parameters adjusted to achieve the best match to the available historical data. The results of the calibration process were discussed with SRRC to confirm acceptance of the outcomes before proceeding to design event modelling.

Based on the above assessment, it is proposed to adopt the same parameters as used for the Albert River Flood Study for the current investigation. The following roughness values and loss rates have been adopted.

Table 13 Adopted hydraulic model roughness values

Land use type	Manning's n
Floodplains	0.060
Watercourse Channel	0.050
Riparian Zones	0.070
Medium Vegetation	0.070
Dense Vegetation	0.090
High Density Residential Areas	0.150
Low Density Residential Areas	0.090

Table 14 Adopted RAFTS model parameters

Event	Calibration parameters		
	IL (mm)	CL (mm/hr)	Bx
January 1974	30	1.75	1.3
April 1990	50	2.7	1.3
January 2008	10	3.5	1.3
January 2013	175	3.0	1.3

5 Design events

The following section of the report covers design event modelling of the 1% AEP plus climate change scenario.

5.1 1% AEP plus Climate Change

The design event modelling for this study consisted of the 1% AEP event with consideration to the impacts of climate change. Using the calibrated hydrologic and hydraulic models, modelling of the 1% AEP event plus climate change was undertaken. The 1987 rainfall (IFD) and temporal patterns were adopted from Australian Rainfall and Runoff (AR&R).

The adopted 1% AEP design event parameters are detailed in Table 15. The final parameters adopted were consistent with the LCC modelling parameters.

Table 15 1% AEP event parameters

Design Event	Calibration parameters		
	Initial Loss Rate (mm)	Continuing Loss Rate (mm/hr)	Bx
1% AEP	0	1.0	1.3

5.1.1 Climate change

There are several aspects of design flood estimation that are likely to be impacted by climate change. These include:

- Rainfall Intensity-Frequency-Duration (IFD) relationships
- Rainfall temporal patterns
- Continuous rainfall sequences
- Antecedent conditions and baseflow regimes

- Compound extremes (eg riverine flooding combined with storm surge inundation)

Typically, the approach to addressing climate change in flood studies is through consideration of sea-level rise (SLR) and/or increased rainfall intensities. Canungra Creek and Biddaddaba Creek are located in the upper reaches of the Logan/Albert River drainage basin and therefore are not influenced by sea level rise. The effect of climate change on the Canungra Creek and Biddaddaba Creek flood levels was therefore assessed for increased rainfall intensity predictions only.

The latest AR&R (2016) recommendations on climate change consider two Representative Concentration Pathways (RCPs) for greenhouse gas and aerosol concentrations driving climate change for the East Coast Cluster – RCP4.5 and RCP8.5. AR&R (2016) recommends using RCP4.5 as the minimum design basis and but notes RCP8.5 should be considered where *'additional expense can be justified on socioeconomic and environmental grounds'*. This guideline recommends an increase in rainfall intensity of 12% for RCP4.5 and 22% for RCP8.5 to the 2090 planning horizon.

SRRC have adopted the 1% AEP event with the RCP4.5 scenario for their Planning Scheme.
This event has been used to set levels for development across the region.

Table 16 Predicted increased rainfall intensity (AR&R, 2016)

Representative Concentration Pathway	Temperature increase (°C) at 2090 horizon	Increase in rainfall intensity (%)
4.5	2.25	12

5.2 Mapping

The TUFLOW model results were analysed and a series of maps (refer Appendix A) were developed to present the results for each modelled return period. Four sets of maps were produced to display:

- Inundation extents with peak water surface levels – these maps present 1 m contours of the peak water surface levels
- Peak depths – these maps present peak depth contours in 0.5 m bands up to a depth of 5 m, with the lower band separated into two bands covering 0 to 0.3 m and 0.3 to 0.5 m
- Peak velocities – these maps present peak velocity contours in 0.5 m bands up to a velocity of 5 m/s
- Hazard maps – Revised guidelines for presentation of flood mapping are now provided in the Australian Emergency Management Handbook Series (2013) produced by Emergency Management Australia (EMA). This handbook and its supporting flood risk management guidelines are intended to replace the SCARM guidelines under which the previous mapping was prepared. The revised guidelines include a revised categorisation for flood hazard which is shown below in Figure 4. The hazard maps have used a simplified version of this classification, where only 3 levels are outlined (Low, Medium and High Hazard). Each of these simplified bands represent 2 bands within the EMA classification.

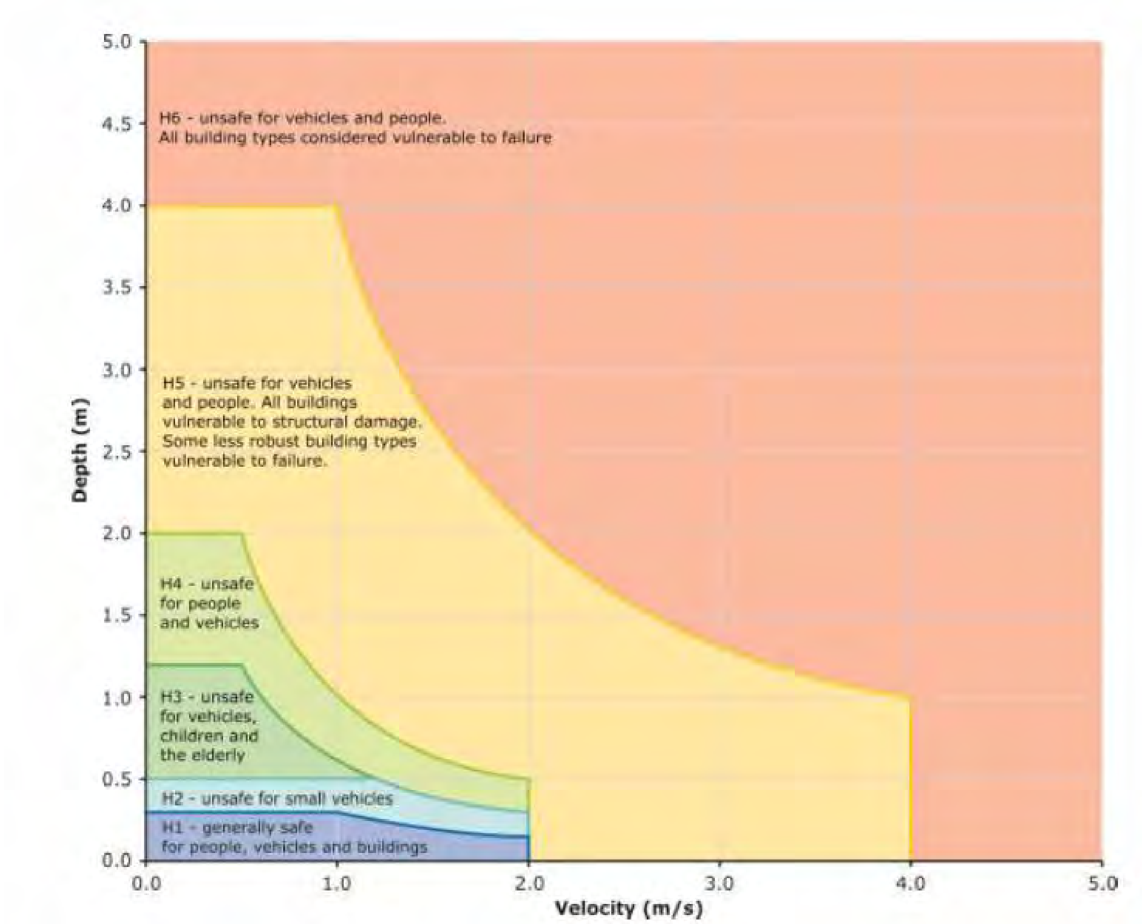

Figure 5 EMA revised flood hazard classification. Source: Australian Emergency Management Handbook Series (2013) - Technical flood risk management guideline: Flood hazard

The flood maps accompanying this report provide a regional overview of the modelling results and are supplemented by GIS data to be supplied to SRRC which can be interrogated to provide further detail. A list of the figures and the full set of maps is presented in Appendix A.

5.3 Property flood levels

Peak water levels at properties affected by the 1% AEP plus climate change scenario event were determined from the flood modelling results. The results are tabulated by property and will be provided to Council in spreadsheet format.

5.4 Gauge rating review

A network of stream alert gauges is owned and operated by various agencies which are used to provide early warning of flooding and for flood forecasting operations by BoM. The stream alert gauges provide classifications for flood severity corresponding to various gauge depths.
The descriptors for these classifications as provided by the BoM are as follows:

- **Minor Flooding:** This causes inconvenience such as closing of minor roads and the submergence of low level bridges and makes the removal of pumps located adjacent to the river necessary. In urban areas inundation may affect some backyards and buildings below the floor level as well as bicycle and pedestrian paths. In rural areas removal of stock and equipment may be required
- **Moderate Flooding:** This causes the inundation of low lying areas requiring the removal of stock and/or the evacuation of some houses. Main traffic bridges may be closed by flood waters. Some buildings may be affected above the floor level.
- **Major Flooding:** This causes inundation of large areas, isolating towns and cities. Major disruptions occur to road and rail links. Many buildings may be affected above the floor level and evacuation of many houses and business premises may be required. Utility services may be impacted. In rural areas, widespread flooding of farmland is likely.

It is understood that the gauge flood classification levels may not be reflective of the actual flood severity at some locations. A review of the gauge level flood classifications has therefore been undertaken as detailed in the following sections.

5.4.1 Benobble Alert gauge

The Benobble Alert gauge is located adjacent to the Main Road Bridge over Canungra Creek, approximately 4.7km downstream of the township of Canungra. The gauge is in a rural area surrounded primarily by pasture and grazing land. The current flood classification gauge depths for the Benobble Alert gauge are shown in Table 17.

Table 17 Existing BoM flood classifications – Benobble Alert gauge

Flood gauge level (m)		
Minor	**Moderate**	**Major**
Benobble Alert (Station #145107A)		
3.0	4.5	6.0

Table 18 details the review findings for the existing BoM warning levels and flooding characteristics of the area at each level. Note that the bridge height for Main Road Bridge is listed on the BoM site as having a gauge height of 9.10 m or a height of 80.91m AHD.

Table 18 Flooding conditions around Benobble gauge with existing BoM warning levels

Water Level at Gauge (m AHD)	Gauge Level (m)	Current Flood Classification	Flood condition description
73.81	**3.0**	Minor	▪ Peak flood waters do not overtop the banks of Canungra Creek nearby the gauge. ▪ Crossing at Main Road Bridge is not overtopped. ▪ No submergence of low level crossings or low-lying agricultural land. ▪ No inundation of residential yards, dwellings or infrastructure.
76.31	**4.5**	Moderate	▪ Peak flood waters have begun to overtop the banks of Canungra Creek nearby the gauge. ▪ Some inundation of low-lying agricultural land. ▪ Bridge crossing at Main Road Bridge is not overtopped. ▪ No submergence of low level crossings. ▪ No inundation of residential yards, dwellings or infrastructure.
77.81	**6.0**	Major	▪ Peak flood waters have overtopped the banks of Canungra Creek nearby the gauge in isolated locations ▪ Some inundation of low-lying agricultural land. ▪ Crossing at Main Road Bridge is not overtopped. ▪ No submergence of low level crossings. ▪ No inundation of residential yards, dwellings or infrastructure.

This review suggests that the existing warning levels at the Benobble Alert gauge for indicating flood severity in the immediate area are too low. Many of the anticipated flooding characteristics for each category are not being observed when each warning level is reached. Most notably, the Main Road Bridge does not become submerged and there is no significant property flooding (residential yards or dwellings or infrastructure) for the moderate or major flood level triggers.

Table 19 details proposed adjusted warning levels for the Benobble Alert gauge, as per the BoM definitions for minor, moderate and major flooding, for the purpose of indicating flooding characteristics in the vicinity of the gauge.

Table 19 Flooding conditions around Benobble Alert gauge with proposed warning levels

Water Level at Gauge (m AHD)	Gauge level (m)	Proposed Flood Classification	Flood condition description
77.81	**6.0**	Minor	▪ Peak flood waters have overtopped the banks of Canungra Creek nearby the gauge in isolated locations ▪ Some inundation of low-lying areas agricultural land. ▪ Crossing at Main Road Bridge is not overtopped. ▪ No submergence of low level crossings. ▪ No inundation of residential yards or dwelling or infrastructure.
79.61	**7.8**	Moderate	▪ Peak flood waters have overtopped the banks of Canungra Creek nearby the gauge. ▪ Inundation of low-lying areas agricultural land. ▪ Low level crossing, private road access at 2501 Beaudesert Nerang Rd, Benobble becomes inundated. ▪ Crossing at Main Road Bridge is not overtopped. ▪ Some residential yards and farm structures become inundated at 2448 Beaudesert Nerang Road, Canungra and surrounds.
80.91	**9.1**	Major	▪ Peak flood waters have overtopped the banks of Canungra Creek nearby the gauge. ▪ Extensive inundation of low-lying agricultural land. ▪ Low level crossing, private road access at 2501 Beaudesert Nerang Rd, Benobble is inundated. ▪ Residential yards and farm structures become inundated at 2448 Beaudesert Nerang Road, Canungra and surrounds. ▪ No inundation of residential yards or dwelling or infrastructure.

5.4.2 Opportunities for additional alert gauges

Review of gauges within the Canungra Creek and Biddaddaba Creek catchments shows that there are no existing alert gauges on Biddaddaba Creek and two existing alert gauges along Canungra Creek.

There are no major population centres or flood sensitive critical infrastructure or properties along Biddaddaba Creek to make a strong case for the inclusion of an additional alert gauge in the Biddaddaba catchment.

The Canungra Creek catchment has one location with a significant population located at Canungra. Of the two alert gauges on Canungra Creek, the Benobble Alert gauge is located downstream of Canungra, and therefore does not represent an opportunity for an early warning system for the town. The Benobble Alert gauge is located adjacent to a major road crossing (Main Road Bridge) and is therefore is a good indicator of road closure for the bridge. The other existing alert gauge is the Double Crossing Road gauge, which is located approximately 5.75km upstream of Canungra.

Average peak velocities in the creek channel, from Double Crossing Road Alert gauge to Canungra are approximately 3m/s. Therefore, the time for peak flows to travel from the gauge to the township is estimated to be approximately 30mins. This lag time between the gauge and the township is not sufficiently long enough to establish a practical early warning system based on the Double Crossing Road alert gauge.

The opportunity to place an additional alert gauge further upstream should be considered. Assuming an average peak velocity of approximately 3m/s along the watercourse, Table 20 lists potential additional alert gauge locations based on a 1hr, 2hr and 3 hr warning time from the gauge to Canungra. Figure C shows the potential locations for additional alert gauges upstream of Canungra.

Table 20 Potential stream gauge locations

Gauge Location	Distance Upstream from Canungra (km)	Chainage (m)*	Approximate warning time to Canungra
Double Crossing Road Alert Gauge	5.75	30,400	30mins
Site 1	10.80	35,450	1hr
Site 2	16.20	40,850	1.5hr

*Note that all chainages are an approximate measure in metres along the creek centre line upstream of the confluence of Canungra Creek with the Albert River.

Given the size of the Canungra township, doubling the warning time to 1hr would likely provide a significant benefit for emergency response or evacuation at the township itself. Increasing the warning time beyond 1hr by considering gauge locations further upstream, such as Site 2 are considered less favourable as the distance increases from the town and potential for significant changes in flood behaviour between the gauge and the township increases.

6 Conclusions

Scenic Rim Regional Council (SRRC) has recently updated its existing flood modelling across all of its major waterway catchments to gain a better understanding of the Natural Hazard (Flood) characteristics. This study consisted of the expansion of hydraulic modelling within Council's boundaries for the Albert River catchment to cover the Canungra and Biddaddaba Creek catchments for the 1% AEP plus RCP 4.5 climate change scenario.

Hydrologic modelling has been adopted and applied form the existing Albert River RAFTS hydrologic model which incorporates the Canungra and Biddaddaba Creek catchments. Hydraulic modelling of the creek corridors has been carried out with development of a 2D TUFLOW hydraulic model.

The TUFLOW model was calibrated to key historical events, including the 1974,1990, 2008 and 2013 events, with a focus on the 2008 event as it had the most historical data available.

The 1% AEP plus RCP 4.5 climate change scenario design event has been run through the calibrated hydraulic model to gain an improved understanding of flooding characteristics in the catchment and emergency management considerations, such as early warning for evacuation and monitoring to assess for flood severity and impacts. The RCP 4.5 climate change scenario was assessed to the 2090 planning horizon. This was allowed for by the application of a 12% increase in rainfall as recommended in AR&R (2016).

Mapping of the modelling results has been prepared and includes flood inundation extents, peak water levels, depths, velocities and hazard zoning in accordance with the AEM guidelines.

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7 Assumptions, limitations and recommendations

The following limitations relate to this study:

- No change is proposed to the calibration of the hydrology model as per the 2017 Albert River Flood Study. The limitations associated with model calibration remain as per the 1% AEP model.
- The hydrologic model assumes existing development conditions
- Representation of hydraulic structures through the watercourse are limited to the detail where structure survey has been undertaken at agreed locations
- The hydraulic modelling presented in this report adopted a 10m grid hydraulic model. This model resolution may not be representative of features such as small local drainage channels.
- Hydraulic models are influenced by the boundary conditions. Areas of flooding in proximity of the downstream boundary condition should be investigated with caution. Note that the downstream boundary of the Canungra and Biddaddaba hydraulic model overlaps with extents from the Albert River Flood Study hydraulic model completed in 2017. Where there is overlap the 2017 Albert River hydraulic model results for the 1% AEP plus RCP 4.5 climate change scenario are taken as a priority.

The following recommendations are made regarding the future analysis that might be undertaken:

- Information presented in this report is indicative only and may vary, depending upon the level of catchment and floodplain development. Filling of land or excavation and levelling may alter the ground levels locally at any time, whilst errors may occur from place to place in local ground elevation data from which the model has been developed.

8 References

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CSIRO, 2000, Floodplain Management in Australia: Best Practice Principles and Guidelines, SCARM Report

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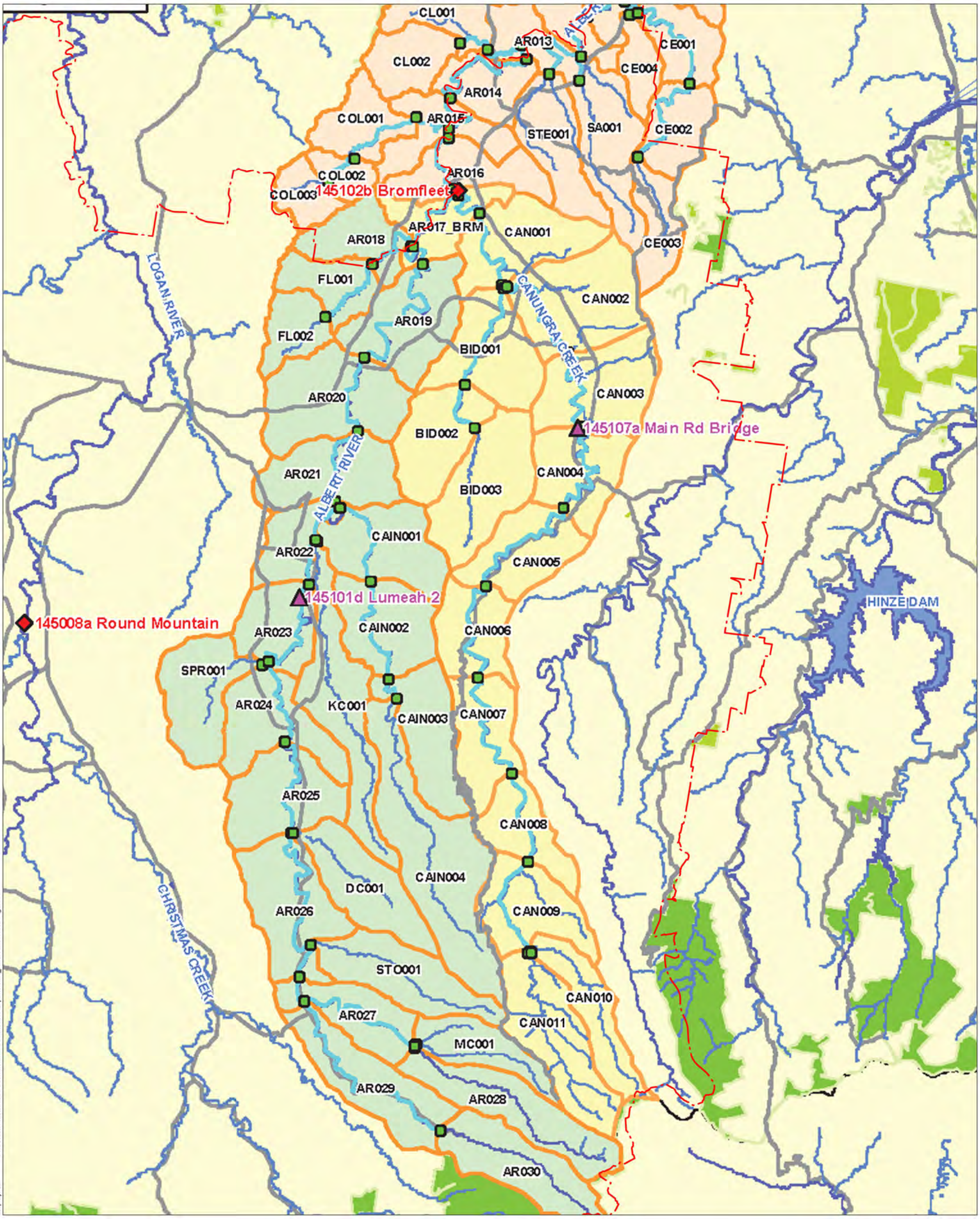
Queensland Government, 2015, Building Act 1975

