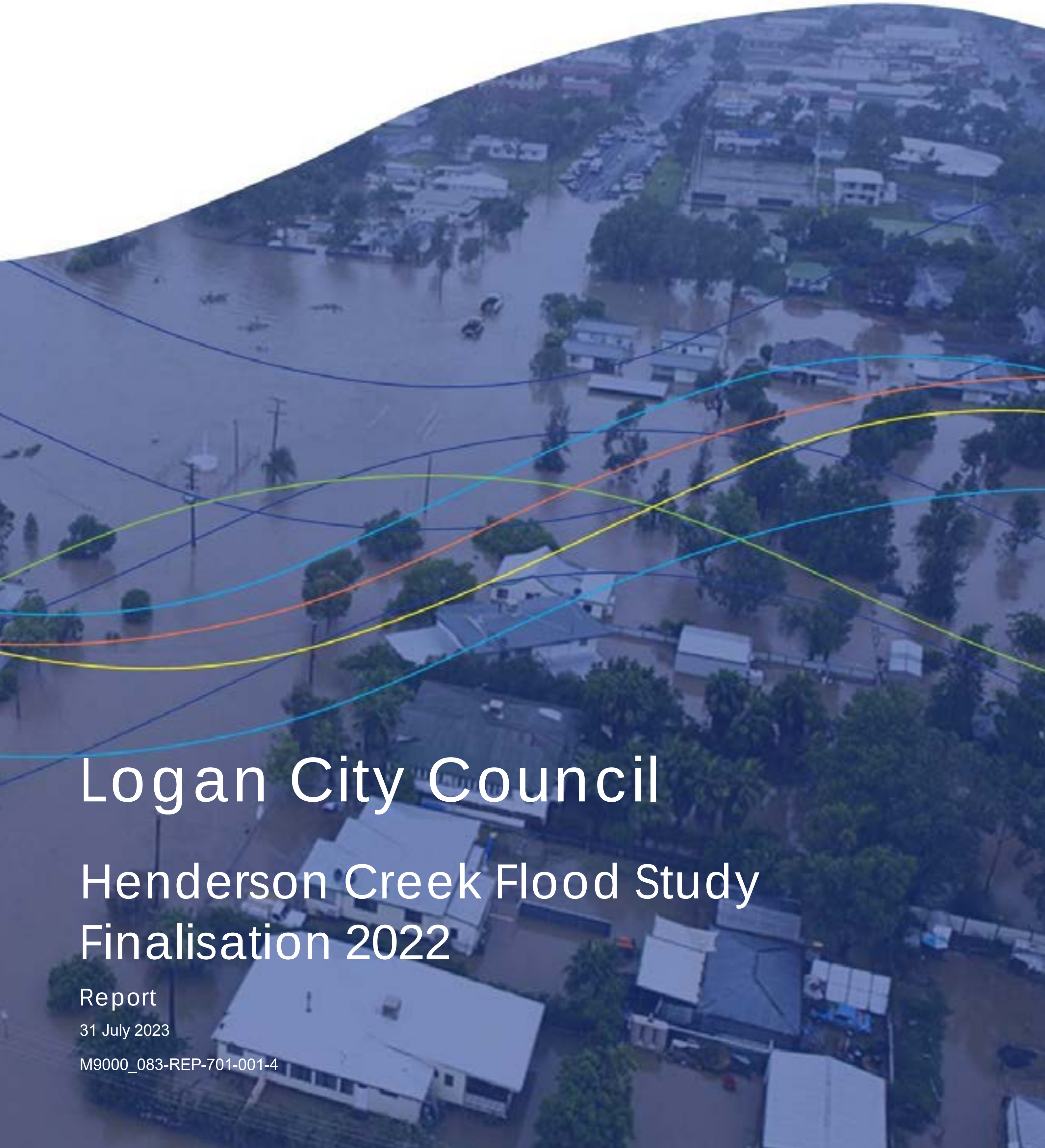

Logan City Council

Henderson Creek Flood Study Finalisation 2022

Report

31 July 2023

M9000_083-REP-701-001-4

Job no. and Project Name: M9000_083 Henderson Creek Flood Study Finalisation 2022
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Rev	Date	Description	Author	Reviewer	Project Mgr.	Approver
0	23/11/2022	Draft Issue – Flood Study	Kelsey Mundt	Mark Page	Mark Page	Daniel Niven
1	7/03/2023	Client Issue – Flood Study	Kelsey Mundt	Mark Page	Mark Page	Daniel Niven
2	12/05/2023	Draft Report – Floodplain Risk Management	Kelsey Mundt	Mark Page	Mark Page	Daniel Niven
3	20/07/2023	Draft Report – Floodplain Risk Management	Kelsey Mundt	Mark Page	Mark Page	Daniel Niven
4	31/07/2023	Final Issue	Kelsey Mundt	Mark Page RPEQ 15454	Mark Page RPEQ 15454	Daniel Niven
Signatures						

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1 INTRODUCTION

1.1 BACKGROUND AND OBJECTIVES

Engeny previously developed a consolidated 1D/2D flood model (Engeny, 2017) covering the extent of the Henderson, Strachan and Jimboomba Creek catchments to provide a consistent approach to development of flood levels across the catchments. The flood model was based on the ARR 1987 methodology and data.

Engeny was subsequently engaged by Logan City Council (Council) to undertake an updated flood study for the Henderson, Strachan and Jimboomba Creek catchments in accordance with the latest Australian Rainfall and Runoff 2019 (ARR 19) Guideline (Ball et. Al, 2019) and to reflect LiDAR topographical data captured in late 2021. Strachan and Jimboomba Creeks are tributaries of Henderson Creek, which ultimately flows into the Logan River. The location of the study area is illustrated in Figure 1.1.

The objective of this study was to provide Council with updated flood modelling and mapping, as well as a high-level flood risk management plan to inform strategic land use zoning and define flood risks for localised catchment scale flooding.

1.2 CATCHMENT DESCRIPTION

Henderson Creek is a tributary of the Logan River, located in the middle of the Logan River catchment and encompasses the suburb of Jimboomba and surrounding areas. Strachan Creek and Jimboomba Creek are major tributaries of Henderson Creek. The overall catchment area of the Henderson Creek system is approximately 44 km^2.

The upper catchment originates in the Birnam Range area, with elevations reaching up to 215 m AHD. The upper catchment is characterised by relatively steep terrain with elevations generally dropping to below 100 m AHD within 500 m of the catchment boundary. Land use within the upper catchment is predominately natural bushland and rural residential, with the exception of the Jimboomba Woods residential development in the upper Henderson Creek catchment.

The floodplain within the mid-catchment (upstream of the Mount Lindsay Hwy) is relatively flat with elevations typically between 20 m AHD and 50 m AHD. Land use within the mid-catchment is mainly rural or rural residential with some more densely urbanised and commercial land uses around the Jimboomba town centre.

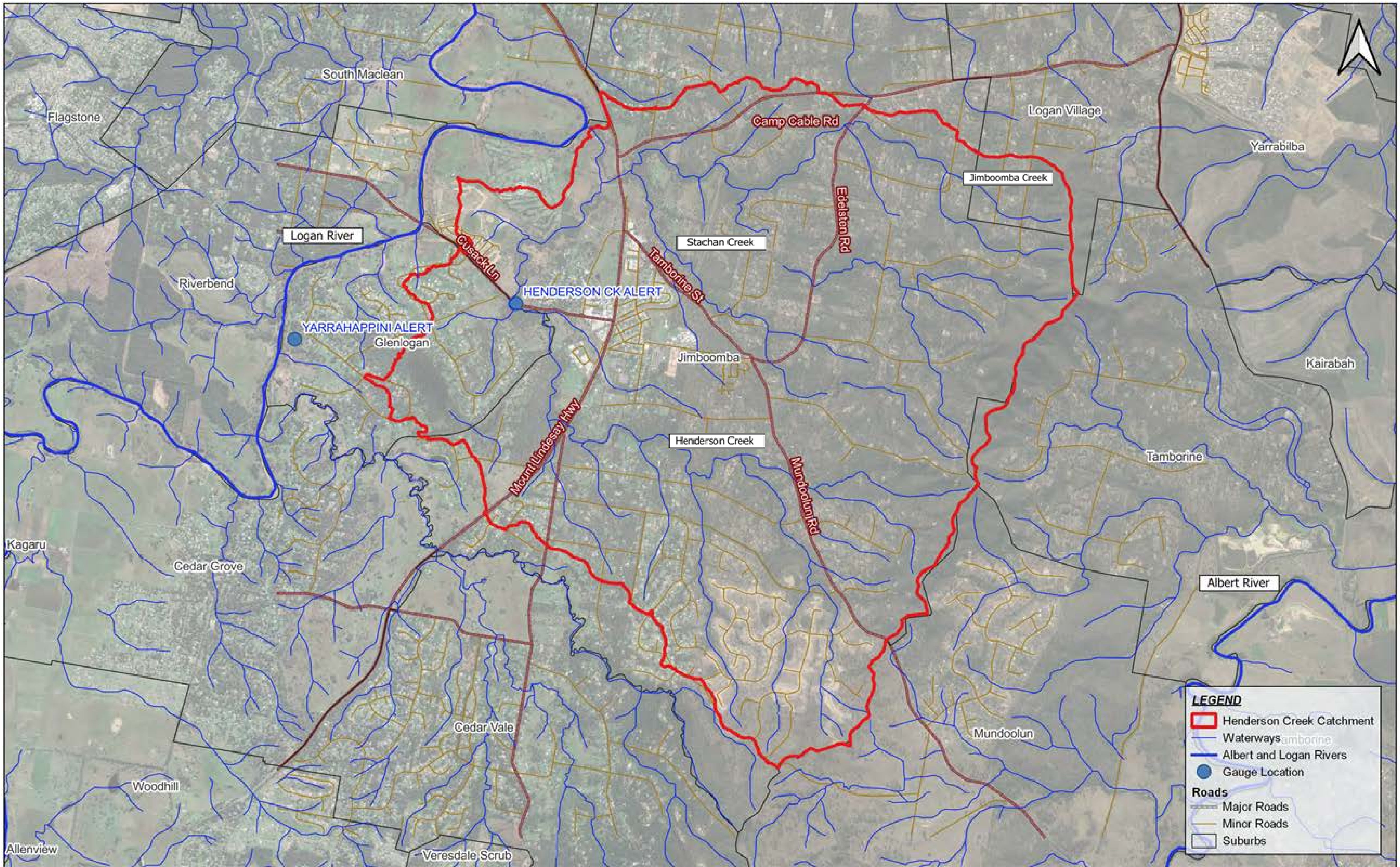
The lower catchment (downstream of the Mount Lindsay Hwy) is typified by very flat grades, with the majority of the area between 10 m AHD and 20 m AHD. Land use within the lower catchment is characterised by large areas of open space along the waterways with some low-density residential properties in the upper catchment.

1.3 STUDY SCOPE

The study scope is outlined as follows:

- Collect and review the most recent Council datasets relating to flooding and drainage within the Henderson Creek system.
- Develop a XPRAFTS hydrologic model for the Henderson Creek catchment in accordance with latest ARR 2019 (Ball et. al., 2019) guidance.
- Develop a 1D/2D TUFLOW model for the Henderson Creek catchment.
- Calculation of design hydrologic flows for the 1:2, 1:5, 1:10, 1:20, 1:50, 1:100, 1:200, 1:500, 1:2,000 AEP and PMP rainfall events and simulation of corresponding flood events using the 1D/2D TUFLOW model.
- Calibration of the XPRAFTS and TUFLOW models to historical storm events.
- Validation of adopted design flows to regional methods and existing models.
- Simulation of design hydrology for various 2090 climate change Representative Concentration Pathway (RCP) scenarios:
  - RCP4.5 for 1:5, 1:10, 1:20, 1:50, 1:100, 1:200, and 1:500 AEP flood events.
  - RCP6.0 and RCP8.5 for the 1:100 AEP flood event.
- Undertake sensitivity analyses (1:100 AEP) for:
  - No blockage of hydraulic structures.

- Increased percentage blockage of hydraulic structures, in accordance with ARR 2019 guidelines.
- Increased hydraulic roughness of 20%.
- Alternative tailwater assumption
- Increase of hydraulic roughness in the waterway extent to represent revegetation.



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Henderson Creek Flood Study Update

Locality Map

Figure 1.1

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2 PROJECT DATA

2.1 TOPOGRAPHIC DATA

1m LiDAR (captured in 2021) topographic survey dataset for the entire catchment was provided by LCC. The datasets were provided in the form of a processed Tagged Image File format which was post-processed to an .asc Digital Elevation Model.

2.2 AERIAL IMAGERY

High resolution aerial imagery was provided by LCC captured in conjunction with the LiDAR in 2021.

2.3 LOGAN CITY COUNCIL GIS DATASETS

The following GIS data were supplied for use in this study:

- Culverts, pipes and bridge information.
- Waterway corridors.
- Land use spatial data (planning scheme zoning).
- Road network spatial data.
- Headwalls.
- Open drains.

2.4 SITE OBSERVATIONS

Council officers undertook a site-based data collection exercise to collect information on hydraulic structures where data was not available within Council's GIS asset database. The dimension, invert level and configuration of structures was captured during this process. This was not a formal survey process, with field observations provided only. As-construction drawings were supplied for hydraulic structures, where available and requested.

2.5 RAINFALL AND RIVER GAUGING

The following datasets were provided by Council for use in the study. No debris survey markers from historical rainfall events were supplied.

- Yarrahappini Alert Water Level Gauging (2015, 2016 and 2017 historical events).
- Henderson Creek Alert Water Level Gauging (2015, 2016 and 2017 historical events).
- Yarrahappini Alert Rainfall Gauging (2015, 2016 and 2017 historical events).

2.6 PREVIOUS STUDIES

2.6.1 Logan Albert Rivers Flood Study (WRM, 2021)

The *Logan Albert Rivers Flood Study* was updated by WRM in 2021. The hydrologic and hydraulic model was calibrated to 1974, 1990, 2013 and 2017 flood events. The hydraulic model was reconfigured and amended with the LCC 2017 LiDAR topographical data. Further description of the flood study is provided in the *Logan Albert Rivers Flood Study* report (WRM, 2021). The static water levels applied as the downstream boundary condition to the Henderson Creek Flood Study hydraulic model have been adopted from this study.

3 HYDROLOGIC MODEL DEVELOPMENT

3.1 OVERVIEW

Hydrologic modelling for this study was undertaken using XPRAFTS software to estimate catchment runoff. XPRAFTS is an industry-standard non-linear hydrologic routing package and has been used extensively in similar studies across Australia. Key input requirements for the XPRAFTS model are:

- Catchment area.
- Catchment slope.
- Degree of urbanisation.
- Rainfall loss rates.
- Design rainfall input.

For this study the two sub-catchment approach was adopted in XPRAFTS whereby pervious and impervious areas were considered separately.

3.2 XPRAFTS MODEL SETUP

3.2.1 Catchment Delineation

Sub catchment delineation and XPRAFTS model schematisation was performed using the CatchmentSIM software. CatchmentSIM utilises DEM terrain data to perform catchment hydrologic analysis such as catchment delineation. The 1 m DEM derived from the 2021 LiDAR data capture was used as the basis for sub-catchment delineation.

For the purpose of delineating the sub catchments for the XPRAFTS model, the following process was adopted:

- The original 1 m DEM was reduced to 5 m resolution to allow reasonable processing times for sub catchment delineation.
- The 5 m LiDAR DEM was pre-processed to remove pits and flats.
- A single outlet was defined at the mouth of the creek to establish the overall Henderson/Jimboomba/Strachan Creek system.
- Additional catchment outlets were defined at critical structure locations (particularly in the upper catchment) to ensure correct flows report to these locations.
- Automated catchment generation algorithms were used to provide additional catchment resolution. This formed the 'base' sub catchment definition.
- The automated catchment generation algorithm was used to delineate sub catchments over the entire catchment are using a target sub catchment area of 30 ha. This layer was then combined with the 'base' sub catchment layer to define the first sub catchment in each flowpath.

The adopted sub catchment delineation is shown in Figure 3.1.

3.2.2 Catchment Properties

A split sub catchment approach in XPRAFTS was adopted, with the following sub catchment characteristics incorporated into the model for the runoff routing calculation:

- Catchment area (pervious and impervious).
- Catchment slope.
- PERN.

Catchment area and slope were generated using CatchmentSIM. PERN values were adopted as per the values set out in Table 3.1. The PERN value is an empirical factor which modifies the estimated storage delay time coefficient (B), allowing differentiation between catchments with the same degree of urbanisation but different roughness. The adopted PERN values have been validated by comparing model results (peak flood level, timing and hydrograph shape) against the recorded water level at the Henderson Creek stream gauge for the three recent historical storm events. In addition, peak flows generated from the XPRAFTS model have been validated against *Queensland Urban Drainage Manual* (QUDM) (IPWEAQ, 2017) Rational Method estimates.

Table 3.1: XPRAFTS PERN Values

Land Use Type	PERN
Pervious Areas	0.05
Impervious Areas	0.015

The sub catchment fraction impervious was calculated by assigning a percentage impervious area to each land use (ultimate zoning) type within the supplied cadastre data. These areas were then intersected with the delineated sub catchments to define a weighted fraction impervious for each sub catchment. The fraction impervious area was then adopted as the area of the second sub catchment in XPRAFTS.

The percentage impervious values that were assigned to various land use types are summarised in Table 3.2.

Table 3.2: Adopted Fraction Impervious Values by Land Use Type

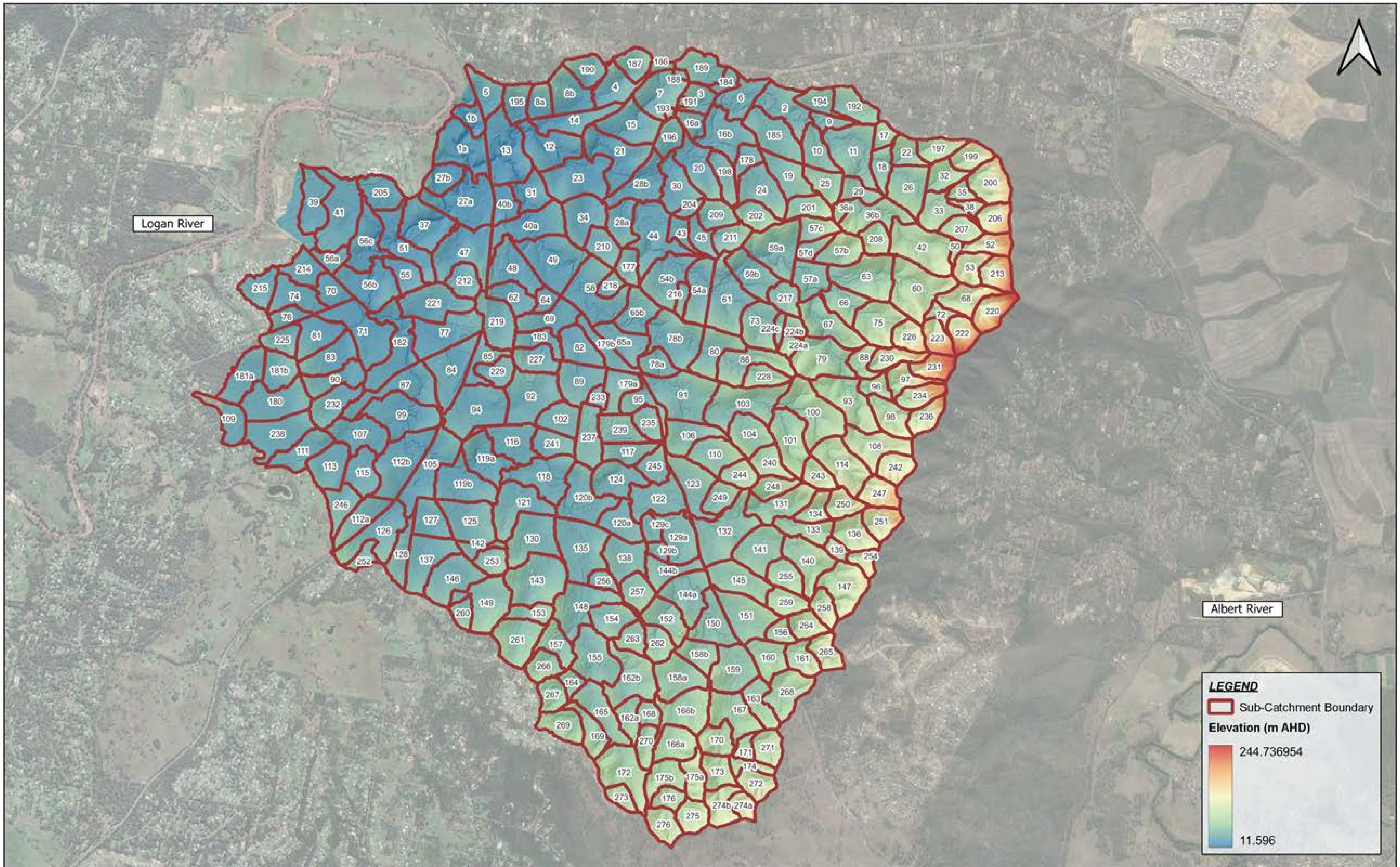
Land Use Type	Fraction Impervious
Centre	90%
Community Facilities	70%
Emerging Community	80%
Environmental Management and Conservation	0%
Low-Medium Density Residential	55%
Low Density Residential	45%
Low Impact Industry	50%
Mixed Use	90%
Recreation and Open Space	20%
Rural	2%
Rural Residential	10%
Special Purpose	65%
Road	90%

The adopted sub catchment properties are detailed in Appendix A.

3.2.3 Channel Routing

The channel routing approach was adopted for channel routing within the XPRAFTS model. This approach routes flow through sub catchments based on the typical channel cross section, hydraulic roughness, mean channel slope and total stream length. The adopted channel routing parameters were validated during the calibration phase and have also been validated to the design hydraulic model results.

It is noted, however, that no hydrologically routed flows have been used to determine design flood levels, with local flows for all sub catchments applied throughout the hydraulic model extent.



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DATA SOURCE
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Henderson Creek Flood Study Update

Sun-Catchment Layout and DEM

Figure 3.1

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4 HYDRAULIC MODEL DEVELOPMENT

4.1 OVERVIEW

The TUFLOW HPC modelling package was selected to undertake the updated hydraulic modelling for the Henderson Creek catchment. Hydrodynamically linked 1D/2D TUFLOW modelling is well suited to this catchment and has been successfully adopted for many similar catchments across Queensland. The hydraulic model layout is presented on Figure 4.3.

The following sections describe the development of the TUFLOW model.

4.2 MODEL TOPOGRAPHY AND EXTENT

The 1 m DEM derived from the 2021 LiDAR capture was used as the basis for the model topography. The 2D model domain covers the entire extent of the catchment.

4.3 GRID SIZE AND TIMESTEP

A grid cell size of 3 m was selected for the TUFLOW model. This resolution was selected to be of sufficient accuracy to model waterways and channels within the catchment while maintaining reasonable model runtimes. The TUFLOW HPC uses an adoptive time step to provide a stable model configuration.

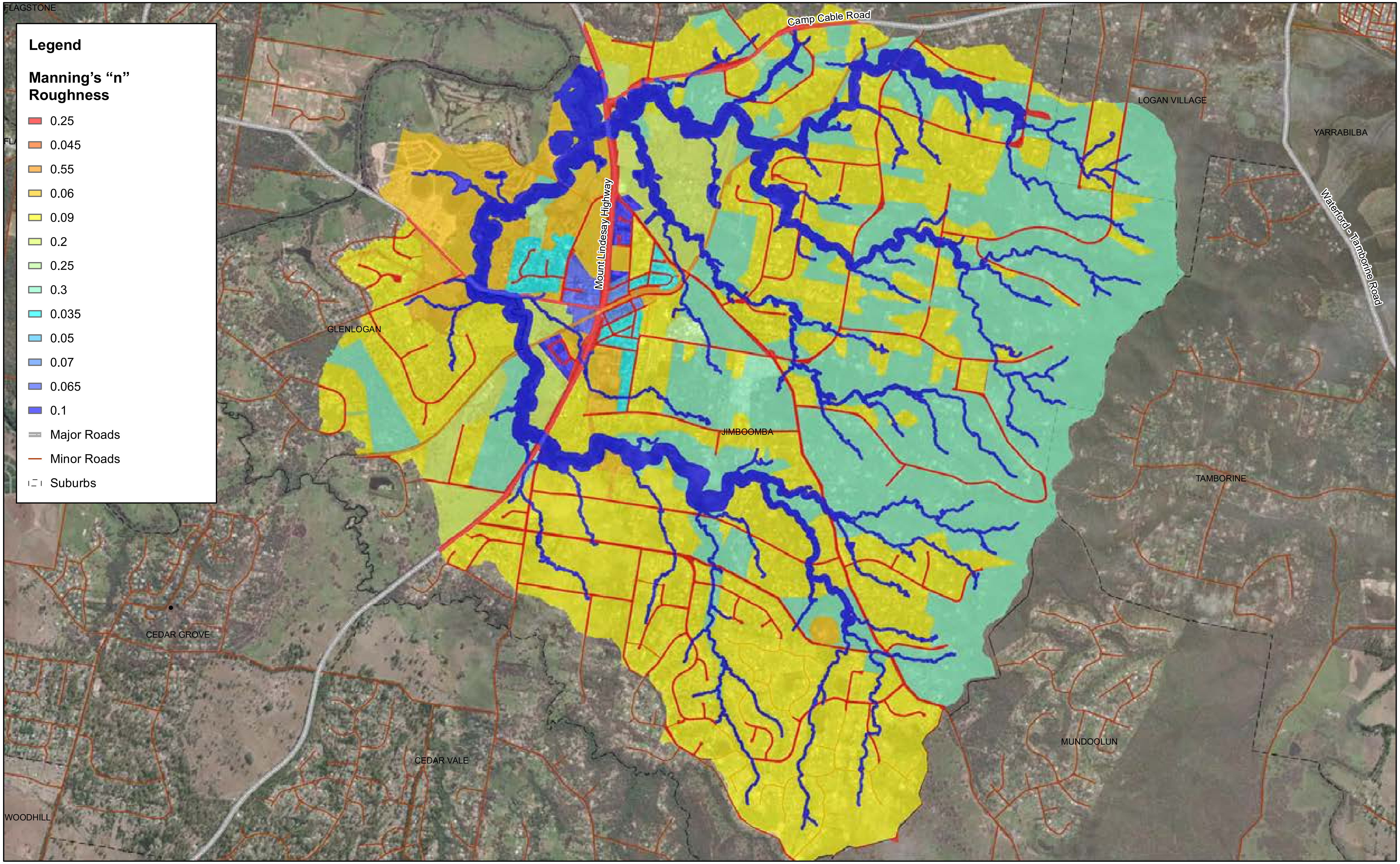
4.4 HYDRAULIC ROUGHNESS

The hydraulic roughness (Manning's 'n') applied in the TUFLOW model was based on the planning scheme GIS dataset supplied by Council, i.e., ultimate land use conditions have been adopted in the hydraulic modelling. Manning's 'n' values adopted for the defined land use types were based on industry standard values consistent with the latest AR&R update (Ball et al, 2019), QUDM (IPWEA, 2017) and *Logan-Albert Rivers Flood Study* (WRM, 2021). The adopted Manning's 'n' values are summarised in Table 4.1 and shown in Figure 4.1 for the historical calibration events and Figure 4.2.

Table 4.1: Land Use and Manning's 'n' Values

Land Use Type	Manning's 'n'
Roads	0.025
Special Purpose (Road)	0.025
Recreation and Open Space	0.045
Rural Residential	0.055
Rural	0.055
Community Facilities	0.06
Environmental Management and Conservation/Dense Bush	0.09
Low Density Residential	0.2
Emerging Community	0.25
Low-Medium Density Residential	0.25

Land Use Type	Manning's 'n'
Centre/Industrial	0.3
Mixed Use	0.3
Waterway in channel – lightly vegetated	0.035
Waterway in channel – moderately vegetated	0.05
Waterway in channel – highly vegetated	0.07
Upper Catchment Watercourse	0.065
Waterway corridor	0.1



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Notes:

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Meters
1 cm = 350 meters
GCS GDA 1994 MGA Zone 56

DATA SOURCE
QLD Government Open Source Data

DESIGNER

ENGENY WATER MANAGEMENT

CLIENT

LOGAN CITY COUNCIL

FIGURE 4.1

Henderson Creek Flood Study Update
Calibration
Manning's "n" Roughness

DRG Ref: **Figure 4-1**

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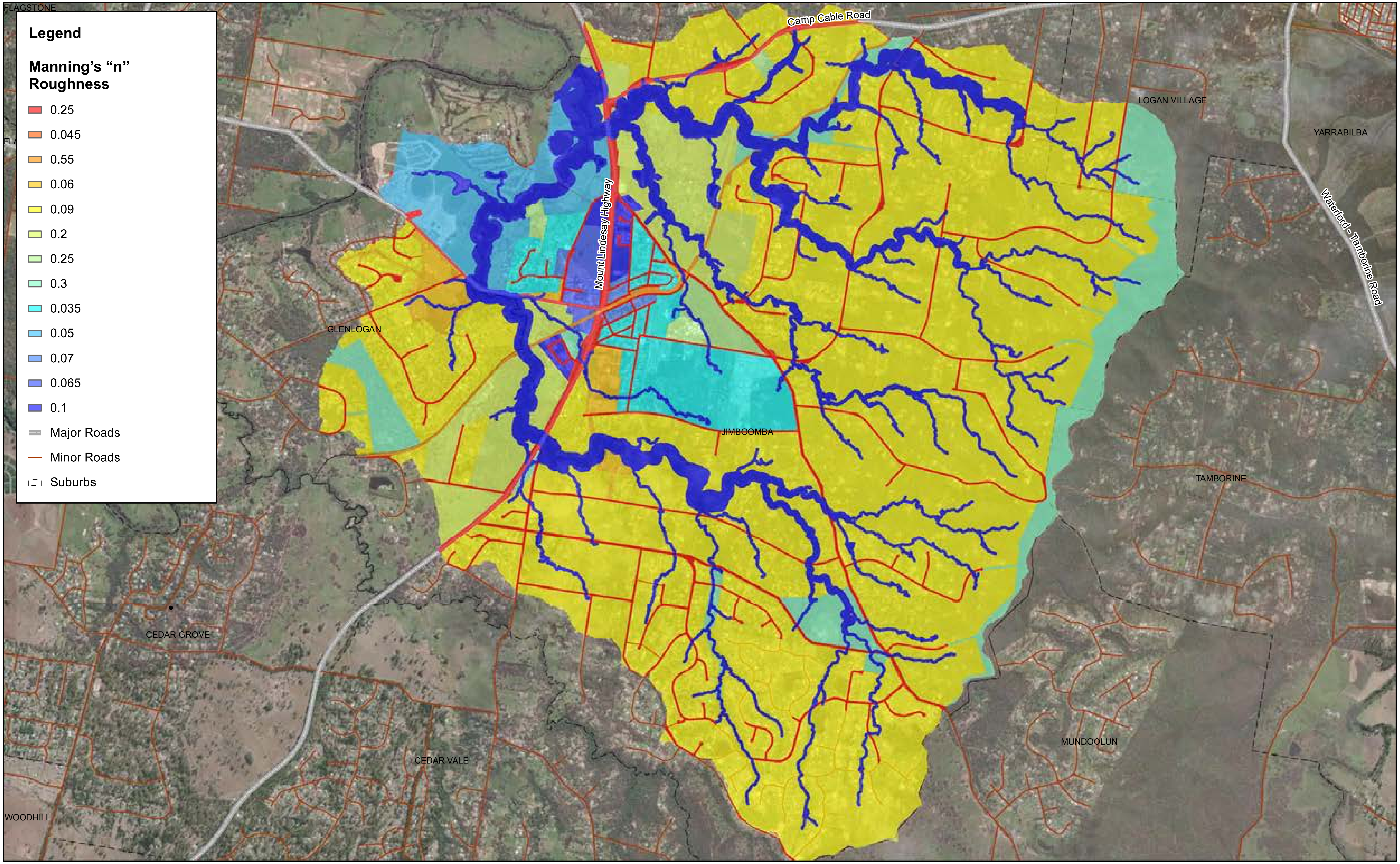

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Meters
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FIGURE 4.2

Henderson Creek Flood Study Update
Design Event
Manning's "n" Roughness

DRG Ref: **Figure 4-2**

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4.5 CHANNEL REPRESENTATION

All waterways within the catchment have been represented intrinsically within the 2D domain. Based on the fine grid resolution adopted it is considered that this approach is adequate to reasonably represent channel conveyance.

4.6 HYDRAULIC STRUCTURES

The following sections detail the approach to representation of hydraulic structures within the TUFLOW model. Structure locations used in the model are presented in Figure 4.3. Details of structures adopted in the model are presented in Appendix C.

4.6.1 Culverts

Culverts (circular and box culverts) have been modelled based on the GIS data supplied by LCC, data extracted from previous models and field data collection undertaken by LCC. Culverts have been represented using embedded dynamically linked 1D elements. The internal culvert equations within TUFLOW automatically estimate energy losses based on the inputted structure geometry.

Manual review of the placement of culverts as shown in the GIS data supplied by LCC has been undertaken, with realignment of the structures to the lowest point of the channel bed where required.

4.6.2 Road Weirs

Weir flow above culverts structures has been modelled in the 2D model domain. Elevations of road weirs were represented using a 2D z-shape breakline approach to accurately model road crest elevations.

4.6.3 Bridges

A number of bridges span the lower sections of the creeks where railway crosses the creeks. Details of bridge structures have been sourced from the *Logan Albert Rivers Flood Study* (WRM, 2021) and aerial photography. These structures have been represented in the model using 2D layered flow constrictions. This approach allows the 2D flow to be split vertically into four layers:

- Beneath the bridge deck.
- The bridge deck.
- Bridge handrails.
- Flow over the top of the structure.

Each layer can be assigned blockages and additional form losses to represent sub grid resolution losses (such as losses due to piers).

Where bridge structure elements were available from the *Logan Albert Rivers Flood Study* (WRM, 2021), these were adopted for use in the current TUFLOW model. The dimensions for one additional bridge (Henderson Creek at Golf Club access road) were obtained from a Council site visit and aerial photography. Form losses adopted for this bridge were based on the form losses adopted in the *Logan Albert Rivers Flood Study* (WRM, 2021) as no pier dimensions or configuration were documented.

4.6.4 Stormwater Network (Pits and Pipes)

Stormwater network (pits and pipes) were not included in the TUFLOW model as this did not form part of the required scope of works. As the majority of the catchment is currently rural or rural residential, minimal underground network exists in the catchment.

4.6.5 Design Blockage

The adopted blockage parameters for the various hydraulic structures in the model are summarized in Table 4.2.

Culvert blockage factors in accordance with AR&R (Ball et al, 2019) were applied to all culverts within the TUFLOW model, with blockage percentages consistent with low adjusted debris potential selected, noting that a sensitivity has been undertaken on a higher adjusted debris potential as summarised in Section 7.3.2. Table 4.2 summarises the blockage factors adopted in this study.

Table 4.2: Adopted Blockage Factors

Culvert Dimensions	Blockage Factor
Culverts: Inlet height < 3 m, or width < 5 m	20%
Culverts: Inlet height > 3 m and width > 5 m	10%
Bridges: Pier Blockage, for clear opening height < 3 m	0%
Bridges: Pier Blockage, for clear opening height > 3 m	0%
Bridges: Guard Rails	100%

4.7 INITIAL WATER LEVELS

Waterbodies contained within the flood plain have been modelled by application of initial water levels. The initial water levels specified for these dam structures are based on the anticipated spill level derived from the DEM terrain data.

4.8 BOUNDARY CONDITIONS

4.8.1 Hydrologic Inputs

Sub catchment flows within the model domain have been applied as ‘flow over area’ boundaries. This type of boundary applies inflows initially in the lowest elevation cell within the catchment and then to all wet cells after that. The inflow boundaries are based on the sub catchment delineation and are shown in Figure 3.1.

4.8.2 Tailwater Conditions

Strachan and Jimboomba Creeks discharge to Logan River via Henderson Creek. Events between the 1:10 AEP and PMF events use static tailwater levels derived from the *Logan Albert Rivers Flood Study* (WRM, 2021). Normal depth boundary conditions have been defined for the 1:2 AEP and 1:5 AEP events. Tailwater levels remain consistent for the climate change runs as per the relevant AEP. A summary of design events and downstream tailwater adopted is presented in Table 4.3.

The tailwater conditions were selected in conjunction with LCC. Tailwater levels have been selected such that the backwater effects from the Logan River are minimal in the lower reaches of the Henderson Creek system as the purpose of the study was to local catchment flood hazard. The contributing catchment for the Logan River to the Henderson Creek junction is in the order of 2,500 sq km, whereas the relevant catchment size for Henderson Creek is 44 sq km. Therefore, it is not expected that flood events of a similar magnitude would occur in both systems, nor have flood peaks occurring, at the same time.

Logan River flood extents for various AEP events were visually inspected and it was observed that a transition to significant lower floodplain inundation occurs between the 1:5 AEP and 1:10 AEP events. The 1:5 AEP Logan River level was adopted as the tailwater condition for the local catchment 1:100 AEP event. Tailwater levels for more frequent event were then adopted based on a sliding scale.

The adopted tailwater levels for the 1:100 AEP and 1:10 AEP events were checked against the ‘quick IFD’ method outlined in Section 8.3.4 of QUDM (IPWEA, 2017). This approach is based on estimation of a main-stream (Logan River) AEP based on equivalent rainfall depths as calculated in the side-stream (local catchment).

Table 4.3: Downstream Boundary Condition

Average Recurrence Interval (AEP)	Tailwater Configuration	Tailwater Level (mAHD)
1:2	Normal Depth	-
1:5	Normal Depth	-
1:10	1:2 AEP Logan River	17.83
1:20	1:2 AEP Logan River	17.83
1:50	1:5 AEP Logan River	21.66
1:100	1:5 AEP Logan River	21.66
1:200	1:5 AEP Logan River	21.66
1:500	1:5 AEP Logan River	21.66
1:2,000	1:5 AEP Logan River	21.66
PMF	1:100 AEP Logan River	29.48

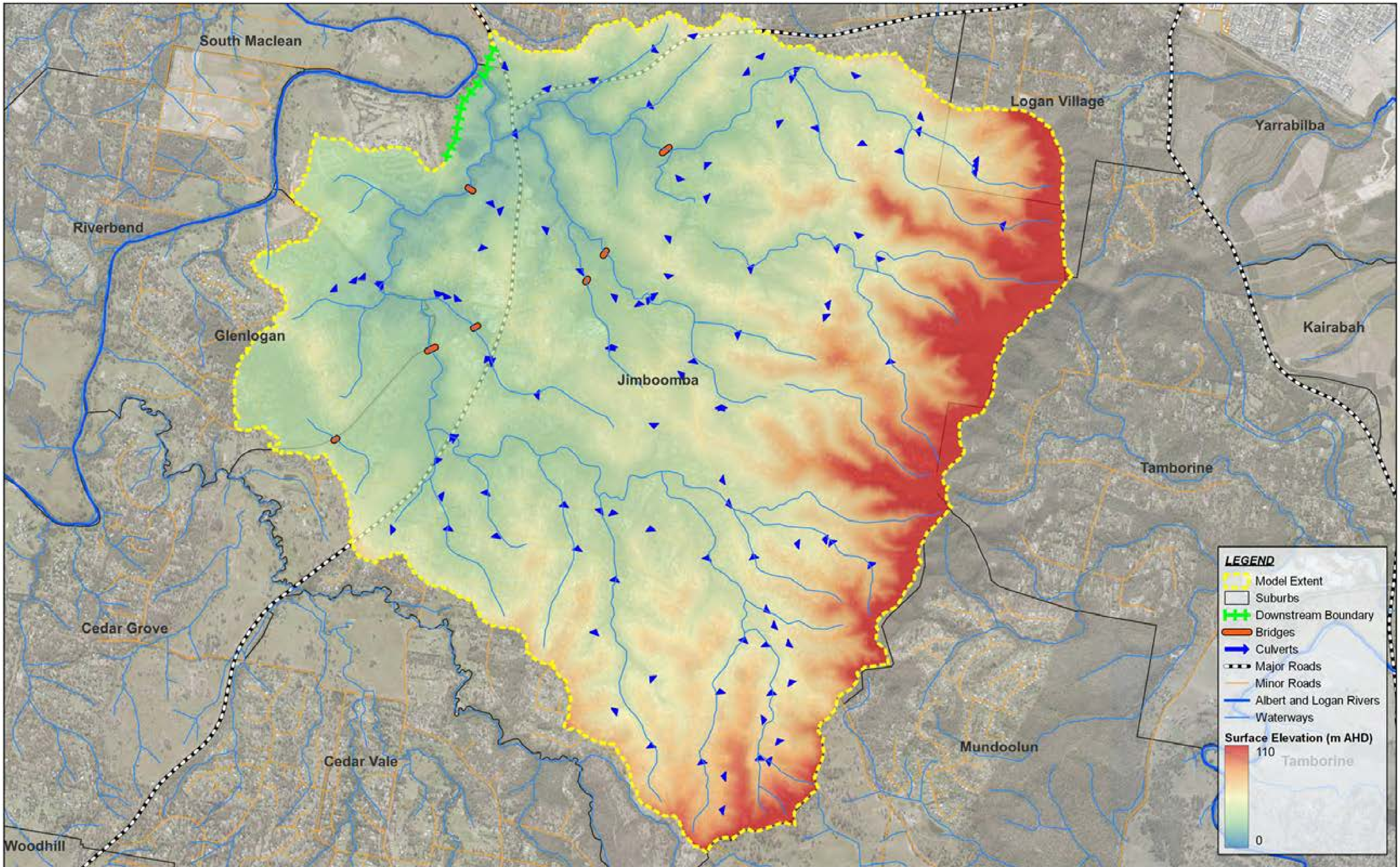

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Figure 4.3

Henderson Creek Flood Study Update

TUFLOW Model Layout

Figure 4.3

5 MODELLING CALIBRATION AND VALIDATION

5.1 MODEL CALIBRATION

A joint hydrology/hydraulic model calibration was undertaken for three historical flood events. Firstly, estimation of flow hydrographs for the Henderson Creek catchment were developed in XPRAFTS for the historical storm events and then simulation of the TUFLOW hydraulic model was undertaken to determine flood levels at the Henderson Creek Alert stream gauge. Calibration of the hydrologic model in isolation was unable to be undertaken due to the lack of rating curve information to translate modelled peak flows to gauged water levels.

The historical storm events considered for model calibration include May 2015, June 2016 and March 2017. These have been selected based on the availability of historical rainfall and river gauge records and presence of some observed local catchment peak prior to Logan River drown out. The estimated respective AEPs are provided in Table 5.1.

The modelling parameters adopted for the historical events were the same as those adopted for the design events with the following alterations:

- Catchment roughness values in the hydraulic model and fraction impervious in the hydrologic model were altered to represent the extent of development observed in historical imagery through the period of 2015 to 2017. The landuse adopted is shown in Figure 4.1.
- The 2017 1m LiDAR dataset was adopted for the topographical information in the hydraulic model, as being most representative of the catchment topography at the time of the calibration events.
- No blockage factors were applied to hydraulic structures.
- Additional parameters, inclusive of losses adopted, relating to the calibration are summarised in Table 5.1.

The historical pluviographic rainfall data to the model was obtained from the Yarrahappini gauge (located 6 km west of the Henderson Creek catchment centroid). Downstream boundary conditions were set using historical water level data from the Yarrahappini Alert stream gauge, applied at the confluence of Henderson Creek and the Logan River. The hydraulic grade results from the *Logan Albert Rivers Flood Study* report (WRM, 2014) have been used to inform a vertical translation of the tailwater series, equal to a hydraulic grade line drop of approximately 3 m from the Yarrahappini Alert to the confluence of Henderson Creek and the Logan River. The adopted parameters for the model calibration are summarised in Table 5.1. The location of the gauges utilised in the calibration process are shown in Figure 5.1.

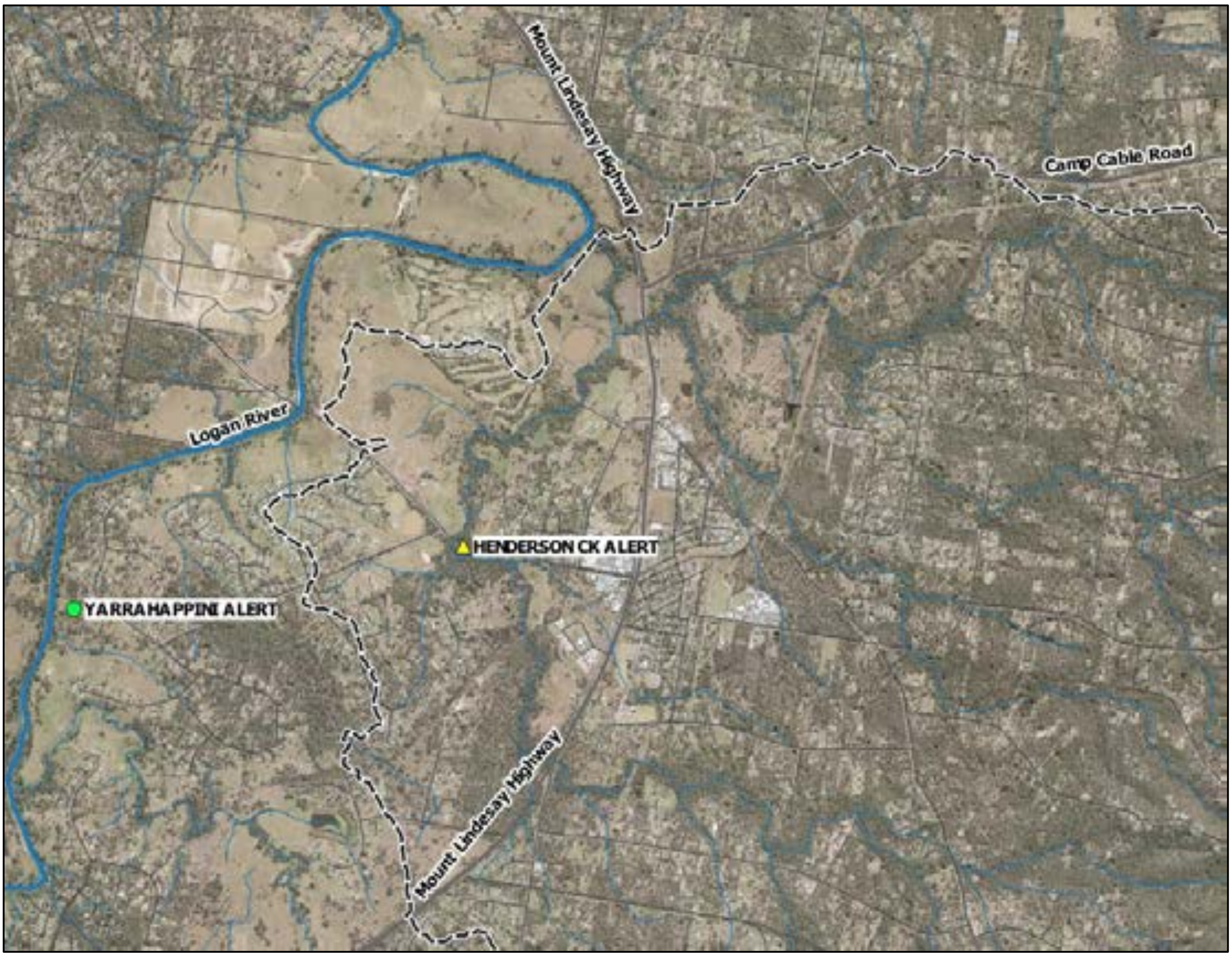

Figure 5.1: Historical Event Calibration Gauges

Table 5.1: Adopted Parameters for Model Calibration

Parameters	May-2015	June-2016	March-2017
Total Rainfall (mm)	160	71	350
Storm Event Duration (hr)	43	7	34
Initial Loss (mm)	45	42	50
Continuing Loss (mm)	1.9	2.5	2.7
Recorded Peak Water Level at Henderson Creek Alert (m AHD) (Local Catchment Response)	21.57	19.57	21.77
Modelled Peak Water Level at Henderson Creek Alert (m AHD) (Local Catchment Response)	21.56	19.64	21.78
Approximate Annual Exceedance Probability of Event (comparison of flood levels at Henderson Creek Alert)	1:20 AEP	<1:2 AEP	1:50 AEP

The accuracy of the model calibration at the Henderson Creek Alert is greatly affected by the Logan River (most significantly in the 2017 flood event), with the water level readings at the Henderson Creek Alert becoming drowned out in the 2015 and 2017 flood event not long after the peak of the local catchment flood response. Therefore, the calibration has focused on calibration for the beginning of the historical event only, where the local catchment response is observed.

It is assumed that the Yarrahappini Alert stopped functioning in the 2016 event, shown by the flattened top of the recorded data, giving some concern to the validity of this event for calibration.

The cumulative rainfall and the recorded and modelled water levels for the 2015 calibration events are presented in Figure 5.2 and Figure 5.3. The results indicated that a reasonable agreement between recorded and modelled water level timeseries were achieved prior to the regional catchment response and given limitations with calibration data.

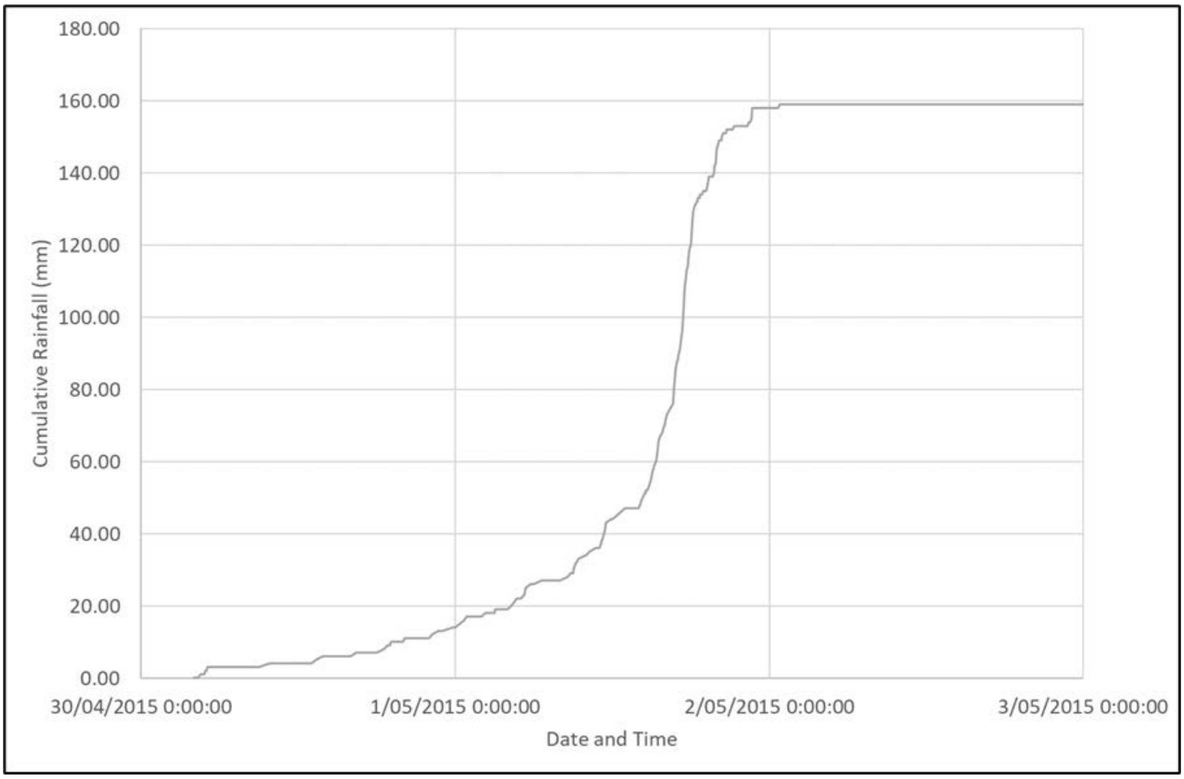

Figure 5.2: 2015 Calibration Event – Cumulative Rainfall

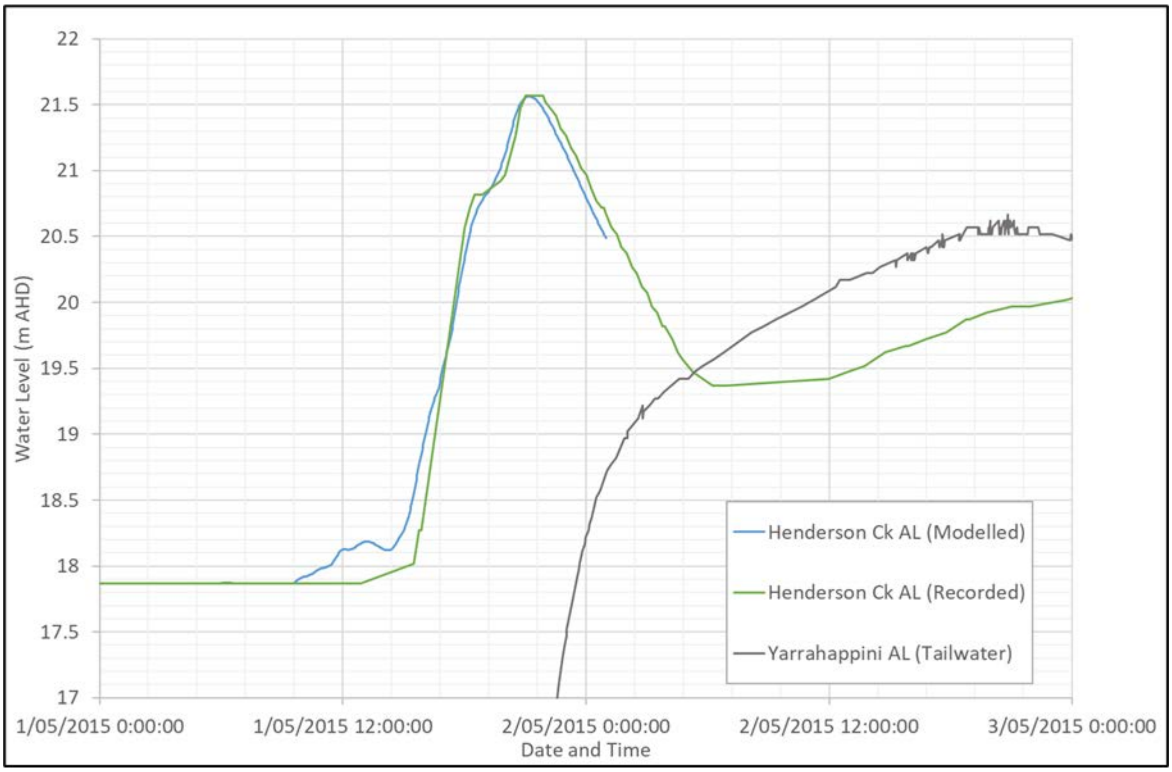

Figure 5.3: 2015 Calibration Event Results

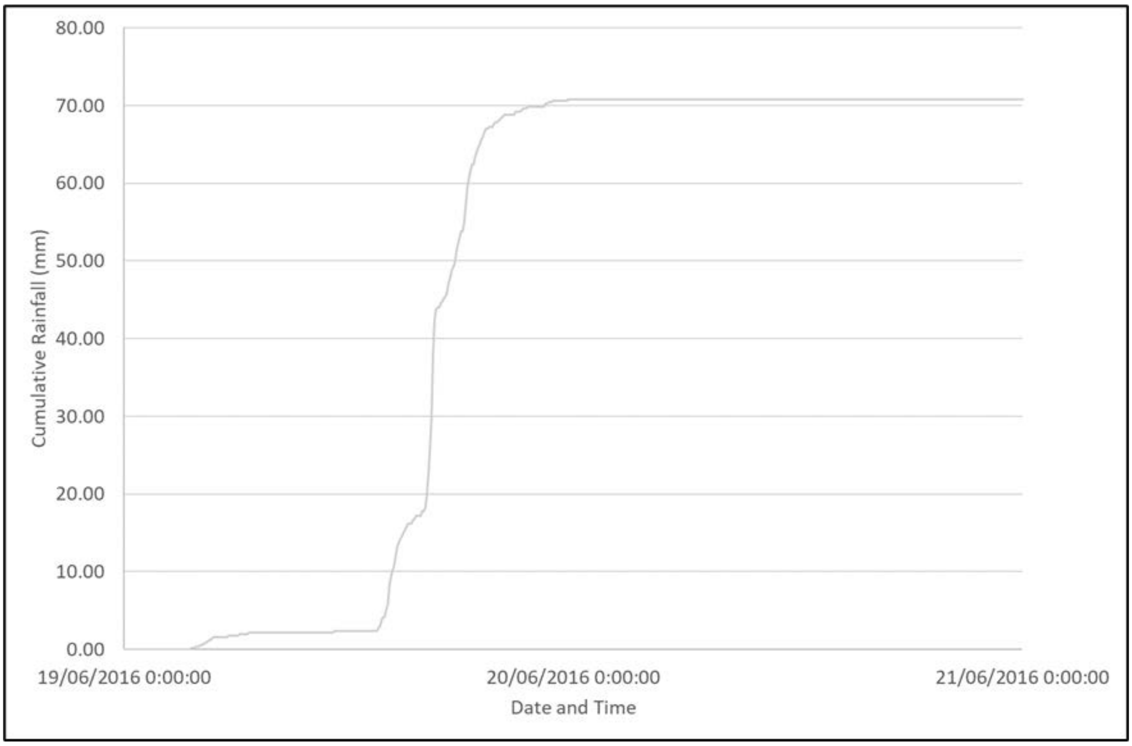

Figure 5.4: 2016 Calibration Event – Cumulative Rainfall

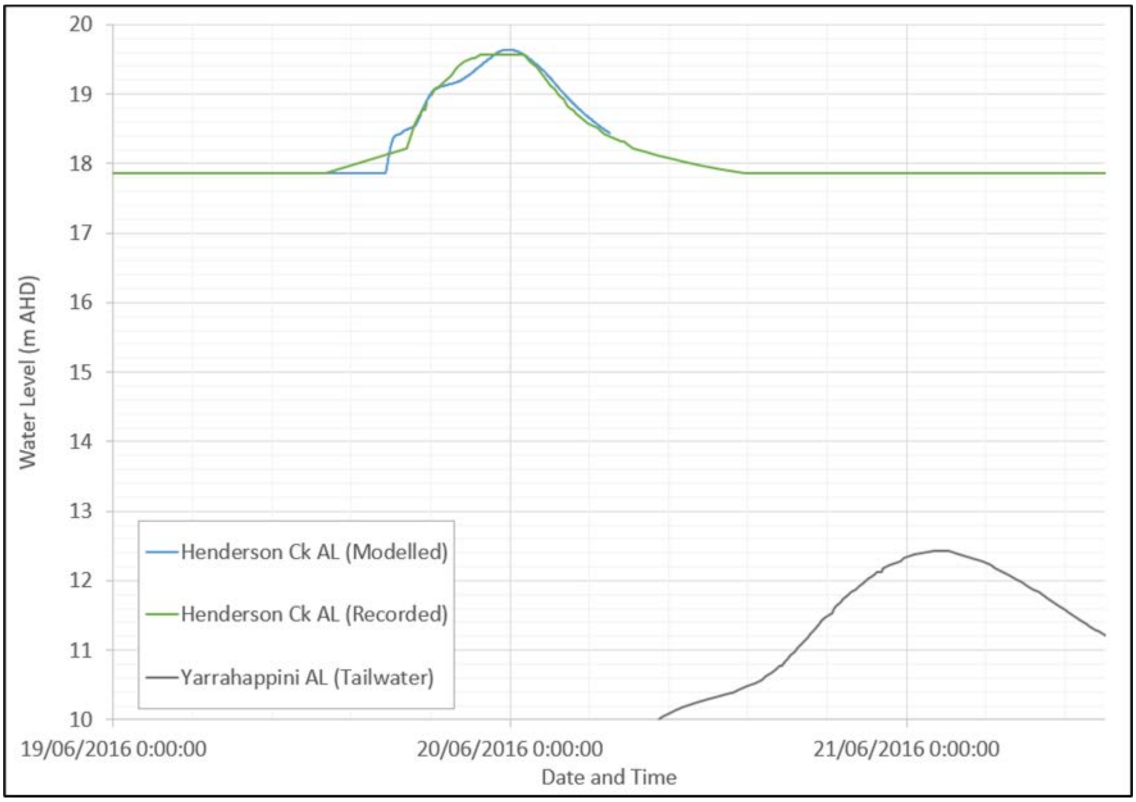

Figure 5.5: 2016 Calibration Event Results

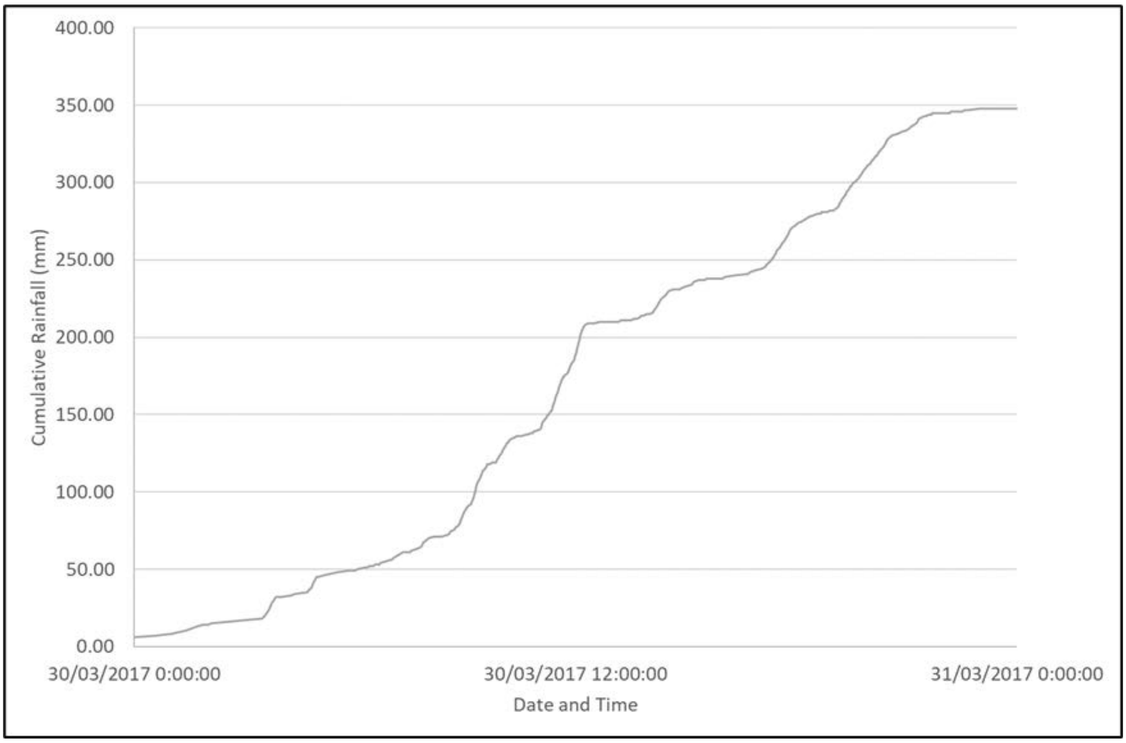

Figure 5.6: 2017 Calibration Event – Cumulative Rainfall

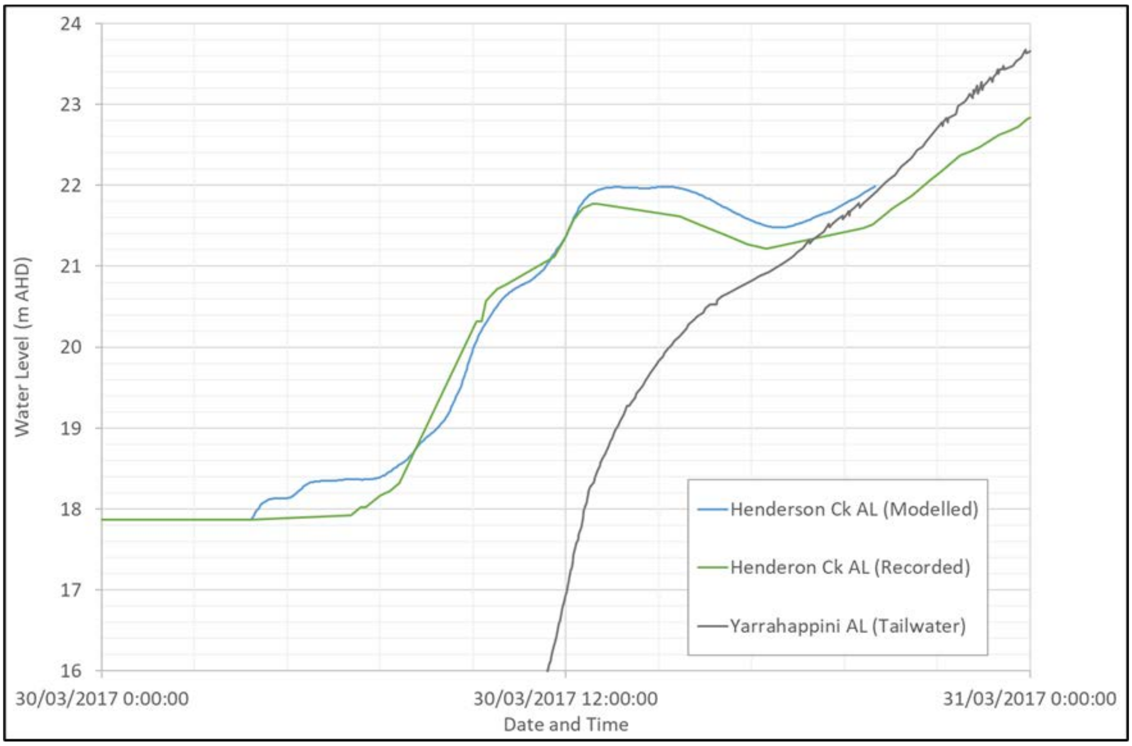

Figure 5.7: 2017 Calibration Event Results

5.2 MODEL VALIDATION

Peak design event flows adopted for this study have been considered for validation against the following sources of design flood flow estimates:

- Flood Frequency Analysis (FFA).
- The Rational Method as documented in the Queensland Urban Drainage Manual (QUDM) (IPWEA, 2017).
- Regional Flood Frequency Estimation Model (RFFE) (Ball et. al., 2019).
- Quantile Regression Technique (QRT) (Palmen and Weeks, 2011).
- Validation of hydrologic and hydraulic model catchment response.

5.2.1 Flood Frequency Analysis

The appropriateness of a Flood Frequency Analysis (FFA) for validation of the peak flows for the catchment was considered. Applicable gauges nearby the catchment for consideration included:

- Logan River at Yarrahappini (145014A).
- Henderson Creek Alert (operated by Logan City Council).

Logan River at Yarrahappini was not considered a suitable gauge for a FFA analysis due to the difference in magnitude of catchment size (2,416 km^2 versus 40 km^2) and topographical and flood behaviour characteristics between Henderson Creek and the Logan River. The Henderson Creek Alert was also discarded as a gauge suitable for FFA analysis due to a limited period of record and lack of rating curve information.

5.2.2 Rational Method

Peak design flood flows from both XPRAFTS and TUFLOW for smaller catchment areas have been validated against peak flow estimates generated using the Rational Method. Table 5.2 summarises peak flows at four (4) locations in the upper catchment where flow is not impacted by existence of hydraulic structures or downstream tailwater. These catchment locations can be viewed on Figure 3.1. The 1:10 AEP and 1:100 AEP events only have been validated as they are representative of a minor and major flood event and combined with the calibration results are sufficient to indicate that the models are producing suitable peak flow estimates. Details of the Rational Method calculations are presented in Appendix B.

Table 5.2: Comparison of Peak Flows with Rational Method

Sub-catchment Outlet	Catchment Area (ha)	Rational Method T_c (min)	AEP	Rational Method Peak Flow (m^3/s)	XPRAFTS Peak Flow (m^3/s)
S60 (PO105)	81	29	1:10	10.9	11.7
			1:100	19.6	22.1
S96 (PO102)	62	16	1:10	11.5	11.5
			1:100	20.3	17.4
S103 (PO99)	148	49	1:10	14.1	13.7
			1:100	26.0	27.3
S131 (PO121)	94	39	1:10	10.5	10.0
			1:100	19.2	20.2

5.2.3 Regional Flood Frequency Estimation Model and Quantile Regression Technique

Peak design flood flows at the study outlet have been compared to peak flow estimates made using the RFFE methodology and Quantile Regression Technique (QRT). Table 5.3 summarises the comparison of peak design flows at the study outlet. Validation using the RFFE methodology and QRT calculations have only been undertaken to the model outlet, due to the methodology being more suited to large catchments and the simplistic nature of the estimate inputs, with catchment area being the only key differentiator between different catchments throughout the model extent.

Table 5.3: Comparison of Peak Flows at RP5/S1 (Catchment Outlet; see Figure 6.2)

AEP	RFFE Peak Flow (m^3/s)	QRT Peak Flow (m^3/s)	XPRAFTS Peak Flow (m^3/s)	TUFLOW Peak Flow (m^3/s)
1:100	488	366	318 (6h tp3)	311
1:10	204	136	162 (6hr tp10)	148

It is considered that the design flows adopted for Henderson, Strachan and Jimboomba Creeks are reasonable based on the presented peak flow analysis. Box and whisker plots from XPRAFTS demonstrating the variation of peak flow estimates per duration dependent on applicable temporal patterns have been provided in Appendix D for the 1:10 AEP and 1:100 AEP flood events. Analysis of peak flows for all events, durations and temporal patterns from TUFLOW at the catchment outlet have been provided in Appendix F.

5.2.4 Validation of Hydrologic Model to Hydraulic Model

In addition to comparing peak flows at key model locations, the 10% and 1% AEP hydrographs for the critical event and duration at the catchment outlet identified in TUFLOW were extracted from XPRAFTS and TUFLOW. A comparison of the hydrographs indicate that both the hydrologic model and hydraulic model are exhibiting similar catchment responses. Total volumes and peaks are similar. Additionally, the same critical duration and median temporal pattern was identified in both the hydrologic and hydraulic model for the 10% AEP event, with a shorter duration (4.5 hour versus 6 hour) indicated in XPRAFTS for the 1% AEP event than in TUFLOW. In order to undertake a like for like comparison, the 1% AEP 6-hour duration storm from both XPRAFTS and TUFLOW has been adopted to complete the validation.

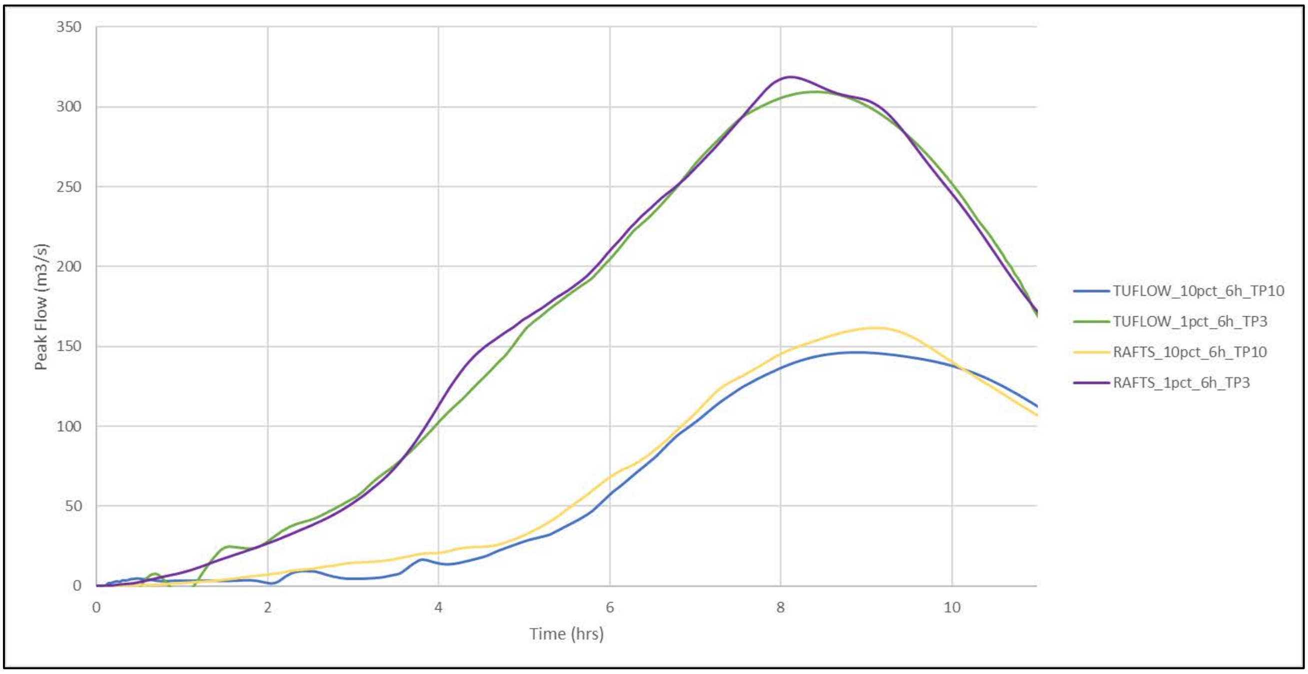

Figure 5.8: Comparison of Peak Hydrographs at RP5/S1 (Catchment Outlet; see Figure 6.2)

6 DESIGN FLOOD MODELLING

6.1 OVERVIEW

The hydraulic model was simulated for a full envelope of critical durations, and the ten ARR 2019 ensemble temporal patterns for all design events. This section summarises the development of the design event parameters key findings from the modelling results.

6.2 DESIGN EVENT RAINFALL INPUTS

6.2.1 Methodology

A summary of the adopted design hydrology methodology for this study is provided in Table 6.1. This approach is consistent with previous flood studies completed for the Council, and specific project direction.

Table 6.1: Summary of Design Event Methodology

Parameter	AEP	Source/Method	Comment
Rainfall Depth	≤ 1:2,000 AEP	ARR 2019	Industry standard.
	PMP	BoM GSDM	Industry standard approach for durations ≤ 6 hours. Adopted in this study for durations up to and including 12 hours, through interpolation with GTSMR method for durations ≥24 hours.
Areal Reduction Factor	≤ 1:2,000 AEP	ARR 2019	Conservative adoption of ARF 1.0.
	PMP	BoM GSDM	Industry standard.
Temporal Pattern	≤ 1:2,000 AEP	ARR2019	Adopted in this study for consistency with other Council studies.
	PMP	BoM GSDM	Industry standard approach for durations ≤ 6 hours. Adopted in this study for durations up to and including 12 hours.
Spatial Distribution	≤ 1:2,000 AEP	ARR2019	Ten locations selected for spatially varying IFD application.
	PMP	BoM GSDM	Industry standard.
Rainfall Losses	≤ 1:2,000 AEP	ARR2019	Adopted initial and continuing losses were based on estimates given in ARR 2019 and adopted for median pre-burst rainfalls and sub-catchment fraction impervious.
	PMP	Adopt Minimum Losses	Adopt 0 mm initial loss and 0 mm/h continuing losses.

6.2.2 Design IFD Data

Design rainfall data for the Henderson Creek catchment was derived for rainfall events between the 1:2 AEP event and the Probable Maximum Precipitation (PMP) event. The design rainfall data was derived using the following methods:

- Rainfall totals in the AEP range 1:2 AEP to 1:2,000 AEP were generated for ten locations within the catchment using the BoM IFD tool (www.bom.gov.au/water/designRainfalls/revised-ifd/). The ten sets of IFD data were applied to XPRAFTS to the catchments falling within the Thiessen Polygons as shown in Figure 6.1.
- PMP rainfall estimates were calculated using the GSDM method (BOM, 2003) for durations less than 6 hours (refer to Section 3.3.5).

Design rainfall totals (point values) for the central IFD location (Location 4 – latitude of -27.832, longitude of 153.04) are summarised in Table 6.2.

Table 6.2: Henderson Creek Design Rainfall Totals (mm) – Location 4

Duration	Flood Event							
	1:2 AEP	1:5 AEP	1:10 AEP	1:20 AEP	1:50 AEP	1:100 AEP	1:200 AEP	1:500 AEP	1:2,000 AEP
30 minutes	30	38	44	51	60	66	74	86	105
1 hour	38	48	56	65	77	87	97	113	138
1.5 hours	42	54	63	74	88	100	112	130	159
2 hours	46	58	69	81	97	110	123	143	175
3 hours	51	66	78	92	111	126	141	163	200
4.5 hours	58	75	89	105	127	146	162	187	229
6 hours	64	83	98	116	142	162	180	208	254
9 hours	74	96	115	136	166	191	211	244	297
12 hours	82	108	129	153	187	215	238	275	335

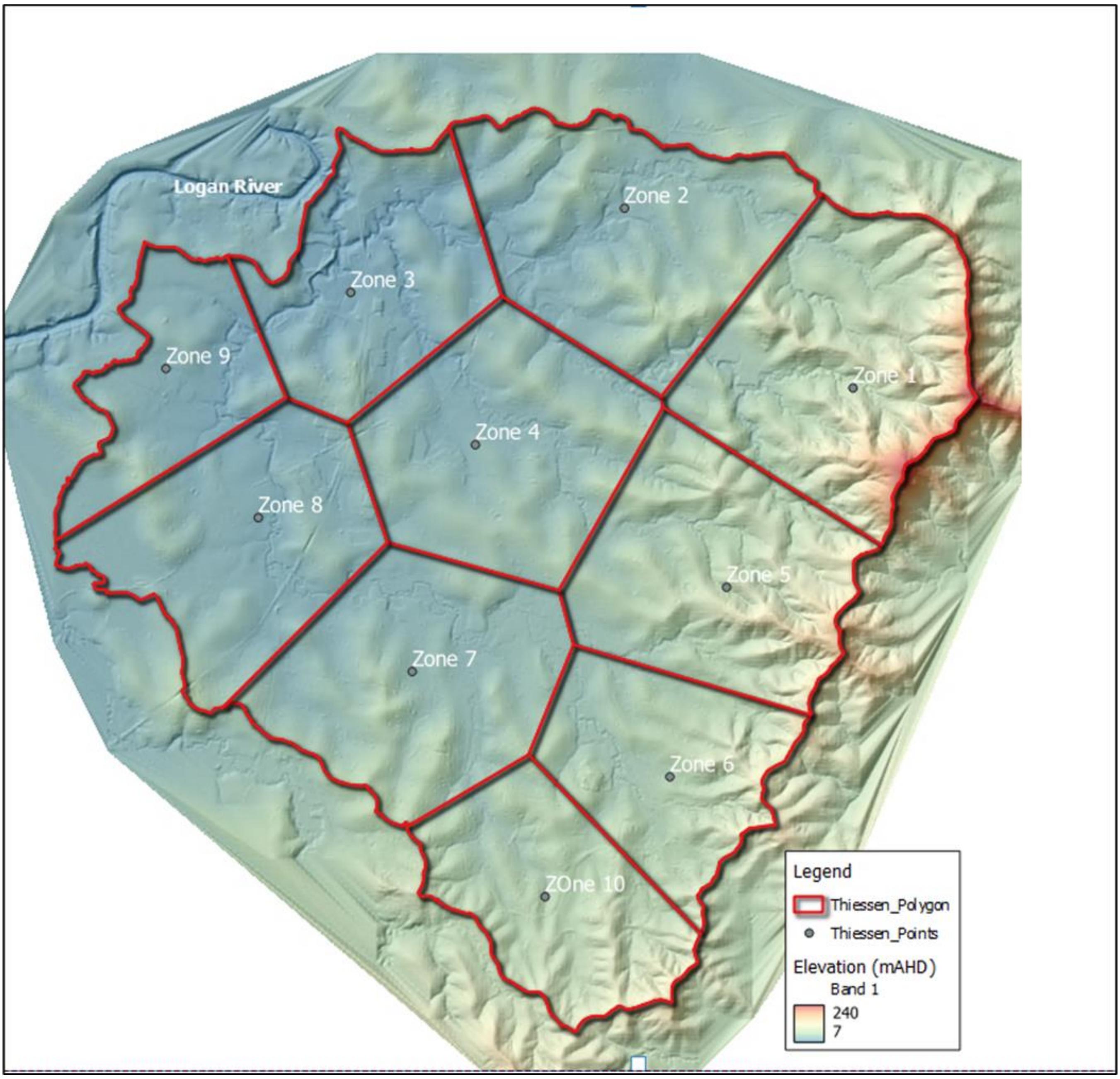

Figure 6.1: IFD Locations

6.2.3 Design Temporal Patterns

The ensemble temporal patterns approach was adopted for design event simulations. Design point patterns from the 'East Coast North' region were used for design events up to the 1:2,000 AEP event. The Generalised Short-Duration Method (GSDM) (BoM, 2003) were adopted for the PMP flood event.

6.2.4 Areal Reduction Factor

A conservative approach of adopting an ARF of 1.0 was adopted for all durations and AEPs up to the 1:2,000 AEP flood event. For the PMP event, the BoM (2003) GSDM guidelines were used.

6.2.5 Design Event Loss Parameters

Pervious Sub-catchment

Design storm rainfall losses (Initial Loss = 26 mm and Continuing Loss = 1.9 mm/h) were sourced from the ARR 2019 Data Hub (http://data.arr-software.org) for storm events up to 1:100 AEP. The continuing loss of 1.9 mm/h is also consistent with the continuing loss adopted for the 2015 historical calibration event. Median pre-burst rainfall depths were also sourced from the ARR 2019 Data Hub (http://data.arr-software.org) for storm events up to 1:100 AEP. The XPRAFTS software applies median pre-burst rainfall depths over six (6) routing increments prior to the design burst temporal patterns.

Zero initial and zero mm/hr continuing loss values have been adopted for the PMP event. Initial loss values were interpolated for storm events between the 1:100 AEP and PMF events using a log-normal interpolation method as recommended in ARR 2019 Section 4.3.2.2.

Impervious Sub-catchment

An initial loss of 0 mm and 1 mm /hr continuing loss were applied to impervious sub-catchments in XPRAFTS across all modelled flood events.

6.2.6 Climate Change

The following 2090 climate change RCP scenarios have been simulated in the hydraulic model:

- RCP4.5 for 1:5, 1:10, 1:20, 1:50, 1:100, 1:500 AEP flood events.
- RCP6.0 and RCP8.5 for the 1:100 AEP flood event.

The applicable increase in rainfall intensity is summarised in Table 6.3.

Table 6.3: 2090 Climate Change Scenario Rainfall Intensities

Climate Change Representative Concentration Pathway	Increase to Rainfall Intensity
RCP4.5	9.5%
RCP6.0	11.5%
RCP8.5	19.7%

6.2.7 Probable Maximum Precipitation (PMP)

Based on the critical duration of the design storms in this study, the Generalised Short-Duration Method (GSDM) (BoM, 2003) was applied to Probable Maximum Precipitation (PMP) generation. The parameters in generating the PMP estimate are given in Table 6.4.

Table 6.4: Probable Maximum Precipitation Parameters

PMP Parameter	Value for Adopted
Catchment Area (km2)	44.1
Elevation Adjustment Factor	1
Moisture Adjustment Factor	0.83

The derived PMP depths used in the study are summarised in Table 6.5.

Table 6.5: Derived Probable Maximum Precipitation Depths

Duration (hrs)	PMP Depth (mm)
0.5	220
1	340
2	500
3	610
4	690
5	760
6	810
9	830
12	850

6.3 CRITICAL DURATION ANALYSES

Critical duration analyses of the TUFLOW hydraulic model approach were carried out for the catchment for all design events with critical duration envelope maps provided in Appendix E. From these results it can be seen that the selected critical duration envelope for all design events up to the 1:2,000 AEP flood events of the 0.5, 1, 1.5, 2, 3, 4.5, 6, 9 and 12 hour storm durations are appropriate. For the 1:2 and 1: 5 AEP flood events, the 18 hour storm duration was also simulated to ensure that the peak flows was captured (the peak flow summary is provided in Appendix F). For the PMF event the 0.5, 1, 1.5, 2, 3, 6, 9 and 12 hour storm durations were modelled.

6.4 INTERPRETATION OF RESULTS

As discussed previously, a full range of critical durations and the ten ARR 2019 ensemble temporal patterns have been simulated. The resulting peak flows and levels throughout this report relate to the storm duration with the highest value from the median of the ten temporal patterns. The maps provided are “max-max” results, also showing the highest value from the median of the ten temporal patterns.

Peak flood levels, depths and mapping are provided in the following sections.

6.4.1 Summary of Design Peak Flows

Peak flows for the simulated design events have been summarized at nine locations throughout the catchment. The peak flows are summarized in Table 6.6 and the locations are shown on Figure 6.2.

Table 6.6: Design Event Peak Flow Summary (m^3/s)

Location ID	Location Description	1:2 AEP	1:5 AEP	1:10 AEP	1:20 AEP	1:50 AEP	1:100 AEP	1:200 AEP	1:500 AEP	1:2,000 AEP	PMF
RP1 (PO15)	Edelsten Road	9.1	15.7	27.1	35.8	43.6	53.3	61.7	76.4	101.1	322.1
RP2 (PO16)	Minugh Road	15.9	25.9	33.0	39.7	51.2	64.1	76.5	98.8	135.2	394.9
RP3 (PO110)	Former Rail Crossing	23.3	49.6	49.6	72.1	92.9	111.7	135.8	158.8	194.1	998.4
RP4 (PO54)	Abell Road	24.4	51.4	73.3	92.2	111.6	130.6	142.0	165.5	205.0	1165.0

Location ID	Location Description	1:2 AEP	1:5 AEP	1:10 AEP	1:20 AEP	1:50 AEP	1:100 AEP	1:200 AEP	1:500 AEP	1:2,000 AEP	PMF
RP5 (PO1)	Catchment Outlet	52.5	107.4	147.3	194.2	266.3	315.7	351.7	422.2	517.0	2482.5
RP6 (PO93)	Cusack Lane	25.0	50.9	73.1	97.9	131.5	159.1	177.8	216.3	276.1	1279.1
RP7 (PO151)	Former Rail Crossing	23.4	48.5	73.2	95.8	122.3	147.6	168.1	199.8	257.7	1127.9
RP8 (PO44)	Kurrajong Park	21.7	44.6	70.0	88.1	116.8	138.4	157.3	186.3	248.6	996.0
RP9 (PO119)	DS Mundoolun Road	17.6	33.1	46.4	62.1	76.4	90.3	103.9	113.9	148.2	638.8

6.4.2 Summary of Design Peak Flood Levels

Peak levels for the simulated design events have been summarised at nine locations throughout the catchment. The peak flows are summarised in Table 6.7 and the locations are shown on Figure 6.2.

Table 6.7: Design Event Peak Level Summary (m AHD)

Location ID	Location Description	1:2 AEP	1:5 AEP	1:10 AEP	1:20 AEP	1:50 AEP	1:100 AEP	1:200 AEP	1:500 AEP	1:2,000 AEP	PMF
RP1	Amber Crescent	47.8	48.8	49.0	49.1	49.1	49.2	49.2	49.3	49.4	49.9
RP2	Edelsten Road 1	34.1	34.6	35.4	35.6	35.7	35.8	35.9	36.0	36.2	37.0
RP3	Former Rail Crossing 1	23.5	24.2	24.6	24.8	25.1	25.3	25.5	25.8	26.2	29.8
RP4	Mount Lindesay Highway 1	15.5	16.9	18.6	18.9	22.3	22.5	22.6	22.9	23.4	29.6
RP5	Minugh Road	41.8	43.0	43.9	44.6	44.9	45.1	45.2	45.5	45.7	46.7
RP6	Edelsten Road 2	34.9	35.2	35.3	35.4	35.6	35.8	35.9	36.1	36.4	37.8
RP7	Swan Road	29.4	30.3	30.4	30.5	30.6	30.7	30.8	30.9	31.0	31.5
RP8	Former Rail Crossing 2	24.8	25.0	25.2	25.3	25.6	25.7	25.8	26.0	26.3	29.7
RP9	Mundoolun Road	44.2	44.8	45.0	45.2	45.4	45.5	45.6	45.7	45.8	46.5
RP10	Kurrajong Road 1	43.8	44.4	44.5	44.6	44.7	44.7	44.8	44.8	44.9	45.7
RP11	Kurrajong Road 2	34.4	34.7	34.9	35.0	35.1	35.3	35.4	35.5	35.7	37.5
RP12	Mount Lindesay Highway	25.7	26.4	26.8	26.8	27.3	27.4	27.5	27.6	27.9	30.4

Location ID	Location Description	1:2 AEP	1:5 AEP	1:10 AEP	1:20 AEP	1:50 AEP	1:100 AEP	1:200 AEP	1:500 AEP	1:2,000 AEP	PMF
RP13	Former Rail Crossing	23.1	23.8	24.3	24.3	24.9	25.1	25.3	25.5	25.9	30.0
RP14	Cusack Lane	20.1	20.9	21.3	21.4	22.3	22.5	22.6	22.8	23.1	29.9
RP15	Golf Club Access	16.9	17.8	18.7	18.9	21.9	22.0	22.0	22.2	22.4	29.7
RP16	Catchment Outlet	14.5	15.6	18.3	18.3	22.2	22.2	22.2	22.2	22.0	29.5

6.4.3 Flood Mapping

Flood mapping for the design flood events is provided in Appendix G of this report. These maps are “max-max” results and have been provided for the following results:

- Level.
- Depth.
- Velocity.
- Hazard – Depth x Velocity Product.
- Hazard – AIDR Classifications.
- Hazard – QRA Classifications.

R	Details	Date
1	First Draft	09/02/22
-	-	
-	-	
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-	-	
-	-	

DESIGNED	SB	CHECKED	KM
DRAWN	SB	CHECKED	KM
APPROVED	-	DATE	09/02/22

Notes:

DISCLAIMER
Engeny Water Management has endeavoured to ensure accuracy and completeness of the data. Engeny assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map.