Aurecon, 2015, Brisbane River Catchment Flood Study – Hydrology Phase Final Report

Appendix A
Figures

Figure	Description
Figure A1	Hydrologic Model Layout and Extents
Figure A2	Hydraulic Model Extents
Figure A3	Stream Gauge Locations
Figure A4-a	Rainfall Gauge Locations
Figure A4-b	1974 Calibration Event
Figure A4-c	1990 Calibration Event
Figure A4-d	2008 Calibration Event
Figure A4-e	2013 Calibration Event
Figure B1-a	1% AEP + CC4-5 Event - Inundation Extent Map
Figure B1-b	1% AEP + CC4-5 Event - Inundation Extent Map
Figure B1-c	1% AEP + CC4-5 Event - Inundation Extent Map
Figure B1-d	1% AEP + CC4-5 Event - Inundation Extent Map
Figure B1-e	1% AEP + CC4-5 Event - Inundation Extent Map
Figure B2-a	1% AEP + CC4-5 Event - Peak Velocity
Figure B2-b	1% AEP + CC4-5 Event - Peak Velocity
Figure B2-c	1% AEP + CC4-5 Event - Peak Velocity
Figure B2-d	1% AEP + CC4-5 Event - Peak Velocity
Figure B2-e	1% AEP + CC4-5 Event - Peak Velocity
Figure B3-a	1% AEP + CC4-5 Event - Peak Depth
Figure B3-b	1% AEP + CC4-5 Event - Peak Depth
Figure B3-c	1% AEP + CC4-5 Event - Peak Depth
Figure B3-d	1% AEP + CC4-5 Event - Peak Depth
Figure B3-e	1% AEP + CC4-5 Event - Peak Depth
Figure B4-a	1% AEP + CC4-5 Event - Peak Hazard
Figure B4-b	1% AEP + CC4-5 Event - Peak Hazard
Figure B4-c	1% AEP + CC4-5 Event - Peak Hazard
Figure B4-d	1% AEP + CC4-5 Event - Peak Hazard
Figure B4-e	1% AEP + CC4-5 Event - Peak Hazard
Figure C	Emergency Management Map

aurecon



Map by: JL

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Legend

SRRC Boundary

Notes:

1:150,000

0 3,000 m 6,000 m

Date: 17/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure A-1**

Hydrologic Model Layout and Extents

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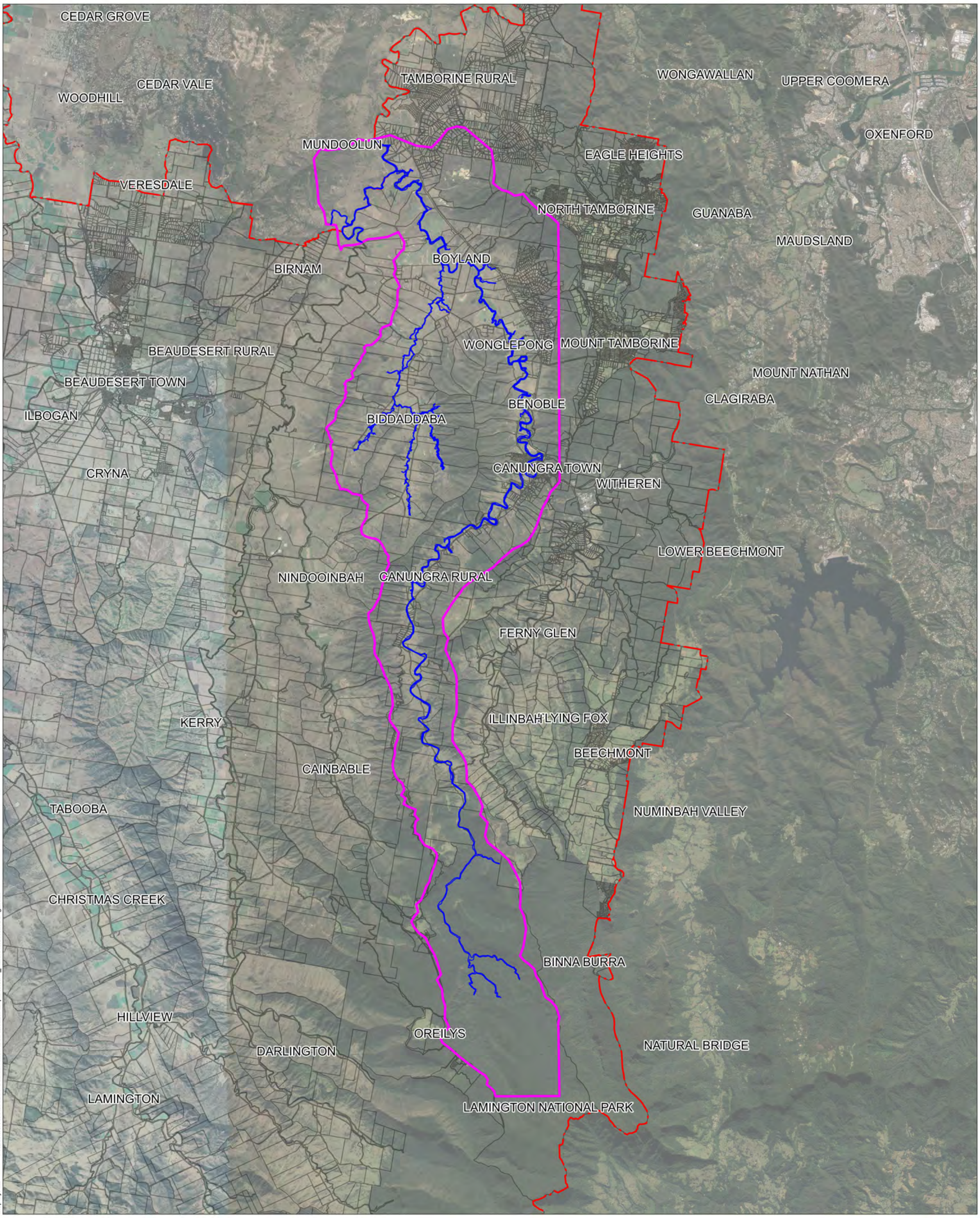


Legend

SRRC Boundary

Cadastral Boundary

2d Hydraulic Model Domain Extent

Canungra and Biddaddaba Creek Alingnments

Notes:

1:150,000

0 3,000 m 6,000 m

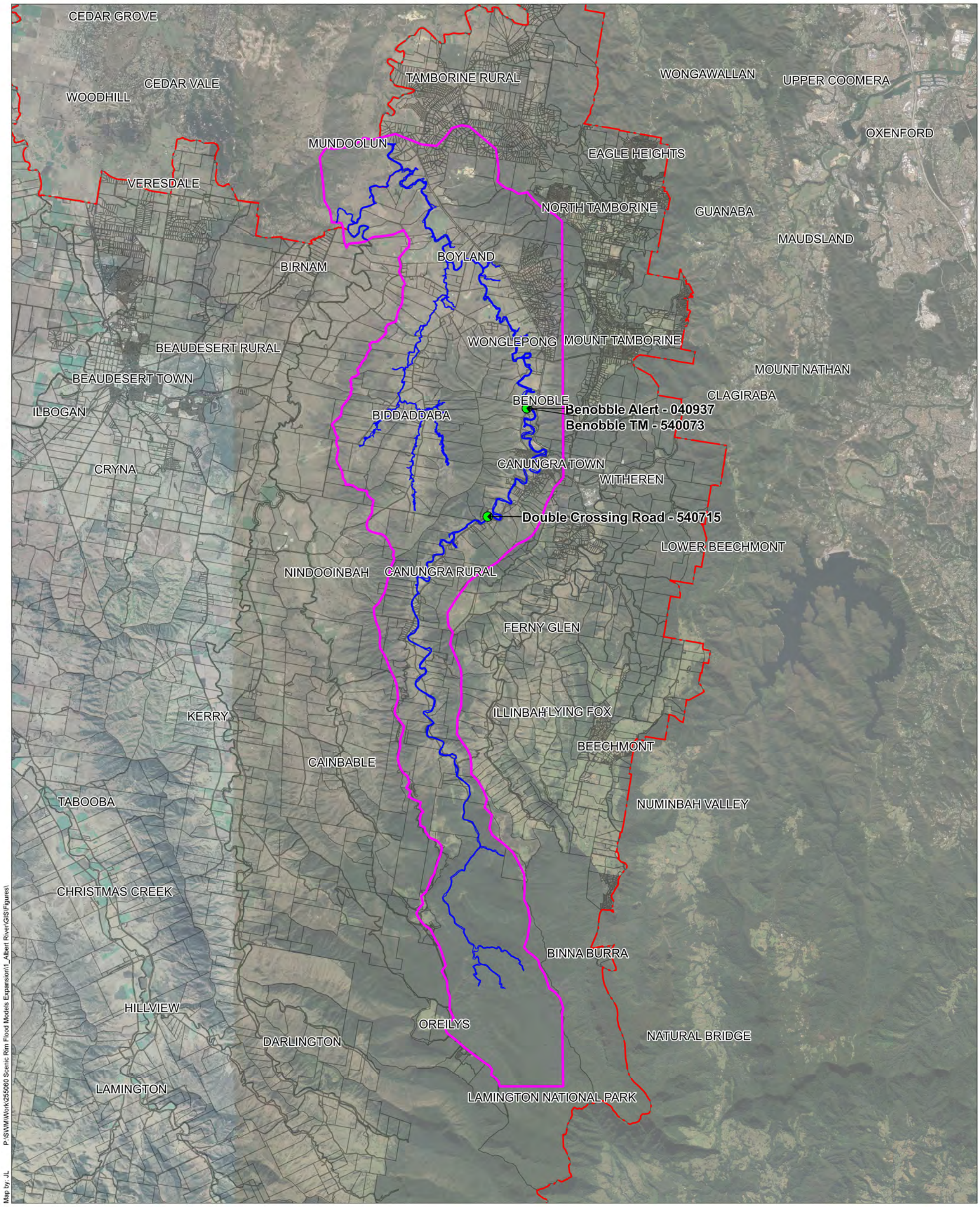
Date: 17/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure A-2**

Hydraulic Model Extents

aurecon



Legend

Notes:

SRRC Boundary

2d Hydraulic Model Domain Extent

Cadastral Boundary

Stream Gauge Locations

Canungra and Biddaddaba Creek Alingnments

1:150,000

0 3,000 m 6,000 m

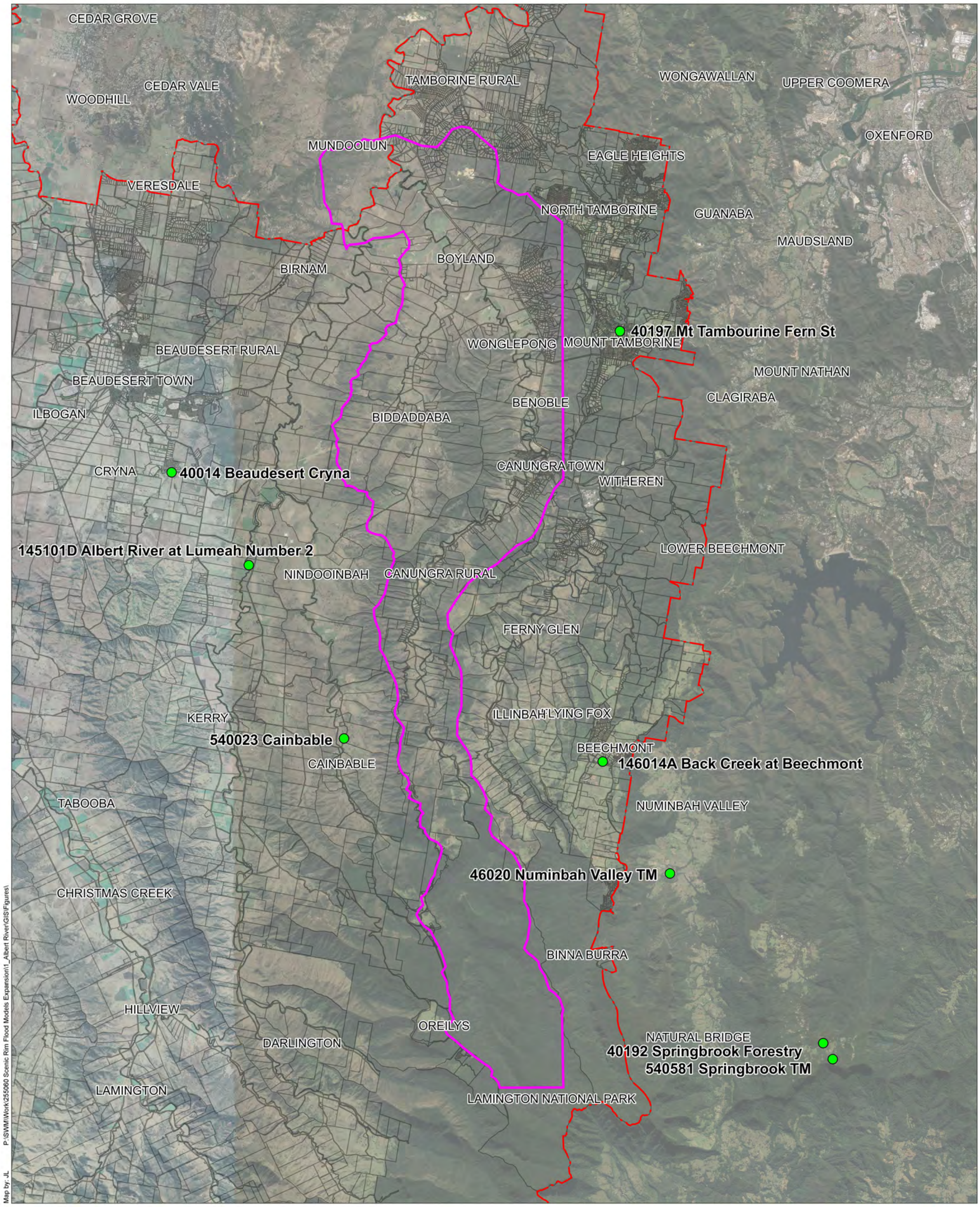
Date: 17/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure A3**

Stream Gauge Locations

aurecon



Legend

SRRC Boundary — 2d Hydraulic Model Domain Extent

Cadastral Boundary — Rainfall Gauge Locations

Notes:

1:150,000

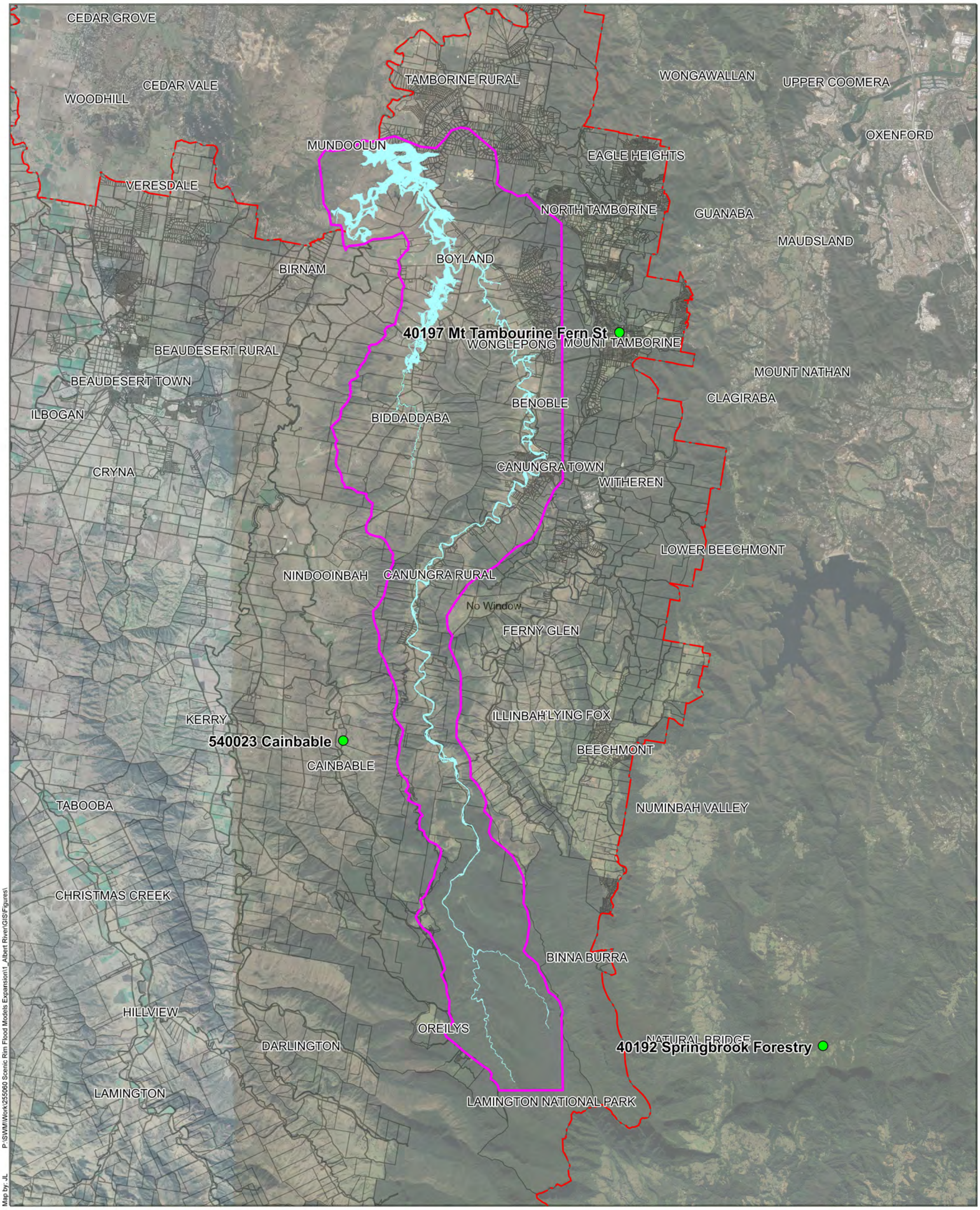
0 3,000 m 6,000 m

Date: 17/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure A-4a**

Rainfall Gauge Locations



Legend

SRRC Boundary

2d Hydraulic Model Domain Extent

Cadastral Boundary

1974 Rainfall Gauge Locations

1974 Calibration Inundation Extent

Notes:

1:150,000

0 | 3,000 m | 6,000 m

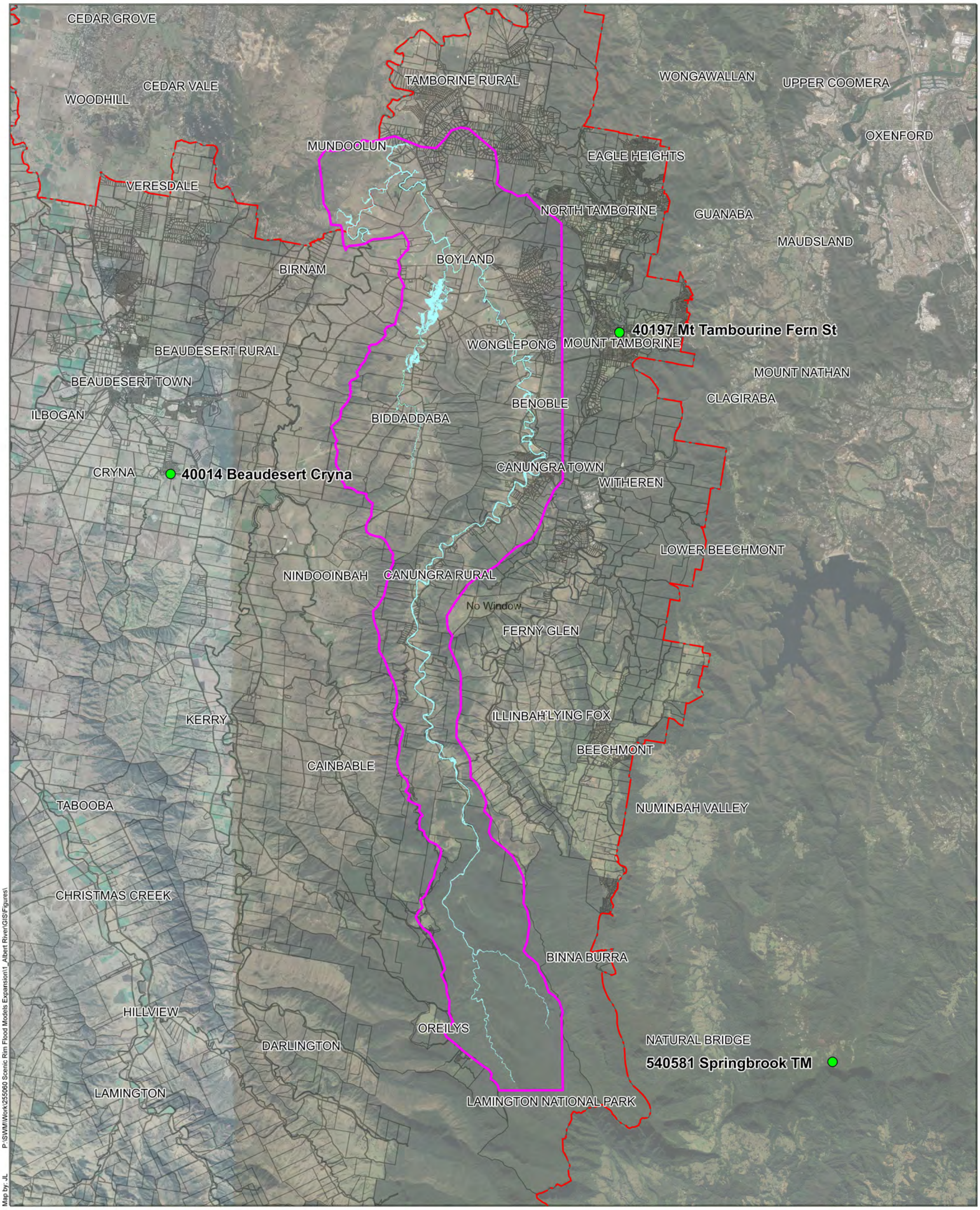
Date: 17/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure A-4b**