DATA SOURCE
QLD Government Open Source Data

DESIGNER
ENGENY WATER MANAGEMENT

CLIENT
LOGAN CITY COUNCIL

FIGURE 6.2

Henderson Creek Flood Study Update
Design Event Result Reporting Locations

DRG Ref: **Figure 6-2**

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6.4.4 Climate Change

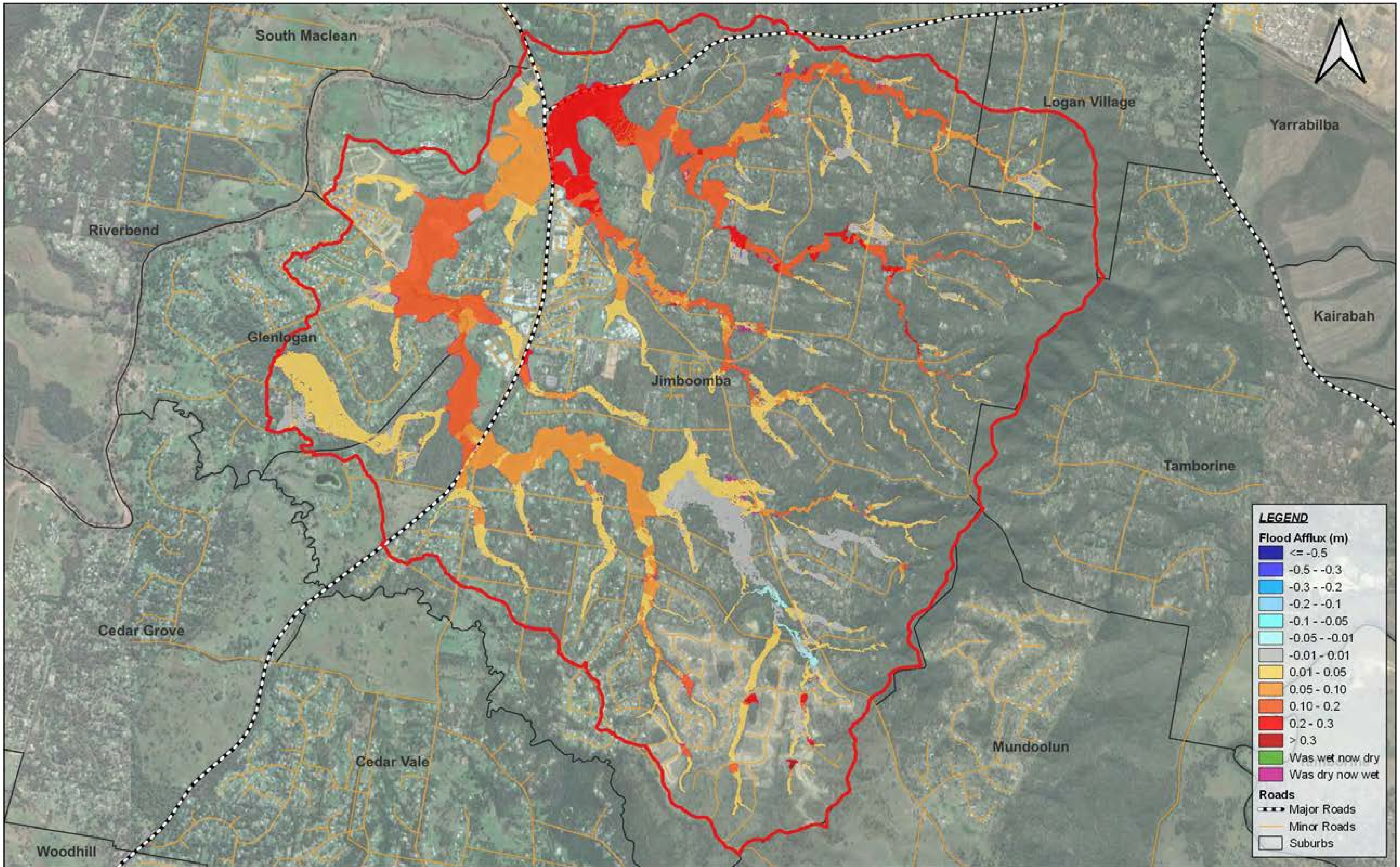
In order to visually illustrate the expected flood level increases, an afflux map showing the expected increase in flood level between the current climate 1:100 AEP flood event and the 2090 horizon Representative Concentration Pathway (RCP) 6.0 1:100 AEP event are provided in Figure 6.3. Mapping for all simulated 2090 horizon RCP 4.5 flood events are provided in Appendix H.

The mapping shows that flood levels are expected to increase in the future climate, with greater increase expected in the higher order streams and towards the catchment outlet. On average, increases in the range of 20 to 150 mm are expected.

The peak flows for the various Climate Change scenarios are summarised in Table 6.8, and the locations are shown on Figure 6.2.

Table 6.8: Design Event Peak Flow Summary – Climate Change 2090 Scenario (m^3/s)

Location ID	Location Description	1:20 AEP RCP4.5	1:50 AEP RCP4.5	1:100 AEP RCP4.5	1:100 AEP RCP6.0	1:100 AEP RCP8.5
RP1 (PO15)	Edelsten Road	41.2	50.5	61.0	63.0	69.3
RP2 (PO16)	Minugh Road	47.2	60.4	75.4	78.5	88.1
RP3 (PO110)	Former Rail Crossing	106.2	128.7	154.7	159.6	175.1
RP4 (PO54)	Abell Road	105.5	123.8	141.9	144.9	154.4
RP5 (PO1)	Catchment Outlet	221.0	297.9	355.7	365.1	393.5
RP6 (PO93)	Cusack Lane	113.3	149.5	178.5	183.7	199.5
RP7 (PO151)	Former Rail Crossing	109.2	138.6	160.5	165.9	181.5
RP8 (PO44)	Kurrajong Park	99.4	130.8	144.9	150.1	166.7
RP9 (PO119)	DS Mundoolun Road	70.6	86.3	92.6	95.3	103.6



R	DETAILS	DATE
1	Final Issue	07-03-2023

DRAWN	JL	CHECKED	TS
APPROVED	MP	DATE	07-03-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DISCLAIMER
Engeny has endeavoured to sure accuracy and completeness of the data. Engeny assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map.

DATA SOURCE
QLD Government Open Data Source

ENGENY

LOGAN CITY COUNCIL

Figure 6.3 - 1% AEP RCP6.0 CC Afflux

Henderson Creek Flood Study Update
1:100 AEP Flood Afflux

7 SENSITIVITY ANALYSES

7.1 OVERVIEW

Three sensitivity scenarios were simulated for the 1:100 AEP flood event to assess the impact of the following changes to modelling parameters:

- Increase to hydraulic roughness (20%).
- Increased blockage of culverts and bridges, in accordance with ARR 2019 guidelines.
- Zero blockage of culverts and bridges.
- Tailwater assumption sensitivity.
- Increase in waterway roughness to reflect revegetation.

7.2 METHODOLOGY

For the simulations of the sensitivity analysis scenarios, the two-hour duration was selected as a representative critical duration for waterways of moderate magnitude through the catchment, and all ensemble temporal patterns were simulated for comparison of the median water level grid to the baseline model.

The following methodology was adopted for modelling of the sensitivity analysis scenarios.

7.2.1 Increased Hydraulic Roughness

The hydraulic roughness Manning's "n" values were increased for all land uses (as shown in Figure 4.1) by a consistent value of 20%. A comparison of the base versus sensitivity analysis roughness values are provided in Table 7.1.

Table 7.1: Land Use and Manning's 'n' Values

Land Use Type	Manning's "n" – Design Case	Manning's "n"- Increased Roughness Sensitivity Analysis
Roads	0.025	0.03
Special Purpose (Road)	0.025	0.03
Recreation and Open Space	0.045	0.054
Rural Residential	0.055	0.066
Rural	0.055	0.066
Community Facilities	0.06	0.072
Environmental Management and Conservation/Dense Bush	0.09	0.108
Low Density Residential	0.2	0.24
Emerging Community	0.25	0.3
Low-Medium Density Residential	0.25	0.3
Centre/Industrial	0.3	0.36
Mixed Use	0.3	0.36
Waterway in channel - lightly vegetated	0.035	0.042
Waterway in channel - moderately vegetated	0.05	0.06
Waterway in channel - highly vegetated	0.07	0.084
Upper Catchment Watercourse	0.065	0.078
Waterway corridor	0.1	0.12

7.2.2 Increased Blockage of Culverts and Bridges

For the increased blockage of culverts and bridges scenario, blockage factors for culverts and some bridges were increased to simulate a severe blockage scenario. A summary of the blockage factors adopted for this scenario is provided in Table 7.2.

7.2.3 No Blockage of Culverts and Bridges

For this scenario, zero blockage was applied to culverts and no debris blockage applied to guard rails on bridges. A summary of the blockage factors adopted for this scenario is provided in Table 7.2.

Table 7.2: Summary of Adopted Blockage Factors

	Blockage Factor		
Hydraulic Structure Type	**Design Blockage Scenario**	**Increased Blockage Scenario**	**No Blockage Scenario**
Culverts: Inlet height < 3 m, or width < 5 m	20%	100%	0%
Culverts: Inlet height > 3 m and width > 5 m	10%	25%	0%
Bridges: Pier Blockage, for clear opening height < 3 m	As per pier configuration	100%	As per pier configuration
Bridges: Pier Blockage, for clear opening height > 3 m	As per pier configuration	As per pier configuration	As per pier configuration
Bridges: Guard Rails	100%	100%	As per guard rail configuration

7.2.4 Sensitivity on Tailwater Assumptions

For the sensitivity on the tailwater assumption, the 1% AEP design flood event was simulated with a constant tailwater level from the Logan River 1% AEP event. This increases the tailwater from a level of 21.66 m AHD (Logan River 1:5 AEP design event) to 29.48 m AHD (Logan River 1:100 AEP design event).

7.2.5 Increase in Waterway Roughness

A review into the current condition of the waterways through the Henderson Creek catchment was undertaken. The intent of this sensitivity is to represent revegetation of any waterways that are considered currently engineered with concrete inverts or grass lined or are in a state of degradation so that they reflect rehabilitation back to natural waterway conditions. As no engineered or degraded channels were observed in the catchment, this sensitivity was deemed unnecessary as no rehabilitation is required to ensure all waterways reflect natural waterway conditions. Generally, a Manning's "n" roughness of 0.10 has been applied in the adopted model parametrisation to reflect the current waterway conditions.

7.3 RESULTS

7.3.1 Increased Hydraulic Roughness

The flood afflux mapping for the scenario where the hydraulic roughness was increased is shown in Figure 7.1. The mapping indicates that the model is sensitive to this parameter and increasing the hydraulic roughness will result in higher flood depths and elevation. A summary of the model results is:

- Increases in modelled flood depth are relatively consistent across the model extent, averaging approximately 30 mm to 60 mm.
- Areas within the catchment extent that are not sensitive to increases in hydraulic roughness include:
  - Upstream of Country Road.
  - In the lower portions of the catchment, at the junction of Strachan Creek, Jimboomba Creek and Henderson Creek.

7.3.2 Increased Blockage of Culverts and Bridges

The flood afflux mapping for the scenario where the blockage of hydraulic structures was increased is shown in Figure 7.2. The mapping indicates that blockage of key hydraulic structures results in localized increases in flood levels upstream of the crossings and reductions in flood levels downstream of the crossings.

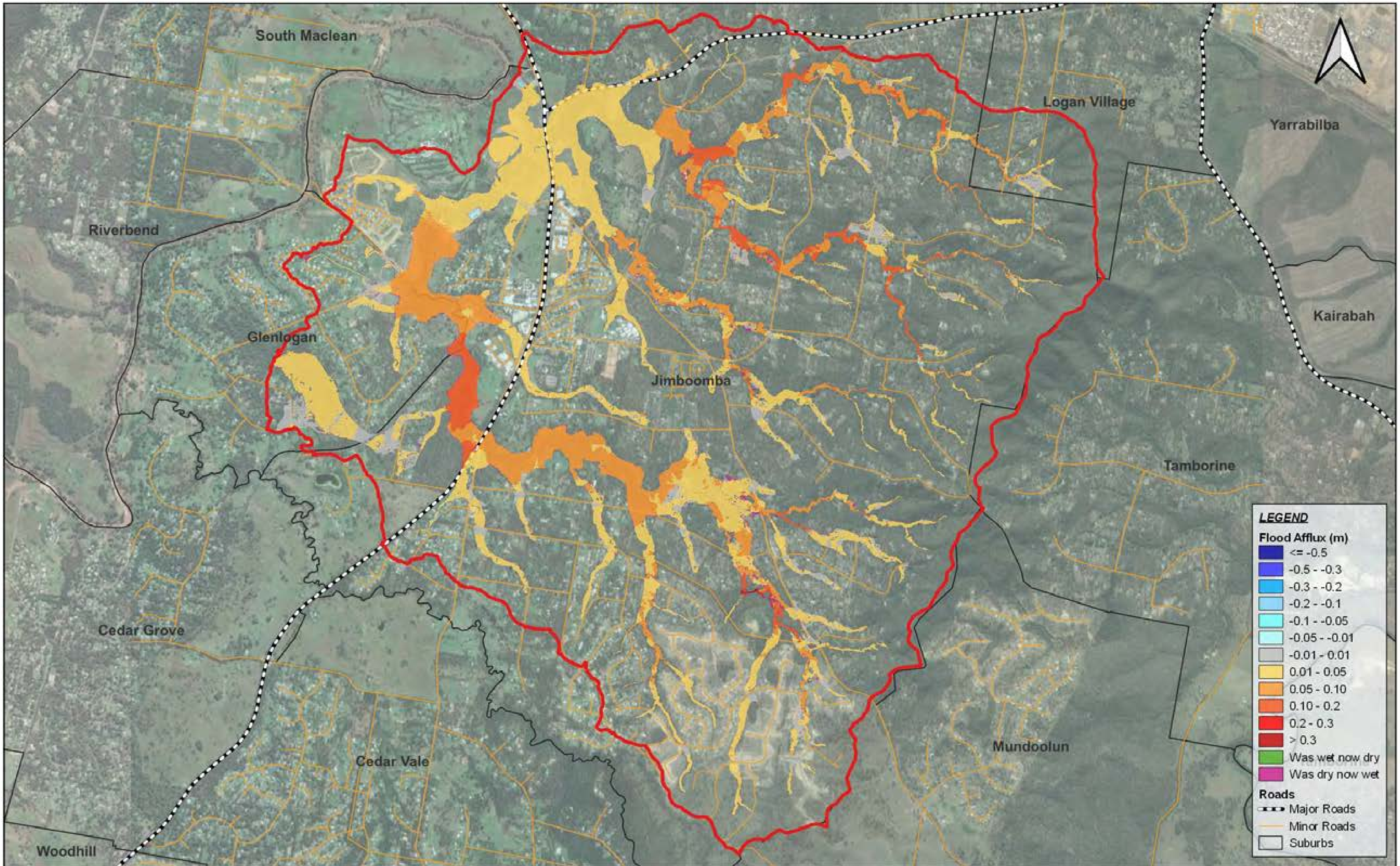
7.3.3 No Blockage of Culverts and Bridges

The flood afflux mapping for the scenario where structures are unblocked are shown in Figure 7.3. As expected, the mapping indicates that eliminating culvert blockage has less impact on modelled flood levels and depths than the other sensitivity analyses. This is due to majority of structures in the catchment having only a 20% blockage for design events, meaning there is minimal difference between the design and sensitivity events, and in the modelled 1% AEP event, the pipe capacities are exceeded, and large amounts of flow overtop the road embankments. Areas where changes in flood level are more prominent are:

- Flood level increases was observed along Henderson Creek through Jimboomba, where reducing the blockage amount causes localised decreases in flood levels upstream of culvert crossings on minor flow paths, but a cumulative increase in flood levels of up to 20 mm as these flow paths converge.
- Flood level reductions of up to 30 mm was observed for a large area along Strachan Creek and Jimboomba Creek upstream of the Mount Lindesay Highway culvert crossing.

7.3.4 Sensitivity on Tailwater Assumptions

This sensitivity scenario modelled a 7.82 m rise to the tailwater level assumption at the confluence of Logan River (1:5 AEP to 1:100 AEP). The flood afflux mapping shown in Figure 7.4 show a considerable increase in the downstream flooding extent, with a significant number of properties previously unaffected, now are inundated. The flood impacts propagate approximately halfway along each of the creek systems that drain towards the Mount Lindesay Hwy. Upstream catchments past this halfway point remain unaffected by the change in the tailwater level.



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0 0.8 1.6 km

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Figure 7.1 - Increase in roughness afflux

Henderson Creek Flood Study Update
1:100 AEP Flood Afflux

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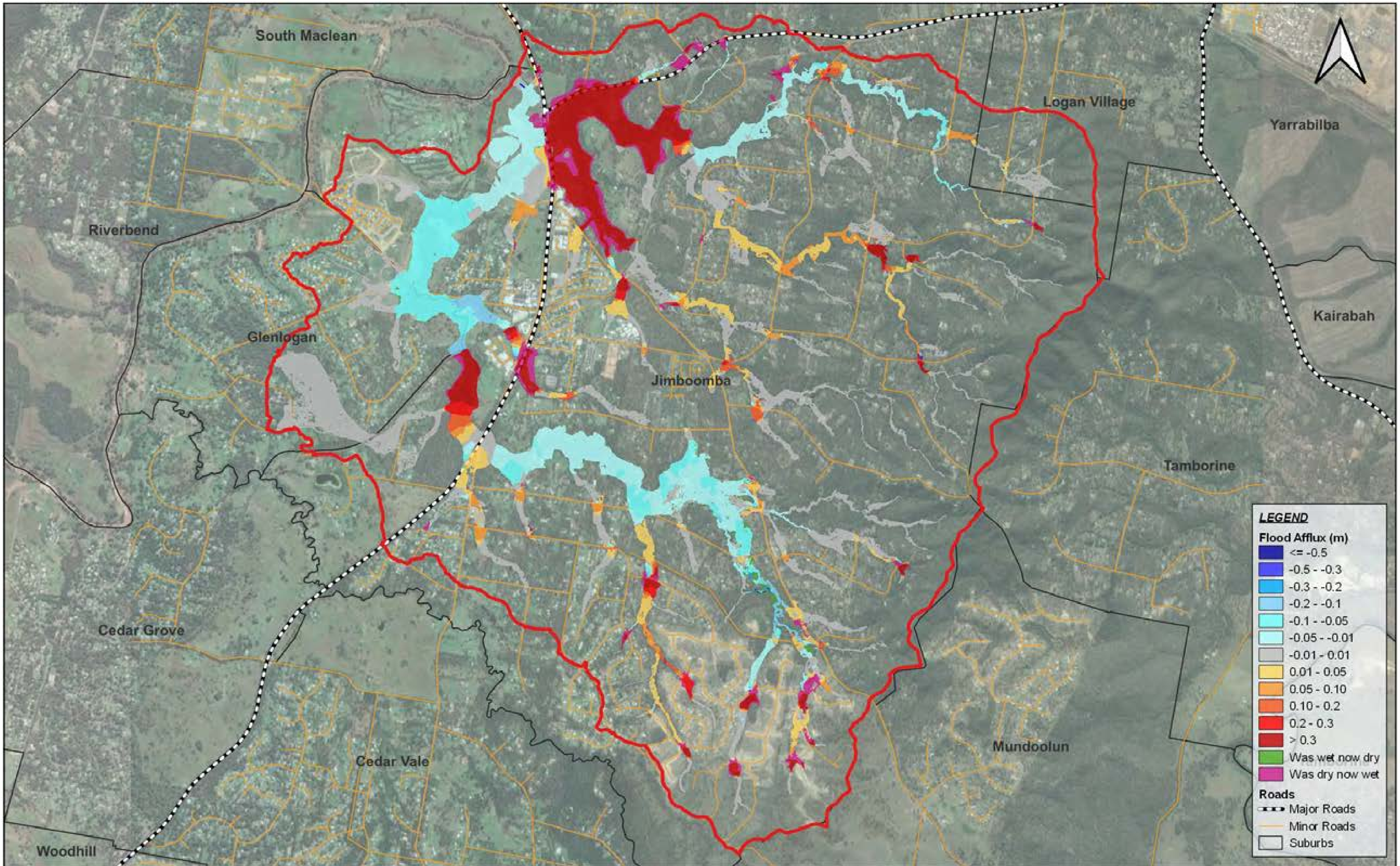

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Figure 7.2 - Increased blockage afflux

Henderson Creek Flood Study Update
1:100 AEP Flood Afflux

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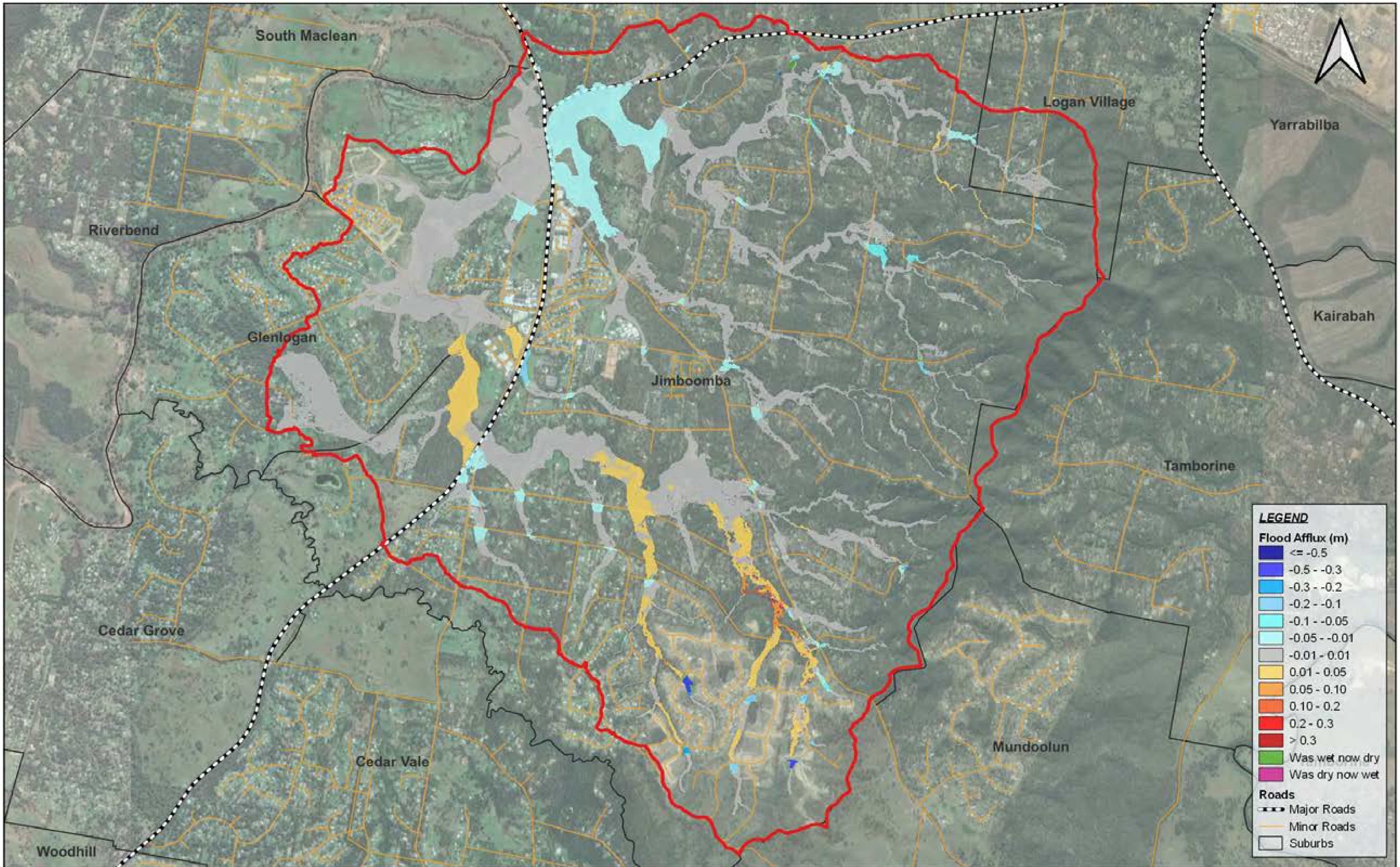

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Figure 7.3 - No structure blockage afflux

Henderson Creek Flood Study Update
1:100 AEP Flood Afflux

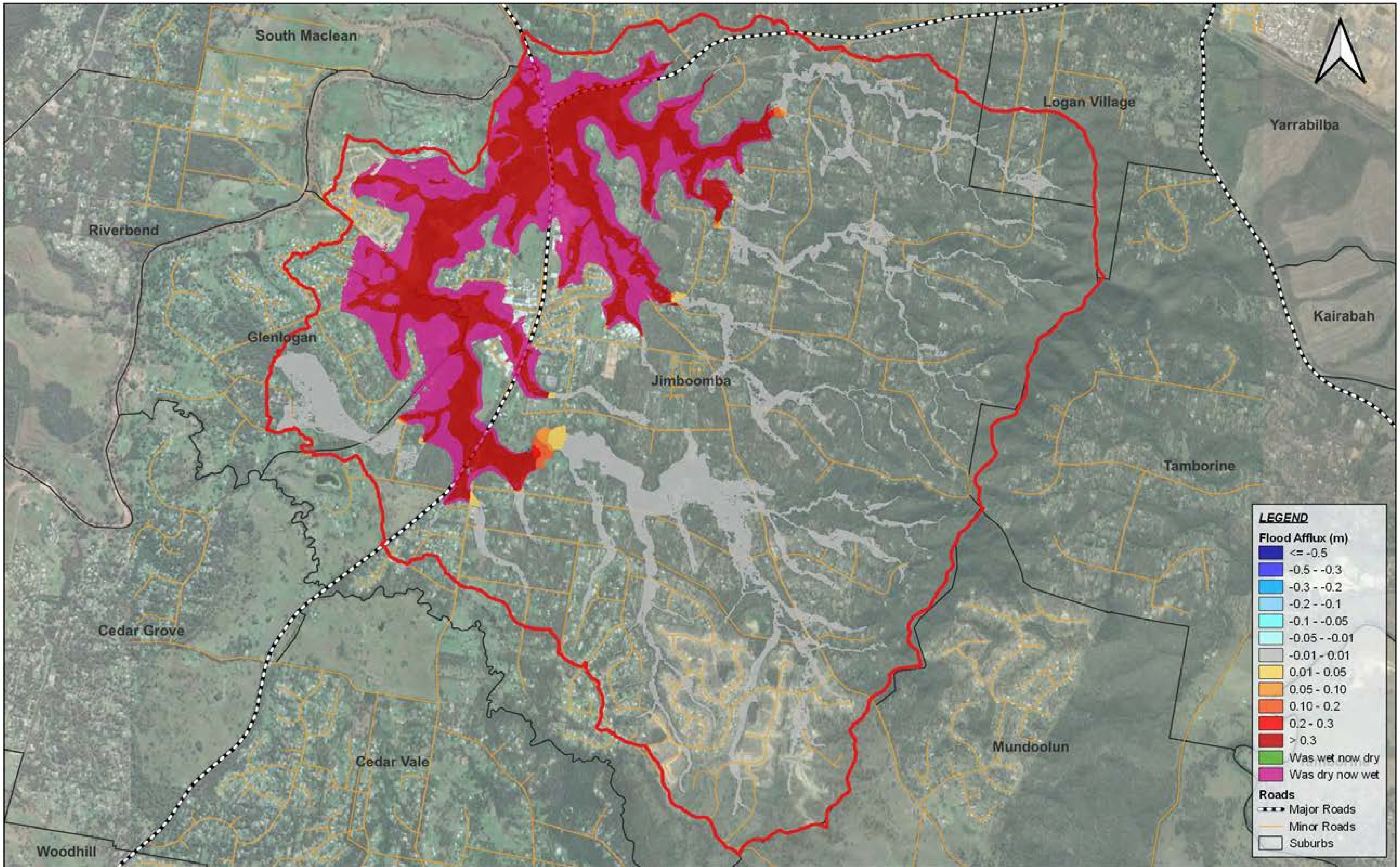

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Figure 7.4 - Tailwater assumption afflux

Henderson Creek Flood Study Update
1:100 AEP Flood Afflux

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8 FLOOD STUDY SUMMARY

8.1 OVERVIEW

XPRAFTS hydrologic and TUFLOW hydraulic models previously developed for Strachan, Jimboomba and Henderson Creeks were updated to be in accordance with ARR 2019 guidelines. The models were calibrated against the January 2013, May 2015 and March 2017 flood events and were validated using numerous methodologies for design events.

Flood behaviour was determined for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5%, 0.2%, 0.5%, 0.05% and PMF flood events, and climate change. A brief summary of the flood study update is provided in the below sections.

8.2 HYDROLOGIC MODEL DEVELOPMENT

The following is a summary of the key parameters of the XPRAFTS hydrologic model.

- Sub-catchment delineation was undertaken to ensure that catchment sizes are generally no larger than 30 hectares.
- Catchment parametrisation was undertaken utilising the 2021 1m LiDAR and the ultimate planning scheme.
- Spatially varied rainfall from ten locations across the catchment were applied to the model.
- Rainfall losses in accordance with ARR 2019 were applied.
- Catchment routing was amended to achieve validation of hydrograph shape between the hydrologic and hydraulic model.

The model was simulated for all design events and calibration events to produce local inflows to the hydraulic model.

8.3 HYDRAULIC MODEL DEVELOPMENT

The following is a summary of the key parameters of the TUFLOW hydraulic model:

- The TUFLOW model was simulated using the latest TUFLOW build at the time (2020-10-AD) and the GPU hardware and the HPC solver.
- The model cell size was 3m and the 2021 1m LiDAR capture was utilised.
- Representation of hydraulic structures (bridges and culverts) throughout the model were undertaken using 2d layered flow constrictions and 1D network elements. Standard blockage factors were applied in accordance with ARR 2019 guidance.
- Local inflow locations have been specified to match the catchment delineation.
- The model discharges to the Logan River, and constant water levels informed by the *Logan Albert Rivers Flood Study* (WRM, 2021) were applied for design events and the Yarrahappini Alert stream gauge for the calibration events.
- Roughness values to match current conditions were utilised for simulation of the calibration events, with amendment to reflect ultimate planning scheme for the design event modelling.

The model was simulated for all durations and temporal patterns for the design events.

8.4 MODELLING CALIBRATION AND VALIDATION

The models were calibrated for the May 2015 (approximately 1:20 AEP), June 2016 (< 1:2 AEP) and March 2017 (approximately 1:50 AEP) flood events. This was achieved through application of pluviographic rainfall data and tailwater levels from the Yarrahappini gauge, with calibration of water level time series recorded and modelled at the Henderson Creek gauge. All three events show accurate replication of the recorded peak, timing and shape, with the modelled result within 10 mm, 70 mm and 10 mm of the recorded peak for the 2015, 2016 and 2017 events respectively. The 2015 event achieves the most accurate calibration, with assumed issues with the 2016 gauge record due to a “flat” recording at the peak and the tail of the 2017 event being influenced by the Logan River tailwater.

For design event validation, the following methods were utilised:

- Flood Frequency Analysis (FFA) – no gauges appropriate for a FFA were available to undertake this method of validation.

- Rational Method - validation of smaller catchments for the 1:10 AEP and 1:100 AEP flood events indicate that the TUFLOW and XPRAFTS peak flow estimates were generally within a range of +/- 15% for all locations considered.
- Quantile Regression Technique (QRT) and Regional Flood Frequency Estimation Model (RFFE) – validation of catchment outlet peak flows indicate that the peak flows produced by the models sit slightly lower for the 1:100 AEP flood event for the QRT method, and significantly lower than the RFFE estimate. For the 1:10 AEP flood event, peak flows produced by the models sit between the peak flows calculated using the validation methods.
- Hydrologic and Hydraulic model comparison – hydrographs for the critical 1:10 AEP and 1:100 AEP events were extracted at the catchment outlet from XPRAFTS and TUFLOW. This comparison shows that both models indicate the same duration and temporal pattern as critical in both models for the 1:10 AEP event, with comparative volumes and peak flow for the 1% AEP flood event.

8.5 MODELLING RESULTS

Peak flood levels and flows for the critical duration and temporal pattern throughout the Henderson Creek catchment have been extracted and summarised in this report. Flood behaviour in the Henderson Creek catchment features defined waterways in the upper catchment, broadening out to wider floodplains between Mundoolun Road and the Mount Lindesay Highway. Flood storage is present in the lower catchment through Jimboomba.

PDF “max-max” mapping for the design flood events have been provided with this report.

8.6 SENSITIVITY ANALYSES

Five sensitivity analyses were undertaken for the 1:100 AEP:

- Increased hydraulic roughness – results in consistent increases in flood level across the model extent.
- Increased blockage of culverts and bridges – results in localised increases of flood level upstream of culvert crossings and reductions downstream of culvert crossings.
- No blockage of culverts and bridges – minimal impact on modelling results, with increases in flood level in Henderson Creek as a result of cumulation of increased flows through upstream culverts. Localised reductions upstream of Mount Lindesay Highway crossing.
- Sensitivity on tailwater assumptions – significant impact to flood extents towards the lower half of the catchment. Flood impacts observed to propagate halfway up the creek systems.
- All waterways in the Henderson Creek catchment are considered to currently reflect natural waterway conditions, and therefore a sensitivity on waterway revegetation was not required.

9 FLOODPLAIN MANAGEMENT PLANNING

Floodplain management planning and assessment of the Henderson Creek catchment has been completed in accordance with Council specifications utilising the flood model outputs from the flood study. The key components of the scope included:

- Provision of additional mapped output, inclusive of:
  - Hydraulic risk classification.
  - Identification of high and low flood islands.
  - Time to inundation mapping.
  - Duration of inundation mapping.
  - Hydraulic function specification.
- Assessment of road immunity and evacuation capability.
- Structural mitigation option assessment.
- Flood damages assessment.

9.1 FLOOD RISK MAPPING OUTPUTS

9.1.1 Hydraulic Risk Classification

Hydraulic risk mapping was developed utilizing the flood hazard results and the matrix shown in Figure 9.2. The flood hazard classification scheme is discussed in Guideline 7.3 of the *Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (*AIDR, 2017).

The AIDR flood hazard vulnerability curves associated with this classification are provided in Figure 9.1. The flood events considered in development of this mapping are as per Figure 9.2, and included:

- 1:10 AEP RCP4.5 2090 climate change
- 1:20 AEP RCP4.5 2090 climate change
- 1:50 AEP RCP4.5 2090 climate change
- 1:100 AEP RCP4.5 2090 climate change
- 1:200 AEP RCP4.5 2090 climate change
- 1:500 AEP RCP4.5 2090 climate change
- 1:2,000 AEP RCP4.5
- PMF.

A final hydraulic risk map which shows the maximum classification at each grid cell across the model extent is provided inFigure 9.3.

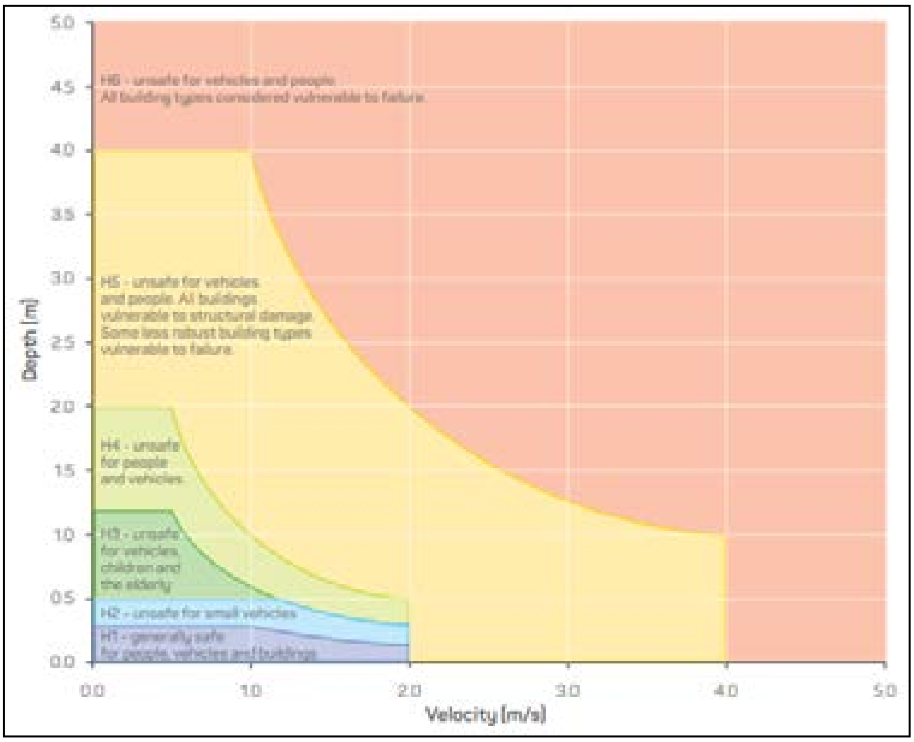
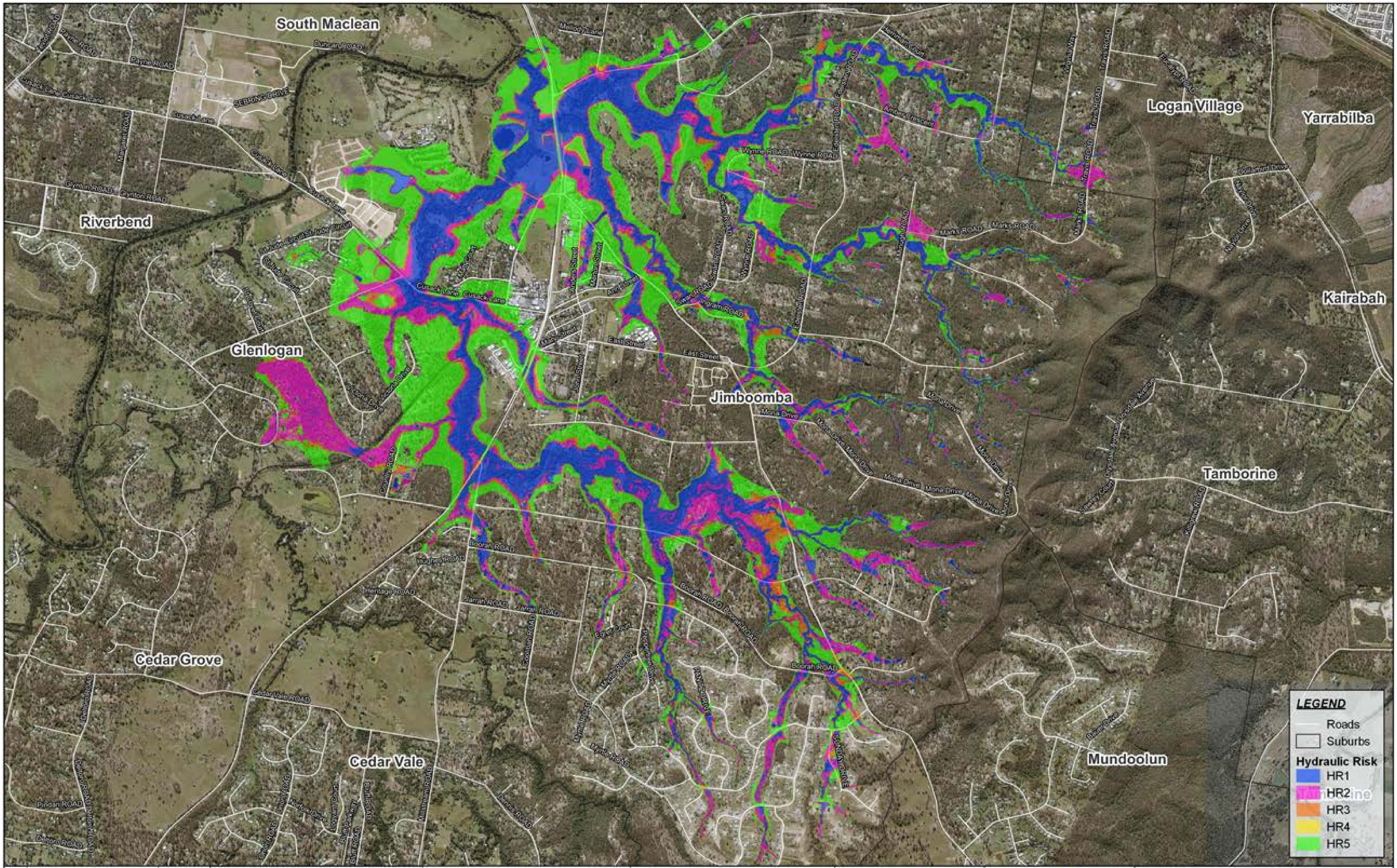


Figure 9.1: AIDR Flood Hazard Vulnerability Curves

AEP Event (%)	Hazard Level (Australian Emergency Management Institute)					
	H1	H2	H3	H4	H5	H6
PMF	HR5	HR5	HR5	HR5	HR5	HR5
0.05	HR5	HR5	HR4	HR4	HR4	HR4
0.2+CC	HR5	HR4	HR4	HR3	HR3	HR3
1+CC	HR4	HR4	HR3	HR2	HR2	HR2
2+CC	HR4	HR3	HR2	HR2	HR1	HR1
5+CC	HR3	HR2	HR2	HR1	HR1	HR1
10+CC	HR2	HR1	HR1	HR1	HR1	HR1

Figure 9.2: Hydraulic Risk Classification Matrix



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0 0.8 1.6 km

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Figure 9.3

Henderson Creek Flood Study

Hydraulic Risk Map

9.1.2 Identification of High and Low Flood Islands

Identification of high and low flood islands has been informed in accordance with *Flood Emergency Response Classification of the Floodplain* (AIDR, 2017). The following definitions in Table 9.1 have been applied to the Henderson Creek catchment floodplain. The corresponding map is shown in Figure 9.4.

Table 9.1: Definition of High and Low Flood Islands

Classification	AIDR Descriptor	Guiding Description
Low Flood Islands	Submerged	Where all the land in the isolated area will be fully submerged in a PMF after becoming isolated.
High Flood Islands	Elevated	Where there is a substantial amount of land in isolated areas elevated above the PMF.

Flood islands have been identified in accordance with the approach provided by Council. Flood islands were determined utilising flood extents from the following flood grids:

- 1:5 AEP RCP4.5 2090 climate change
- 1:10 AEP RCP4.5 2090 climate change
- 1:20 AEP RCP4.5 2090 climate change
- 1:50 AEP RCP4.5 2090 climate change
- 1:100 AEP RCP4.5 2090 climate change
- 1:200 AEP RCP4.5 2090 climate change
- 1:500 AEP RCP4.5 2090 climate change
- 1:2,000 AEP RCP4.5
- PMF.

Low and high flood islands were spatially determined and classified as per the definition provided in Table 9.1. The flood event at which island become isolated was determined by when depth of flooding across access roads exceeds 300 mm and is noted on the digital data. The flood event at which each island becomes inundated is also noted on the digital data. Flood islands with an area less than 1 ha were excluded.

The isolation duration for the high flood islands in a Henderson Creek flood event is likely to be relatively short (i.e. less than 6 hours) due to the relatively short catchment response time. Isolation due to Logan River flooding is more severe however was not the focus of this study.

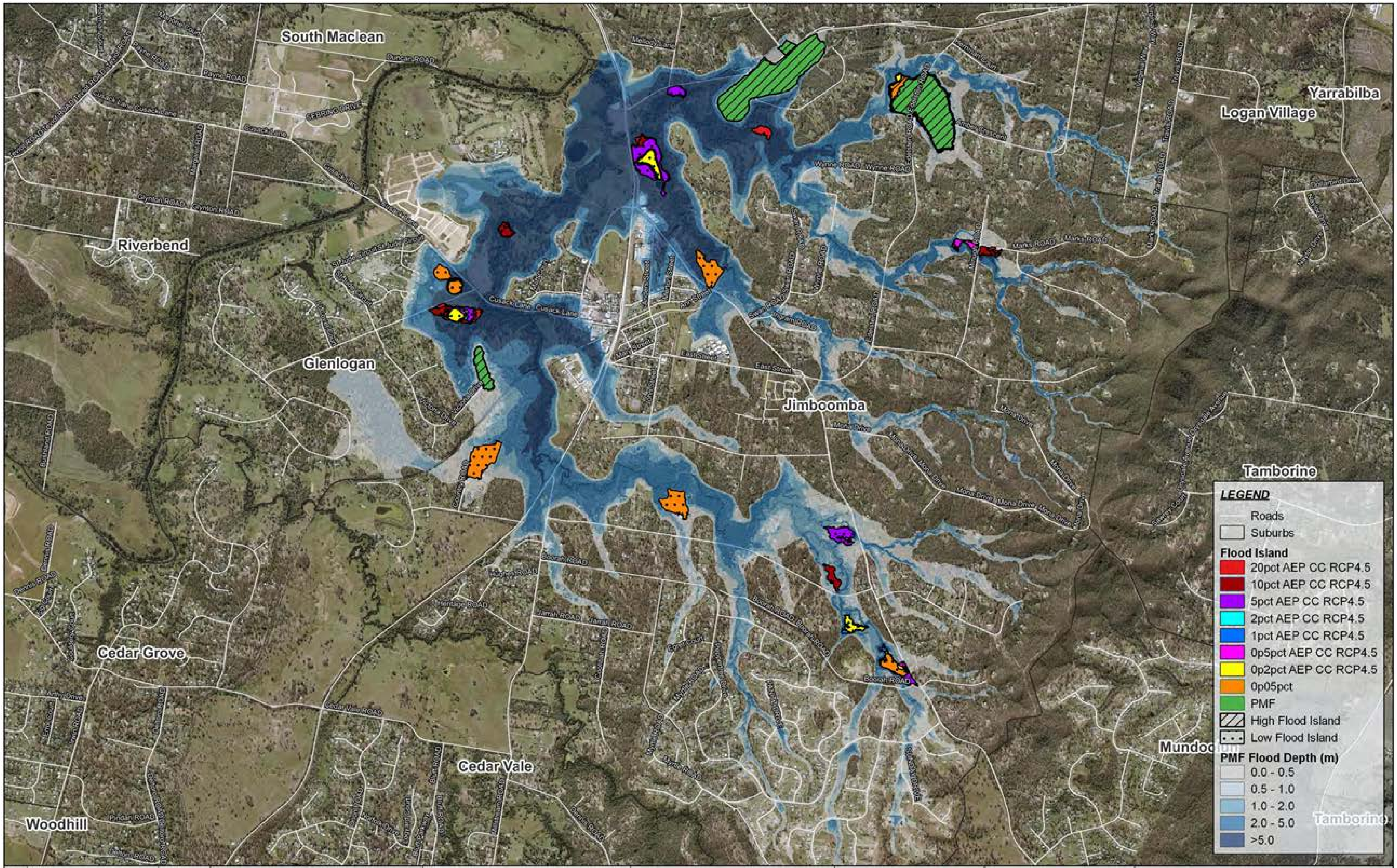

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Figure 9.4

Henderson Creek Flood Study

Low and High Flood Islands

Figure 9.4

9.1.3 Time to Inundation and Duration of Inundation Mapping

Time to inundation and duration of inundation mapping has been produced for the 0.05% AEP event utilising TUFLOW's automatically generated grids. For time to inundation, the time until each model cell in the floodplain is flooded (>0.01 m) is shown in Figure 9.5. For duration of inundation, the total time cells in the floodplain are submerged (>0.01 m) is shown in Figure 9.6.

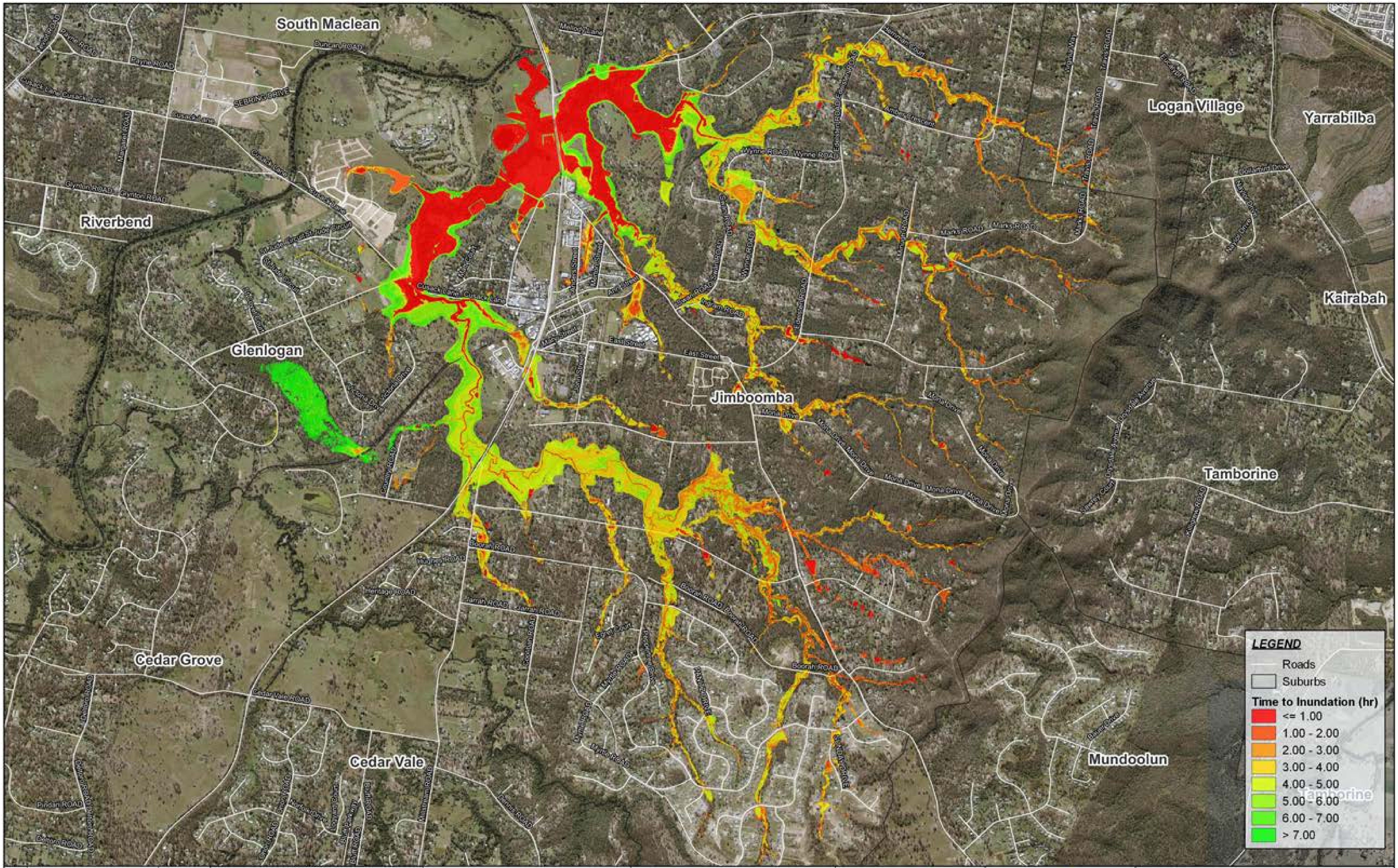

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Figure 9.5

Henderson Creek Flood Study

0.05% AEP Time to Inundation Map

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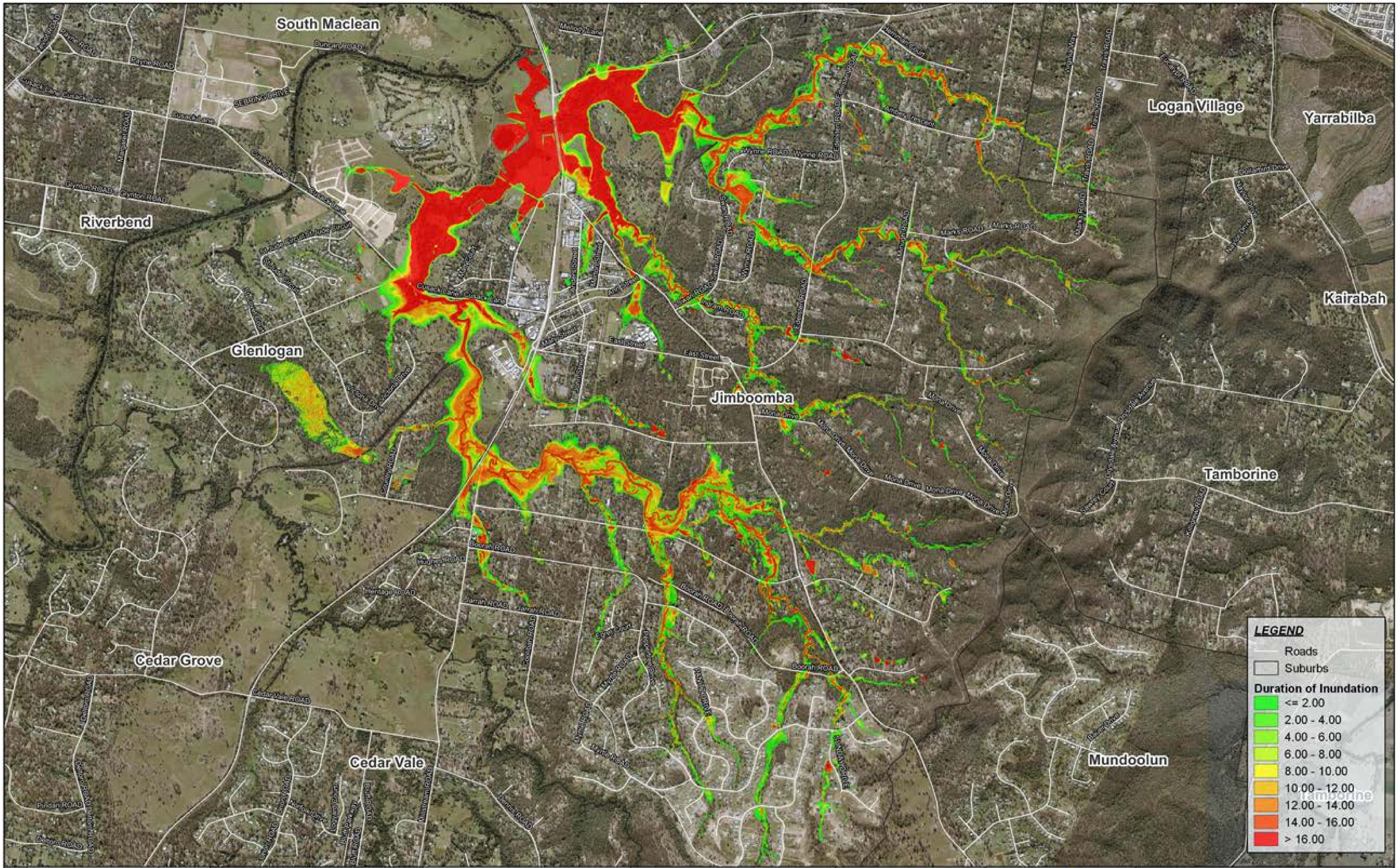

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Figure 9.6

Henderson Creek Flood Study

0.05% AEP Duration of Inundation Map

9.1.4 Hydraulic Function Specification

Hydraulic function mapping has been completed utilising the categorisation from the hydraulic risk mapping as summarised in Table 9.2. The hydraulic function map is provided in Figure 9.7. The hydraulic risk categorisation is explained further in Section 9.1.1, and is a function of the AIDR hazard classification of flood events ranging from the 1:10 AEP to PMF flood events.

Table 9.2: Hydraulic Function Classification

Hydraulic Function	Hydraulic Risk Categorisation (as per Figure 9.3)
Conveyance	HR1 and HR2
Storage	HR3 and HR4
Fringe	HR5

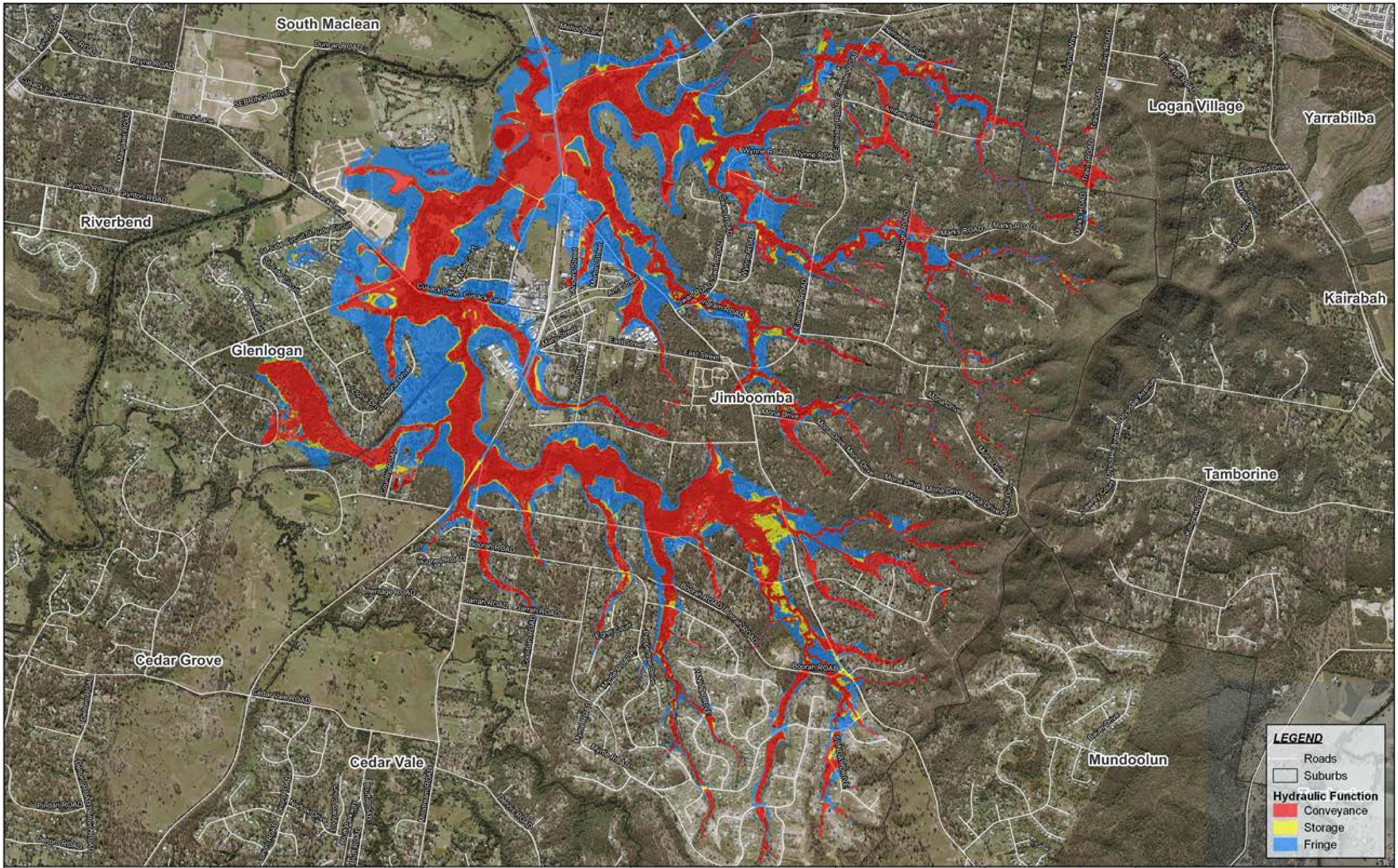

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Figure 9.7

Henderson Creek Flood Study

Hydraulic Function Map

9.2 ROAD IMMUNITY AND EVACUATION CAPABILITY

9.2.1 Road Immunity

A flood immunity and trafficability assessment has been completed for road crossings within the Henderson Creek catchment. Analysis of road crossings was undertaken for all flood events analysed and the identified flood immunity is shown in Figure 9.8. Numerous local roads have flood immunity of less than the 50% AEP, The Mt Lindsay Highway was determined to have flood immunity of at least 2% AEP. Note that no roads analysed have 1% AEP flood immunity.

Trafficability at road crossings was also assessed by identifying the most frequent flood event which inundates the road crossing segment to a depth of greater than 300 mm. The road trafficability mapping is presented in Figure 9.9.

The flood immunity and trafficability of road crossings within the catchment is generally considered to be low and is likely to restrict access and evacuation during flood events, however the duration of inundation is also low and therefore the greatest risk to the community is considered to relate to road safety during flood events.

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Figure 9.8

Henderson Creek Flood Study

Road Crossing Immunity

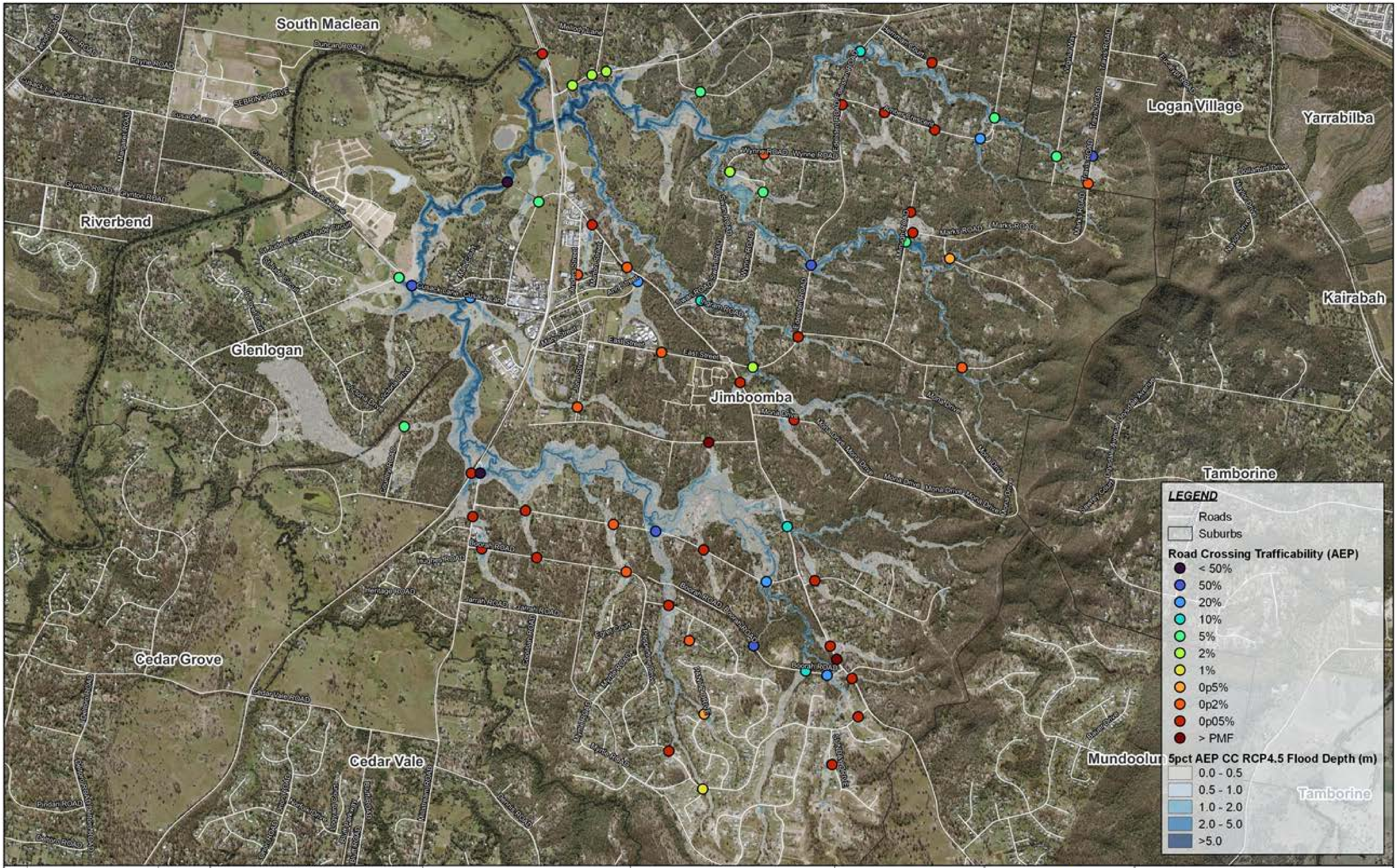

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Figure 9.9

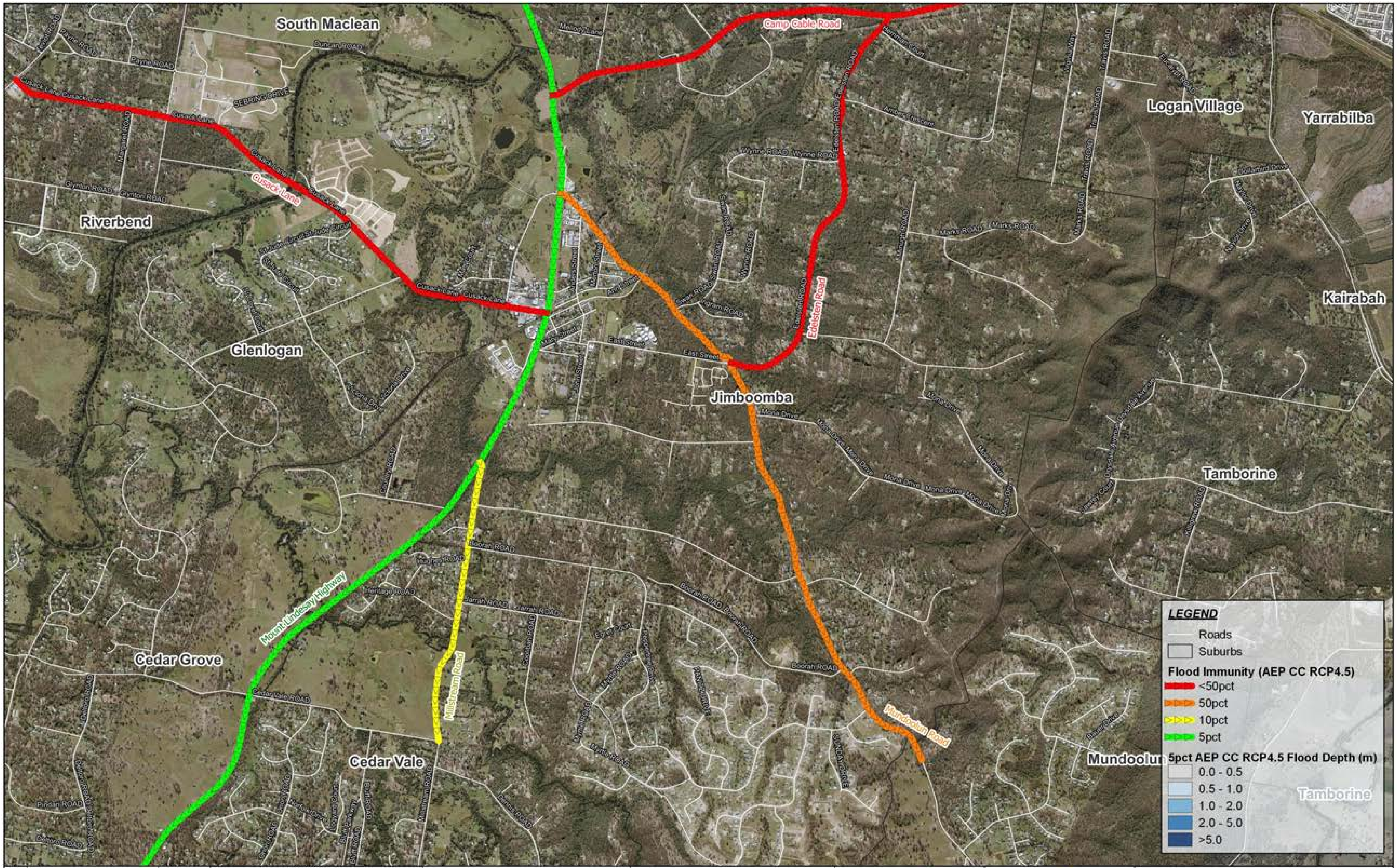
Henderson Creek Flood Study

Road Crossing Trafficability

9.2.2 Evacuation Routes and Restrictions

As presented in the previous section, the flood immunity at road crossings across the catchment is generally low. This will result in roads being cut in frequent events which will cause evacuation and access restrictions. However, the duration of inundation at road crossings was also determined to be relatively short (less than 6 hours) and therefore this does not pose a significant isolation risk to the community. The evacuation and isolation impacts will be more significant for areas within the lower part of the catchment where there is influence from the Logan River.

An analysis for the time of inundation and duration of inundation was undertaken for the 0.05% AEP event, which has been provided to Council in digital format.



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0 0.8 1.6 km

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Figure 9.10

Henderson Creek Flood Study

Evacuation Route Immunity

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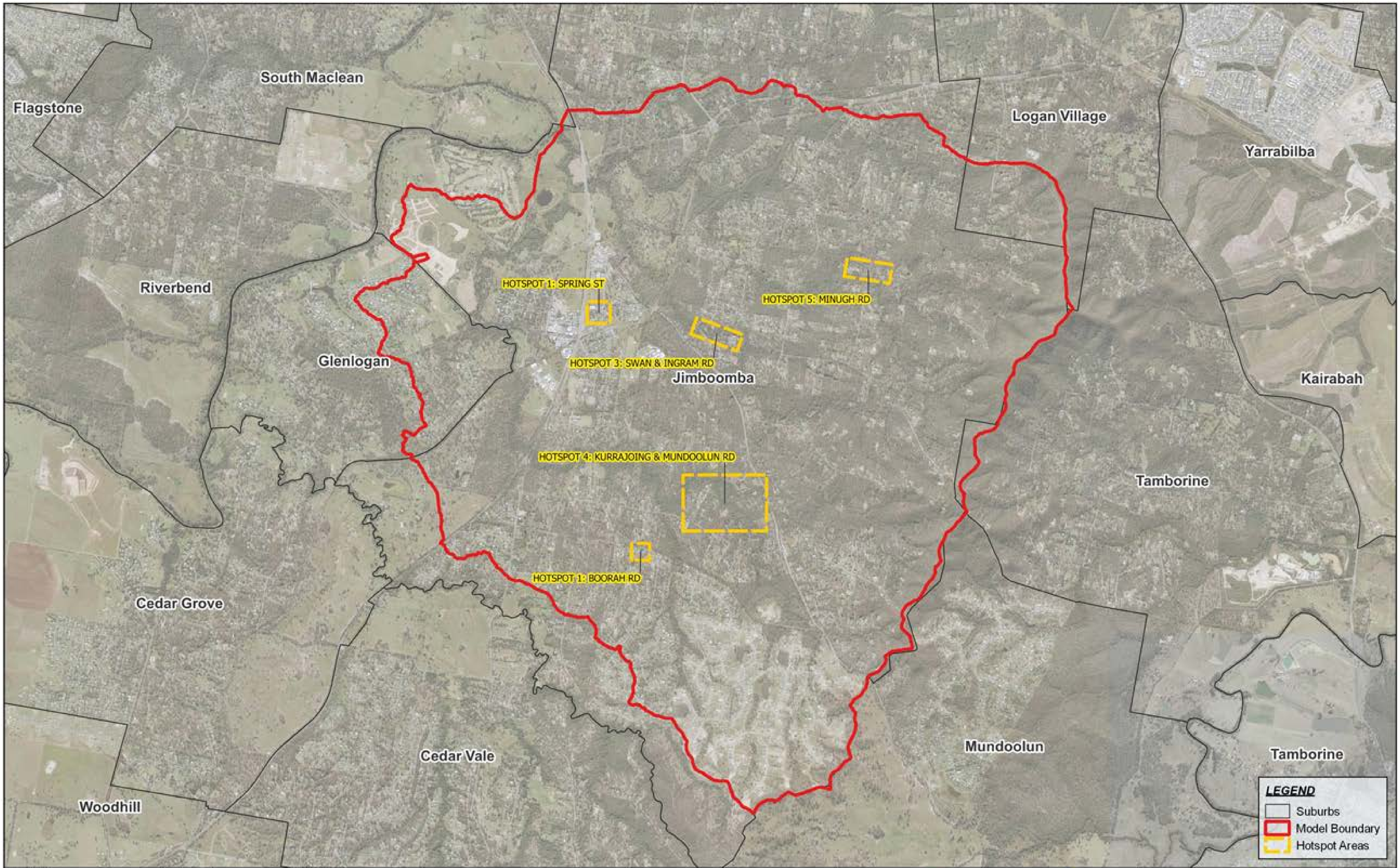
9.3 STRUCTURAL MITIGATION OPTION ASSESSMENT

9.3.1 Impacted Areas

A review of the flood results for the range of events analysed has identified five (5) key flooding hotspot areas. These hotspot areas were identified based on 1% AEP CC RCP4.5 building inundation to a number of properties with close proximity to each other. In the absence of known building floor levels, it as conservatively assumed that the floor levels matched the ground elevation of the building polygons. The identified flooding hotspot areas within the catchment are shown in Figure 9.10. Based on the building polygons provided by Council, the number of buildings potentially inundated for the range of events analysed was calculated based on building located within the inundation extent for each event. A summary is provided in Table 9.3. It was estimated that 47 buildings could be impacted in the 1% CC RCP4.5 AEP event and 377 buildings in the PMF. It should be noted that this does not represent the number of houses impacted, as some building polygon may be digitised sheds and other structures. It also does not consider inundation from the Logan River for the lower parts of the catchment.

Table 9.3: Buildings Potentially Inundated

Flood Event (AEP)	Number of Buildings Potentially Inundated
20% CC RCP4.5	19
10% CC RCP4.5	26
5% CC RCP4.5	35
2% CC RCP4.5	44
1% CC RCP4.5	53
0.5% CC RCP4.5	60
0.2% CC RCP4.5	78
PMF	377



R	DETAILS	DATE
1	Final Issue	11-05-2023

DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	11-05-2023

NOTES:

SCALE @ A3 - 1:40,000
GDA2020 / MGA zone 56

DATA SOURCE
QLD Government Open Data Source

ENGENY

LOGAN CITY COUNCIL

Figure 9.11

Henderson Creek Flood Study

Flood Hotspot Areas

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-002-A-Henderson Ck_Results_Review_ZL.qgz

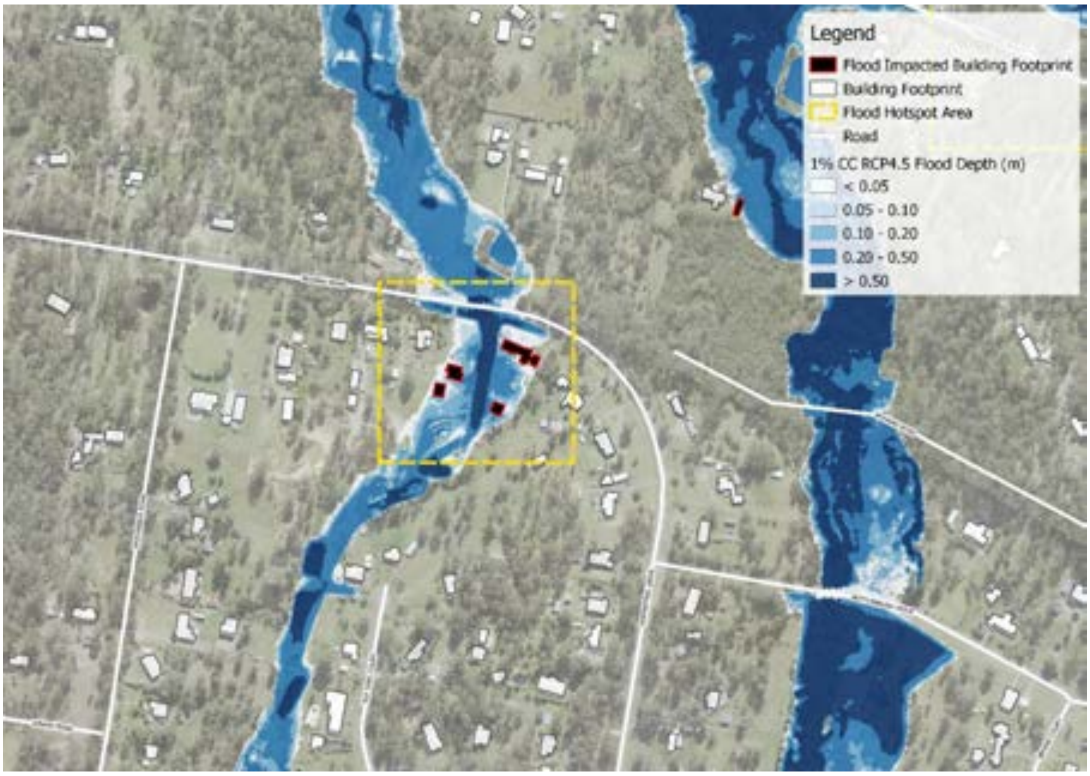


Figure 9.12: Hotspot 1 – Boorah Road

Figure 9.13: Hotspot 2 – Spring Street

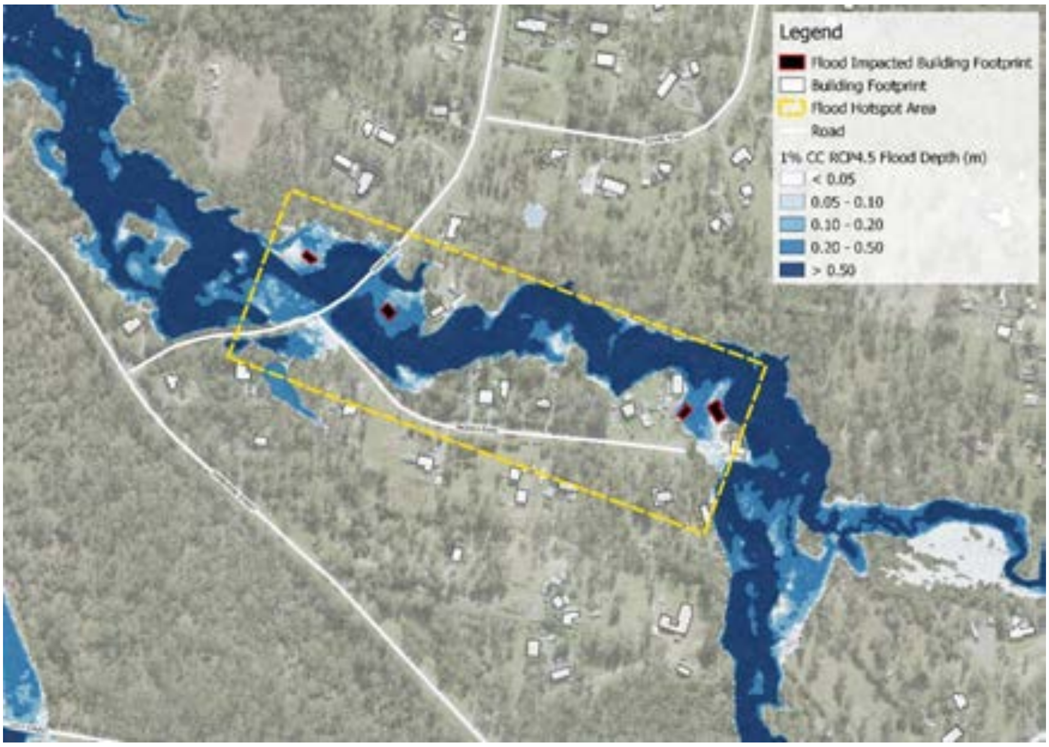


Figure 9.14: Hotspot 3- Ingram Road

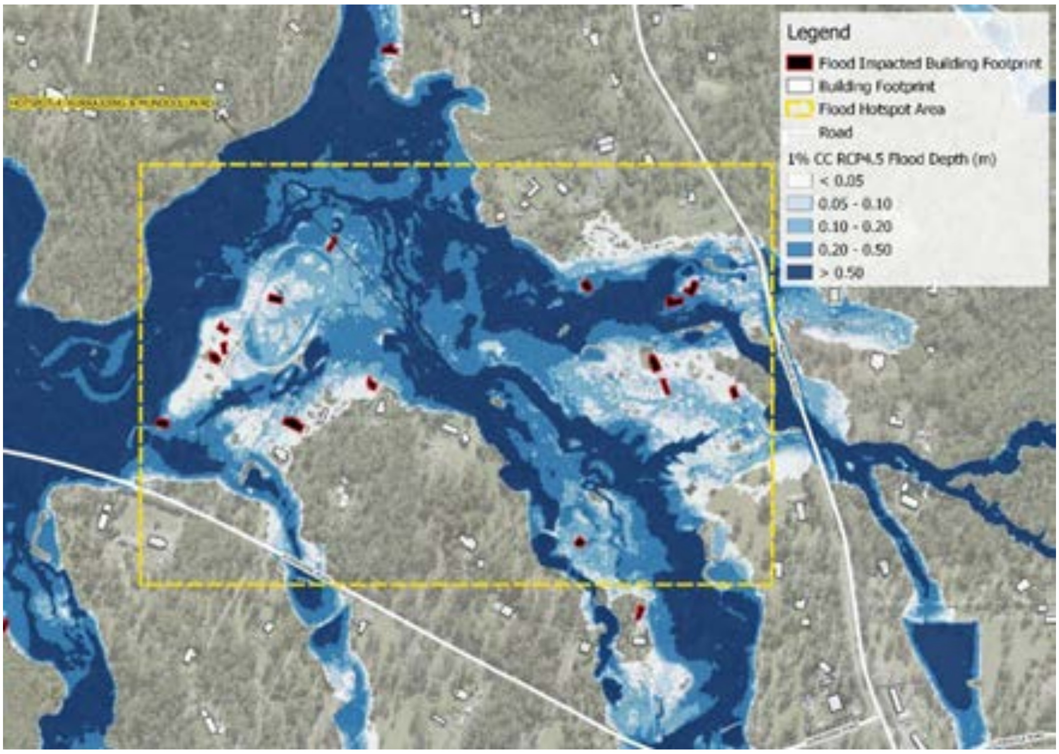


Figure 9.15: Hotspot 4 – Kurrajong Road

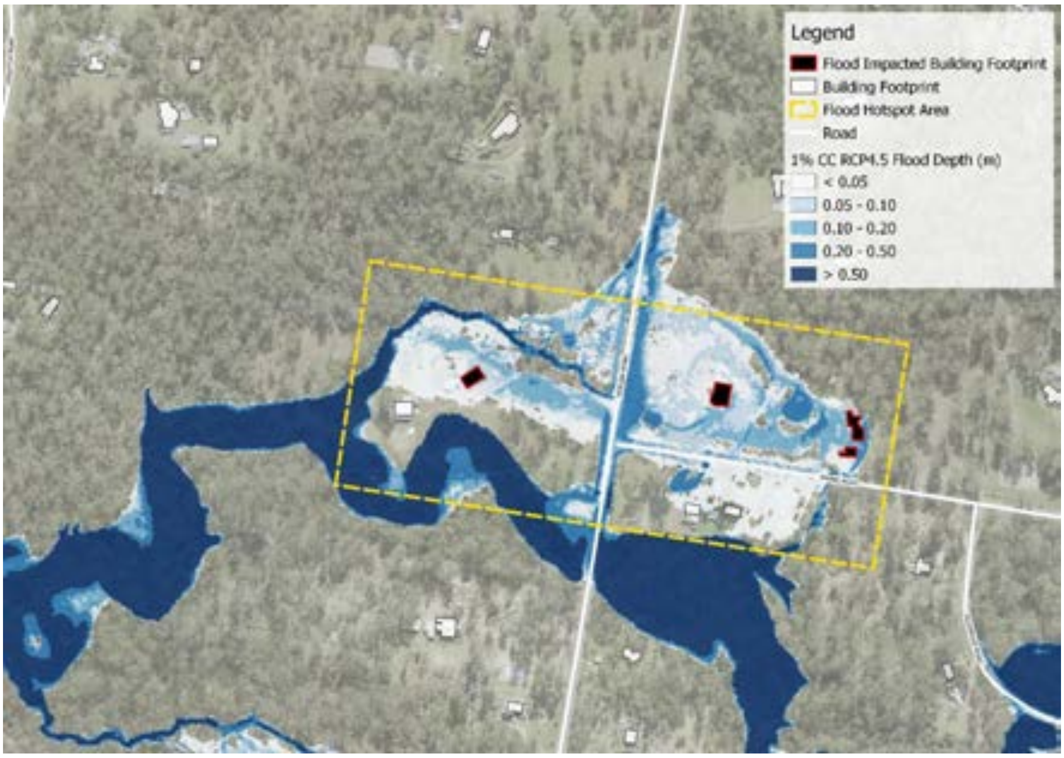


Figure 9.16: Hotspot 5 – Marks Road

Qualitative Option Identification

It was evident from a review of the flood modelling results and impacted properties that there are limited opportunities for structural mitigation. The potential structural mitigation options considered are outlined as follows:

- Levee protection – construction of earthen levees to protect flood affected buildings was considered however given the low density of flood affected properties, the likely adverse impacts associated with flow redistribution and that the works would be on private property, it was considered that levee protection would not be feasible.
- Flow attenuation from upstream detention structures – construction of online detention structures was considered however was not deemed to be viable due to the limited number of properties that would benefit, the potential for the structures to be referable, and the anticipated environmental impacts associated with the earthworks. Creating online storage at road crossings was also considered to be unfeasible.
- Cross drainage upgrade to reduce property inundation – The option to modify the cross-drainage capacity to reduce property inundation was considered, however the adverse flood impacts and costs associated with significant road raising deemed this option to be unviable.
- Cross drainage upgrade to improve road immunity – increase the cross-drainage capacity and therefore improving road immunity was considered to be a viable option which would also provide a benefit to the community in terms of road safety. As such, this option was further assessed (refer section below).
- House raising – this is considered to be a private matter and whist Council can assist property owners in an advisory manner, funding would normally be provided by the property owner.

9.3.2 Flood Assessment of Options

The assessment of the hotspot areas demonstrated that only a small number of properties would benefit from any potential structural mitigation solution. Therefore, the potential structural mitigation options were selected based on their ability to facilitate maximum evacuation potential as well as to provide improvements to the overall trafficability. For the purpose of this high-level floodplain management plan, two road crossings located at Kurrajong Rd (near Mundoolun Rd) and Edelsten Road were identified to be part of the key evacuation routes to service areas reliant on these crossings for flood evacuation. It should be noted that the proposed mitigation options considered have been practically sized, taking into account the existing creek channel and road geometry.

The locations are shown in Figure 9.17 below.

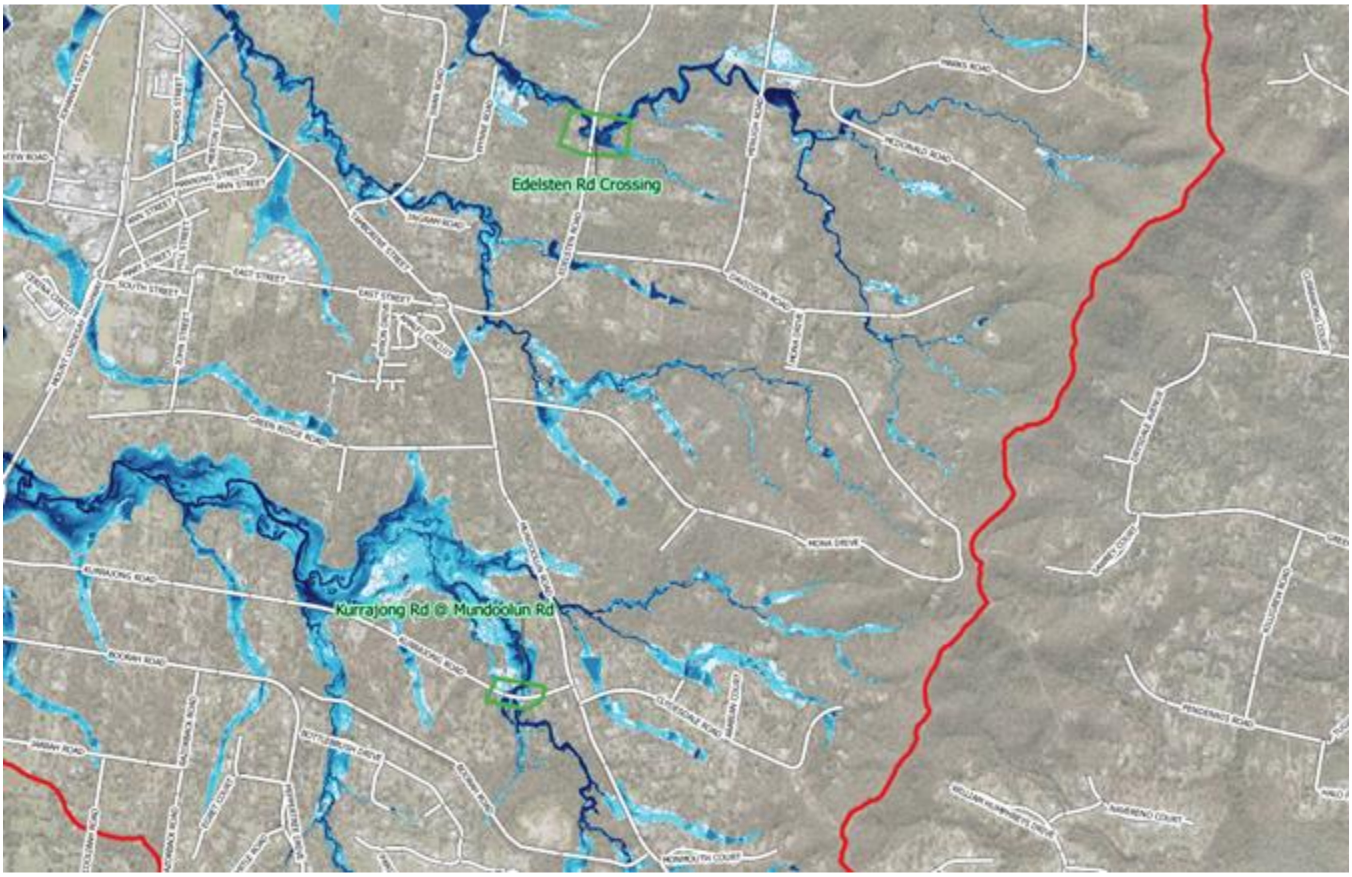


Figure 9.17: Cross Drainage Upgrade Locations

The details for each crossing are outlined below.

Kurrajong Rd Crossing:

- Current Cross drainage - 4 / 1500 mm RCPs (~6m waterway width).
- Trafficable up to and including the 10% AEP CC RCP4.5 (Depths < 300 mm).
- Available waterway width, including channel widening works ~18 m.
- Depth from channel bed to road crest ~ 2.5 m.
- Proposed upgrade: 9 / 2000 mm x 2200 mm RCBCs based on geometry and road level.

Edelsten Rd Crossing:

- Current Cross drainage - 3/ 2400 x 1500 RCBCs (~7.2m waterway width).
- Trafficable up to and including the 50% AEP (Depths < 300 mm).
- Available waterway width, including channel widening works ~18 m.
- Depth from channel bed to road crest ~ 2.0 m.
- Proposed upgrade: 7 / 2400 mm x 1800 mm RCBCs based on geometry and road level.

The proposed upgrades were incorporated into the TUFLOW model to assess the benefit provided by the upgrade. The model was simulated for all design events. Flood impact mapping for the mitigation option assessment is provided in Appendix I. A summary of results is provided below for each crossing.

Kurrajong Rd Upgrade Mitigation Results

- Flood event triggering flood depth >300 mm: 10% AEP CC RCP4.5.
- Flood depth of the 10% AEP CC RCP4.5 (Pre-Structure Mitigation): 369 mm.
- Flood depth of the 10% AEP CC RCP4.5 (Post Structure Mitigation): 184 mm (185 mm reduction in flood depth over the road – now trafficable).
- Time of closure >300 mm - 10% AEP CC RCP4.5 (Pre-Structure Mitigation): 0.62 hours.
- Time of closure >300 mm - 10% AEP CC RCP4.5 (Post-Structure Mitigation): 0 hours.
- Flood depth on road in the 1% AEP CC RCP4.5 (Pre-Structure Mitigation): 515 mm.
- Flood depth on road in the 1% AEP CC RCP4.5 (Post Structure Mitigation): 446 mm (69 mm reduction in flood depth).

Edelsten Rd Upgrade Mitigation Results

- Flood event triggering flood depth >300 mm: 20% AEP.
- Flood depth of the 20% AEP CC RCP4.5 (Pre-Structure Mitigation): 365 mm.
- Flood depth of the 20% AEP CC RCP4.5 (Post Structure Mitigation): 258 mm (107 mm reduction in flood depth over the road – now trafficable).
- Time of closure >300 mm - 20% AEP CC RCP4.5 (Pre-Structure Mitigation): 0.7 hours.
- Time of closure >300 mm - 20% AEP CC RCP4.5 (Post-Structure Mitigation): 0 hours.
- Flood depth on road in the 1% AEP CC RCP4.5 (Pre-Structure Mitigation): 939 mm.
- Flood depth on road in the 1% AEP CC RCP4.5 (Post Structure Mitigation): 917 mm (22 mm reduction in flood depth).

The results showed that the Kurrajong Rd upgrade would provide a 185 mm reduction in flood depth over the road in the 10% AEP CC RCP4.5 event, enabling trafficable condition for this design event. It also reduced the flood depth over the road by 69 mm in the 1% AEP CC RCP4.5 event, however the flood depth was still above 300 mm and would still be untrafficable.

The results for the Edelsten Rd upgrade showed that the increased culvert capacity would enable trafficable conditions in the 20% AEP CC RCP4.5 event due to a flood depth reduction of 107 mm, enabling trafficable condition for this design event. It also reduced the flood depth over the road by 22 mm in the 1% AEP CC RCP4.5 event, however the flood depth was still above 300 mm and would still be untrafficable.

Overall, the culvert upgrades provide limited benefit in terms of improved flood immunity and flood depth reductions over the road. This is largely due to the volume of water that overtops the road. Increasing the road height and further increasing the culvert capacity would be required to provide a tangible benefit.

9.3.3 Costing of Options

Preliminary cost estimates for each of the road crossing upgrades are summarized as follows:

- Edelsten Road Upgrade: $1.6M.
- Kurrajong Road Upgrade: $1.5M.

The preliminary estimates were included 29% contingency and the breakdown is provided in Appendix I. Given that the upgrades are not expected to benefit reduce the number of flood impacted buildings and will only provide an minor improvement to road flood immunity, it is not anticipated that the works will be feasible. Rather, it is advised that flooded road safety measures be considered to reduce the risk to motorists during a flood event.

10 FLOOD DAMAGE ASSESSMENT

A flood damages assessment for the full range of flood events (incorporating climate change) has been completed and the process has been outlined in the below sections.

10.1 METHODOLOGY

10.1.1 Input GIS Data

To undertake a flood damage assessment, the following GIS data inputs were required:

- Design event maximum flood levels.
- Building polygons / assumed floor size of building.
- Floor levels.
- Classification of the type of building and the number of storeys.

The following process was undertaken to prepare the GIS dataset for the flood damage assessment:

- Confirmation that all buildings within the Henderson Creek PMF flood extent are included in the supplied Council dataset or delineated where they are not. 286 buildings have been determined to be within the PMF flood extent.
- Calculation of the floor area using geometry analysis tools. Classification of this calculated floor area into small (< 140 sqm), medium (140-210 sqm) and large (>210 sqm).
- Classification of the various buildings into the following type classifications:
    - Lowset, single storey (Slab-On-Ground or Stumps).
    - Highset.
    - Double storey.
    - Multi-unit single storey.
    - Multi-unit double storey.
- Council's 2016 surveyed floor level survey set was supplied for use in the assessment. Where there were buildings that were not included in this survey set, the maximum LiDAR elevation underneath the building polygon was adopted.
- Finally, inspections of the design event flood heights were made against the building dataset.

10.1.2 Stage-Damage Curves

The stage damage curves utilised in the flood damage assessment were supplied by Council and are the same curves utilised in the Brisbane River Catchment Flood Study (BRCFS). The development of these curves is outlined extensively in the *Brisbane River Strategic Floodplain Management Plan – Technical Evidence Report* (BMT, 2018).

10.1.3 Base Case Flood Damage Estimate

Average Annual Damage (AAD) is used to account for the probabilistic nature of flood damages. It represents the theoretical tangible damage incurred on average each year if a very long period of flood records is considered. It takes into account the value of the damage in each flood and the probability of the flood.

The flood damage estimate is a summation of:

- The direct damages (internal, external and structural damages) as specified by the BRCFS stage-damage curves, adjusted to actual direct damage (70% of potential direct damage).
- Indirect damages estimated at 15% of the actual direct damage.
- Intangible damage, calculated by an uplift factor applied to actual direct and indirect damage as per factors provided by Council in Table 10.1.

Table 10.1: Intangible Damage Uplift Factors

AEP	Intangibles Uplift Factor as % of 1% AEP Uplift Factor	Proposed Intangibles Uplift Factor
5% RCP4.5 CC	0%	0.00
2% RCP4.5 CC	60%	0.72
1% RCP4.5 CC	100%	1.20
PMF	380%	4.56

A summary of the total flood damages in the Henderson Creek catchment due to flood, and the contribution of each event to the AAD is summarised in Table 10.2 and shown in Figure 10.1. The contribution each event to the AAD is shown graphically in Figure 10.2. The estimation of AAD involves calculating the area underneath the curve shown in this figure. The 20% AEP RCP4.5 climate change flood event contributes the largest to the AAD in the catchment, whereas the 0.2% AEP RCP4.5 climate change and 0.5% AEP RCP4.5 climate change flood event contributes the least.

Table 10.2: Flood Damage Estimate

Flood Event (% AEP)	Potential Direct Flood Damage	Actual Direct Flood Damage	Indirect Flood Damage	Intangible Cost Estimate	Total Flood Damage	Contribution to Annual Average Damage
PMF / 0.001%	$45,273,400	$31,691,380	$4,753,707	$166,189,597	**$202,634,684**	**$54,523**
0.05%	$4,448,400	$3,113,880	$467,082	$16,329,187	**$19,910,149**	**$19,248**
0.20% RCP4.5 CC	$3,248,800	$2,274,160	$341,124	$3,138,341	**$5,753,625**	**$13,368**
0.50% RCP4.5 CC	$1,783,300	$1,248,310	$187,247	$1,722,668	**$3,158,224**	**$15,518**
1% RCP4.5 CC	$1,721,500	$1,205,050	$180,758	$1,662,969	**$3,048,777**	**$25,203**
2% RCP4.5 CC	$1,438,600	$1,007,020	$151,053	$833,813	**$1,991,886**	**$43,004**
5% RCP4.5 CC	$1,087,000	$760,900	$114,135	$-	**$875,035**	**$39,155**
10% RCP4.5 CC	$858,600	$601,020	$90,153	$-	**$691,173**	**$57,807**
20% RCP4.5 CC	$577,600	$404,320	$60,648	$-	**$464,968**	**$109,424**
50% RCP4.5 CC	$328,600	$230,020	$34,503	$-	**$264,523**	**$66,131**

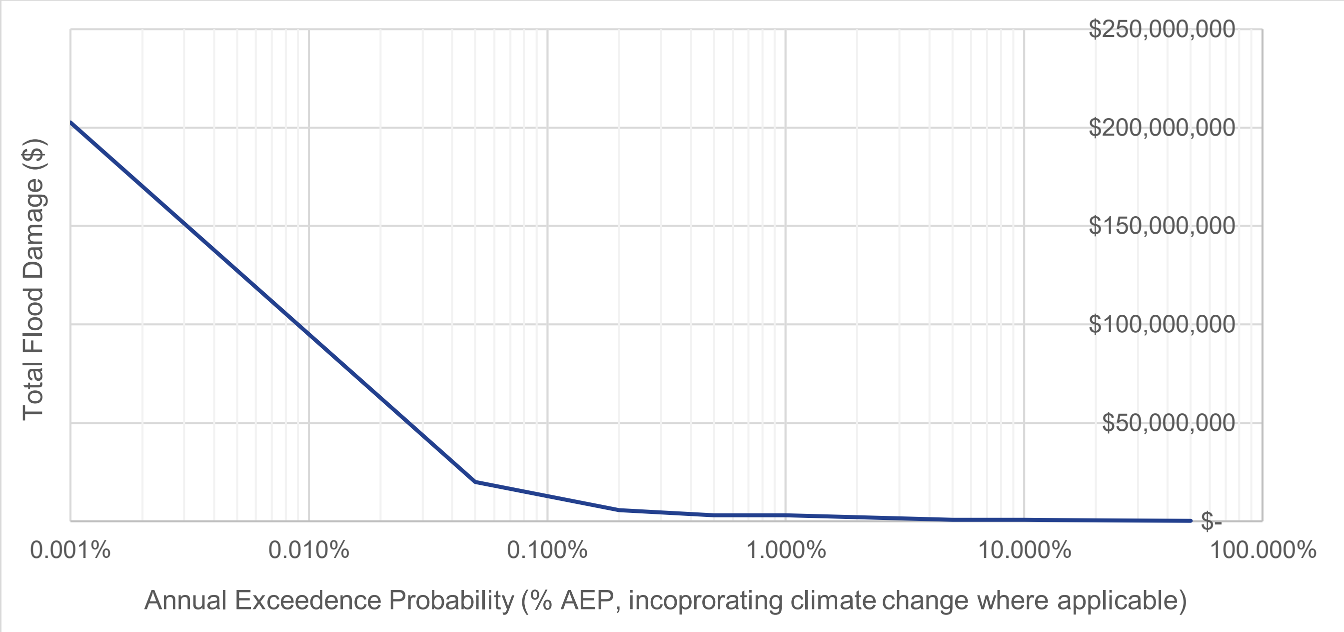


Figure 10.1: Damage vs Annual Exceedance Probability Event

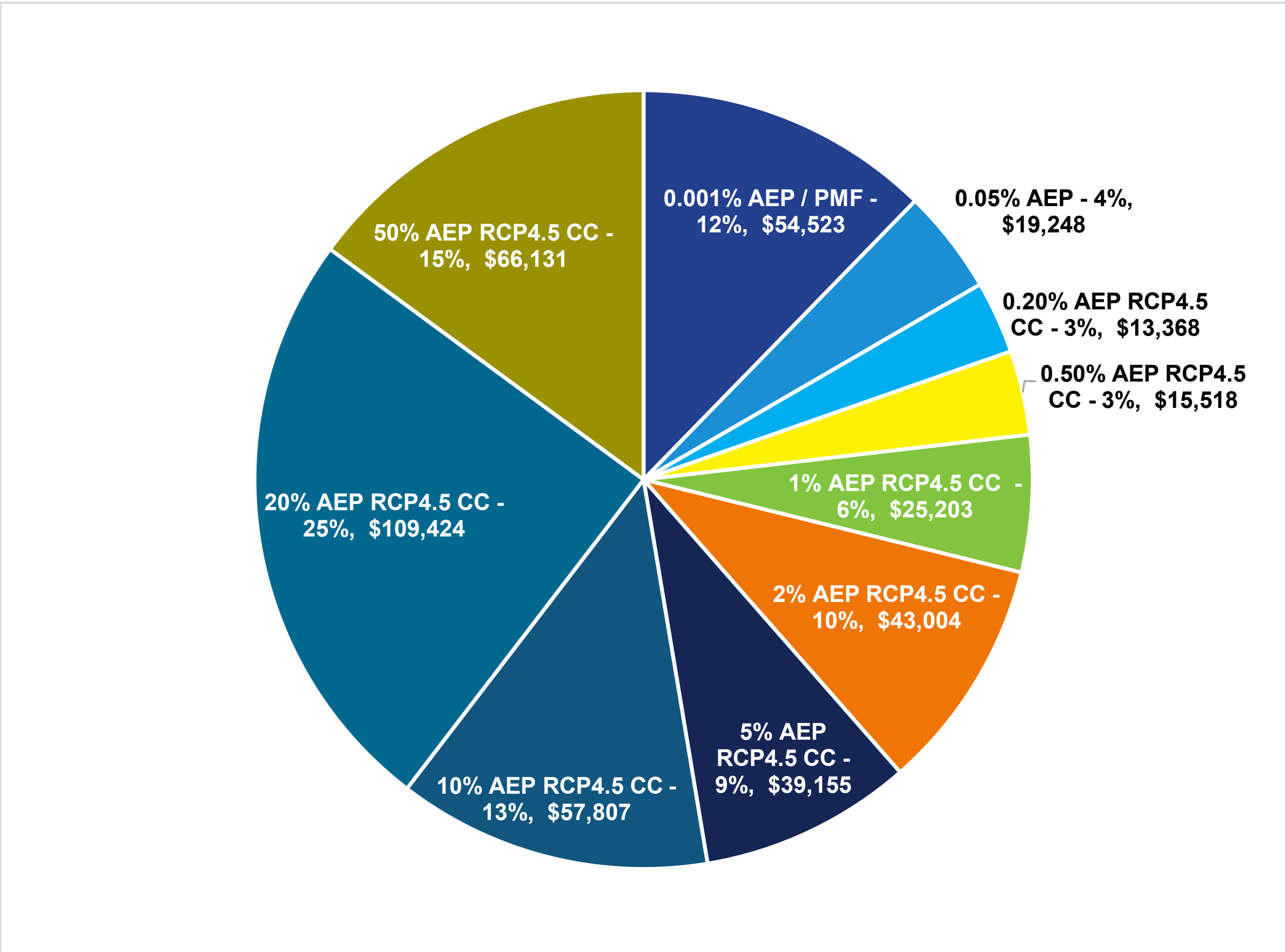


Figure 10.2: Event Contribution to AAD

10.1.4 Mitigated Case Flood Damage Estimate

A flood damage assessment was not completed for the mitigated case due to the mitigation options assessed as part of the study. The cross-drainage upgrade options are not expected to materially impact the base case flood damages as they are focused on improving road flooding.

11 FLOODPLAIN MANAGEMENT PLANNING SUMMARY

The floodplain management planning for the Henderson Creek catchment has included definition of flood risks based on hydraulic model results and consideration for:

- Hydraulic risks.
- Low and high flood islands.
- Time and duration of inundation at flooded road crossings.
- Hydraulic function.
- Road crossing flood immunity.
- Road crossing flood trafficability.
- Evacuation road flood immunity.
- Flooding hotspot areas.

Outputs from the flood risk analysis have included mapping and digital outputs which were provided to Council to enable further consideration and flood risk planning.

11.1.1 Summary of Key Floodplain Management Issues

The key floodplain risk and management issues for the Henderson Creek catchment are summarised below:

- The greatest flood risk across the catchment is considered to generally relate to safety at flooded roads due to the relatively quick catchment response time and low immunity of road crossings.
- The number of buildings identified to be potentially flooded in the 1% AEP event was 47.
- The identified flood islands mapping shows that a large portion of the isolated area starts to become isolated in the 10% AEP event.
- Five flooding hotspots were determined based on multiple buildings shown to be inundation within close proximity.
- Structural flood mitigation measures were generally considered to be ineffective or restrictive due to the location of the impacted buildings and potential impacts caused by diverting flow (i.e. levees).
- Cross drainage upgrades were investigated at Edelsten Road and Kurrajong Road, where minor improvements in flood depth reduction (up to 255mm in 10% AEP for Edelsten Road) was observed.
- The estimated cost of construction for the Edelsten Road and Kurrajong Road cross drainage upgrades was $1.6M and 1.5M respectively.
- Council undertake a review of the risk associated with the flooded roads, seek to prioritise road crossings based on risk and identify safety improvement measures for high priority roads.

12 CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations from the flood study and floodplain management planning were:

- Updated XPRAFTS hydrologic and TUFLOW hydraulic models have been developed for the Henderson Creek catchment in accordance with ARR2019 guidelines and recommendations, which have been validated to industry sensitivity methods and calibrated to three historical calibration events.
- Design event modelling was completed for the 1:2 AEP event through to the PMF event.
- Sensitivity assessments were completed on increased hydraulic roughness, increased blockage of culverts and bridges, and tailwater assumptions. Of these sensitivities the hydraulic model was determined to be most sensitive to hydraulic roughness assumptions, with consistent increases across the model extent of between 30 mm to 60 mm. Increasing structure blockage resulted in localised increases in flood levels upstream of structures, and decreases in flood levels downstream of structures. Tailwater assumptions can greatly impact on the flood levels within the lower half of the catchment.
- A detailed climate change assessment was also completed for the catchment, which showed that flood levels are responsive to increases in the catchment of varying degrees dependent on the Representative Concentration Pathway inspected.
- The streamflow gauge in the Henderson Creek catchment located at Cusack Lane is influenced by Logan River flooding in large events. It is recommended that Council consider installation of a gauge further up the catchment to assist with future model calibrations and understanding of flood behaviour.
- The closest pluviographic rainfall station to the Henderson Creek catchment is located outside the catchment boundary (the Yarrahappini Alert). To assist with future model calibration and potential flood warning systems, Council should consider installation of rainfall gauges within the Henderson Creek catchment.
- The greatest flood risk across the catchment is considered to generally relate to safety at flooded roads due to the relatively quick catchment response time and low immunity of road crossings.
- The number of buildings identified to be potentially flooded in the 1% AEP event was 53.
- The identified flood islands mapping shows that a large portion of the isolated area starts to become isolated in the 10% AEP event.
- Five flooding hotspots were determined based on multiple buildings shown to be inundation within close proximity.
- Structural flood mitigation measures were generally considered to be ineffective or restrictive due to the location of the impacted buildings and potential impacts caused by diverting flow (i.e., levees).
- Cross drainage upgrades were investigated at Edelsten Road and Kurrajong Road, where minor improvements in flood depth reduction (up to 184 mm in 10% AEP CC RCP4.5 for Kurrajong Road) was observed.
- The estimated cost of construction for the Edelsten Road and Kurrajong Road cross drainage upgrades was $1.6M and 1.5M respectively.
- Council undertake a review of the risk associated with the flooded roads, seek to prioritise road crossings based on risk and identify safety improvement measures for high priority roads.

13 QUALIFICATIONS

a) In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b) Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

c) Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:

   i) Additional sources of information not presently available (for whatever reason) are provided or become known to Engeny; or

   ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.

d) Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the works, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works. All limitations of liability shall apply for the benefit of the employees, agents and representatives of Engeny to the same extent that they apply for the benefit of Engeny.

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g) This Report does not provide legal advice.

14 REFERENCES

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Appendix A:
Subcatchment Parameters

Appendix Table A 1 – Historical Calibration Model Subcatchment Parameters

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
S1b	1	4.839	0.05	0	0.54
	2	3.113	0.015	100	0.54
S2	1	16.666	0.05	0	1.23
	2	3.057	0.015	100	1.23
S3	1	7.902	0.05	0	3.96
	2	1.189	0.015	100	3.96
S4	1	10.197	0.05	0	3.06
	2	5.003	0.015	100	3.06
S5	1	9.807	0.05	0	1.66
	2	2.386	0.015	100	1.66
S6	1	13.853	0.05	0	1.13
	2	0.929	0.015	100	1.13
S7	1	16.242	0.05	0	3.48
	2	3.728	0.015	100	3.48
S8b	1	14.166	0.05	0	1.95
	2	3.943	0.015	100	1.95
S9	1	5.328	0.05	0	1.66
	2	0.837	0.015	100	1.66
S10	1	11.112	0.05	0	2.05
	2	1.319	0.015	100	2.05
S11	1	23.245	0.05	0	1.06
	2	3.775	0.015	100	1.06
S12	1	21.036	0.05	0	1.35

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	2.071	0.015	100	1.35
S13	1	24.427	0.05	0	1.12
	2	5.259	0.015	100	1.12
S14	1	13.176	0.05	0	1.52
	2	2.797	0.015	100	1.52
S15	1	16.334	0.05	0	3
	2	4.908	0.015	100	3
S16b	1	18.342	0.05	0	1.56
	2	2.969	0.015	100	1.56
S17	1	4.553	0.05	0	7.74
	2	0.964	0.015	100	7.74
S18	1	7.839	0.05	0	3.28
	2	1.146	0.015	100	3.28
S19	1	13.695	0.05	0	1.38
	2	2.109	0.015	100	1.38
S20	1	17.343	0.05	0	1.56
	2	1.793	0.015	100	1.56
S21	1	23.765	0.05	0	0.92
	2	2.541	0.015	100	0.92
S22	1	8.563	0.05	0	4.56
	2	0.632	0.015	100	4.56
S23	1	27.146	0.05	0	1.81
	2	0.686	0.015	100	1.81
S24	1	17.413	0.05	0	1.97

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	2.093	0.015	100	1.97
S25	1	9.576	0.05	0	3.5
	2	1.765	0.015	100	3.5
S26	1	16.939	0.05	0	2.7
	2	2.248	0.015	100	2.7
S27a	1	5.8642	0.05	0	1.28
	2	24.1128	0.015	100	1.28
S28b	1	15.608	0.05	0	1.34
	2	2.959	0.015	100	1.34
S29	1	7.363	0.05	0	3.62
	2	1.064	0.015	100	3.62
S30	1	15.013	0.05	0	2.02
	2	2.102	0.015	100	2.02
S31	1	12.336	0.05	0	2.71
	2	0.252	0.015	100	2.71
S32	1	9.095	0.05	0	4.38
	2	1.435	0.015	100	4.38
S33	1	12.217	0.05	0	2.77
	2	1.908	0.015	100	2.77
S34	1	17.627	0.05	0	2.15
	2	1.578	0.015	100	2.15
S35	1	4.582	0.05	0	4.74
	2	0.467	0.015	100	4.74
S36b	1	17.86	0.05	0	2.73

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	1.985	0.015	100	2.73
S37	1	5.29	0.05	0	1.17
	2	17.963	0.015	100	1.17
S38	1	3.903	0.05	0	6.42
	2	0.155	0.015	100	6.42
S39	1	3.5468	0.05	0	1.01
	2	14.1852	0.015	100	1.01
S40a	1	18.15	0.05	0	1.07
	2	4.908	0.015	100	1.07
S41	1	5.9934	0.05	0	1.6
	2	23.9726	0.015	100	1.6
S42	1	23.784	0.05	0	3.08
	2	3.656	0.015	100	3.08
S43	1	6.077	0.05	0	0.99
	2	0.894	0.015	100	0.99
S44	1	23.67	0.05	0	0.72
	2	4.603	0.015	100	0.72
S45	1	7.814	0.05	0	2.51
	2	0.891	0.015	100	2.51
S47	1	8.0229	0.05	0	1.04
	2	20.0081	0.015	100	1.04
S48	1	5.897	0.05	0	1.39
	2	14.379	0.015	100	1.39
S49	1	27.687	0.05	0	1.13

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	2.233	0.015	100	1.13
S50	1	2.076	0.05	0	8.08
	2	0.489	0.015	100	8.08
S51	1	5.4972	0.05	0	2.67
	2	14.9258	0.015	100	2.67
S52	1	9.577	0.05	0	11.37
	2	0.393	0.015	100	11.37
S53	1	9.661	0.05	0	8.24
	2	0.922	0.015	100	8.24
S54b	1	18.86	0.05	0	1.74
	2	2.963	0.015	100	1.74
S55	1	4.2742	0.05	0	2.16
	2	6.4718	0.015	100	2.16
S56b	1	4.7627	0.05	0	0.85
	2	18.9593	0.015	100	0.85
S57a	1	11.864	0.05	0	1.35
	2	1.932	0.015	100	1.35
S58	1	26.277	0.05	0	1.05
	2	2.585	0.015	100	1.05
S59b	1	15.888	0.05	0	1.11
	2	1.765	0.015	100	1.11
S60	1	25.94	0.05	0	5.98
	2	3.516	0.015	100	5.98
S61	1	23.385	0.05	0	2.54

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	3.545	0.015	100	2.54
S62	1	3.957	0.05	0	2.08
	2	7.846	0.015	100	2.08
S63	1	21.5	0.05	0	2.45
	2	4.325	0.015	100	2.45
S64	1	2.678	0.05	0	1.48
	2	2.745	0.015	100	1.48
S65b	1	12.321	0.05	0	1.35
	2	2.921	0.015	100	1.35
S66	1	11.107	0.05	0	2.86
	2	1.489	0.015	100	2.86
S67	1	18.84	0.05	0	2.96
	2	2.093	0.015	100	2.96
S68	1	13.512	0.05	0	7.03
	2	0.501	0.015	100	7.03
S69	1	5.694	0.05	0	1.3
	2	9.951	0.015	100	1.3
S70	1	7.047	0.05	0	1.06
	2	2.631	0.015	100	1.06
S71	1	23.562	0.05	0	1.47
	2	5.141	0.015	100	1.47
S72	1	4.635	0.05	0	5.96
	2	0.477	0.015	100	5.96
S73	1	15.788	0.05	0	3.84

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	1.755	0.015	100	3.84
S74	1	12.631	0.05	0	1.41
	2	3.199	0.015	100	1.41
S75	1	17.331	0.05	0	6.78
	2	2.426	0.015	100	6.78
S76	1	5.904	0.05	0	2.36
	2	1.248	0.015	100	2.36
S77	1	14.718	0.05	0	1.63
	2	10.505	0.015	100	1.63
S78b	1	23.287	0.05	0	1.46
	2	3.138	0.015	100	1.46
S79	1	21.199	0.05	0	3.52
	2	3.112	0.015	100	3.52
S80	1	14.349	0.05	0	3.62
	2	2.798	0.015	100	3.62
S81	1	13.41	0.05	0	1.47
	2	2.811	0.015	100	1.47
S82	1	4.339	0.05	0	1.2
	2	10.266	0.015	100	1.2
S83	1	14.643	0.05	0	1.9
	2	2.517	0.015	100	1.9
S84	1	9.672	0.05	0	0.88
	2	14.289	0.015	100	0.88
S85	1	4.362	0.05	0	2.66

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	6.265	0.015	100	2.66
S86	1	16.854	0.05	0	3.28
	2	3.255	0.015	100	3.28
S87	1	21.105	0.05	0	1.08
	2	2.549	0.015	100	1.08
S88	1	6.765	0.05	0	6.64
	2	1.328	0.015	100	6.64
S89	1	9.519	0.05	0	2.48
	2	8.491	0.015	100	2.48
S90	1	12.579	0.05	0	2.48
	2	1.838	0.015	100	2.48
S91	1	25.584	0.05	0	1.51
	2	4.367	0.015	100	1.51
S92	1	14.442	0.05	0	1.47
	2	12.707	0.015	100	1.47
S93	1	21.063	0.05	0	2.14
	2	3.101	0.015	100	2.14
S94	1	21.955	0.05	0	1.48
	2	7.331	0.015	100	1.48
S95	1	5.626	0.05	0	2.83
	2	5.076	0.015	100	2.83
S96	1	6.089	0.05	0	3.88
	2	0.699	0.015	100	3.88
S97	1	9.342	0.05	0	11.97

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	0.984	0.015	100	11.97
S98	1	12.692	0.05	0	4.49
	2	1.177	0.015	100	4.49
S99	1	25.281	0.05	0	1.28
	2	1.56	0.015	100	1.28
S100	1	24.737	0.05	0	2.59
	2	4.301	0.015	100	2.59
S101	1	19.124	0.05	0	2.92
	2	2.125	0.015	100	2.92
S102	1	7.119	0.05	0	1.32
	2	6.082	0.015	100	1.32
S103	1	25.79	0.05	0	1.29
	2	3.056	0.015	100	1.29
S104	1	13.914	0.05	0	3.03
	2	1.863	0.015	100	3.03
S105	1	19.501	0.05	0	0.95
	2	6.292	0.015	100	0.95
S106	1	13.353	0.05	0	1.9
	2	2.437	0.015	100	1.9
S107	1	17.344	0.05	0	1.31
	2	1.834	0.015	100	1.31
S108	1	16.865	0.05	0	5.36
	2	2.651	0.015	100	5.36
S109	1	10.642	0.05	0	0.18

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	2.467	0.015	100	0.18
S110	1	14.416	0.05	0	3.17
	2	1.828	0.015	100	3.17
S111	1	13.288	0.05	0	0.32
	2	2.55	0.015	100	0.32
S112b	1	23.977	0.05	0	0.96
	2	4.5	0.015	100	0.96
S113	1	15.305	0.05	0	0.79
	2	1.364	0.015	100	0.79
S114	1	20.049	0.05	0	4.98
	2	2.329	0.015	100	4.98
S115	1	13.478	0.05	0	0.84
	2	1.356	0.015	100	0.84
S116	1	16.274	0.05	0	0.62
	2	2.704	0.015	100	0.62
S117	1	9.526	0.05	0	2.13
	2	1.613	0.015	100	2.13
S118	1	20.057	0.05	0	0.42
	2	3.77	0.015	100	0.42
S119a	1	14.898	0.05	0	0.54
	2	3.721	0.015	100	0.54
S120b	1	19.789	0.05	0	0.84
	2	3.968	0.015	100	0.84
S121	1	20.291	0.05	0	1.68

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	2.951	0.015	100	1.68
S122	1	17.342	0.05	0	0.73
	2	3.673	0.015	100	0.73
S123	1	17.139	0.05	0	2.16
	2	2.966	0.015	100	2.16
S124	1	15.283	0.05	0	0.68
	2	2.531	0.015	100	0.68
S125	1	19.234	0.05	0	2.21
	2	3.419	0.015	100	2.21
S126	1	17.872	0.05	0	1.99
	2	5.91	0.015	100	1.99
S127	1	11.37	0.05	0	1.38
	2	2.161	0.015	100	1.38
S128	1	8.835	0.05	0	3.69
	2	2.853	0.015	100	3.69
S129a	1	16.347	0.05	0	0.55
	2	2.629	0.015	100	0.55
S130	1	20.106	0.05	0	1.63
	2	4.249	0.015	100	1.63
S131	1	16.25	0.05	0	3.33
	2	2.248	0.015	100	3.33
S132	1	25.857	0.05	0	1.17
	2	3.918	0.015	100	1.17
S133	1	11.06	0.05	0	2.5

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	1.229	0.015	100	2.5
S134	1	7.351	0.05	0	4.42
	2	0.966	0.015	100	4.42
S135	1	24.776	0.05	0	0.96
	2	4.915	0.015	100	0.96
S136	1	12.717	0.05	0	5.89
	2	1.23	0.015	100	5.89
S137	1	18.154	0.05	0	1.28
	2	3.794	0.015	100	1.28
S138	1	15.147	0.05	0	1.43
	2	2.45	0.015	100	1.43
S139	1	3.925	0.05	0	6.52
	2	0.436	0.015	100	6.52
S140	1	17.546	0.05	0	2.15
	2	2.36	0.015	100	2.15
S141	1	17.915	0.05	0	1.9
	2	2.814	0.015	100	1.9
S142	1	3.664	0.05	0	3.58
	2	1.34	0.015	100	3.58
S143	1	24.107	0.05	0	1.86
	2	5.121	0.015	100	1.86
S144a	1	18.911	0.05	0	0.56
	2	1.314	0.015	100	0.56
S145	1	16.637	0.05	0	1.93

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	2.725	0.015	100	1.93
S146	1	19.366	0.05	0	2.23
	2	2.805	0.015	100	2.23
S147	1	18.958	0.05	0	5.05
	2	2.084	0.015	100	5.05
S148	1	20.444	0.05	0	2.11
	2	4.439	0.015	100	2.11
S149	1	20.107	0.05	0	3.37
	2	3.727	0.015	100	3.37
S150	1	16.453	0.05	0	0.09
	2	1.497	0.015	100	0.09
S151	1	19.67	0.05	0	2.49
	2	3.285	0.015	100	2.49
S152	1	12.785	0.05	0	3.46
	2	1.876	0.015	100	3.46
S153	1	6.971	0.05	0	2.96
	2	1.444	0.015	100	2.96
S154	1	11.776	0.05	0	2.52
	2	2.193	0.015	100	2.52
S155	1	21.172	0.05	0	1
	2	2.46	0.015	100	1
S156	1	5.423	0.05	0	3.53
	2	0.855	0.015	100	3.53
S157	1	9.362	0.05	0	4.81

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	2.779	0.015	100	4.81
S158a	1	16.286	0.05	0	1.78
	2	3.17	0.015	100	1.78
S159	1	17.54	0.05	0	1.08
	2	3.346	0.015	100	1.08
S160	1	11.501	0.05	0	2.13
	2	2.602	0.015	100	2.13
S161	1	9.362	0.05	0	5.49
	2	1.112	0.015	100	5.49
S162a	1	7.078	0.05	0	1.73
	2	2.122	0.015	100	1.73
S163	1	9.915	0.05	0	2.96
	2	2.096	0.015	100	2.96
S164	1	4.81	0.05	0	3.73
	2	0.545	0.015	100	3.73
S165	1	16.18	0.05	0	1.83
	2	2.045	0.015	100	1.83
S166b	1	16.456	0.05	0	1.81
	2	4.91	0.015	100	1.81
S167	1	16.767	0.05	0	2.2
	2	3.03	0.015	100	2.2
S168	1	5.409	0.05	0	3.22
	2	0.674	0.015	100	3.22
S169	1	8.903	0.05	0	3.6

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	2.546	0.015	100	3.6
S170	1	9.925	0.05	0	3.21
	2	1.446	0.015	100	3.21
S171	1	3.942	0.05	0	3.95
	2	0.983	0.015	100	3.95
S172	1	20.181	0.05	0	2.09
	2	3.803	0.015	100	2.09
S173	1	9.189	0.05	0	4.03
	2	1.937	0.015	100	4.03
S174	1	4.991	0.05	0	4.14
	2	0.816	0.015	100	4.14
S175b	1	10.814	0.05	0	2.21
	2	2.498	0.015	100	2.21
S176	1	6.661	0.05	0	3.39
	2	0.642	0.015	100	3.39
S177	1	6.898	0.05	0	5.17
	2	1.216	0.015	100	5.17
S178	1	6.062	0.05	0	1.98
	2	1.536	0.015	100	1.98
S179b	1	2.834	0.05	0	1.25
	2	8.067	0.015	100	1.25
S180	1	22.227	0.05	0	0.42
	2	2.307	0.015	100	0.42
S181a	1	16.171	0.05	0	0.6

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	1.168	0.015	100	0.6
S182	1	19.9935	0.05	0	0.37
	2	6.3965	0.015	100	0.37
S183	1	4.248	0.05	0	1.86
	2	5.027	0.015	100	1.86
S184	1	4.247	0.05	0	2.82
	2	0.651	0.015	100	2.82
S185	1	18.565	0.05	0	1.92
	2	2.645	0.015	100	1.92
S186	1	1.559	0.05	0	3.73
	2	1.094	0.015	100	3.73
S187	1	8.667	0.05	0	5.33
	2	1.251	0.015	100	5.33
S188	1	1.291	0.05	0	7.05
	2	0.244	0.015	100	7.05
S189	1	11.12	0.05	0	2.4
	2	2.943	0.015	100	2.4
S190	1	9.669	0.05	0	5.4
	2	1.274	0.015	100	5.4
S191	1	1.052	0.05	0	10.42
	2	0.121	0.015	100	10.42
S192	1	11.938	0.05	0	3.87
	2	1.514	0.015	100	3.87
S193	1	0.828	0.05	0	12.91

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	0.219	0.015	100	12.91
S194	1	7.824	0.05	0	3.28
	2	1.714	0.015	100	3.28
S195	1	7.932	0.05	0	2.79
	2	2.645	0.015	100	2.79
S196	1	8.302	0.05	0	6.18
	2	1.267	0.015	100	6.18
S197	1	8.744	0.05	0	7.05
	2	1.273	0.015	100	7.05
S198	1	9.239	0.05	0	3.07
	2	1.544	0.015	100	3.07
S199	1	9.498	0.05	0	10.87
	2	0.726	0.015	100	10.87
S200	1	17.004	0.05	0	11.73
	2	0.001	0.015	100	11.73
S201	1	9.742	0.05	0	4.57
	2	1.127	0.015	100	4.57
S202	1	9.156	0.05	0	6.35
	2	1.311	0.015	100	6.35
S204	1	3.114	0.05	0	7.52
	2	0.372	0.015	100	7.52
S205	1	2.7766	0.05	0	0.88
	2	11.1074	0.015	100	0.88
S206	1	10.362	0.05	0	18.47

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	0.041	0.015	100	18.47
S207	1	8.461	0.05	0	7.87
	2	1.189	0.015	100	7.87
S208	1	8.225	0.05	0	8.48
	2	1.026	0.015	100	8.48
S209	1	9.343	0.05	0	4.17
	2	1.5	0.015	100	4.17
S210	1	10.333	0.05	0	2.53
	2	0.785	0.015	100	2.53
S211	1	7.97	0.05	0	5.74
	2	2.148	0.015	100	5.74
S212	1	1.459	0.05	0	4.08
	2	9.412	0.015	100	4.08
S213	1	10.832	0.05	0	22.19
	2	0.256	0.015	100	22.19
S214	1	8.89	0.05	0	0.45
	2	2.844	0.015	100	0.45
S215	1	10.341	0.05	0	0.92
	2	1.712	0.015	100	0.92
S216	1	3.775	0.05	0	3.53
	2	0.42	0.015	100	3.53
S217	1	8.232	0.05	0	4.5
	2	1.499	0.015	100	4.5
S218	1	5.277	0.05	0	4.07

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	0.162	0.015	100	4.07
S219	1	5.817	0.05	0	2.35
	2	13.157	0.015	100	2.35
S220	1	12.808	0.05	0	26.38
	2	0.001	0.015	100	26.38
S221	1	9.379	0.05	0	2.92
	2	13.587	0.015	100	2.92
S222	1	9.942	0.05	0	25.35
	2	0.122	0.015	100	25.35
S223	1	9.234	0.05	0	22.32
	2	0.594	0.015	100	22.32
S224c	1	2.6	0.05	0	5.93
	2	0.72	0.015	100	5.93
S225	1	8.654	0.05	0	3.79
	2	1.614	0.015	100	3.79
S226	1	9.012	0.05	0	17.97
	2	1.153	0.015	100	17.97
S227	1	5.827	0.05	0	3.35
	2	6.633	0.015	100	3.35
S228	1	8.6	0.05	0	5.62
	2	0.956	0.015	100	5.62
S229	1	5.981	0.05	0	3.16
	2	3.717	0.015	100	3.16
S230	1	9.263	0.05	0	12.87

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	1.099	0.015	100	12.87
S231	1	9.845	0.05	0	28.82
	2	0.463	0.015	100	28.82
S232	1	12.751	0.05	0	2.11
	2	2.905	0.015	100	2.11
S233	1	2.208	0.05	0	3.63
	2	1.807	0.015	100	3.63
S234	1	9.722	0.05	0	15.18
	2	0.65	0.015	100	15.18
S235	1	4.799	0.05	0	3.45
	2	4.256	0.015	100	3.45
S236	1	10.393	0.05	0	13.68
	2	0.065	0.015	100	13.68
S237	1	10.867	0.05	0	2.16
	2	5.561	0.015	100	2.16
S238	1	22.77	0.05	0	0.12
	2	1.345	0.015	100	0.12
S239	1	7.043	0.05	0	3.06
	2	6.37	0.015	100	3.06
S240	1	9.1	0.05	0	7.92
	2	1.694	0.015	100	7.92
S241	1	9.667	0.05	0	2.17
	2	1.591	0.015	100	2.17
S242	1	10.184	0.05	0	9.62

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	0.556	0.015	100	9.62
S243	1	7.723	0.05	0	8.58
	2	0.973	0.015	100	8.58
S244	1	7.999	0.05	0	4.5
	2	1.348	0.015	100	4.5
S245	1	8.404	0.05	0	2.35
	2	1.205	0.015	100	2.35
S246	1	11.069	0.05	0	2.91
	2	0.962	0.015	100	2.91
S247	1	9.58	0.05	0	18.13
	2	1.922	0.015	100	18.13
S248	1	7.806	0.05	0	9.48
	2	1.319	0.015	100	9.48
S249	1	8.888	0.05	0	3.77
	2	0.988	0.015	100	3.77
S250	1	8.203	0.05	0	12.66
	2	1.437	0.015	100	12.66
S251	1	11.076	0.05	0	16.4
	2	0.613	0.015	100	16.4
S252	1	4.736	0.05	0	4.95
	2	1.25	0.015	100	4.95
S253	1	7.706	0.05	0	4.44
	2	1.076	0.015	100	4.44
S254	1	5.767	0.05	0	10.13

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	0.289	0.015	100	10.13
S255	1	9.095	0.05	0	4.23
	2	2.096	0.015	100	4.23
S256	1	4.418	0.05	0	2.64
	2	1.141	0.015	100	2.64
S257	1	9.072	0.05	0	3.5
	2	2.008	0.015	100	3.5
S258	1	7.728	0.05	0	8.2
	2	0.843	0.015	100	8.2
S259	1	9.065	0.05	0	3.73
	2	1.35	0.015	100	3.73
S260	1	5.075	0.05	0	4.51
	2	1.15	0.015	100	4.51
S261	1	16.859	0.05	0	3.95
	2	3.618	0.015	100	3.95
S262	1	8.3	0.05	0	3.65
	2	2.272	0.015	100	3.65
S263	1	7.415	0.05	0	3.6
	2	1.547	0.015	100	3.6
S264	1	8.804	0.05	0	8.45
	2	0.936	0.015	100	8.45
S265	1	9.537	0.05	0	8.85
	2	0.694	0.015	100	8.85
S266	1	8.384	0.05	0	5.97

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	1.582	0.015	100	5.97
S267	1	7.699	0.05	0	6.89
	2	1.854	0.015	100	6.89
S268	1	15.147	0.05	0	3.76
	2	2.781	0.015	100	3.76
S269	1	10.922	0.05	0	5.46
	2	2.432	0.015	100	5.46
S270	1	7.02	0.05	0	3.66
	2	1.291	0.015	100	3.66
S271	1	9.833	0.05	0	6.85
	2	1.1	0.015	100	6.85
S272	1	9.323	0.05	0	5.8
	2	1.002	0.015	100	5.8
S273	1	5.224	0.05	0	7.98
	2	0.917	0.015	100	7.98
S274b	1	11.156	0.05	0	8.45
	2	1.129	0.015	100	8.45
S275	1	9.253	0.05	0	7.77
	2	1.296	0.015	100	7.77
S276	1	9.392	0.05	0	6.85
	2	1.978	0.015	100	6.85
S274a	1	6.031	0.05	0	13.68
	2	0.578	0.015	100	13.68
S175a	1	8.193	0.05	0	4.13

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	1.943	0.015	100	4.13
S166a	1	12.943	0.05	0	2.41
	2	1.878	0.015	100	2.41
S158b	1	9.805	0.05	0	1.38
	2	1.674	0.015	100	1.38
S162b	1	19.266	0.05	0	1.33
	2	4.887	0.015	100	1.33
S144b	1	9.953	0.05	0	0.46
	2	2.089	0.015	100	0.46
S129c	1	4.837	0.05	0	0.75
	2	0.537	0.015	100	0.75
S129b	1	3.238	0.05	0	1.33
	2	0.588	0.015	100	1.33
S120a	1	12.207	0.05	0	1.34
	2	1.568	0.015	100	1.34
S119b	1	19.609	0.05	0	0.44
	2	3.413	0.015	100	0.44
S112a	1	12.011	0.05	0	2.86
	2	2.599	0.015	100	2.86
S181b	1	11.417	0.05	0	3.56
	2	1.718	0.015	100	3.56
S56a	1	1.3327	0.05	0	0.61
	2	5.5943	0.015	100	0.61
S56c	1	3.9355	0.05	0	1.67

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	15.7395	0.015	100	1.67
S78a	1	8.127	0.05	0	1.36
	2	1.244	0.015	100	1.36
S65a	1	11.679	0.05	0	1.3
	2	2.994	0.015	100	1.3
S179a	1	6.683	0.05	0	1.35
	2	5.724	0.015	100	1.35
S54a	1	15.392	0.05	0	1.64
	2	2.208	0.015	100	1.64
S224b	1	4.042	0.05	0	6.95
	2	0.619	0.015	100	6.95
S224a	1	3.658	0.05	0	7.15
	2	0.555	0.015	100	7.15
S59a	1	22.668	0.05	0	1.19
	2	3.181	0.015	100	1.19
S57c	1	8.151	0.05	0	5.88
	2	1.234	0.015	100	5.88
S57b	1	11.901	0.05	0	4.81
	2	1.874	0.015	100	4.81
S36a	1	2.249	0.05	0	8.58
	2	0.25	0.015	100	8.58
S16a	1	5.819	0.05	0	8.42
	2	1.062	0.015	100	8.42
S28a	1	10.948	0.05	0	1.44

Subcatchment Name	Subcatchment Number	Total Area [ha] (Design Events)	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Vectored Slope [%]
	2	1.804	0.015	100	1.44
S40b	1	7.924	0.05	0	2.05
	2	1.954	0.015	100	2.05
S27b	1	2.1434	0.05	0	2.1
	2	8.5726	0.015	100	2.1
S1a	1	9.8016	0.05	0	0.56
	2	15.2584	0.015	100	0.56
S8a	1	7.521	0.05	0	1.92
	2	1.534	0.015	100	1.92
S57d	1	5.289	0.05	0	5.88
	2	0.888	0.015	100	5.88

Appendix B:
Rational Method Calculation Details

Appendix Figure B. 1 S60

Output - Design Flow Data

Rational Equation

Sub-Catchment Name: S60

Design Event	Discharge (m3/sec)	Discharge (l/sec)
Q_{100} =	19.6	19645.0
Q_{50} =	16.9	16940.4
Q_{20} =	13.2	13195.2
Q_{10} =	10.9	10910.4
Q_{5} =	8.9	8935.6
Q_{2} =	6.3	6314.1
Q_{1} =	4.7	4692.0
$Q_{0.25}$ =	2.3	2346.0

Rational Equation

Q = CIA/360

Input Data

Catchment Area (ha) =	81.41		
Runoff Coefficient C10 =	0.53		
Time of Concentration (min) =	28.6	<==== Insert selected Tc for the catchment	
Friend's Equation - Tc (min) =	44.5	L (m) =	1629
Bransby-Williams - Tc (min) =	43.4	n =	0.05
Average Velocity .5 m/s - Tc (min) =	54.3	So (%) =	5.62
Average Velocity .75 m/s - Tc (min) =	36.2	Equal Slope (m/km) =	56.2
Average Velocity 1. m/s - Tc (min) =	28.6	R =	0.75
Modified Friend's - Tc (min) =	933.2	Ch =	19.06

Intensity (mm/hr)		Fy
Q_{100} =	136.6	1.2
Q_{50} =	122.9	1.15
Q_{20} =	104.9	1.05
Q_{10} =	91.0	1
Q_{5} =	78.5	0.95
Q_{2} =	62.0	0.85
Q_{1} =	48.9	0.8
$Q_{0.25}$ =	24.5	0.8

Appendix Figure B. 2 S96

Output - Design Flow Data

Rational Equation

Sub-Catchment Name: S96

Design Event	Discharge (m3/sec)	ischarge (l/se
Q_{100} =	20.3	20344.0
Q_{50} =	17.6	17632.5
Q_{20} =	13.8	13803.2
Q_{10} =	11.5	11459.7
Q_{5} =	9.4	9389.2
Q_{2} =	6.6	6635.6
Q_{1} =	5.0	4956.2
$Q_{0.25}$ =	2.5	2478.1

Rational Equation

Q = CIA/360

Input Data

Catchment Area (ha) =	62.22		
Runoff Coefficient C10 =	0.53		
Time of Concentration (min) =	15.9	<==== Insert selected Tc for the catchment	
Friend's Equation - Tc (min) =	37.6	L (m) =	1284
Bransby-Williams - Tc (min) =	32.2	n =	0.05
Average Velocity .5 m/s - Tc (min) =	42.8	So (%) =	8.73
Average Velocity .75 m/s - Tc (min) =	28.5	Equal Slope (m/km) =	87.3
Average Velocity 1 m/s - Tc (min) =	15.9	R =	0.75
Modified Friend's - Tc (min) =	901.1	Ch =	19.06

Intensity (mm/hr)		Fy
Q_{100} =	185.1	1.2
Q_{50} =	167.4	1.15
Q_{20} =	143.5	1.05
Q_{10} =	125.1	1
Q_{5} =	107.9	0.95
Q_{2} =	85.2	0.85
Q_{1} =	67.6	0.8
$Q_{0.25}$ =	33.8	0.8

Appendix Figure B. 3 S103

Rational Equation

Sub-Catchment Name: S103

Rational Equation

$$Q = CIA/360$$

Input Data

Catchment Area (ha) =	148			
Runoff Coefficient C10 =	0.53			
Time of Concentration (min) =	49.0	<===== Insert selected Tc for the catchment		
Friend's Equation - Tc (min) =	68.0		L (m) =	3027
Bransby-Williams - Tc (min) =	94.6		n =	0.05
Average Velocity .5 m/s - Tc (min) =	100.9		So (%) =	1.89
Average Velocity .75 m/s - Tc (min) =	67.3		Equal Slope (m/km) =	18.9
Average Velocity 1.0 m/s - Tc (min) =	49.0		R =	0.75
Modified Friend's - Tc (min) =	1056.3		Ch =	19.06
Intensity (mm/hr)		Fy		
Q_{100} =	99.5	1.2		
Q_{50} =	88.9	1.15		
Q_{20} =	75.2	1.05		
Q_{10} =	64.9	1		
Q_{5} =	55.6	0.95		
Q_{2} =	43.8	0.85		
Q_{1} =	34.6	0.8		
$Q_{0.25}$ =	17.3	0.8		

Output - Design Flow Data

Design Event	Discharge (m3/sec)	ischarge (l/se
Q_{100} =	26.0	26024.7
Q_{50} =	22.3	22271.5
Q_{20} =	17.2	17196.4
Q_{10} =	14.1	14143.9
Q_{5} =	11.5	11511.7
Q_{2} =	8.1	8111.5
Q_{1} =	6.0	6039.6
$Q_{0.25}$ =	3.0	3019.8

Appendix Figure B. 4 S131

Rational Equation

Sub-Catchment Name: S131

Rational Equation

$$Q = CIA/360$$

Input Data

Catchment Area (ha) =	94.07			
Runoff Coefficient C10 =	0.53			
Time of Concentration (min) =	39.1	<===== Insert selected Tc for the catchment		
Friend's Equation - Tc (min) =	54.3		L (m) =	1992
Bransby-Williams - Tc (min) =	59.9		n =	0.05
Average Velocity .5 m/s - Tc (min) =	66.4		So (%) =	2.88
Average Velocity .75 m/s - Tc (min) =	44.3		Equal Slope (m/km) =	28.8
Average Velocity .9 m/s - Tc (min) =	39.1		R =	0.75
Modified Friend's - Tc (min) =	860.8		Ch =	19.06
Intensity (mm/hr)		Fy		
Q_{100} =	115.4	1.2		
Q_{50} =	103.4	1.15		
Q_{20} =	87.8	1.05		
Q_{10} =	76.1	1		
Q_{5} =	65.4	0.95		
Q_{2} =	51.5	0.85		
Q_{1} =	40.8	0.8		
$Q_{0.25}$ =	20.4	0.8		

Output - Design Flow Data

Design Event	Discharge (m3/sec)	ischarge (l/se
Q_{100} =	19.2	19179.8
Q_{50} =	16.5	16470.9
Q_{20} =	12.8	12772.0
Q_{10} =	10.5	10536.6
Q_{5} =	8.6	8600.7
Q_{2} =	6.1	6067.8
Q_{1} =	4.5	4515.6
$Q_{0.25}$ =	2.3	2257.8

Appendix C:

Hydraulic Structure Details

Appendix Table C1

ID	Type	Length (m)	US_Invert (m AHD)	DS_Invert (m AHD)	% Blockage	Width (m)	Height (m)	Number of Cells
22	B	12	-99999	-99999	20	0	0	0
24	B	10	-99999	-99999	20	0	0	0
25	C	53.5	11.15	11.1	10	5.35	0	2
155	c	15	50	49.8	20	1.2	0	3
156	c	15	52.6	52	20	2.1	0	0
157	c	15	50.4	50.3	20	1.2	0	0
158	R	15	38.7	38.5	20	2.1	1.5	7
241439067	C	13	42	41.94	20	2.1	0	3
241439097	C	17.9039	47	46.3	20	1.8	0	0
241439098	C	18.6337	47	46.3	20	1.8	0	0
241439099	C	19.1315	45.5	45.4	20	1.5	0	0
241439100	C	10	47.1	47	20	0.6	0	2
241439102	C	10.3376	49.65	49.6	20	0.6	0	0
241439103	C	10.6861	49.65	49.6	20	0.6	0	0
241439117	R	11	56.1	56	20	0.9	0.6	4
241439265	C	16.8613	49.444	49.334	20	0.9	0	0
241439266	C	18.2877	49.444	49.334	20	0.9	0	0
241439267	C	18.5235	49.444	49.334	20	0.9	0	0
241439268	C	17.8594	68.375	67.641	20	1.65	0	0
241439284	C	16.1933	39	38.8	20	1.35	0	0
241439285	C	16.7835	31.8	31.7	20	1.8	0	0
241439286	C	12	32.55	32.45	20	1.5	0	5
241439291	C	10	32.8	32.6	20	1.65	0	0

ID	Type	Length (m)	US_Invert (m AHD)	DS_Invert (m AHD)	% Blockage	Width (m)	Height (m)	Number of Cells
241439292	C	19.62	36	35.8	20	1.8	0	3
241439295	R	11.7327	33.4	33	20	2.4	1.5	3
241439430	C	10.6931	57.2	55.3	20	0.9	0	0
241439470	C	18	27.28	27.08	20	1.65	0	3
241439473	C	14	27.835	27.685	20	1.35	0	0
241439474	C	14.4849	27.885	27.75	20	1.5	0	0
241439475	C	20.2796	31.56	31.265	20	1.2	0	0
241440794	C	12.2705	39.75	39.45	20	0.675	0	0
241440907	C	11.1543	38.4	38.38	20	0.675	0	11
241441458	C	28	57.3	57	20	2.1	0	2
241441472	C	14.0781	39	38.8	20	0.45	0	0
241441473	C	14.9092	39	38.8	20	0.45	0	0
241441514	C	13.42	41.28	41.205	20	1.5	0	4
241441516	C	14.6628	37.275	37.14	20	1.35	0	0
241441521	C	10.98	32.225	32.164	20	1.35	0	7
241441523	R	9.75	33.711	33.635	20	1.2	0.6	5
241441656	C	12	82.6	82.2	20	1.8	0	0
241441672	C	16	47.5	47	20	2.1	0	2
241441693	C	20.0566	53	52.8	20	0.75	0	0
241441694	C	9.98905	55	54	20	0.9	0	0
241441706	C	13.42	42.1	42	20	1.8	0	3
241441712	C	10.2729	40	39.8	20	1.2	0	2
241441715	C	10.6939	29	28.8	20	0.375	0	0
241441716	C	12.0152	29	28.8	20	0.375	0	0

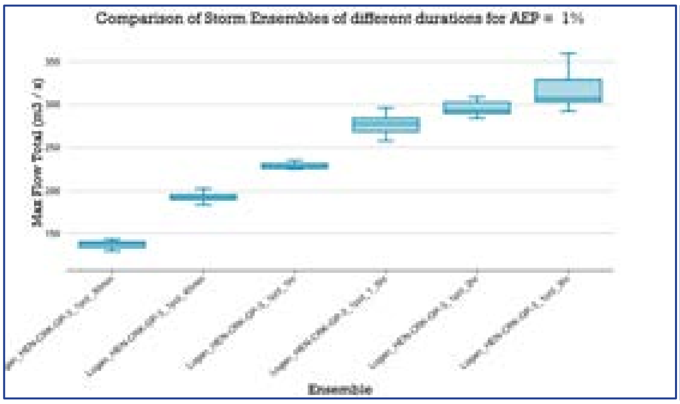
ID	Type	Length (m)	US_Invert (m AHD)	DS_Invert (m AHD)	% Blockage	Width (m)	Height (m)	Number of Cells
45_152A	C	12	54.96	54.68	20	0.9	0	1
45_153	C	15.5	31.48	31.08	20	0.9	0	1
assu_03	R	-1	41.011	40.797	20	1.2	0.6	2
C1	C	-1	24.505	24.367	20	1.2	0	6
C100	C	-1	25.6	25.5	20	1.05	0	6
C11	C	-1	47.75	47.62	20	0.75	0	3
C12	C	41.7	43.31	43.038	20	1.65	0	1
C13	R	-1	33.1	32.98	20	0.9	0.3	2
C14	R	-1	28.94	28.87	20	1.2	0.6	3
C15	C	-1	30.75	30.5	20	0.9	0	4
C16	R	9.75	28.65	28.25	20	1.2	0.6	4
C17A	C	15	31	30.9	20	0.6	0	2
C17B	C	15	31	30.9	20	0.45	0	4
C18	C	-1	22.4	22.1	20	0.45	0	4
C19	C	10	21.7	21.3	20	0.45	0	3
C2	C	12.8	20.926	19.601	20	0.9	0	1
C20	C	-1	25	24.75	20	1.2	0	2
C21	R	10	22.5	22.4	20	1.2	0.3	2
C22	C	10.98	20.55	20.54	20	0.6	0	3
C23	C	24.4	28.3	28.13	20	1.2	0	1
C24	C	12.2	27.19	26.98	20	0.825	0	1
C25	C	-1	22.8	22.6	20	1.2	0	2
C26	R	10.98	42.5	42.25	20	0.9	0.6	3
C27	C	25.83	25.29	25.1	20	2.1	0	7

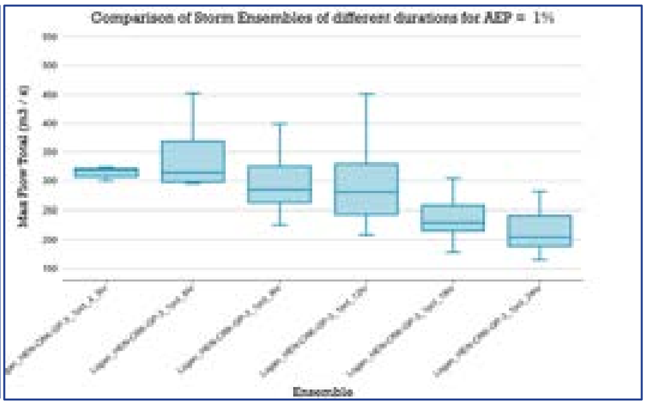
ID	Type	Length (m)	US_Invert (m AHD)	DS_Invert (m AHD)	% Blockage	Width (m)	Height (m)	Number of Cells
C28	C	11	29.603	29.537	20	0.75	0	10
C3	C	12	52.419	52.086	20	0.4	0	1
C4	C	-1	58.2	58.1	20	0.3	0	5
C5	C	-1	57	56.8	20	0.3	0	5
C6	C	-1	51.84	51.58	20	0.3	0	5
C8	C	16	19.101	19.083	20	1.2	0	2
C9	C	21.6	38.699	38.601	20	3	0	1
CX1	C	-1	24.7	24.2	20	1.05	0	2
CX2	C	-1	19	18.3	20	0.525	0	2
CX3	C	-1	48	47	20	0.525	0	2
RS_005	C	19.52	62.03	61.48	20	1.2	0	3
RS_006	C	21.96	56.42	56.35	20	1.5	0	3
RS_008	C	24.4	56.9	56.66	20	0.825	0	2
RS_009	C	22.16	49.8	49.55	20	0.675	0	3
RS_010	C	9.76	65.1	65	20	0.9	0	2
S_001	C	29.58	69.96	69.75	20	0.825	0	4
S_002	C	26.9	72.99	72.65	20	1.05	0	3
S_003	C	24.56	88.57	88.35	20	0.9	0	1
S_004	C	29.281	76.04	75.7	20	0.825	0	1
S_005	R	27.5	67.02	66.86	20	1.5	1.2	3
S_006	C	34.16	57.23	57.03	20	1.05	0	2
S_008	R	-1	57.1	56.95	20	1.8	1.2	3
S_012	C	24	54.65	53.69	20	0.525	0	1
S_013	C	16.8	37.16	37.04	20	0.6	0	4

ID	Type	Length (m)	US_Invert (m AHD)	DS_Invert (m AHD)	% Blockage	Width (m)	Height (m)	Number of Cells
S_014	R	8.5	33.99	33.59	20	1.2	0.6	2
SD212706	C	-1	78.28	77.87	20	0.825	0	1
SD37523	C	-1	24.9	24.65	20	0.9	0	1
SD39181	C	-1	28.2	26.3	20	1.2	0	1
SD39250	C	15.86	25.83	25.7	20	0.675	0	3
SD39562	C	-1	27.28	26.97	20	1.2	0	2
SD39563	C	-1	22.93	22.17	20	2.4	0	1
SD39723	C	-1	33.8	33.49	20	1.35	0	1

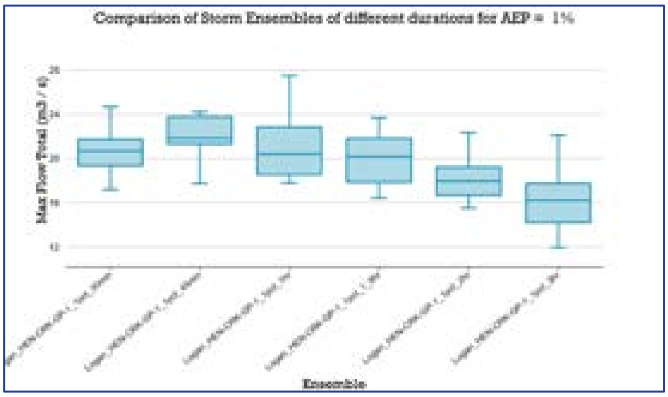
Appendix D:
Box and Whisker Plots

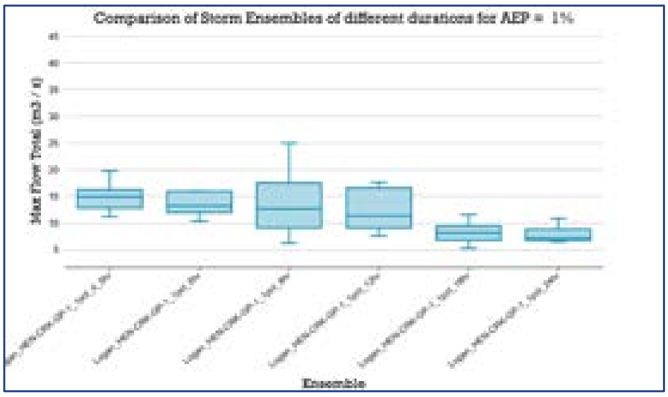
Appendix Figure D. 1 1% AEP Box and Whisker Plots – S1b



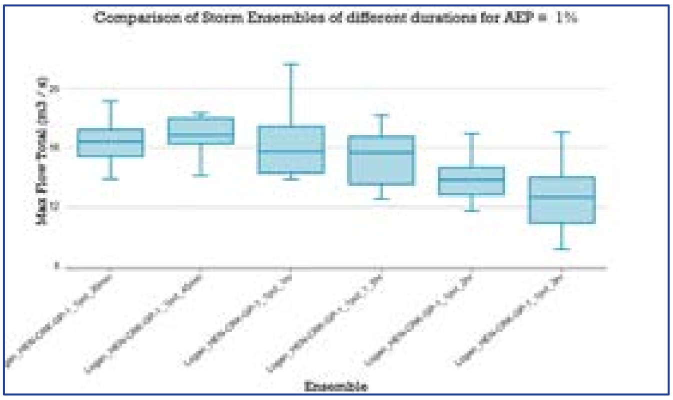


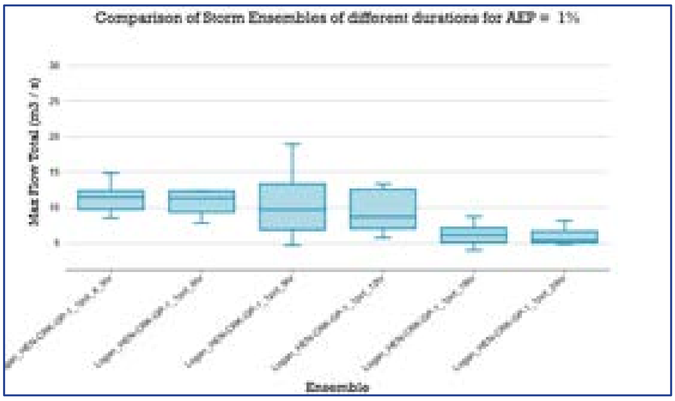
Appendix Figure D. 2 1% AEP Box and Whisker Plots – S60



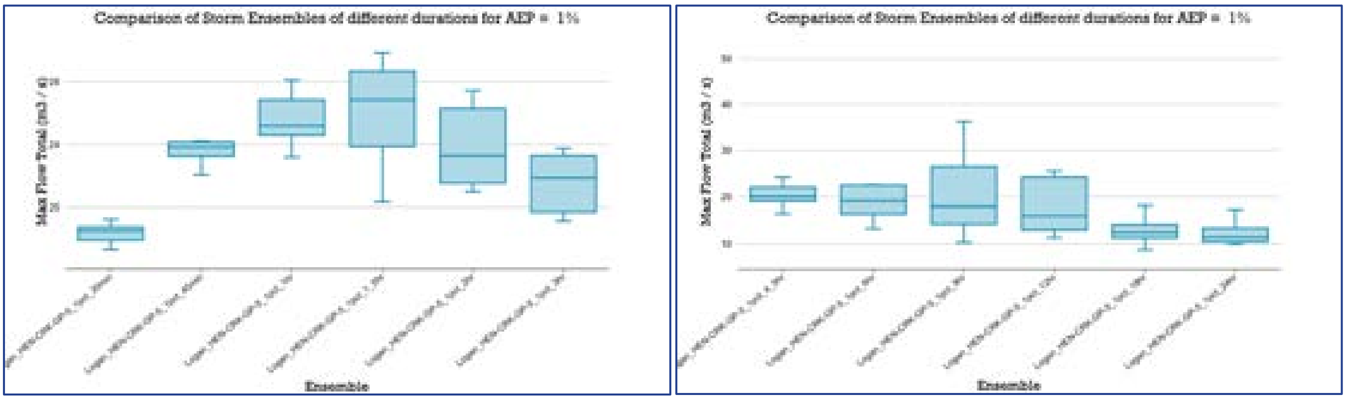


Appendix Figure D. 3 1% AEP Box and Whisker Plots – S96

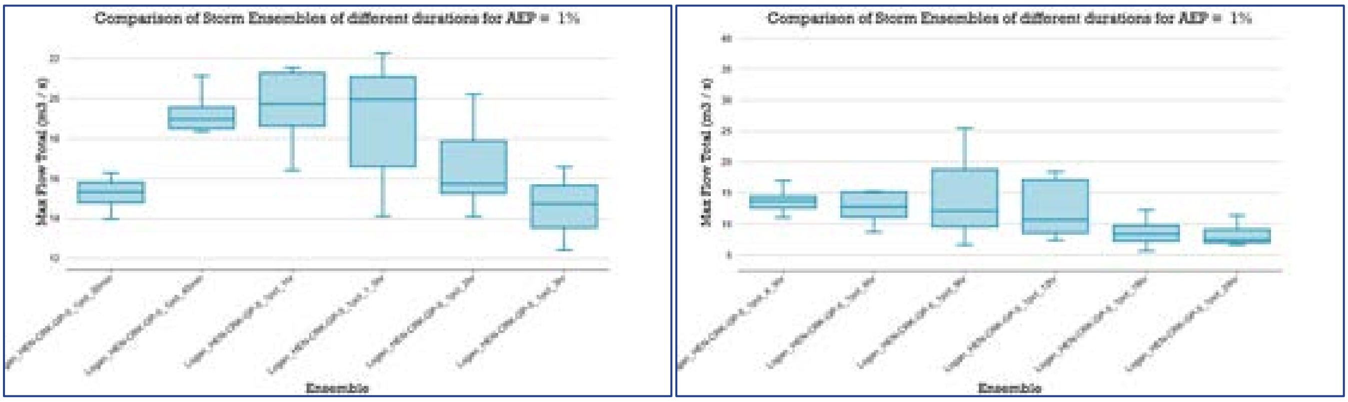




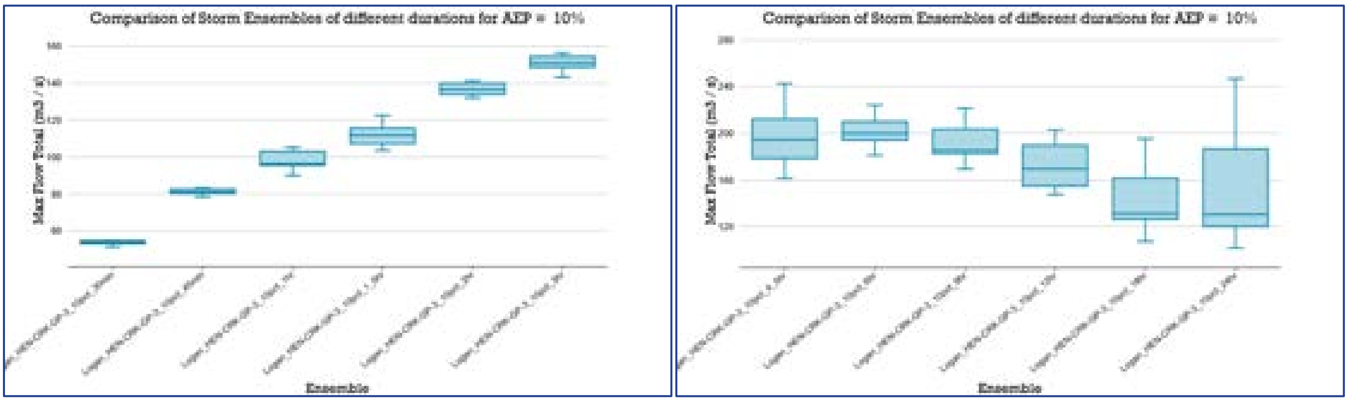
Appendix Figure D. 4 1% AEP Box and Whisker Plots – S103



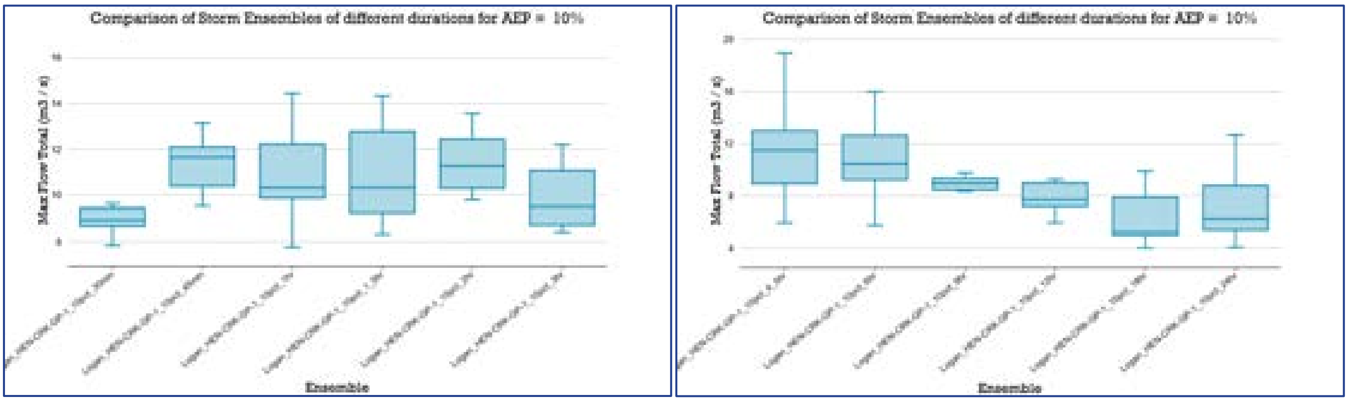
Appendix Figure D. 5 1% AEP Box and Whisker Plots – S131



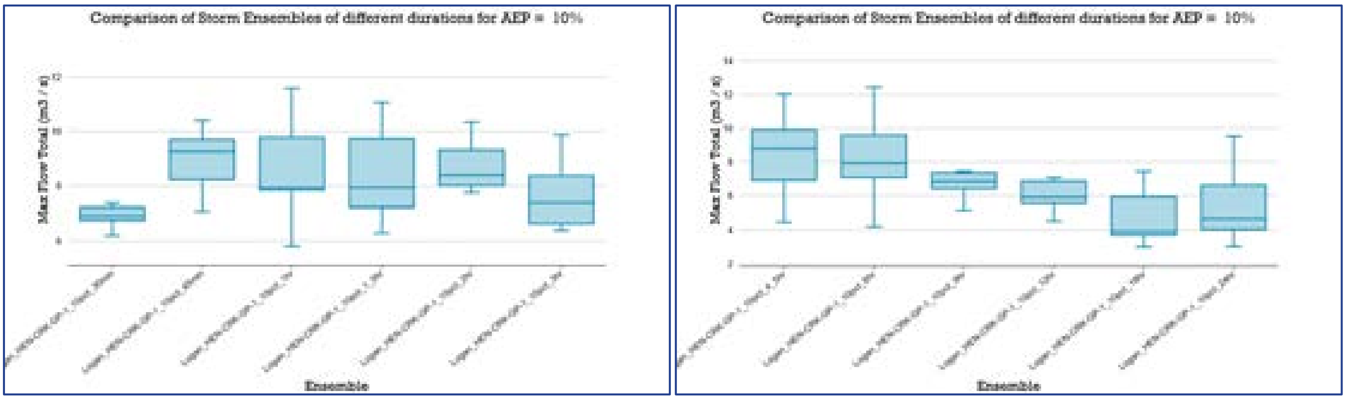
Appendix Figure D. 6 10% AEP Box and Whisker Plots – S1b



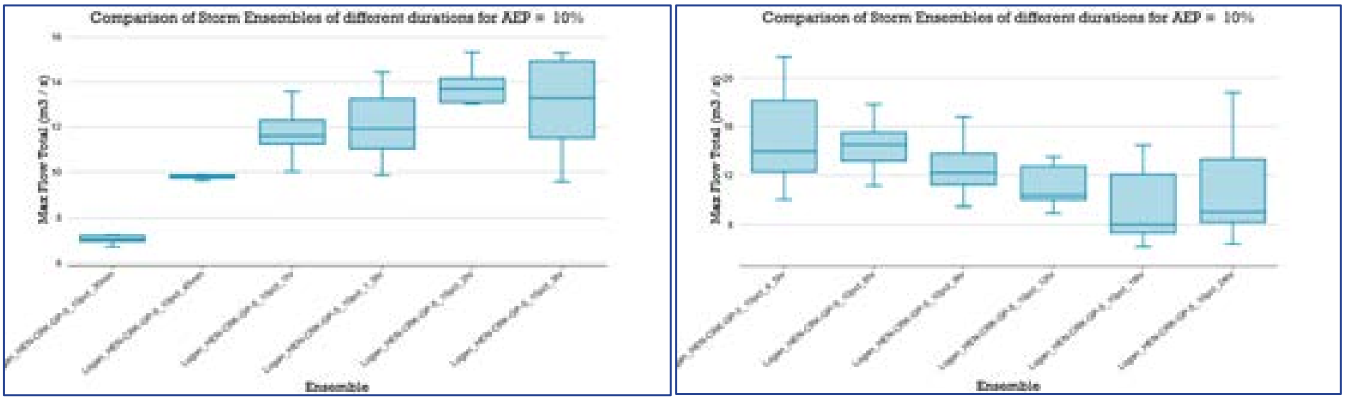
Appendix Figure D. 7 10% AEP Box and Whisker Plots – S60



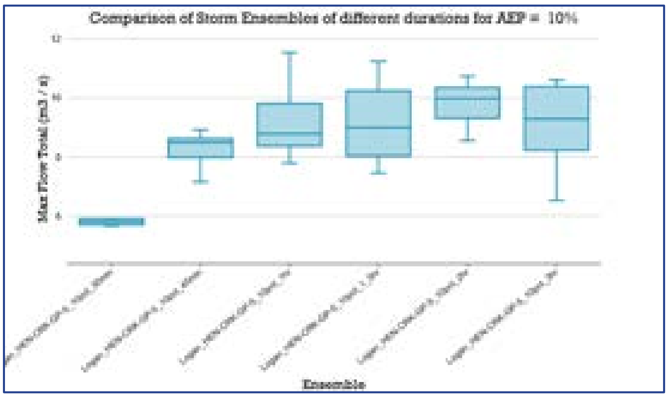
Appendix Figure D. 8 10% AEP Box and Whisker Plots – S96

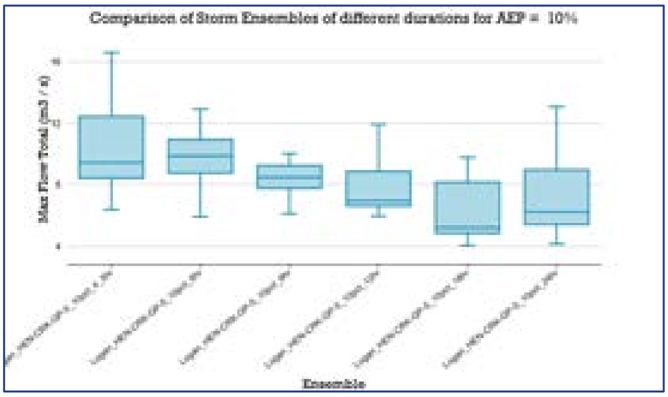


Appendix Figure D. 9 10% AEP Box and Whisker Plots – S103

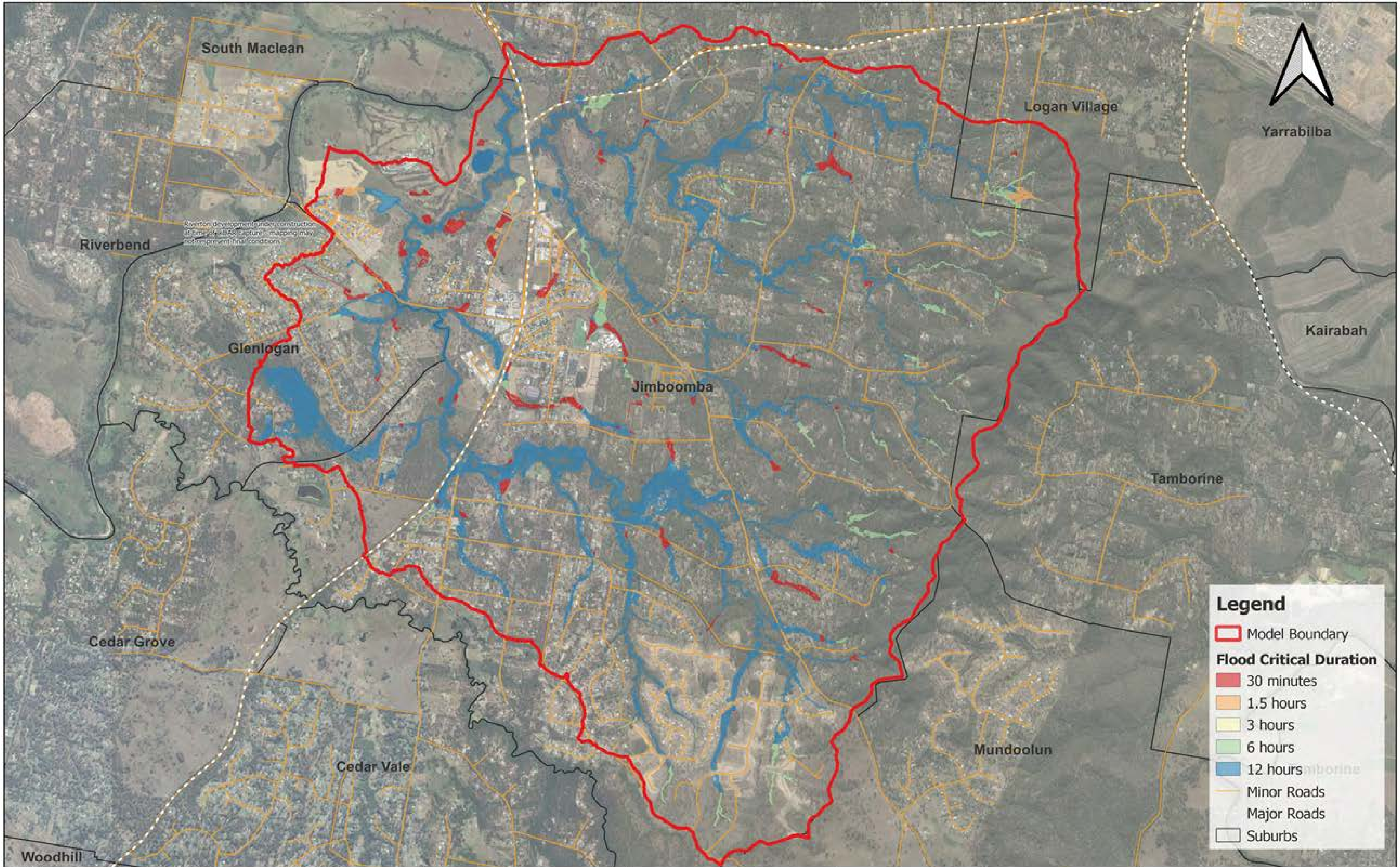


Appendix Figure D. 10 10% AEP Box and Whisker Plots – S131





Appendix E:
Critical Duration Mapping



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
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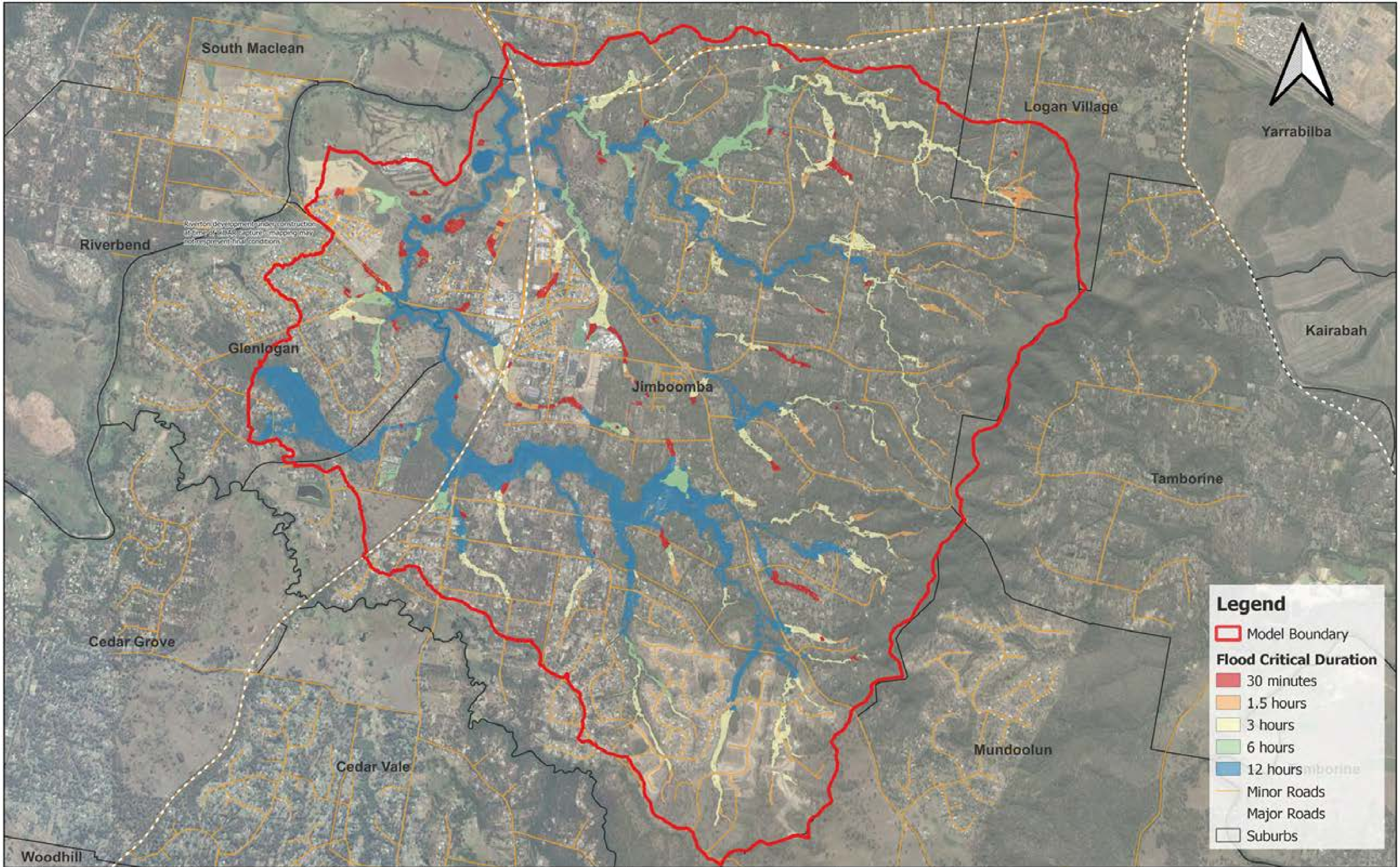
Appendix E.1.1

Henderson Creek Flood Study Update
1:2 AEP Flood Critical Duration

Appendix E.1.1

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



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APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

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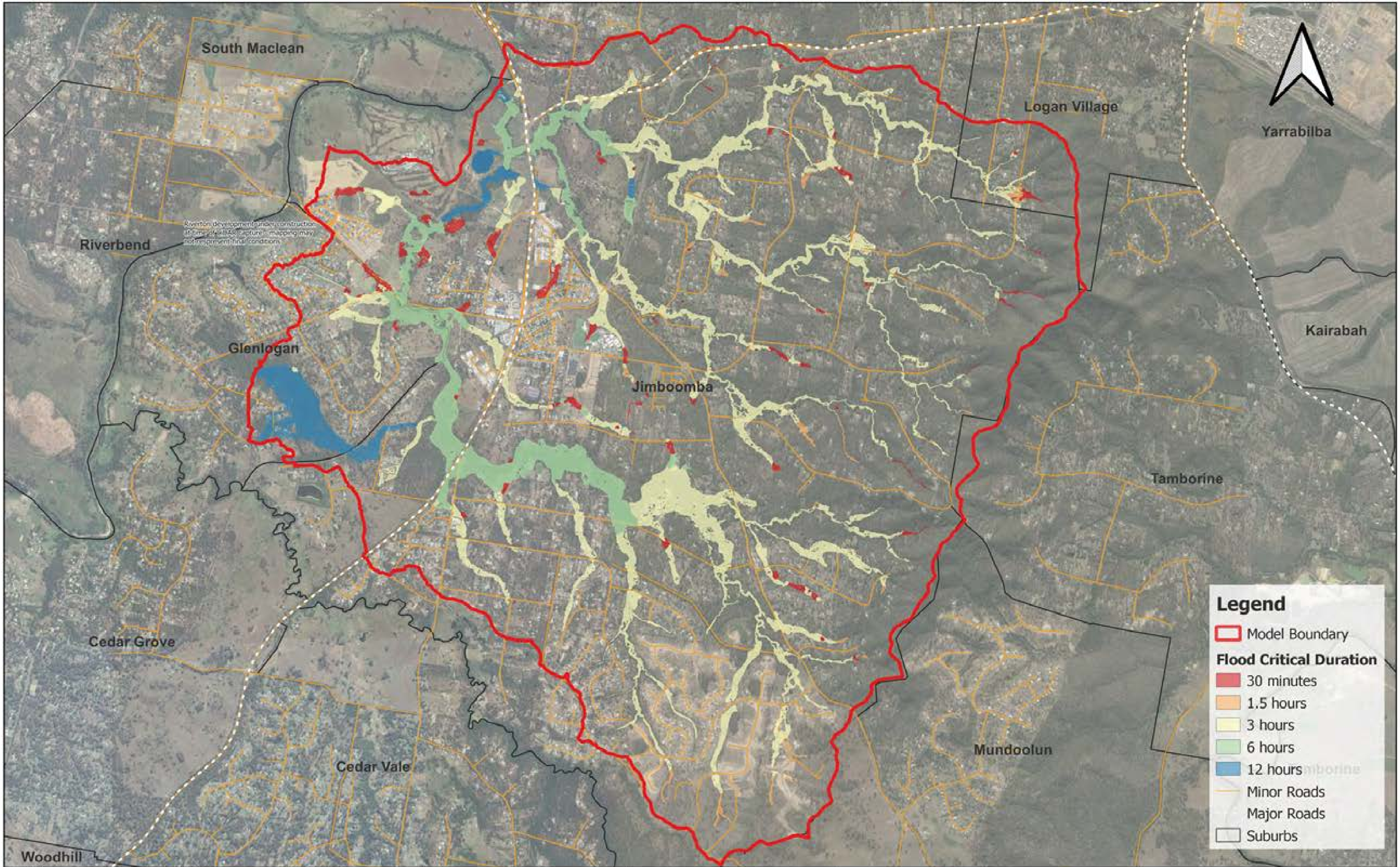
Appendix E.1.2