1974 Calibration Event

aurecon



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Legend

- SRRC Boundary
- Cadastral Boundary
- 1990 Calibration Inundation Extent
- 2d Hydraulic Model Domain Extent
- 1974 Rainfall Gauge Locations

Notes:

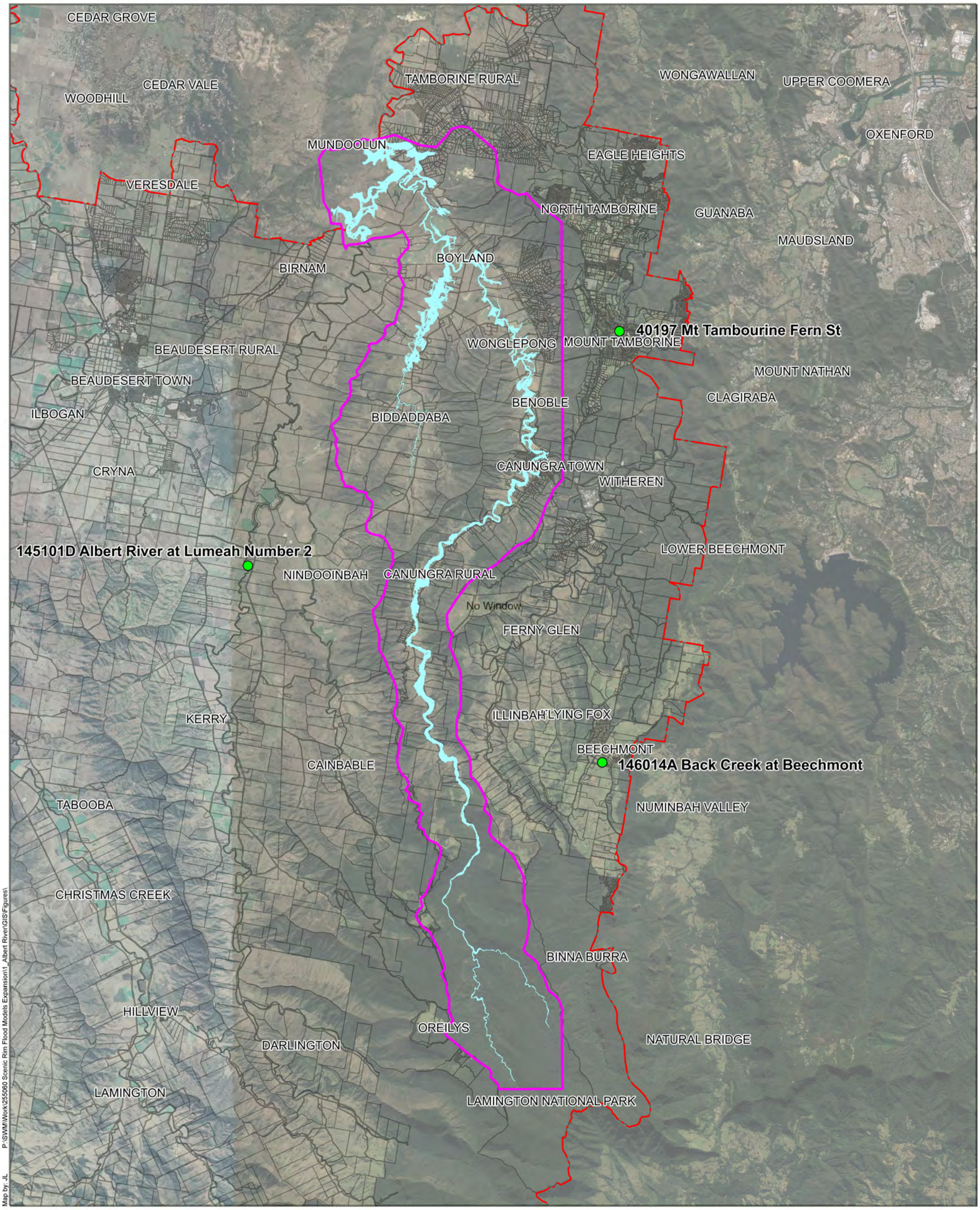
1:150,000
0   3,000 m   6,000 m

Date: 17/11/2018   Version: 0   Job No: 252966
Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study   **Figure A-4c**

1990 Calibration Event

aurecon



Legend

SRRC Boundary
2d Hydraulic Model Domain Extent
Cadastral Boundary
2008 Rainfall Gauge Locations
2008 Calibration Inundation Extent

Notes:

1:150,000

0 3,000 m 6,000 m

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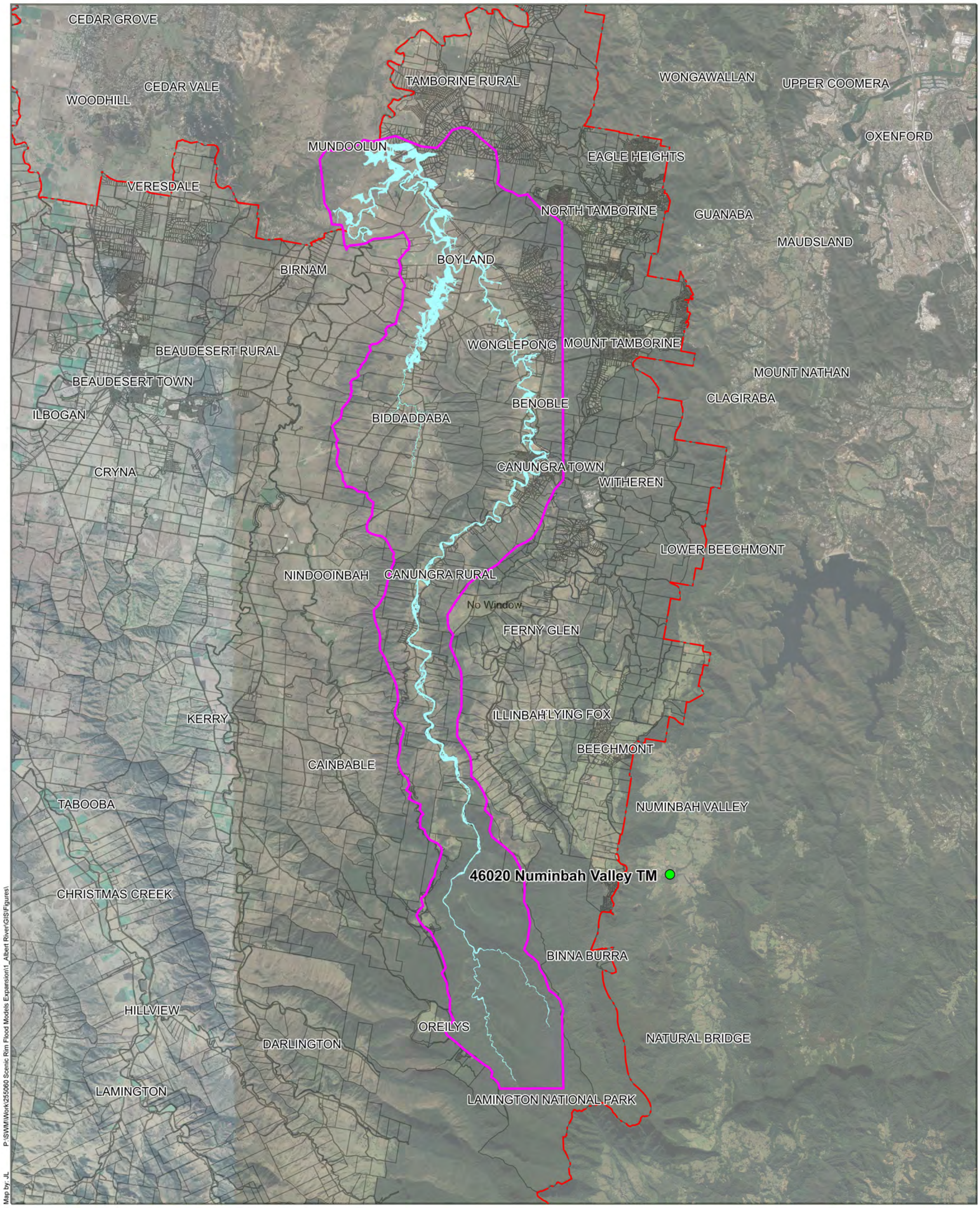
Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure A-4d**

2008 Calibration Event

aurecon



Legend

SRRC Boundary
2d Hydraulic Model Domain Extent
Cadastral Boundary
2013 Rainfall Gauge Locations
2013 Calibration Inundation Extent

Notes:

1:150,000

0 3,000 m 6,000 m

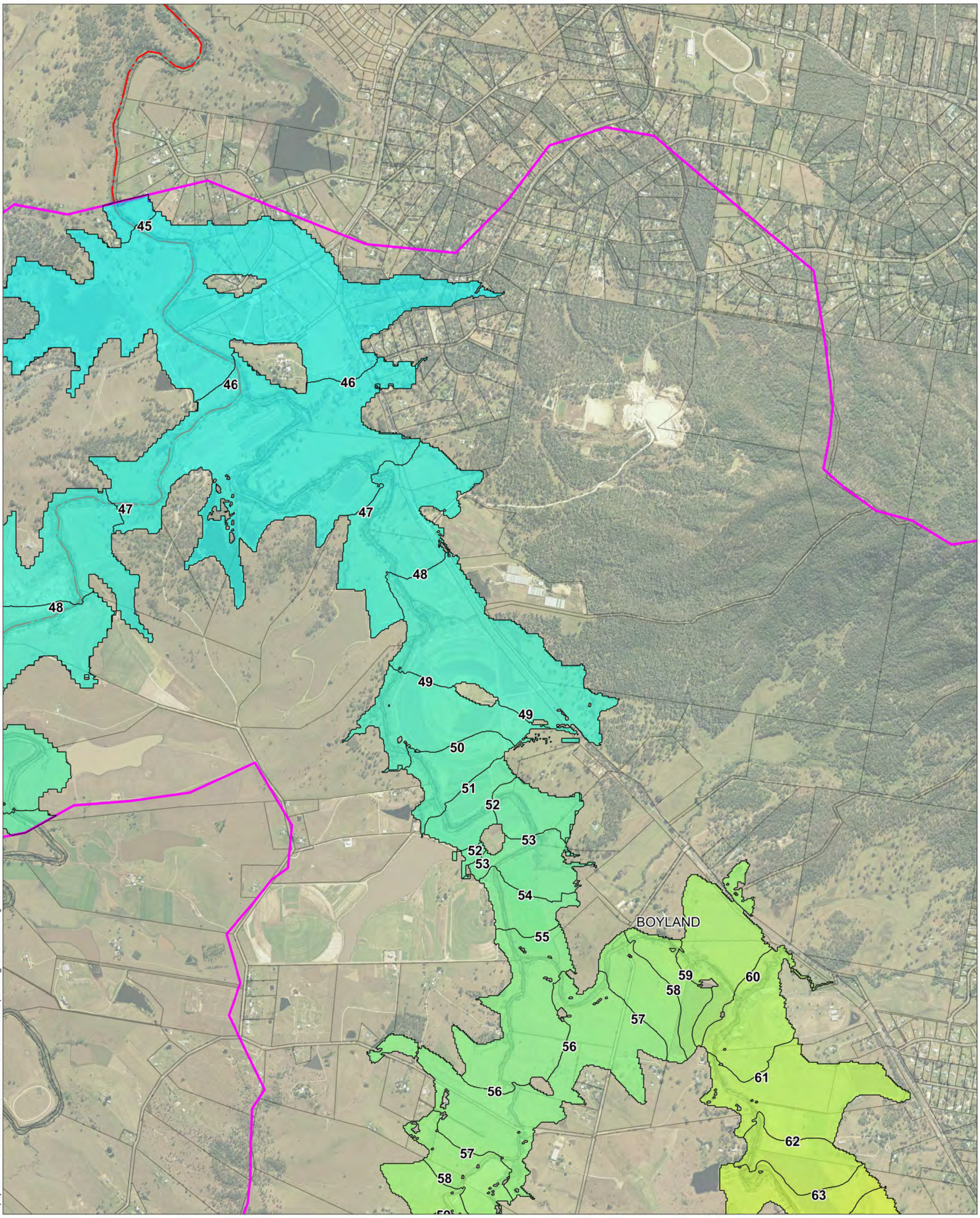
Date: 17/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure A-4e**

2013 Calibration Event

aurecon



Legend

- SRRC Boundary
- Cadastral Boundary
- Hydraulic Model Extent
- Inundation Extent
- Peak Water Level Contour (mAHD)

Notes:

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0 625 m 1,250 m

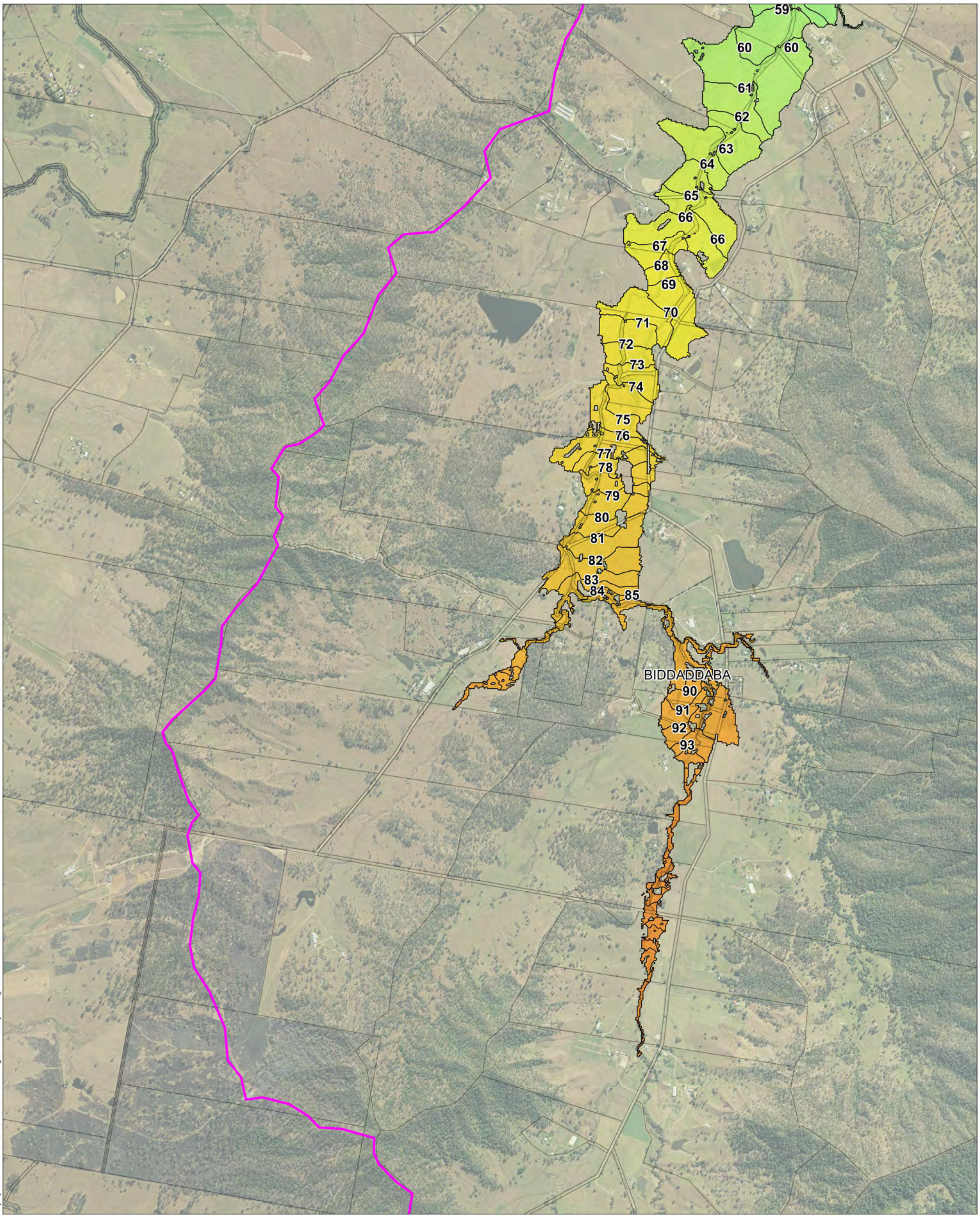
Date: 17/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure B1-a**

1% AEP + Climate Change (CC4-5) Event - Inundation Extent

aurecon



Legend

SRRC Boundary

Cadastral Boundary

Hydraulic Model Extent

Inundation Extent

Peak Water Level Contour (mAHD)

Notes:

1:25,000

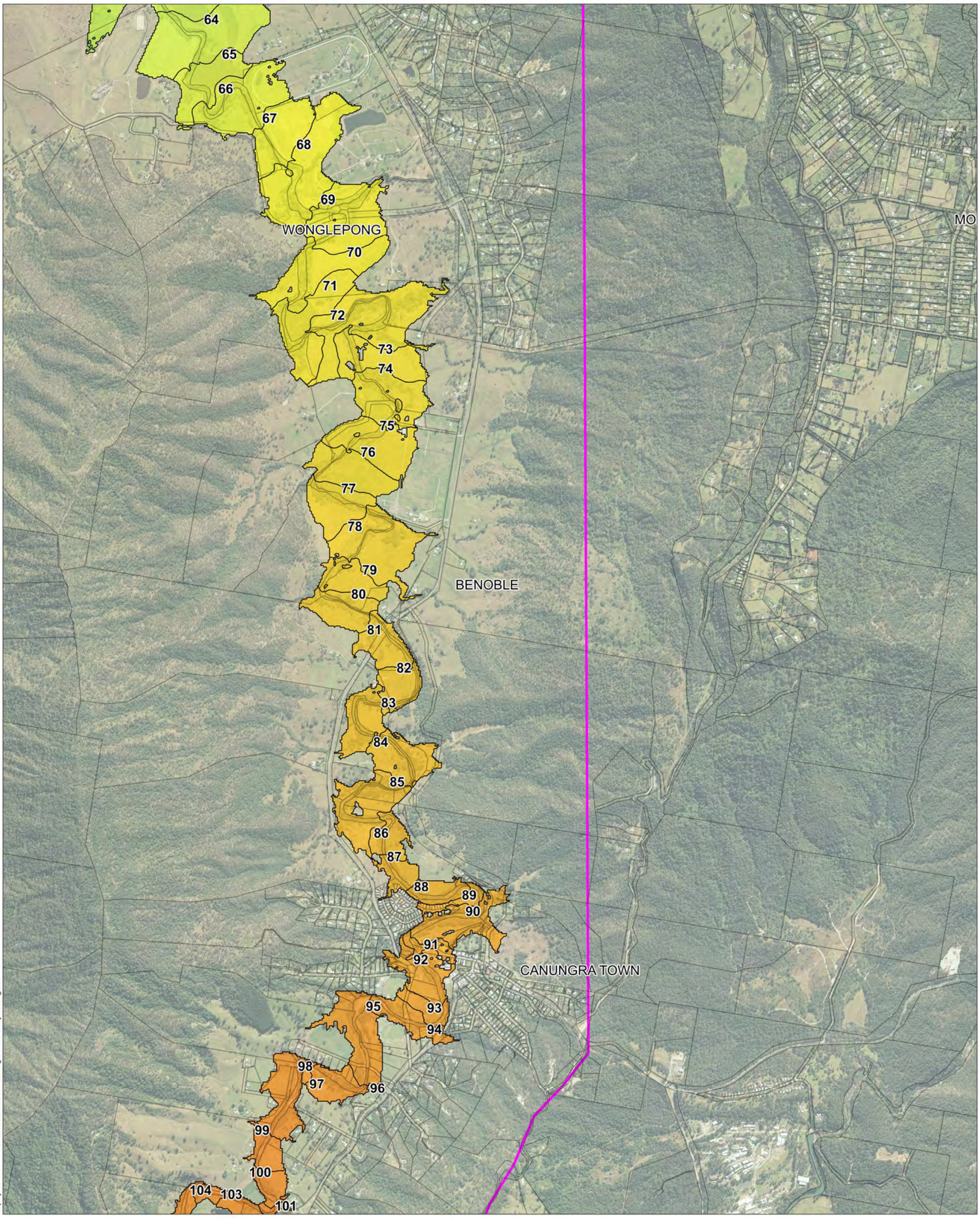
0 625 m 1,250 m

Date: 14711/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure B1-b**

1% AEP + Climate Change (CC4-5) Event - Inundation Extent



Legend

SRRC Boundary

Cadastral Boundary

Hydraulic Model Extent

Inundation Extent

Peak Water Level Contour (mAHD)

Notes:

1:25,000

0 625 m 1,250 m

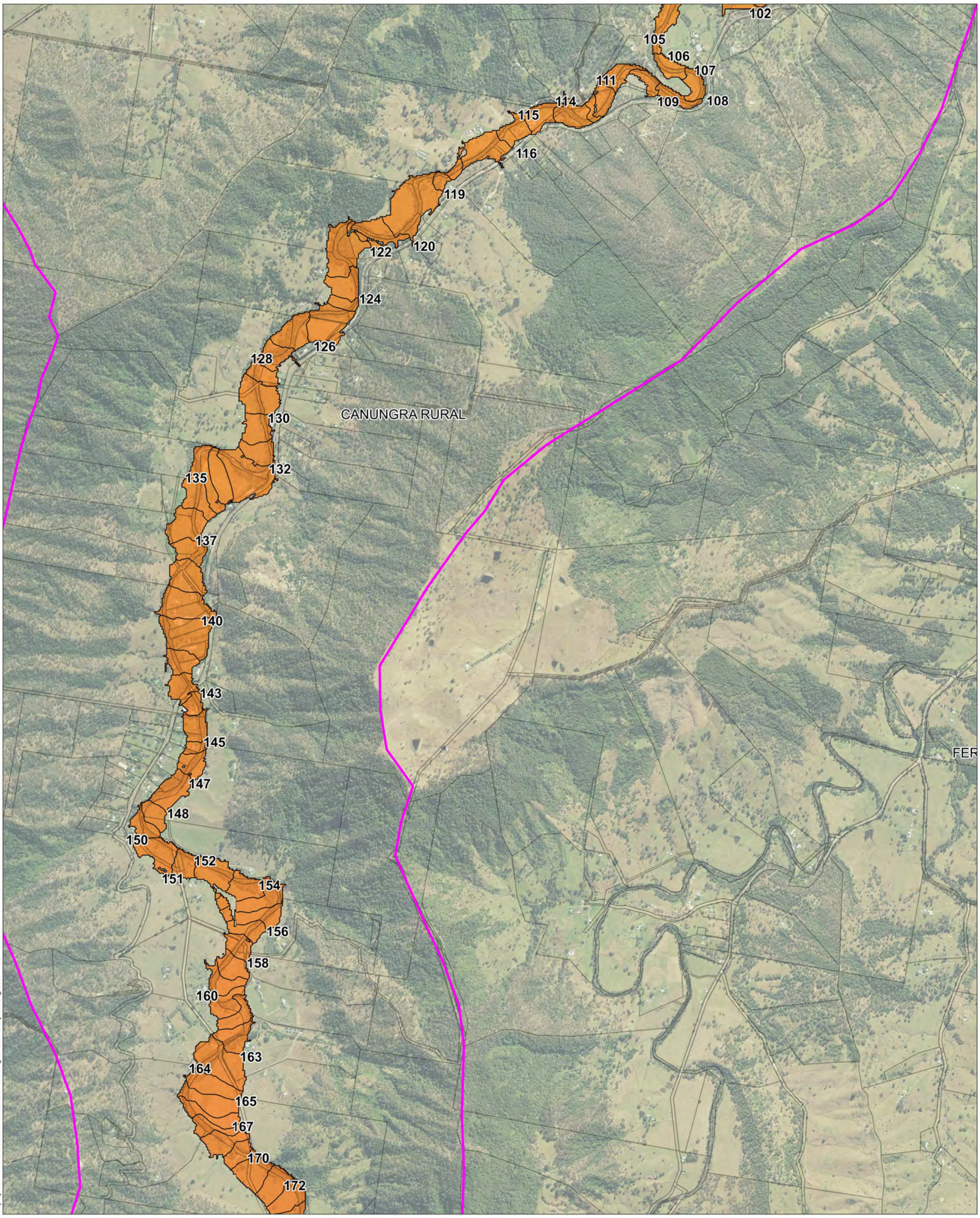
Date: 14/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure B1-c**

1% AEP + Climate Change (CC4-5) Event - Inundation Extent

aurecon



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Legend

SRRC Boundary

Cadastral Boundary

Hydraulic Model Extent

Inundation Extent

Peak Water Level Contour (mAHD)

Notes:

1:25,000

0 625 m 1,250 m

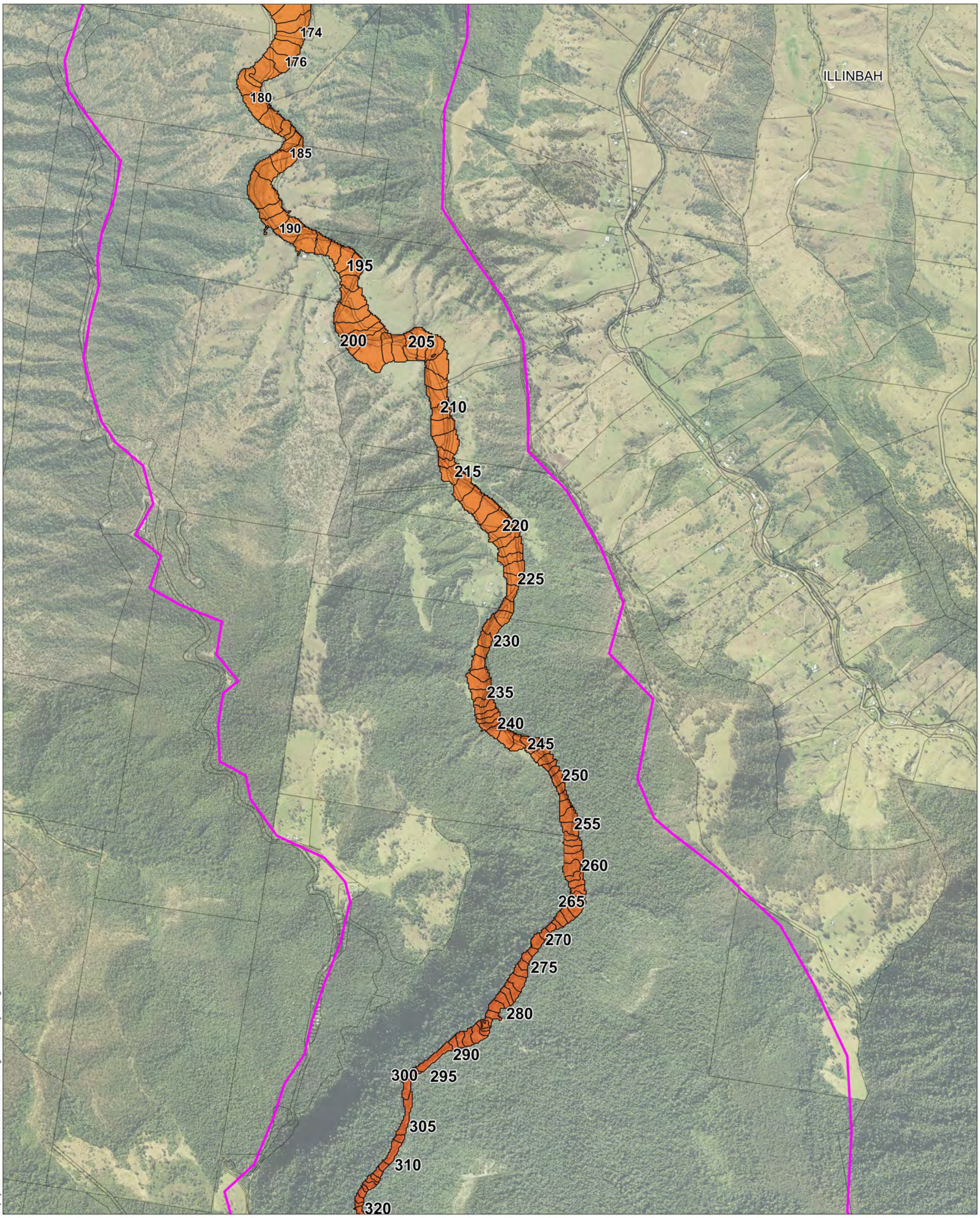
Date: 14/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure B1-d**

1% AEP + Climate Change (CC4-5) Event - Inundation Extent

aurecon



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Legend

SRRC Boundary

Cadastral Boundary

Hydraulic Model Extent

Inundation Extent

Peak Water level Contour (mAHD)

Notes:

1:25,000

0   625 m   1,250 m

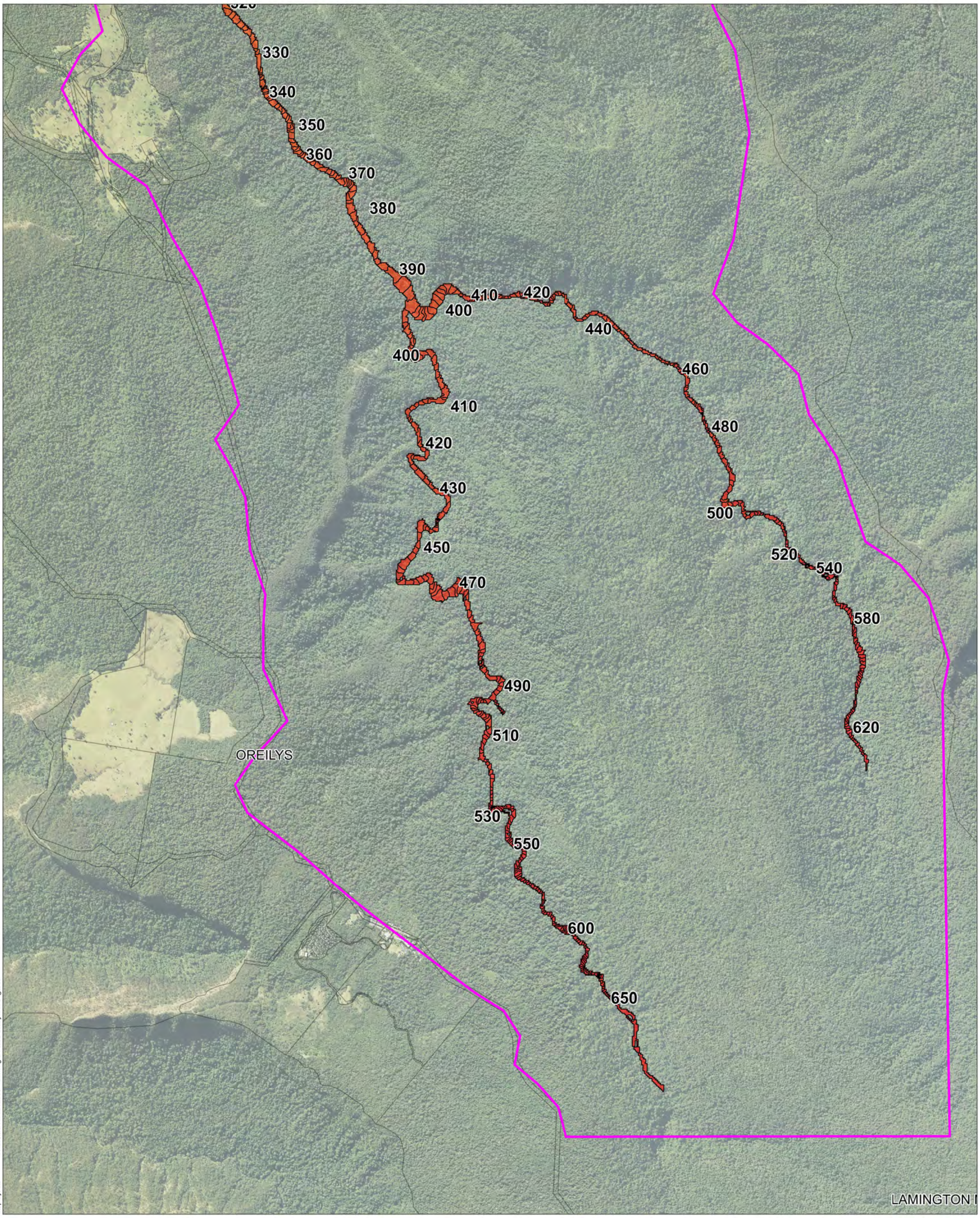
Date: 14/11/2018   Version: 0   Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study   **Figure B1-e**

1% AEP + Climate Change (CC4-5) Event - Inundation Extent

aurecon



Legend

- SRRC Boundary
- Cadastral Boundary
- Hydraulic Model Extent
- Inundation Extent
- Peak Water level Contour (mAHD)

Notes:

1:25,000

0 | 625 m | 1,250 m

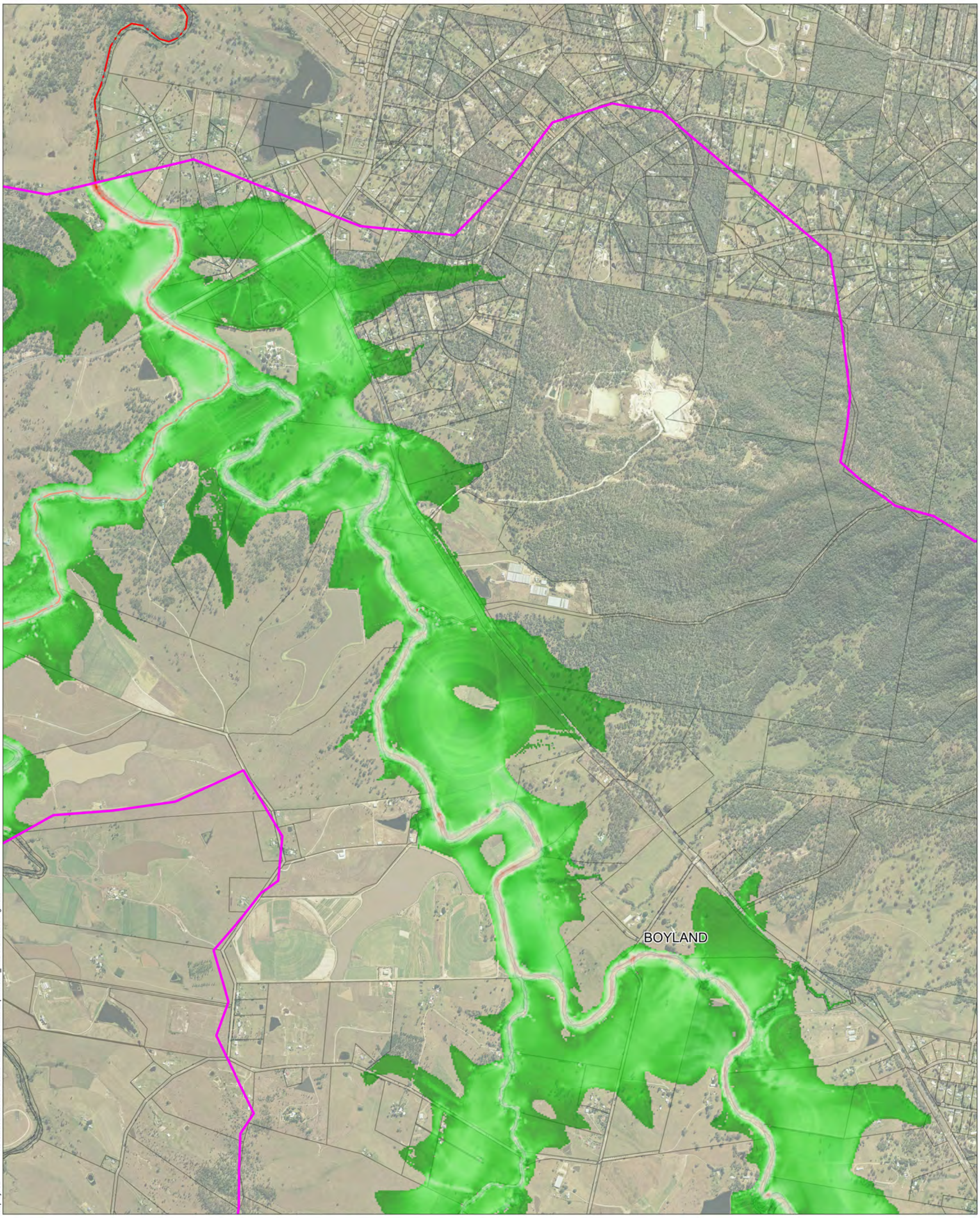
Date: 14/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study Figure B1-f

1% AEP + Climate Change (CC4-5) Event - Inundation Extent

aurecon



Map by: JL   P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\1_Albert River\GIS\Figures\

Legend

- SRRC Boundary
- Cadastral Boundary
- Hydraulic Model Extent

Velocity (m/s)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:25,000

0   625 m   1,250 m

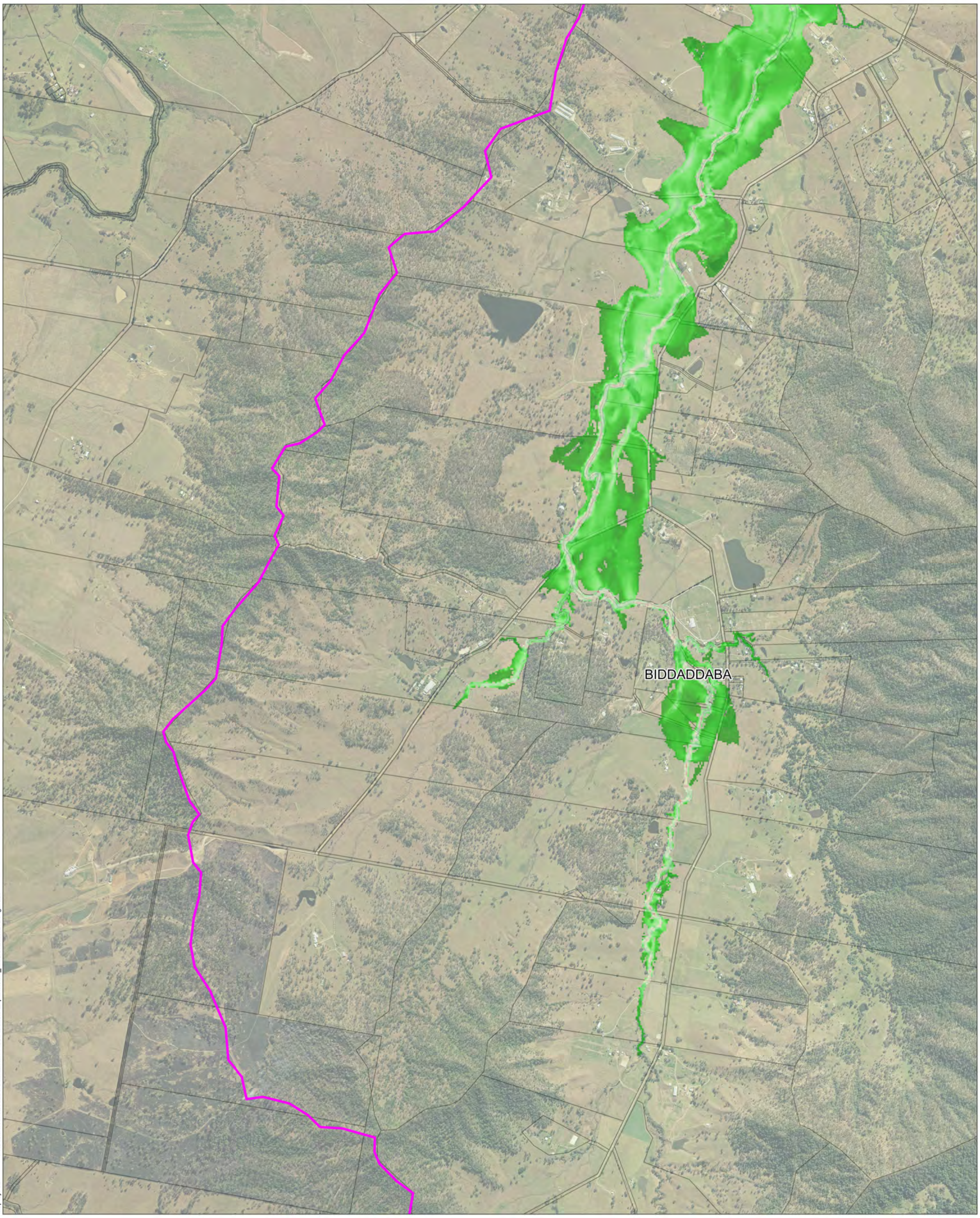
Date: 17/11/2018   Version: 0   Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure B2-a**