Henderson Creek Flood Study Update
1:5 AEP Flood Critical Duration

Appendix E.1.2



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DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

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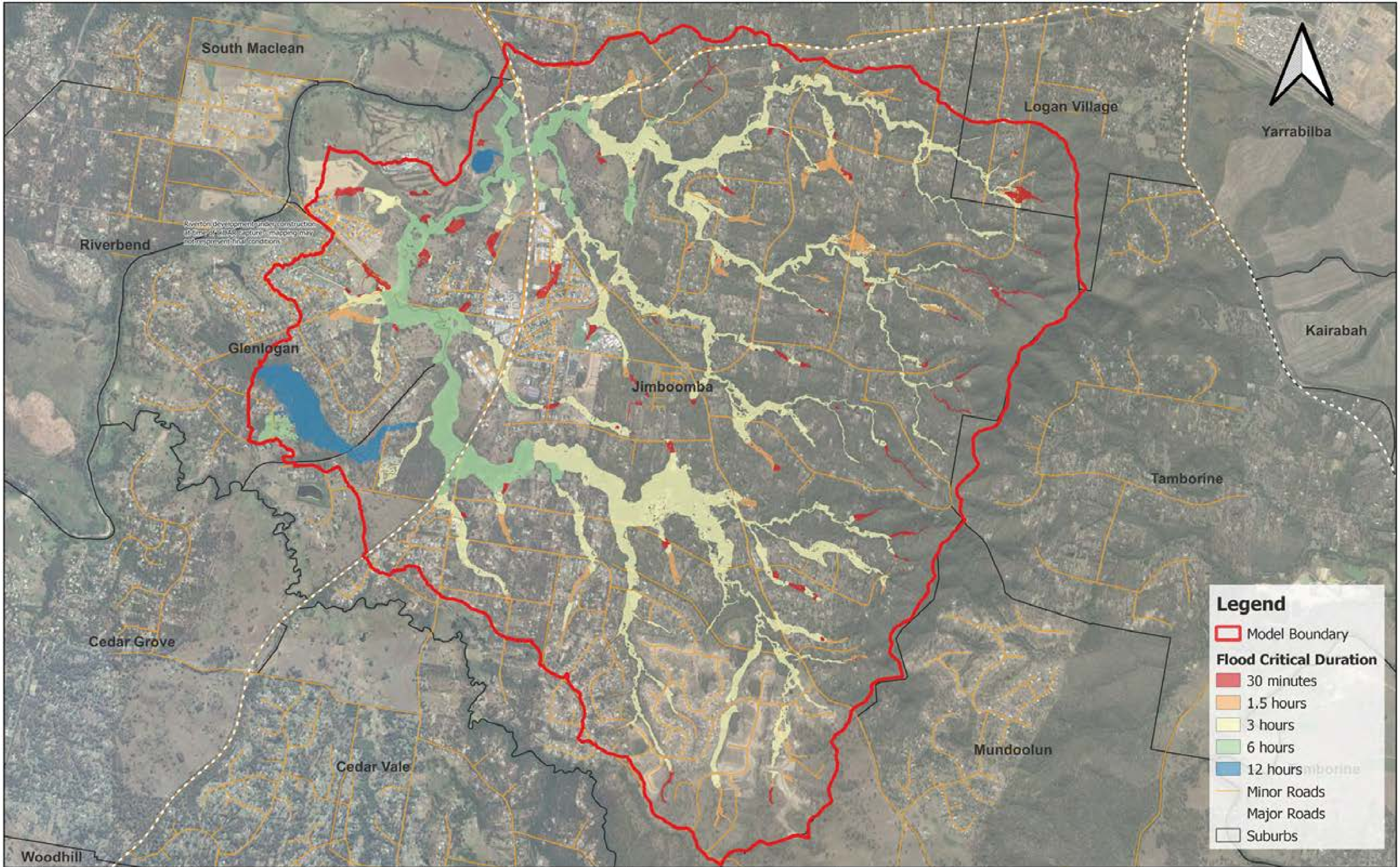
Appendix E.1.3

Henderson Creek Flood Study Update
1:10 AEP Flood Critical Duration

Appendix E.1.3

M:\Projects\M9000_Logan_City_Council\M9000_083 Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



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DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

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Appendix E.1.4

Henderson Creek Flood Study Update
1:20 AEP Flood Critical Duration

Appendix E.1.4

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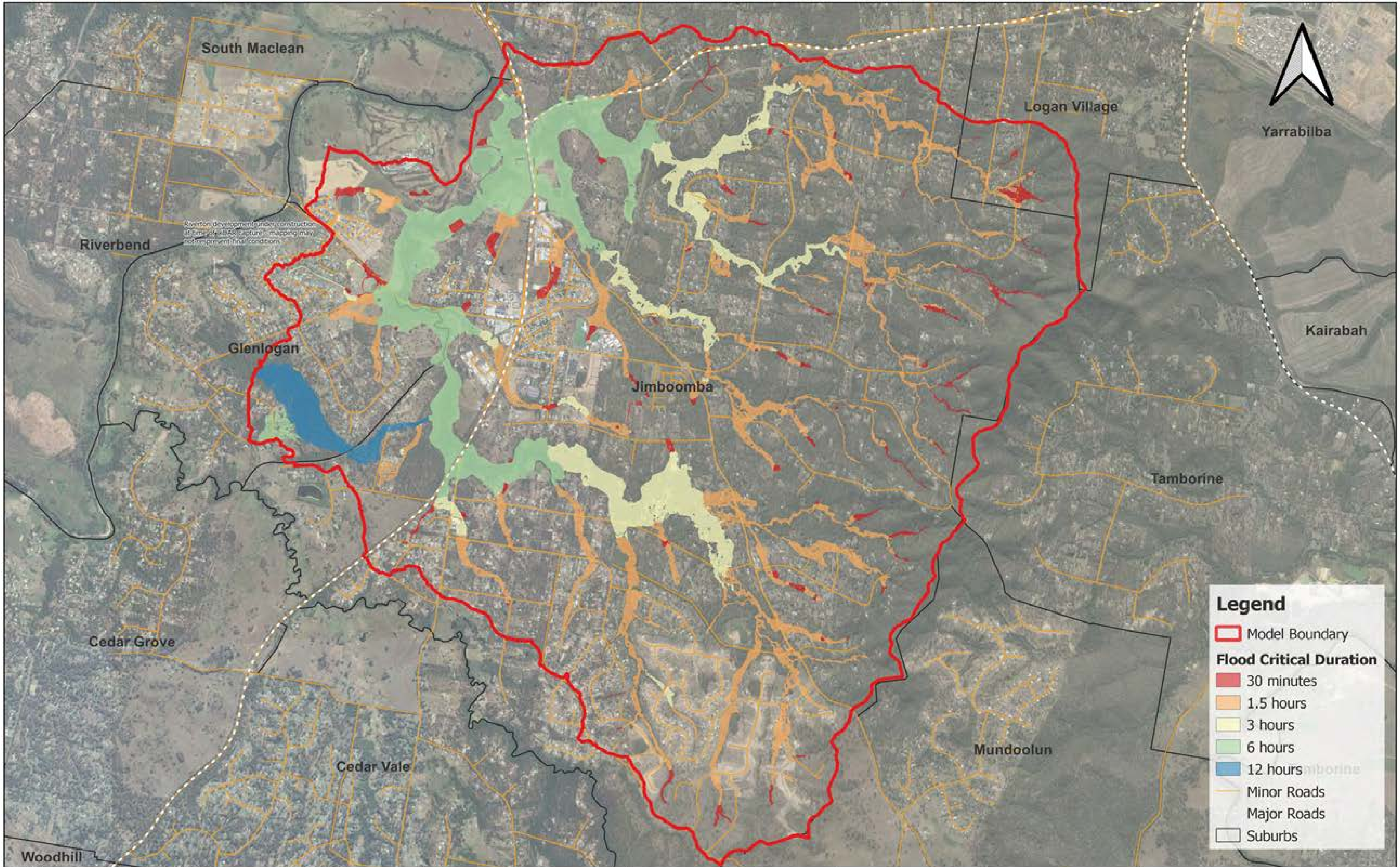

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DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

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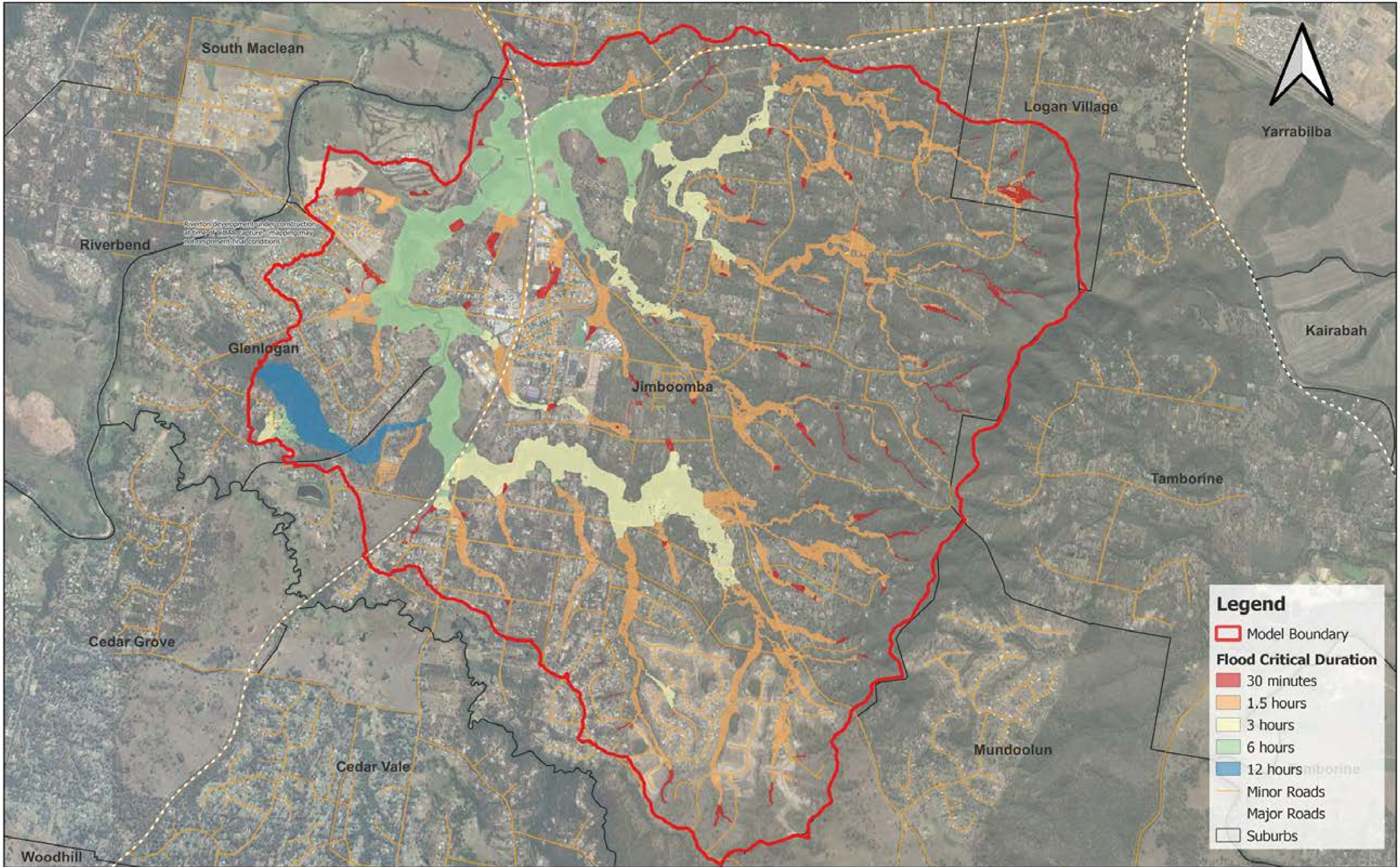
Appendix E.1.5

Henderson Creek Flood Study Update
1:50 AEP Flood Critical Duration

Appendix E.1.5



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NOTES:

N

0 0.8 1.6 km

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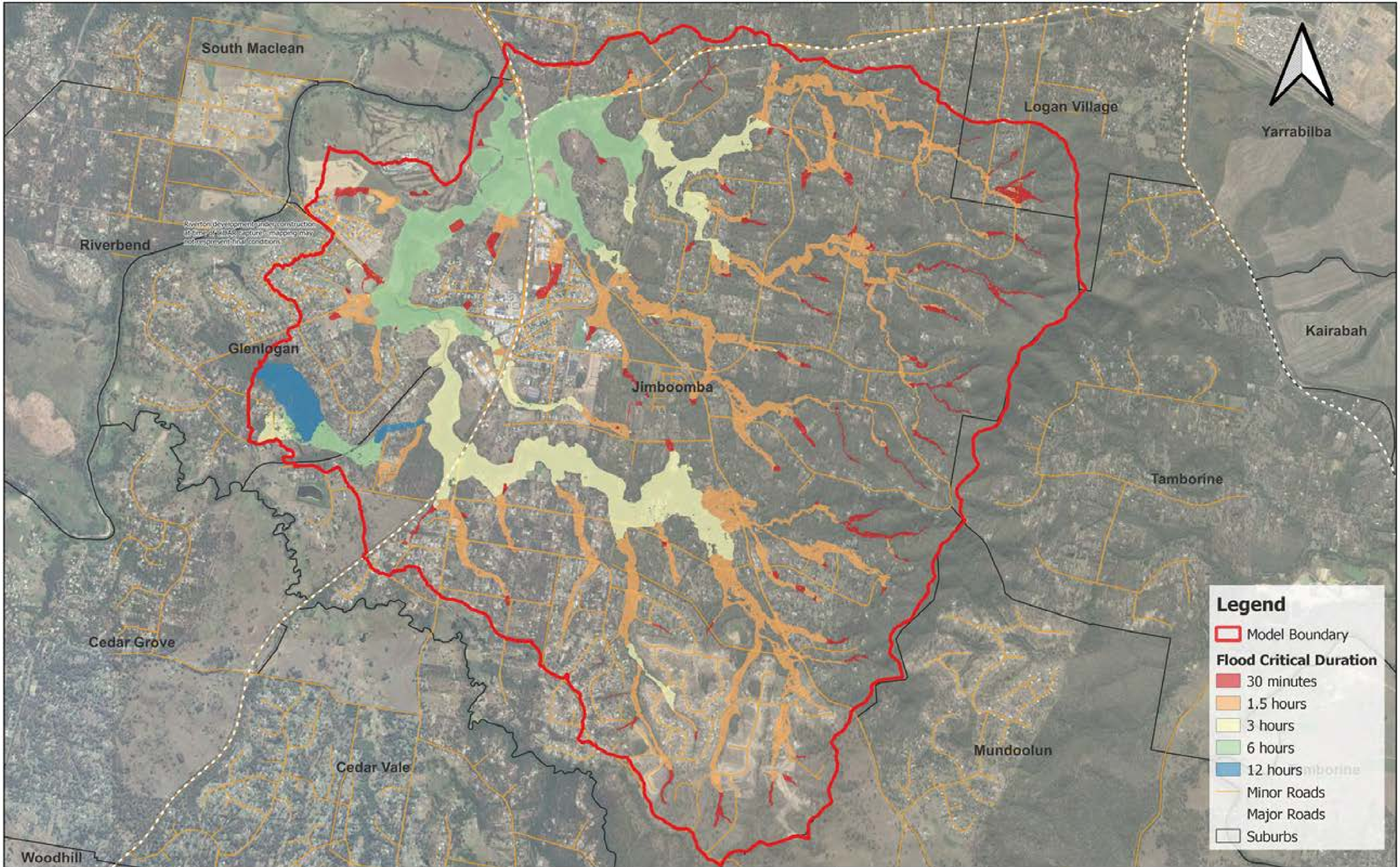
Appendix E.1.6

Henderson Creek Flood Study Update
1:100 AEP Flood Critical Duration

Appendix E.1.6



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APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

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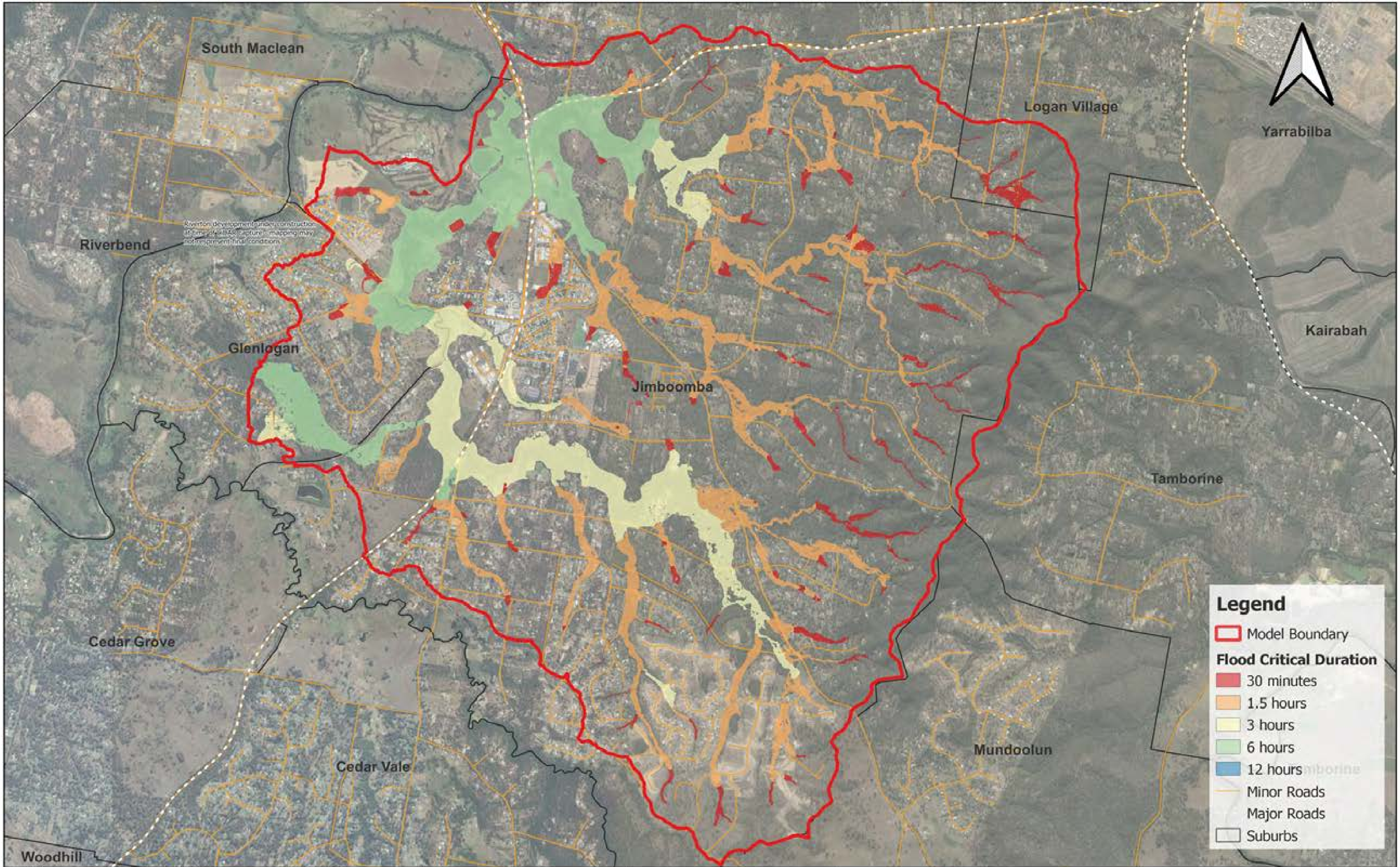
Appendix E.1.7

Henderson Creek Flood Study Update
1:200 AEP Flood Critical Duration

Appendix E.1.7



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1	Final Issue	19-07-2023

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APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

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Appendix E.1.8

Henderson Creek Flood Study Update
1:500 AEP Flood Critical Duration

Appendix E.1.8

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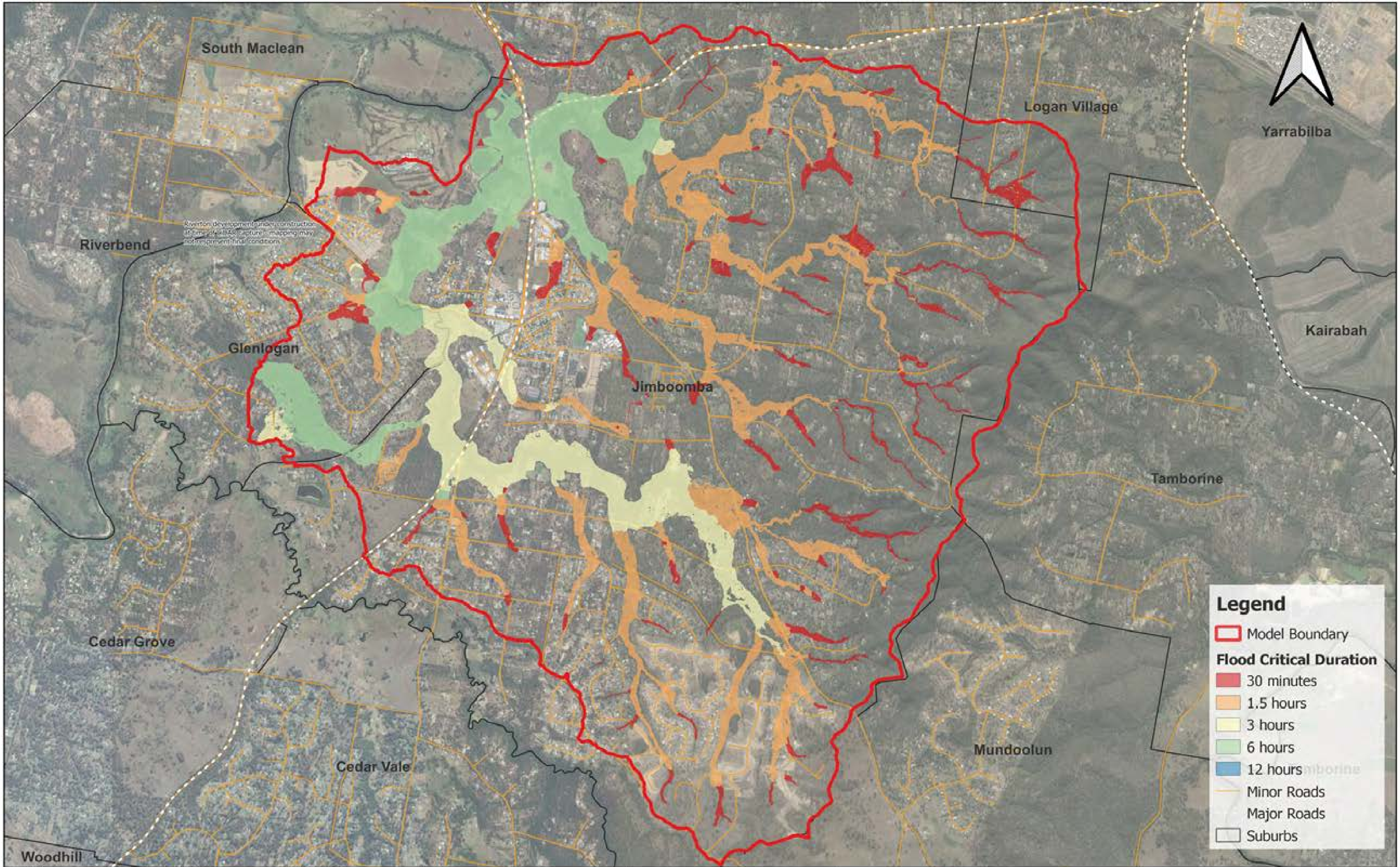

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APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
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Appendix E.1.9

Henderson Creek Flood Study Update
1:2000 AEP Flood Critical Duration

Appendix E.1.9

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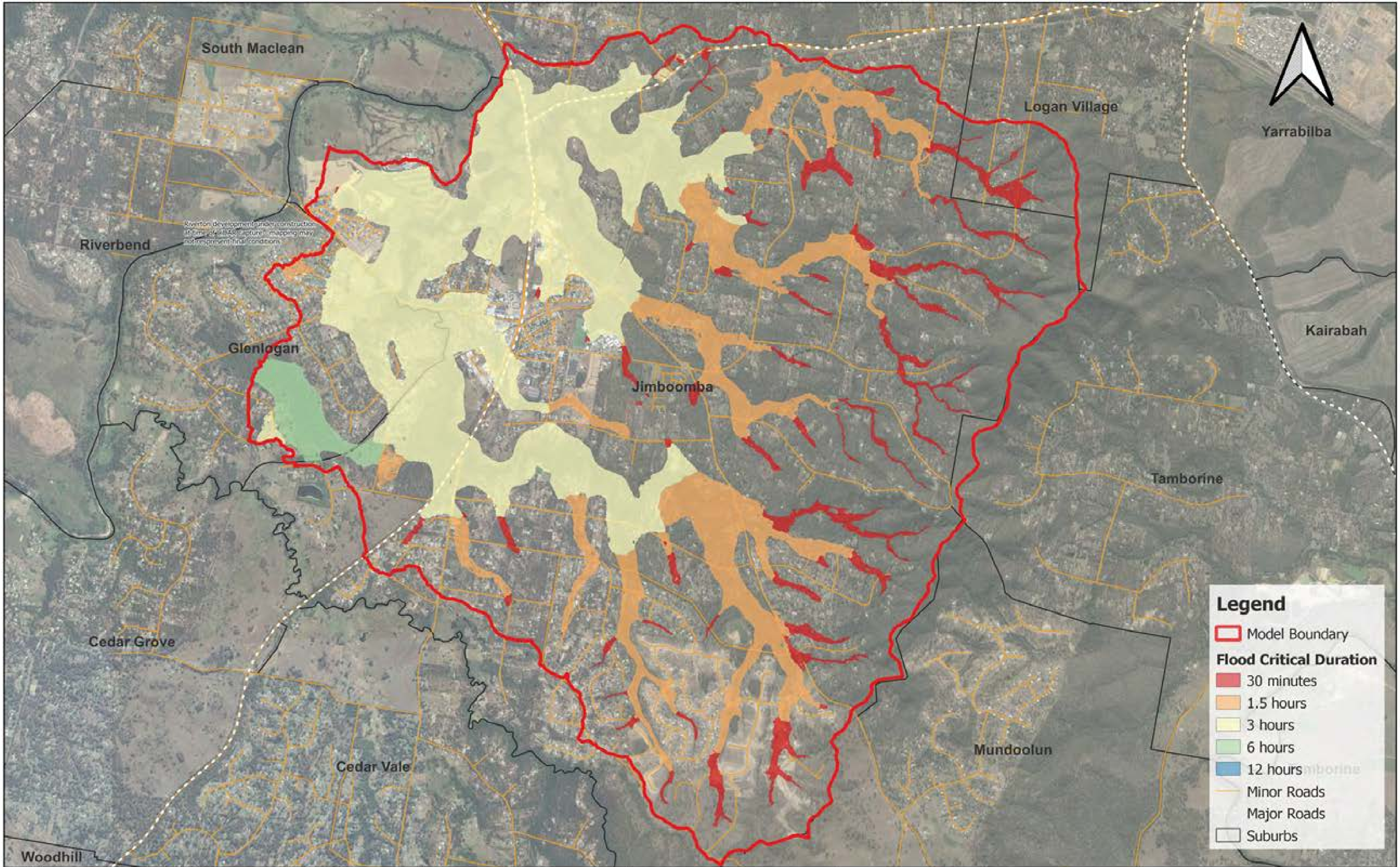

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1	Final Issue	19-07-2023

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APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
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Appendix E.1.10

Henderson Creek Flood Study Update
PMF Flood Critical Duration

Appendix E.1.10

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Appendix F:
Peak Flow Analysis (PO1)

Location – catchment outlet PO1
Highlighted result is the critical duration, median temporal pattern peak flow.

Event	Durn	TP1	TP2	TP3	TP4	TP5	TP6	TP7	TP8	TP9	TP10	Median
PMF	30min	**1283.29**										1283.29
PMF	1hr	**2026.52**										2026.52
PMF	1_5hr	**2263.18**										2263.18
PMF	2hr	**2468.54**										2468.54
PMF	3hr	**2482.53**										**2482.53**
PMF	4hr	**2318.2**										2318.2
PMF	5hr	**2159.75**										2159.75
PMF	6hr	**1994.33**										1994.33
PMF	9hr	**1452.44**										1452.44
PMF	12hr	**1151.27**										1151.27
0p05pct	30min	208.65	209.79	210.36	209.46	209.11	208.49	**209.72**	209.74	209.94	209.51	209.72
0p05pct	1hr	329.27	330.09	328.33	326.21	**327.28**	329.01	325.72	326.77	326.88	327.02	327.28
0p05pct	1_5hr	397.38	405.21	**400.2**	393.62	399.68	406.29	399.56	398.99	404.31	406.28	400.2
0p05pct	2hr	445.95	440.56	**442.92**	441.04	441.87	441.14	440.62	443.98	448.65	453.56	442.92
0p05pct	3hr	507.31	473	516.12	500.75	494.35	495.31	495.33	484.65	**498.52**	523.42	498.52
0p05pct	4_5hr	528.99	536.26	509.67	496.66	481.13	504.67	**517**	534.49	496.39	571.86	**517**
0p05pct	6hr	601.85	462.78	**497.9**	493.67	505.56	477.85	591.59	568.19	450.76	479.92	497.9
0p05pct	9hr	**451.77**	399.38	415	433.71	521.4	458.03	531.11	404.2	390.87	477.15	451.77
0p05pct	12hr	431.29	**448.65**	384.19	356.59	564.36	369.39	374.82	669.18	466.54	507.86	448.65
0p2pct	30min	143.64	**144.23**	144.51	144.12	144.02	143.64	144.28	144.34	144.38	144.21	144.23
0p2pct	1hr	248.02	247.96	245.43	243.98	244.6	246.49	243.81	243.79	**245.42**	244.6	245.42
0p2pct	1_5hr	304.72	311.04	**306.66**	301.56	306.24	311.79	306.59	306.11	310.31	311.72	306.66
0p2pct	2hr	349.61	345.24	**346.16**	345.58	345.17	345.78	345.05	347.94	351.59	355.86	346.16
0p2pct	3hr	410.1	380.93	416.81	403.01	397.94	399.07	399.22	391.54	**401.66**	422.46	401.66
0p2pct	4_5hr	432.16	437.05	416.27	402.93	392.13	410.7	**422.22**	435.96	405.28	458.41	**422.22**
0p2pct	6hr	462.81	378.36	**408.55**	403.17	415.16	392.31	472.27	452.65	363.28	392.71	408.55
0p2pct	9hr	371.35	320.84	340.08	356.76	417.03	**369.63**	432.8	329.28	314.92	395.59	369.63

0p2pct	12hr	354.49	**370.47**	314.92	284.17	437.25	299.94	302.24	508.96	380.2	422.12	370.47
0p5pct	30min	112.62	120.82	117.96	116.52	117.3	116.93	116.01	120.09	**117.07**	116.94	117.07
0p5pct	1hr	185.08	185.53	184.42	183.3	184.01	184.77	183.59	183.83	183.95	**184.12**	184.12
0p5pct	1_5hr	20.18	171.58	**243.43**	240.25	243.03	247.56	243.69	183.27	246.18	247.26	243.43
0p5pct	2hr	283.98	280.68	**281.1**	280.79	280.23	281	280.34	282.64	285.28	289.14	281.1
0p5pct	3hr	340.56	316.15	346.8	334.47	330.28	331.28	331.31	324.45	**333.49**	351.51	333.49
0p5pct	4_5hr	364.26	369.99	**351.71**	342.93	336.85	349.81	357.84	368.64	342.9	0	**351.71**
0p5pct	6hr	391.44	318.21	**346.19**	343.95	354.72	333.79	400.31	384.88	319.64	325.71	346.19
0p5pct	9hr	320.21	266.17	293.81	305.99	357.57	**308.41**	377.77	276.67	262.43	344.46	308.41
0p5pct	12hr	304.07	**322.08**	269.64	236.65	379.55	254.02	251.92	441.95	324.15	372.33	322.08
1pct	30min	99.7	109.42	106.26	105.29	105.58	104.78	105.18	108.6	**105.44**	105.37	105.44
1pct	1hr	151.9	152.05	151.01	149.99	150.7	151.45	150.26	150.52	150.65	**150.82**	150.82
1pct	1_5hr	203.06	206.63	203.73	201.62	203.31	207.19	**204.19**	203.78	206	206.81	204.19
1pct	2hr	241.89	239.75	240.32	**240.79**	239.94	239.7	239.54	240.82	242.7	245.94	240.79
1pct	3hr	298.34	276.66	303.39	291.79	288.29	289.36	289.56	284.28	**291.29**	307.07	291.29
1pct	4_5hr	324	327.91	312.36	304.24	298.19	309.24	**315.72**	327.27	305.18	345.45	**315.72**
1pct	6hr	345.37	285.15	**310.39**	309.25	317.44	299.64	359.69	339.63	286.52	290.64	310.39
1pct	9hr	284.11	239.15	265.18	**275.42**	314.84	269.7	336.5	246.71	232.43	311.04	275.42
1pct	12hr	272.61	289.2	242.64	209.15	333.39	221.39	219.75	393.9	**286.61**	333.97	286.61
1pct_Sens1	30min	100.4	110.24	107.37	106.09	**106.31**	105.5	106.17	109.62	106.54	106.24	106.31
1pct_Sens1	1hr	154.58	154.76	153.61	152.31	**153.01**	153.98	152.06	152.68	152.76	152.94	153.01
1pct_Sens1	1_5hr	205.29	209.02	206.11	203.62	205.61	209.71	**206.43**	205.85	208.31	209.23	206.43
1pct_Sens1	2hr	244.43	241.77	241.98	**242.45**	242.16	242	241.32	243.31	245.19	248.62	242.45
1pct_Sens1	3hr	300.84	279.59	306.46	295.28	291.72	292.42	292.43	286.85	**294.4**	310.46	294.4
1pct_Sens1	4_5hr	326.5	331.35	315.22	307.47	301.15	312.02	**318.81**	330.28	308.12	348.94	**318.81**
1pct_Sens1	6hr	349.57	287.28	**312.83**	310.62	320.22	302.01	363.47	343.46	286.84	292.65	312.83
1pct_Sens1	9hr	286.54	240.74	265.8	**276.47**	318.44	273.29	340.18	248.1	233.75	313.3	276.47
1pct_Sens1	12hr	274.11	290.72	244.17	207.98	337.16	222.11	221.39	398.51	**289.4**	336.67	289.4
1pct_Sens2	30min	81.16	88.06	88.79	81.43	86.14	91.54	84.11	**86.03**	84.53	82.75	86.03

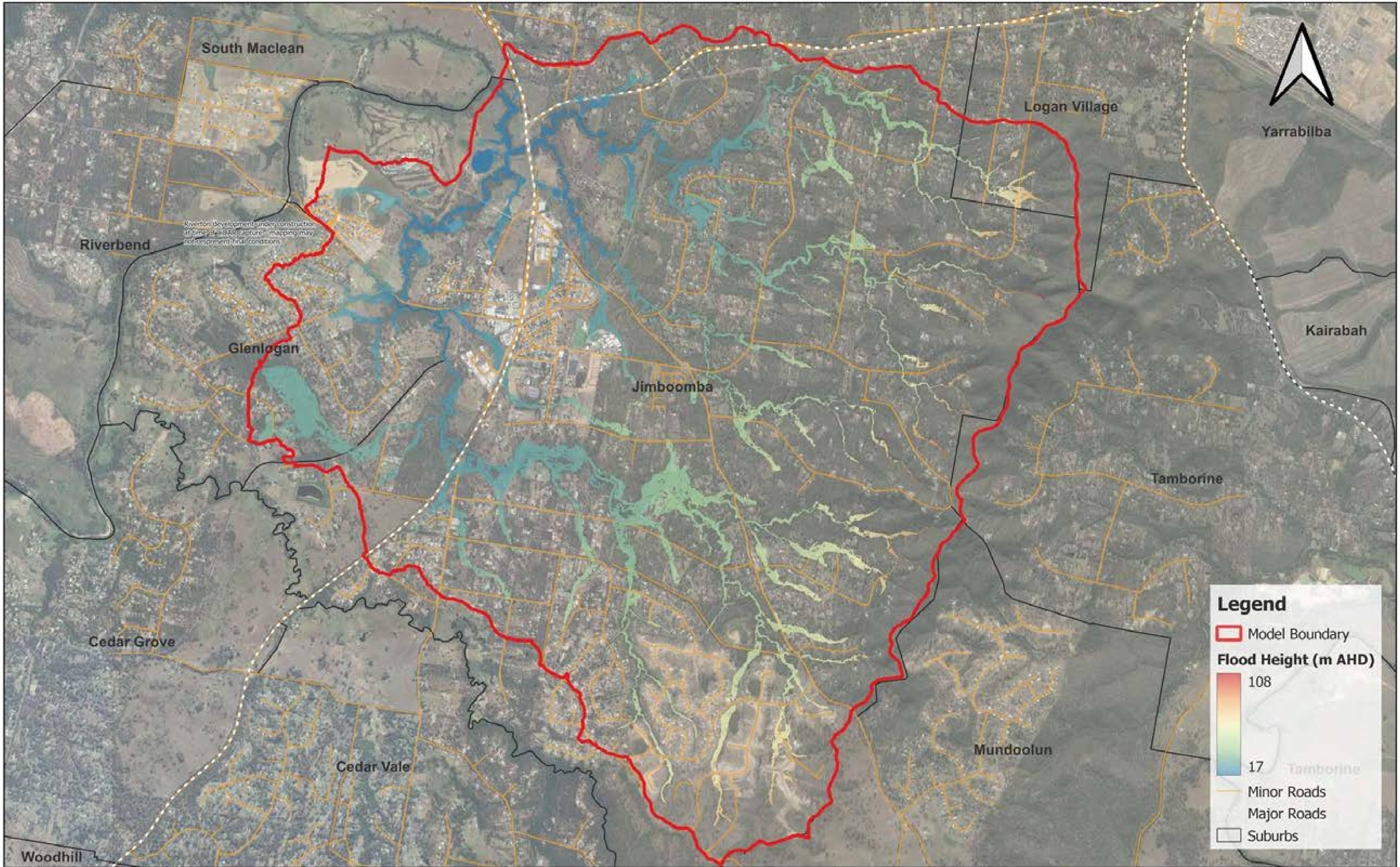
1pct_Sens2	1hr	95	91.81	77.46	80.05	76.61	**78.5**	82	76.38	77.61	77.6	78.5
1pct_Sens2	1_5hr	81.86	97.7	82.18	**87.35**	85.17	92.54	85.46	86.58	98.98	96.4	87.35
1pct_Sens2	2hr	121.21	119.93	118.08	119.65	117.36	**120.16**	118.94	120.3	121.9	124.28	120.16
1pct_Sens2	3hr	212.68	201.03	214.28	204.86	203.53	204.32	**205.69**	206.41	205.49	213.38	205.69
1pct_Sens2	4_5hr	277	267.03	263.65	246.4	242.18	246.02	245.72	270.42	**266.99**	286.48	266.99
1pct_Sens2	6hr	252.21	277.24	294.69	269.6	289.78	**283.2**	334.11	249.11	253.26	293.95	**283.2**
1pct_Sens2	9hr	211.54	**246.15**	264.46	256.32	217.95	222.82	258.73	206.32	214.79	291.45	246.15
1pct_Sens2	12hr	280.74	295.73	**246.82**	209.79	239.48	198.3	195.98	316.14	226.89	354.05	246.82
1pct_Sens3	30min	90.23	97.11	96.2	94.04	93.67	92.92	**94.47**	96.47	94.77	93.99	94.47
1pct_Sens3	1hr	136.18	136.38	135.39	134.26	**134.87**	135.73	134.03	134.57	134.66	134.79	134.87
1pct_Sens3	1_5hr	178.22	181.05	178.78	177.24	178.36	181.51	**179.14**	178.8	180.49	181.15	179.14
1pct_Sens3	2hr	213.92	212.06	211.39	211.97	210.83	**212.37**	211.44	212.92	214.44	217.1	212.37
1pct_Sens3	3hr	269.29	252.5	272.56	263.43	260.91	262.01	262.41	258.83	**263.32**	275.12	263.32
1pct_Sens3	4_5hr	298.71	300.26	**289.01**	280.5	273.84	283.51	288.51	300.33	283.94	314.86	289.01
1pct_Sens3	6hr	309.53	271.4	292.64	**293.96**	297.22	283.14	331.67	307.94	274.28	274.95	**293.96**
1pct_Sens3	9hr	**260.85**	224.42	259.34	265.97	279.97	240.88	303.55	227.33	221.86	297.1	260.85
1pct_Sens3	12hr	263.24	278.15	231.51	210.72	296.17	208.01	208.99	355.39	**271.7**	311.12	271.7
1pct_Sens5	30min	302.08	**309.35**	345.66	294.24	281.16	306.11	315.26	310.14	317.67	290.88	309.35
1pct_Sens5	1hr	422.46	359.98	289.71	277.08	264.59	**287.13**	303.54	249	281.1	276.15	287.13
1pct_Sens5	1_5hr	317.13	392.89	300.79	**368.86**	349.87	338.82	333.31	376.4	400	382.98	368.86
1pct_Sens5	2hr	422.73	**395.04**	367.66	396.78	365.11	414.28	368.12	388.9	396.65	383.07	395.04
1pct_Sens5	3hr	442.59	438.27	471.93	**440.78**	433	433.88	435.63	497.67	438.37	465.93	**440.78**
1pct_Sens5	4_5hr	448.17	**435.63**	404.3	382.89	348.83	419.12	415.16	442.6	444.54	521	435.63
1pct_Sens5	6hr	542.05	386.25	389	**402.43**	358.58	405.44	525.94	535.55	333.34	374.19	402.43
1pct_Sens5	9hr	365.7	320.76	262.36	283.53	493.59	377.68	488.65	285.28	299.15	**331.12**	331.12
1pct_Sens5	12hr	325.8	**325.85**	257	262.95	580.09	253.44	285.4	586.51	392.9	457.35	325.85
1pct_CC_RCP4_5	30min	110.12	118.57	115.7	114.26	115.04	114.58	113.81	117.83	**114.77**	114.67	114.77
1pct_CC_RCP4_5	1hr	185.88	186.22	184.95	183.78	184.49	185.4	183.98	184.27	184.37	**184.59**	184.59
1pct_CC_RCP4_5	1_5hr	240.33	244.78	242.74	239.55	**243.03**	247.35	242.82	241.82	244.54	246.58	243.03

1pct_CC_RCP4_5	2hr	279.66	276.09	276.11	276.18	275.12	**276.64**	275.65	278.07	281.1	284.77	276.64
1pct_CC_RCP4_5	3hr	341.32	314.85	346.68	297.48	329.37	330.75	**331.05**	324.94	332.99	351.05	331.05
1pct_CC_RCP4_5	4_5hr	366.9	369.63	352.32	339.35	329.6	346.29	**355.7**	369.17	343.19	390.01	**355.7**
1pct_CC_RCP4_5	6hr	389.92	321.13	**347.75**	340.45	353.64	333.96	404.28	381.74	308.77	333.3	347.75
1pct_CC_RCP4_5	9hr	315.34	267.01	290.52	304.75	351.69	**308.12**	370.25	277.34	263.41	340.13	308.12
1pct_CC_RCP4_5	12hr	302.8	**317.16**	269.11	235.63	369.62	253.15	254	434.53	319.15	364.24	317.16
1pct_CC_RCP6	30min	112.83	120.98	118.13	116.68	117.48	117.11	116.16	120.26	**117.24**	117.11	117.24
1pct_CC_RCP6	1hr	193.27	193.63	192.36	191.06	191.86	192.78	191.27	191.59	191.71	**191.94**	191.94
1pct_CC_RCP6	1_5hr	248.75	252.43	248.88	246.56	**250.92**	253.2	249.45	250.79	251.81	253.12	250.92
1pct_CC_RCP6	2hr	288.73	285.09	285.22	285.17	284.24	**285.6**	284.62	287.14	290.32	294.11	285.6
1pct_CC_RCP6	3hr	350.62	323.58	356.15	342.75	338.46	339.82	340.08	333.75	**342.13**	360.74	342.13
1pct_CC_RCP6	4_5hr	376.1	379.16	361.32	348.16	338.17	355.24	**365.13**	378.59	351.89	399.19	**365.13**
1pct_CC_RCP6	6hr	399.79	329.01	**356.26**	349.26	362.31	341.87	413.78	391.91	316.32	341.47	356.26
1pct_CC_RCP6	9hr	323.44	273.72	297.35	312.02	361.13	**316.84**	379.26	284.63	269.98	347.99	316.84
1pct_CC_RCP6	12hr	309.92	**324.56**	275.46	243.3	379.33	259.73	261.5	445.02	327.73	372.47	324.56
1pct_CC_RCP8_5	30min	124.96	128.25	125.89	125.41	125.26	125.08	**125.6**	127.65	125.67	125.48	125.6
1pct_CC_RCP8_5	1hr	216.14	216.59	215.21	213.79	214.59	215.7	213.82	214.32	214.42	**214.65**	214.65
1pct_CC_RCP8_5	1_5hr	273.16	278.93	274.74	270.49	274.39	279.66	**274.87**	274.42	278.28	279.53	274.87
1pct_CC_RCP8_5	2hr	316.51	312.49	313.01	312.67	312.04	**313.02**	312.18	314.85	318.32	322.32	313.02
1pct_CC_RCP8_5	3hr	378.75	350.17	384.88	371.18	366.45	367.74	367.97	360.69	**370.23**	389.92	370.23
1pct_CC_RCP8_5	4_5hr	403.4	407.37	388.5	374.99	364.5	382.59	**393.45**	406.54	378.29	428.19	**393.45**
1pct_CC_RCP8_5	6hr	431.12	353.12	**382.27**	376.02	388.59	366.55	442.42	421.92	339.21	366.77	382.27
1pct_CC_RCP8_5	9hr	347.56	297.77	318.69	334.31	389.3	**343.34**	405.96	307.14	292.64	371.9	343.34
1pct_CC_RCP8_5	12hr	331.84	**347.14**	294.8	263.66	408.03	279.07	323.43	476.72	353.8	396.96	347.14
2pct	30min	89.82	99.87	97.43	95.98	95.71	94.81	**96.4**	99.84	96.71	95.99	96.4
2pct	1hr	126.21	126.19	125.15	124.11	**124.7**	125.46	124	124.43	124.54	124.65	124.7
2pct	1_5hr	163.96	166.9	164.43	162.65	164.04	167.43	**164.84**	164.3	166.39	166.95	164.84
2pct	2hr	197.74	195.24	194.74	195.17	194.18	**195.62**	194.75	196.4	197.96	200.72	195.62
2pct	3hr	248.62	233.46	252.5	**243.63**	241.92	241.67	242.16	238.14	244.64	255.08	243.63

2pct	4_5hr	273.34	275.76	263.55	257.62	252.24	262.11	**266.1**	275.44	258.35	291.49	266.1
2pct	6hr	286.75	246.18	265.63	**266.27**	271.11	260.16	307.45	282.61	246.36	247.43	**266.27**
2pct	9hr	239.58	200	226.56	**236.54**	258.1	219.74	281.43	202.59	191.6	268.64	236.54
2pct	12hr	236.8	250.85	206.81	180.27	275.63	182.85	181.56	332.79	**243.98**	286.28	243.98
2pct_CC_RCP4_5	30min	98.4	108.1	104.99	103.96	104.27	103.46	103.89	107.27	**104.17**	104.08	104.17
2pct_CC_RCP4_5	1hr	145.91	146.06	144.95	143.68	**144.38**	145.28	143.46	144.03	144.1	144.28	144.38
2pct_CC_RCP4_5	1_5hr	192.84	196.2	193.49	191.44	193.03	196.75	**193.91**	193.43	195.56	196.34	193.91
2pct_CC_RCP4_5	2hr	230.03	226.52	225.98	226.45	225.33	**226.88**	225.92	227.71	229.57	233.33	226.88
2pct_CC_RCP4_5	3hr	282.11	261.67	286.7	275.73	272.44	273.46	273.74	268.95	**275.21**	290	275.21
2pct_CC_RCP4_5	4_5hr	306.27	309.68	295.28	287.65	281.61	291.75	**297.9**	309.22	288.87	326.68	**297.9**
2pct_CC_RCP4_5	6hr	325.41	270.94	**295.01**	294.16	301.4	285.01	341.63	320.19	272.49	275.55	295.01
2pct_CC_RCP4_5	9hr	267	223.08	252.29	**261.39**	294.45	253.41	316.77	232.08	216.69	295.28	261.39
2pct_CC_RCP4_5	12hr	262.02	275.35	231.42	198.95	313.71	208.5	206.17	373	**271.41**	317.5	271.41
5pct	30min	53.41	53.48	53.11	53.5	53.57	53.63	53.75	53.68	53.66	**53.61**	53.61
5pct	1hr	96.66	94.86	94.73	93.61	**95.35**	96.31	96.05	95.33	95.23	97.4	95.35
5pct	1_5hr	112.49	110.11	113.68	109.2	109.76	**111.65**	111.16	109.79	112.55	114.18	111.65
5pct	2hr	140.89	141.17	132.5	133.18	138.48	137.27	136.74	139.78	**138.84**	139.37	138.84
5pct	3hr	154.61	157.26	155.53	**162.12**	153.84	164.81	166.42	162.03	165.43	168.25	162.12
5pct	4_5hr	167.39	149.99	168.42	167.3	167.73	189.33	178.91	**168.53**	175.83	187.09	168.53
5pct	6hr	199.26	165.09	182.12	164.99	197.61	178.54	188.24	203.8	203.8	**194.18**	**194.18**
5pct	9hr	213.59	191.08	188.06	161.77	191.37	154.24	148.29	154.36	183.94	**185.95**	185.95
5pct	12hr	143.02	228.62	142.93	148.97	**170.14**	149.57	178.02	166.21	202.19	202.43	170.14
5pct_CC_RCP4_5	30min	65.21	65.27	65.01	65.38	65.41	**65.49**	65.64	65.56	65.58	65.51	65.49
5pct_CC_RCP4_5	1hr	112.35	110.14	110.11	108.82	**110.73**	111.92	111.65	110.7	110.61	113.31	110.73
5pct_CC_RCP4_5	1_5hr	130.25	126.68	131.8	125.79	126.4	**128.87**	127.99	126.34	130.17	132.28	128.87
5pct_CC_RCP4_5	2hr	160.4	161	149.84	151.01	**158.16**	156.26	154.95	159.03	158	158.56	158.16
5pct_CC_RCP4_5	3hr	173.81	177.3	174.88	**182.96**	172.85	185.95	188	182.71	186.63	189.72	182.96
5pct_CC_RCP4_5	4_5hr	191.75	172.31	189.4	187.24	**192.43**	212.41	202.29	192.35	201.5	212.83	192.43
5pct_CC_RCP4_5	6hr	225.46	186.21	208.23	186.76	225.08	203.77	215.02	232.57	232.36	**220.98**	**220.98**

5pct_CC_RCP4_5	9hr	241.95	214.47	212.75	179.83	215.09	179.26	167.47	172.79	**211.01**	210.38	211.01
5pct_CC_RCP4_5	12hr	159.68	258.47	166.5	174.03	**192.3**	166.7	199.54	187.41	226.9	228.13	192.3
10pct	30min	35.18	39.53	36.86	36.28	36.2	38.17	38.88	**38.34**	39.4	39.63	38.34
10pct	1hr	70.88	69.05	69.01	68.22	69.49	70.42	70.12	**69.52**	69.42	71.47	69.52
10pct	1_5hr	83.85	81.47	84.8	80.58	80.89	**82.92**	82.79	81.51	83.88	85.39	82.92
10pct	2hr	105.5	105.55	98.46	98.63	103.05	102.7	102.17	104.92	**104.22**	104.52	104.22
10pct	3hr	116.81	119.09	117.5	**123.28**	116.14	125.4	126.3	123.15	125.95	128.17	123.28
10pct	4_5hr	125.27	113.47	128.65	128.92	128.54	145.6	138.6	**129.78**	132.89	145.15	129.78
10pct	6hr	153.99	125.61	134.96	126.4	148.21	132.81	142.91	156.37	152.99	**147.32**	**147.32**
10pct	9hr	167.45	150.25	147.81	131.95	150.14	117.12	112	123.01	139.43	**144.31**	144.31
10pct	12hr	116.6	180.47	110.3	113.28	**134.07**	120.49	144.33	133.85	162.73	161.52	134.07
20pct	30min	13.45	13.36	13.34	13.37	**13.43**	13.34	13.45	13.41	13.44	**13.43**	13.43
20pct	1hr	41.24	41.14	40.4	41.5	**41.75**	42.13	41.96	41.37	42.42	42.45	41.75
20pct	1_5hr	50.14	49.87	48.53	51.06	51.68	50.43	**50.75**	50.63	52.88	52.44	50.75
20pct	2hr	61.26	61.69	61.51	63.9	65.85	63.32	64.09	**63.92**	65.76	66.06	63.92
20pct	3hr	73.96	70.76	76.84	74.71	79.47	78.85	76.82	**77.29**	82.88	82.86	77.29
20pct	4_5hr	87.54	84.46	78.17	88.64	89.2	**90.26**	92.36	90.29	93.76	98.23	90.26
20pct	6hr	94.88	80.16	87.6	87.71	**93.07**	94.39	87.05	104.09	92.7	106.92	93.07
20pct	9hr	126.07	77.28	87.56	106.45	**104.33**	102.12	108.52	93.51	109.95	103.38	104.33
20pct	12hr	84.55	117.14	**107.37**	102.69	95.42	81.61	98.99	134.7	110.03	137.99	**107.37**
50pct	30min	3.18	**3.16**	3.15	**3.16**	**3.16**	**3.16**	3.17	**3.16**	3.17	3.17	3.16
50pct	1hr	11.41	**11.91**	11.28	11.9	11.84	11.94	12.07	11.68	12.25	12.15	11.91
50pct	1_5hr	17.39	16.72	18.2	17.62	18.25	17.44	**17.88**	17.36	18.33	18.1	17.88
50pct	2hr	22	21.52	21.04	22.08	**22.76**	23.09	22.68	23.01	23.14	23.4	22.76
50pct	3hr	25.74	25.48	26.24	28.76	28.19	29.78	27.89	**28.44**	30.35	30.21	28.44
50pct	4_5hr	34.2	32.97	33.26	36.06	38.72	**38.04**	38.66	35.43	40.52	39.85	38.04
50pct	6hr	40.64	36.07	38.45	37.29	40.27	**40.62**	39.2	43.88	41.46	46.1	40.62
50pct	9hr	57.82	36.66	47.24	45.85	50.21	**47.58**	50.46	44.04	50	46.94	47.58
50pct	12hr	37.09	**52.52**	40.06	54.16	50.64	44.21	49.84	67.58	54.67	70.78	**52.52**

Appendix G:
Design Event Flood Mapping



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DISCLAIMER
Engeny has endeavoured to sure accuracy and completeness of the data. Engeny assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map.

DATA SOURCE
QLD Government Open Data Source

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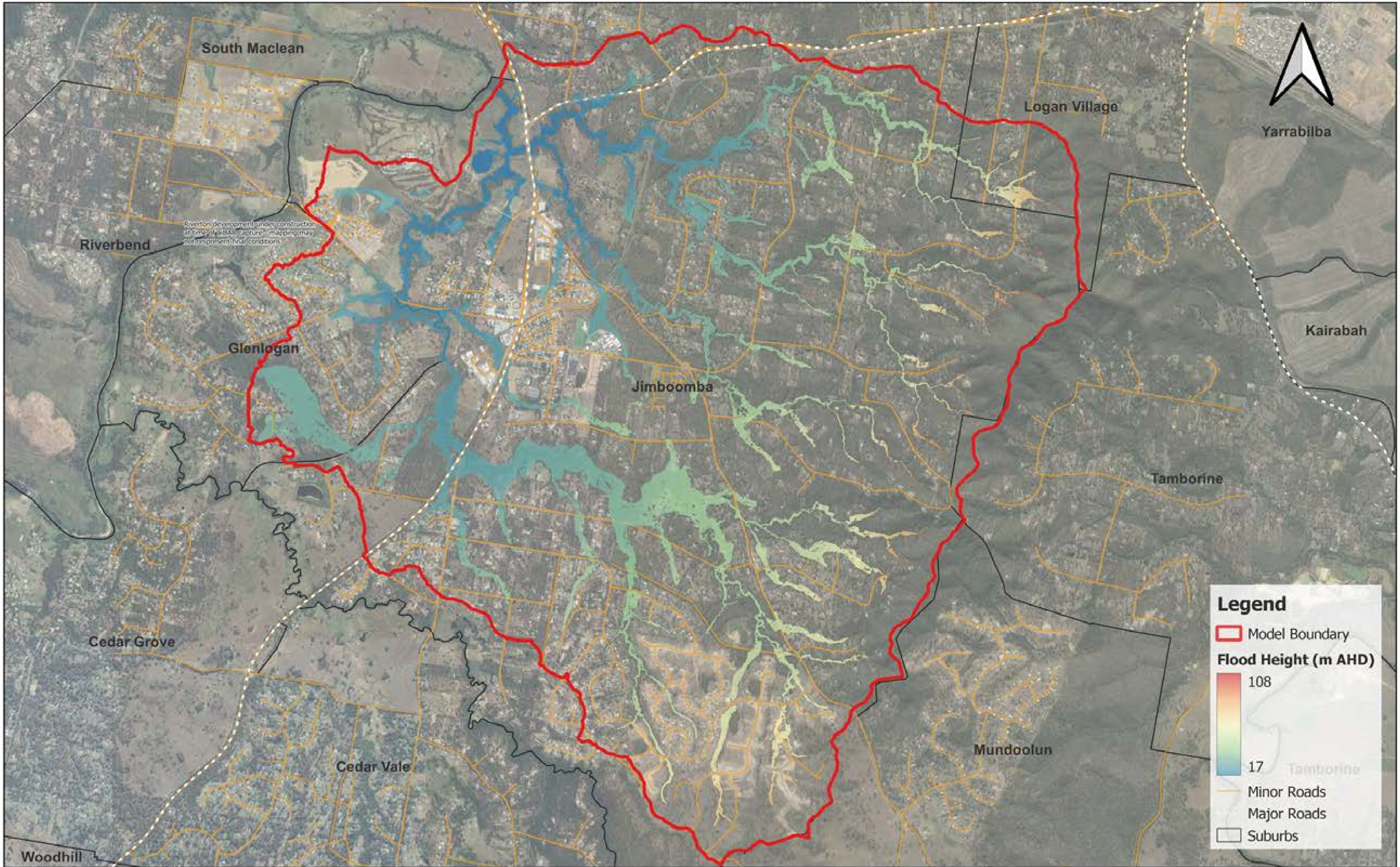
LOGAN CITY COUNCIL

Appendix G.1.1

Henderson Creek Flood Study Update
1:2 AEP Flood Height

Appendix G.1.1

M:\Projects\M9000_Logan_City_Council\M9000_083 Henderson Ck FS 2022\05 Design\GIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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DATA SOURCE
QLD Government Open Data Source

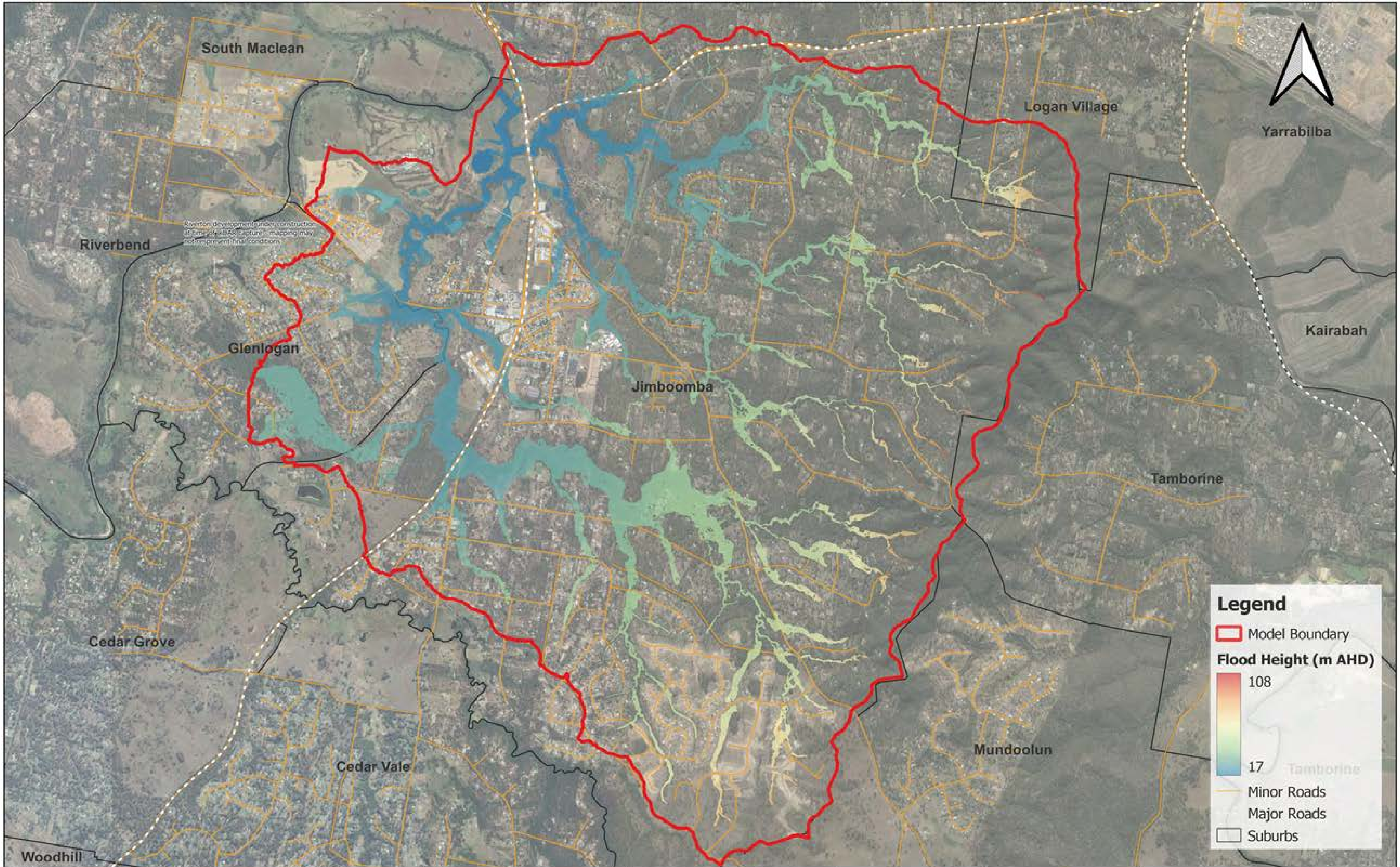
ENGENY

LOGAN CITY COUNCIL

Appendix G.1.2

Henderson Creek Flood Study Update
1:5 AEP Flood Height

Appendix G.1.2



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 | 0.8 | 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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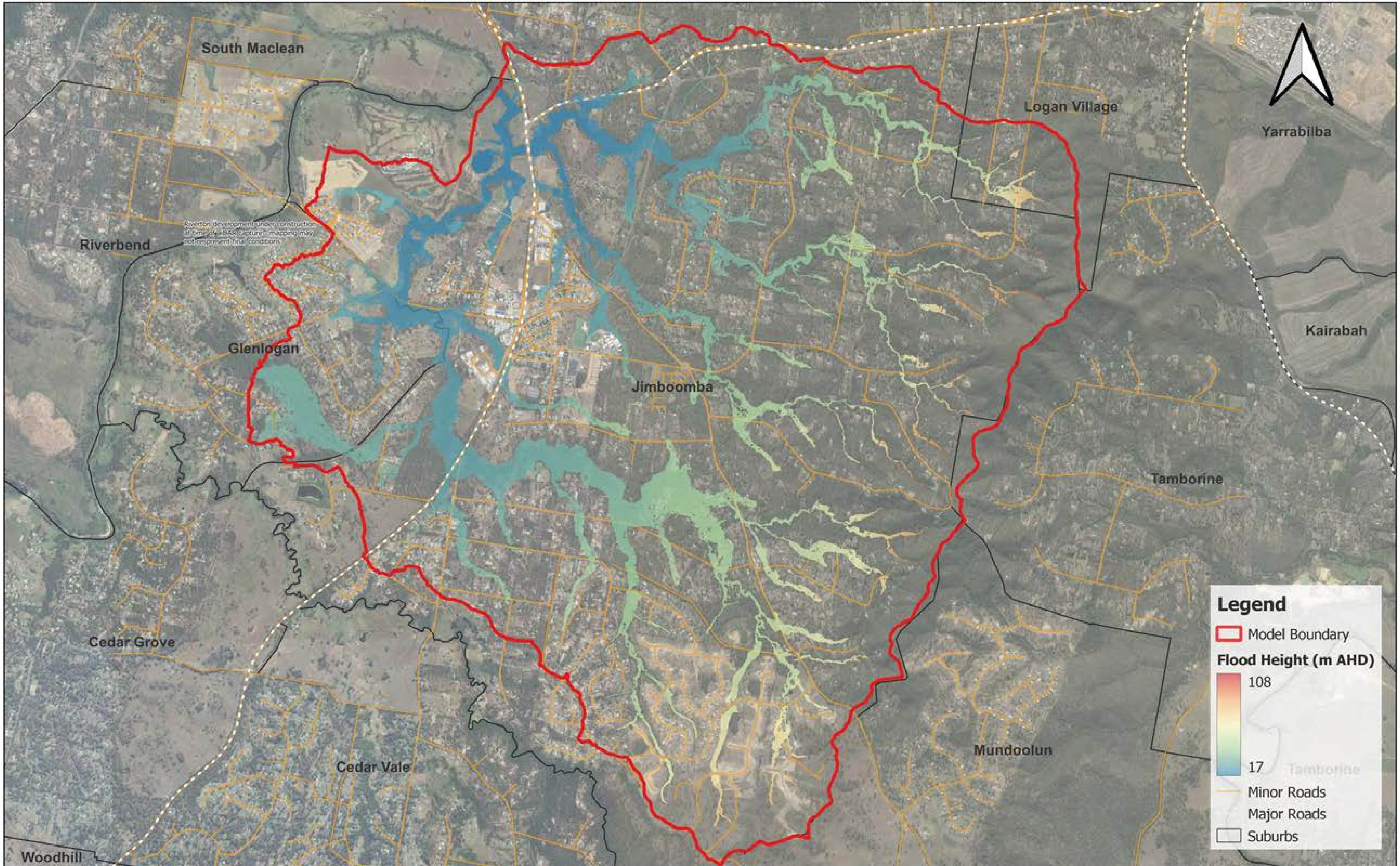
Appendix G.1.3

Henderson Creek Flood Study Update
1:10 AEP Flood Height

Appendix G.1.3



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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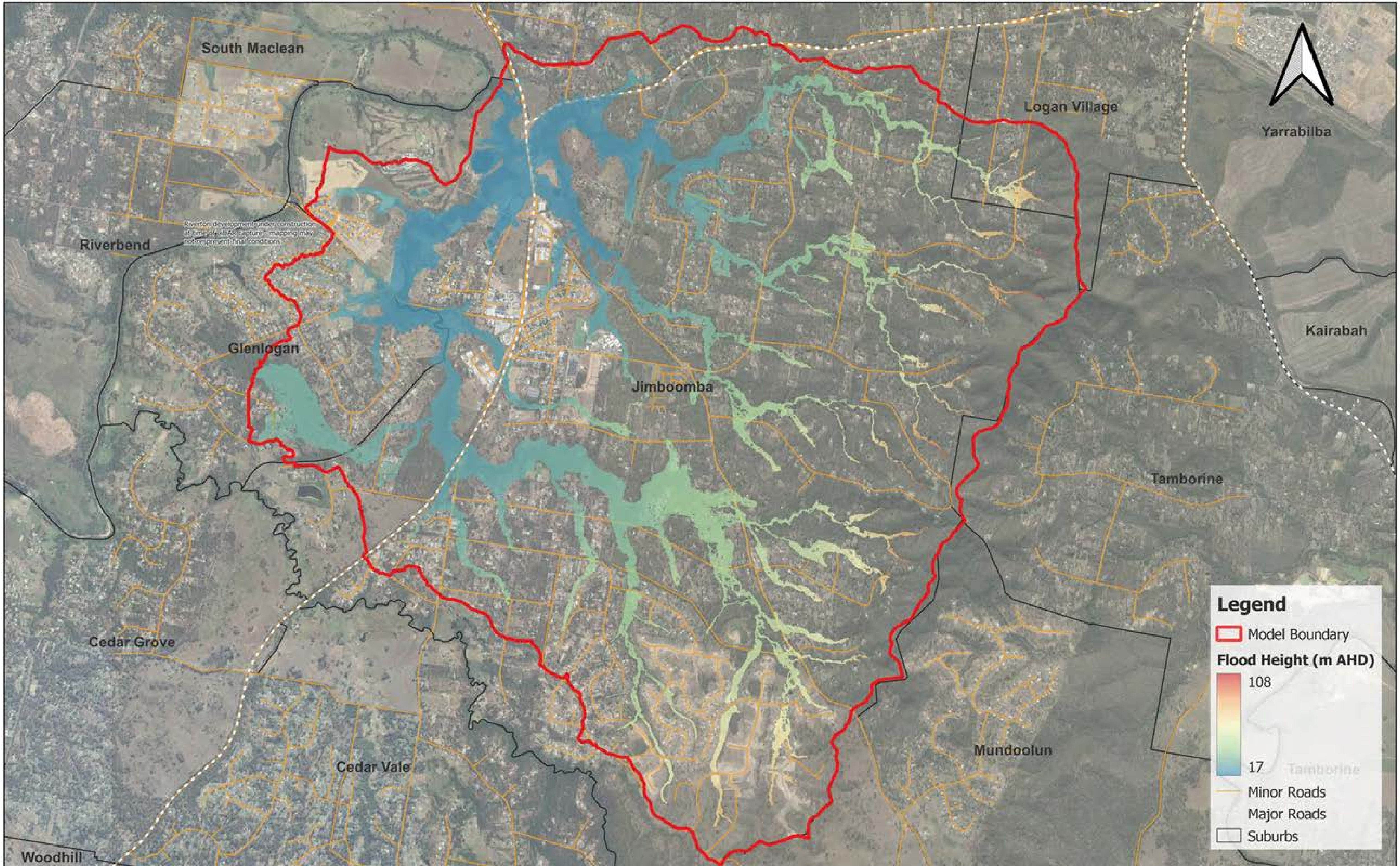
Appendix G.1.4

Henderson Creek Flood Study Update
1:20 AEP Flood Height

Appendix G.1.4



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1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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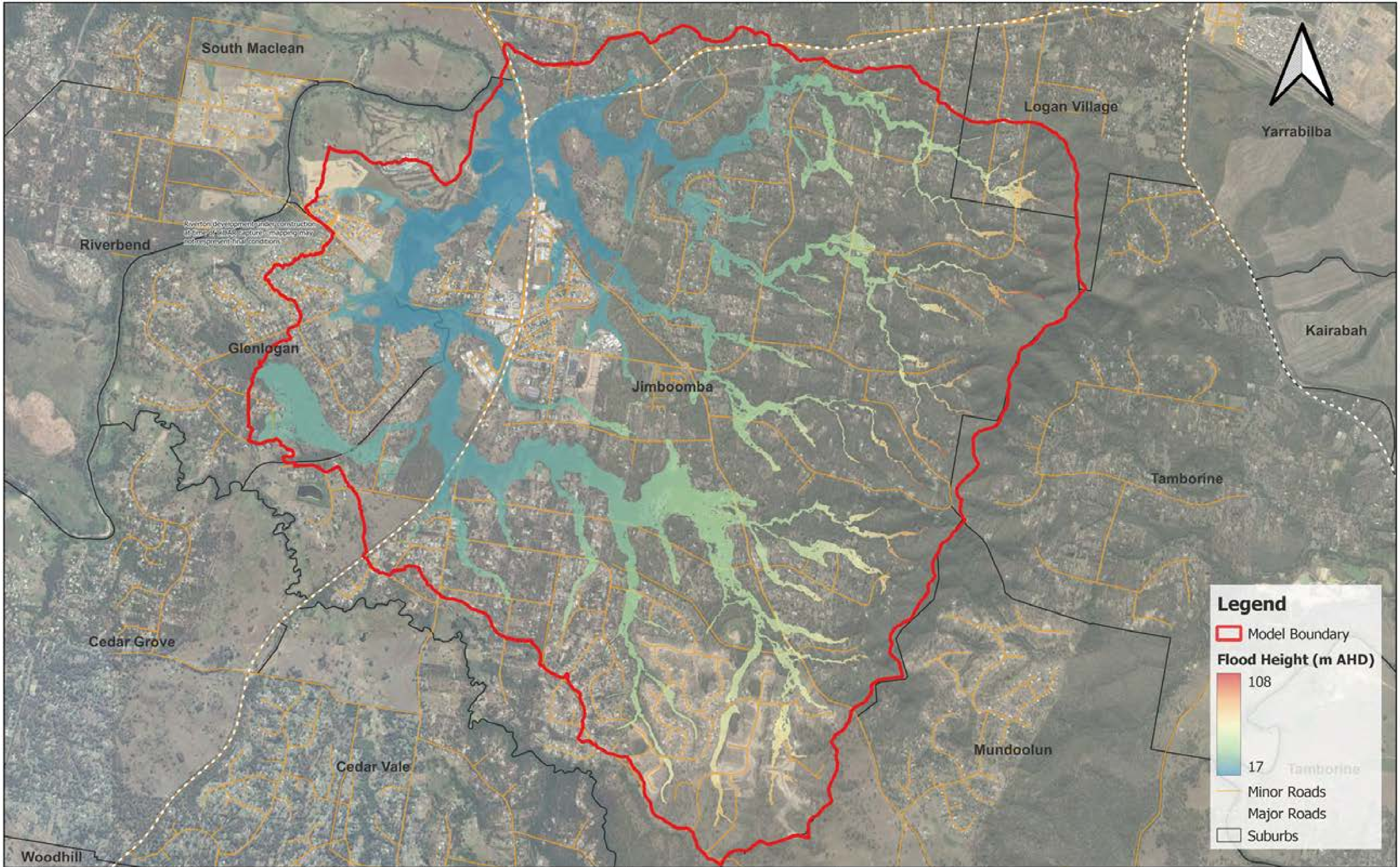
Appendix G.1.5

Henderson Creek Flood Study Update
1:50 AEP Flood Height

Appendix G.1.5



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DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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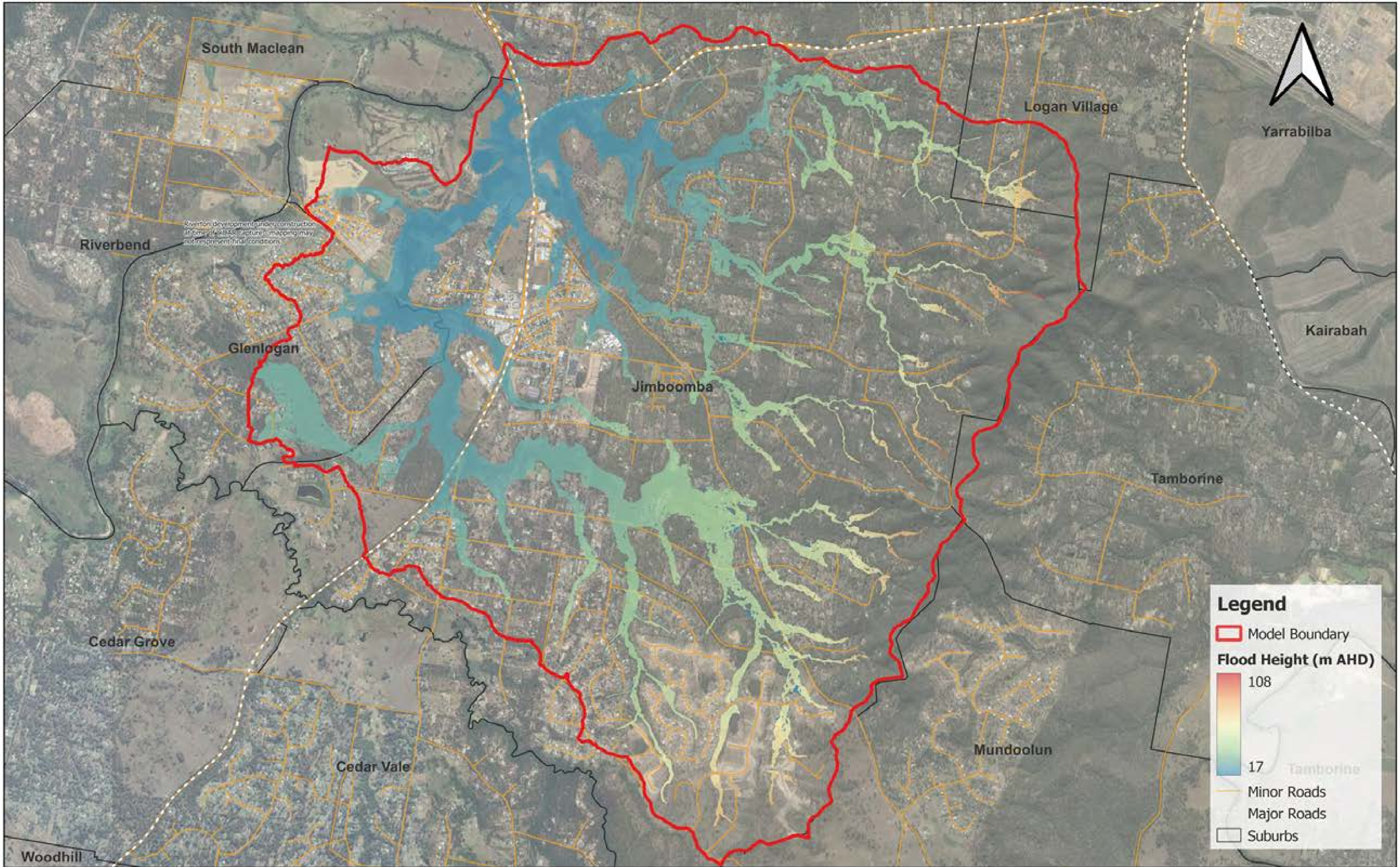
Appendix G.1.6

Henderson Creek Flood Study Update
1:100 AEP Flood Height

Appendix G.1.6

M:\Projects\M9000_Logan_City_Council\M9000_083 Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



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1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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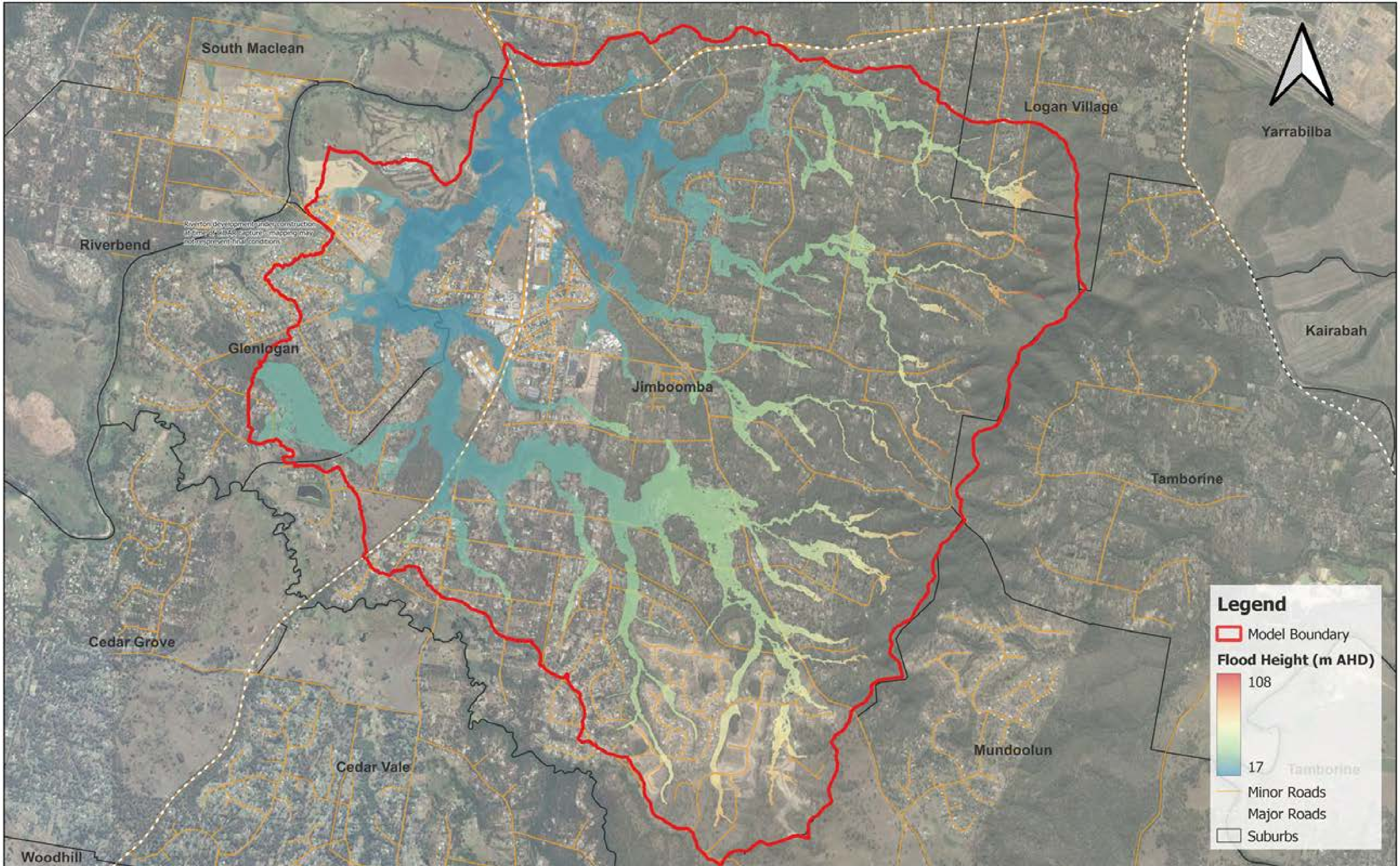
Appendix G.1.7

Henderson Creek Flood Study Update
1:200 AEP Flood Height

Appendix G.1.7



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APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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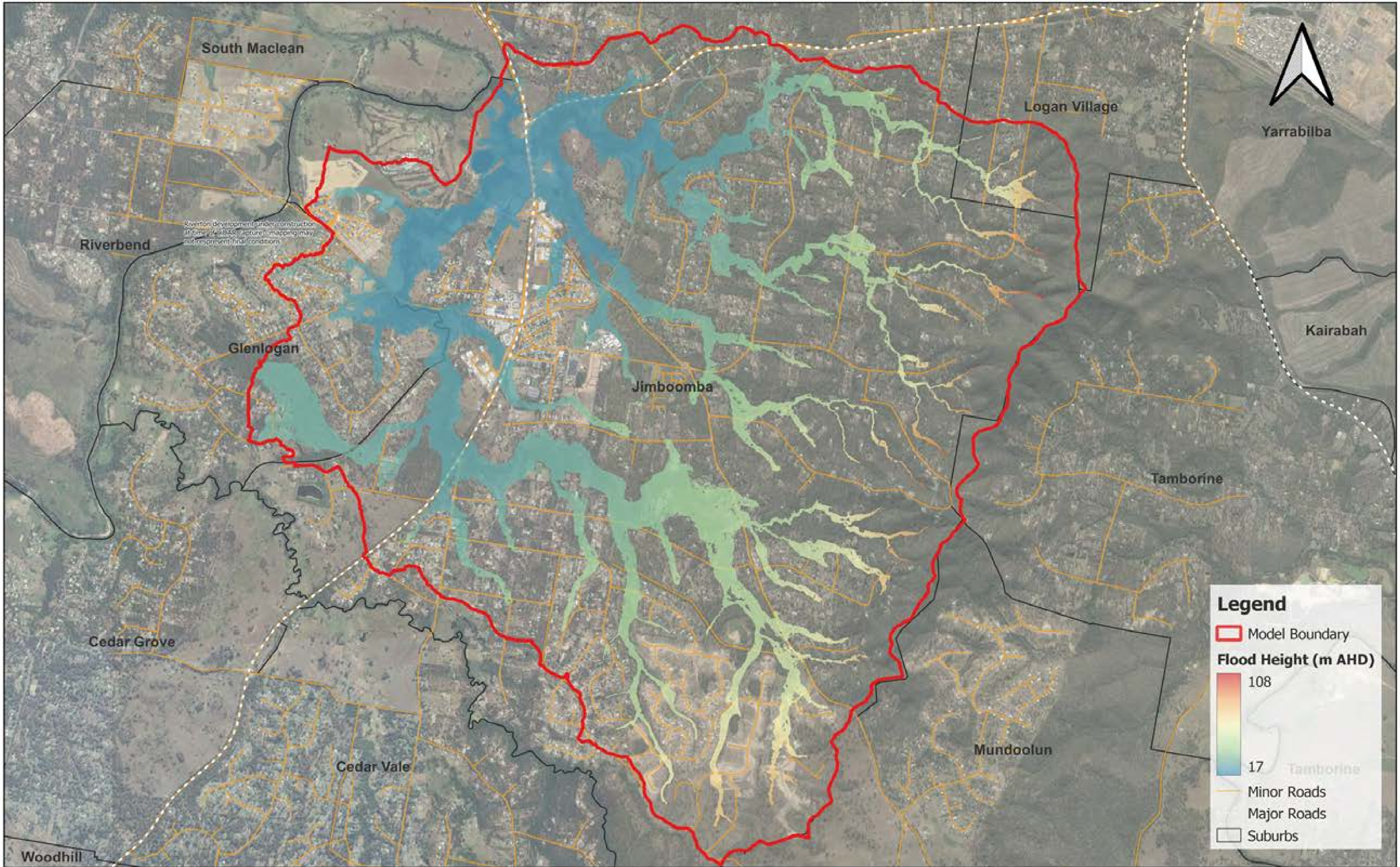
Appendix G.1.8

Henderson Creek Flood Study Update
1:500 AEP Flood Height

Appendix G.1.8



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DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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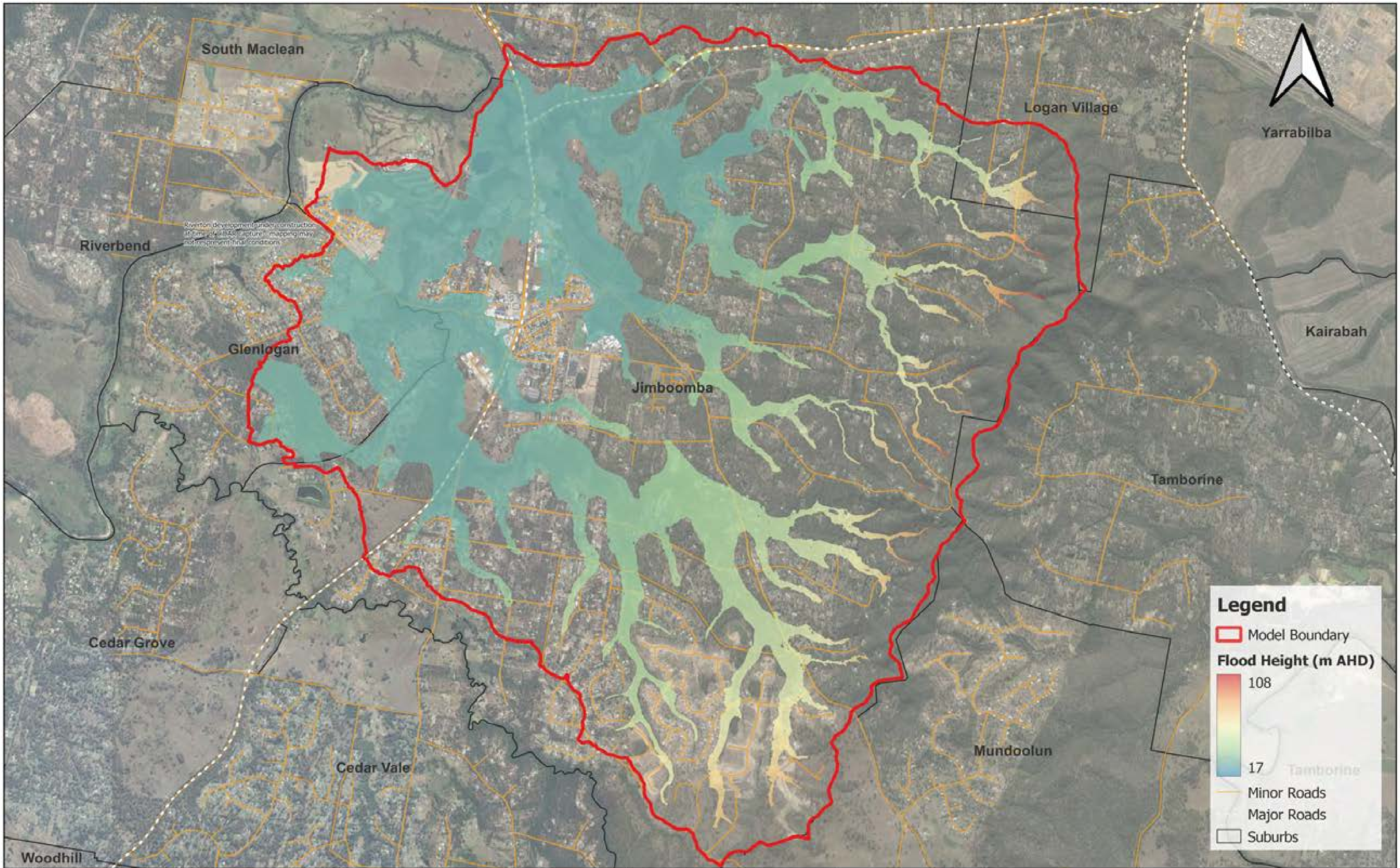
Appendix G.1.9