1% AEP + Climate Change (CC4-5) Event - Peak Velocities

aurecon



Map by: JL

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Legend

SRRC Boundary
Cadastral Boundary
Hydraulic Model Extent

Velocity (m/s)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:25,000

0 625 m 1,250 m

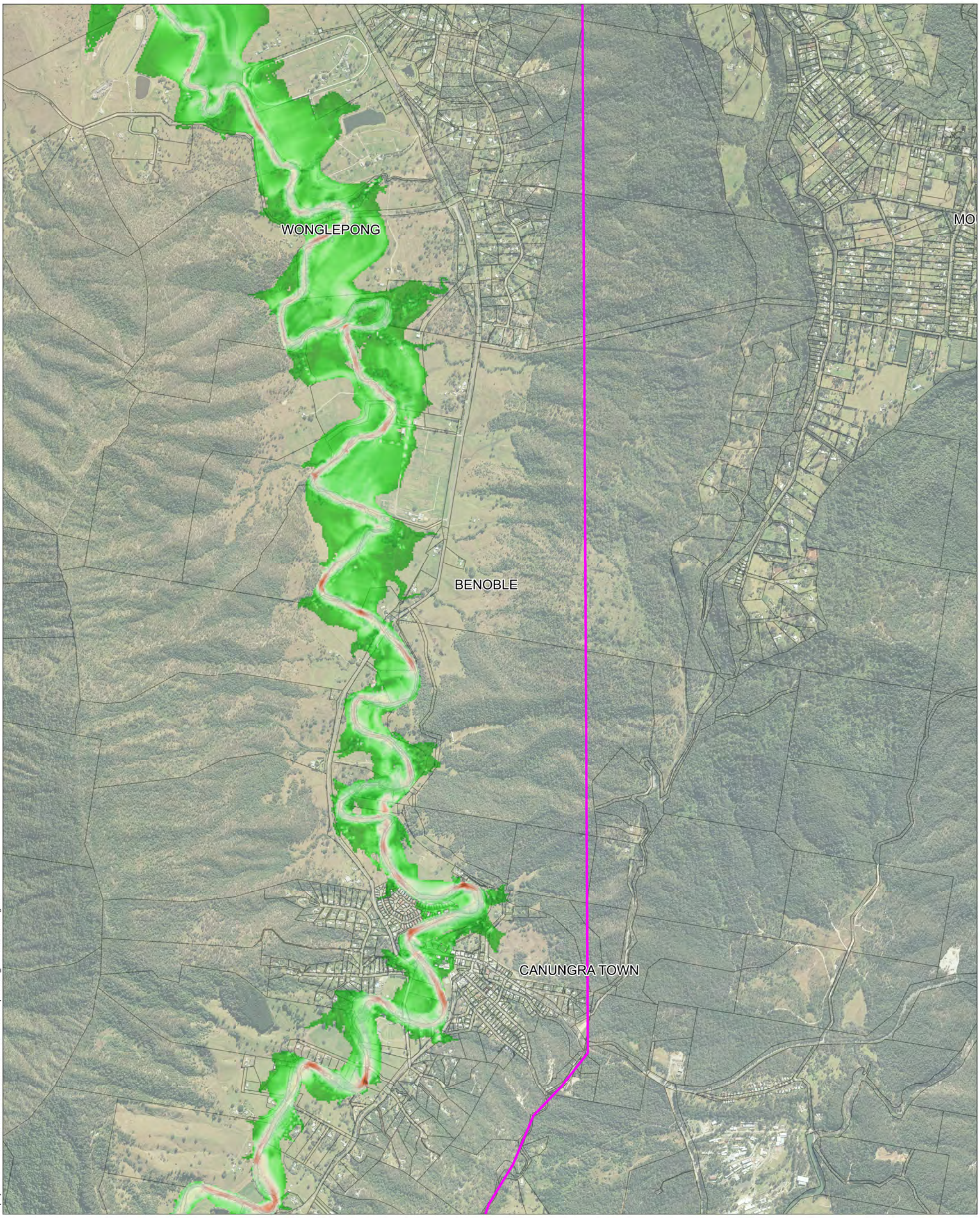
Date: 17/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study Figure B2-b

1% AEP + Climate Change (CC4-5) Event - Peak Velocities

aurecon



Legend

- SRRC Boundary
- Cadastral Boundary
- Hydraulic Model Extent

Velocity (m/s)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:25,000

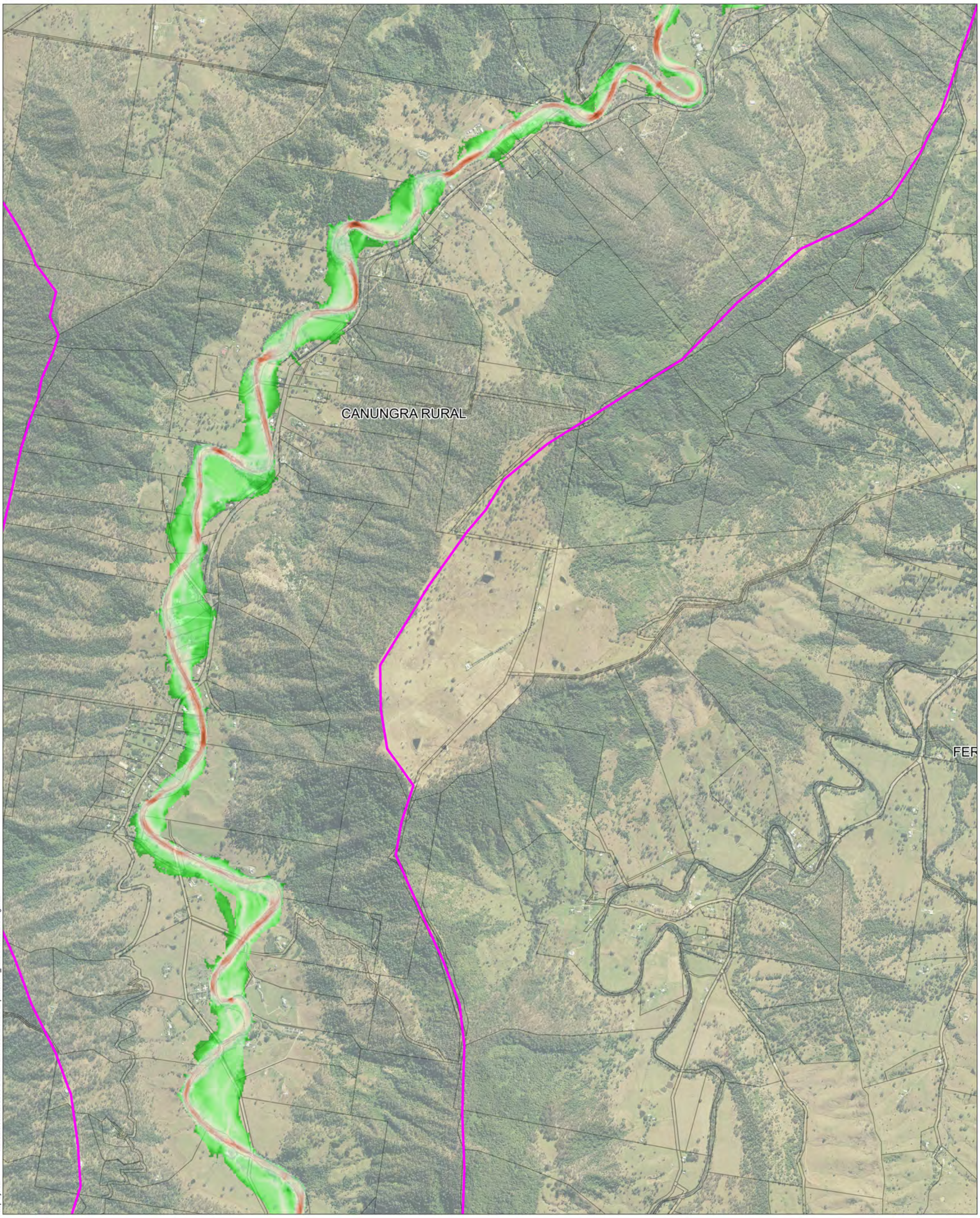
0 625 m 1,250 m

Date: 17/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study Figure B2-c

1% AEP + Climate Change (CC4-5) Event - Peak Velocities



Legend

Velocity (m/s)

- SRRC Boundary
- Cadastral Boundary
- Hydraulic Model Extent

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:25,000

0 625 m 1,250 m

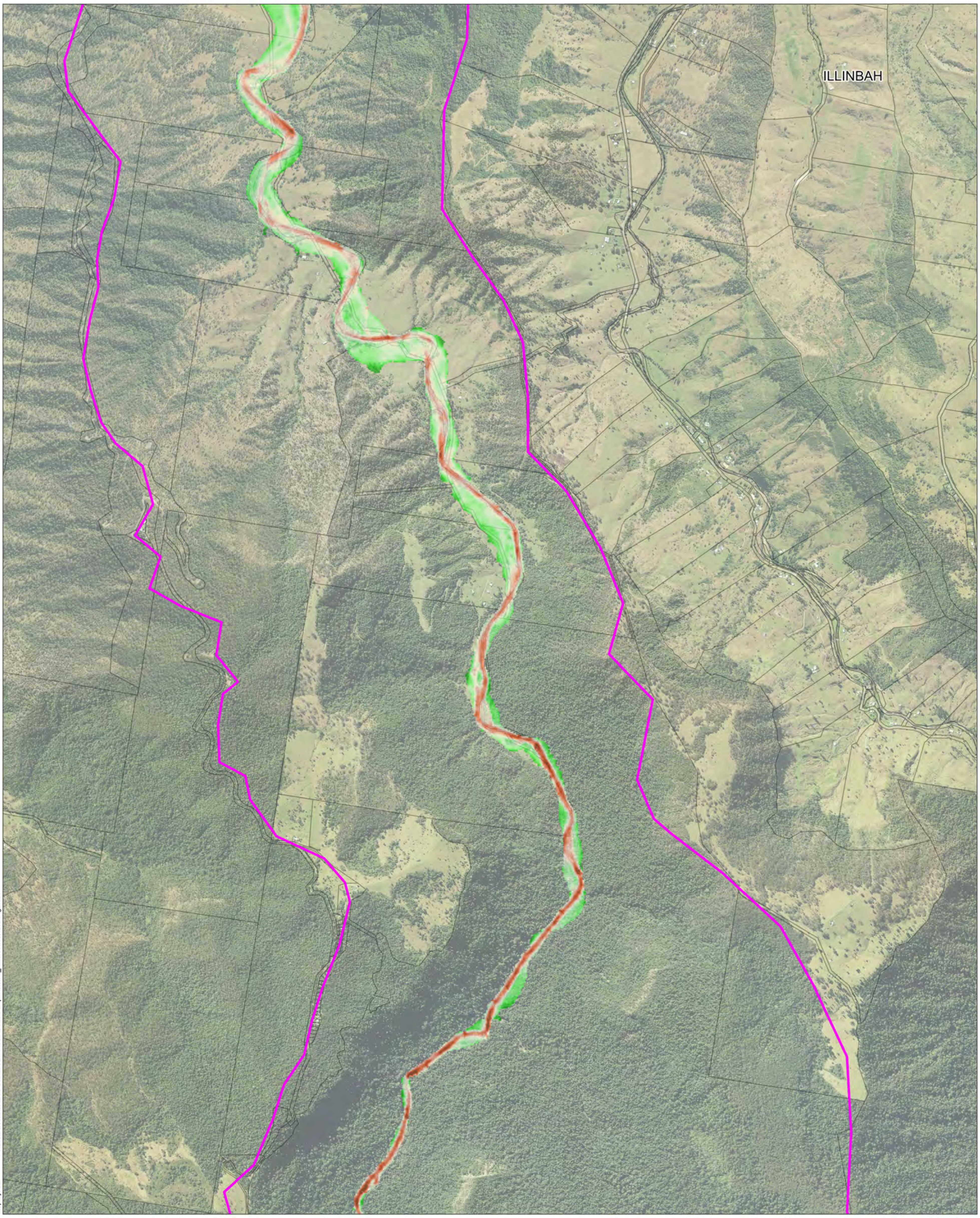
Date: 17/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study Figure B2-d

1% AEP + Climate Change (CC4-5) Event - Peak Velocities

aurecon



Map by: JL

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Legend

SRRC Boundary

Cadastral Boundary

Hydraulic Model Extent

Velocity (m/s)

0.0 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0
2.5 to 3.0	

Notes:

1:25,000

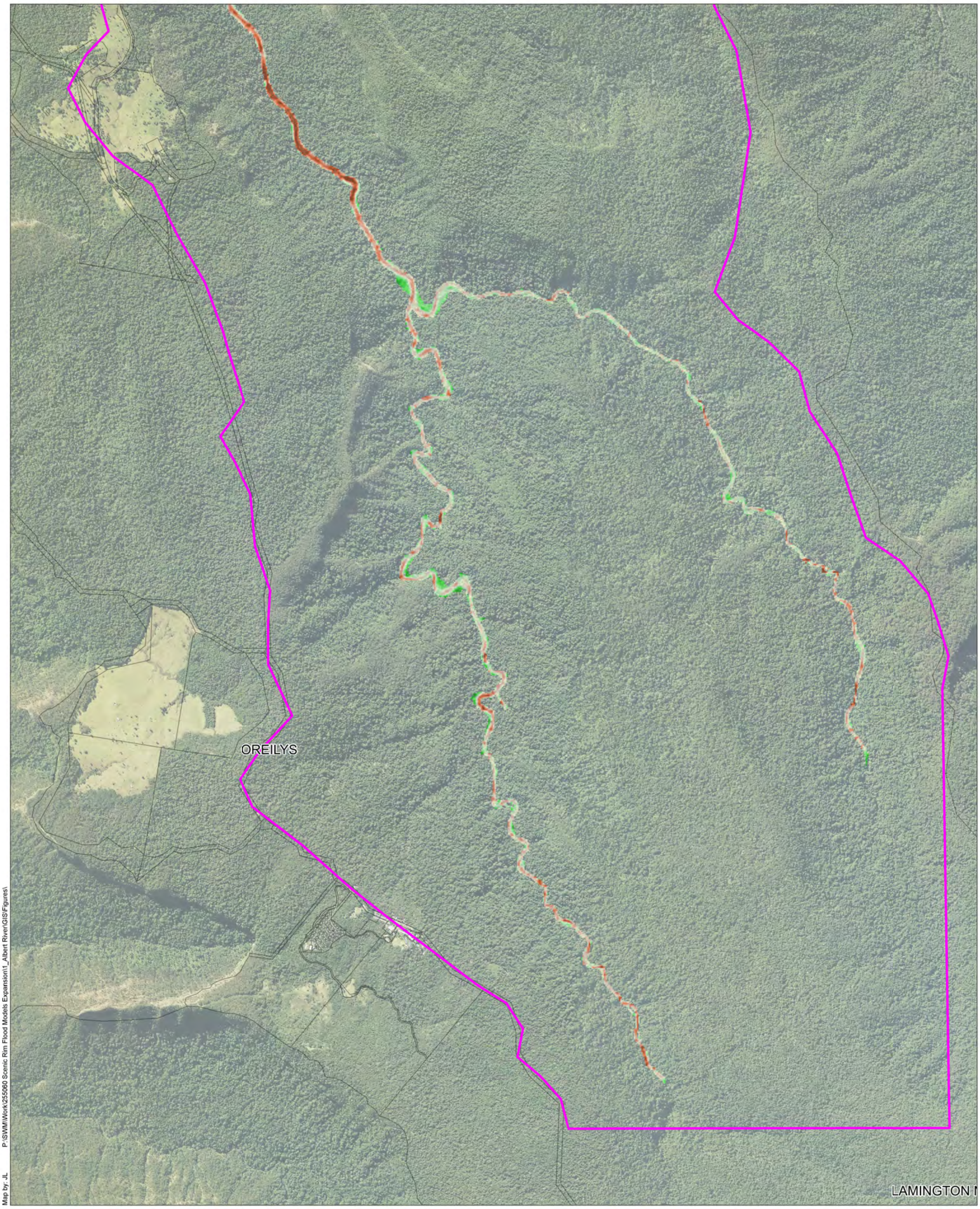
0 625 m 1,250 m

Date: 17/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure B2-e**

1% AEP + Climate Change (CC4-5) Event - Peak Velocities



Legend

SRRC Boundary

Cadastral Boundary

Hydraulic Model Extent

Velocity (m/s)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:25,000

0 625 m 1,250 m

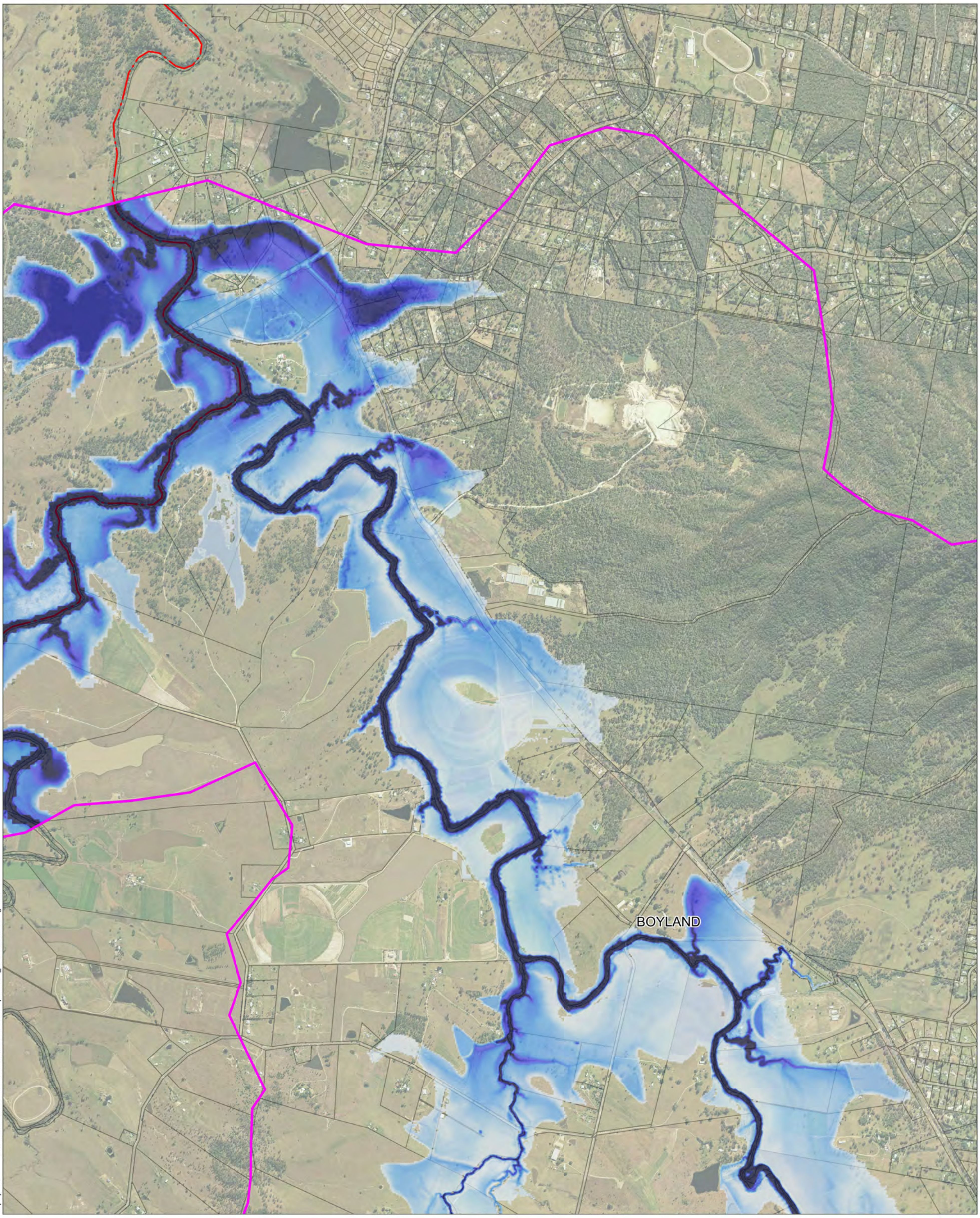
Date: 17/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study Figure B2-f

1% AEP + Climate Change (CC4-5) Event - Peak Velocities

aurecon



Map by: JDT P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\1_Albert River\GIS\Figures\

Legend

SRRC Boundary

Cadastral Boundary

Hydraulic Model Extent

Depth (m)

0.0 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0
2.5 to 3.0	

Notes:

1:25,000

0 625 m 1 250 m

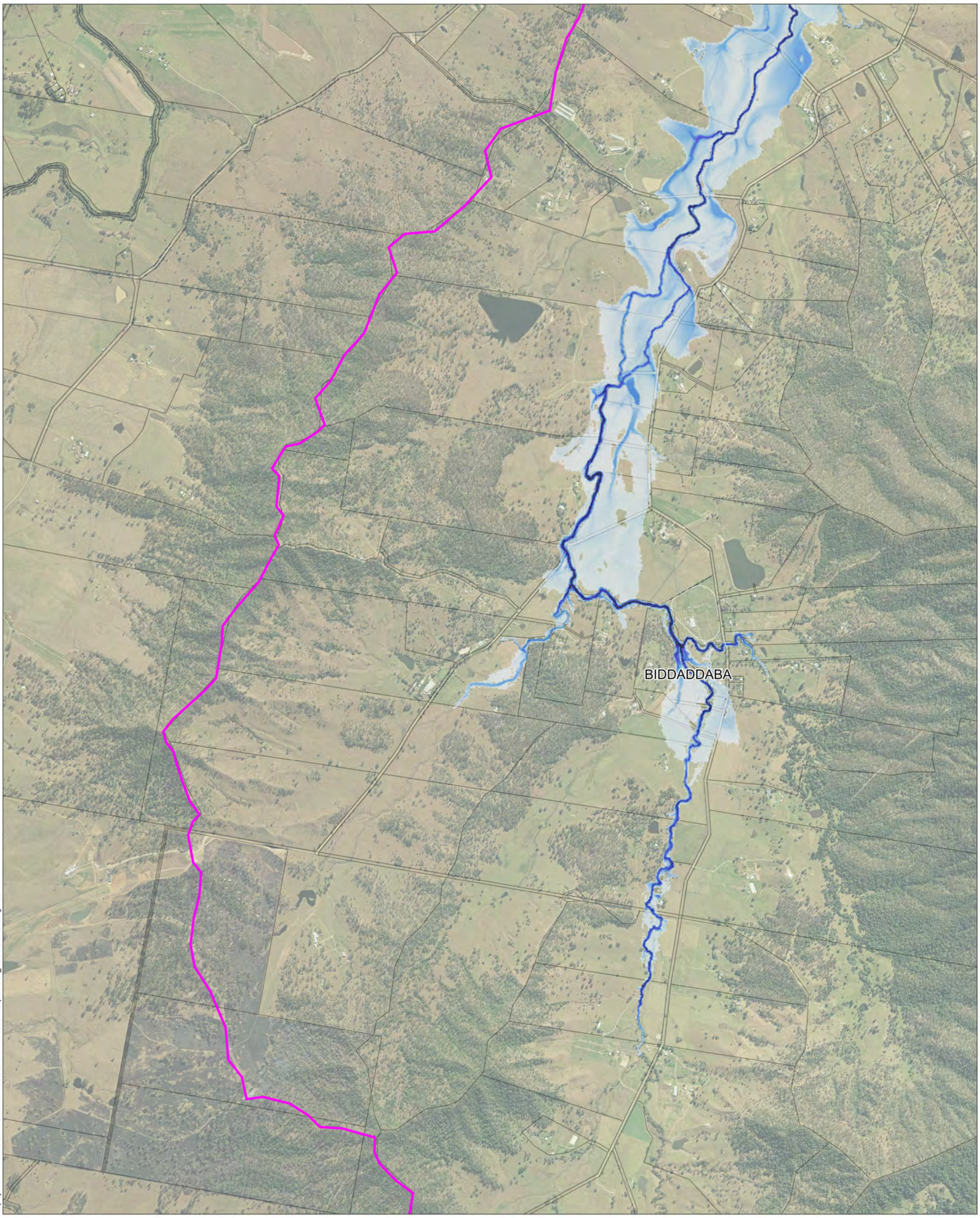
Date: 17/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study Figure B3-a

1% AEP + Climate Change (CC4-5) Event - Peak Depths

aurecon



Map by: JL

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Legend

	Depth (m)	
SRRC Boundary	0.0 to 0.5	3.0 to 3.5
Cadastral Boundary	0.5 to 1.0	3.5 to 4.0
Hydraulic Model Extent	1.0 to 1.5	4.0 to 4.5
	1.5 to 2.0	4.5 to 5.0
	2.0 to 2.5	> 5.0
	2.5 to 3.0	

Notes:

1:25,000

0 625 m 1,250 m

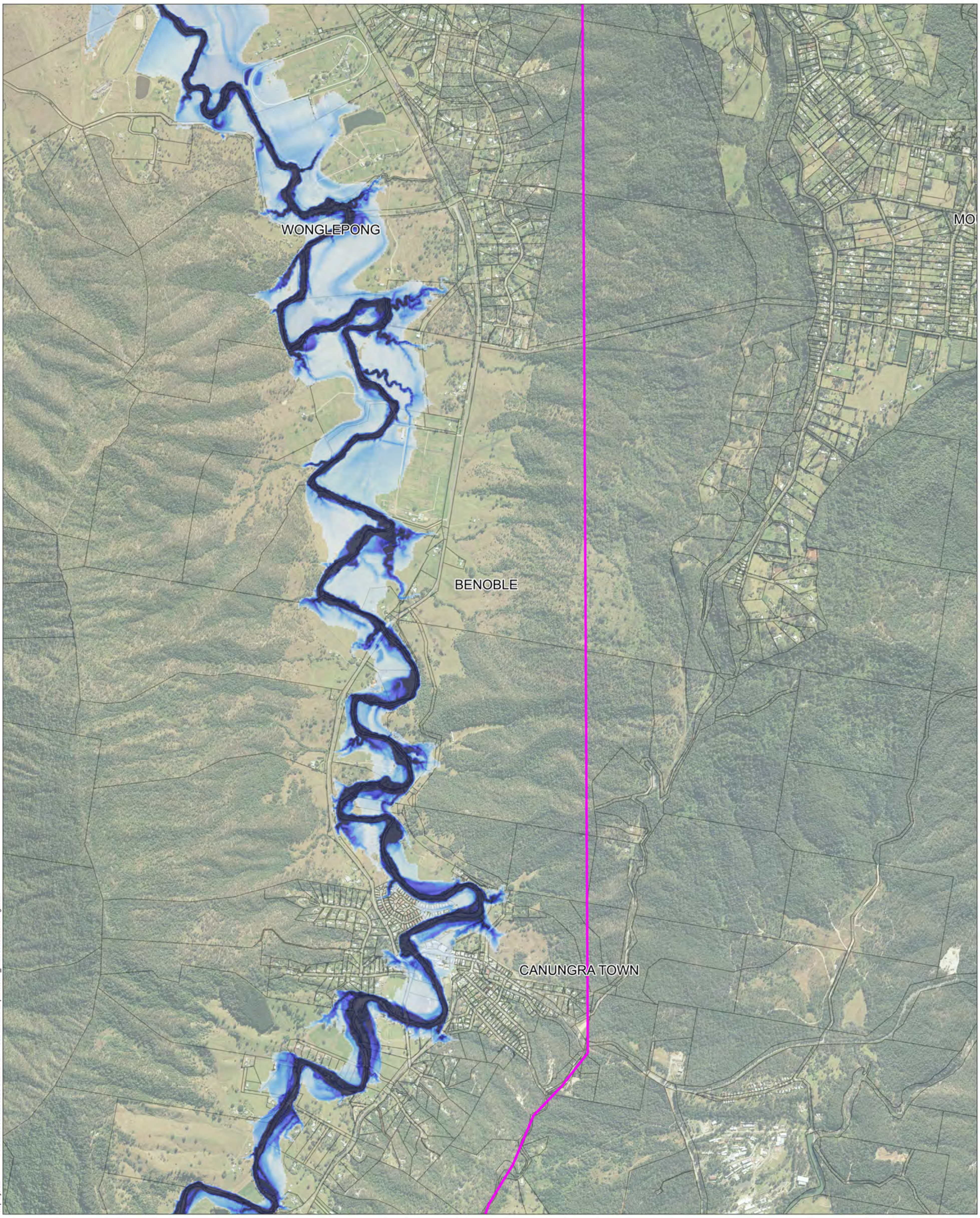
Date: 17/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure B3-b**

1% AEP + Climate Change (CC4-5) Event - Peak Depths

aurecon



Map by: JL   P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\1_Albert River\GIS\Figures\

Legend

SRRC Boundary
Cadastral Boundary
Hydraulic Model Extent

Depth (m)

0.0 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0
2.5 to 3.0	

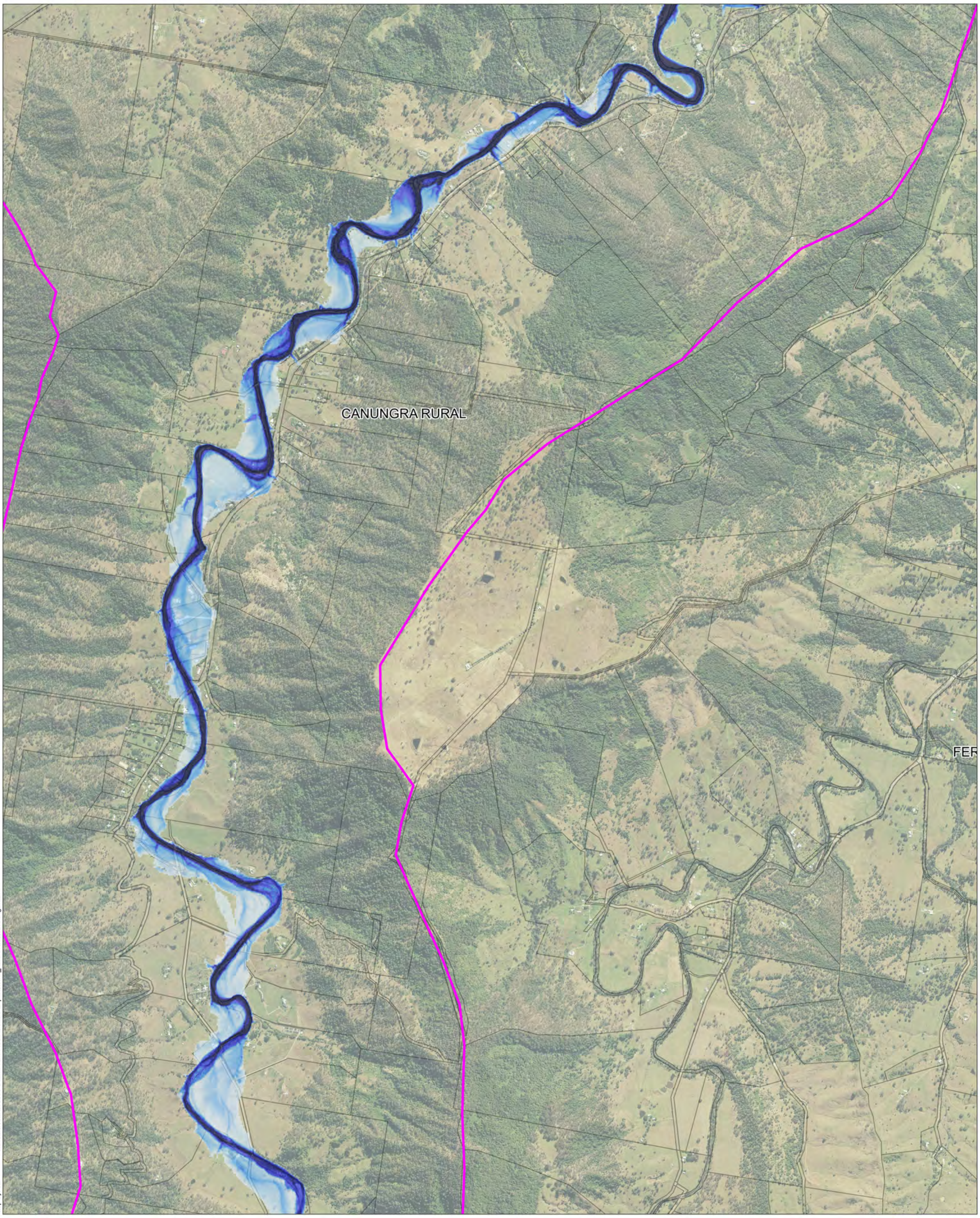
Notes:

1:25,000
0   625 m   1,250 m

Date: 17/11/2018   Version: 0   Job No: 252966
Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study   **Figure B3-c**

1% AEP + Climate Change (CC4-5) Event - Peak Depths



Map by: JL

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Legend

- SRRC Boundary
- Cadastral Boundary
- Hydraulic Model Extent

Depth (m)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 3.5
- 3.5 to 4.0
- 4.0 to 4.5
- 4.5 to 5.0
- > 5.0

Notes:

1:25,000

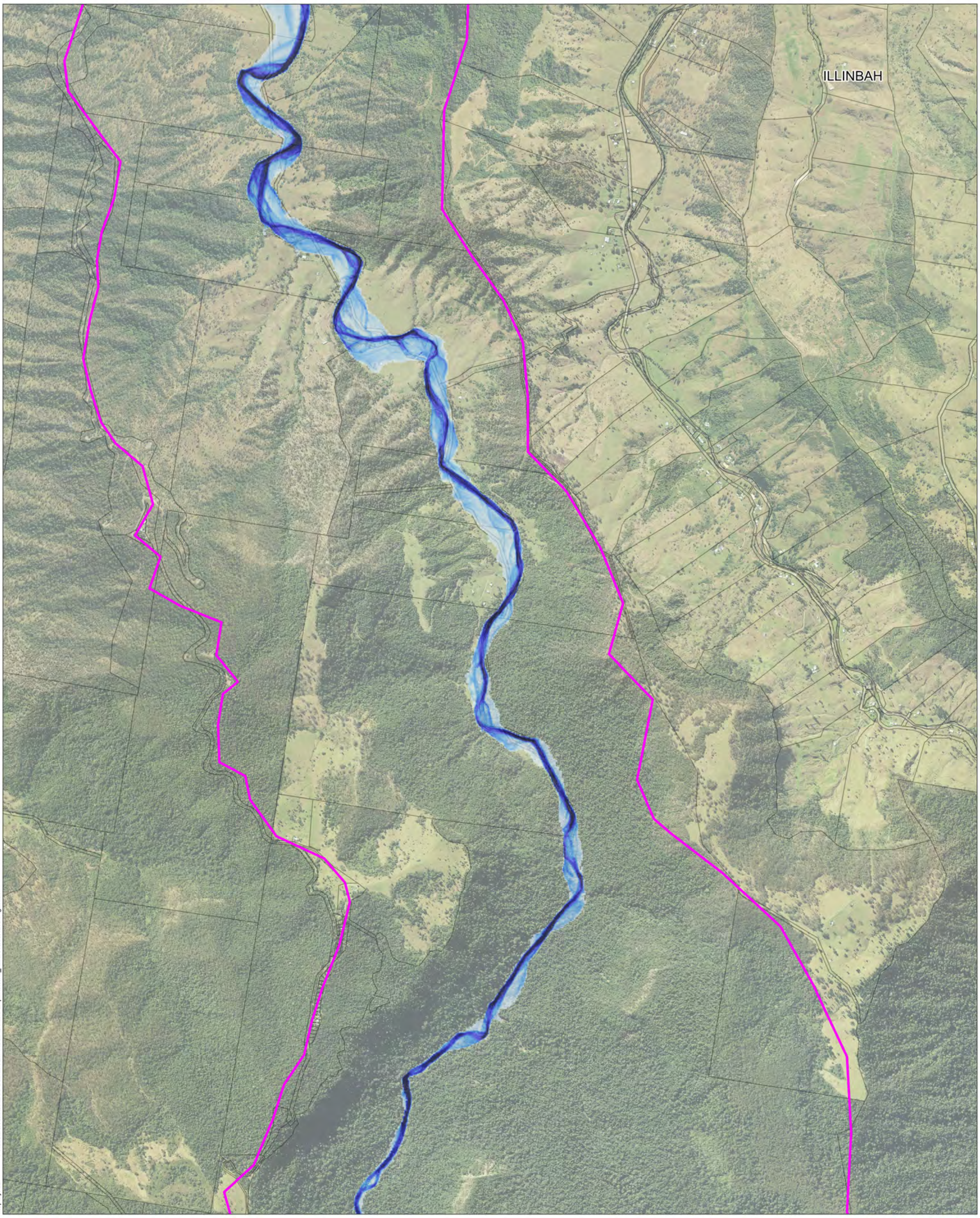
0 625 m 1,250 m

Date: 17/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure B3-d**

1% AEP + Climate Change (CC4-5) Event - Peak Depths



Legend

Depth (m)

SRRC Boundary	0.0 to 0.5	3.0 to 3.5
Cadastral Boundary	0.5 to 1.0	3.5 to 4.0
Hydraulic Model Extent	1.0 to 1.5	4.0 to 4.5
	1.5 to 2.0	4.5 to 5.0
	2.0 to 2.5	> 5.0
	2.5 to 3.0	

Notes:

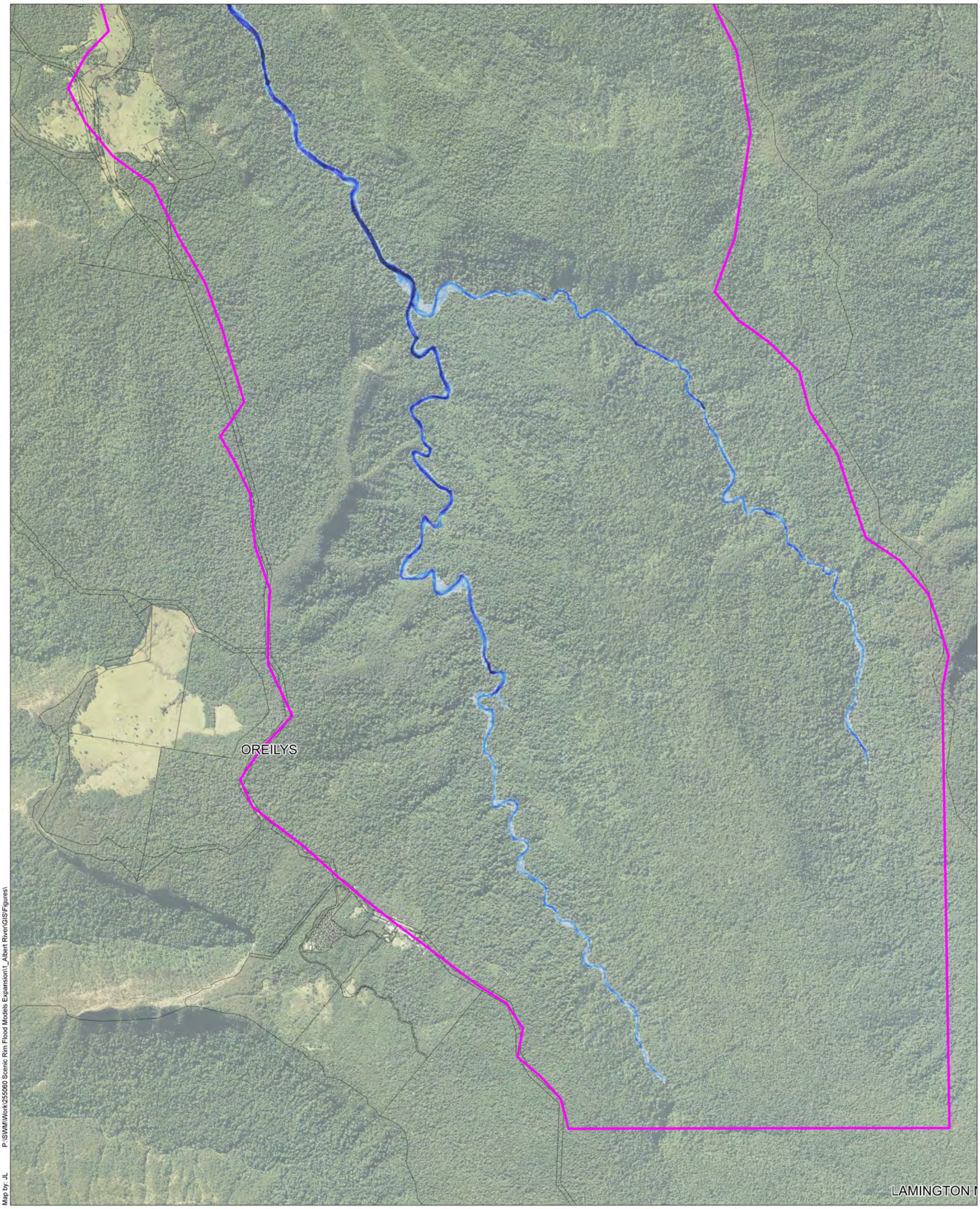
1:25,000
0 625 m 1,250 m

Date: 17/11/2018 Version: 0 Job No: 252966
Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure B3-e**

1% AEP + Climate Change (CC4-5) Event - Peak Depths

aurecon



Legend

- SRRC Boundary
- Cadastral Boundary
- Hydraulic Model Extent

Depth (m)

0.0 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0
2.5 to 3.0	

Notes:

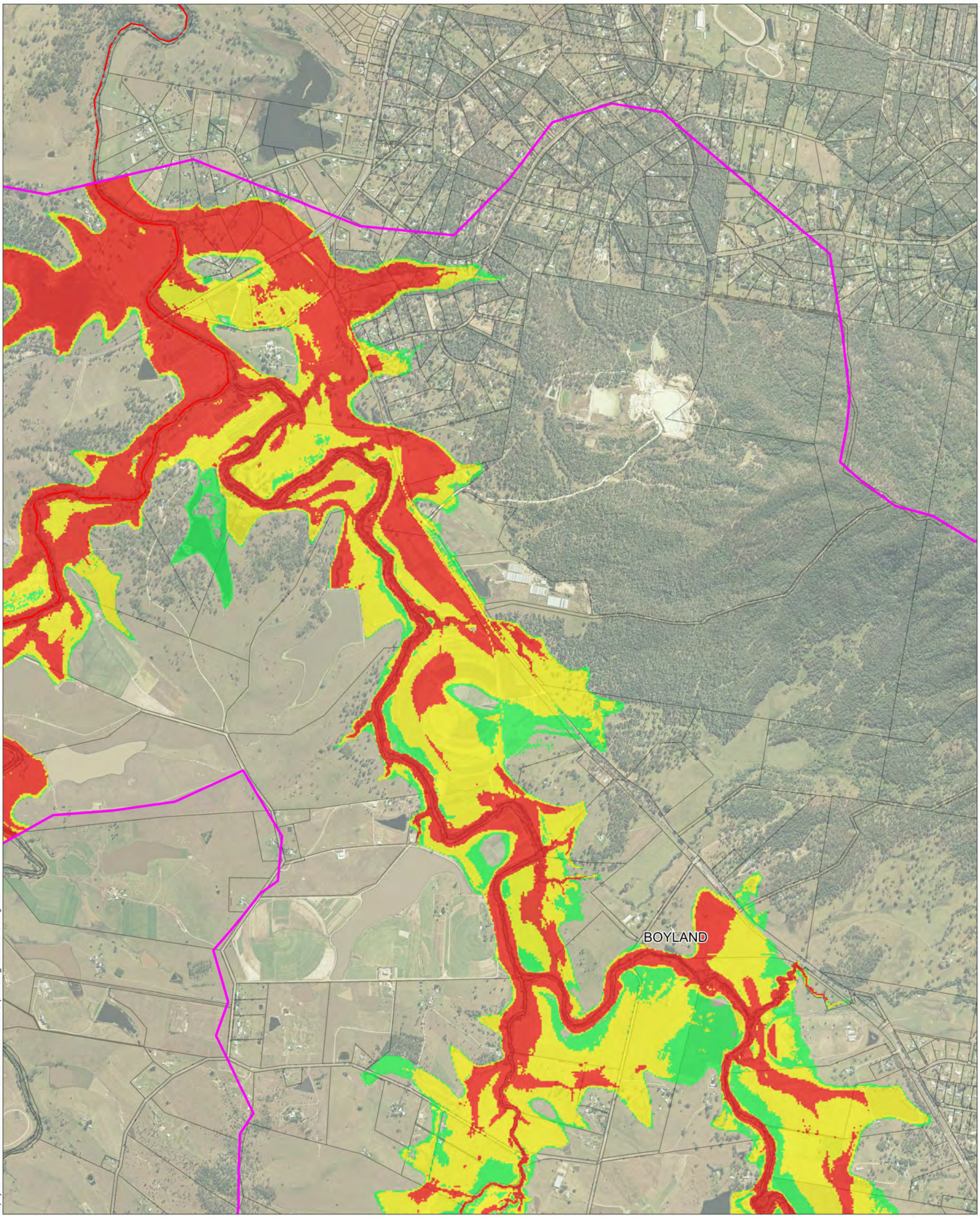
1:25,000
0 625 m 1,250 m

Date: 17/11/2018 Version: 0 Job No: 252966
Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure B3-f**