Henderson Creek Flood Study Update
1:2000 AEP Flood Height

Appendix G.1.9

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



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APPROVED	MP	DATE	19-07-2023

NOTES:

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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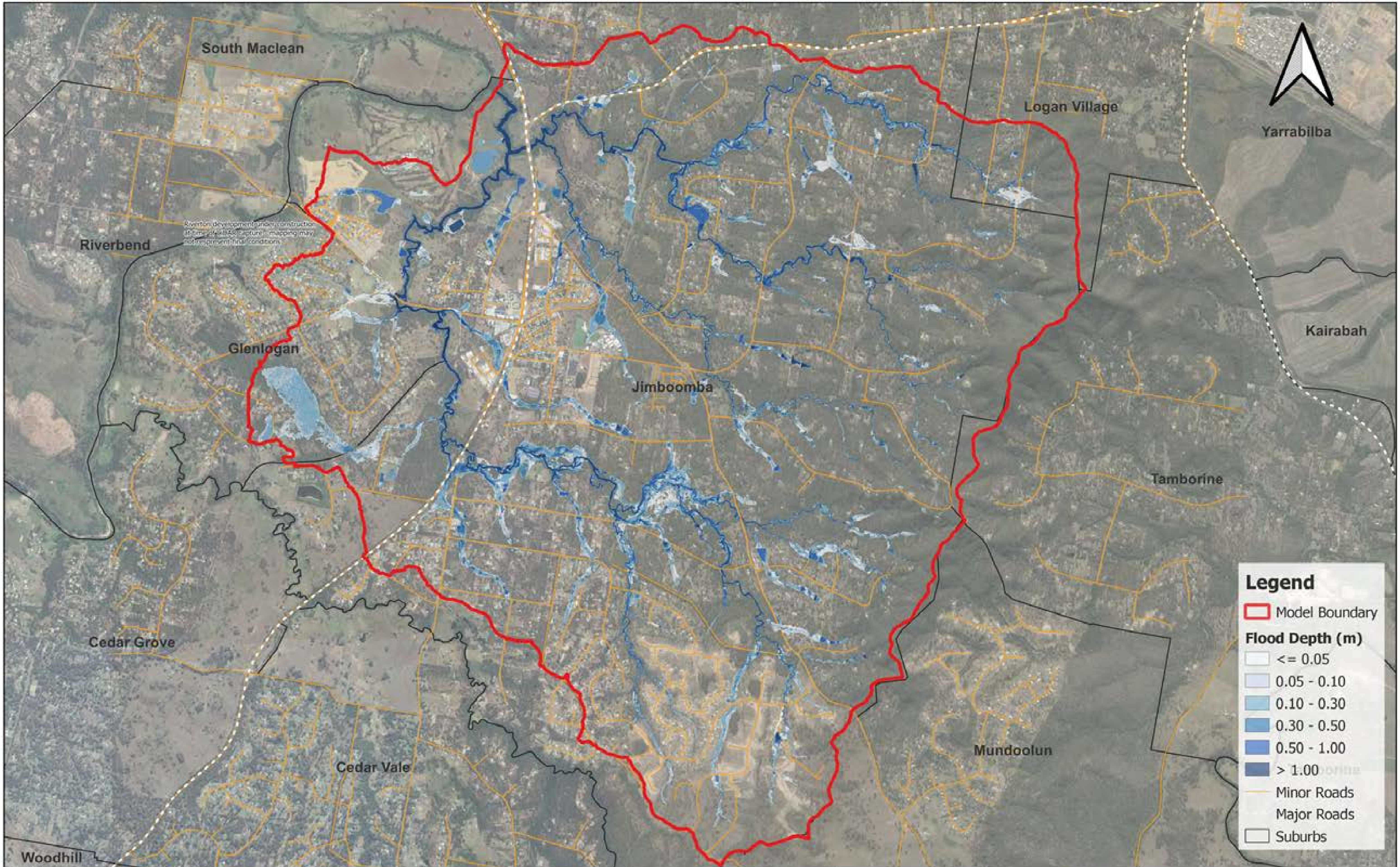
Appendix G.1.10

Henderson Creek Flood Study Update
PMF Flood Height

Appendix G.1.10

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

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DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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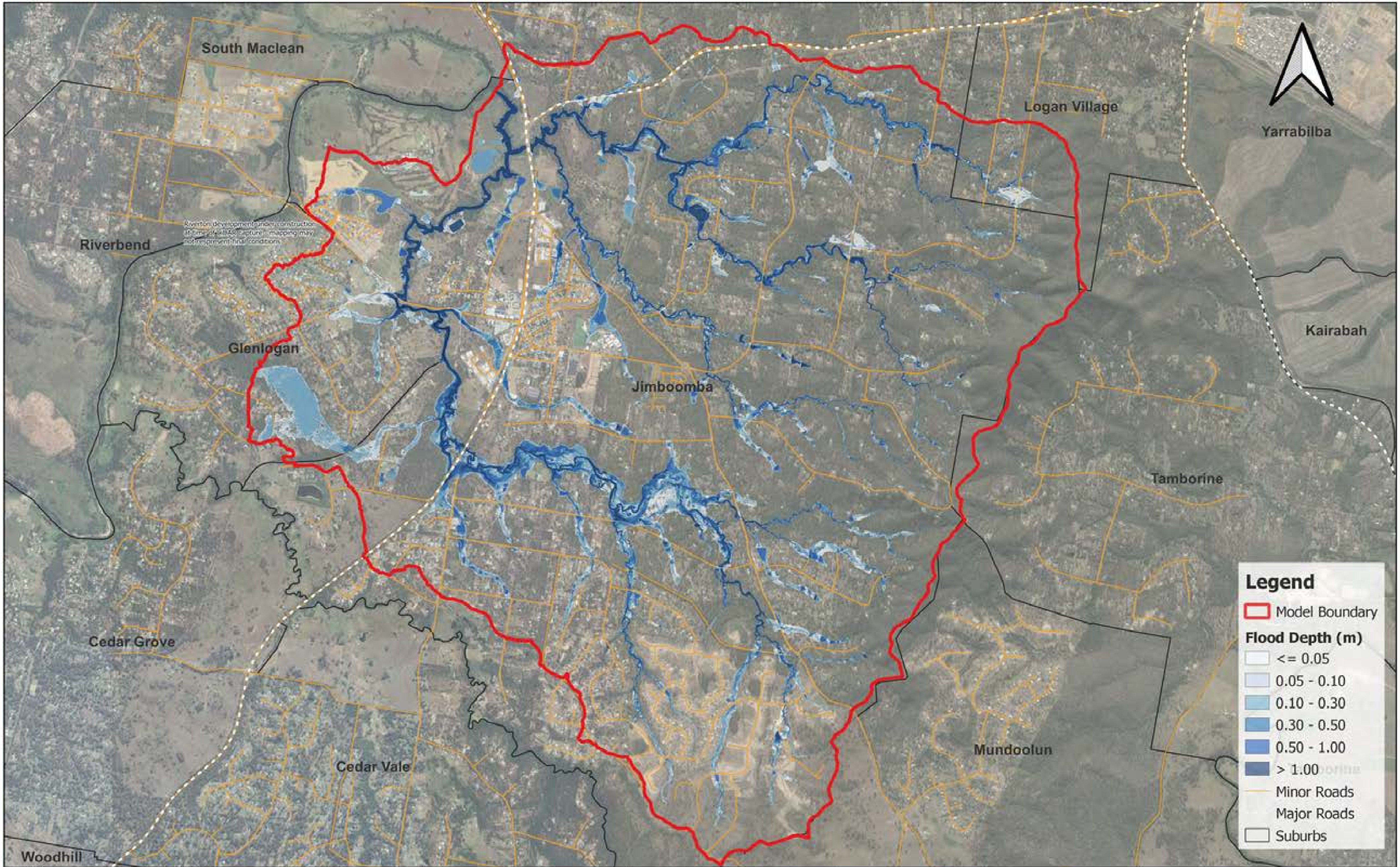
Appendix G.2.1

Henderson Creek Flood Study Update
1:2 AEP Flood Depth

Appendix G.2.1



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DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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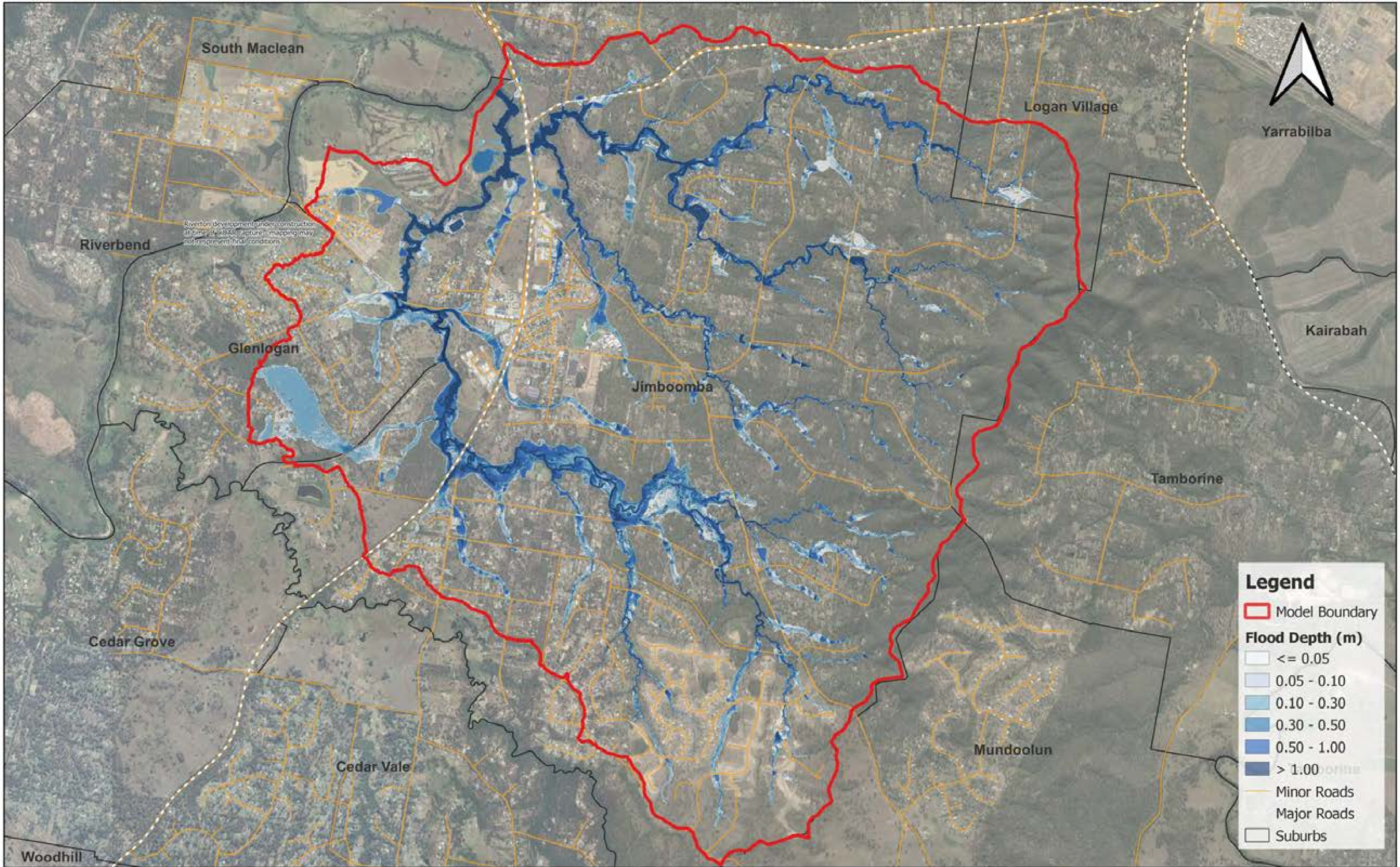
Appendix G.2.2

Henderson Creek Flood Study Update
1:5 AEP Flood Depth

Appendix G.2.2



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APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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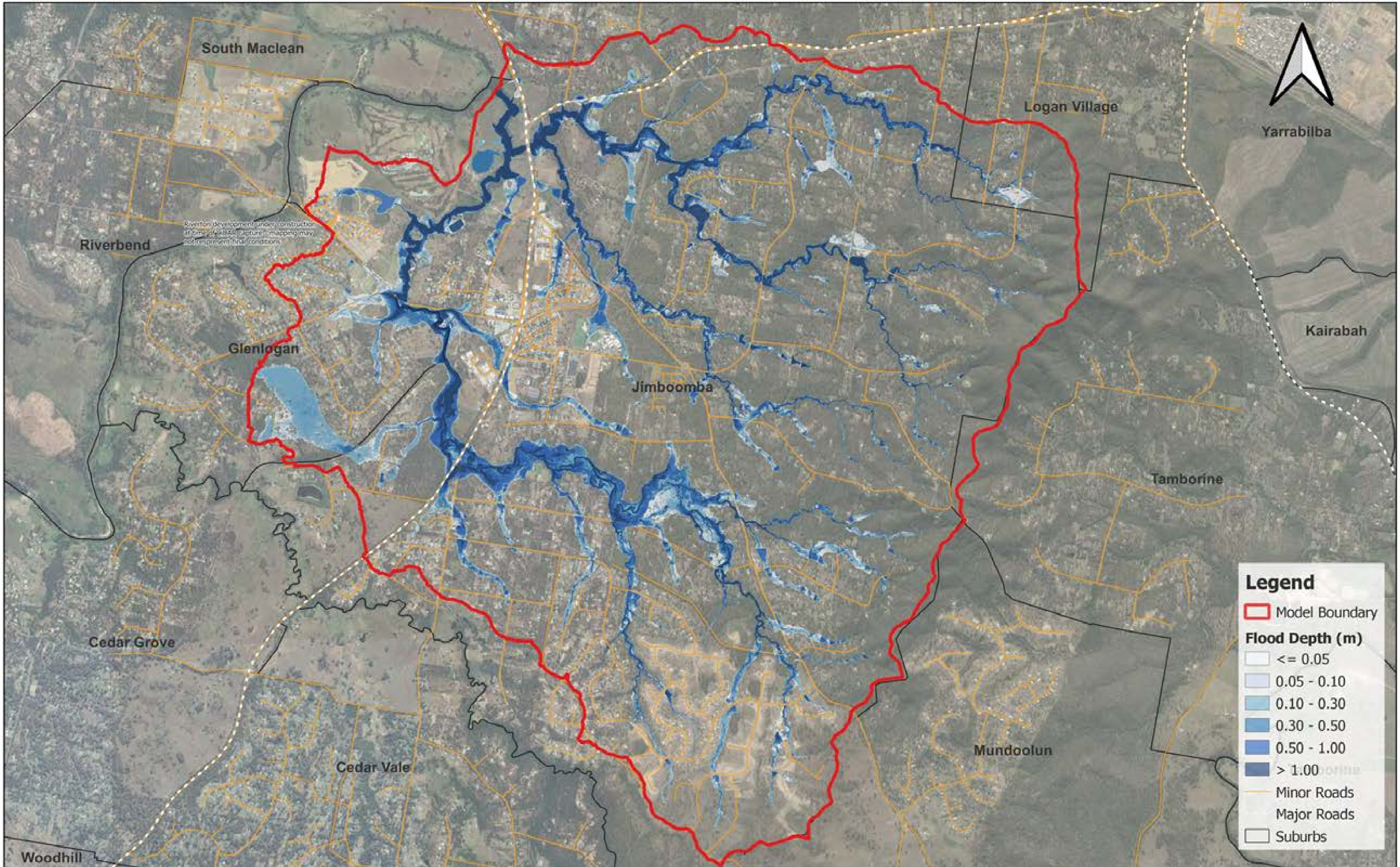
Appendix G.2.3

Henderson Creek Flood Study Update
1:10 AEP Flood Depth

Appendix G.2.3

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



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APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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Appendix G.2.4

Henderson Creek Flood Study Update
1:20 AEP Flood Depth

Appendix G.2.4

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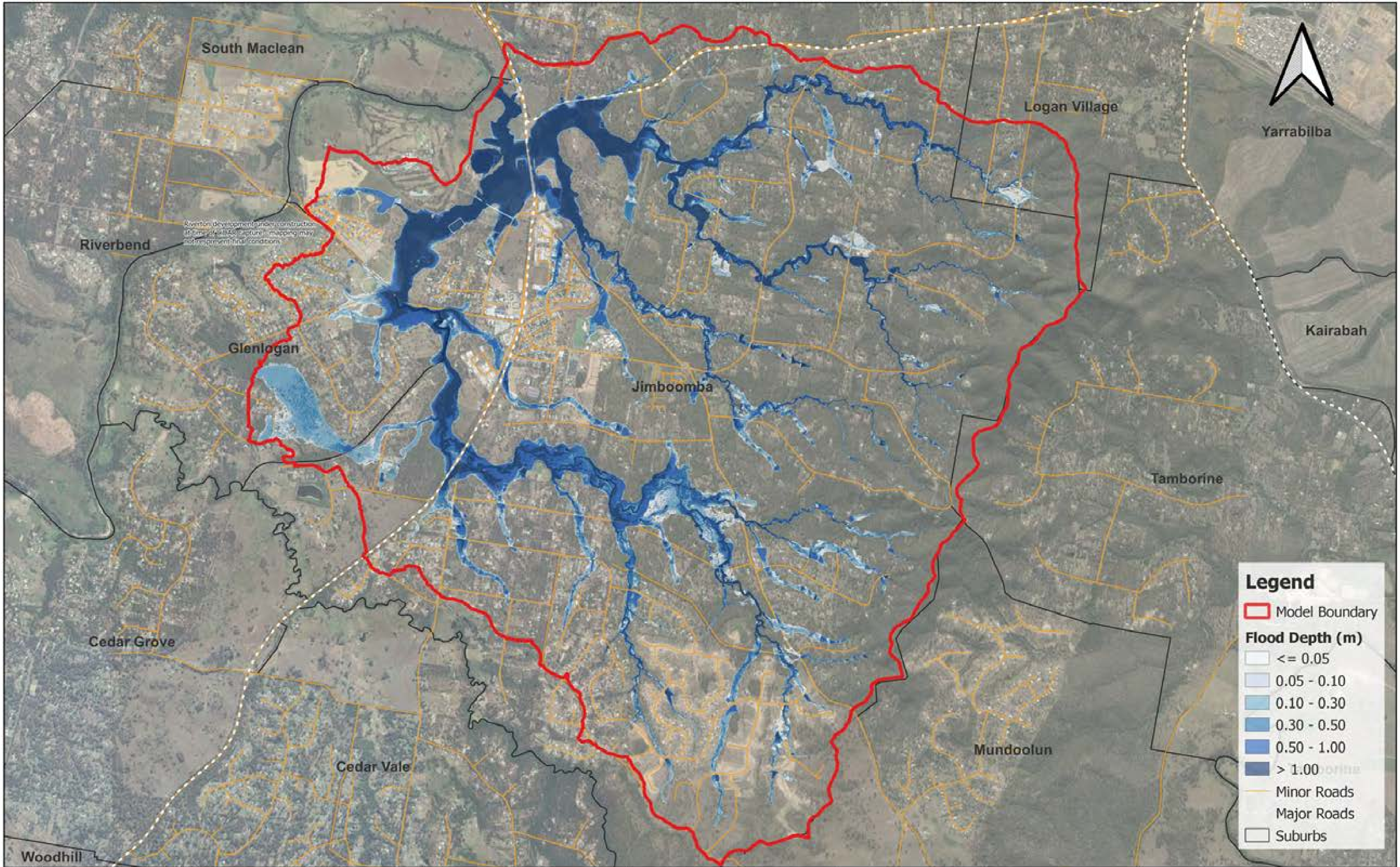

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APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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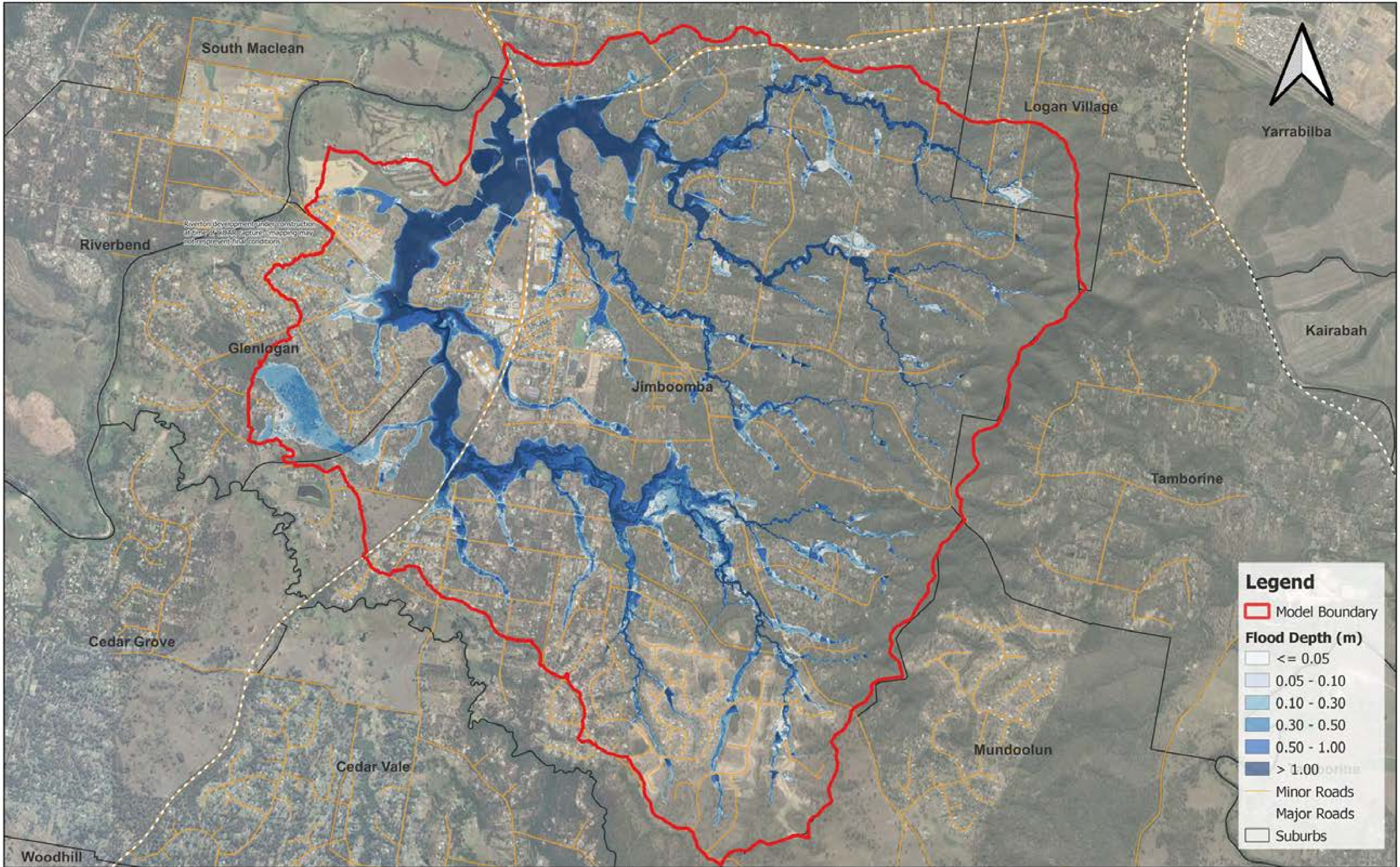
Appendix G.2.5

Henderson Creek Flood Study Update
1:50 AEP Flood Depth

Appendix G.2.5



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NOTES:

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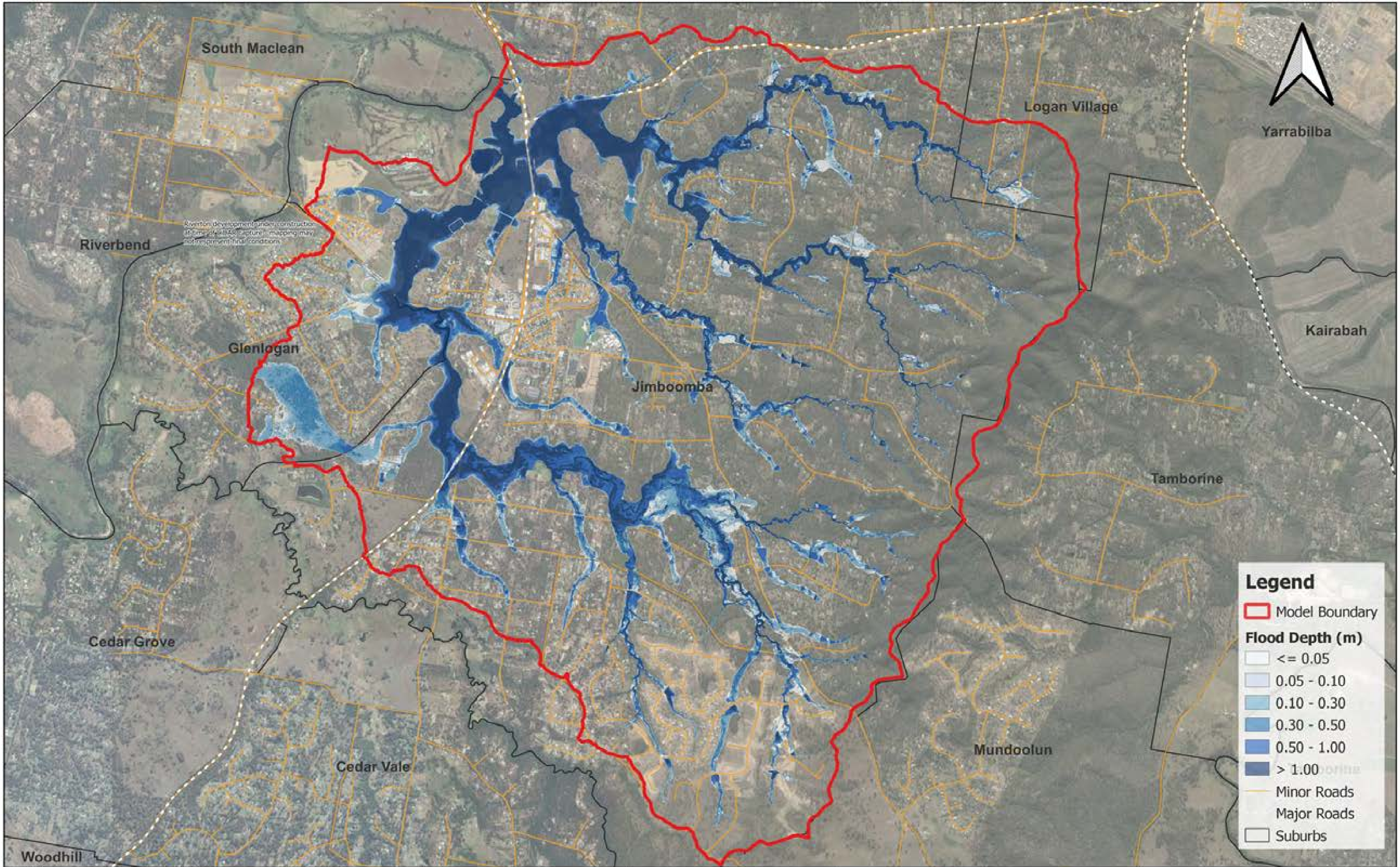
Appendix G.2.6

Henderson Creek Flood Study Update
1:100 AEP Flood Depth

Appendix G.2.6

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



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APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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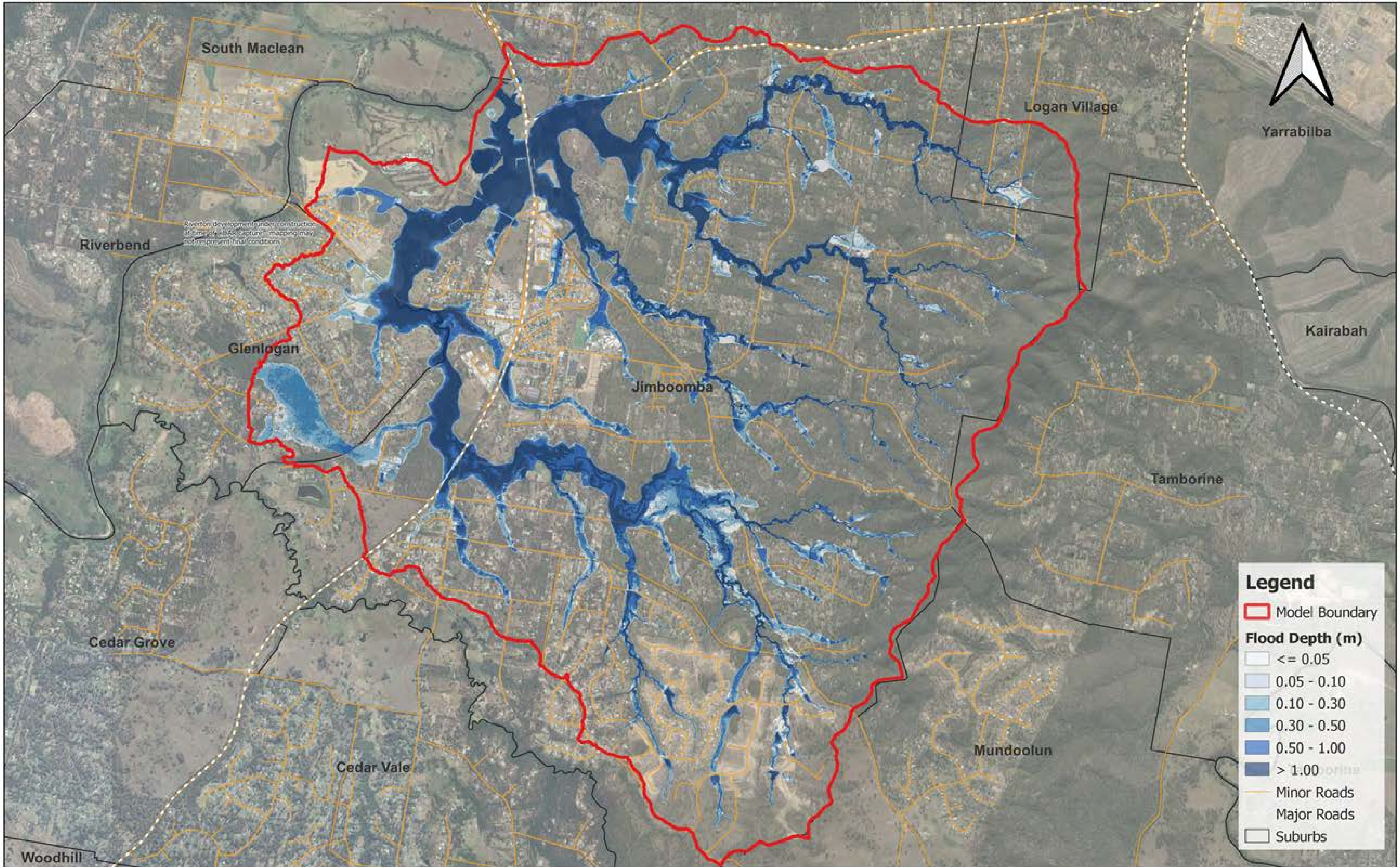
Appendix G.2.7

Henderson Creek Flood Study Update
1:200 AEP Flood Depth

Appendix G.2.7

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\GIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



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N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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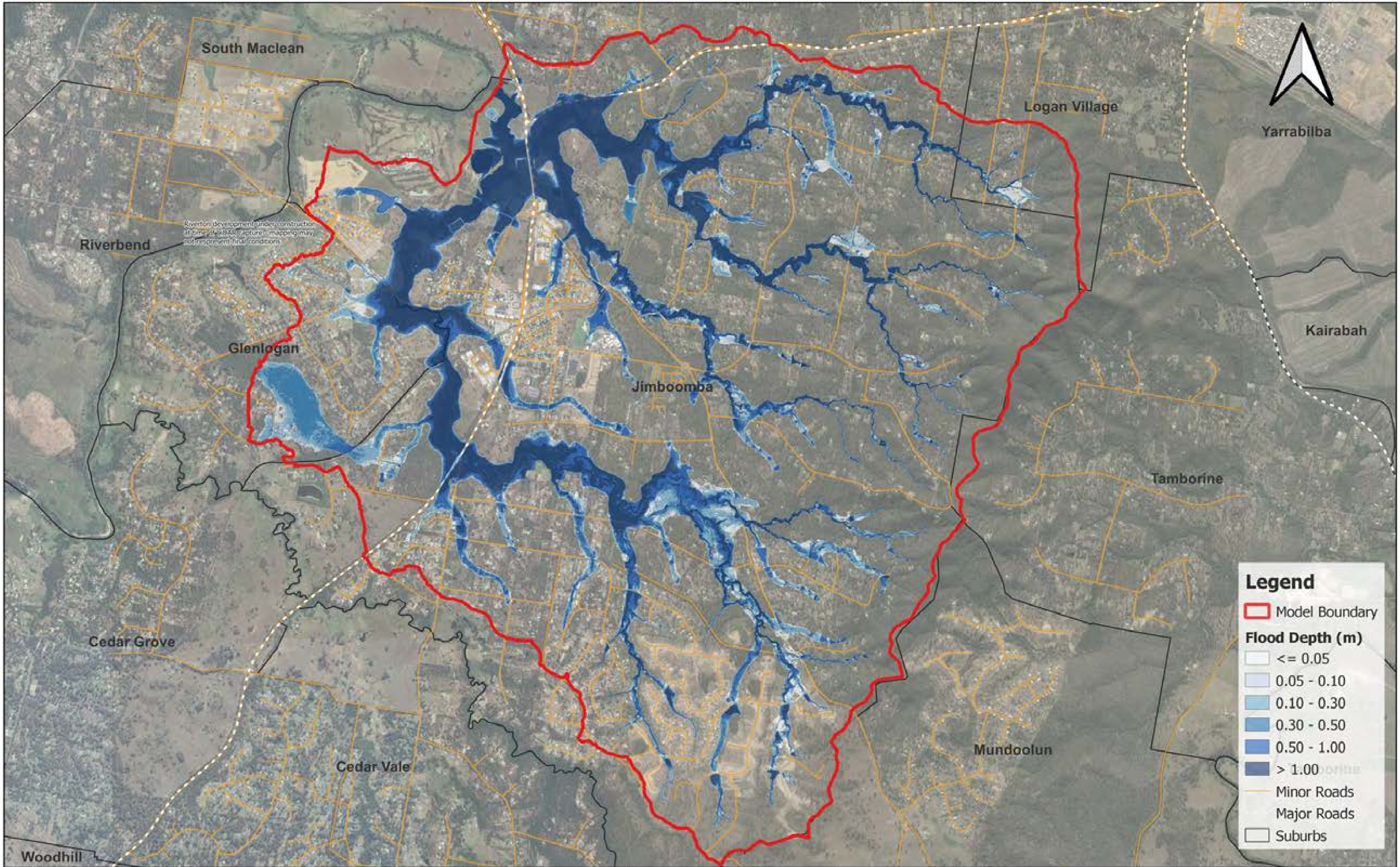
Appendix G.2.8

Henderson Creek Flood Study Update
1:500 AEP Flood Depth

Appendix G.2.8

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



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N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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Appendix G.2.9

Henderson Creek Flood Study Update
1:2000 AEP Flood Depth

Appendix G.2.9

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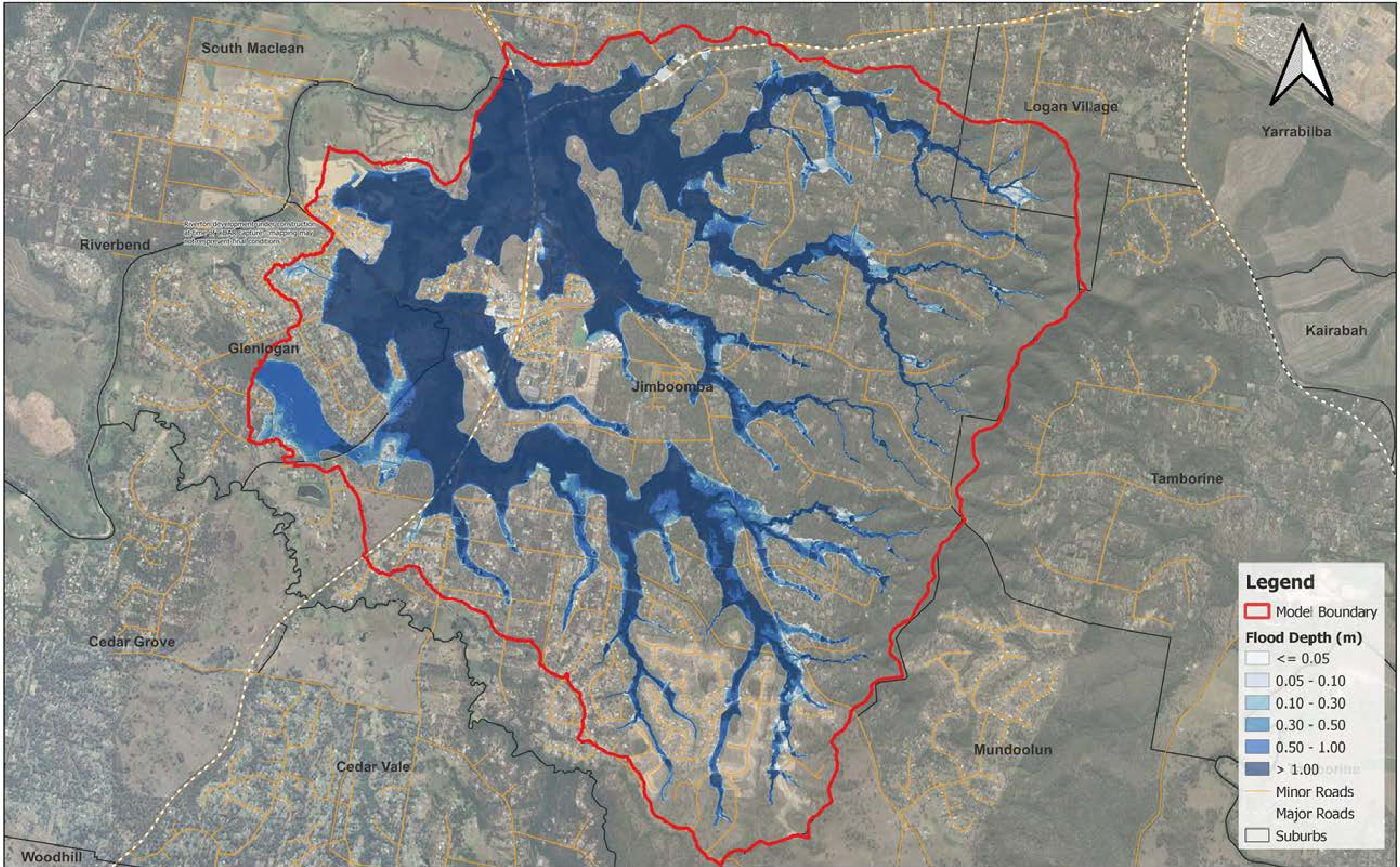

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N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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Appendix G.2.10

Henderson Creek Flood Study Update
PMF Flood Depth

Appendix G.2.10

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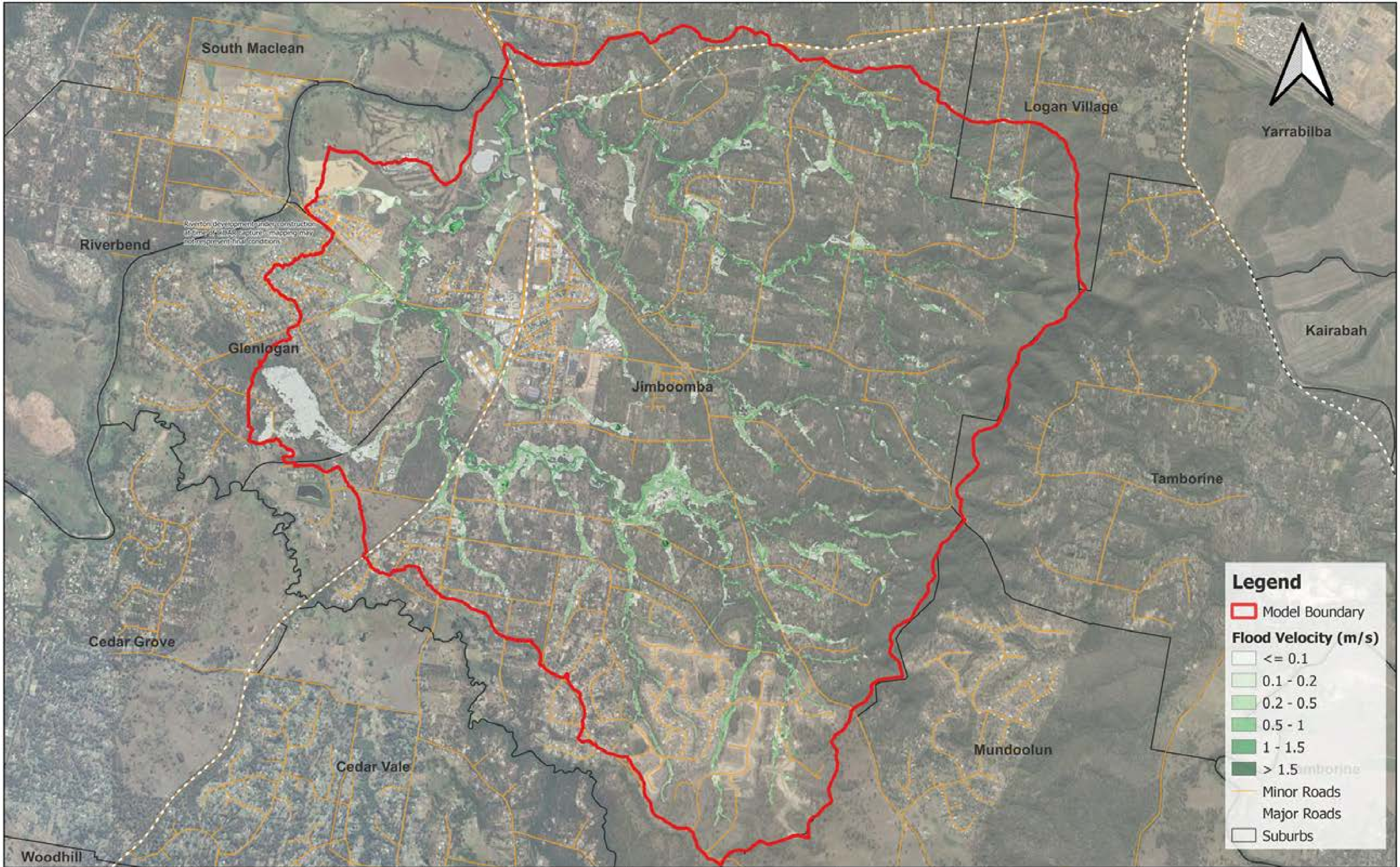

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N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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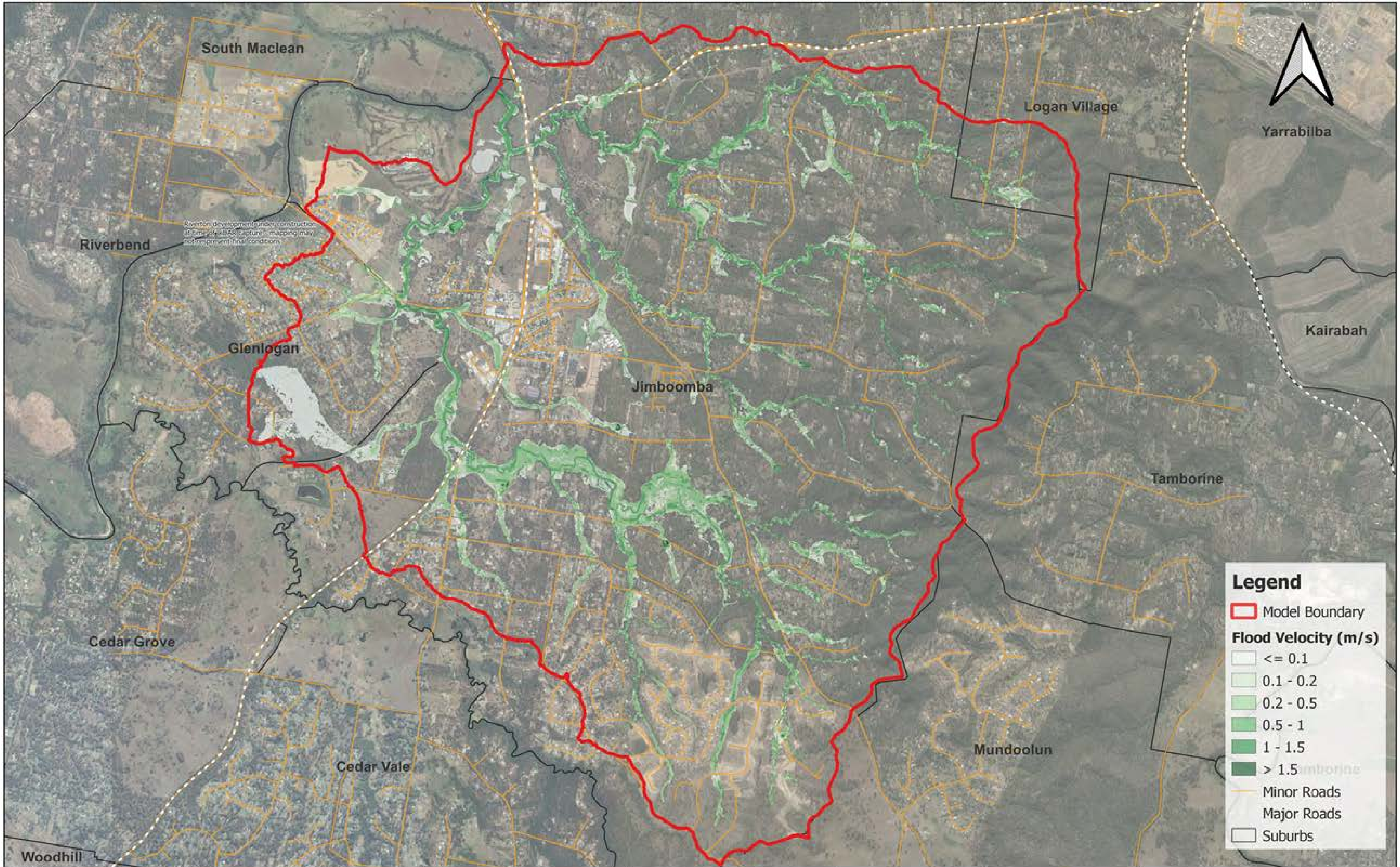
Appendix G.3.1

Henderson Creek Flood Study Update
1:2 AEP Flood Velocity

Appendix G.3.1



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NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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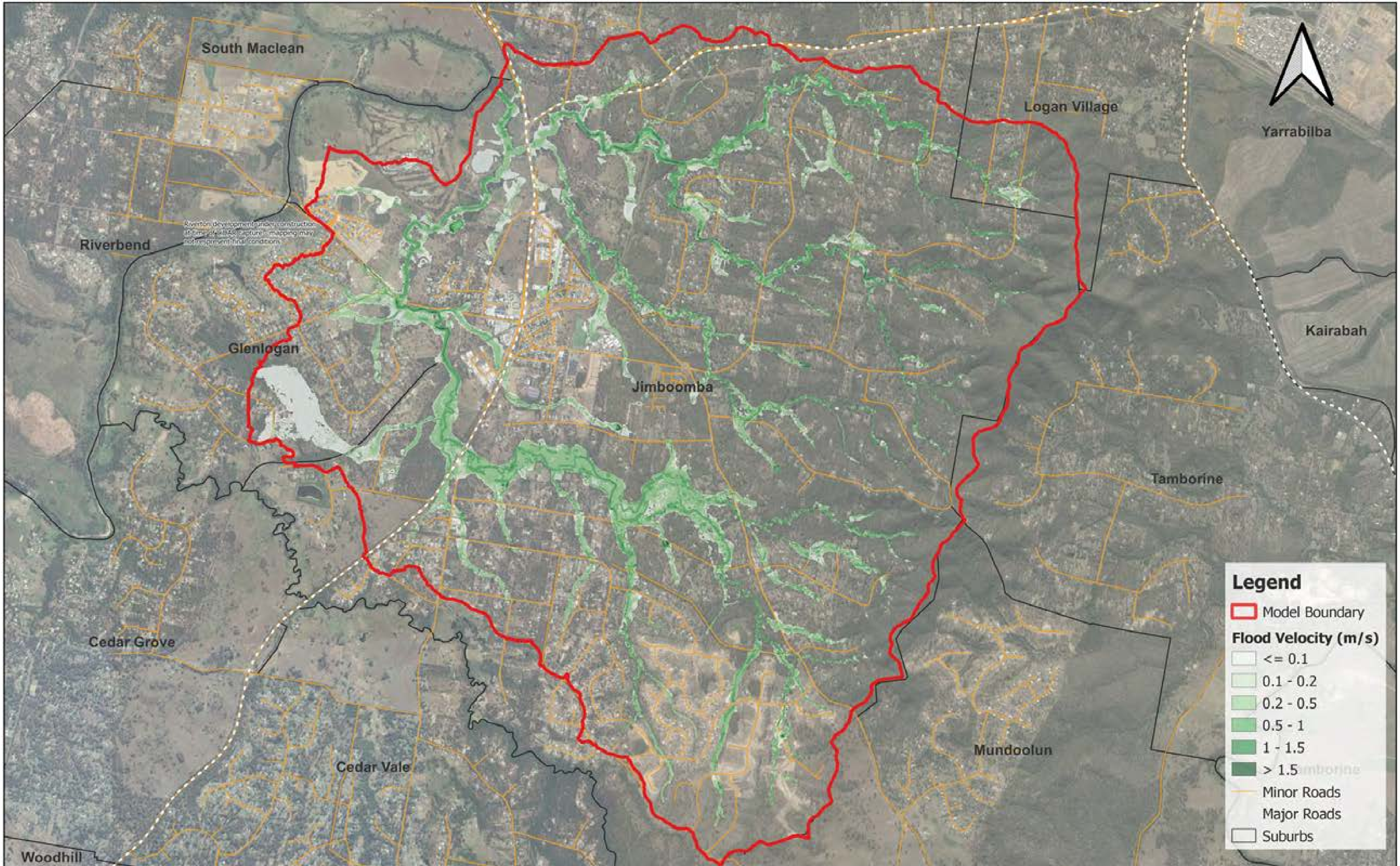
Appendix G.3.2

Henderson Creek Flood Study Update
1:5 AEP Flood Velocity

Appendix G.3.2



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N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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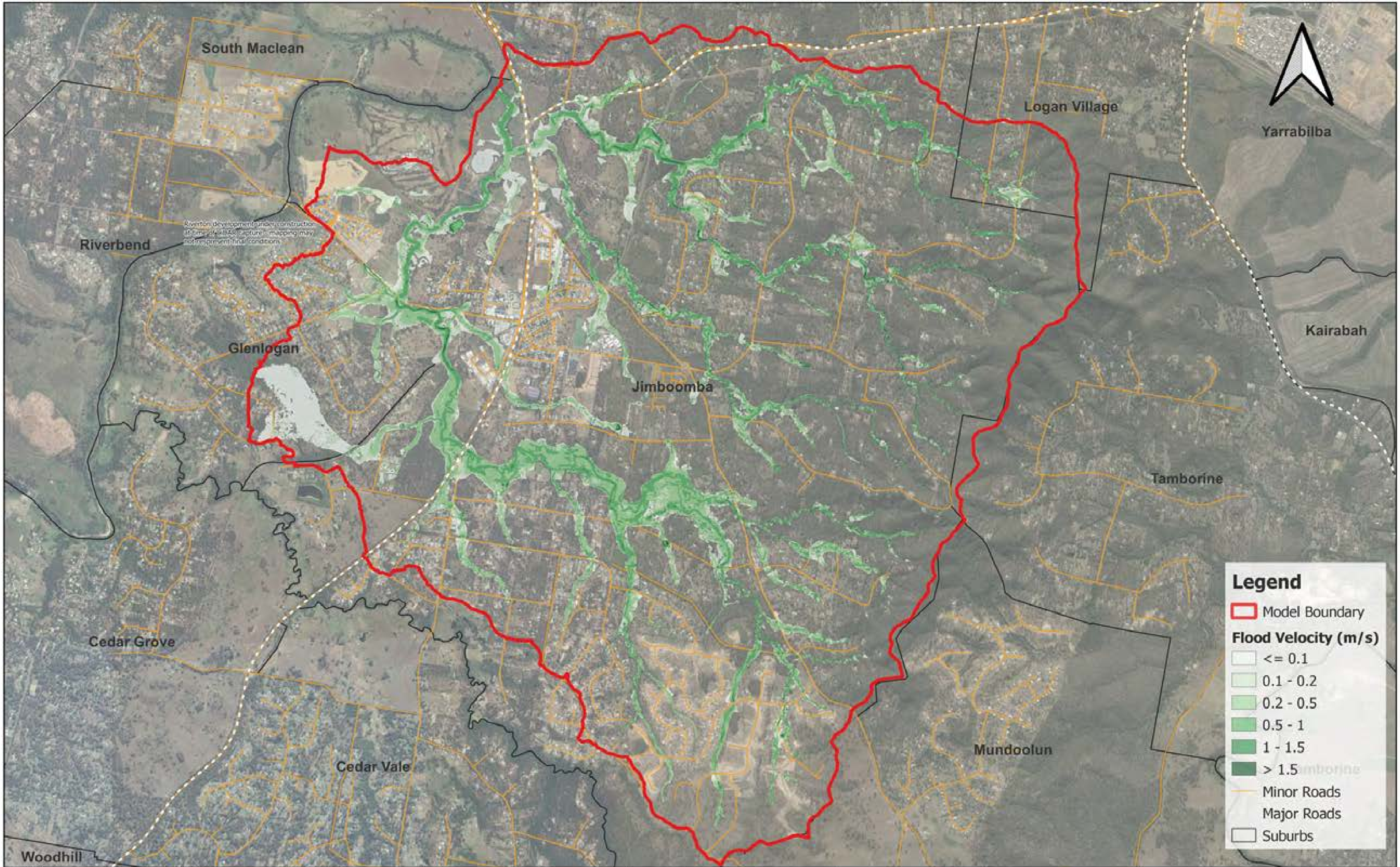
Appendix G.3.3

Henderson Creek Flood Study Update
1:10 AEP Flood Velocity

Appendix G.3.3



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NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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Appendix G.3.4

Henderson Creek Flood Study Update
1:20 AEP Flood Velocity

Appendix G.3.4

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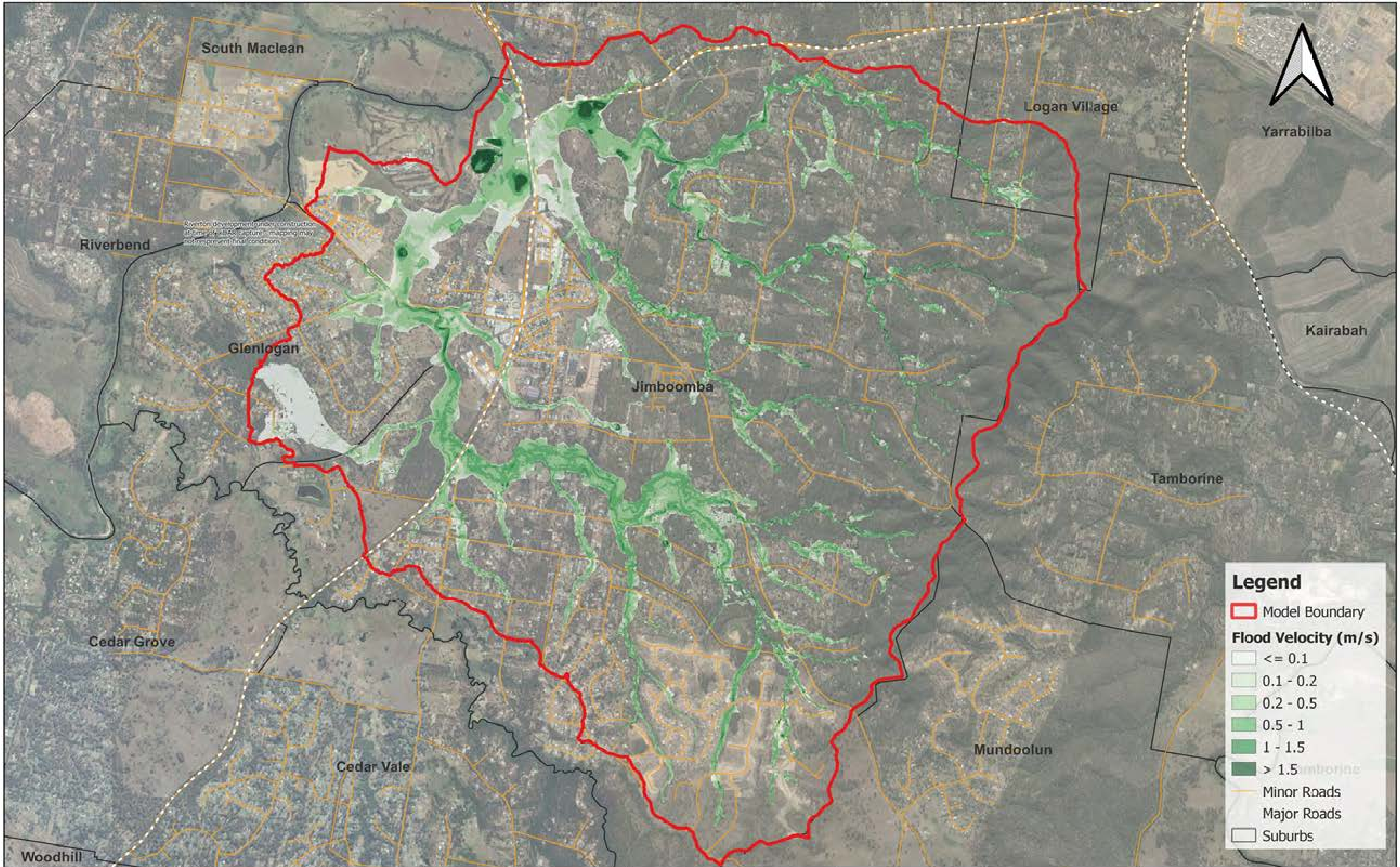

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N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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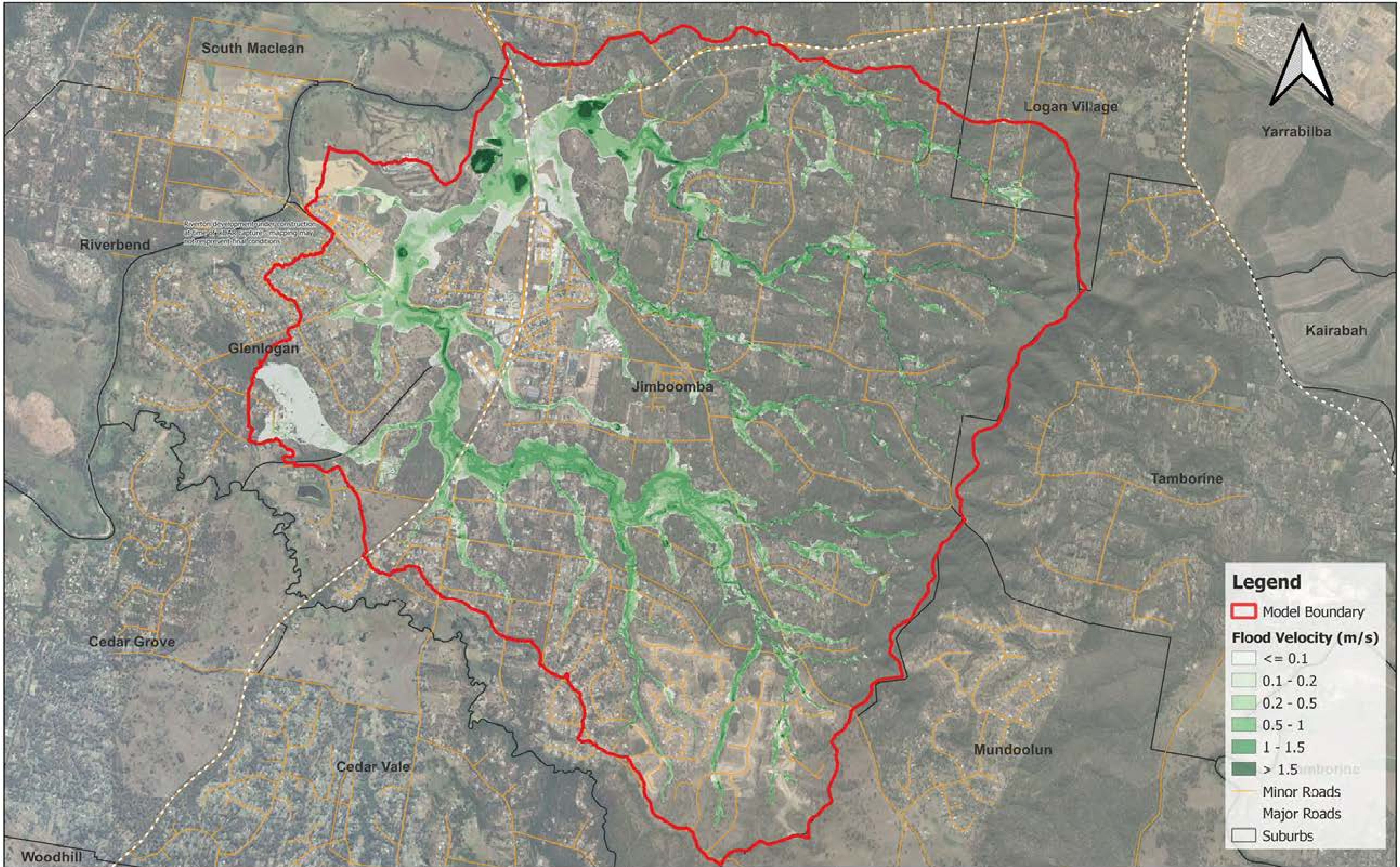
Appendix G.3.5

Henderson Creek Flood Study Update
1:50 AEP Flood Velocity

Appendix G.3.5



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NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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Appendix G.3.6

Henderson Creek Flood Study Update
1:100 AEP Flood Velocity

Appendix G.3.6

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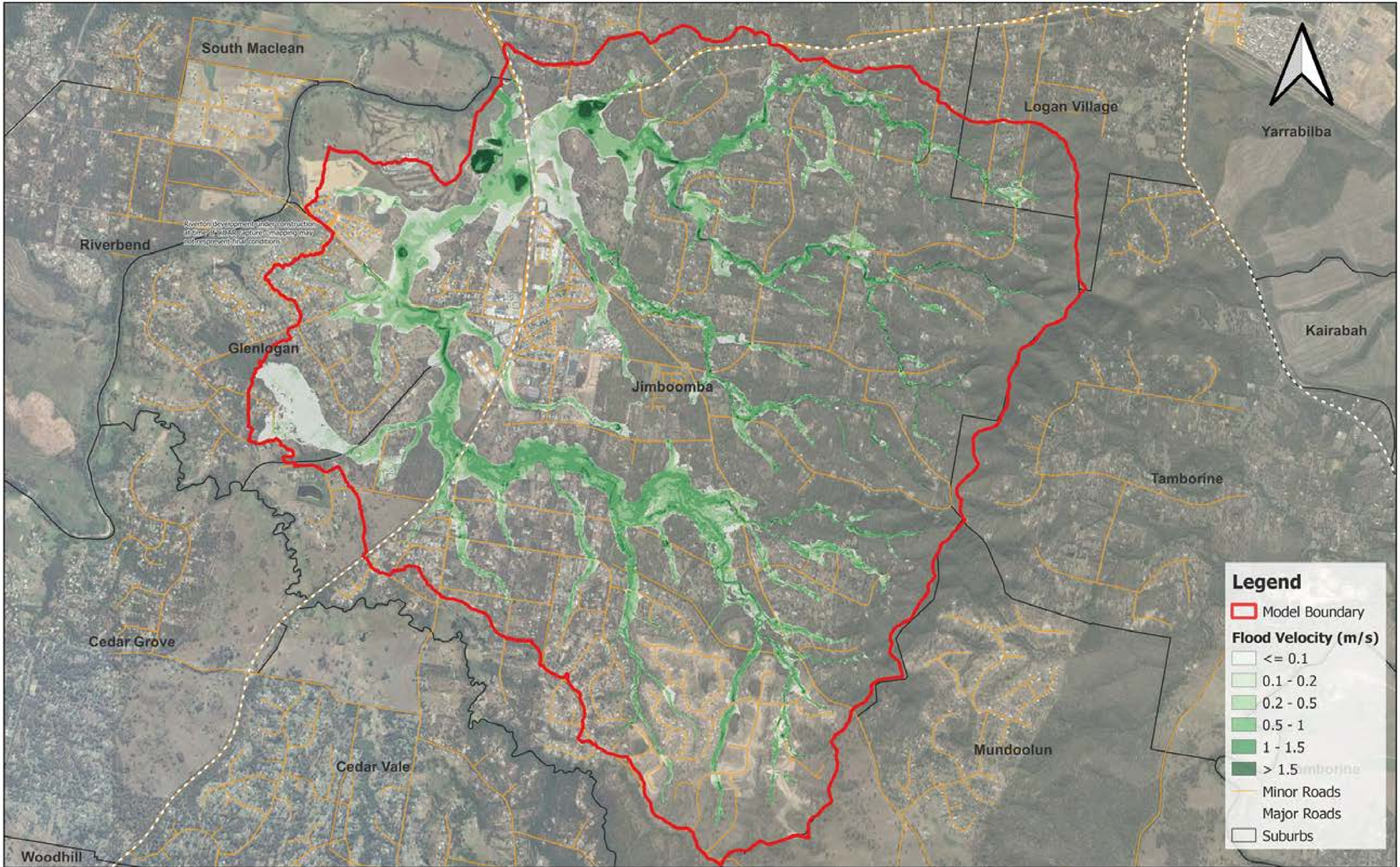

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APPROVED	MP	DATE	19-07-2023

NOTES:

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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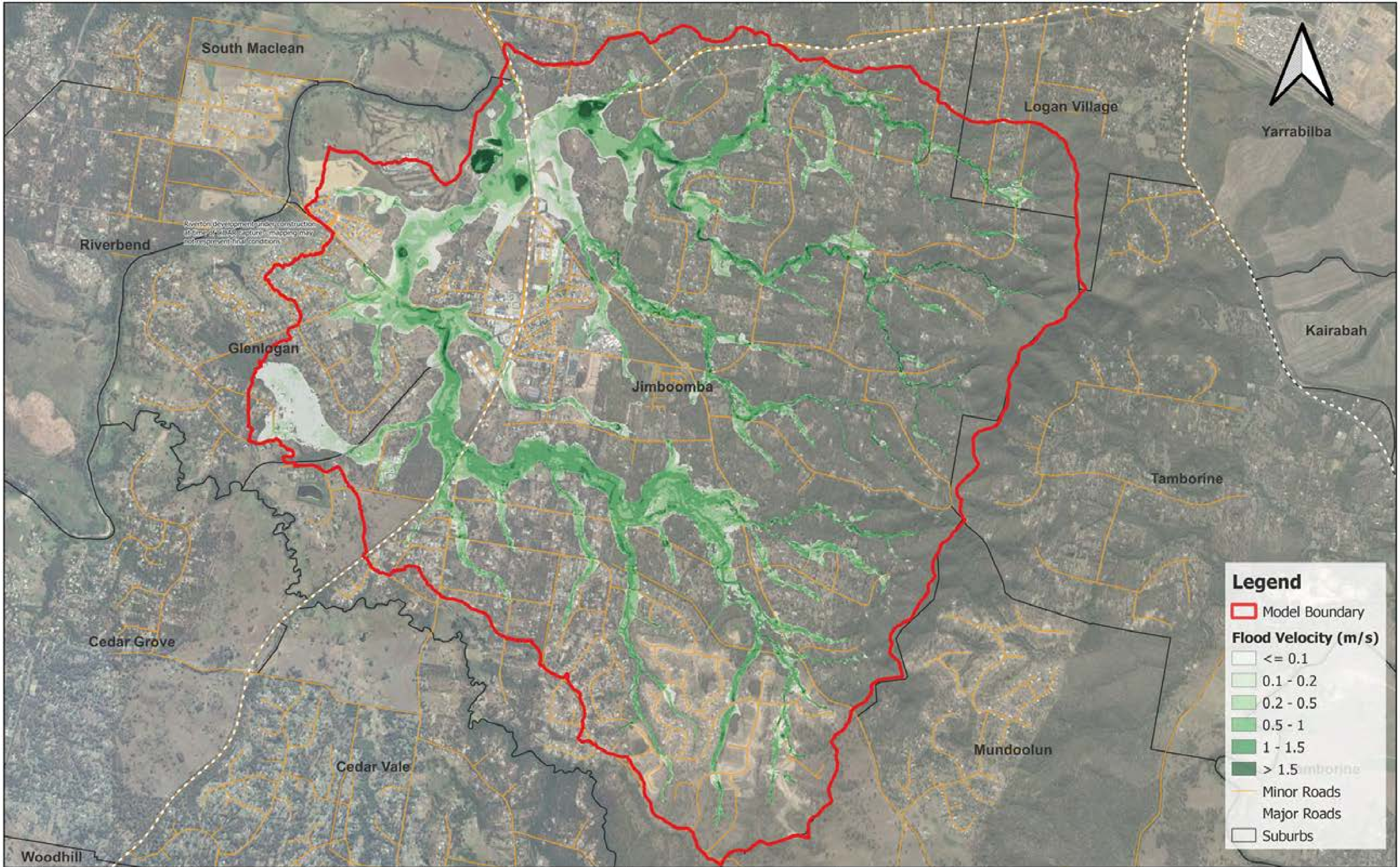
Appendix G.3.7

Henderson Creek Flood Study Update
1:200 AEP Flood Velocity

Appendix G.3.7



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APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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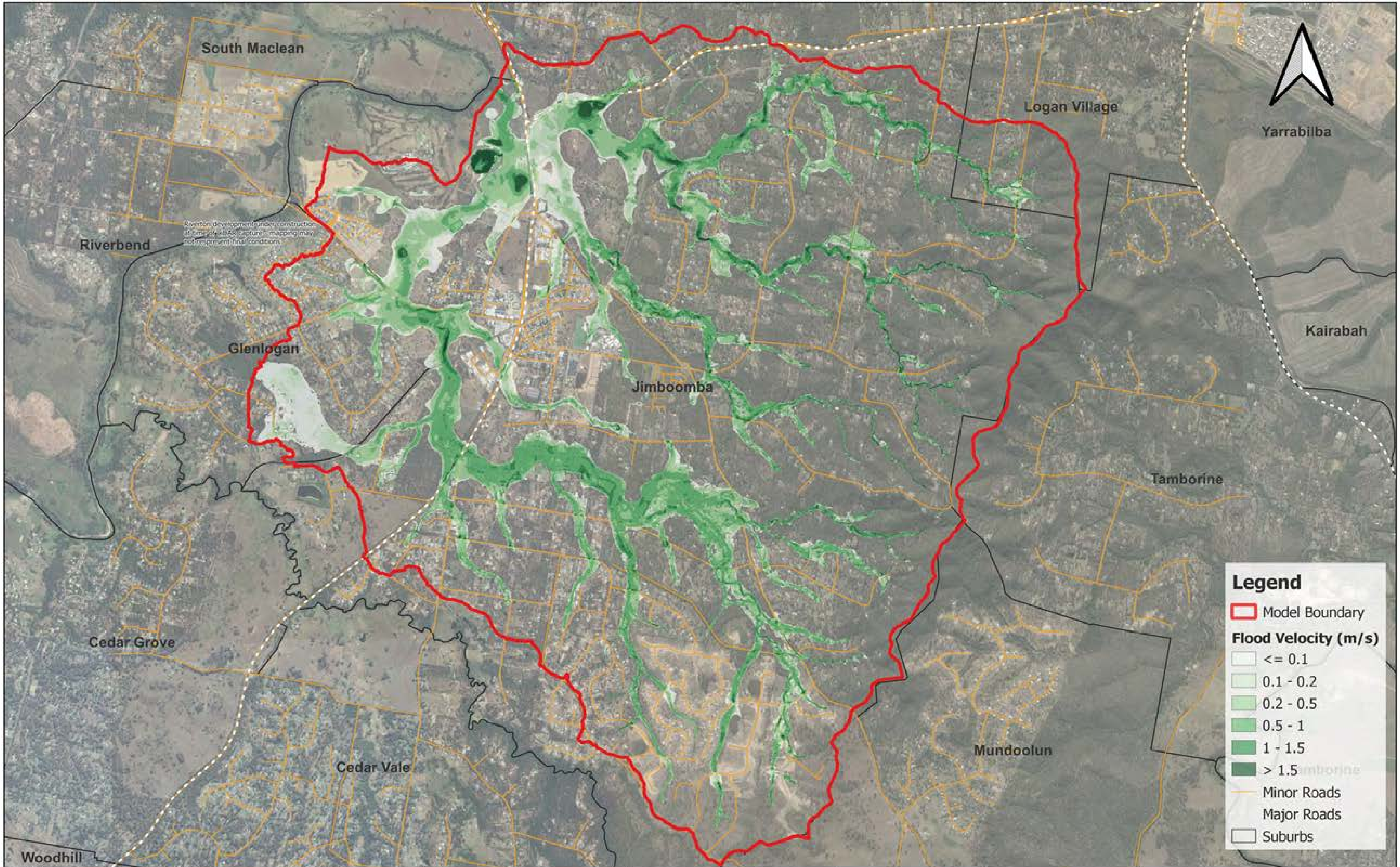
Appendix G.3.8

Henderson Creek Flood Study Update
1:500 AEP Flood Velocity

Appendix G.3.8

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



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SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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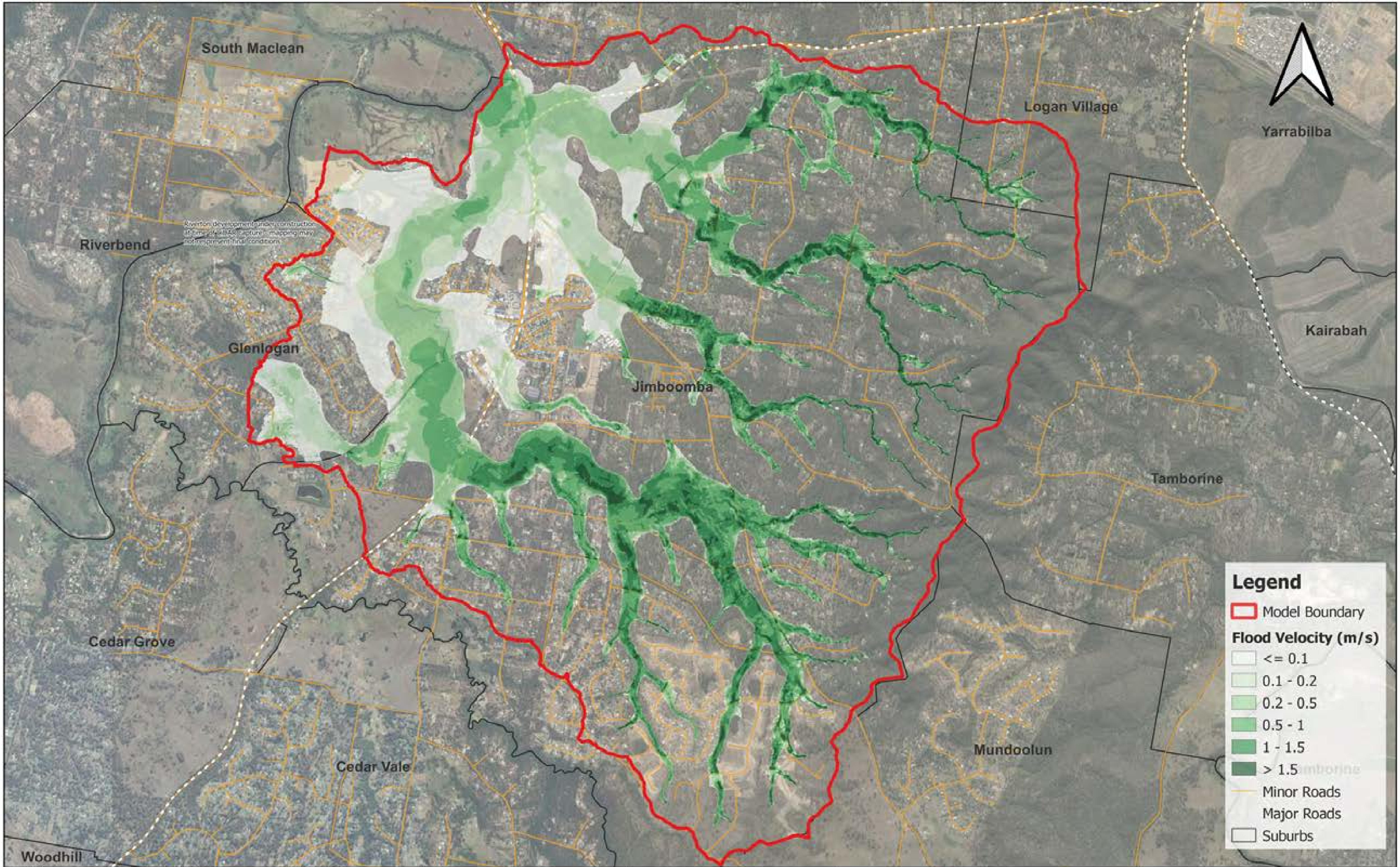
Appendix G.3.9

Henderson Creek Flood Study Update
1:2000 AEP Flood Velocity

Appendix G.3.9



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APPROVED	MP	DATE	19-07-2023

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SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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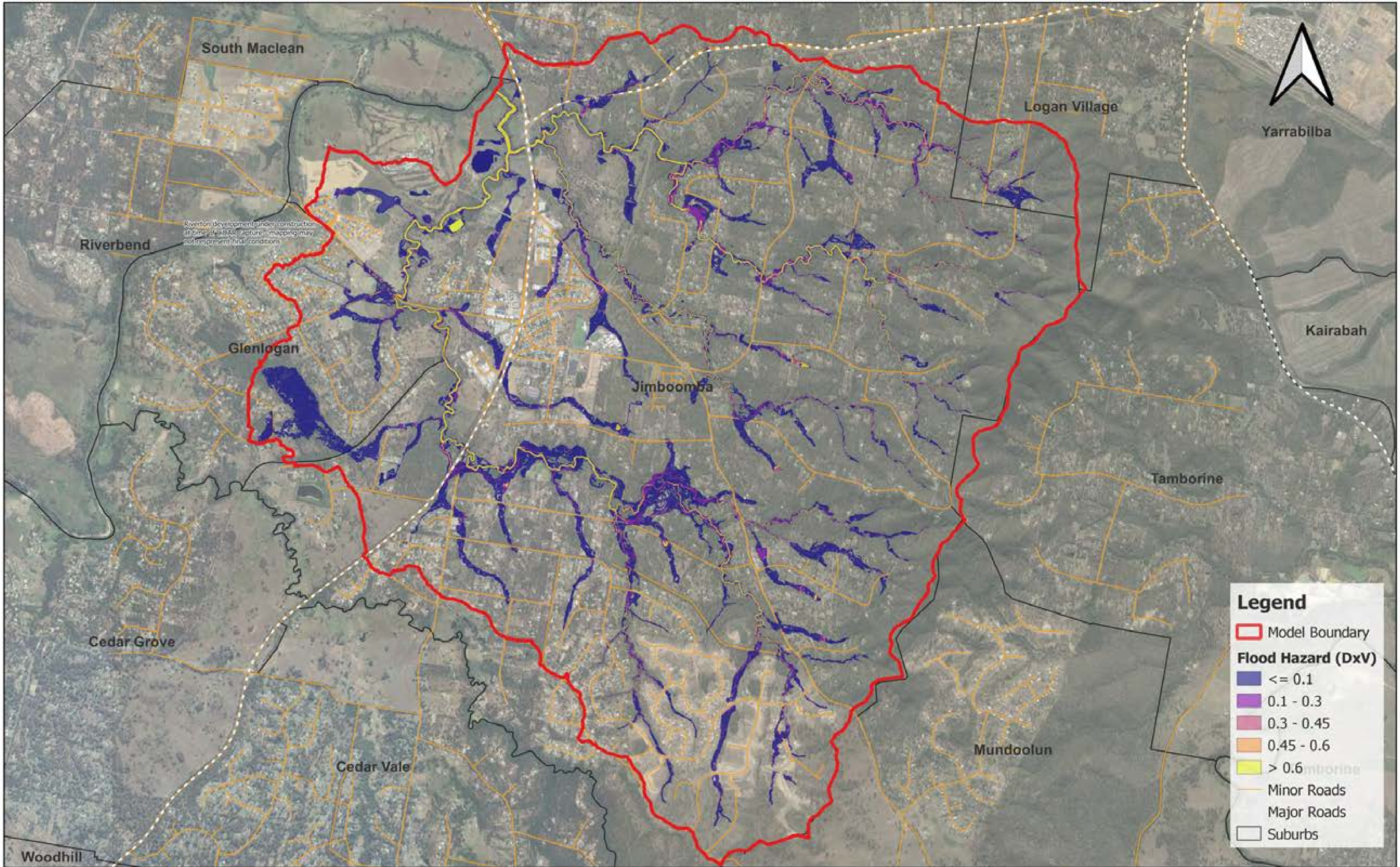
Appendix G.3.10

Henderson Creek Flood Study Update
PMF Flood Velocity

Appendix G.3.10

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



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0 0.8 1.6 km

SCALE @ A3 - 1:35,000
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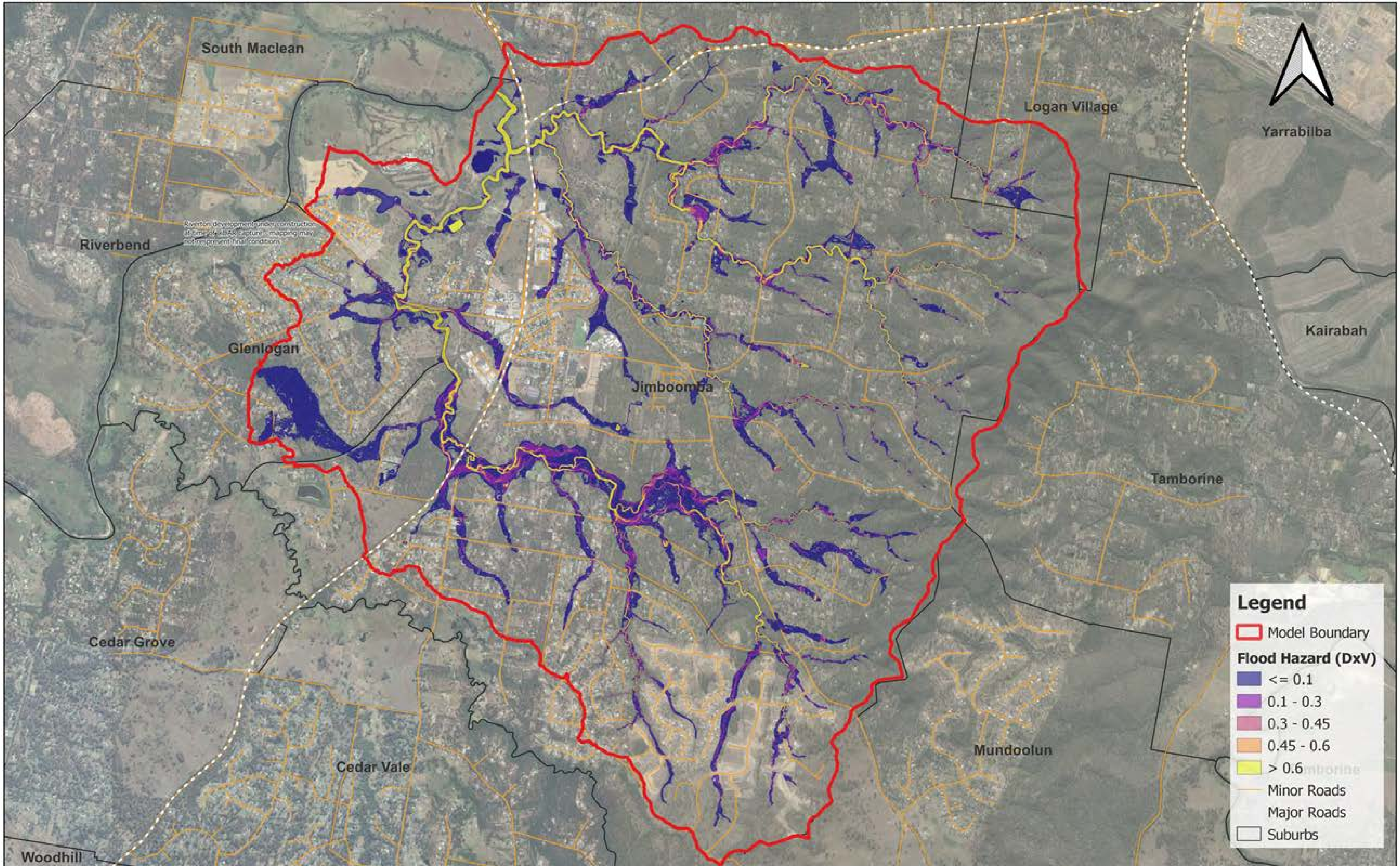
Appendix G.4.1

Henderson Creek Flood Study Update
1:2 AEP Flood Hazard (DxV)

Appendix G.4.1

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



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N

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SCALE @ A3 - 1:35,000
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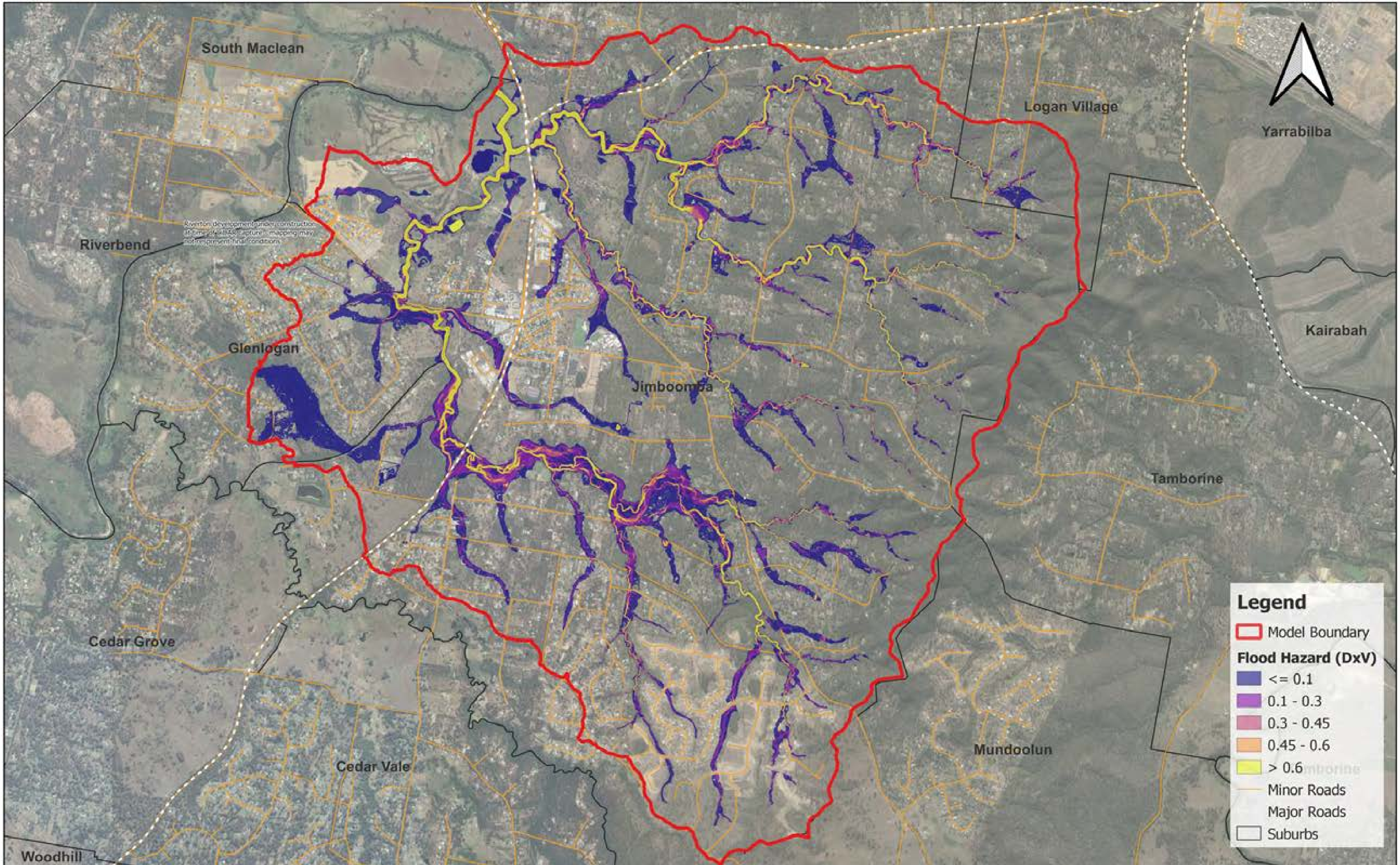
Appendix G.4.2

Henderson Creek Flood Study Update
1:5 AEP Flood Hazard (DxV)

Appendix G.4.2

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\GIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



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1	Final Issue	19-07-2023

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DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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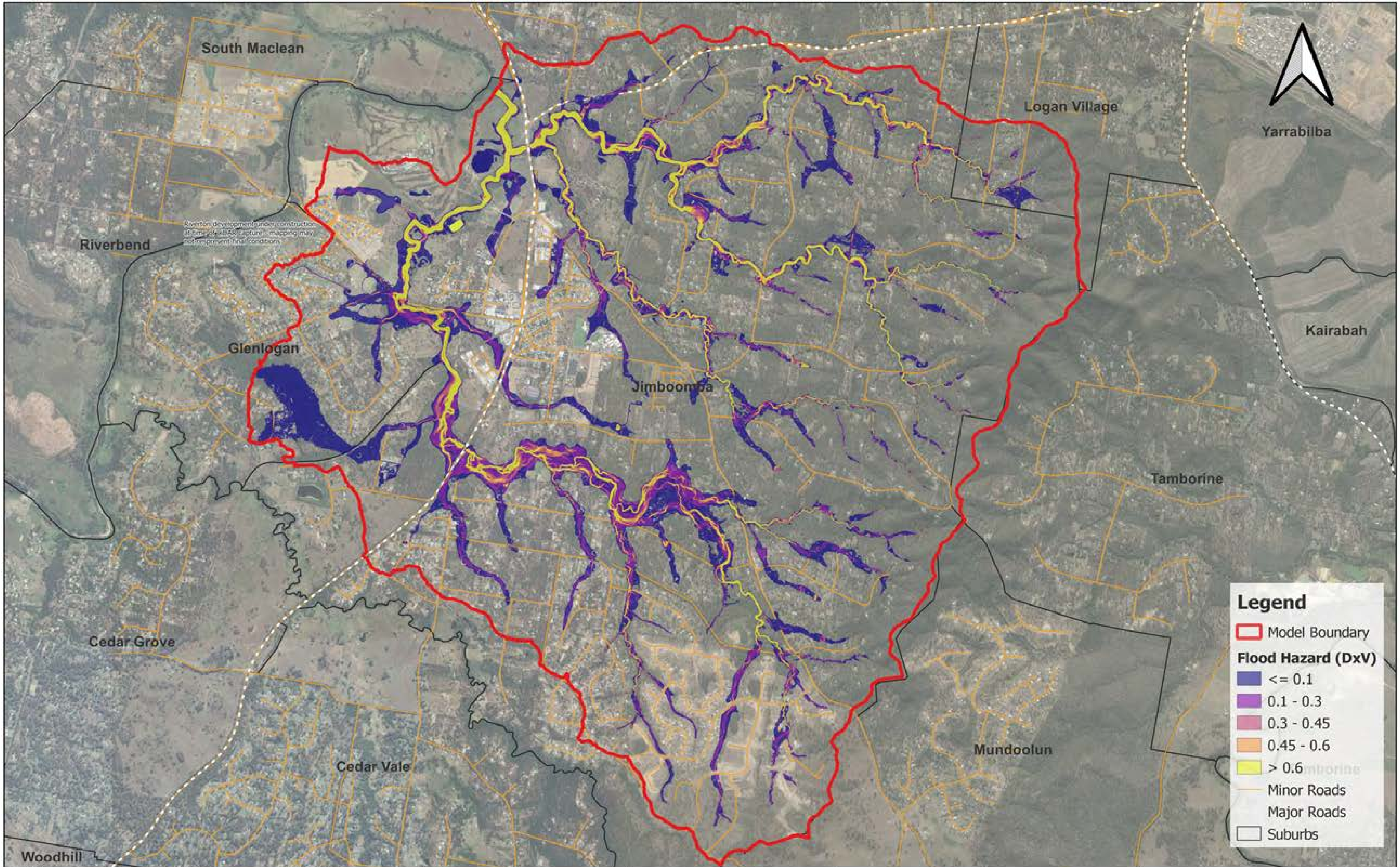
Appendix G.4.3

Henderson Creek Flood Study Update
1:10 AEP Flood Hazard (DxV)

Appendix G.4.3

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



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N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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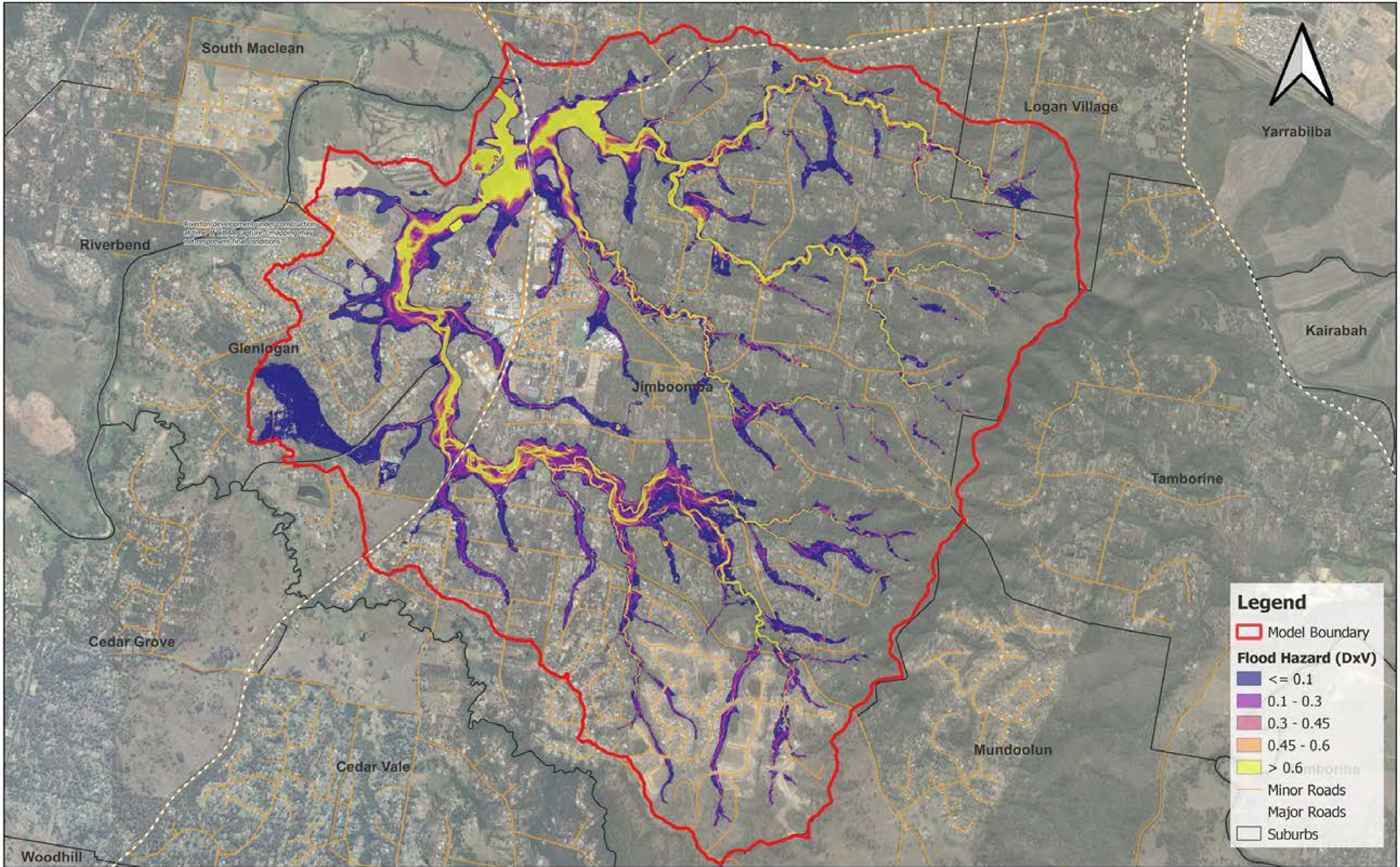
Appendix G.4.4

Henderson Creek Flood Study Update
1:20 AEP Flood Hazard (DxV)

Appendix G.4.4

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



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0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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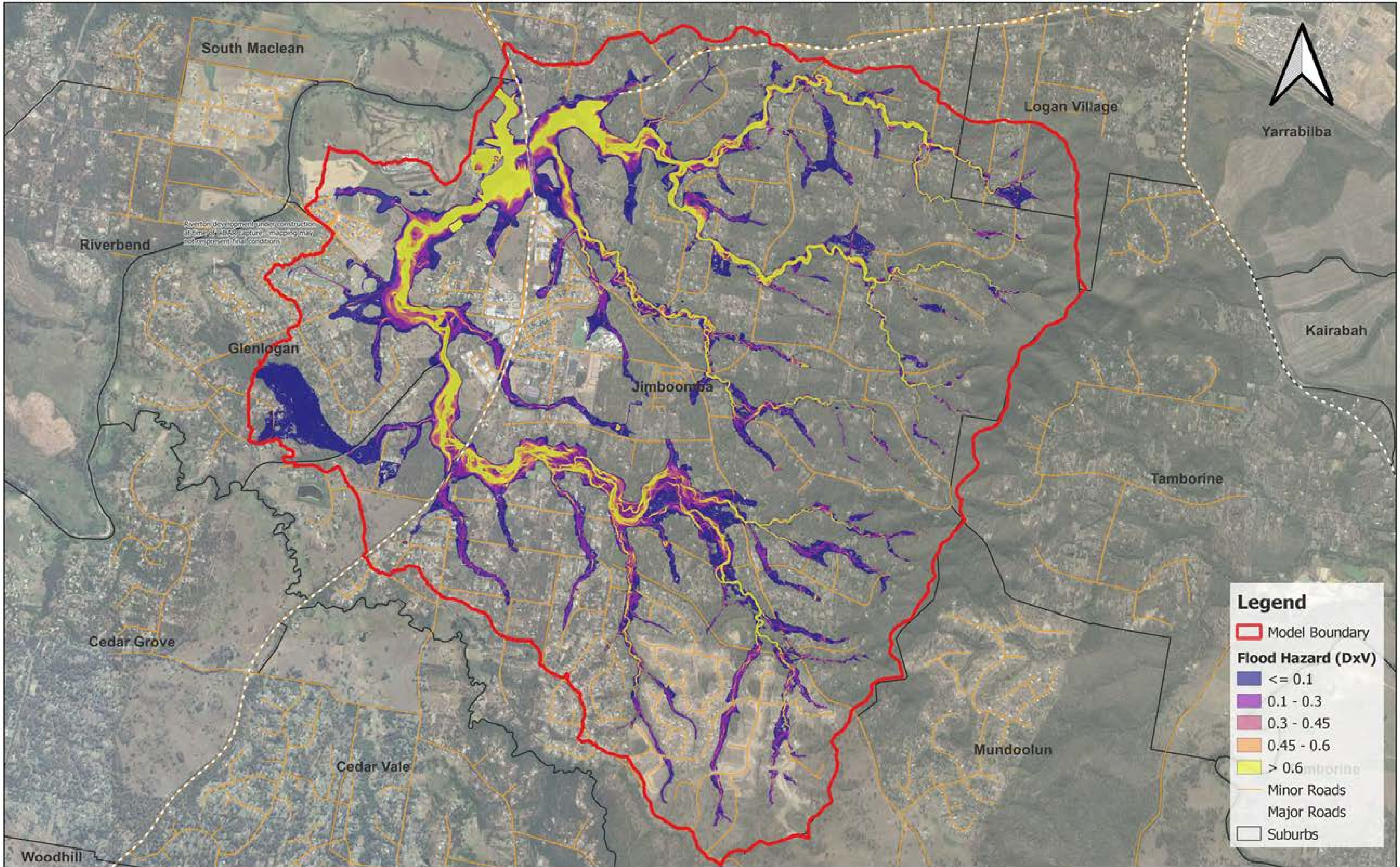
Appendix G.4.5

Henderson Creek Flood Study Update
1:50 AEP Flood Hazard (DxV)

Appendix G.4.5



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0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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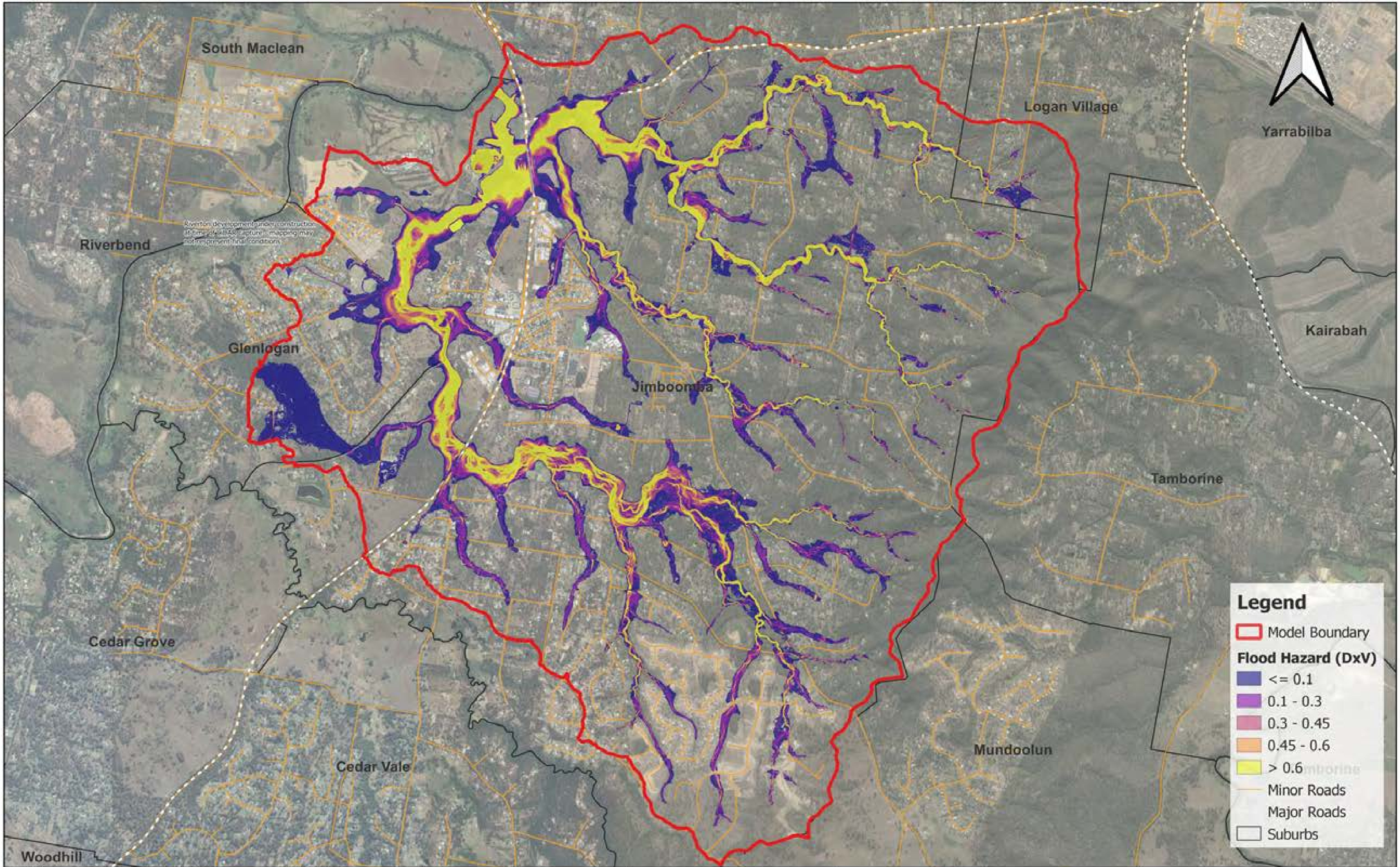
Appendix G.4.6

Henderson Creek Flood Study Update
1:100 AEP Flood Hazard (DxV)

Appendix G.4.6



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0 0.8 1.6 km

SCALE @ A3 - 1:35,000
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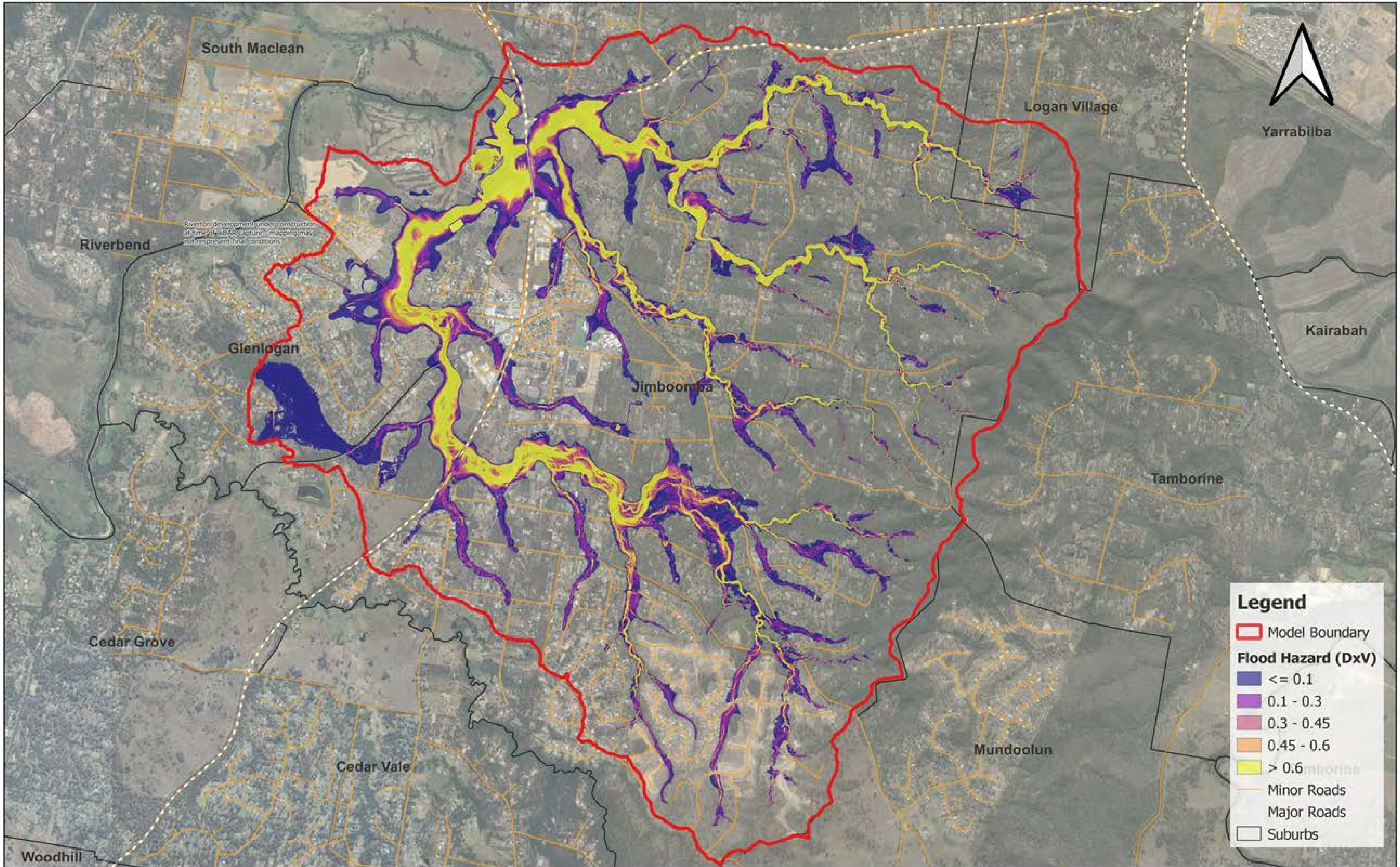
Appendix G.4.7

Henderson Creek Flood Study Update
1:200 AEP Flood Hazard (DxV)

Appendix G.4.7

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\GIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



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0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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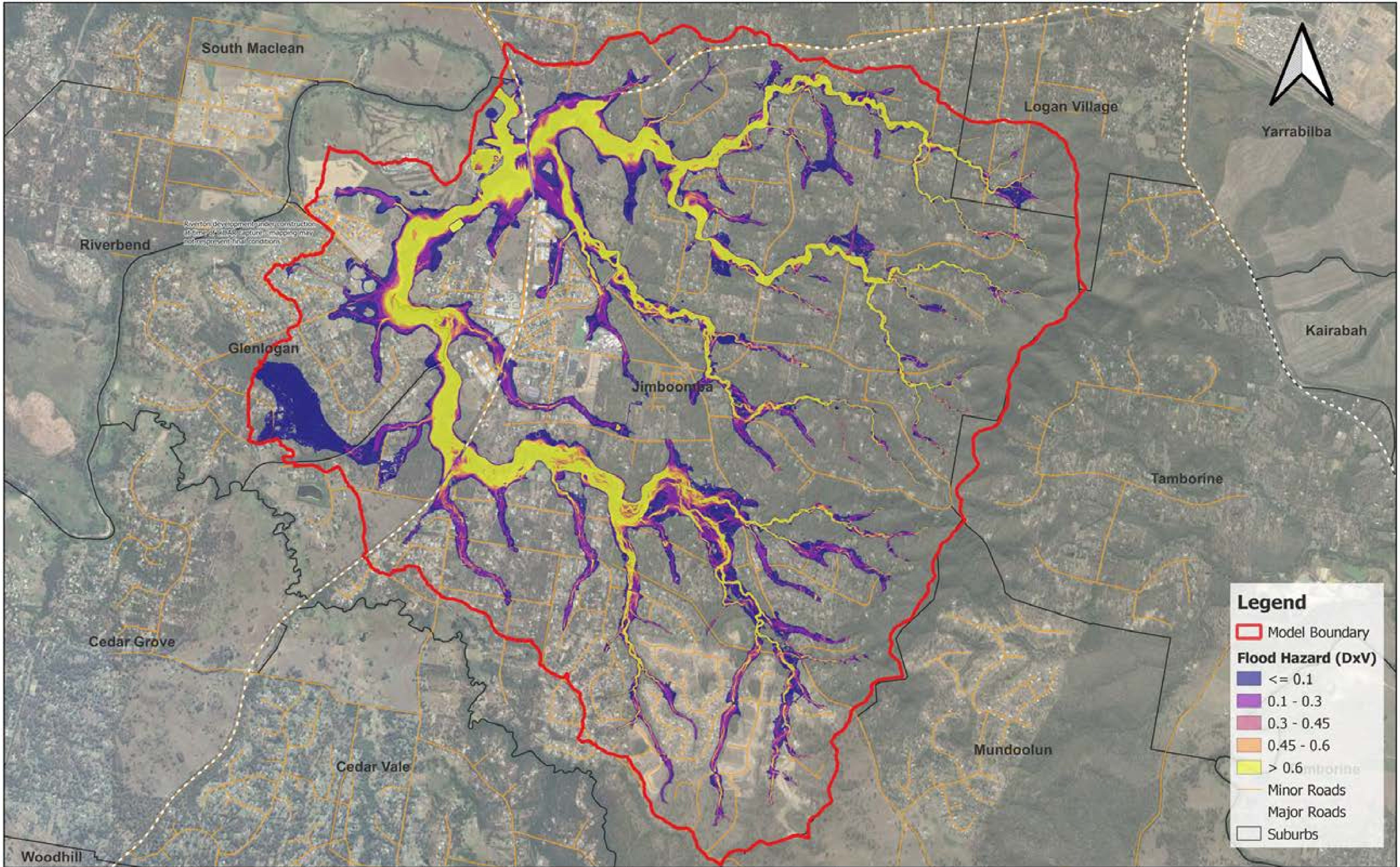
Appendix G.4.8

Henderson Creek Flood Study Update
1:500 AEP Flood Hazard (DxV)

Appendix G.4.8



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SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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Appendix G.4.9

Henderson Creek Flood Study Update
1:2000 AEP Flood Hazard (DxV)

Appendix G.4.9

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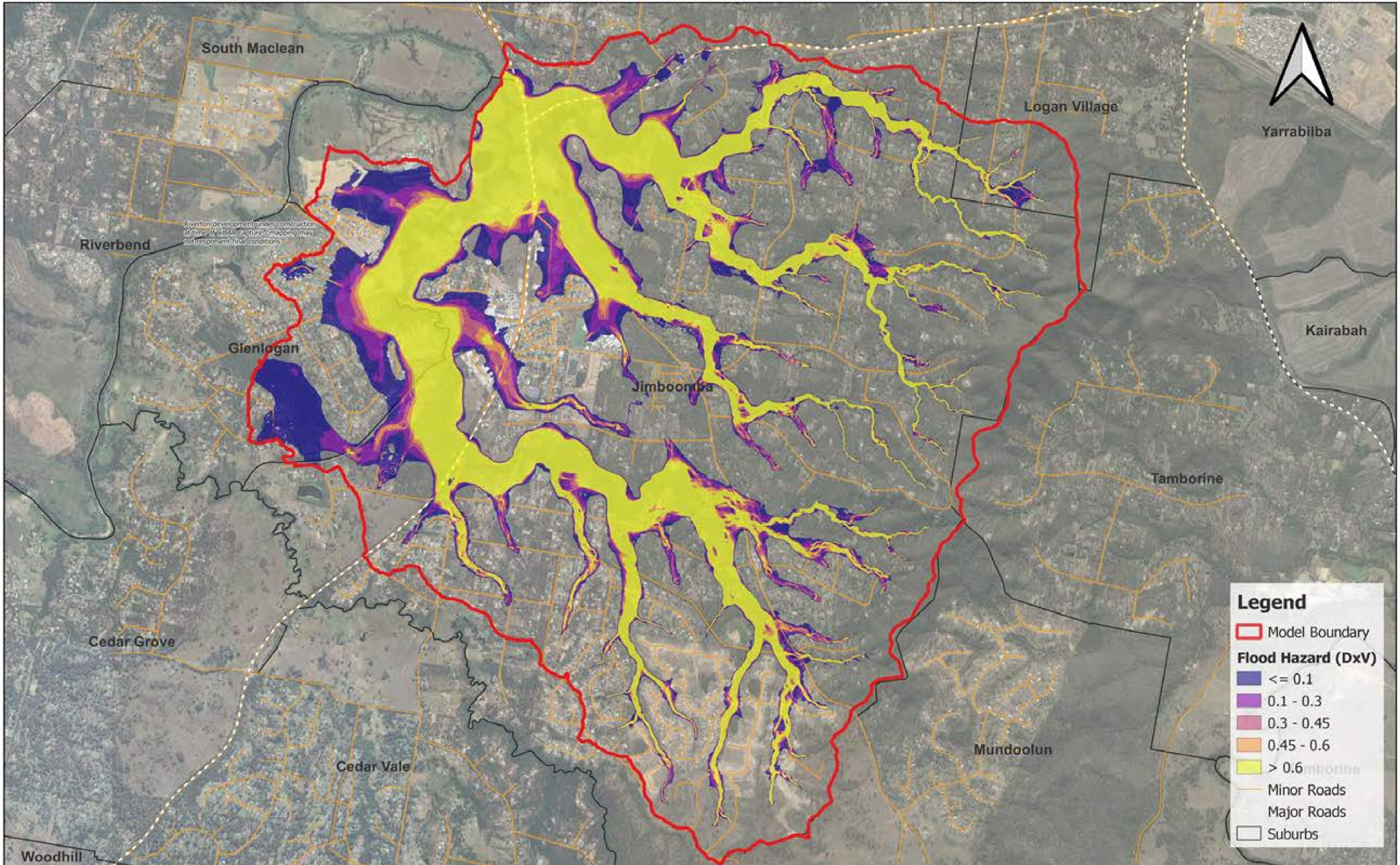

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0 0.8 1.6 km

SCALE @ A3 - 1:35,000
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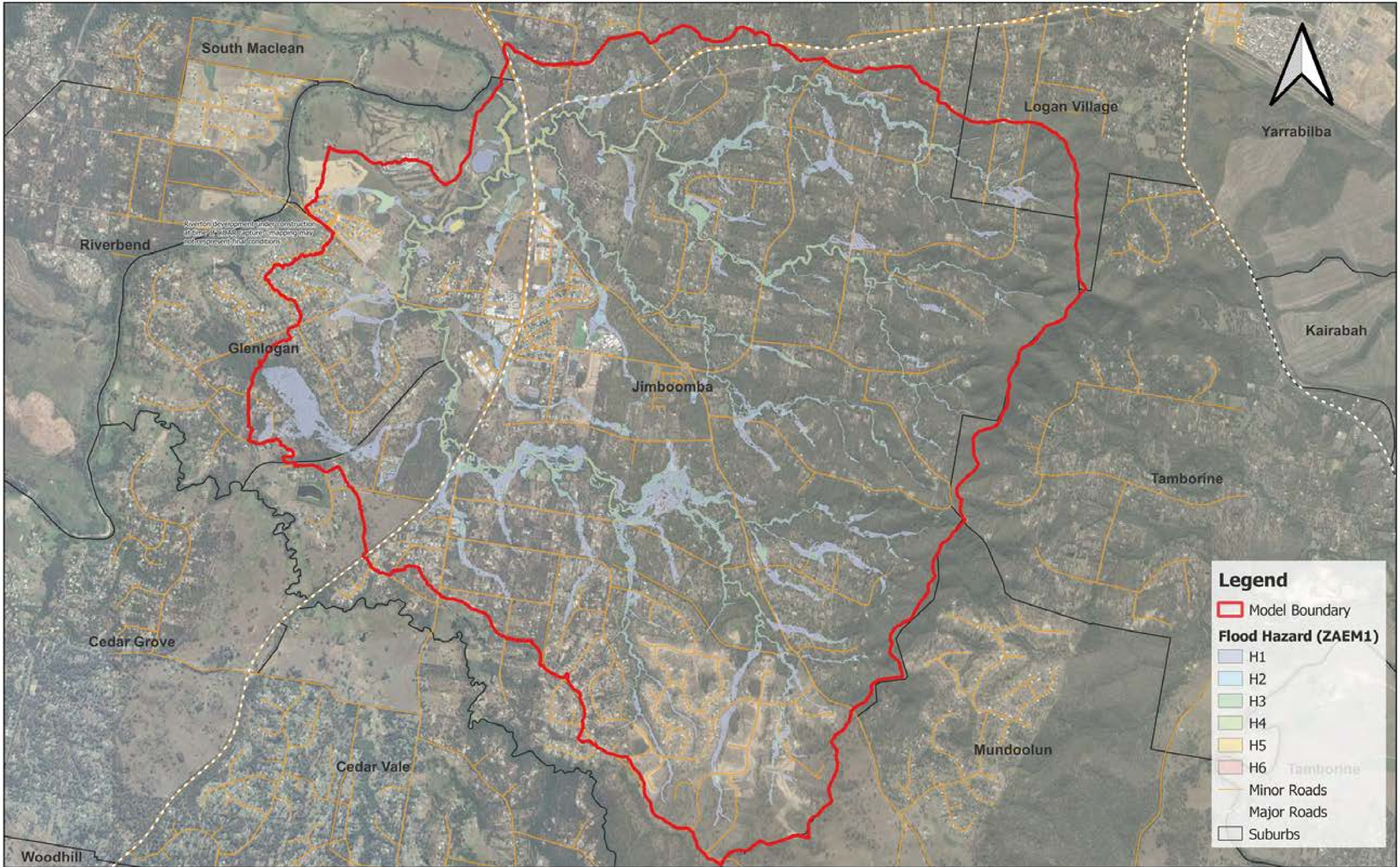
Appendix G.4.10

Henderson Creek Flood Study Update
PMF Flood Hazard (DxV)

Appendix G.4.10

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\GIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



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0 0.8 1.6 km

SCALE @ A3 - 1:35,000
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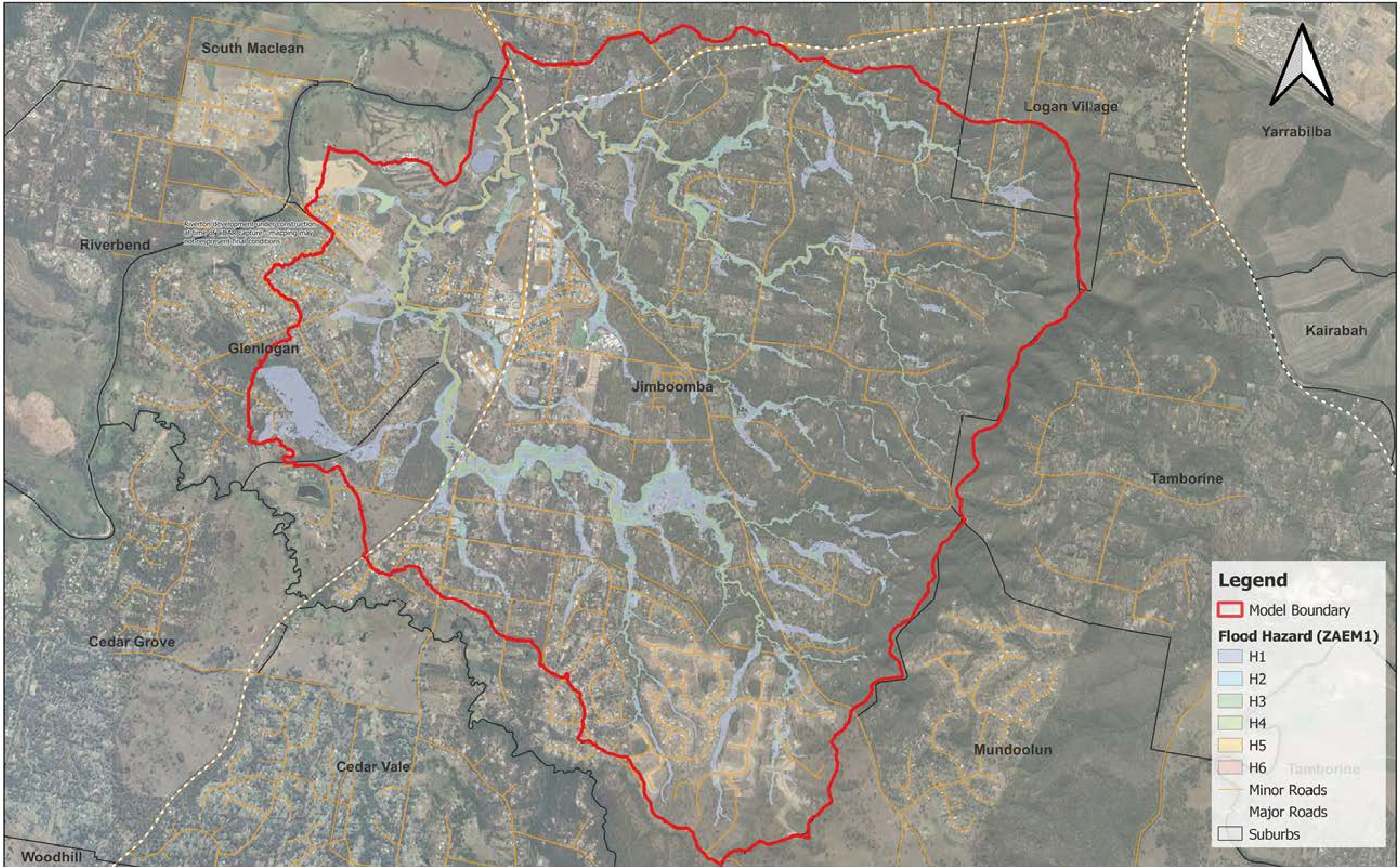
Appendix G.5.1

Henderson Creek Flood Study Update
1:2 AEP Flood Hazard (ZAEM1)

Appendix G.5.1



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SCALE @ A3 - 1:35,000
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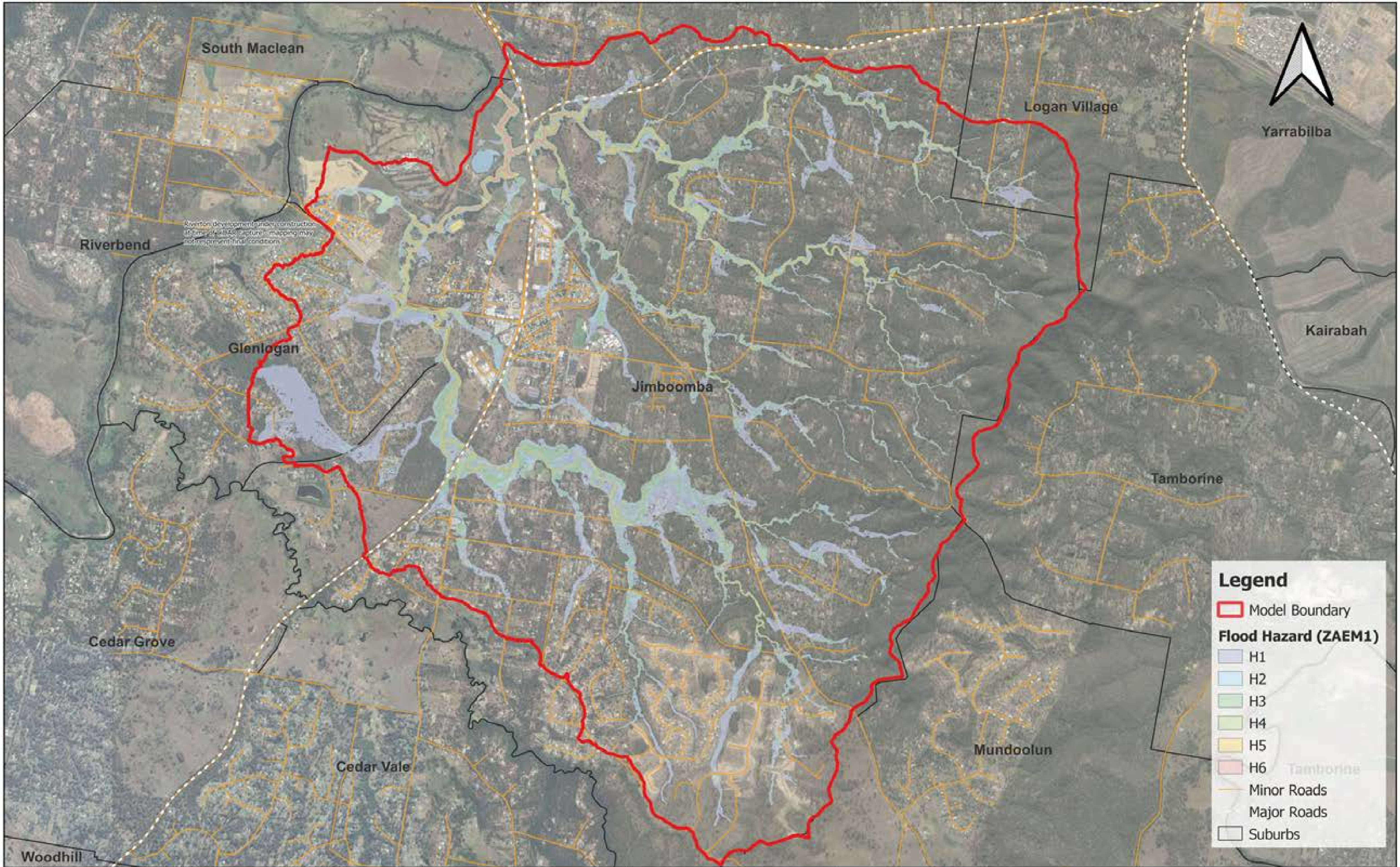
Appendix G.5.2

Henderson Creek Flood Study Update
1:5 AEP Flood Hazard (ZAEM1)

Appendix G.5.2



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0 0.8 1.6 km

SCALE @ A3 - 1:35,000
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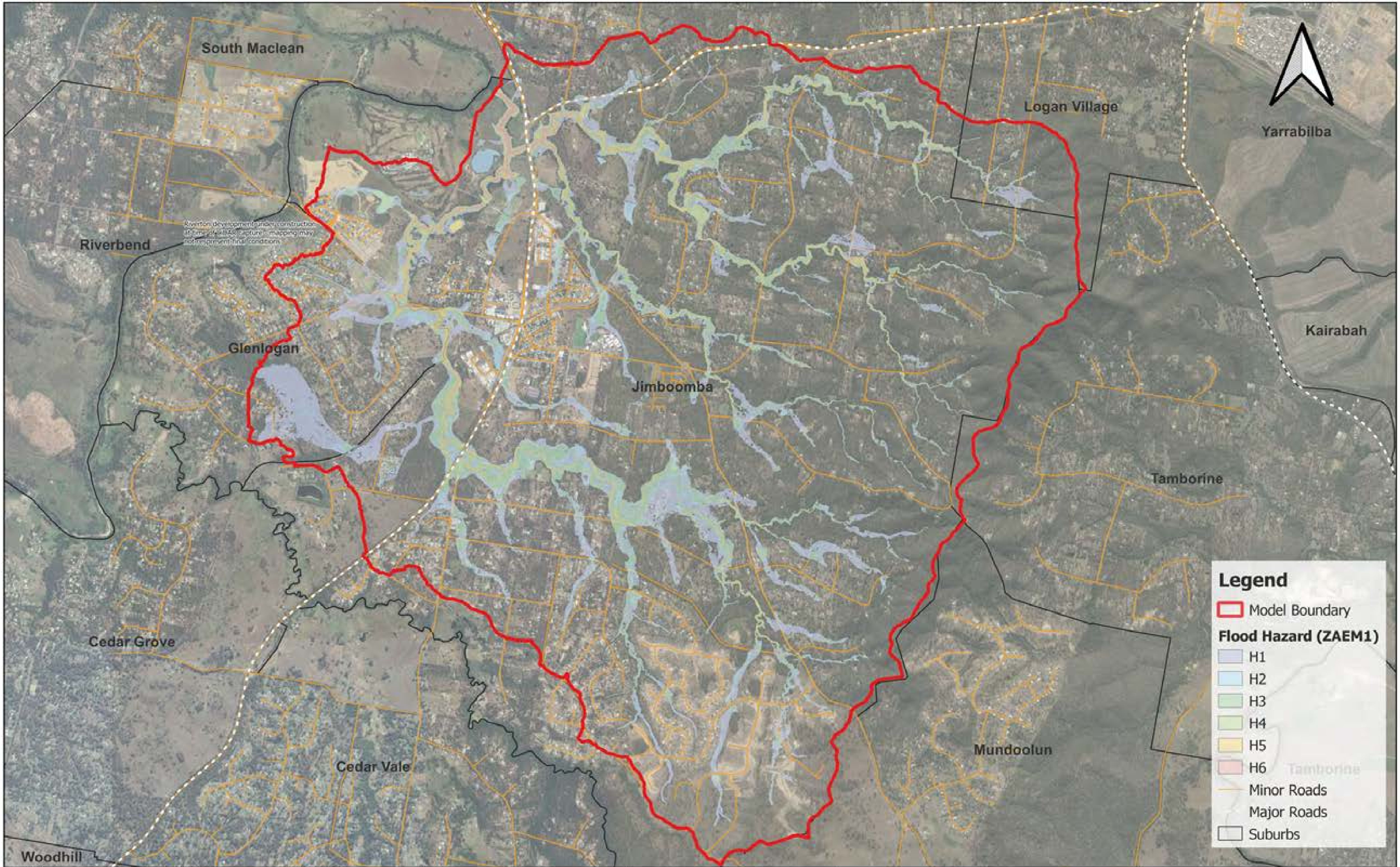
Appendix G.5.3

Henderson Creek Flood Study Update
1:10 AEP Flood Hazard (ZAEM1)

Appendix G.5.3



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SCALE @ A3 - 1:35,000
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Appendix G.5.4

Henderson Creek Flood Study Update
1:20 AEP Flood Hazard (ZAEM1)

Appendix G.5.4

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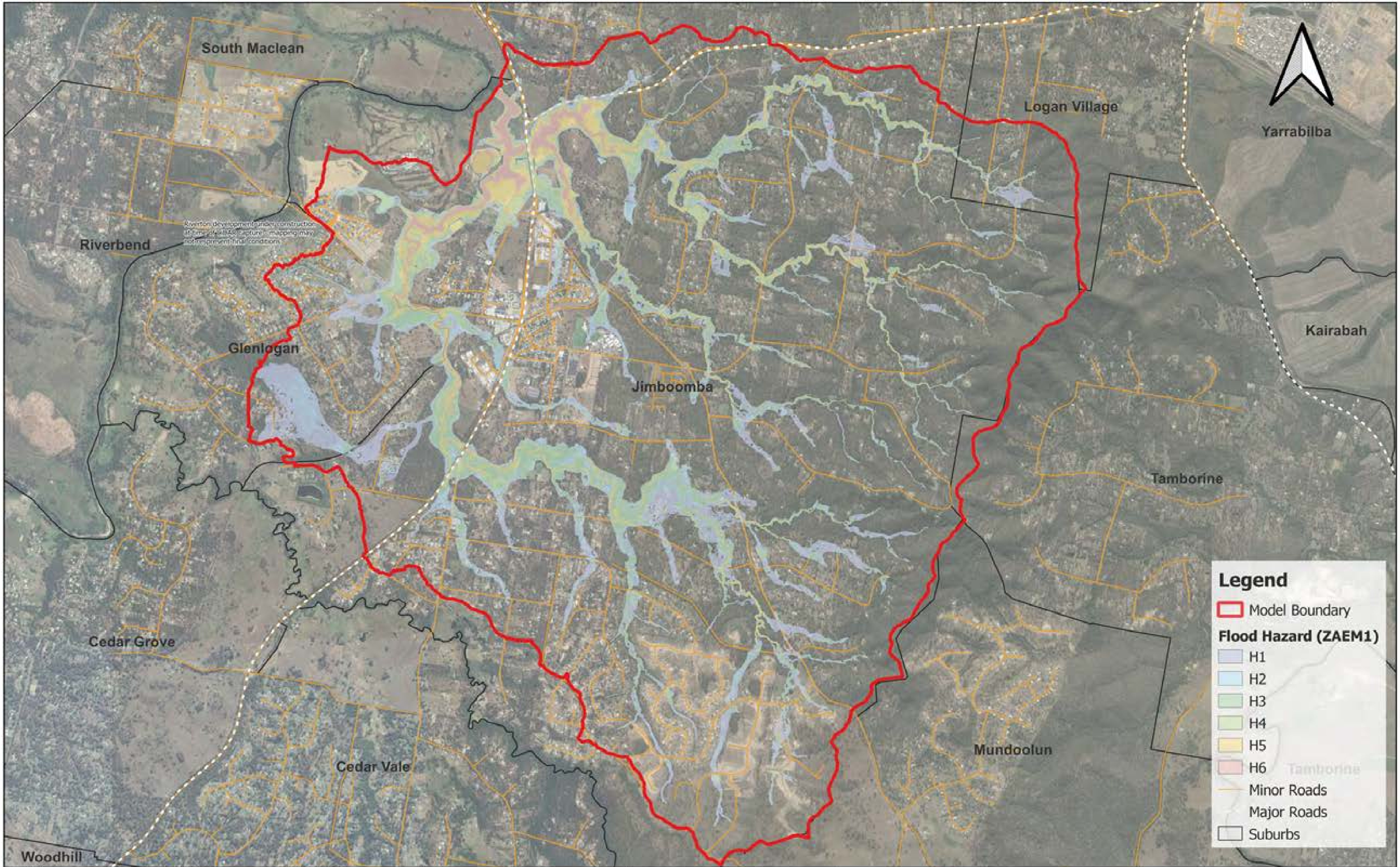

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0 0.8 1.6 km

SCALE @ A3 - 1:35,000
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Appendix G.5.5

Henderson Creek Flood Study Update
1:50 AEP Flood Hazard (ZAEM1)

Appendix G.5.5

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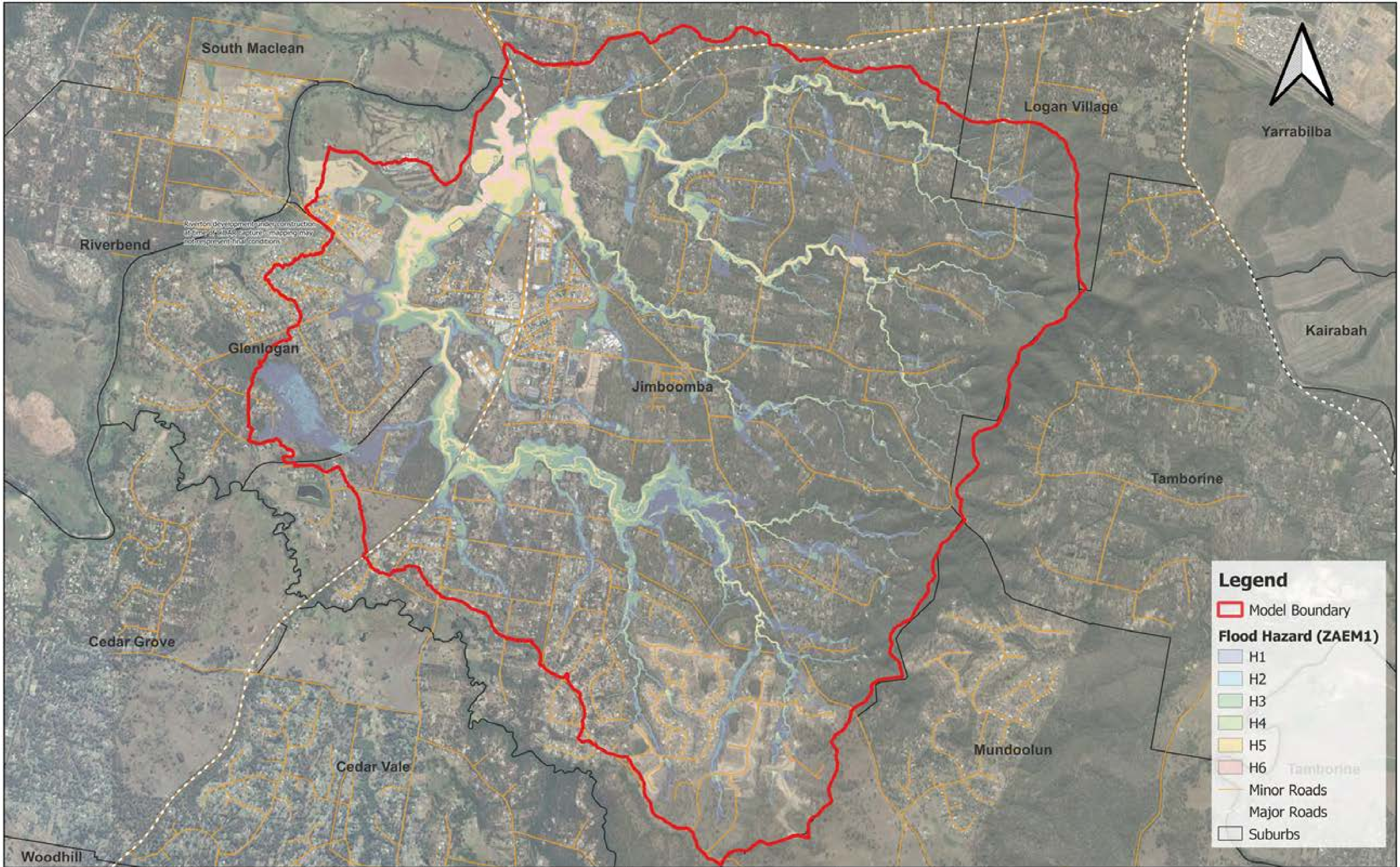

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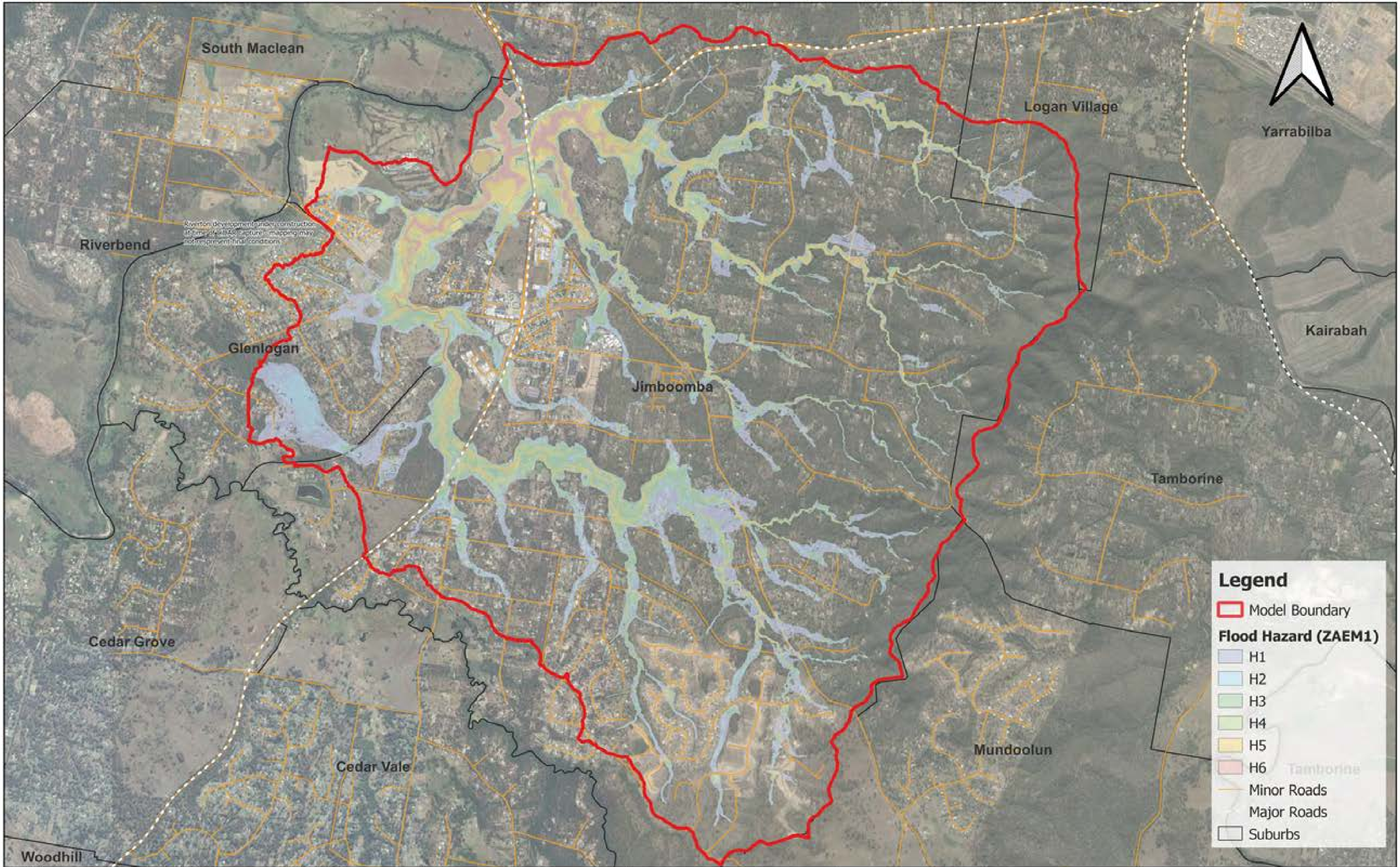
Appendix G.5.6

Henderson Creek Flood Study Update
1:100 AEP Flood Hazard (ZAEM1)

Appendix G.5.6



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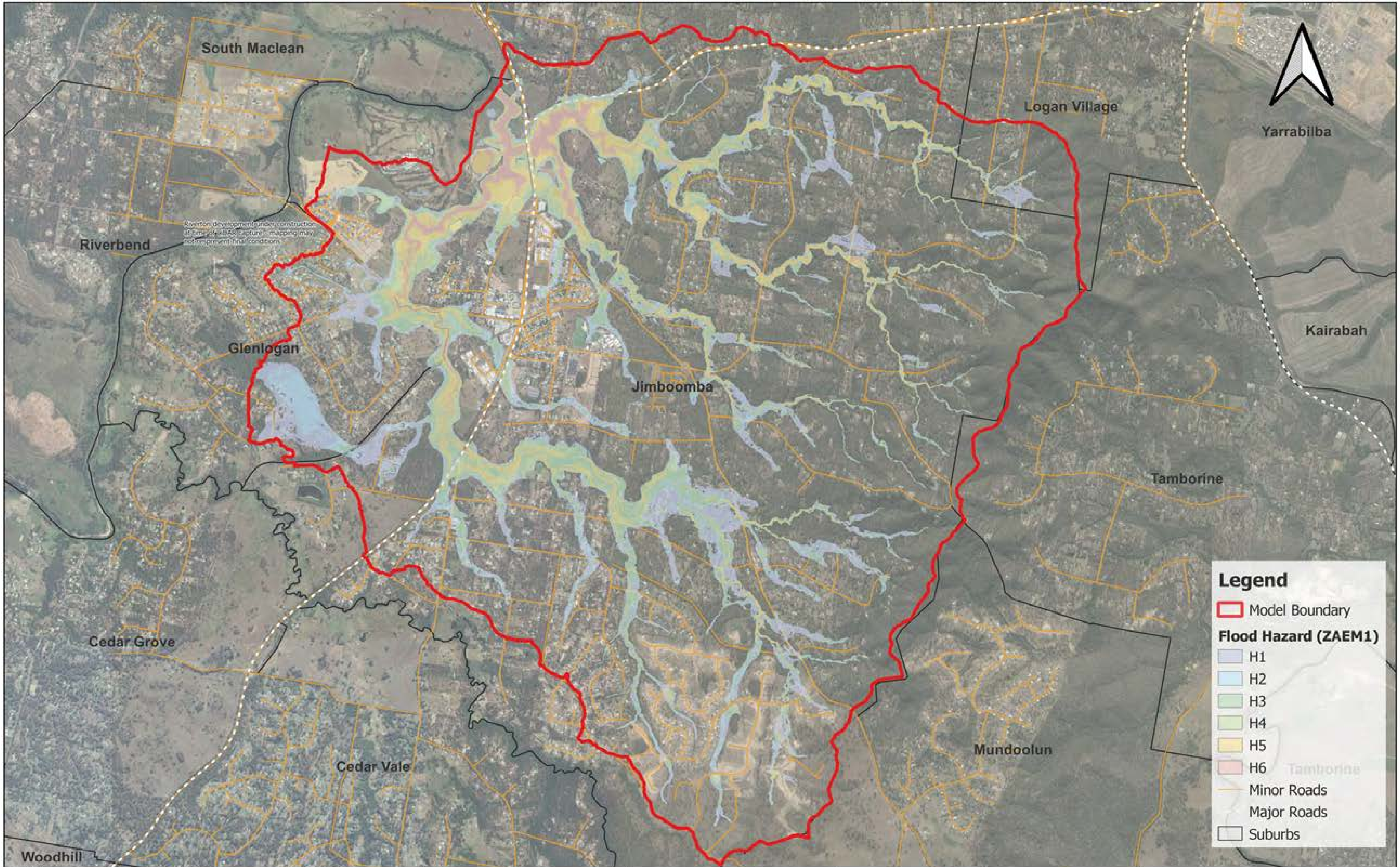
Appendix G.5.7

Henderson Creek Flood Study Update
1:200 AEP Flood Hazard (ZAEM1)

Appendix G.5.7



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N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
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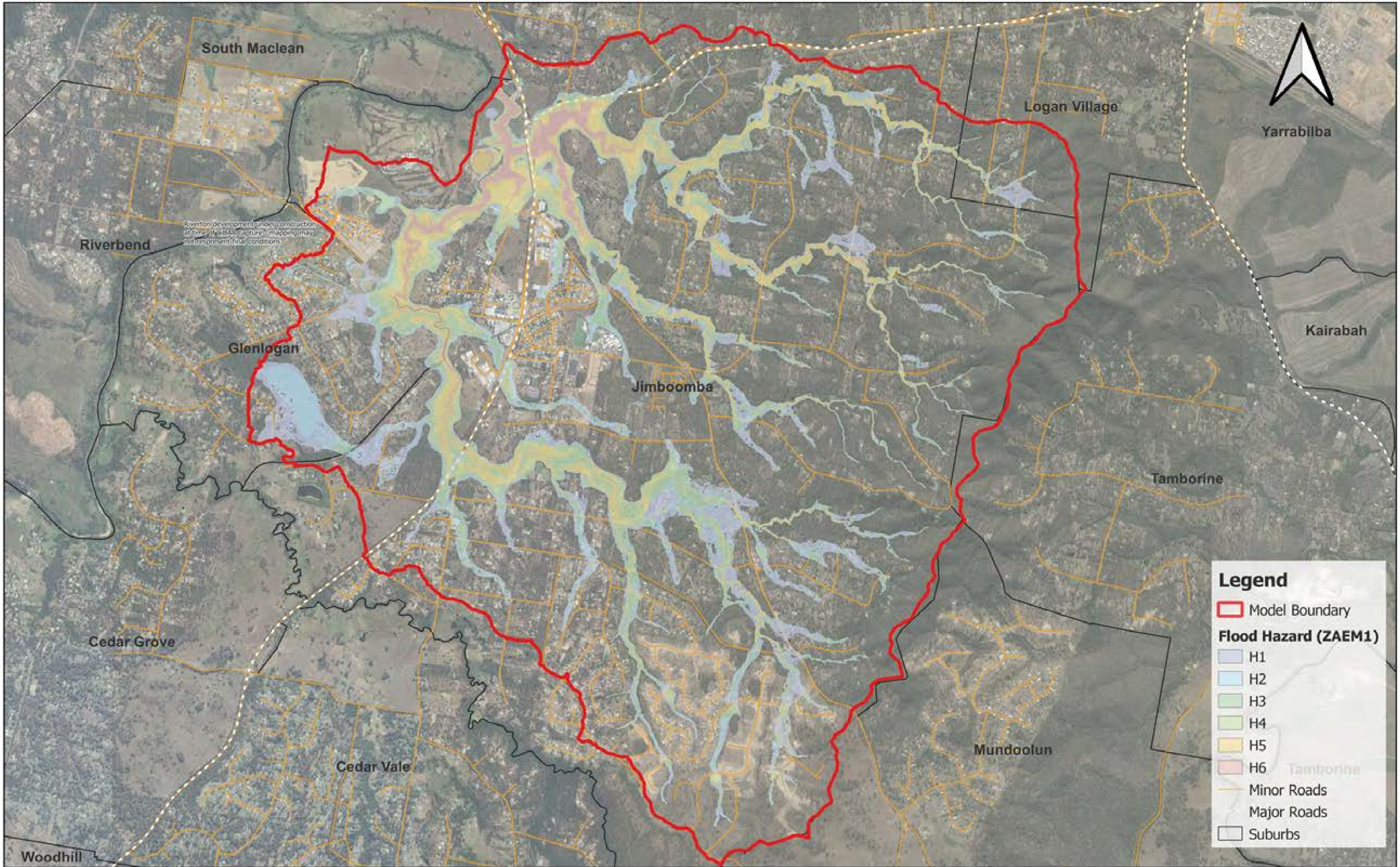
Appendix G.5.8

Henderson Creek Flood Study Update
1:500 AEP Flood Hazard (ZAEM1)

Appendix G.5.8



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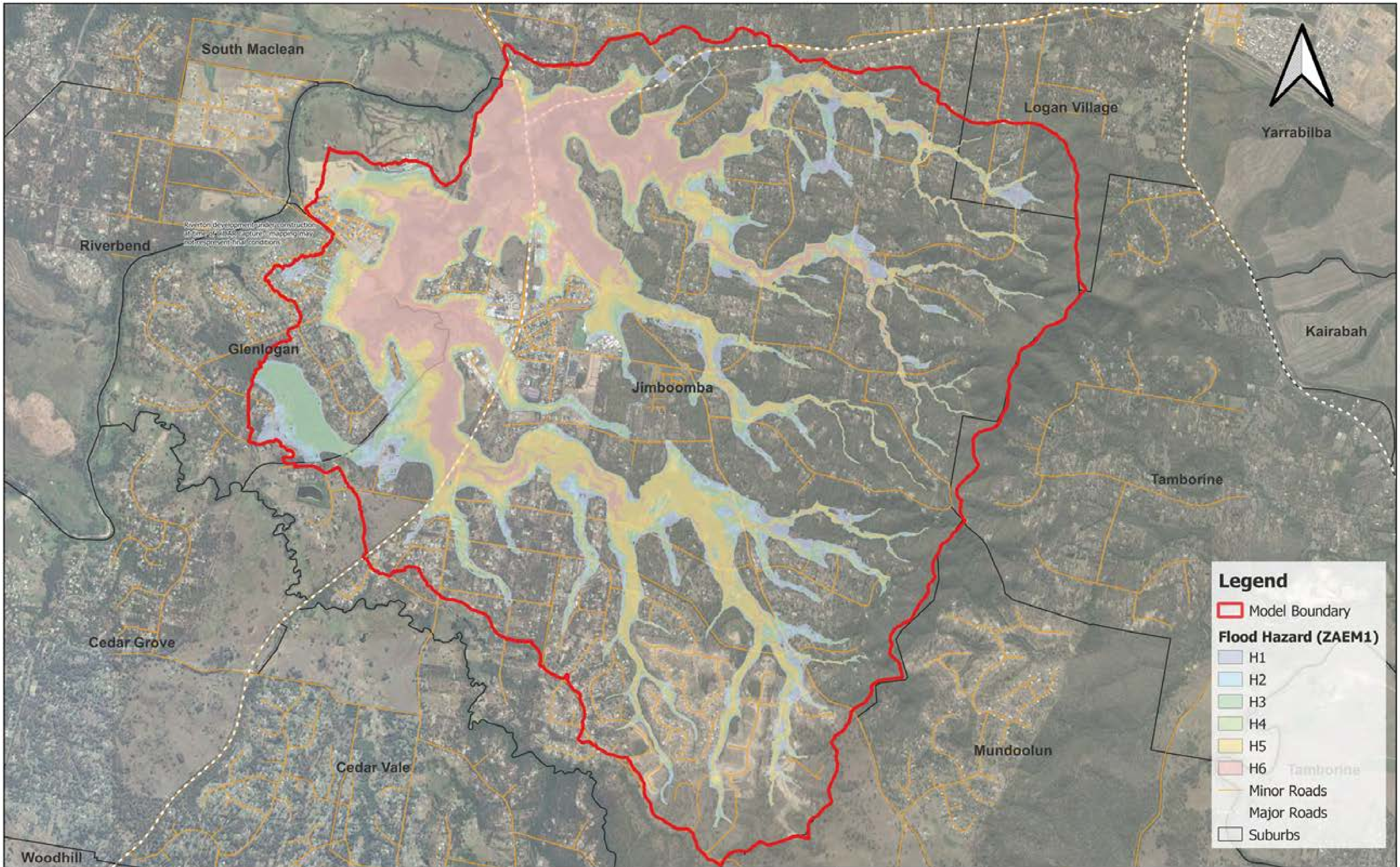
Appendix G.5.9

Henderson Creek Flood Study Update
1:2000 AEP Flood Hazard (ZAEM1)

Appendix G.5.9



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Appendix G.5.10

Henderson Creek Flood Study Update
PMF Flood Hazard (ZAEM1)

Appendix G.5.10

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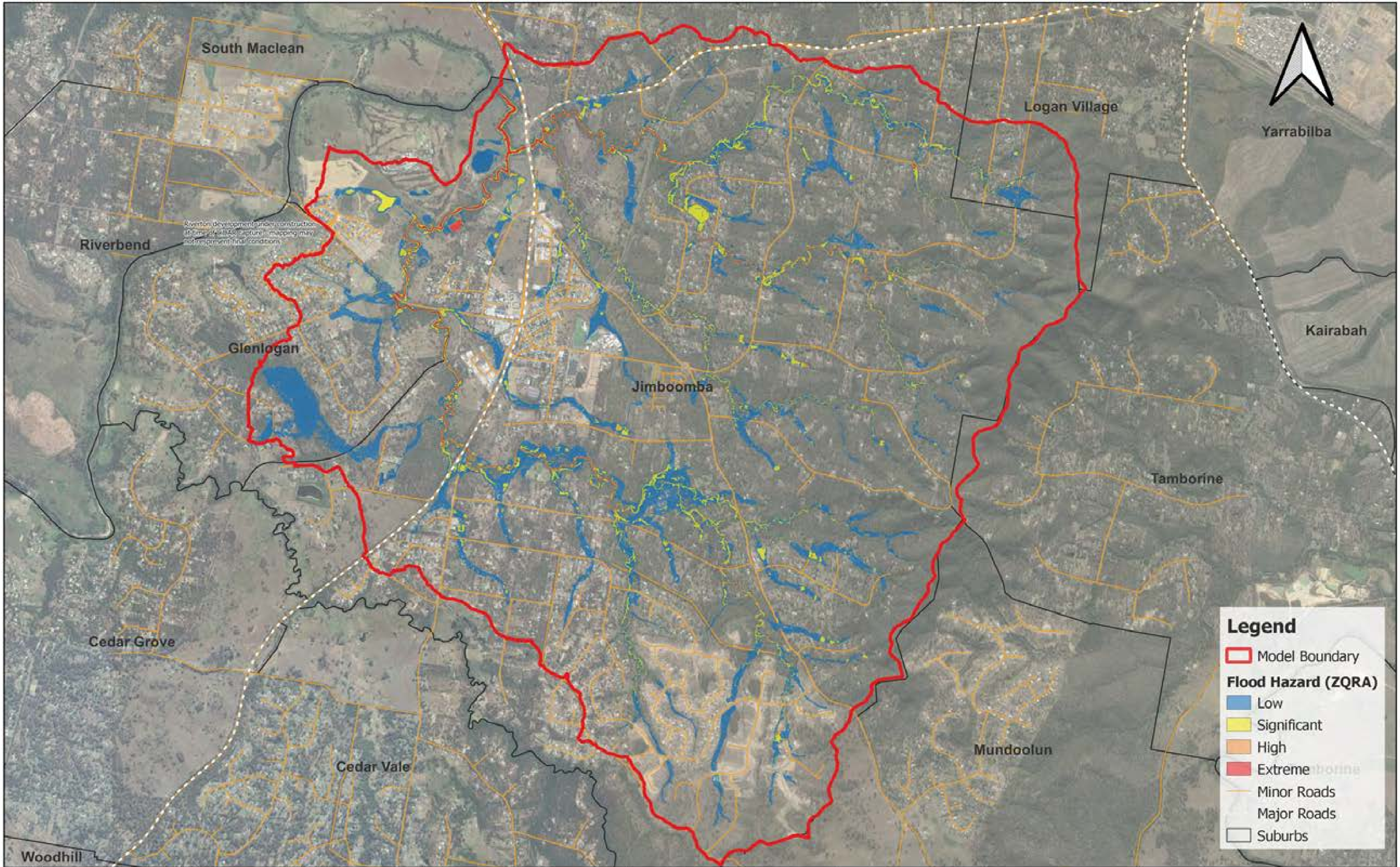

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0 0.8 1.6 km

SCALE @ A3 - 1:35,000
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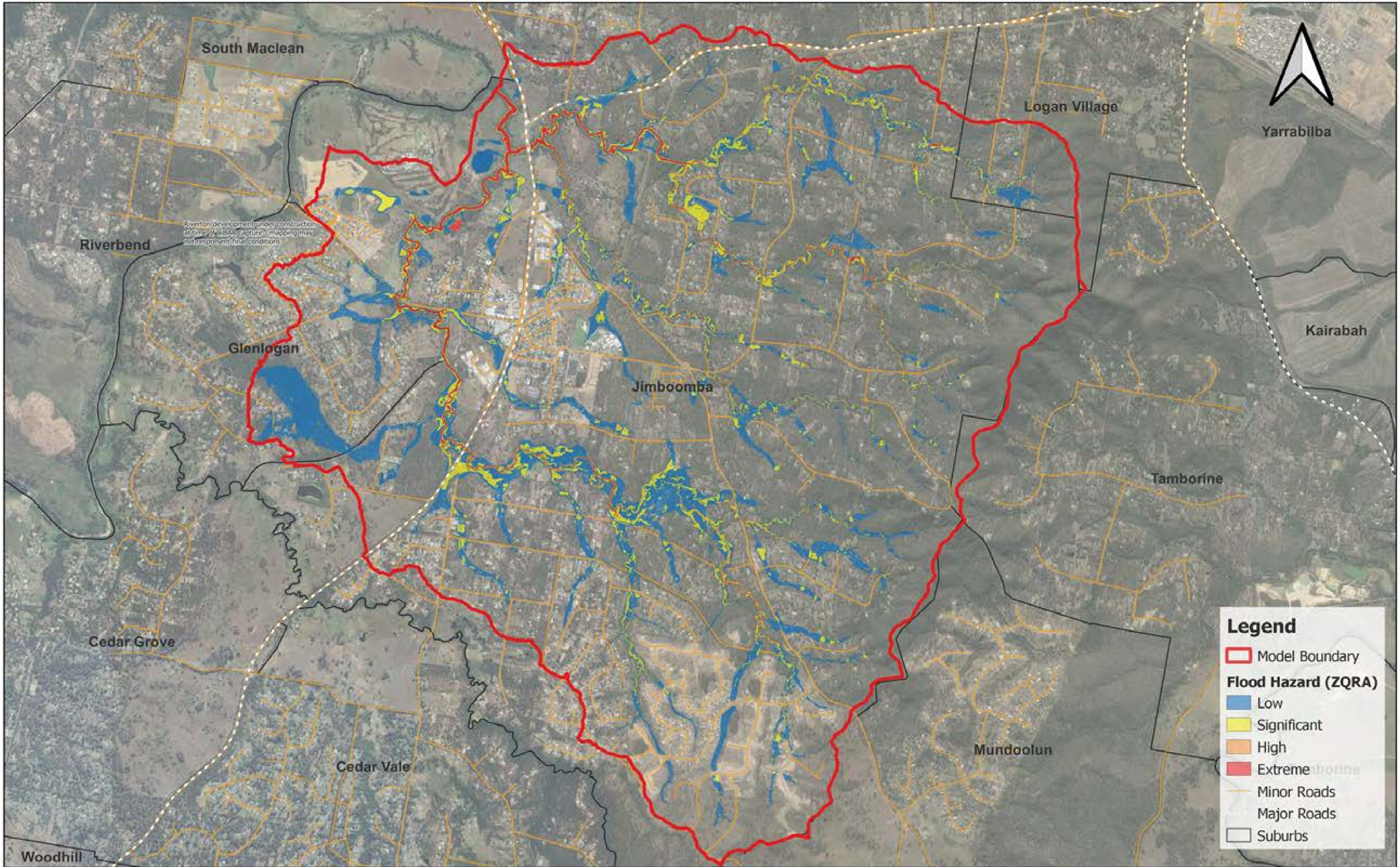
Appendix G.6.1

Henderson Creek Flood Study Update
1:2 AEP Flood Hazard (ZQRA)

Appendix G.6.1



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0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DISCLAIMER
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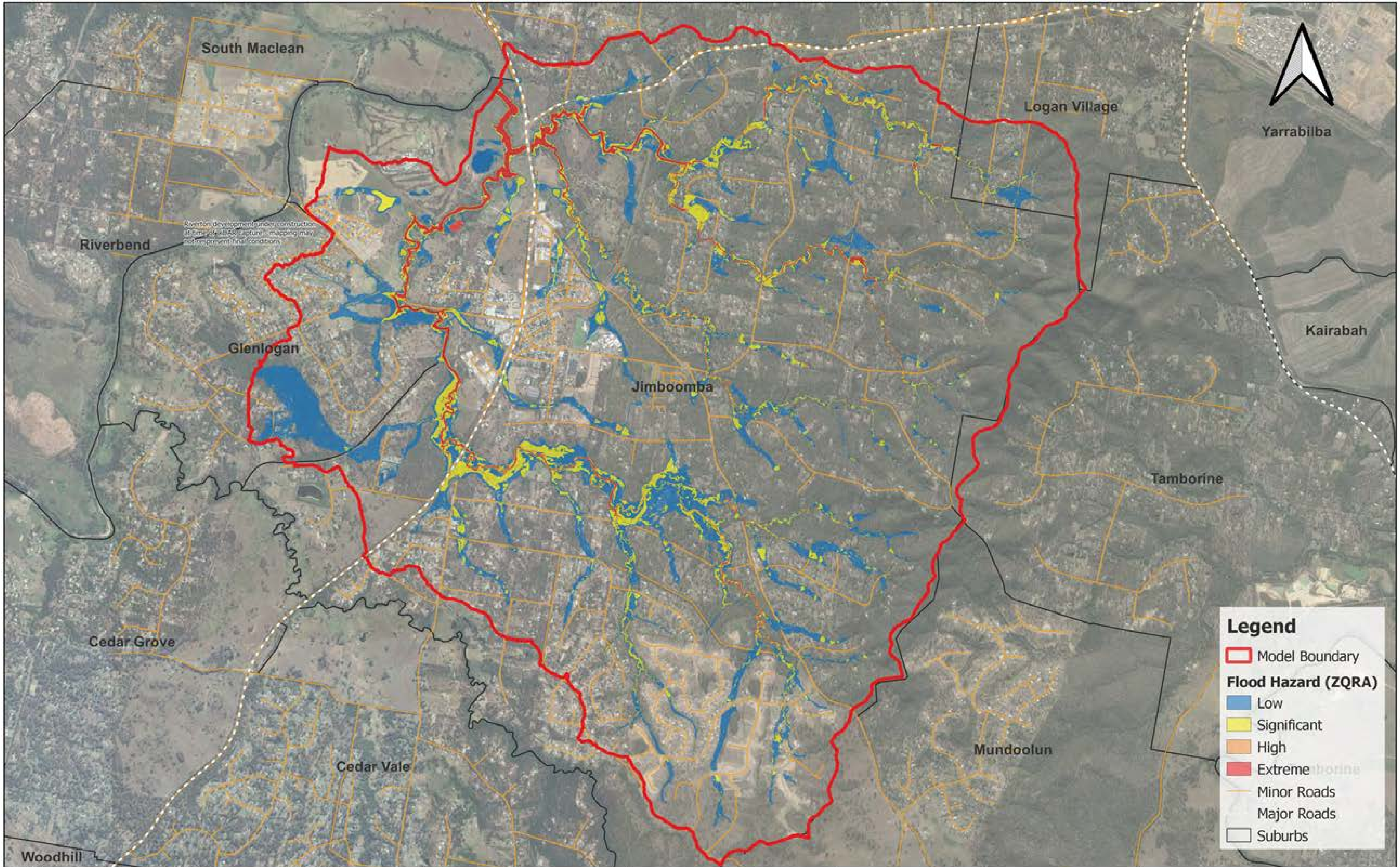
Appendix G.6.2

Henderson Creek Flood Study Update
1:5 AEP Flood Hazard (ZQRA)

Appendix G.6.2

M:\Projects\M9000_Logan_City_Council\M9000_083 "Henderson Ck FS 2022\05 Design\GIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DATA SOURCE
QLD Government Open Data Source

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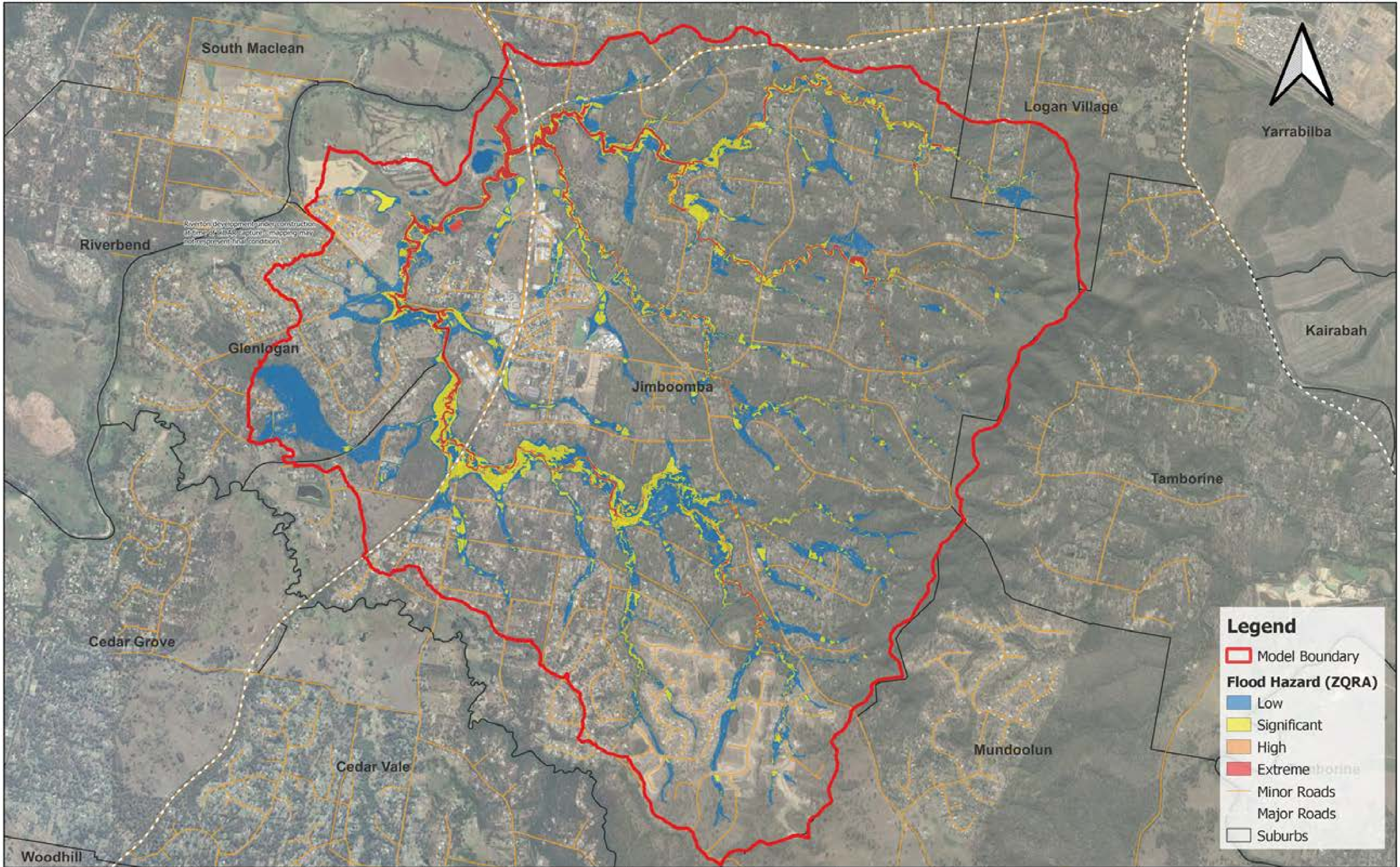
Appendix G.6.3

Henderson Creek Flood Study Update
1:10 AEP Flood Hazard (ZQRA)

Appendix G.6.3



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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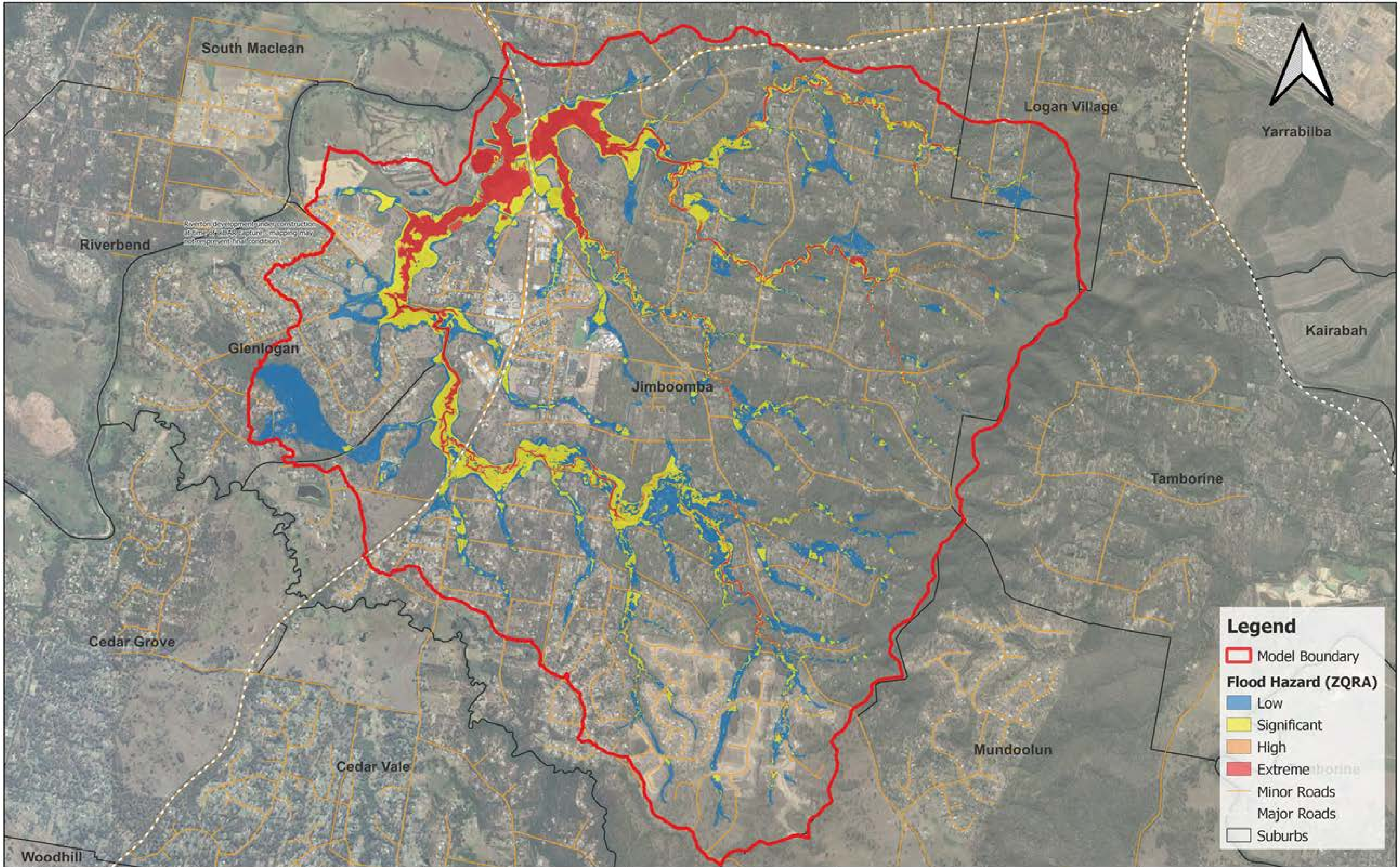
Appendix G.6.4

Henderson Creek Flood Study Update
1:20 AEP Flood Hazard (ZQRA)

Appendix G.6.4

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DISCLAIMER

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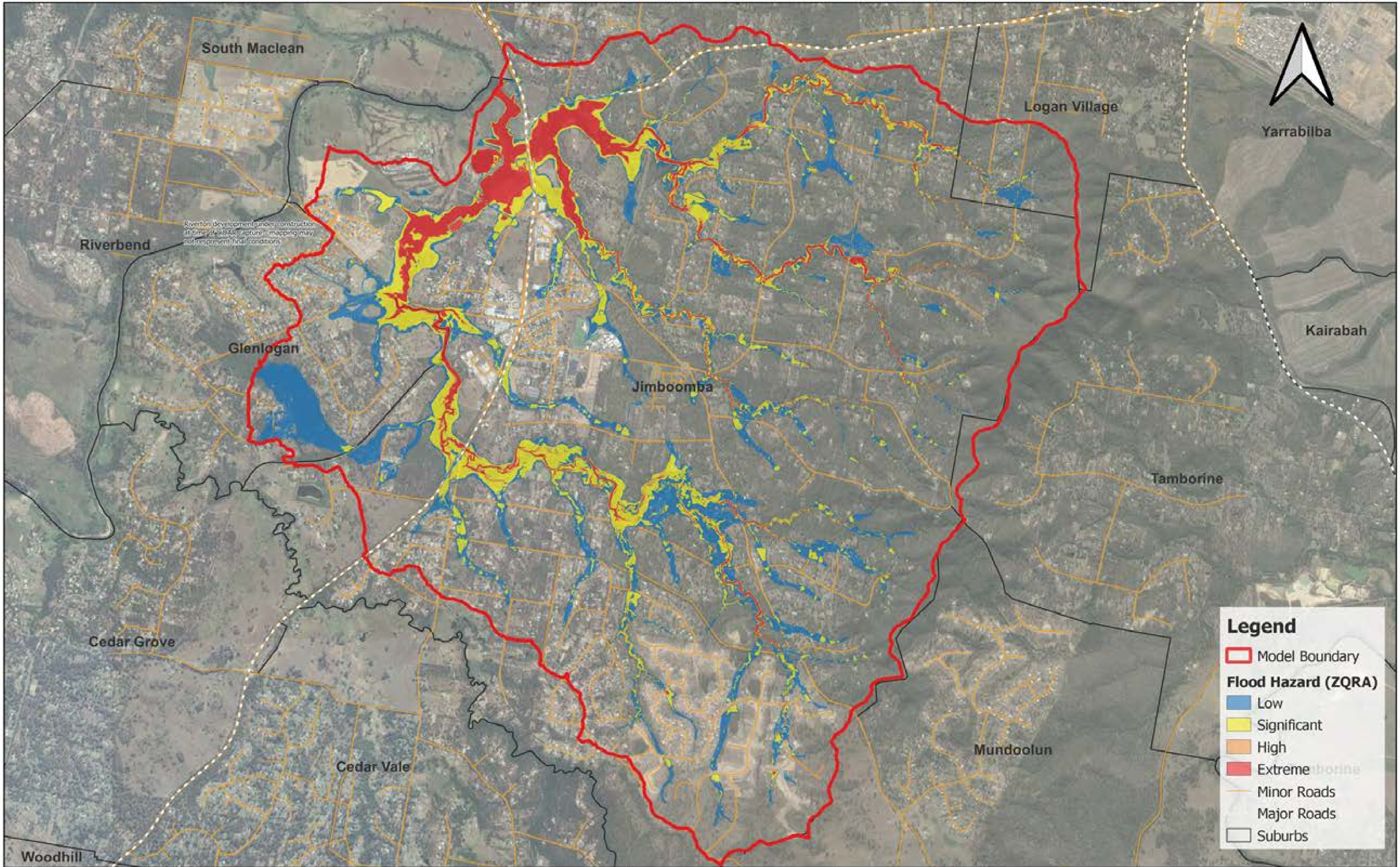
Appendix G.6.5

Henderson Creek Flood Study Update
1:50 AEP Flood Hazard (ZQRA)