1% AEP + Climate Change (CC4-5) Event - Peak Depths

aurecon



Legend

SRRC Boundary
Cadastral Boundary
Hydraulic Model Extent

Low Hazard
Medium Hazard
High Hazard

Notes:

1:25,000

0 625 m 1,250 m

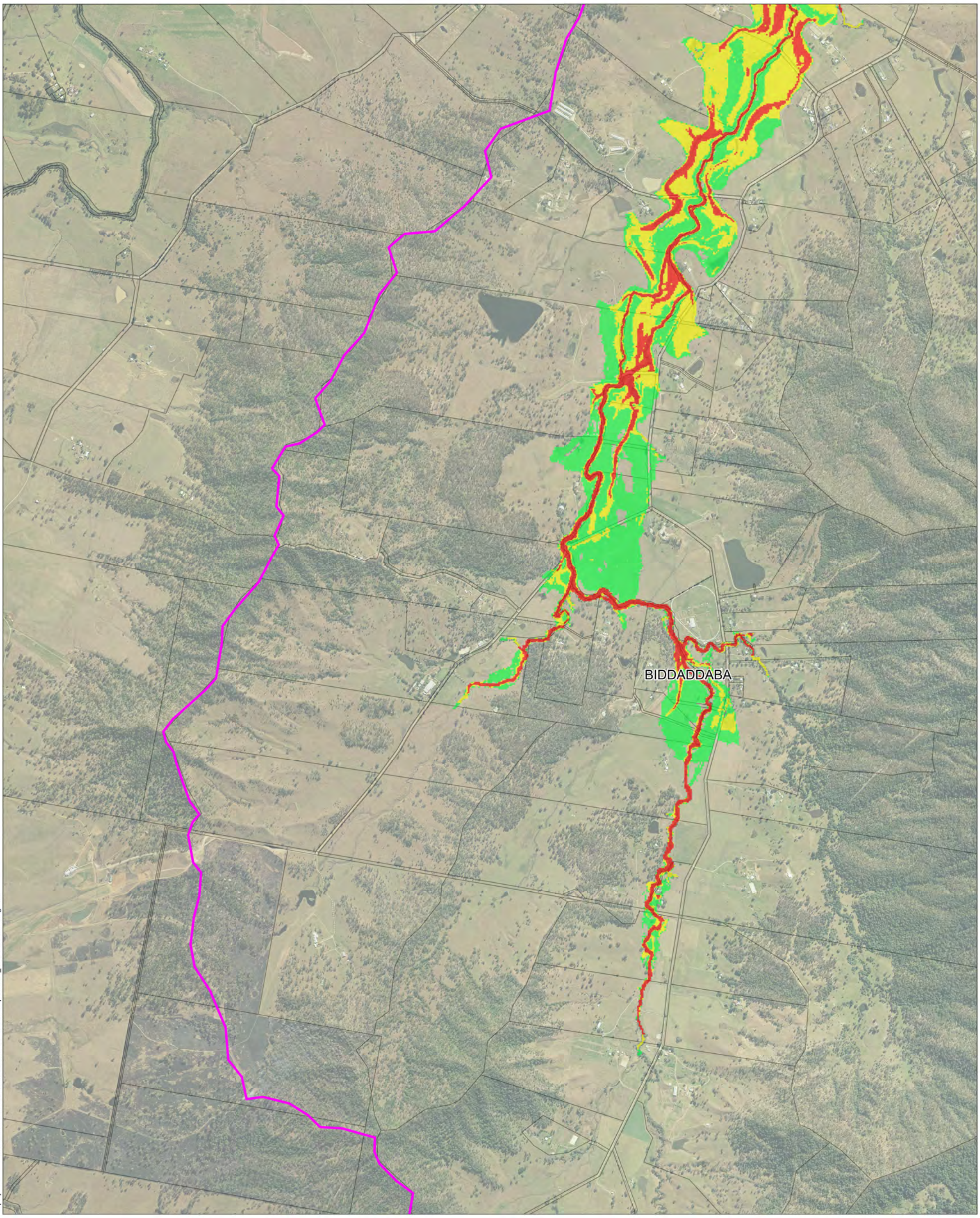
Date: 17/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure B4-a**

1% AEP + Climate Change (CC4-5) Event - Peak Hazards

aurecon



Map by: JL

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Legend

- SRRC Boundary
- Cadastral Boundary
- Hydraulic Model Extent
- Low Hazard
- Medium Hazard
- High Hazard

Notes:

1:25,000

0 625 m 1,250 m

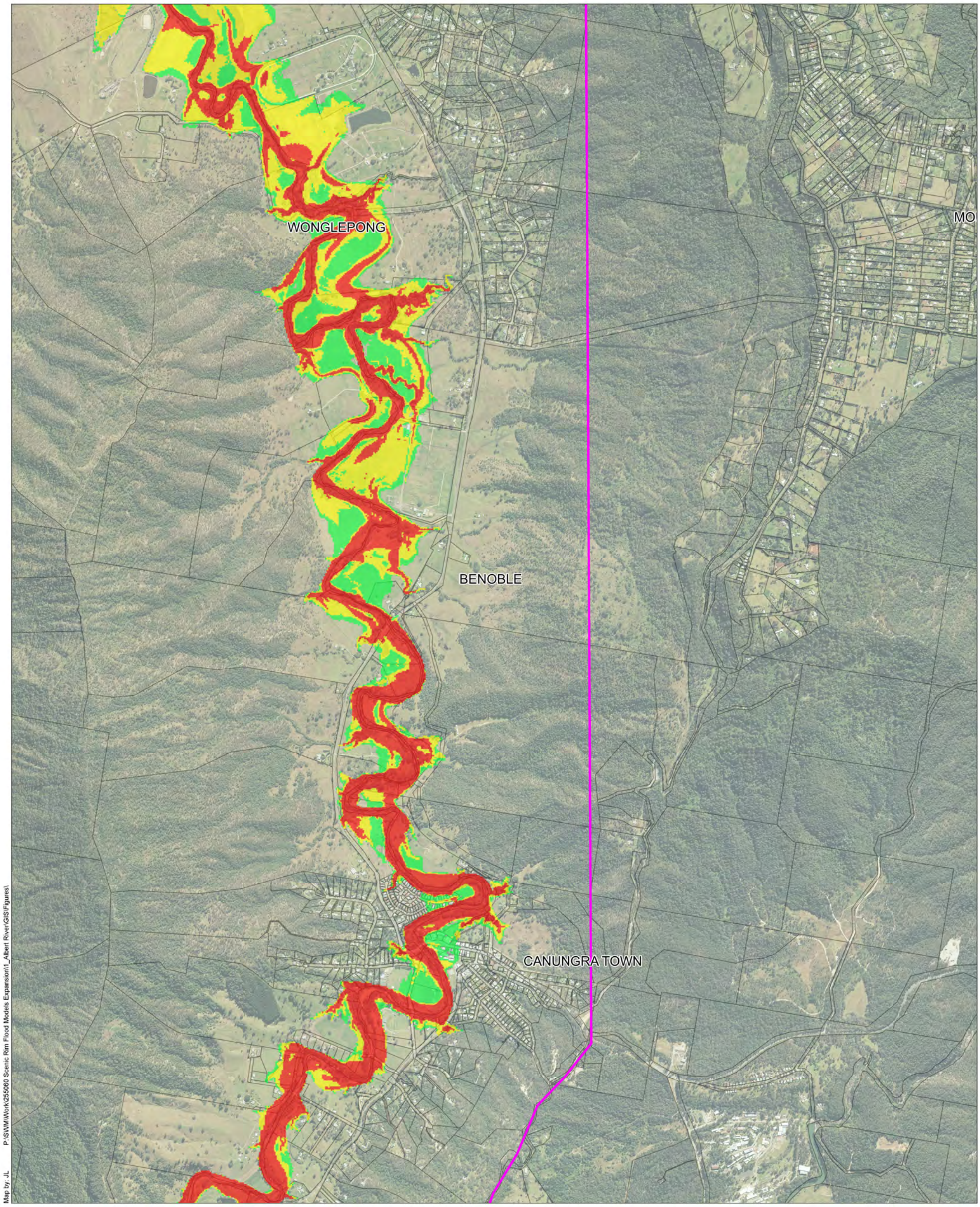
Date: 17/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study Figure B4-b

1% AEP + Climate Change (CC4-5) Event - Peak Hazards

aurecon



Legend

- SRRC Boundary
- Cadastral Boundary
- Hydraulic Model Extent
- Low Hazard
- Medium Hazard
- High Hazard

Notes:

1:25,000

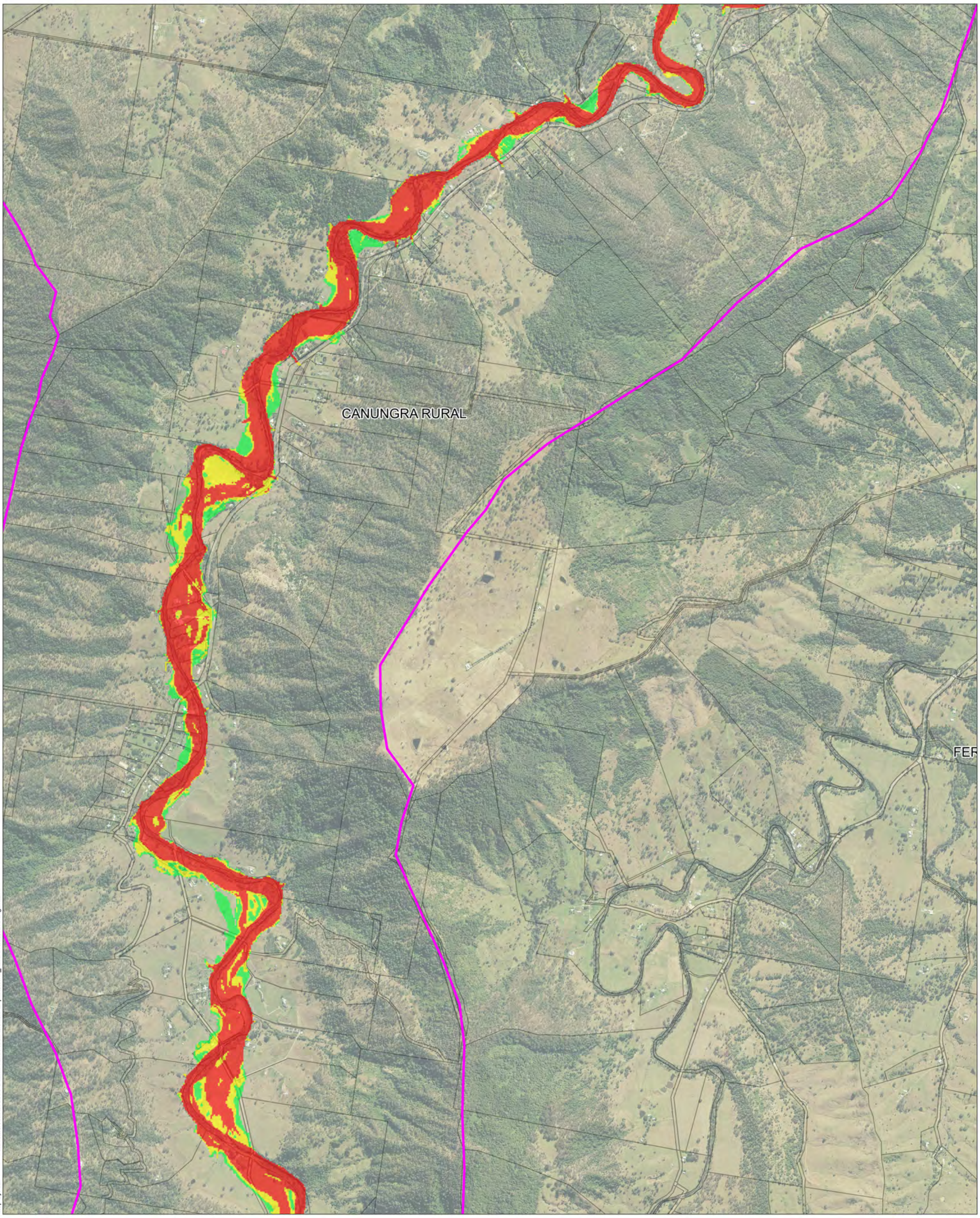
0 625 m 1,250 m

Date: 17/11/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure B4-c**

1% AEP + Climate Change (CC4-5) Event - Peak Hazards



Map by: JL
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Legend

- SRRC Boundary
- Cadastral Boundary
- Hydraulic Model Extent
- Low Hazard
- Medium Hazard
- High Hazard

Notes:

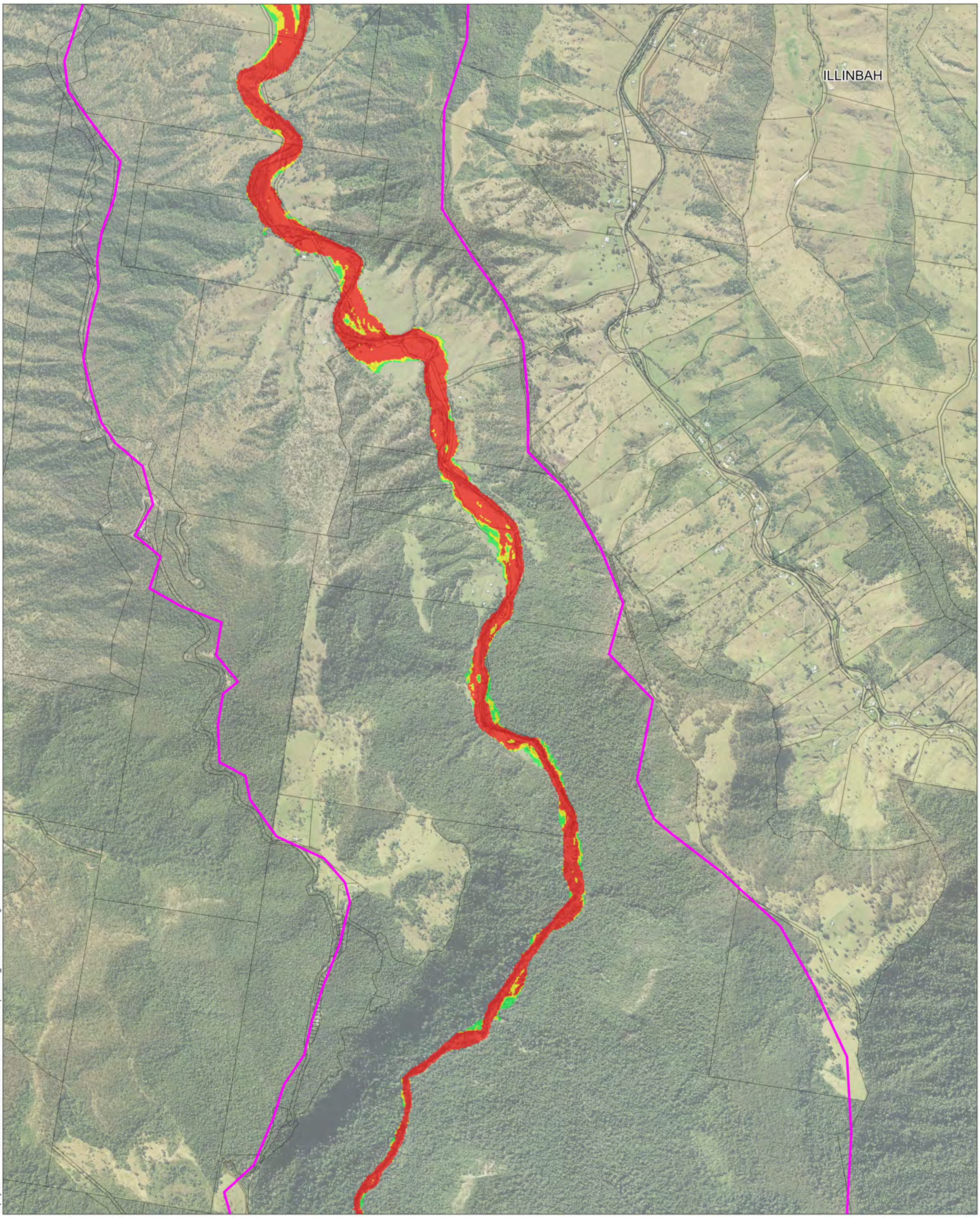
1:25,000
0 625 m 1,250 m

Date: 17/11/2018 Version: 0 Job No: 252966
Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure B4-d**

1% AEP + Climate Change (CC4-5) Event - Peak Hazards

aurecon



Legend

SRRC Boundary
Cadastral Boundary
Hydraulic Model Extent

Low Hazard
Medium Hazard
High Hazard

Notes:

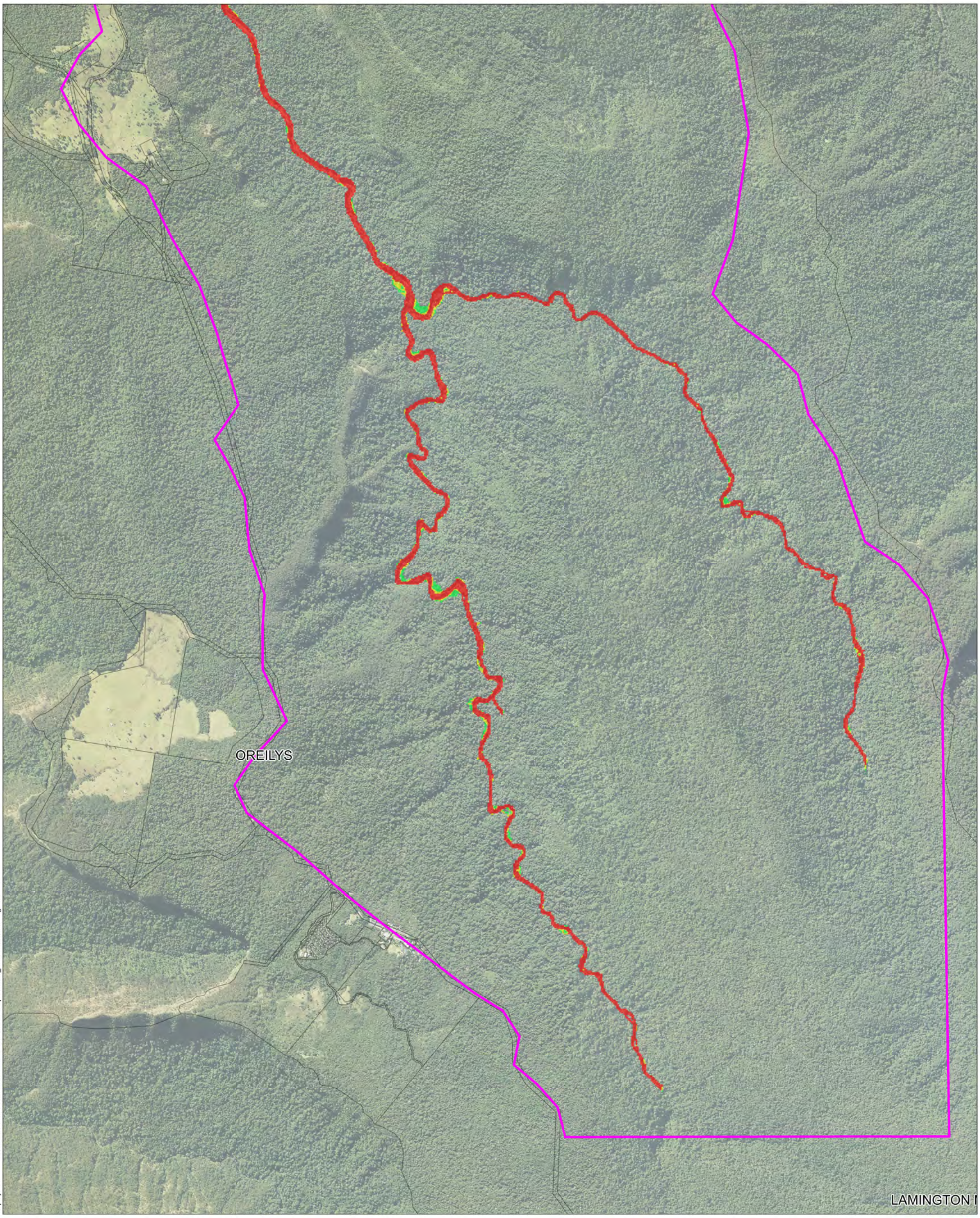
1:25,000
0 625 m 1,250 m

Date: 17/11/2018 Version: 0 Job No: 252966
Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study **Figure B4-e**