Appendix G.6.5

M:\Projects\M9000_Logan_City_Council\M9000_083 "Henderson Ck FS 2022\05 Design\GIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DISCLAIMER
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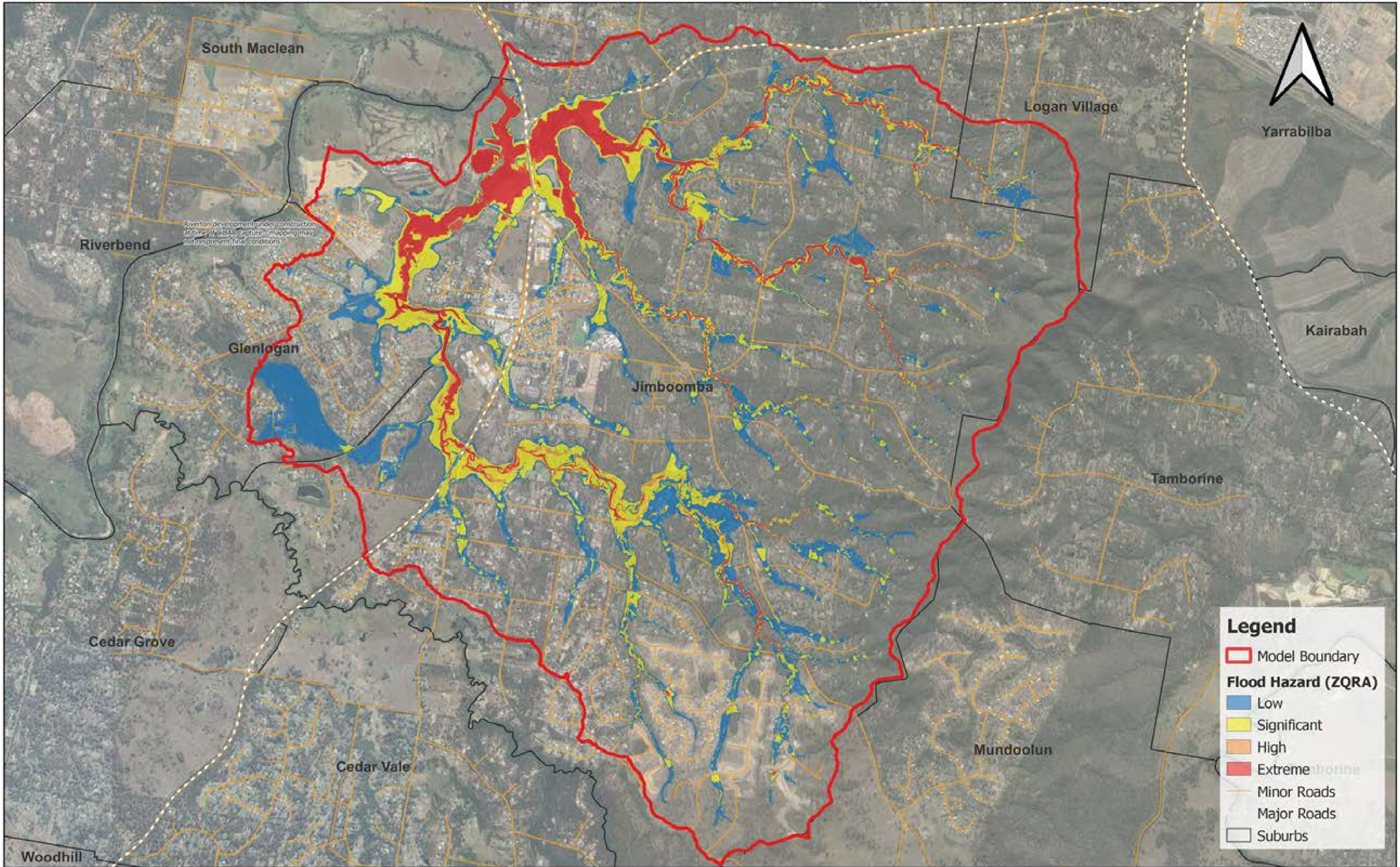
Appendix G.6.6

Henderson Creek Flood Study Update
1:100 AEP Flood Hazard (ZQRA)

Appendix G.6.6



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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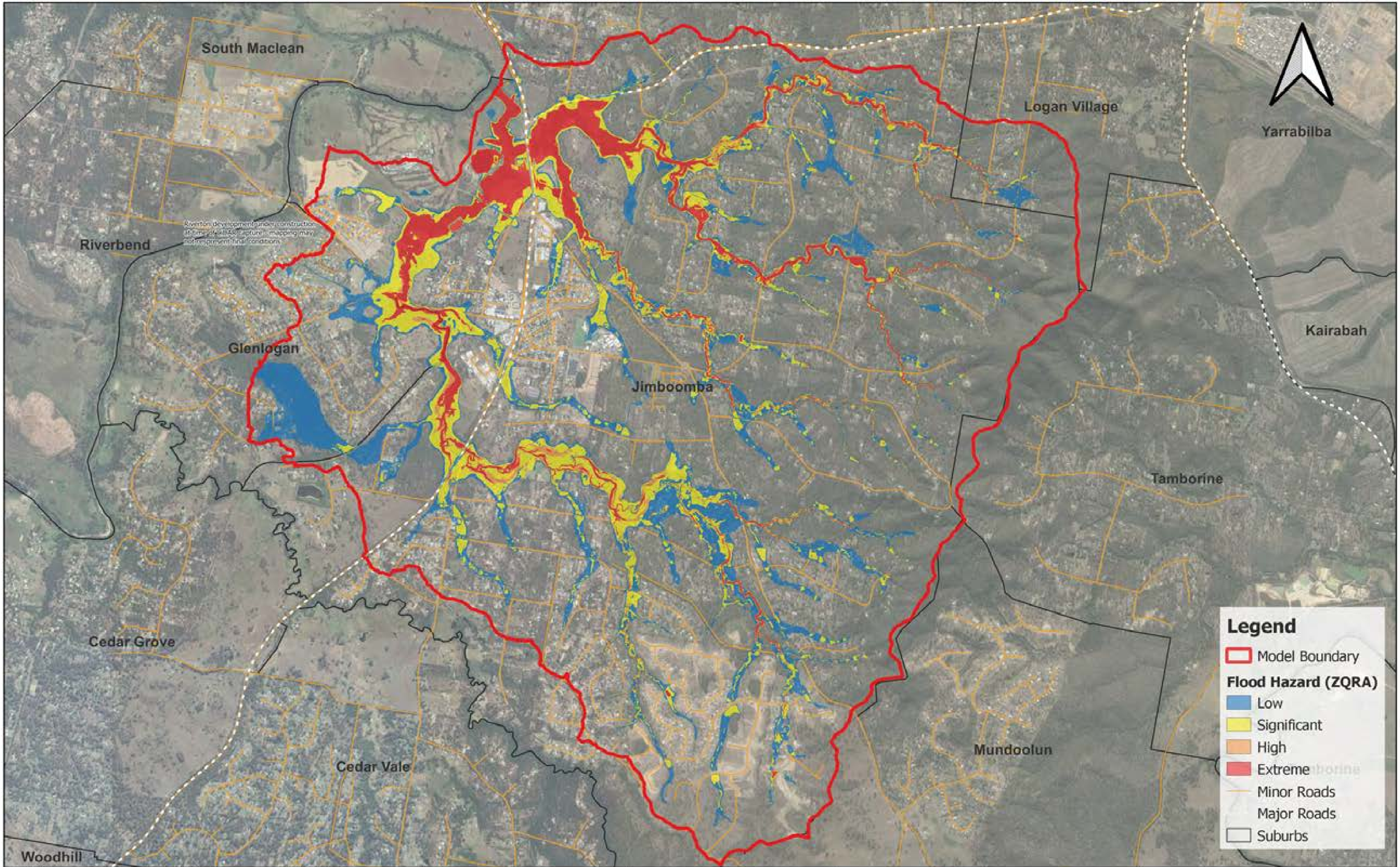
Appendix G.6.7

Henderson Creek Flood Study Update
1:200 AEP Flood Hazard (ZQRA)

Appendix G.6.7



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DISCLAIMER
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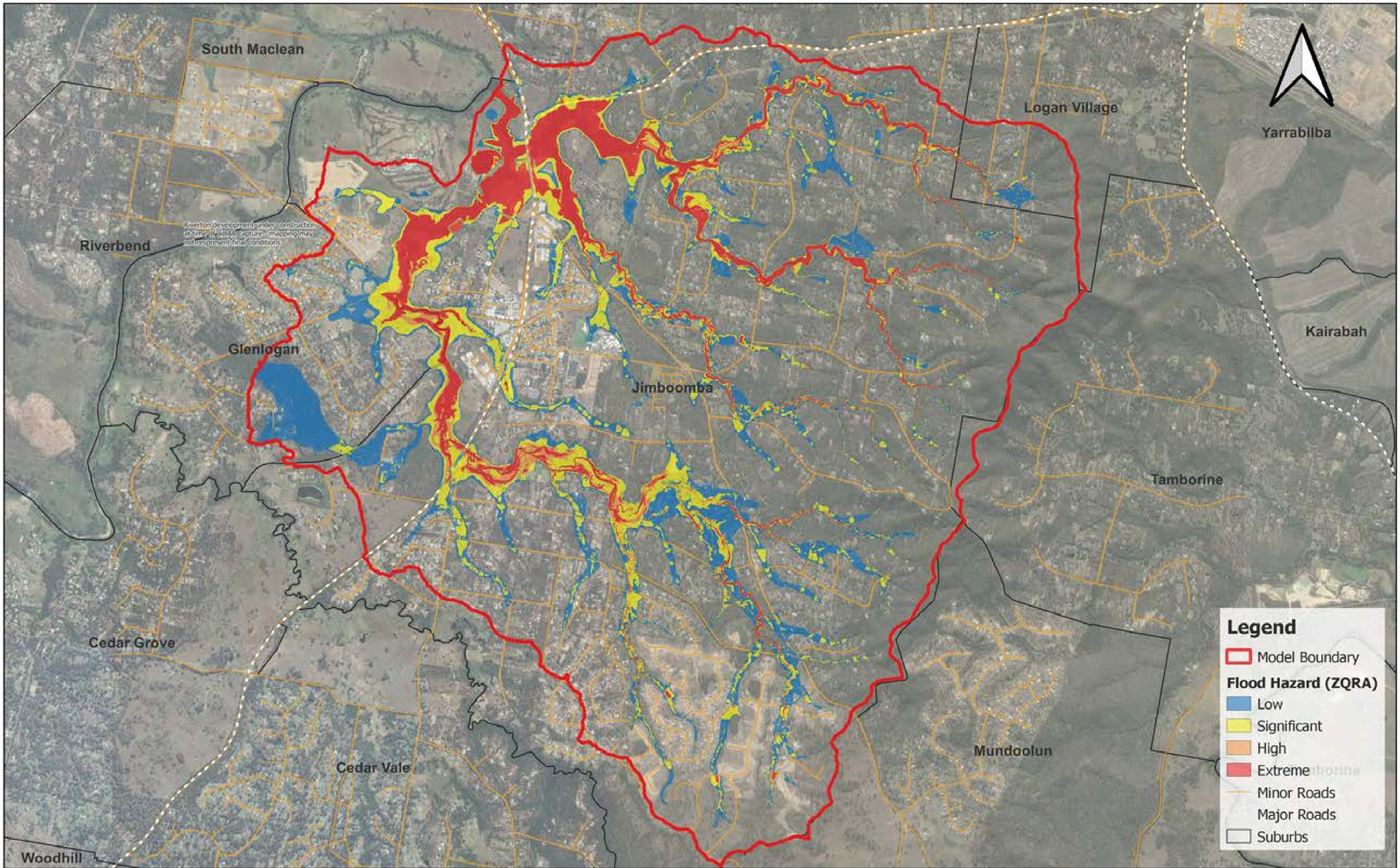
Appendix G.6.8

Henderson Creek Flood Study Update
1:500 AEP Flood Hazard (ZQRA)

Appendix G.6.8

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DISCLAIMER
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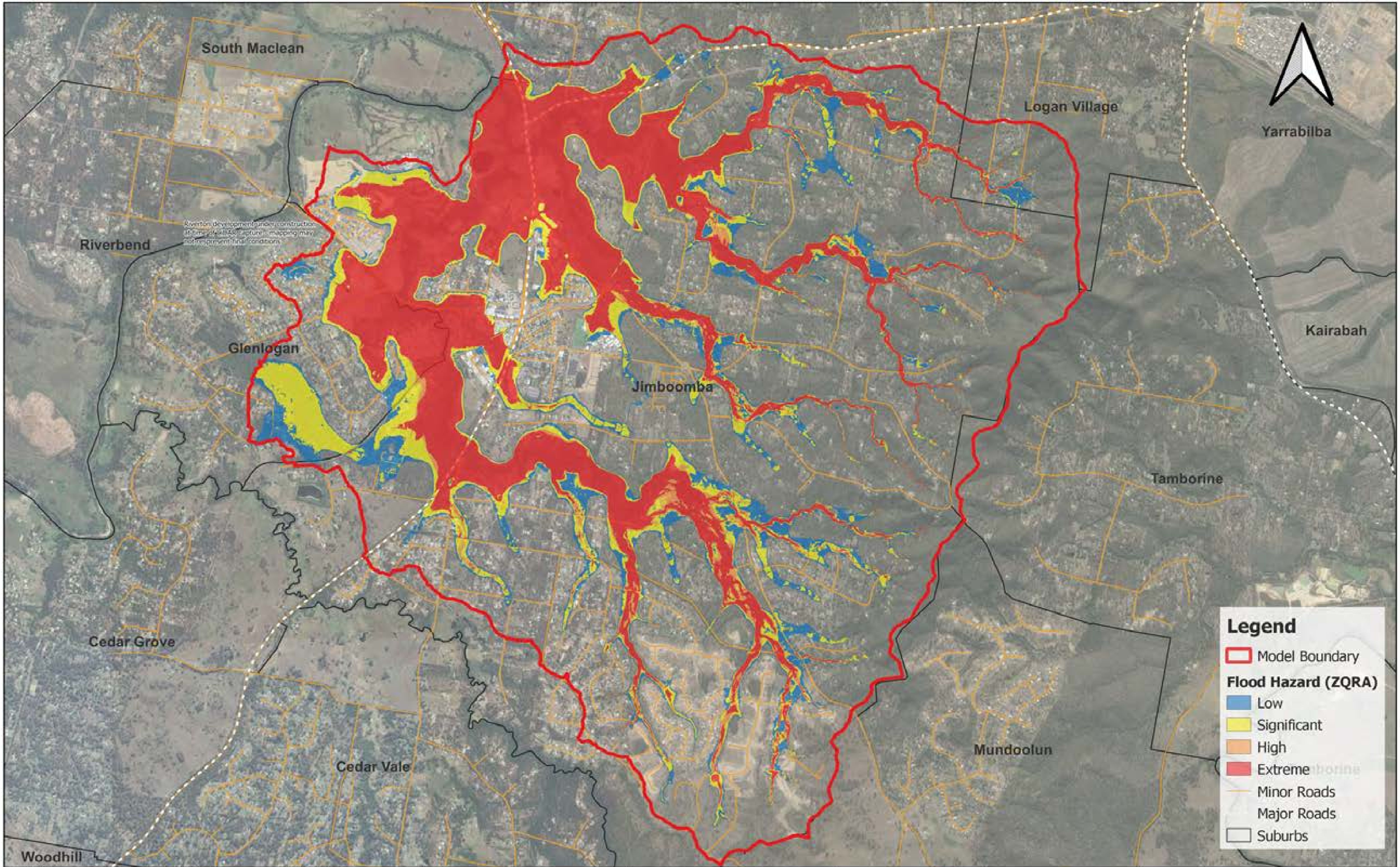
Appendix G.6.9

Henderson Creek Flood Study Update
1:2000 AEP Flood Hazard (ZQRA)

Appendix G.6.9

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	TS
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DISCLAIMER
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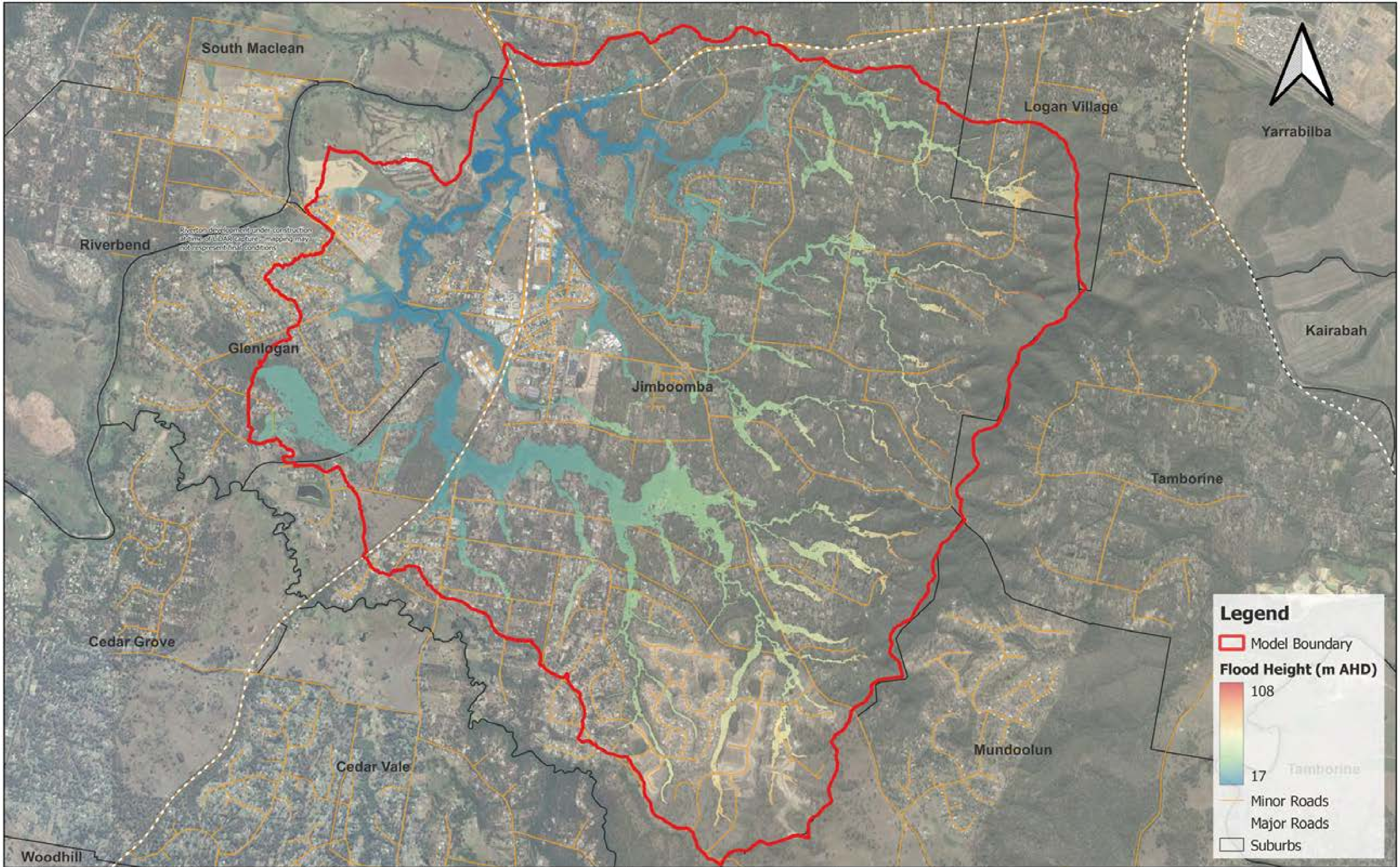
Appendix G.6.10

Henderson Creek Flood Study Update
PMF Flood Hazard (ZQRA)

Appendix G.6.10

Appendix H:
Climate Change Mapping



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DISCLAIMER
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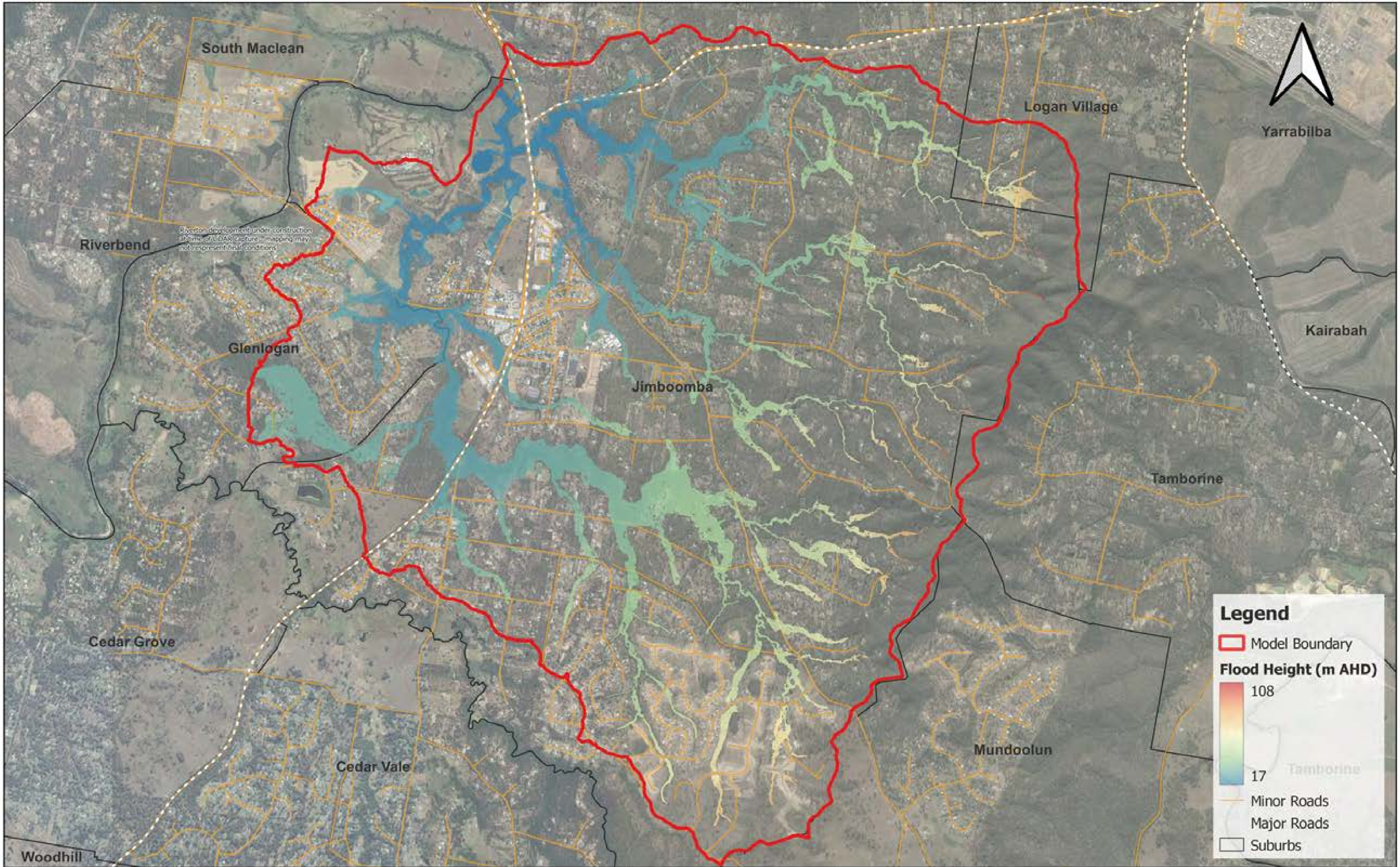
Appendix H.1.1

Henderson Creek Flood Study Update
1:5 AEP CC RCP4.5 Flood Height

Appendix H.1.1

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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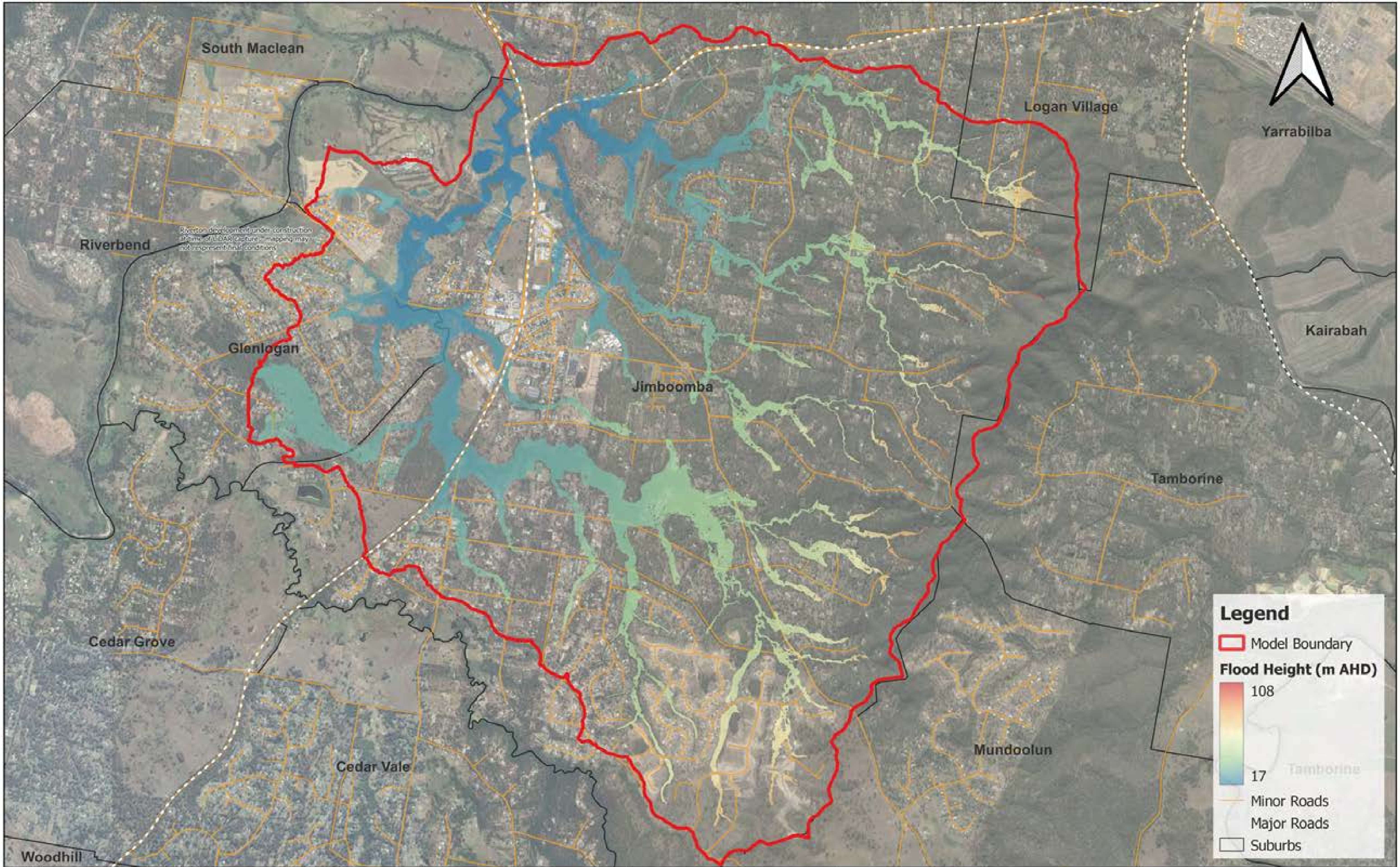
Appendix H.1.2

Henderson Creek Flood Study Update
1:10 AEP CC RCP4.5 Flood Height

Appendix H.1.2

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\GIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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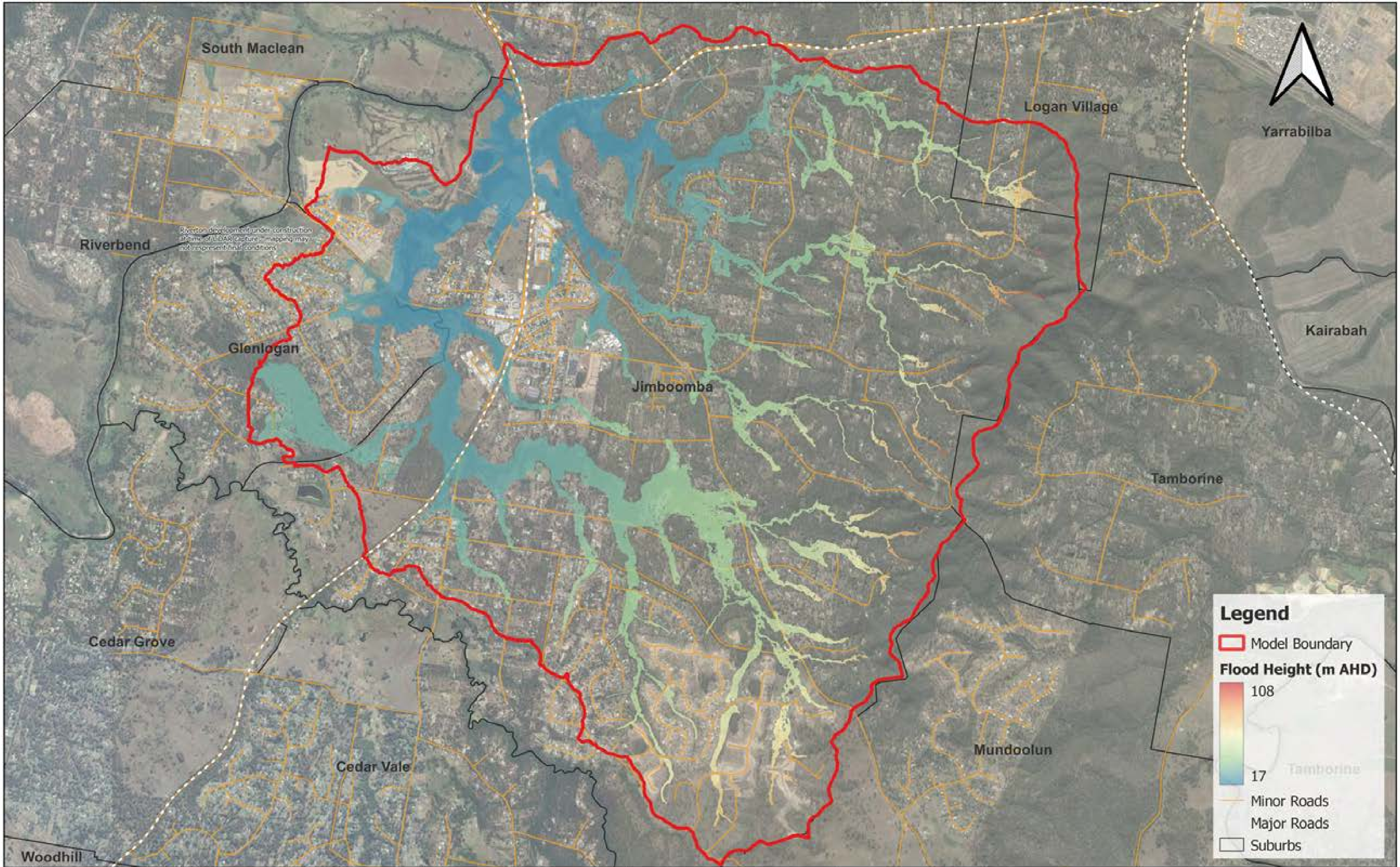
Appendix H.1.3

Henderson Creek Flood Study Update
1:20 AEP CC RCP4.5 Flood Height

Appendix H.1.3

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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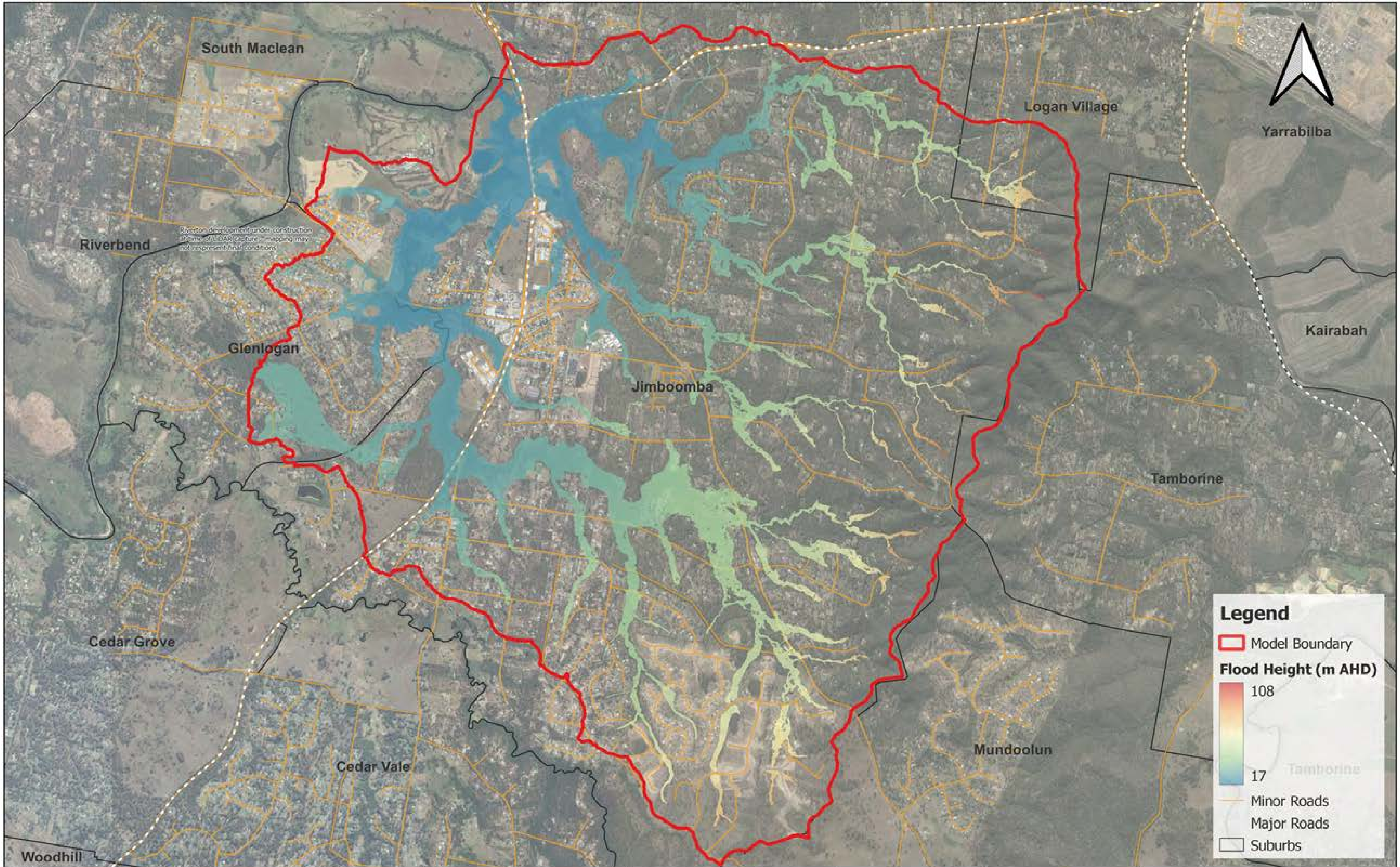
Appendix H.1.4

Henderson Creek Flood Study Update
1:50 AEP CC RCP4.5 Flood Height

Appendix H.1.4

M:\Projects\M9000_Logan_City_Council\M9000_083 "Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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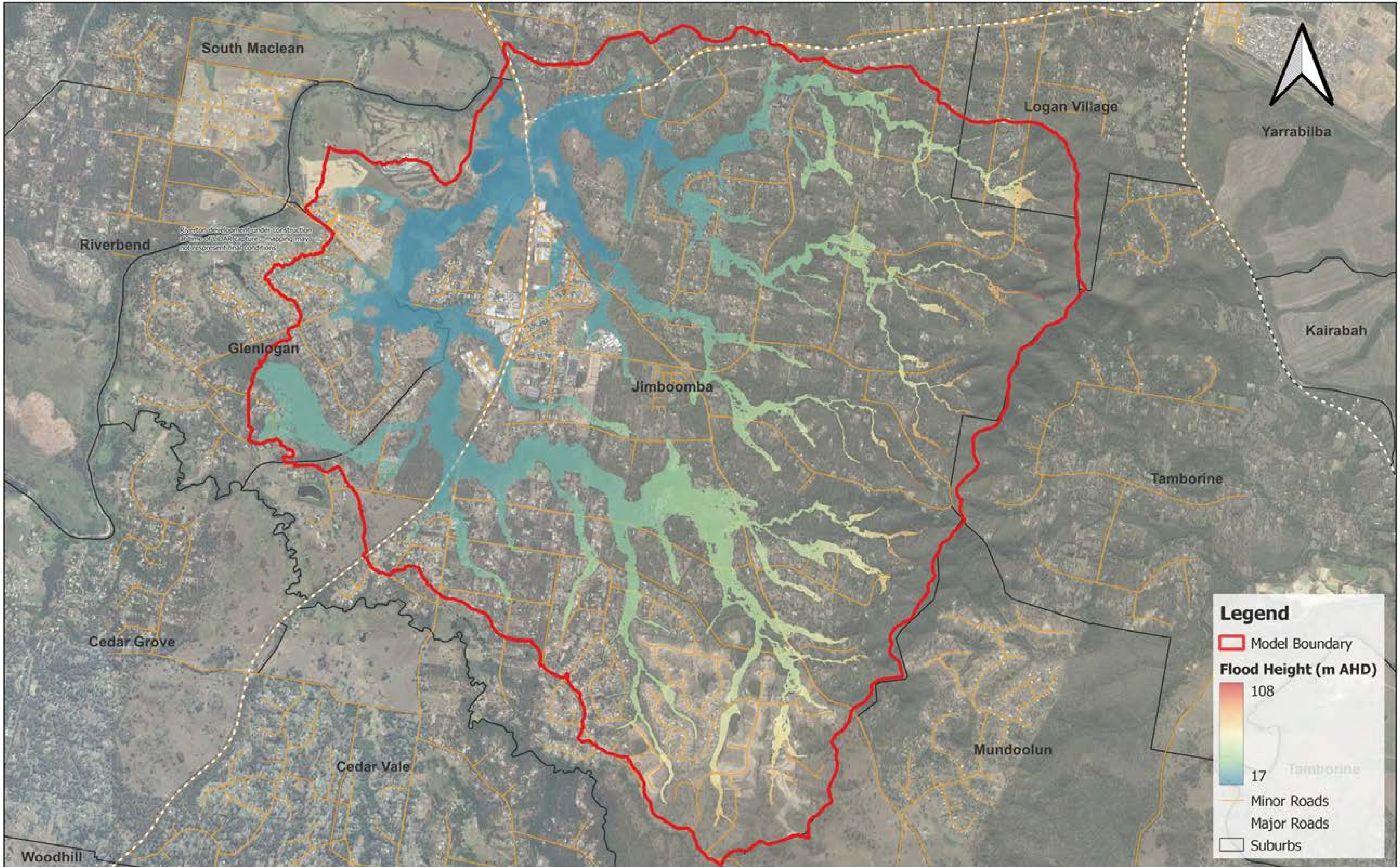
Appendix H.1.5

Henderson Creek Flood Study Update
1:100 AEP CC RCP4.5 Flood Height

Appendix H.1.5

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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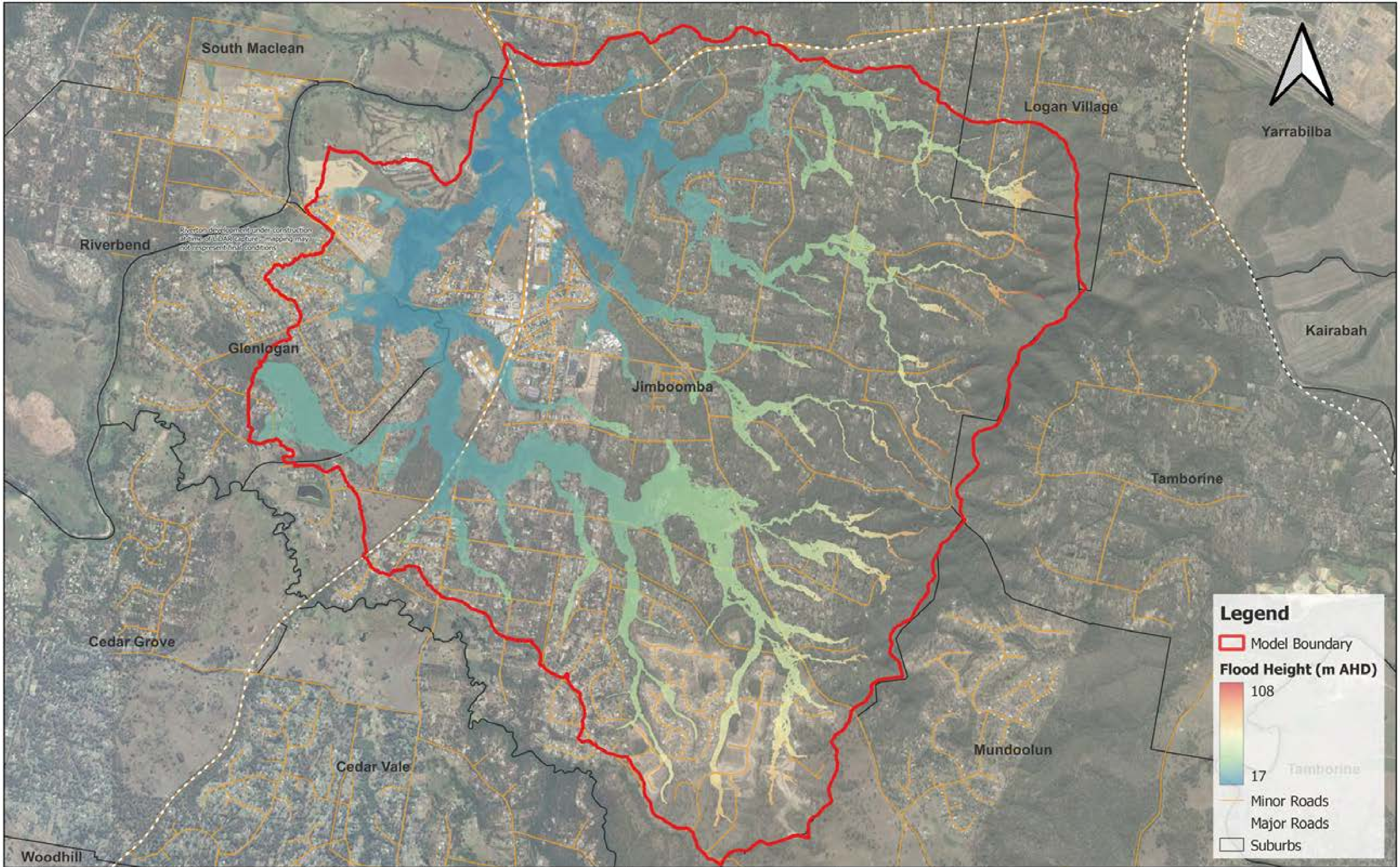
Appendix H.1.6

Henderson Creek Flood Study Update
1:200 AEP CC RCP4.5 Flood Height

Appendix H.1.6

M:\Projects\M9000_Logan_City_Council\M9000_083 Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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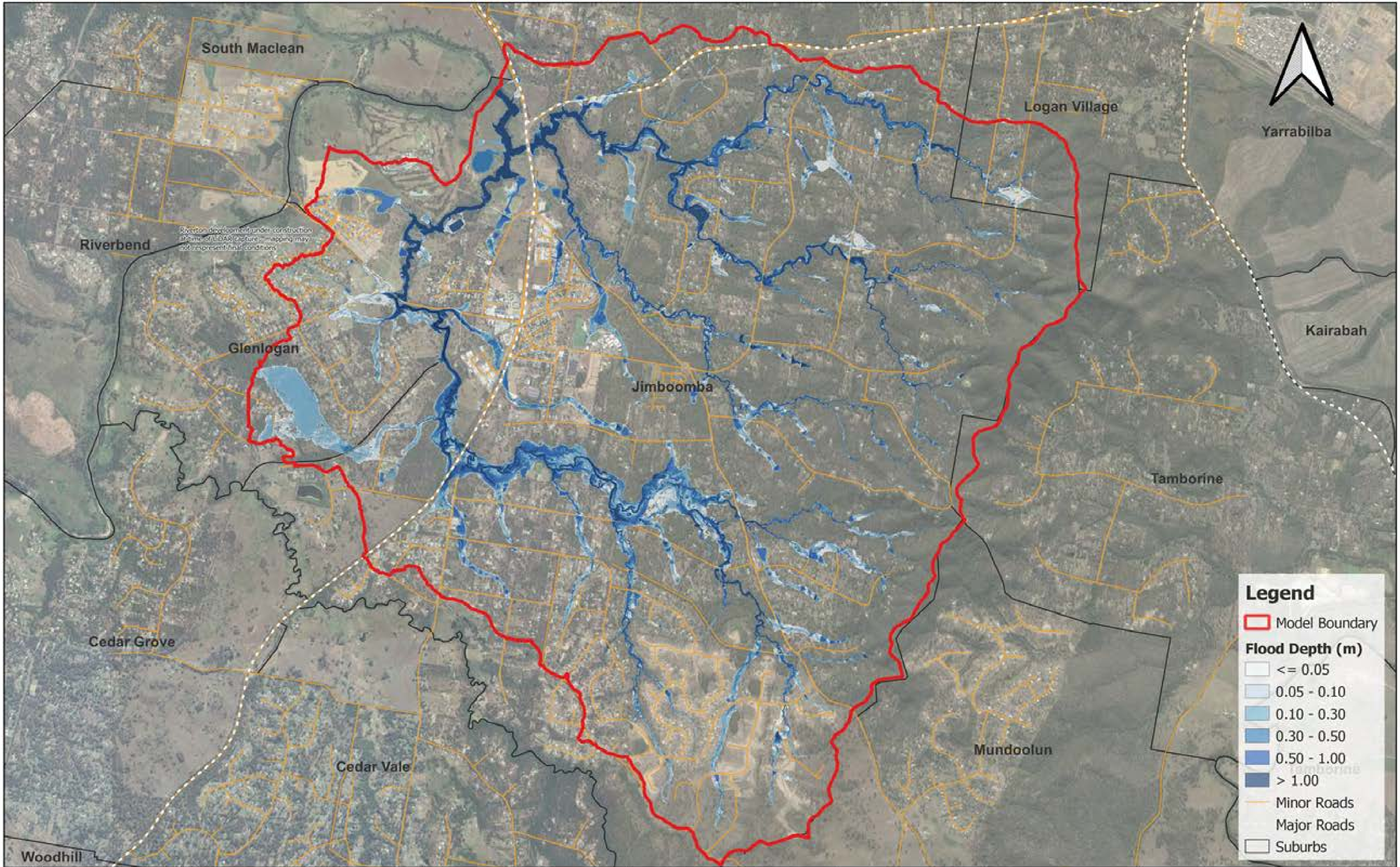
Appendix H.1.7

Henderson Creek Flood Study Update
1:500 AEP CC RCP4.5 Flood Height

Appendix H.1.7

M:\Projects\M9000_Logan_City_Council\M9000_083 Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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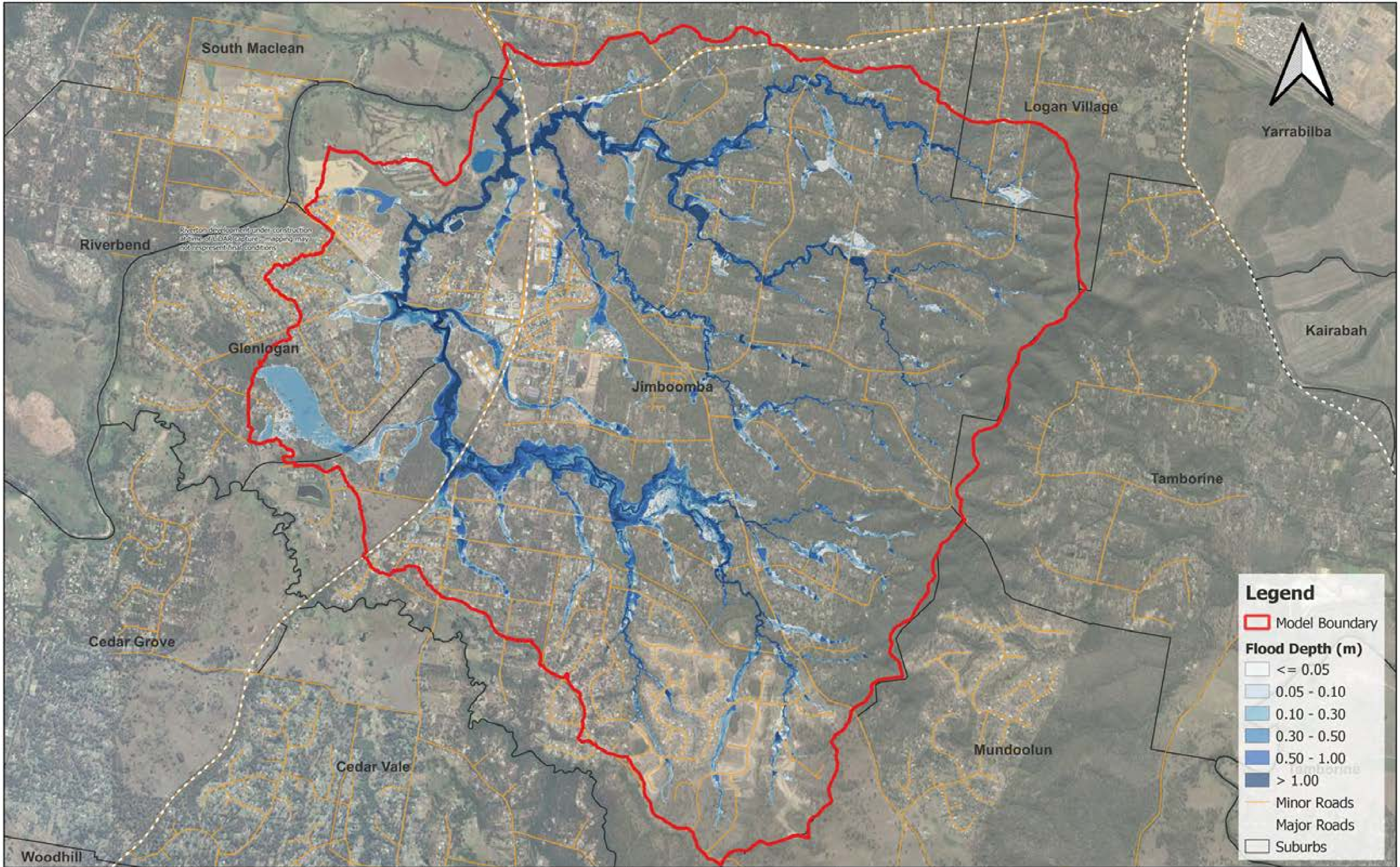
Appendix H.2.1

Henderson Creek Flood Study Update
1:5 AEP CC RCP4.5 Flood Depth

Appendix H.2.1

M:\Projects\M9000_Logan_City_Council\M9000_083 Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DISCLAIMER
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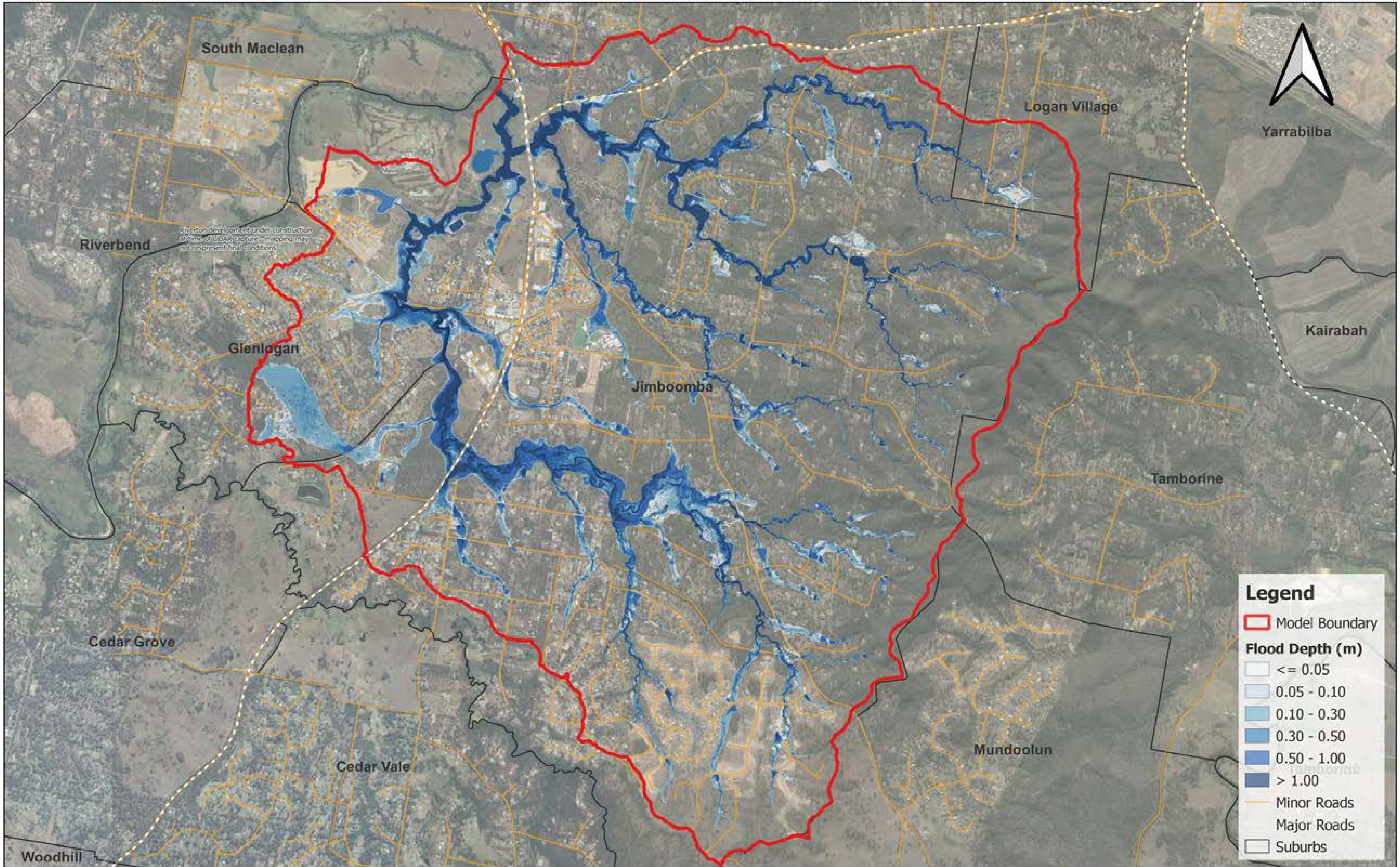
Appendix H.2.2

Henderson Creek Flood Study Update
1:10 AEP CC RCP4.5 Flood Depth

Appendix H.2.2

M:\Projects\M9000_Logan_City_Council\M9000_083 "Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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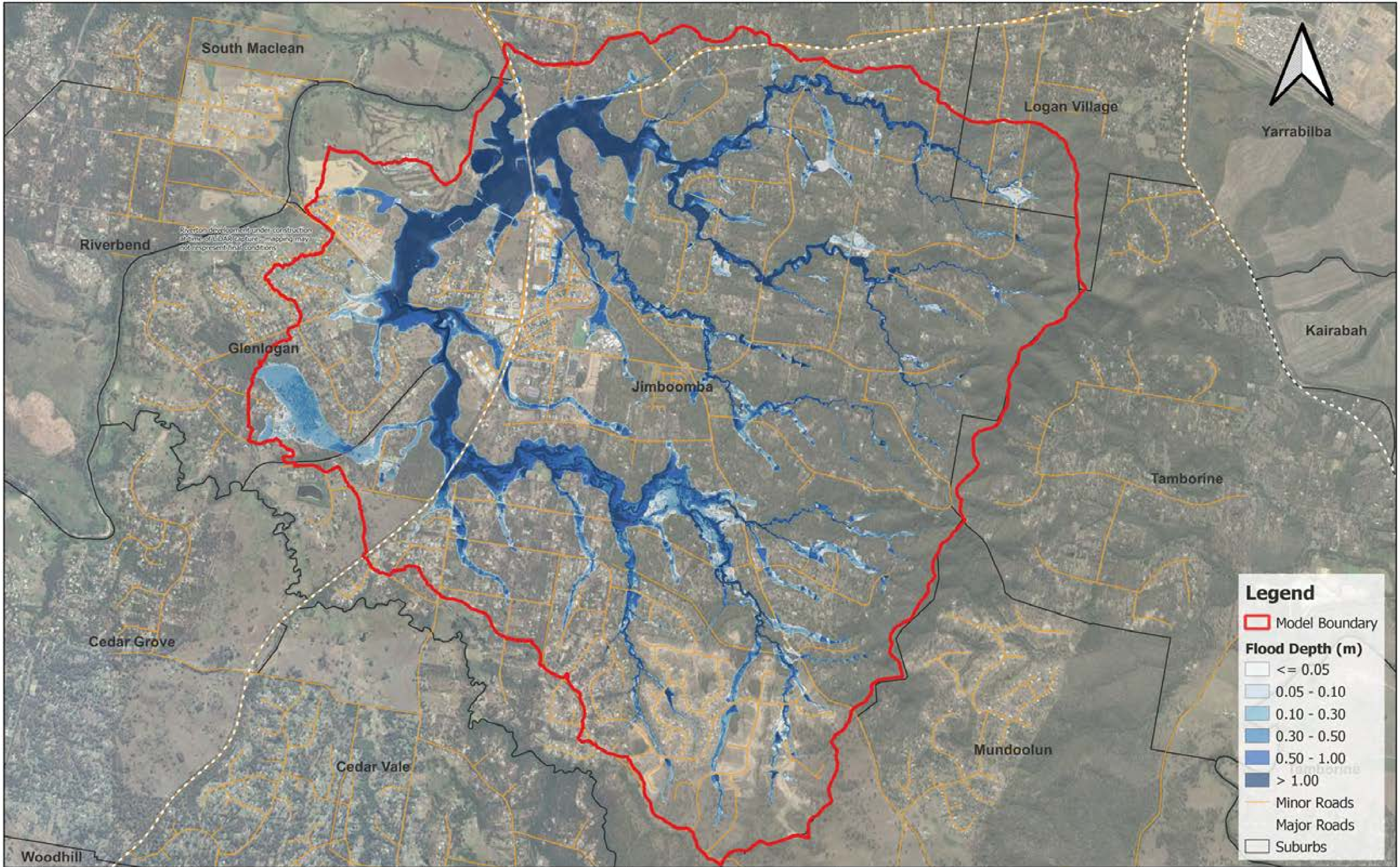
Appendix H.2.3

Henderson Creek Flood Study Update
1:20 AEP CC RCP4.5 Flood Depth

Appendix H.2.3

M:\Projects\M9000_Logan_City_Council\M9000_083 Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



Tamborine

R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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DATA SOURCE
QLD Government Open Data Source

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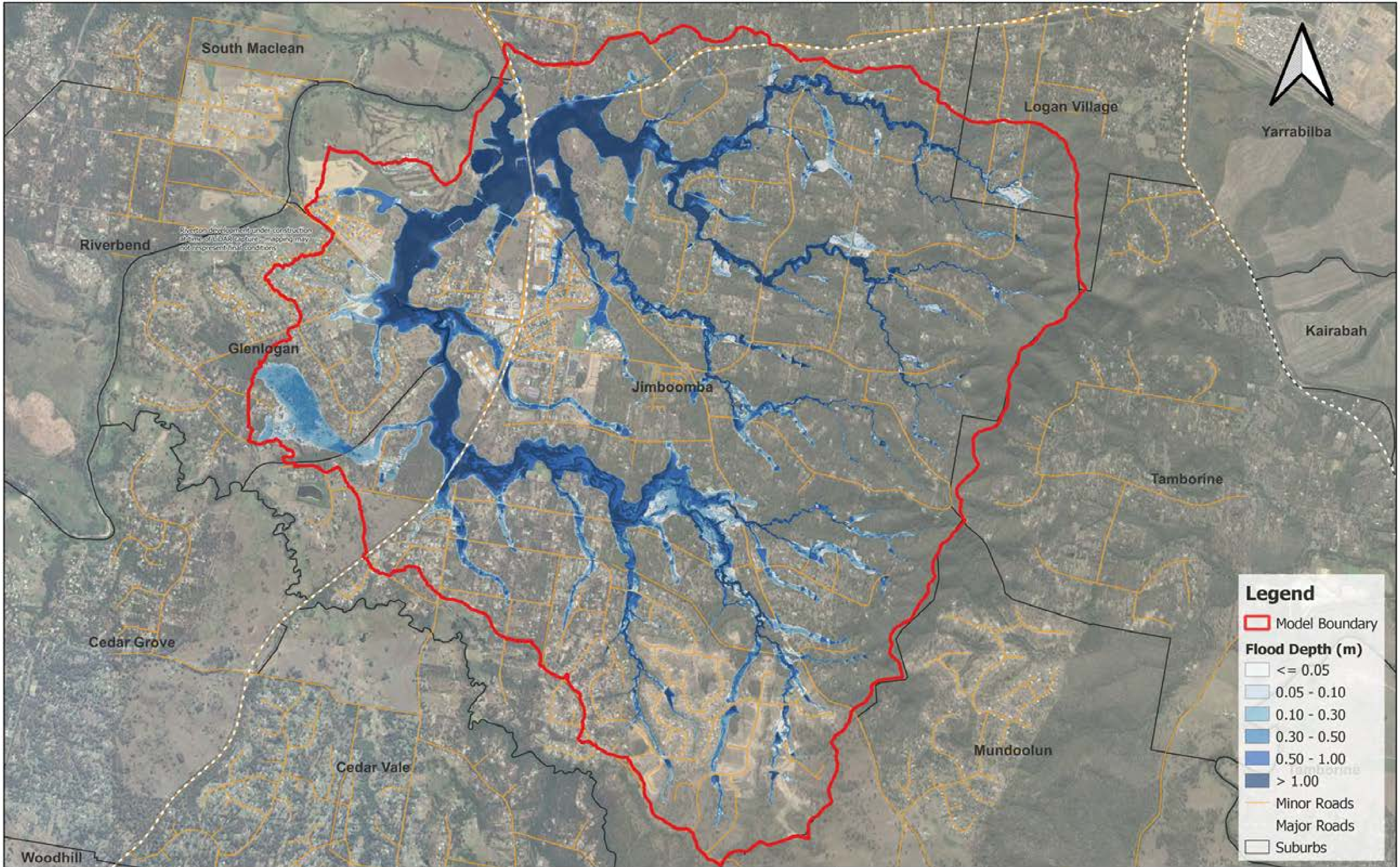
Appendix H.2.4

Henderson Creek Flood Study Update
1:50 AEP CC RCP4.5 Flood Depth

Appendix H.2.4

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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QLD Government Open Data Source

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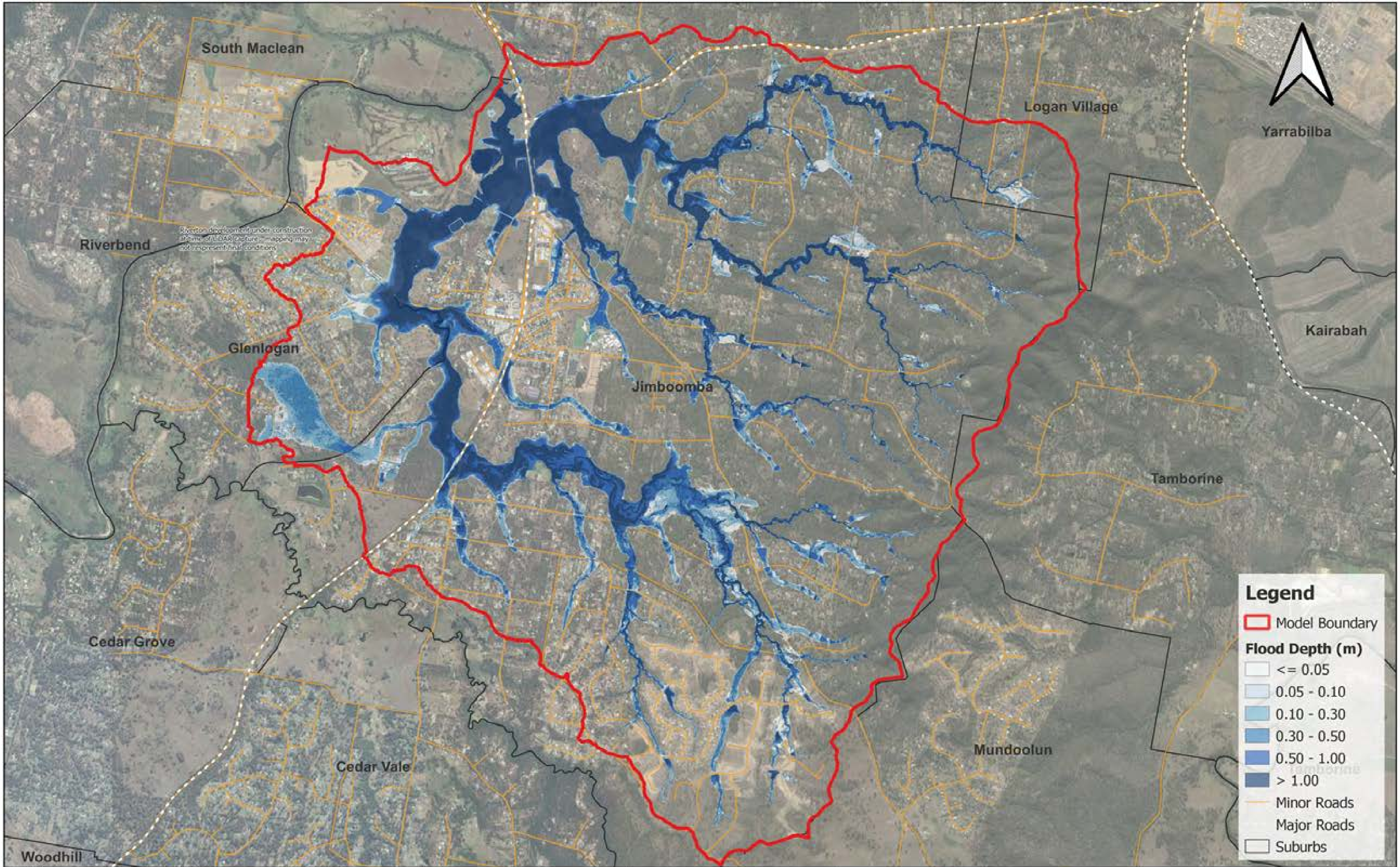
Appendix H.2.5

Henderson Creek Flood Study Update
1:100 AEP CC RCP4.5 Flood Depth

Appendix H.2.5

M:\Projects\M9000_Logan_City_Council\M9000_083 "Henderson Ck FS 2022\05 Design\GIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DATA SOURCE
QLD Government Open Data Source

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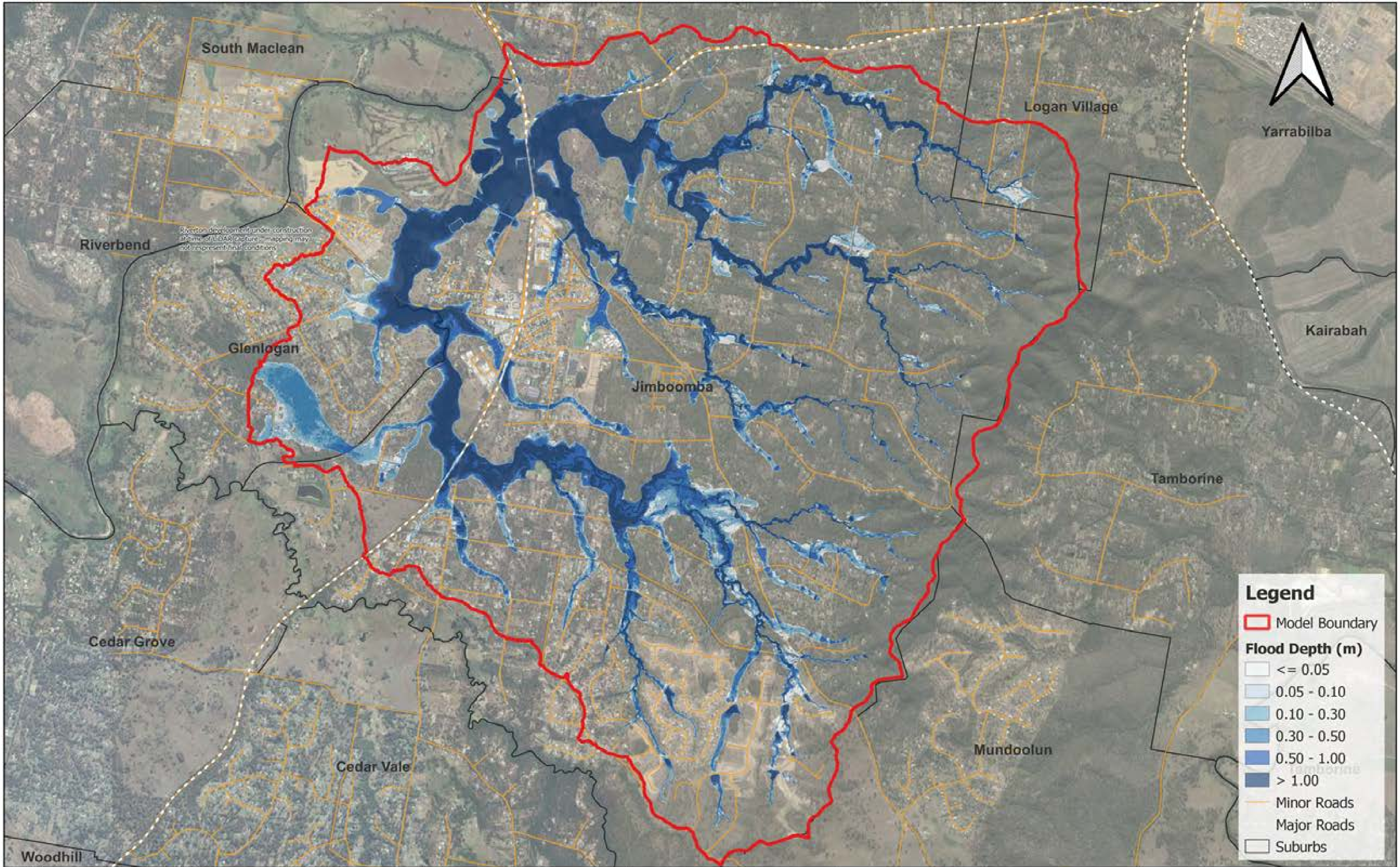
Appendix H.2.6

Henderson Creek Flood Study Update
1:200 AEP CC RCP4.5 Flood Depth

Appendix H.2.6

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\GIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DISCLAIMER
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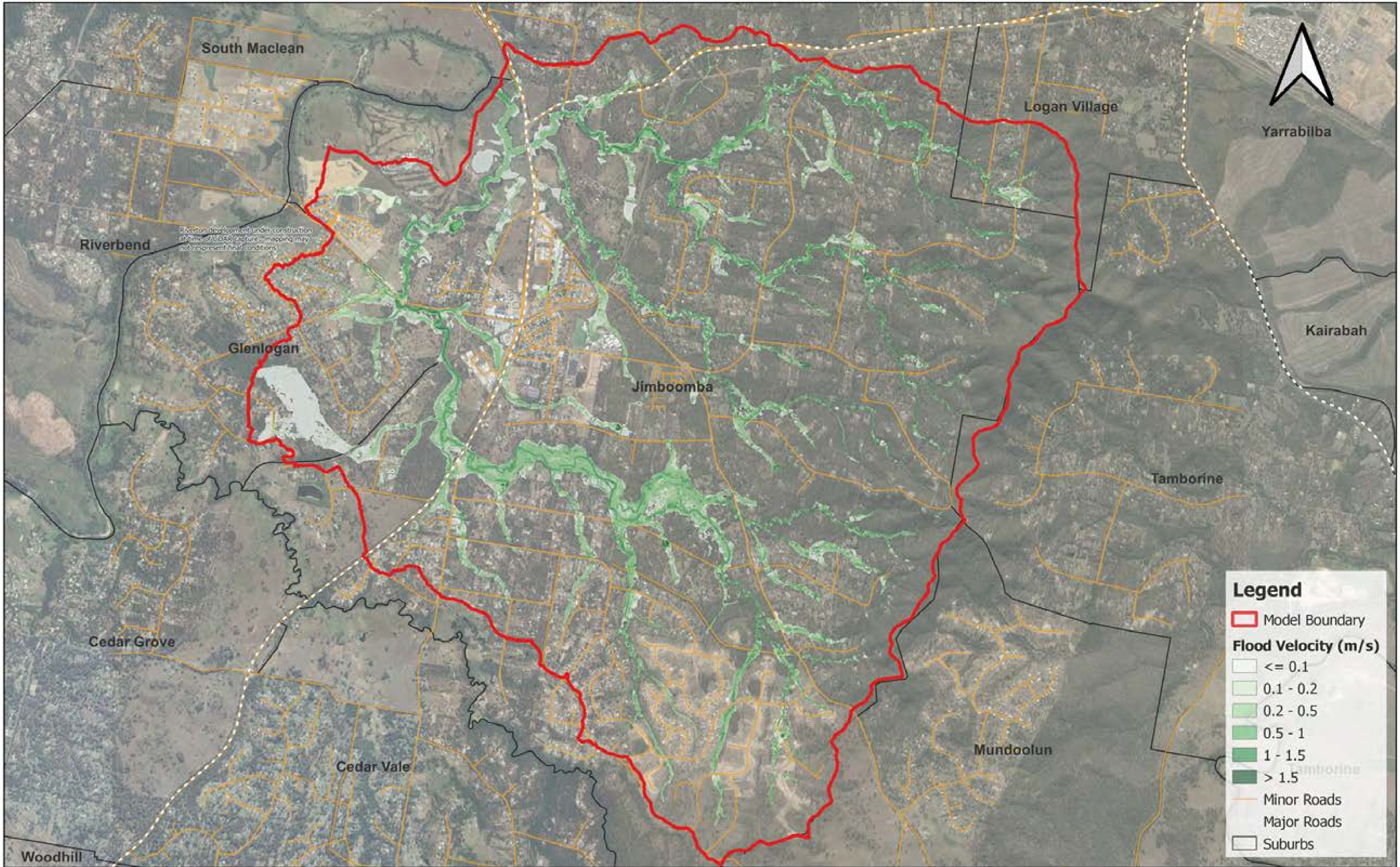
Appendix H.2.7

Henderson Creek Flood Study Update
1:500 AEP CC RCP4.5 Flood Depth

Appendix H.2.7

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\GIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DISCLAIMER
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DATA SOURCE
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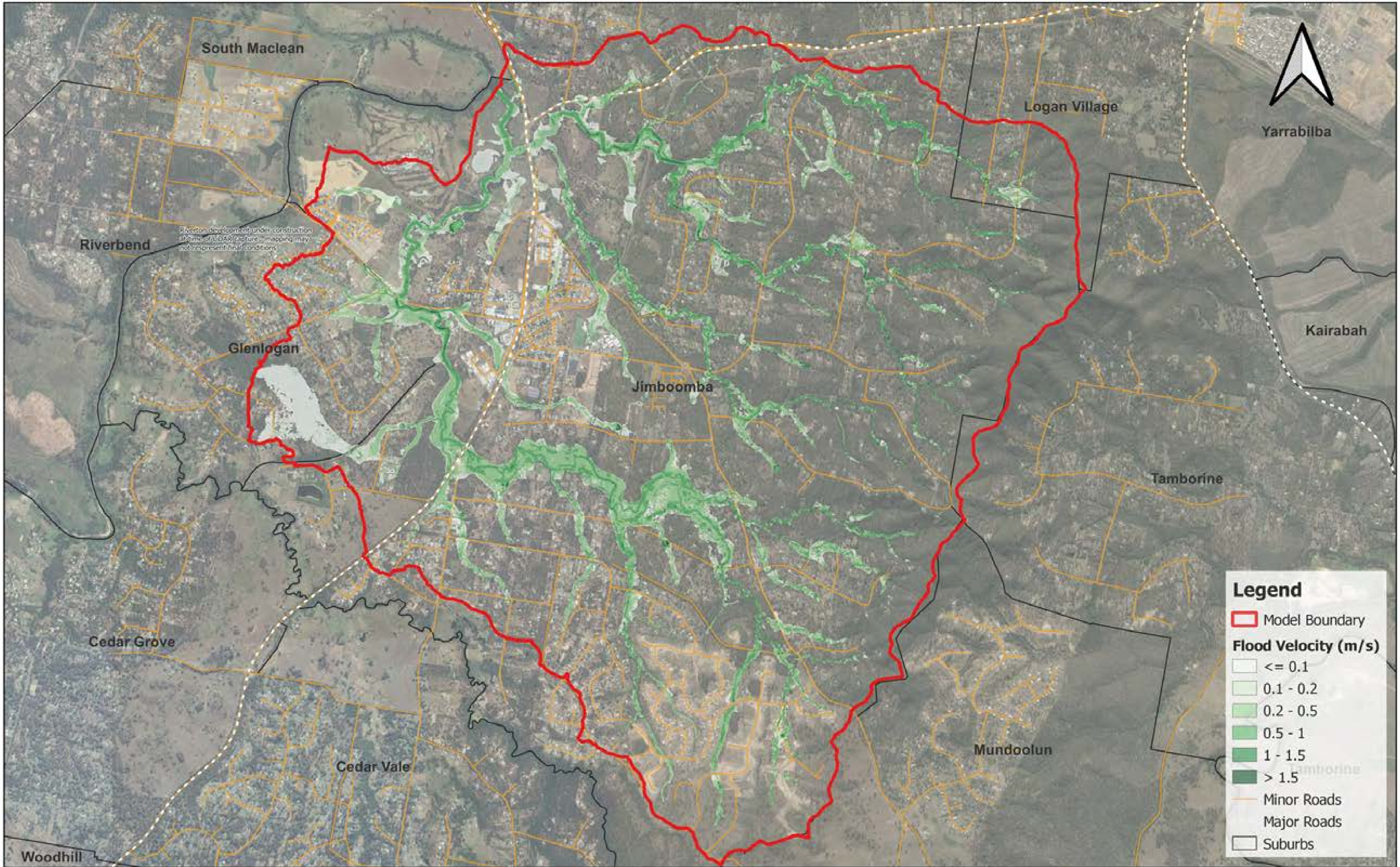
Appendix H.3.1

Henderson Creek Flood Study Update
1:5 AEP CC RCP4.5 Flood Velocity

Appendix H.3.1

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\GIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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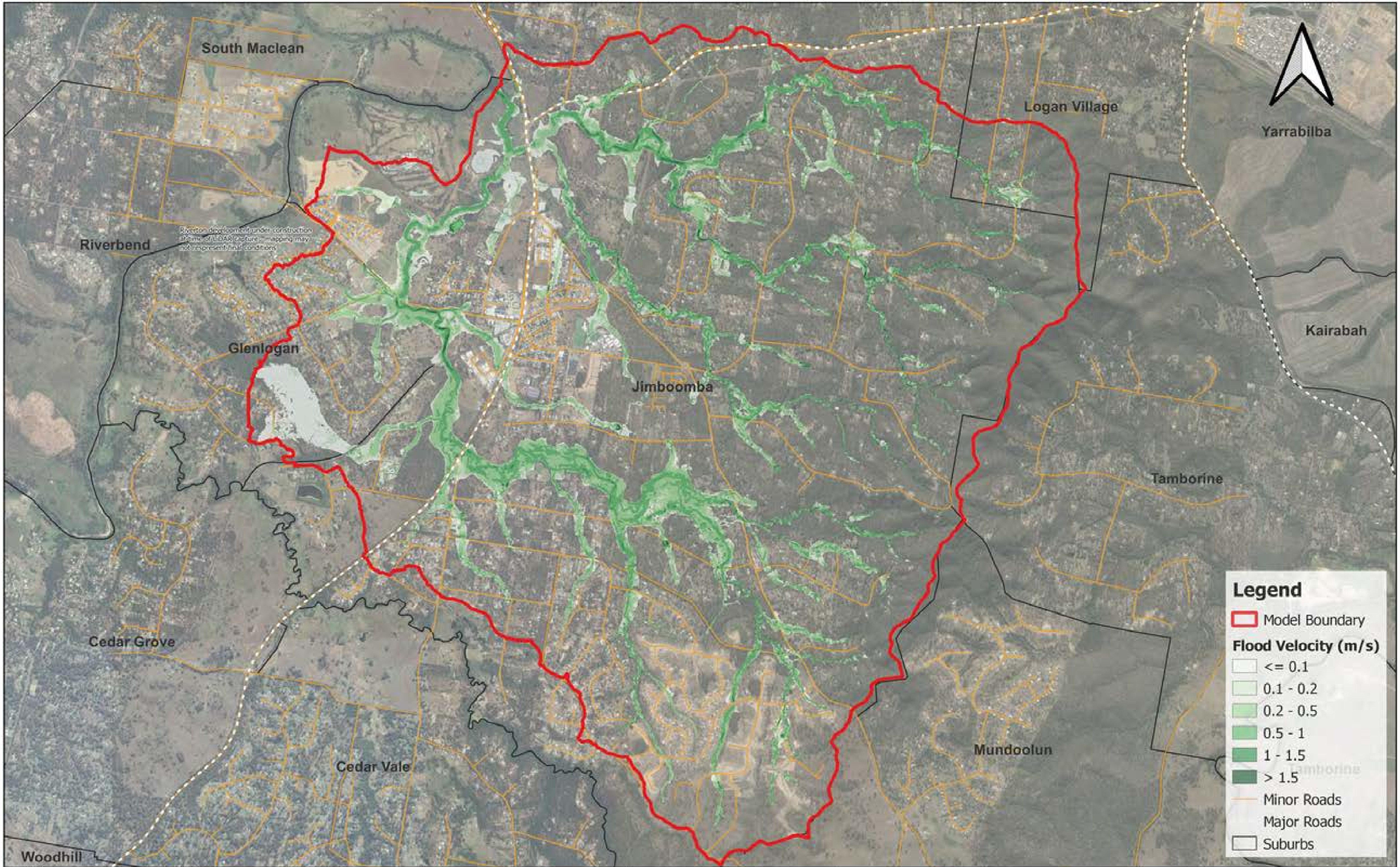
Appendix H.3.2

Henderson Creek Flood Study Update
1:10 AEP CC RCP4.5 Flood Velocity

Appendix H.3.2

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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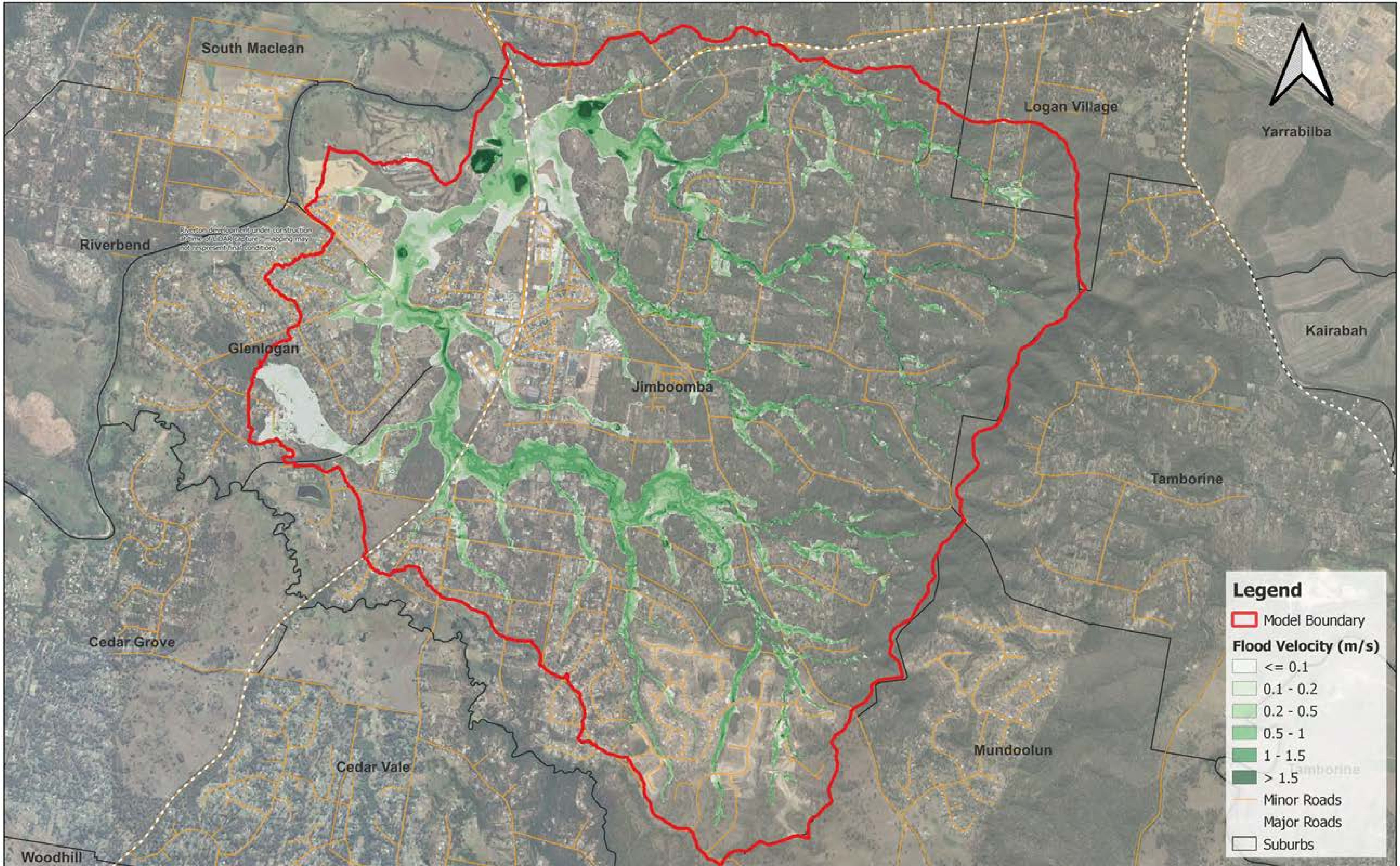
Appendix H.3.3

Henderson Creek Flood Study Update
1:20 AEP CC RCP4.5 Flood Velocity

Appendix H.3.3

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



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1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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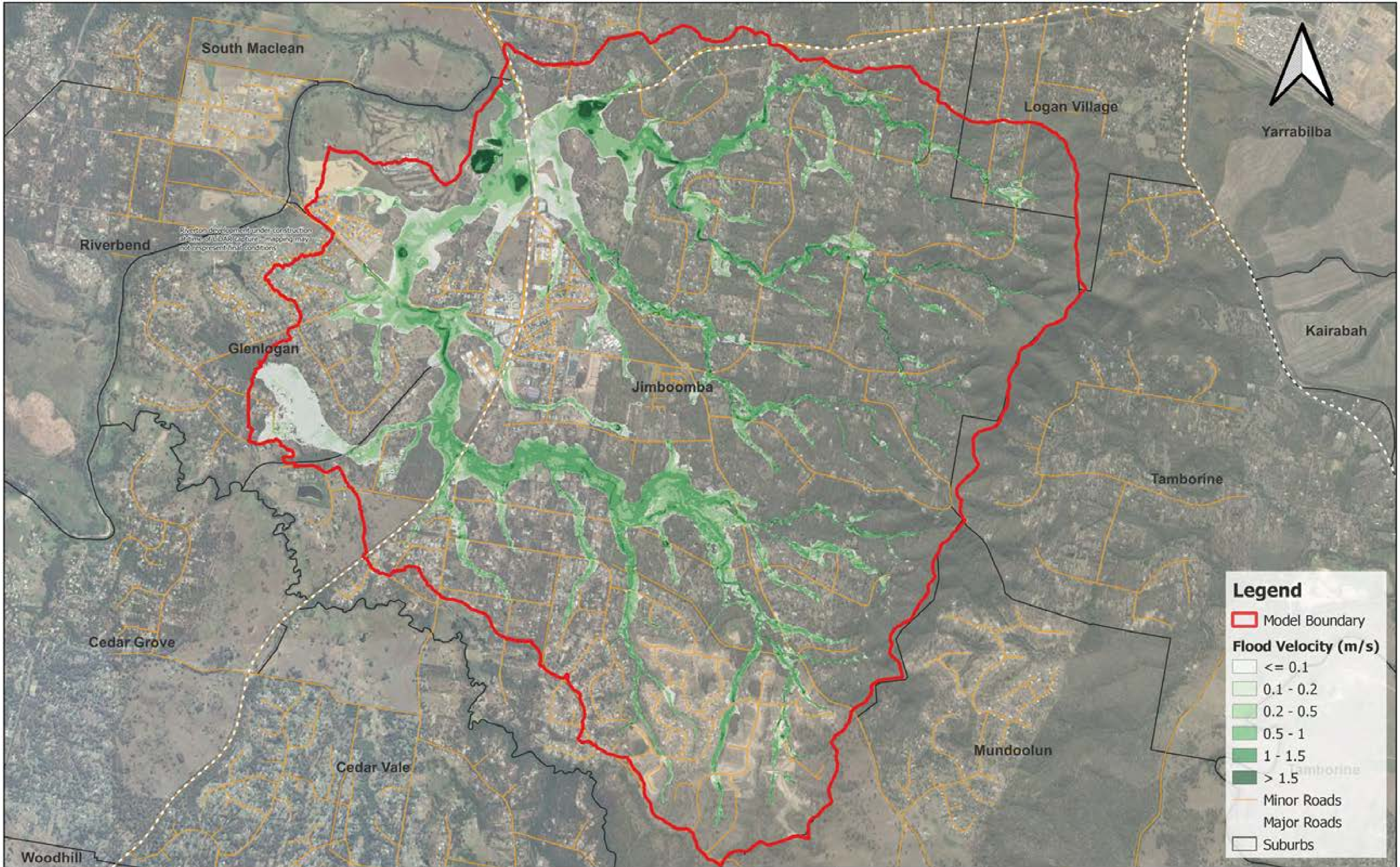
Appendix H.3.4