1% AEP + Climate Change (CC4-5) Event - Peak Hazards

aurecon



Map by: JL   P:\SWM\Work\255060 Scenic Rim Flood Models Expansion\1_Albert River\GIS\Figures\

Legend

- SRRC Boundary
- Cadastral Boundary
- Hydraulic Model Extent
- Low Hazard
- Medium Hazard
- High Hazard

Notes:

1:25,000

0   625 m   1,250 m

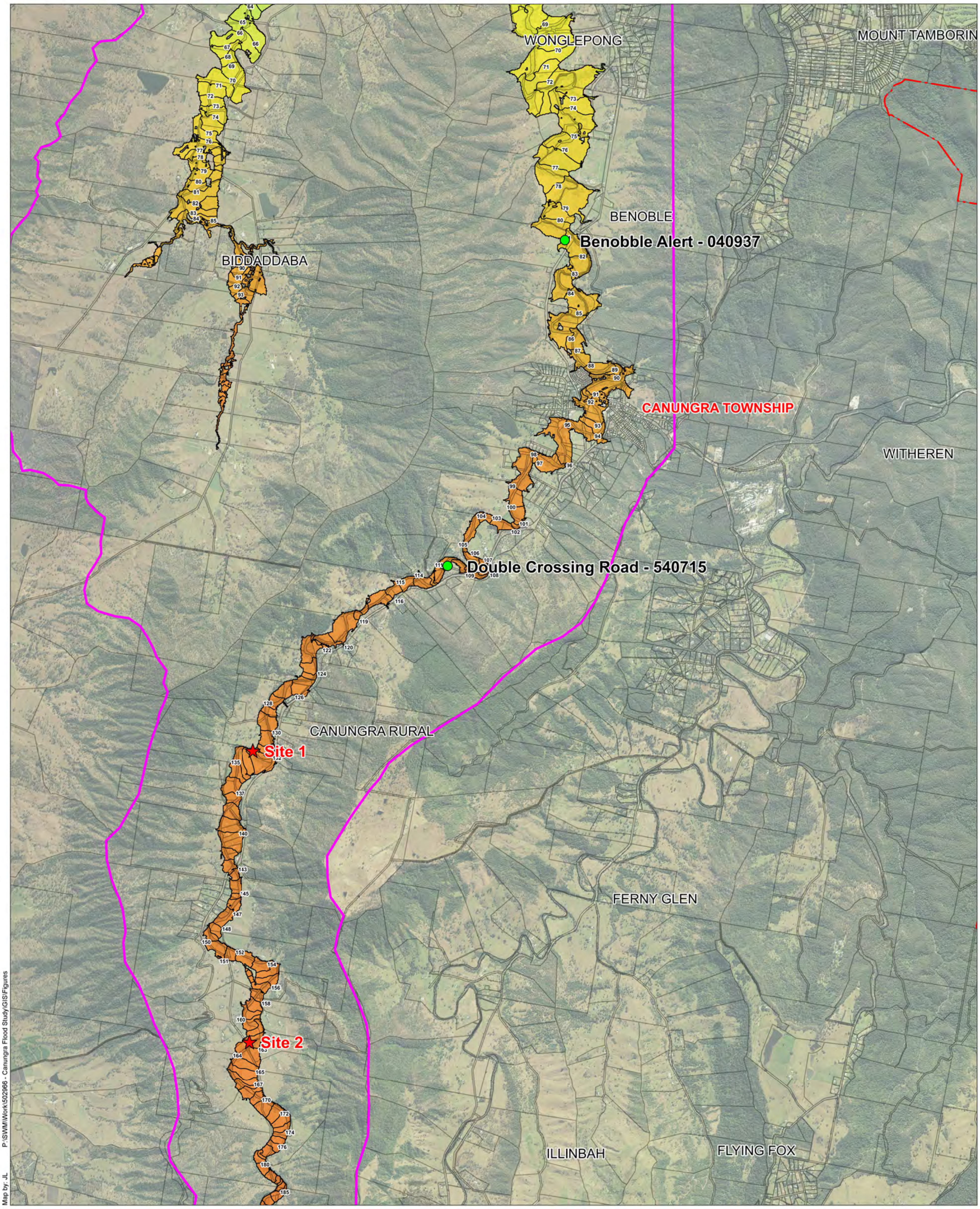
Date: 17/11/2018   Version: 0   Job No: 252966

Projection: MGA Zone 56

Canungra & Biddaddaba Flood Study   **Figure B4-f**

1% AEP + Climate Change (CC4-5) Event - Peak Hazards

aurecon



Legend

- Casdastral Boundary
- SRRC Boundary
- Hydraulic Model Extent
- Existing Alert Gauge Locations
- Potential New Alert Gauge Locations
- Inundation Extent - 1% AEP + CC4-5
- Peak Water Level Contour (mAHD)

Notes:

1:50,000

0 500 m 1,000 m

Date: 04/12/2018 Version: 0 Job No: 252966

Projection: MGA Zone 56

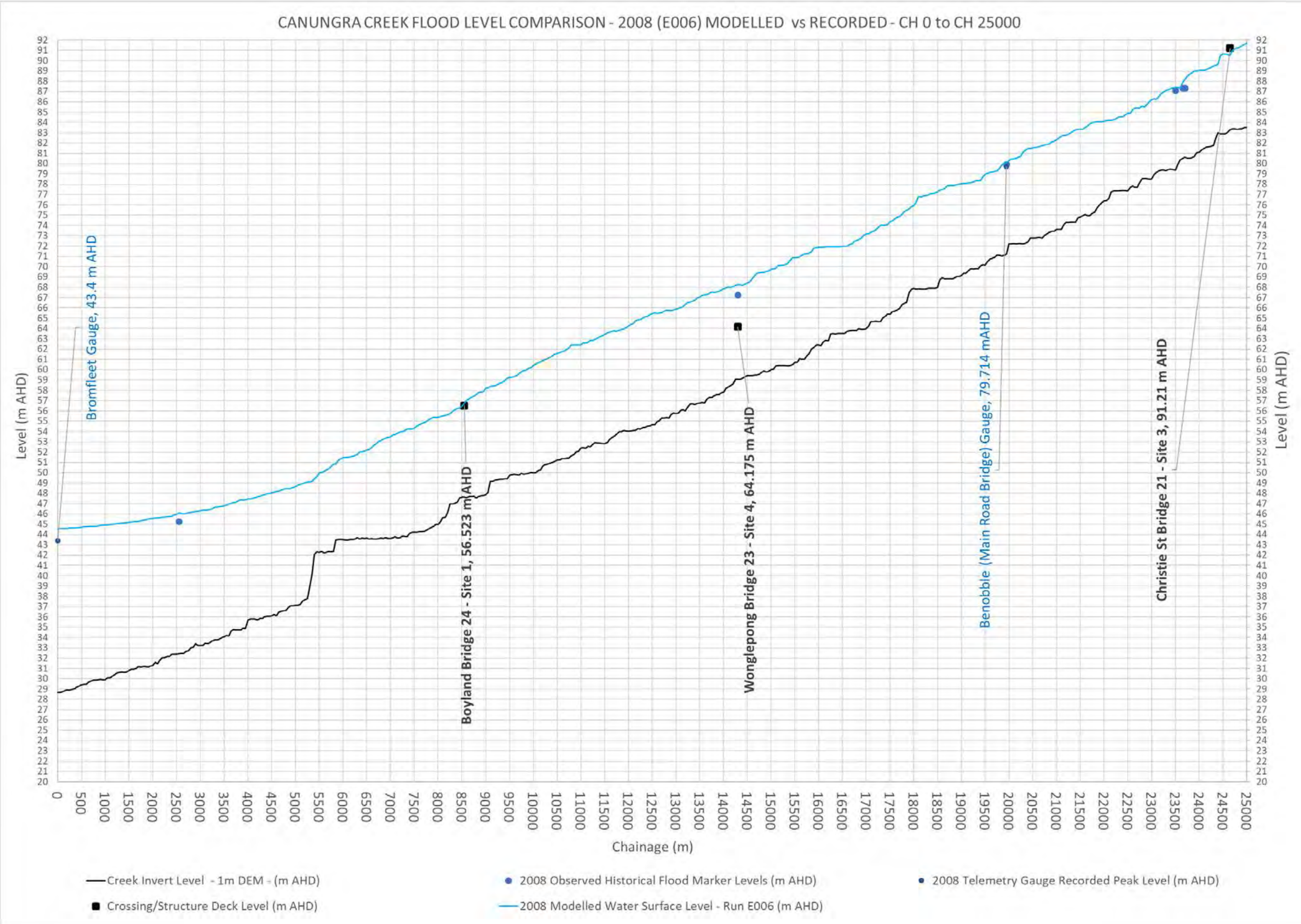
Canungra & Biddaddaba Flood Study **Figure C**

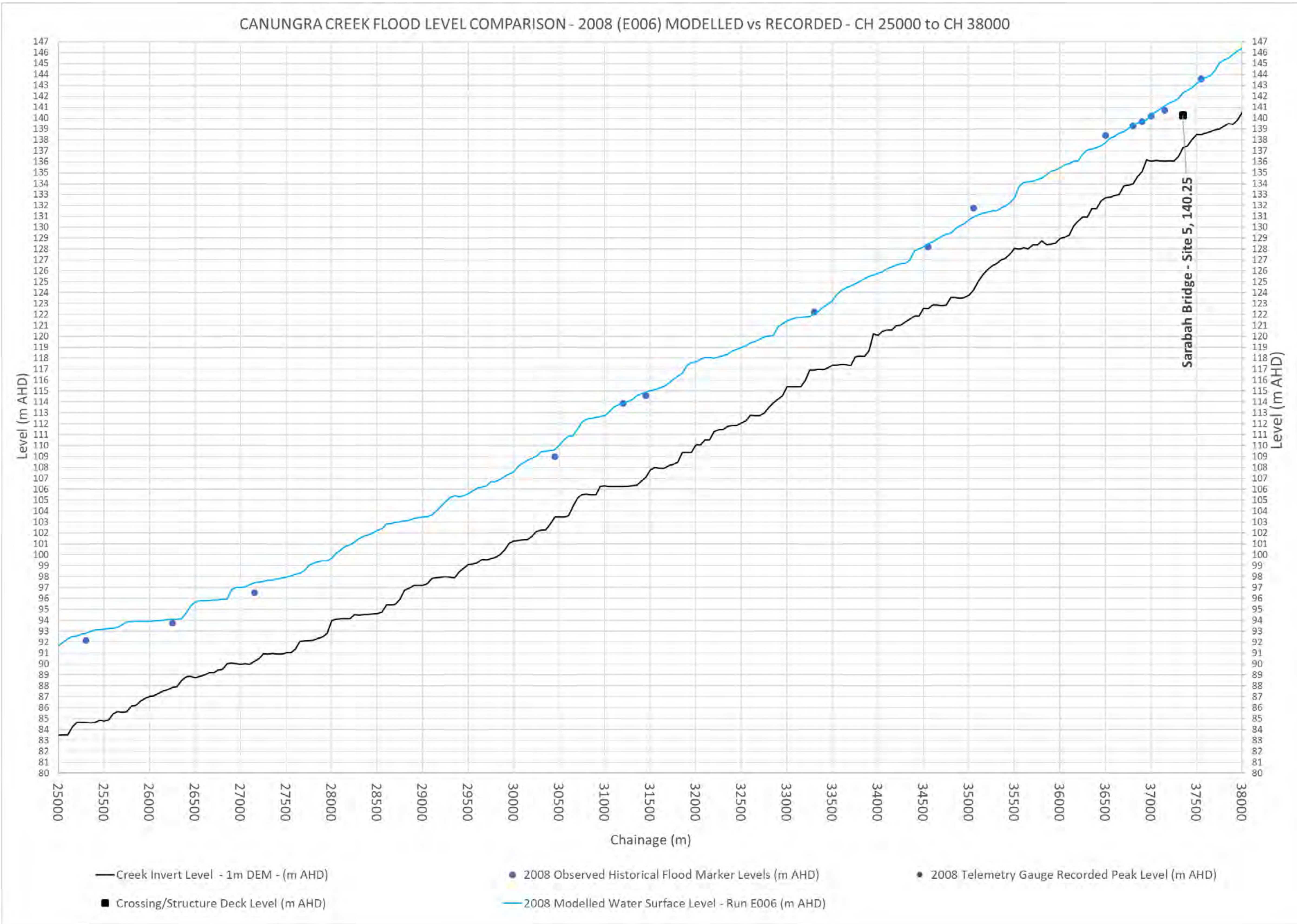
Emergency Management Map

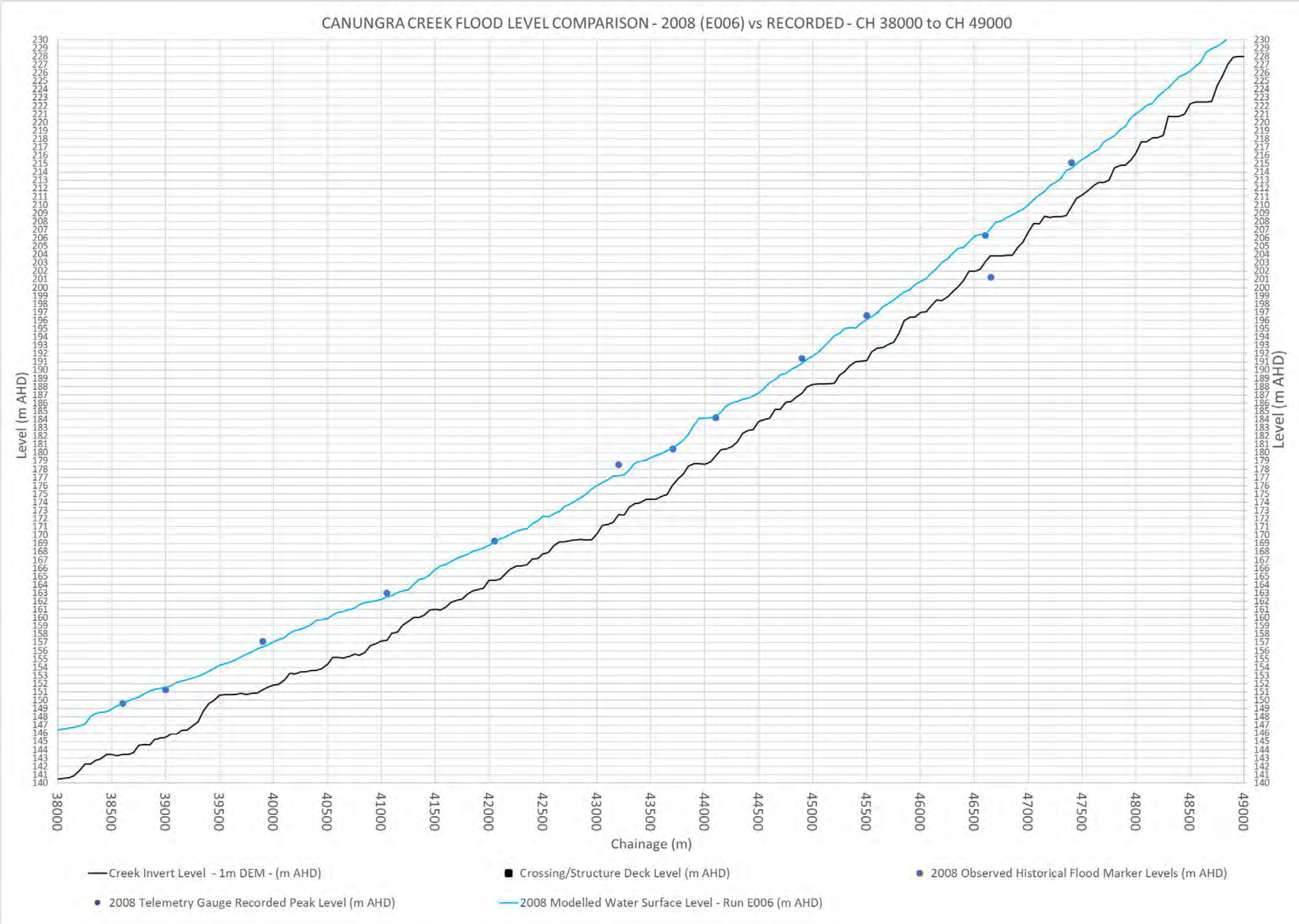
Appendix B

2008 Calibration Figures

ATTACHMENT A – Modelled 2008 (E006) vs 2008 Observed – Long Section Comparison




CANUNGRA CREEK FLOOD LEVEL COMPARISON - 2008 (E006) MODELLED vs RECORDED - CH 25000 to CH 38000
Level (m AHD)
Chainage (m)
Sarabah Bridge - Site 5, 140.25
Creek Invert Level - 1m DEM - (m AHD)
2008 Observed Historical Flood Marker Levels (m AHD)
2008 Telemetry Gauge Recorded Peak Level (m AHD)
Crossing/Structure Deck Level (m AHD)
2008 Modelled Water Surface Level - Run E006 (m AHD)



CANUNGRA CREEK FLOOD LEVEL COMPARISON - 2008 (E006) vs RECORDED - CH 38000 to CH 49000
Level (m AHD)
Chainage (m)
Creek Invert Level - 1m DEM - (m AHD)
Crossing/Structure Deck Level (m AHD)
2008 Observed Historical Flood Marker Levels (m AHD)
2008 Telemetry Gauge Recorded Peak Level (m AHD)
2008 Modelled Water Surface Level - Run E006 (m AHD)

ATTACHMENT B – Modelled 2008 (E006) vs 2008 Observed – Tabulated Comparison

Location	Chainage (m)	Approximate Channel Invert (m AHD)	2008 Observed Flood Marker Level (m AHD)	2008 Observed Flood Marker Depth of Flow (m)	2008 Modelled Level (E006) (m AHD)	2008 Modelled Depth (E006) (m)	% Difference in flow depth Observed vs Modelled (m)
Mundoolun Connection Rd Lot 3 RP141768	2550	32.42	45.28	12.86	46.08	13.66	6.22%
Boyland Bridge Biddaddaba Rd	8550	47.63	56.60	8.97	56.72	9.09	1.35%
Wonglepong Bridge Beaudesert Nerang Rd	14300	59.06	67.24	8.18	68.25	9.19	12.36%
Benobble Bridge	19950	71.21	79.95	8.74	80.13	8.92	2.06%
Lot 90 SP138087	23500	79.40	87.10	7.70	87.41	8.01	4.05%
Sewerage Treatment Plant - Control Room	23650	80.50	87.33	6.83	87.85	7.34	7.54%
Sewerage Treatment Plant	23700	80.65	87.33	6.68	88.14	7.50	12.13%
Concrete Causeway Coburg Road	25300	84.67	92.18	7.51	92.83	8.16	8.70%
Murphy Bridge Murphy Rd	26250	87.87	93.78	5.91	94.10	6.23	5.44%
Geiger Bridge	27150	90.23	96.56	6.33	97.43	7.21	13.74%
Double Crossing Bridge	30450	103.47	109.00	5.53	109.64	6.17	11.52%
Lot 23 WD4101	31200	106.24	113.90	7.66	113.86	7.62	-0.47%
Concrete Causeway	31450	107.14	114.59	7.45	114.92	7.78	4.44%
Curtis Bridge	33300	116.93	122.28	5.35	122.10	5.16	-3.42%
Concrete causeway Curtis Road	34550	122.54	128.22	5.68	128.48	5.94	4.58%
Lot 3 RP193583	35050	124.25	131.78	7.53	130.97	6.73	-10.70%
Bridge on Colvin Rd	36500	132.70	138.43	5.73	137.74	5.04	-12.07%
Lot 5 RP868688	36800	133.95	139.30	5.35	139.39	5.43	1.62%
Lot 5 RP868688	36900	135.11	139.71	4.61	139.66	4.56	-1.05%
Lot 2 RP854891	37000	136.06	140.19	4.13	140.36	4.30	4.09%
Lot 3 RP854891	37150	136.06	140.74	4.68	141.13	5.07	8.34%
Lot3 RP171682	37550	138.52	143.61	5.09	143.47	4.95	-2.83%
Lot 5 RP40093	38600	143.39	149.61	6.22	149.52	6.13	-1.42%
Lot 6 RP40093	39000	145.53	151.29	5.76	151.56	6.03	4.66%
Rymera Rd	39900	151.25	157.12	5.88	156.48	5.23	-11.03%
Lot 10 SP123012	41050	157.23	162.98	5.75	162.51	5.28	-8.23%
Sarabah Rd Lot 6 RP208436	42050	164.55	169.32	4.78	169.14	4.59	-3.88%
Sarabah Rd Lot 21 RP908220	43200	172.49	178.54	6.04	177.21	4.72	-21.91%
Sarabah Rd Lot 1 RP40398	43700	176.05	180.46	4.41	180.55	4.50	2.12%
Lot 16 W311132	44100	179.61	184.25	4.64	184.30	4.69	1.17%
Canungra Ck Lot 17 W311132	44900	187.17	191.44	4.26	190.78	3.61	-15.42%
Sarabah Rd Lot 17 W311132	45500	191.11	196.61	5.50	196.12	5.01	-8.92%
Sarabah Rd	46600	203.10	206.36	3.26	206.42	3.32	2.01%
Lot 2 RP49857	46650	203.84	201.26	-2.58	207.09	3.25	-226.02%
Sarabah Rd	47400	209.80	215.13	5.32	214.46	4.66	-12.44%

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