Henderson Creek Flood Study Update
1:50 AEP CC RCP4.5 Flood Velocity

Appendix H.3.4



R	DETAILS	DATE
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DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DISCLAIMER
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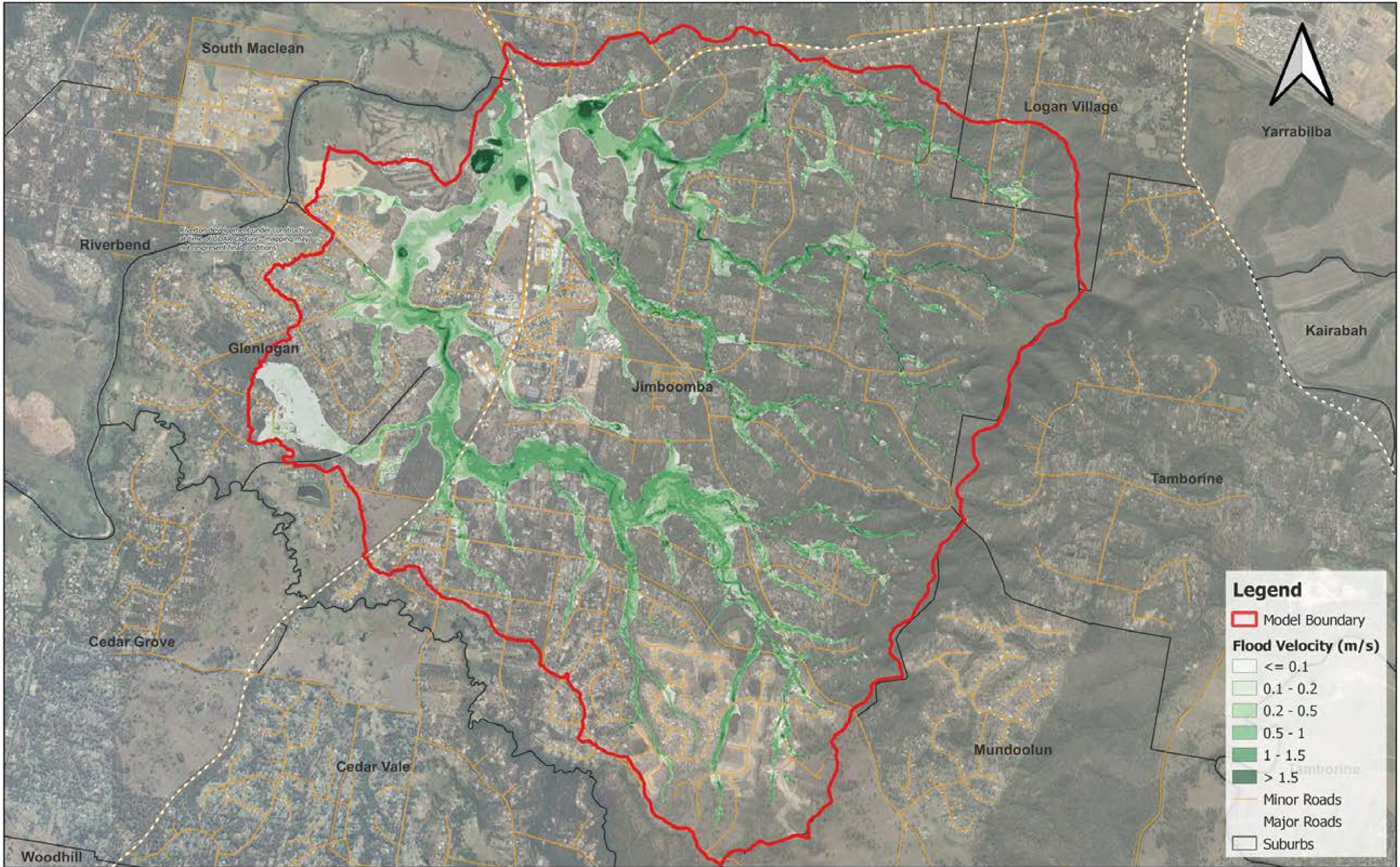
Appendix H.3.5

Henderson Creek Flood Study Update
1:100 AEP CC RCP4.5 Flood Velocity

Appendix H.3.5

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



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1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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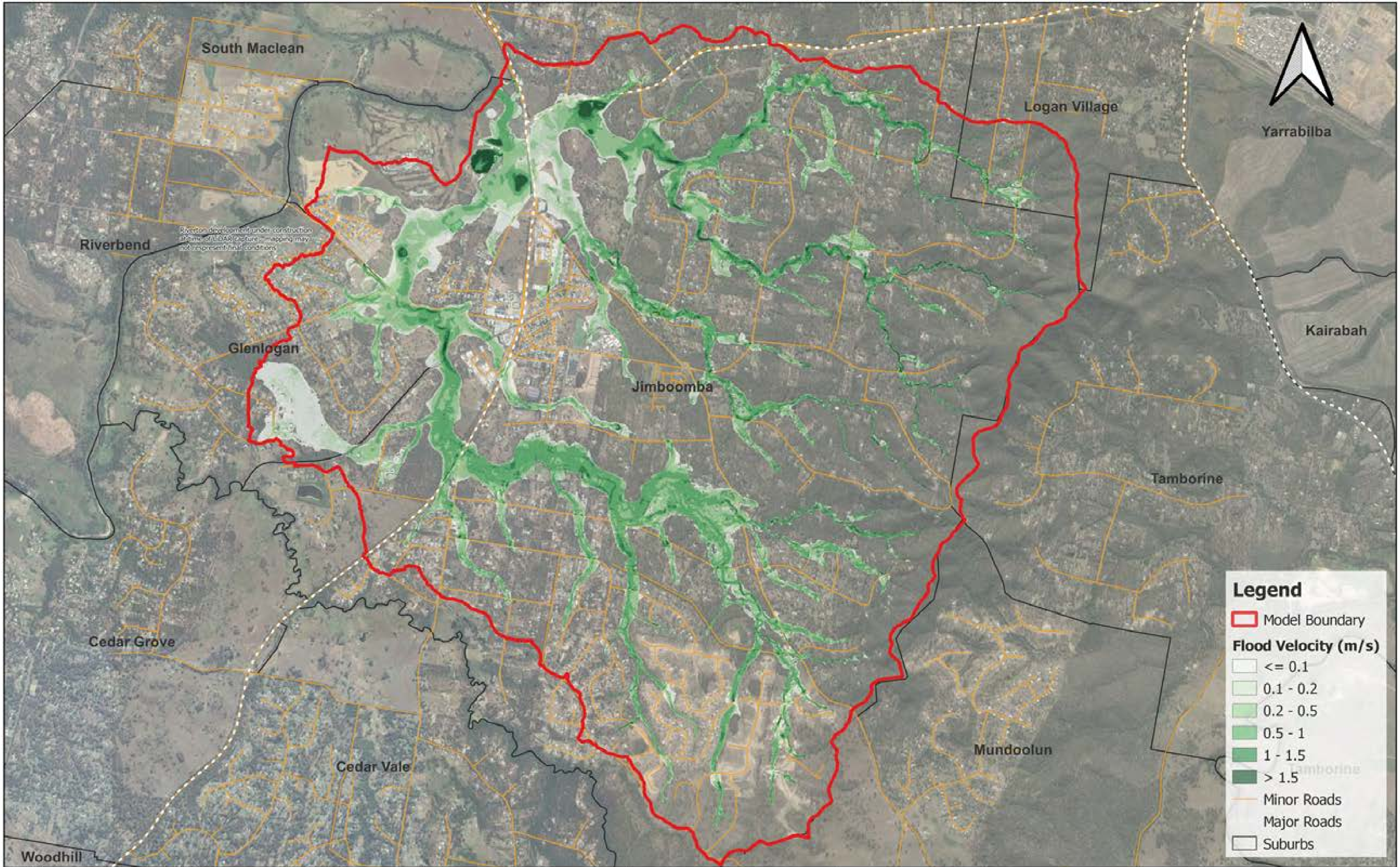
Appendix H.3.6

Henderson Creek Flood Study Update
1:200 AEP CC RCP4.5 Flood Velocity

Appendix H.3.6



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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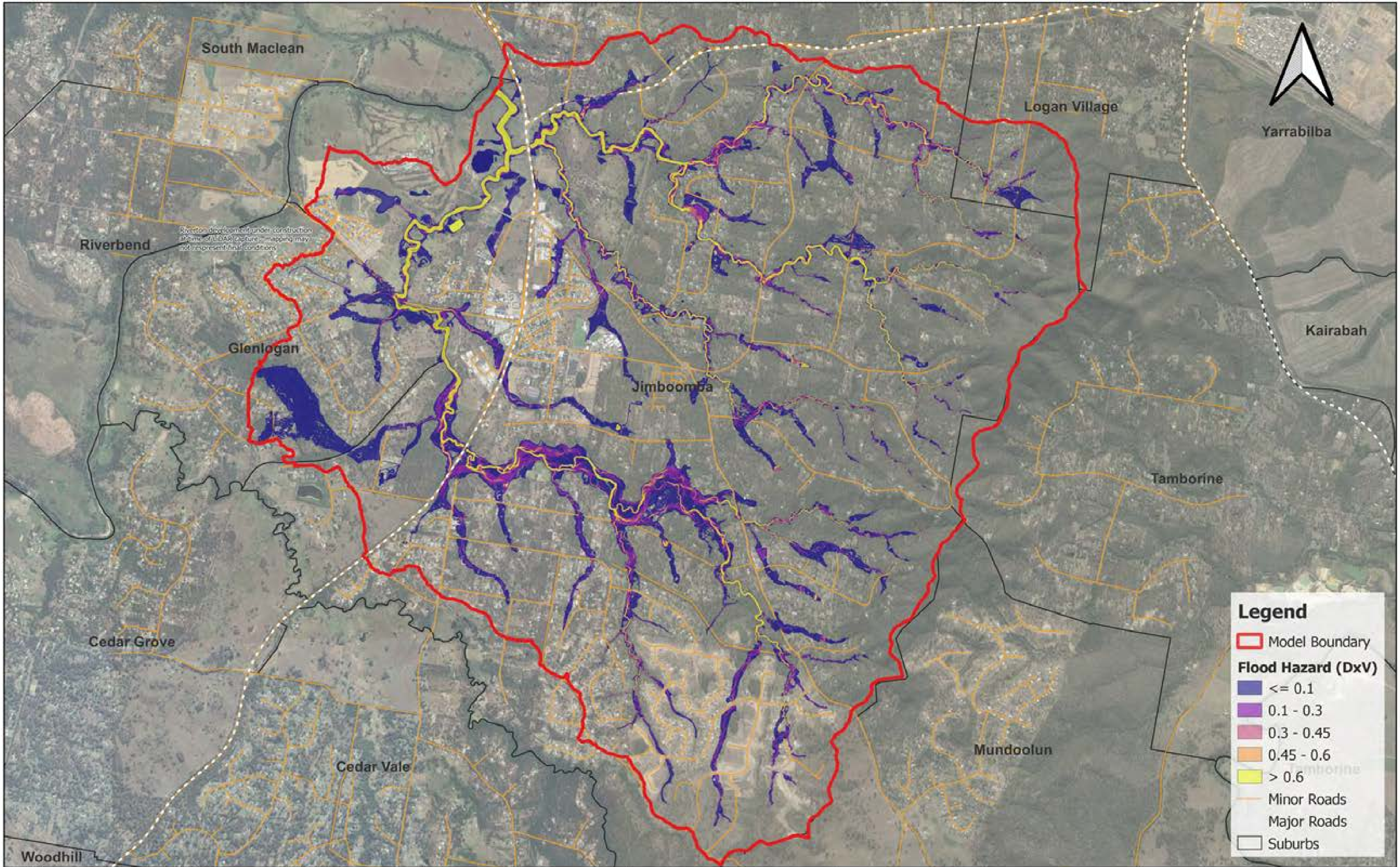
Appendix H.3.7

Henderson Creek Flood Study Update
1:500 AEP CC RCP4.5 Flood Velocity

Appendix H.3.7



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DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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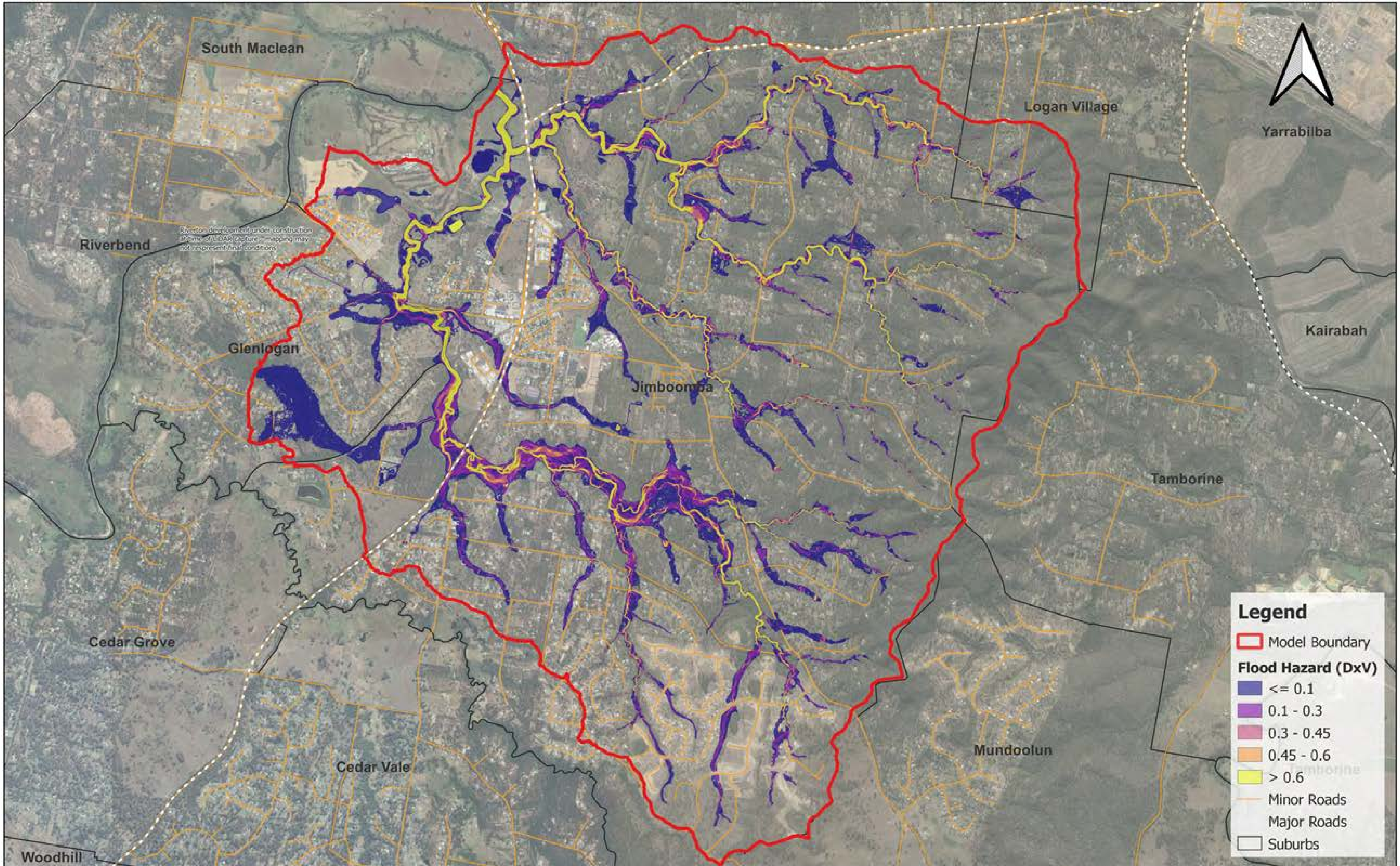
Appendix H.4.1

Henderson Creek Flood Study Update
1:5 AEP CC RCP4.5 Flood Hazard (DxV)

Appendix H.4.1

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\GIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



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DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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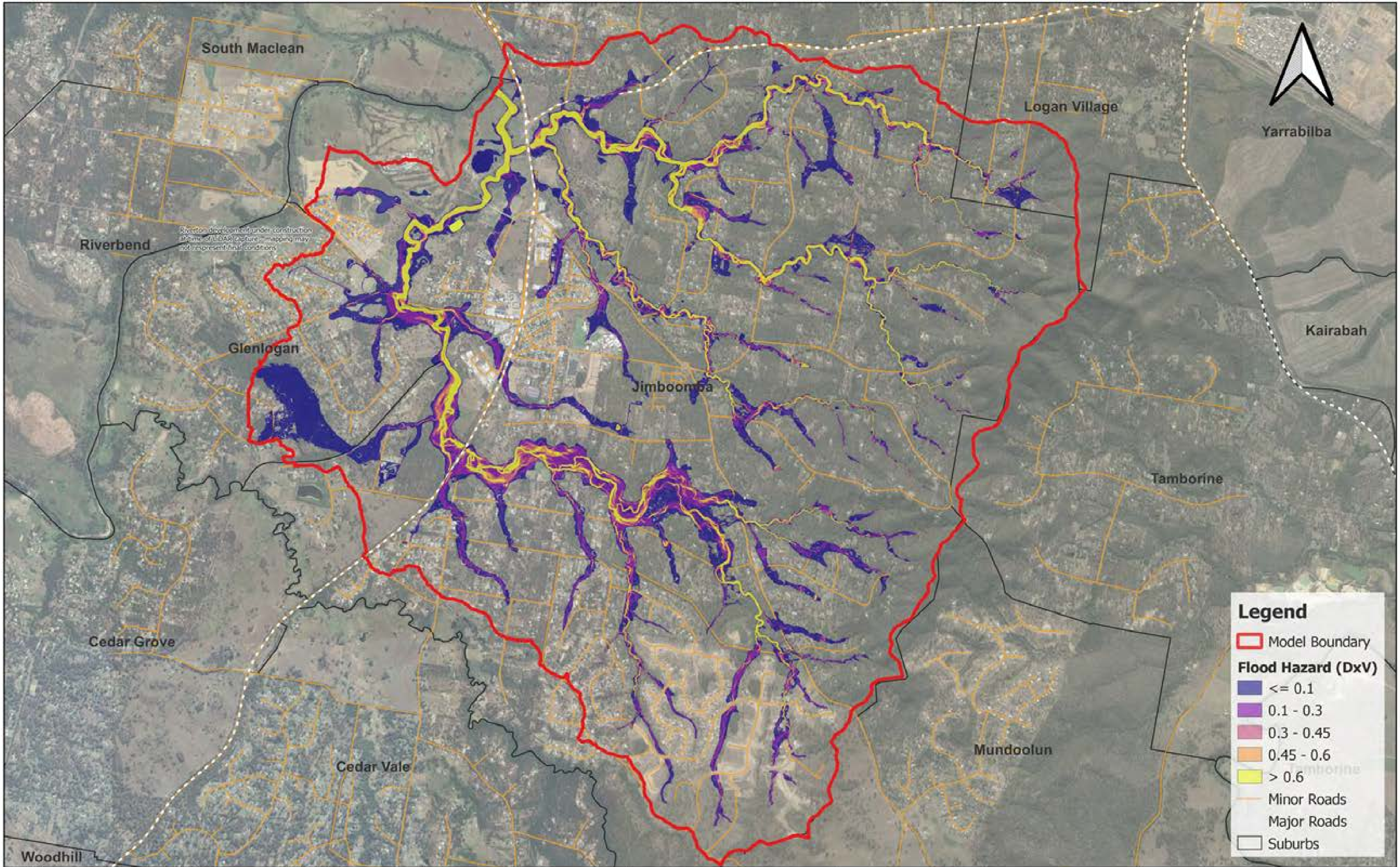
Appendix H.4.2

Henderson Creek Flood Study Update
1:10 AEP CC RCP4.5 Flood Hazard (DxV)

Appendix H.4.2



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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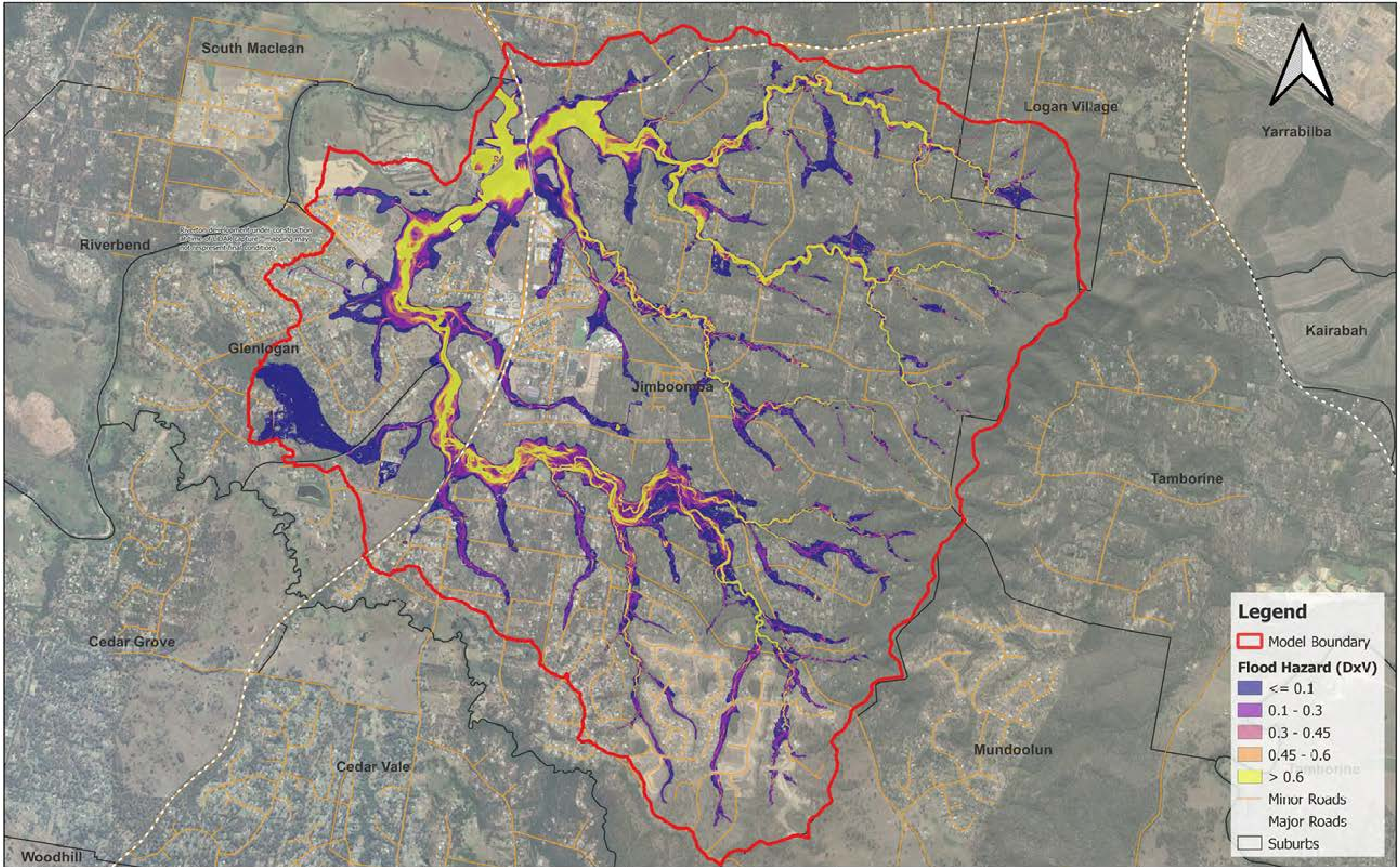
Appendix H.4.3

Henderson Creek Flood Study Update
1:20 AEP CC RCP4.5 Flood Hazard (DxV)

Appendix H.4.3

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



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DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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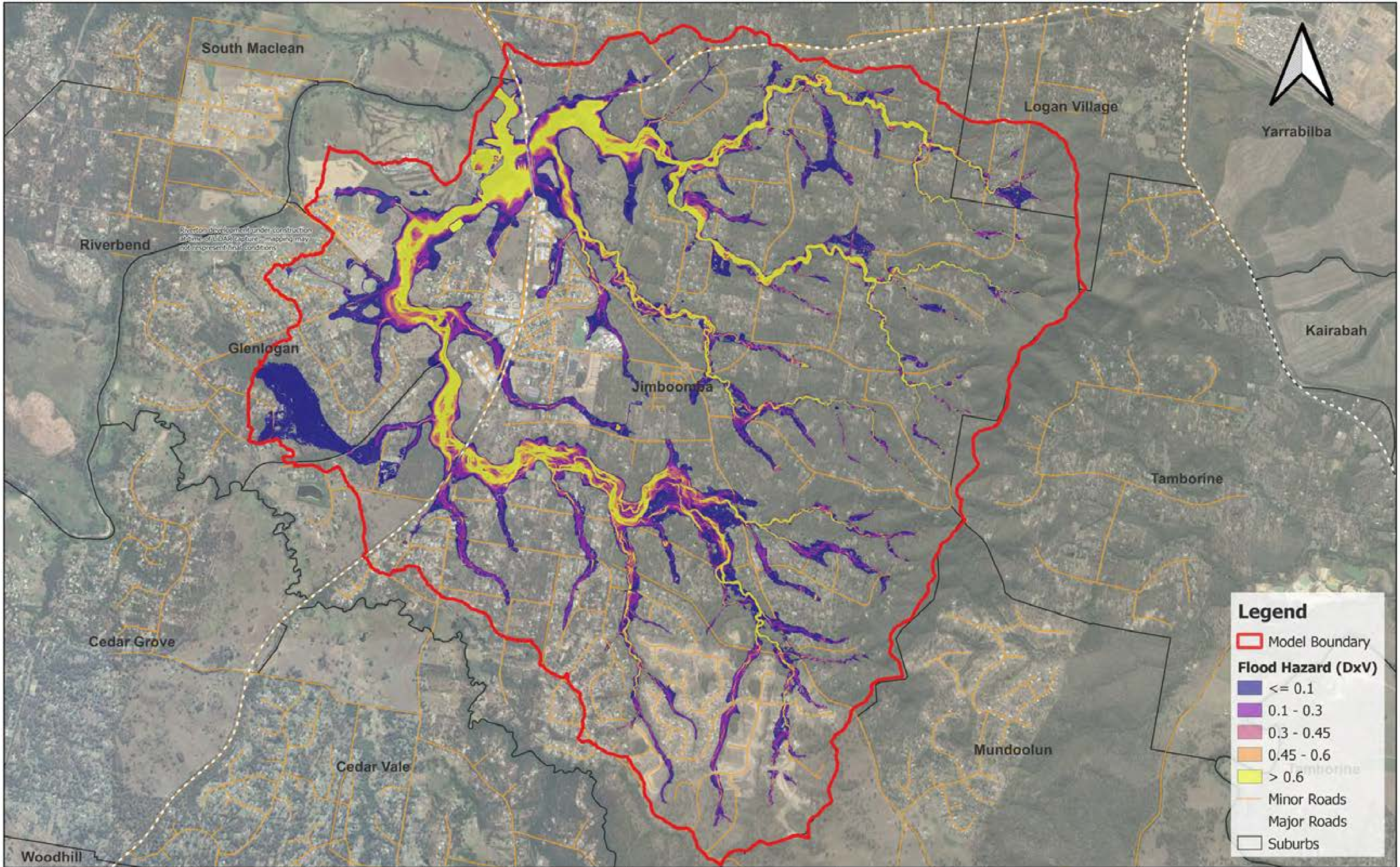
Appendix H.4.4

Henderson Creek Flood Study Update
1:50 AEP CC RCP4.5 Flood Hazard (DxV)

Appendix H.4.4



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DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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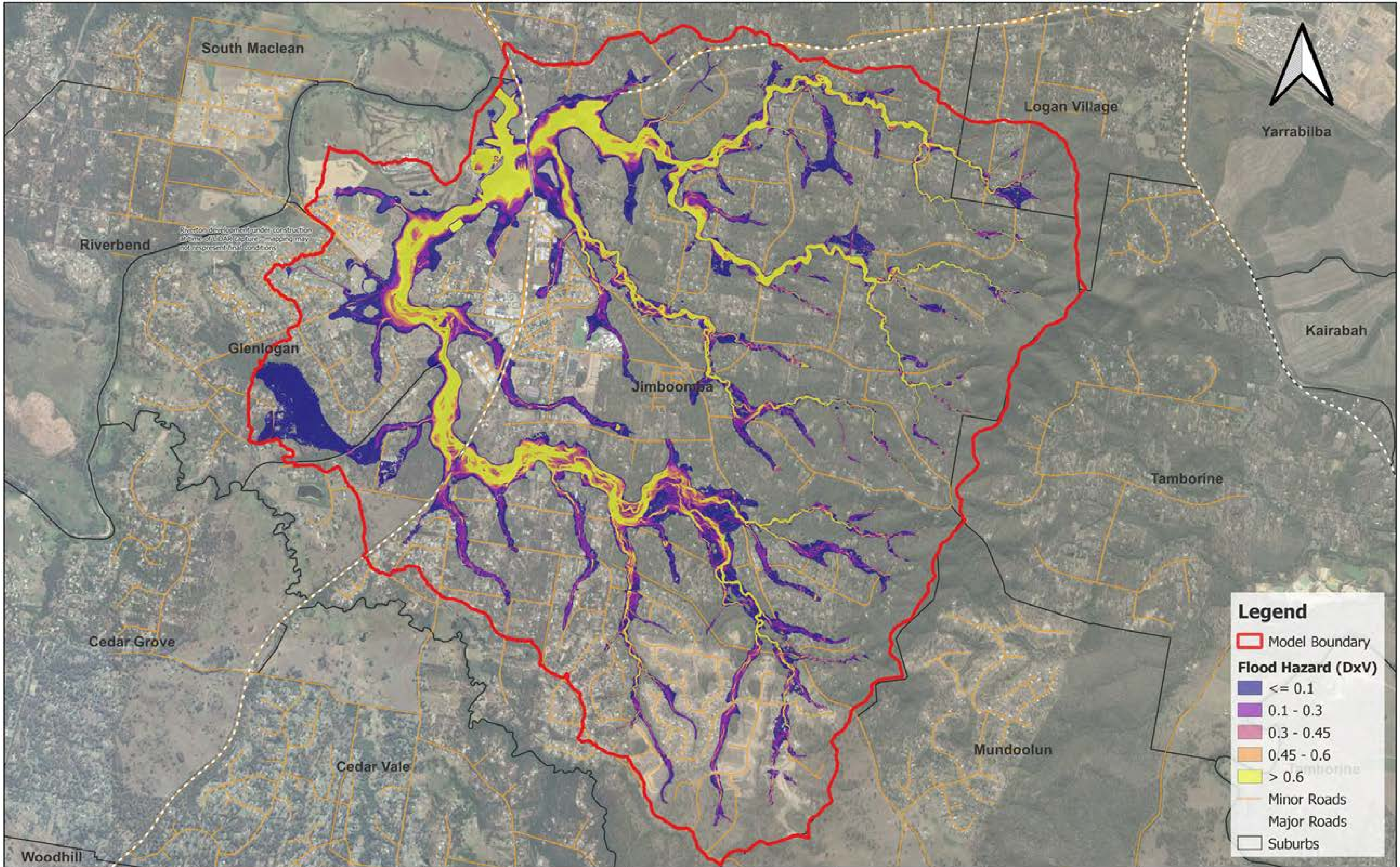
Appendix H.4.5

Henderson Creek Flood Study Update
1:100 AEP CC RCP4.5 Flood Hazard (DxV)

Appendix H.4.5

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



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DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DISCLAIMER
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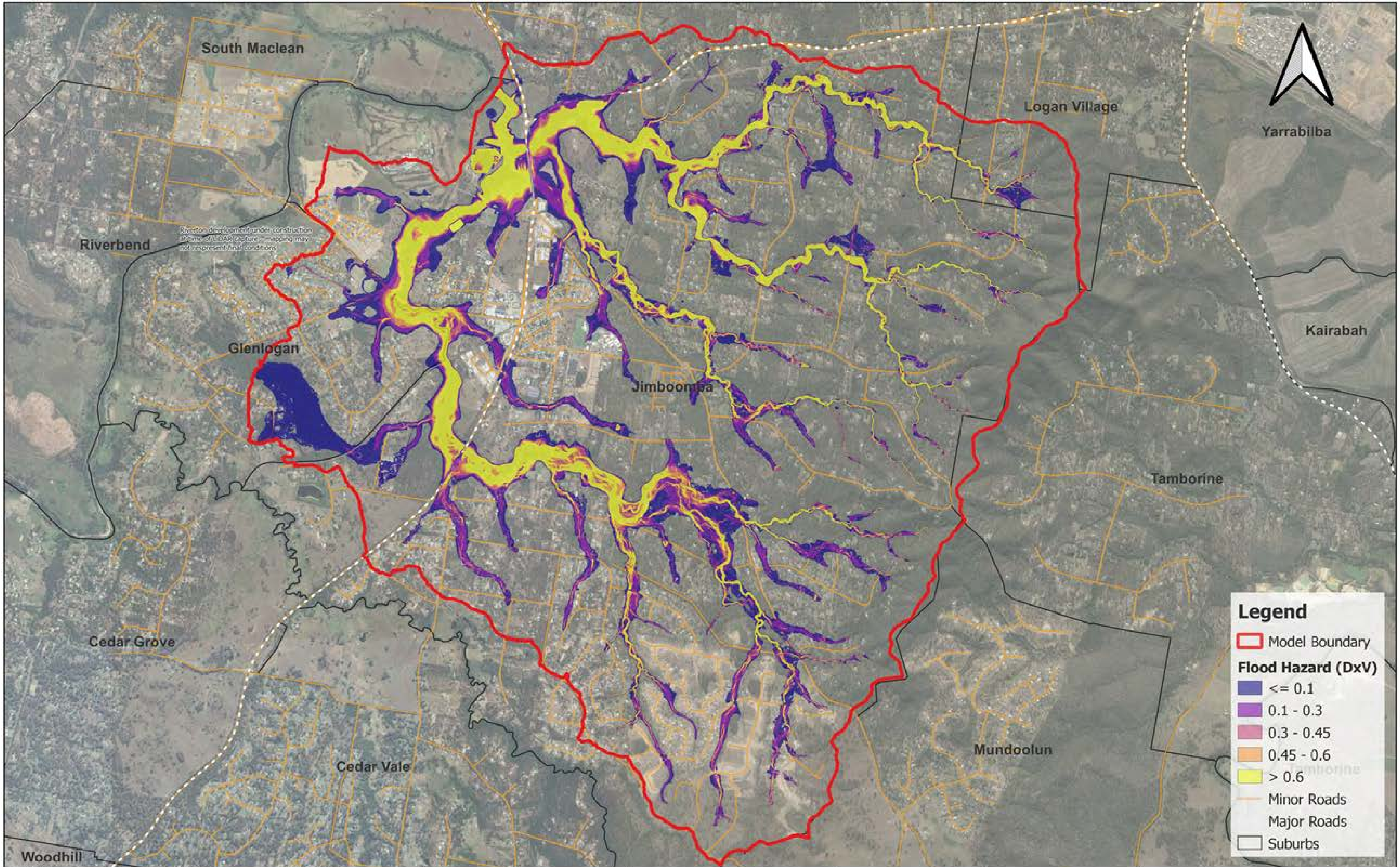
Appendix H.4.6

Henderson Creek Flood Study Update
1:200 AEP CC RCP4.5 Flood Hazard (DxV)

Appendix H.4.6

M:\Projects\M9000_Logan_City_Council\M9000_083 Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



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APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DATA SOURCE
QLD Government Open Data Source

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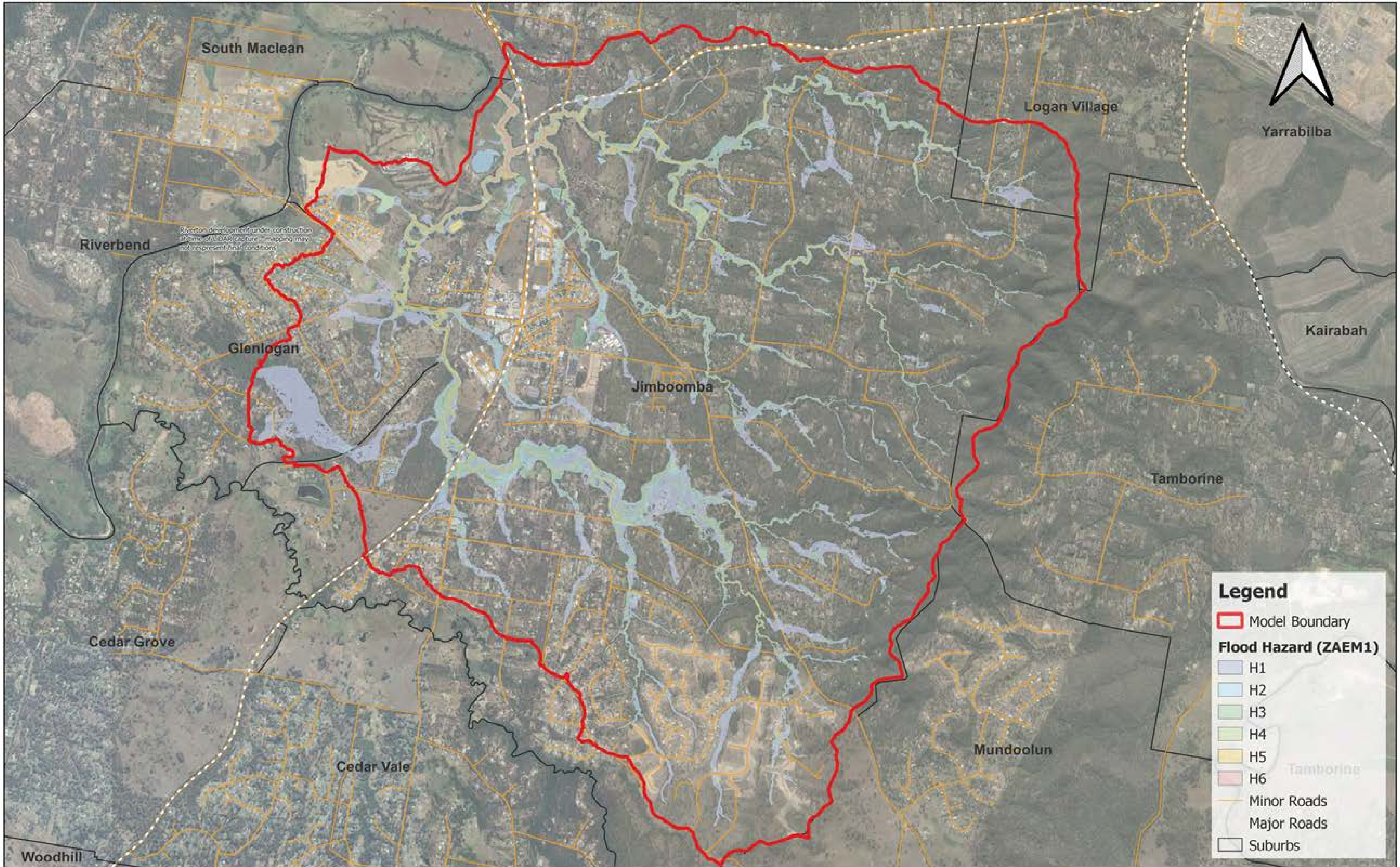
Appendix H.4.7

Henderson Creek Flood Study Update
1:500 AEP CC RCP4.5 Flood Hazard (DxV)

Appendix H.4.7



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APPROVED	MP	DATE	19-07-2023

NOTES:

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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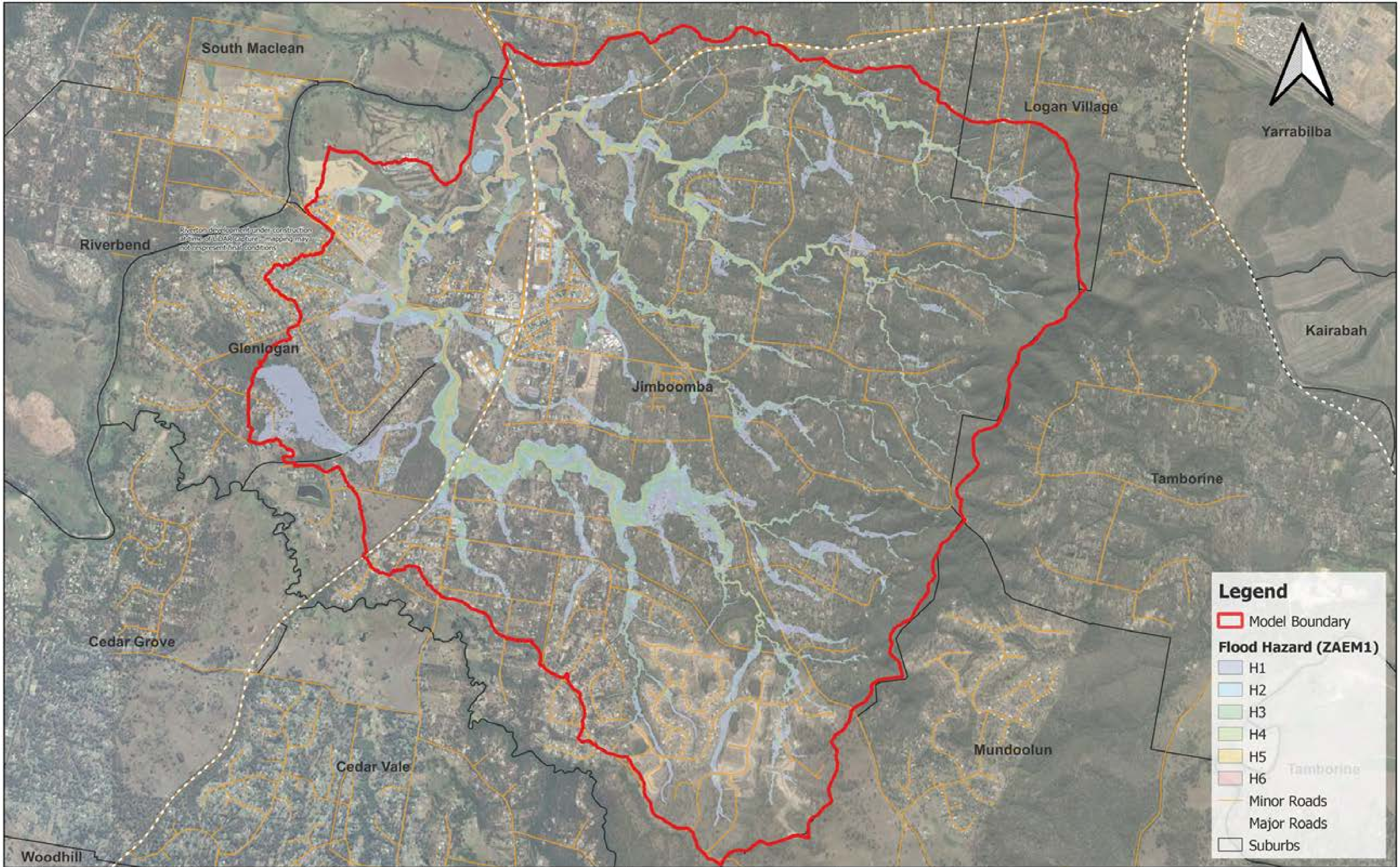
Appendix H.5.1

Henderson Creek Flood Study Update
1:5 AEP CC RCP4.5 Flood Hazard (ZAEM1)

Appendix H.5.1

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



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1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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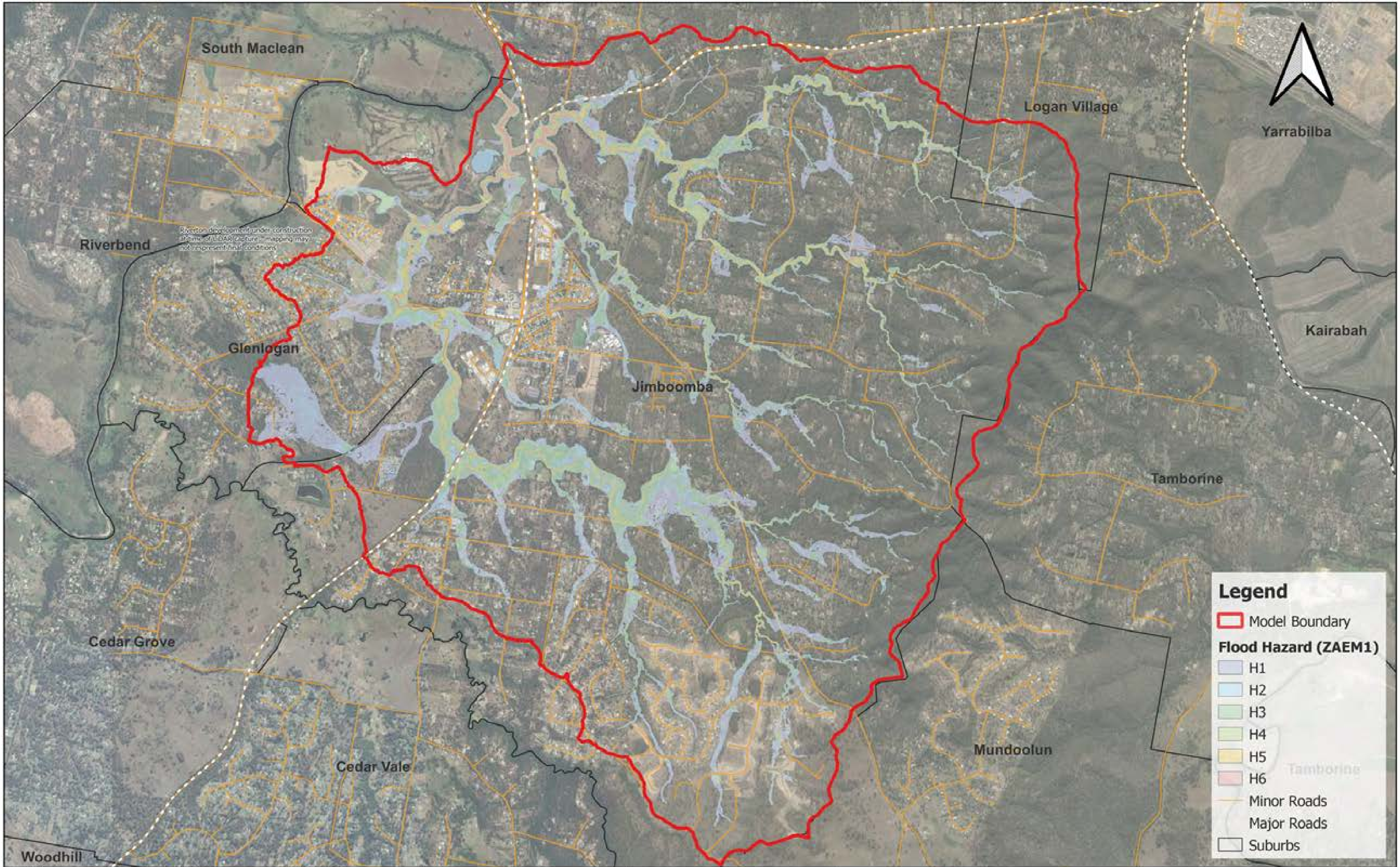
Appendix H.5.2

Henderson Creek Flood Study Update
1:10 AEP CC RCP4.5 Flood Hazard (ZAEM1)

Appendix H.5.2



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APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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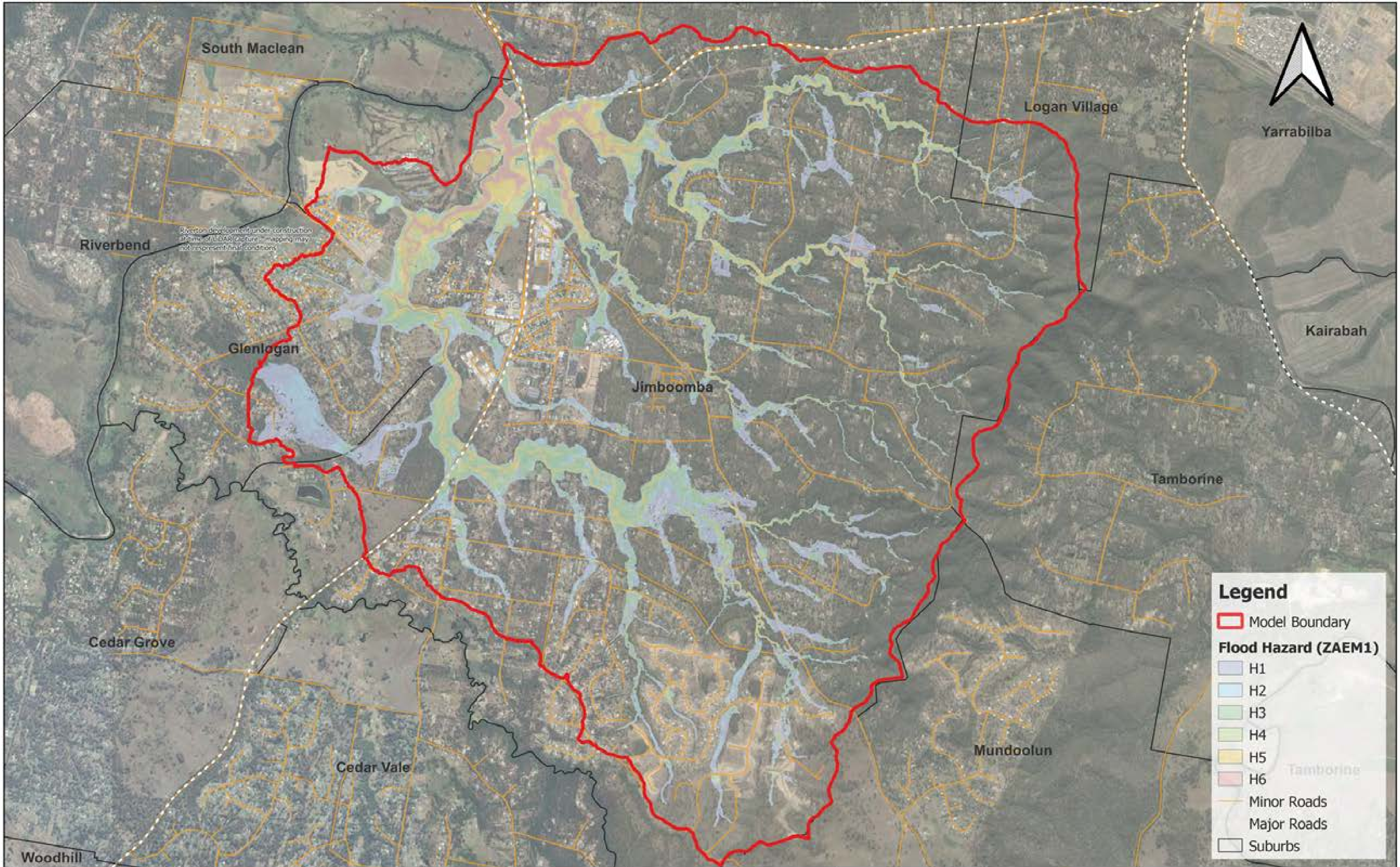
Appendix H.5.3

Henderson Creek Flood Study Update
1:20 AEP CC RCP4.5 Flood Hazard (ZAEM1)

Appendix H.5.3

M:\Projects\M9000_Logan_City_Council\M9000_083 "Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



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APPROVED	MP	DATE	19-07-2023

NOTES:

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0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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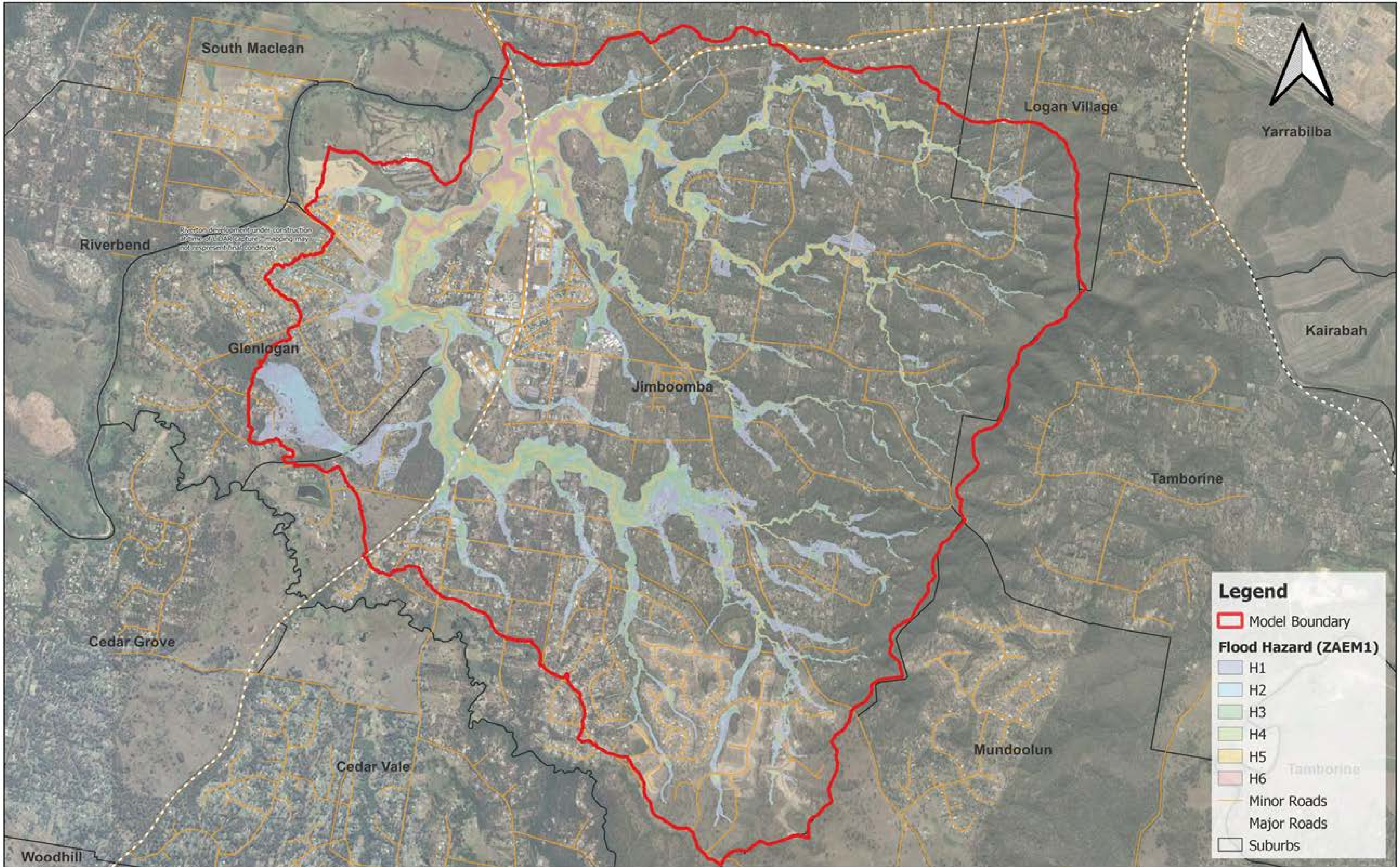
Appendix H.5.4

Henderson Creek Flood Study Update
1:50 AEP CC RCP4.5 Flood Hazard (ZAEM1)

Appendix H.5.4



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DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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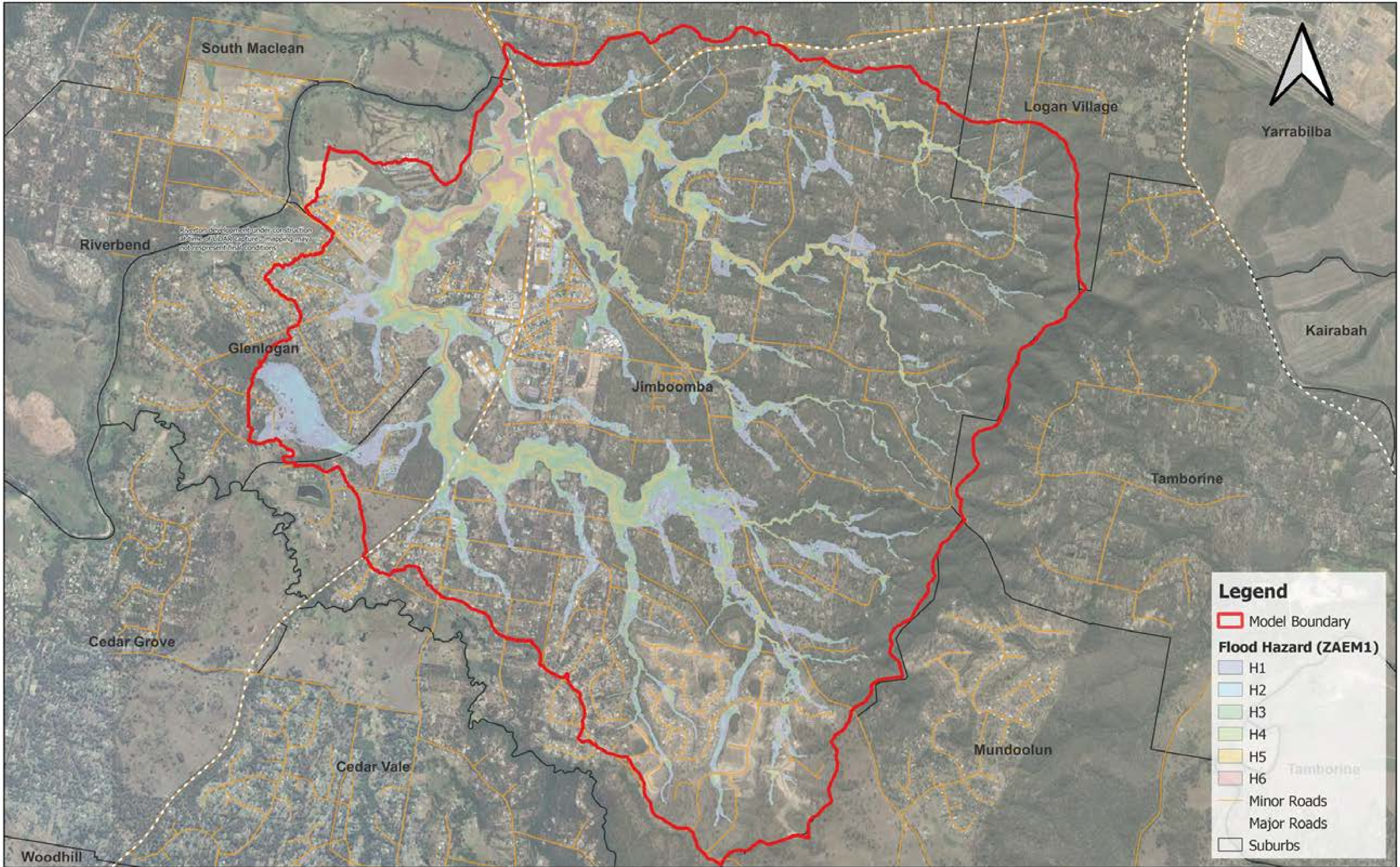
Appendix H.5.5

Henderson Creek Flood Study Update
1:100 AEP CC RCP4.5 Flood Hazard (ZAEM1)

Appendix H.5.5

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



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1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

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SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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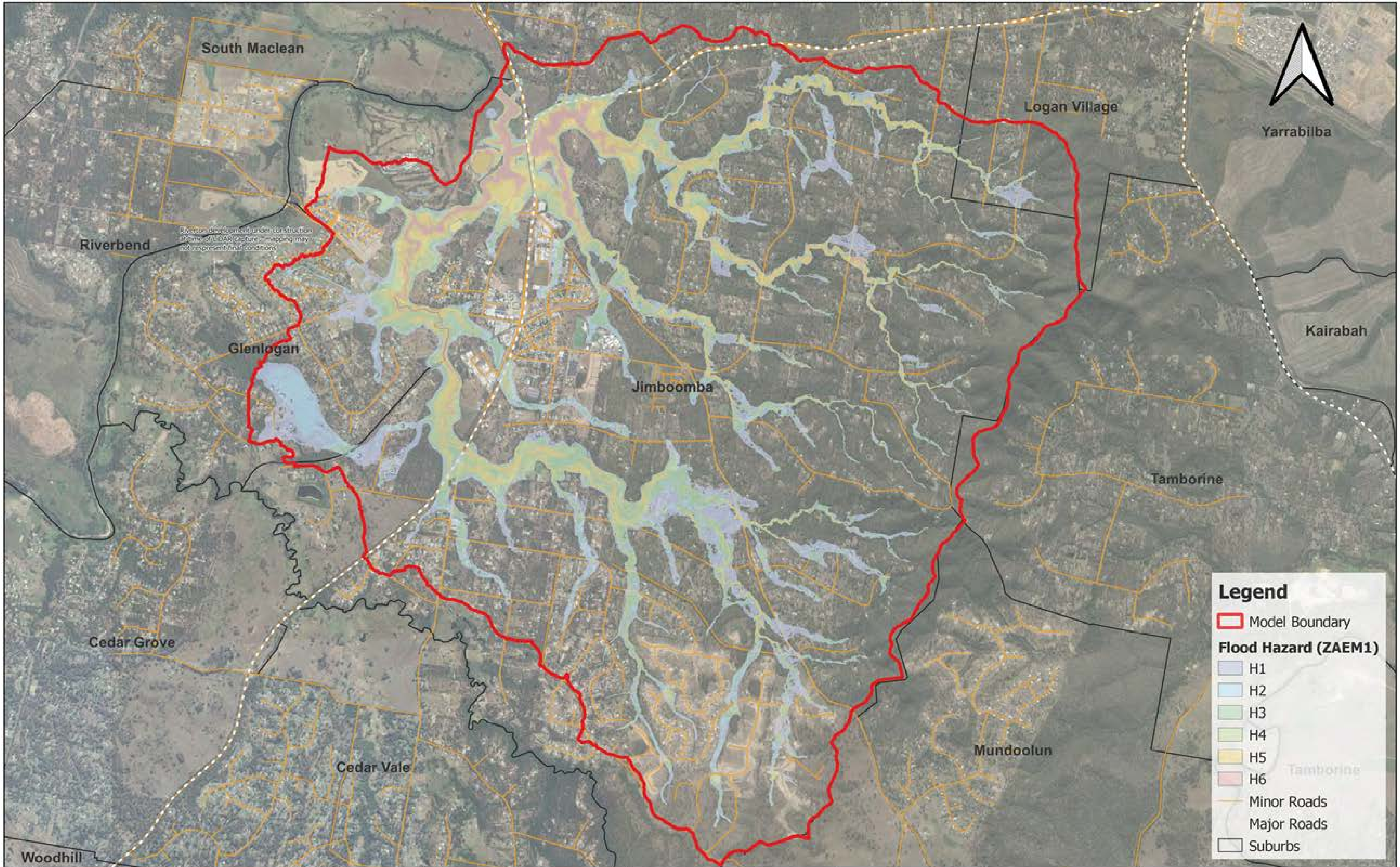
Appendix H.5.6

Henderson Creek Flood Study Update
1:200 AEP CC RCP4.5 Flood Hazard (ZAEM1)

Appendix H.5.6

M:\Projects\M9000_Logan_City_Council\M9000_083 "Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



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1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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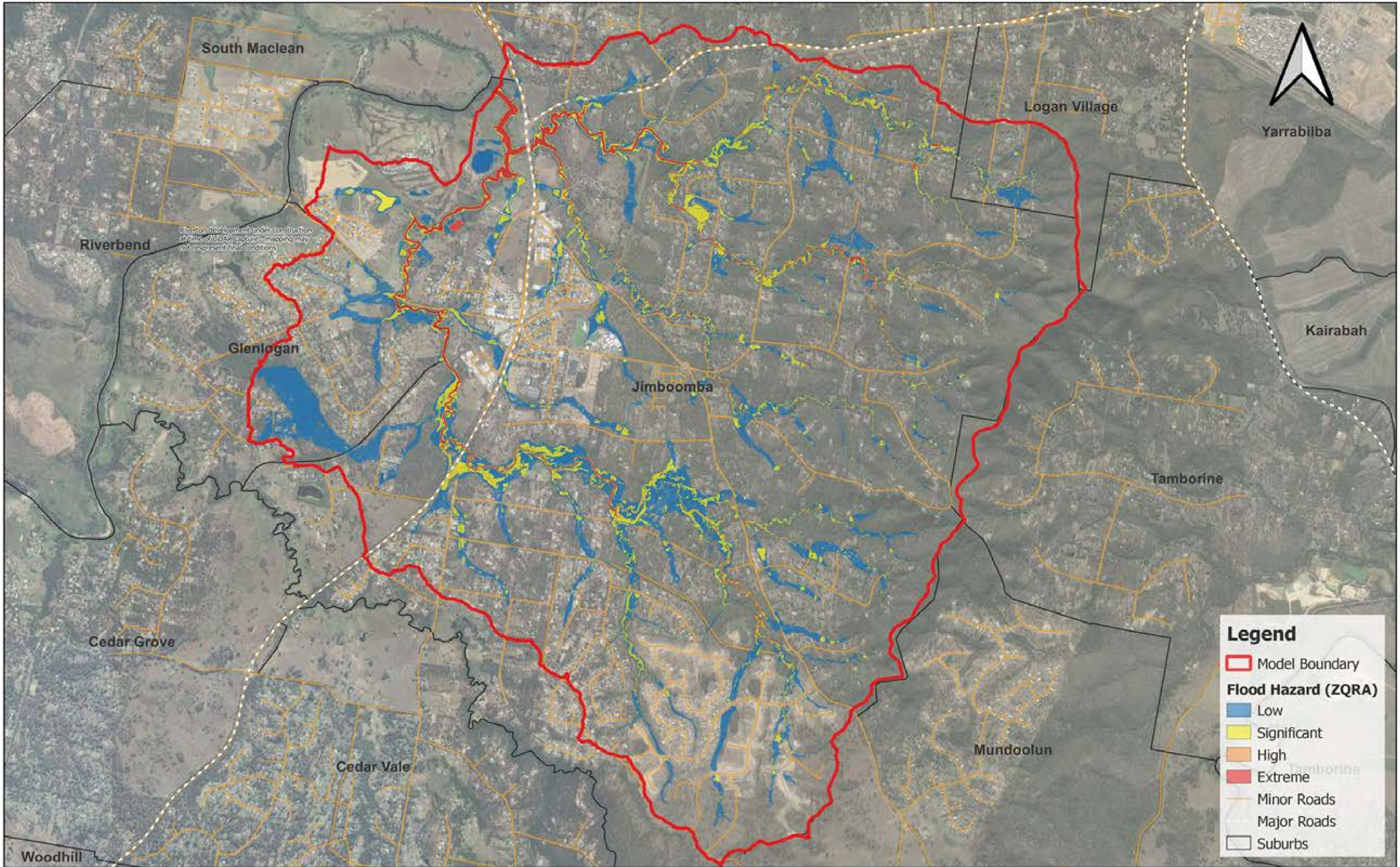
Appendix H.5.7

Henderson Creek Flood Study Update
1:500 AEP CC RCP4.5 Flood Hazard (ZAEM1)

Appendix H.5.7

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\GIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

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DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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Appendix H.6.1

Henderson Creek Flood Study Update
1:5 AEP CC RCP4.5 Flood Hazard (ZQRA)

Appendix H.6.1

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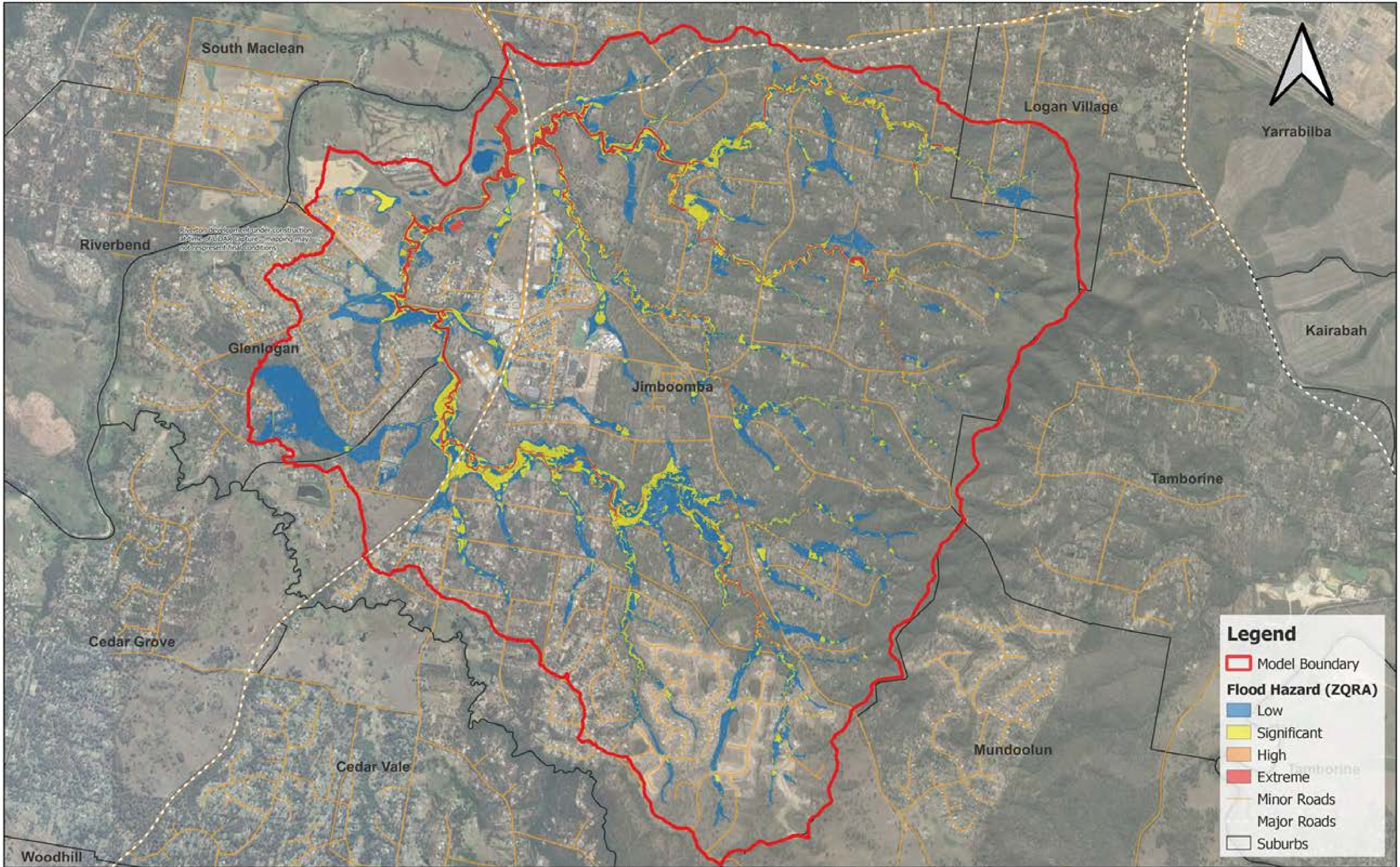

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1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

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0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DATA SOURCE
QLD Government Open Data Source

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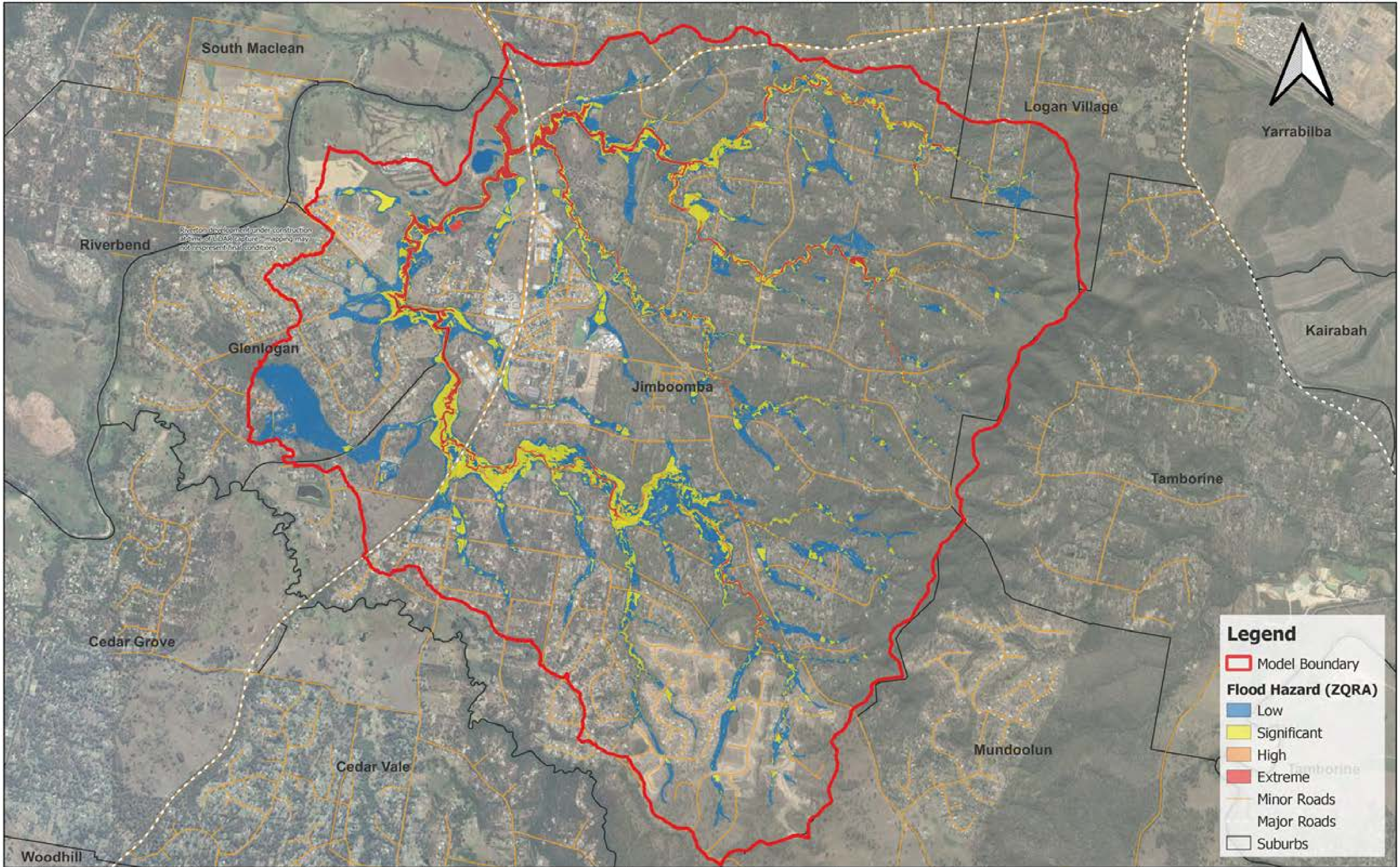
Appendix H.6.2

Henderson Creek Flood Study Update
1:10 AEP CC RCP4.5 Flood Hazard (ZQRA)

Appendix H.6.2



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

DISCLAIMER
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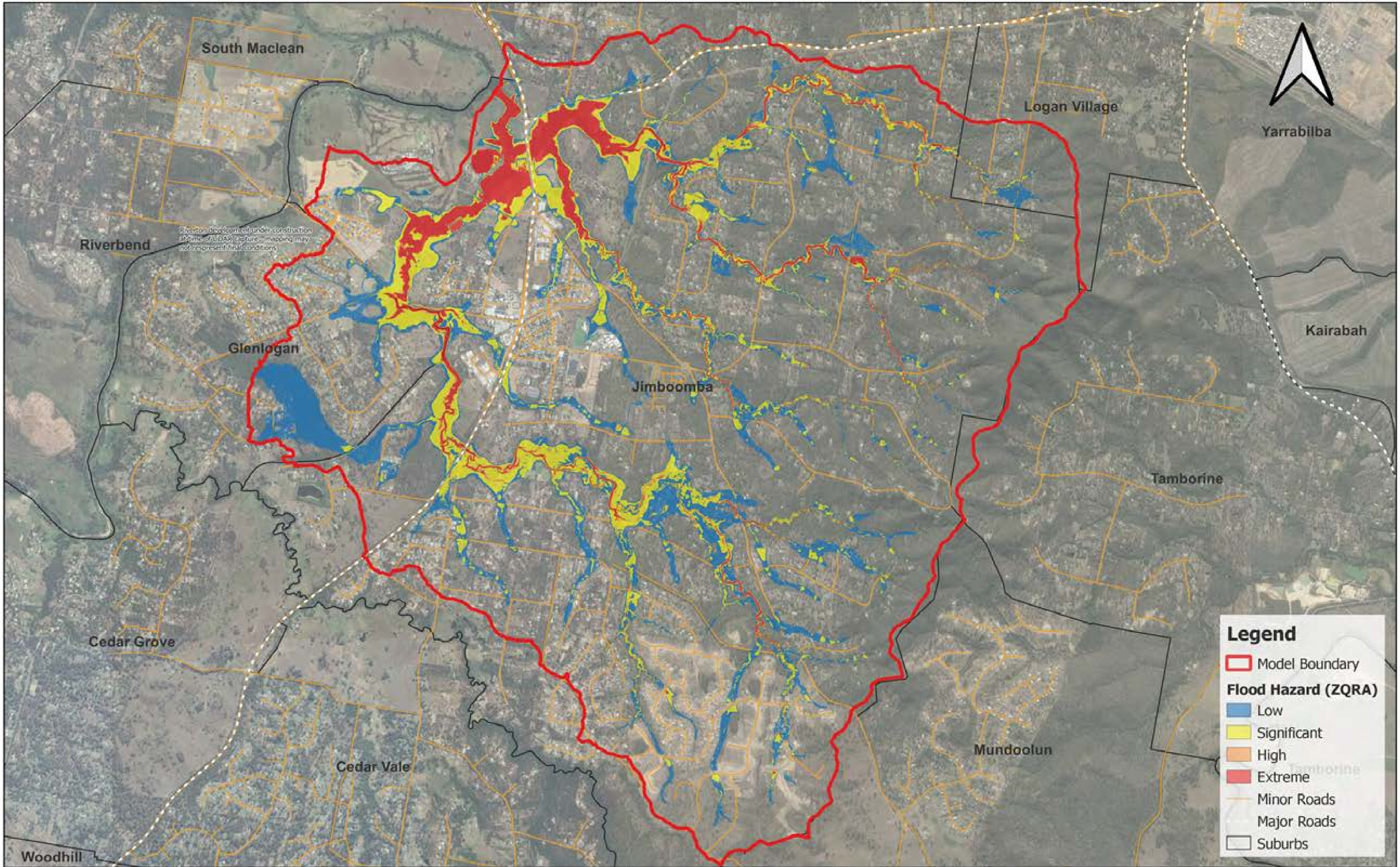
Appendix H.6.3

Henderson Creek Flood Study Update
1:20 AEP CC RCP4.5 Flood Hazard (ZQRA)

Appendix H.6.3

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\GIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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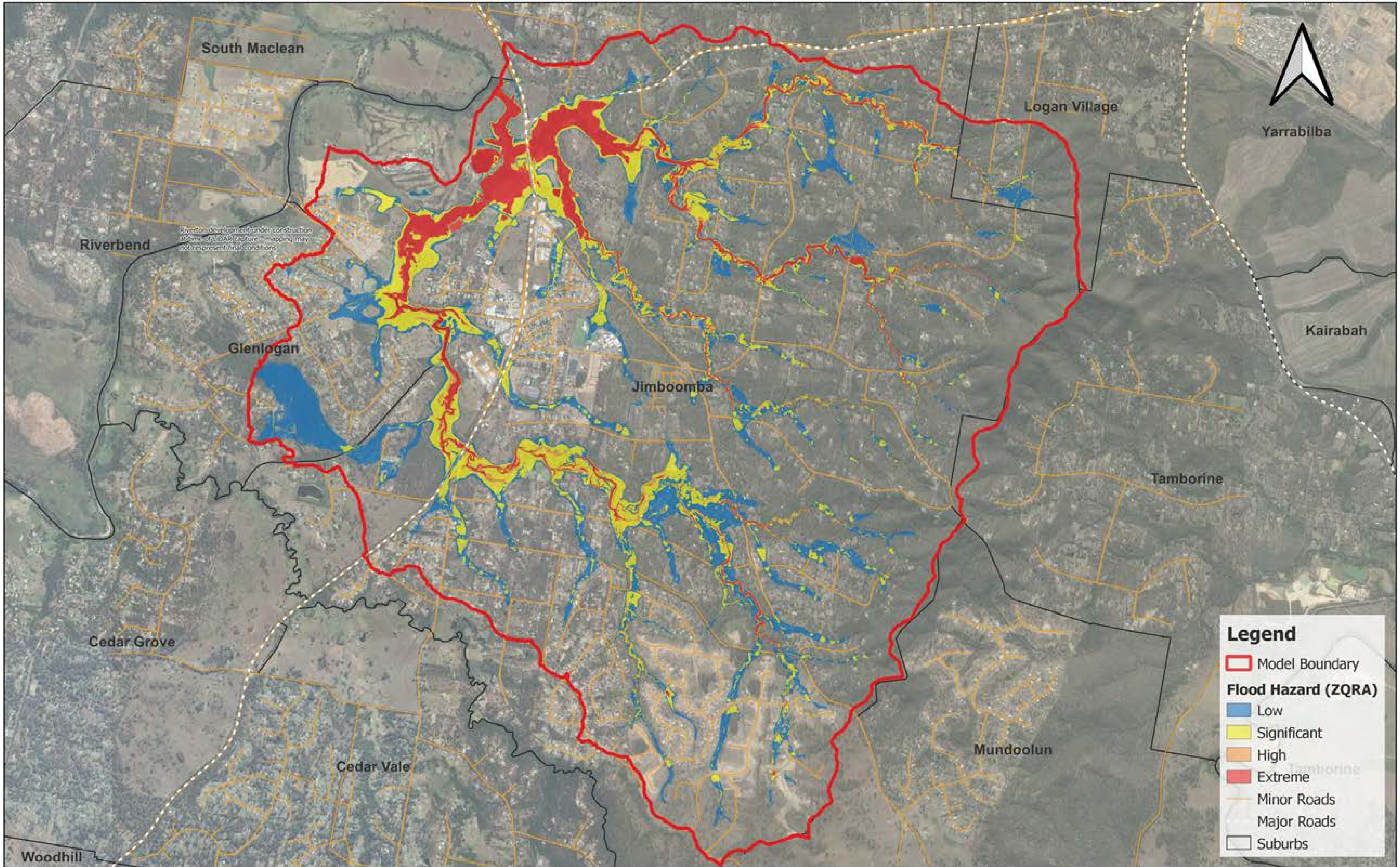
Appendix H.6.4

Henderson Creek Flood Study Update
1:50 AEP CC RCP4.5 Flood Hazard (ZQRA)

Appendix H.6.4

M:\Projects\M9000_Logan_City_Council\M9000_083 Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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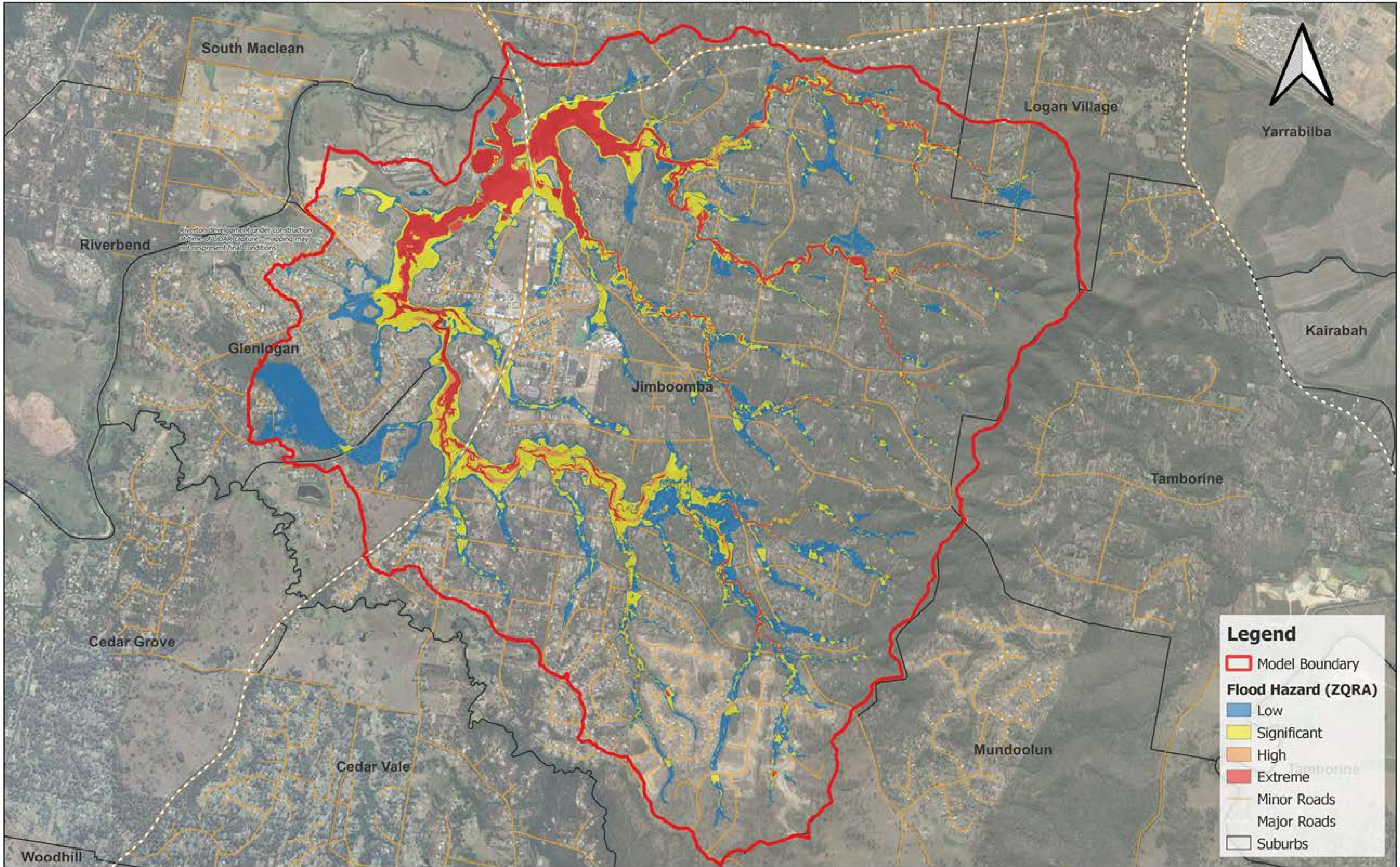
Appendix H.6.5

Henderson Creek Flood Study Update
1:100 AEP CC RCP4.5 Flood Hazard (ZQRA)

Appendix H.6.5

M:\Projects\M9000_Logan_City_Council\M9000_083 Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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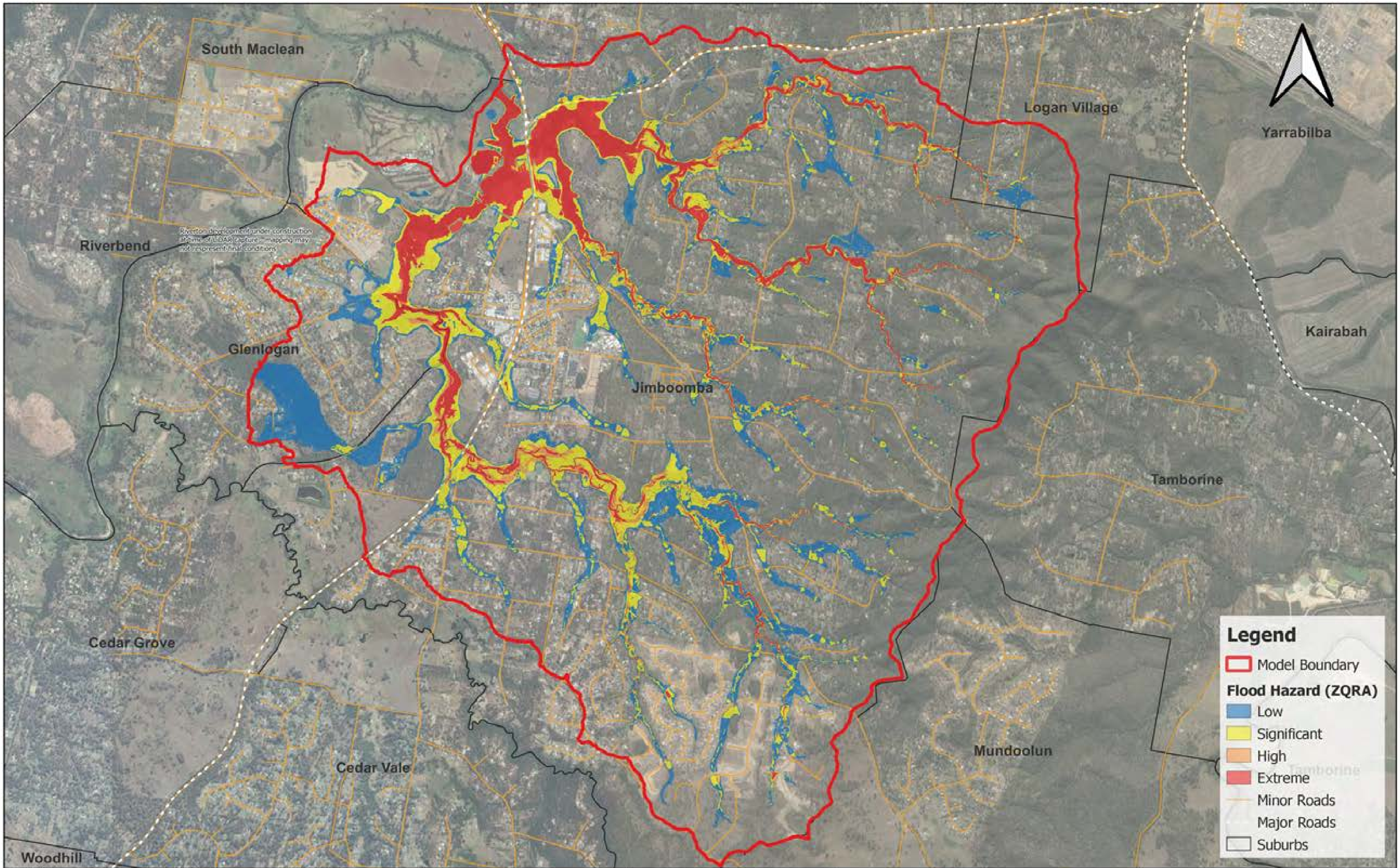
Appendix H.6.6

Henderson Creek Flood Study Update
1:200 AEP CC RCP4.5 Flood Hazard (ZQRA)

Appendix H.6.6

M:\Projects\M9000_Logan_City_Council\M9000_083 *Henderson Ck FS 2022\05 Design\GIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz



R	DETAILS	DATE
1	Final Issue	19-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	19-07-2023

NOTES:

N

0 0.8 1.6 km

SCALE @ A3 - 1:35,000
GDA2020 / MGA zone 56

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Appendix H.6.7

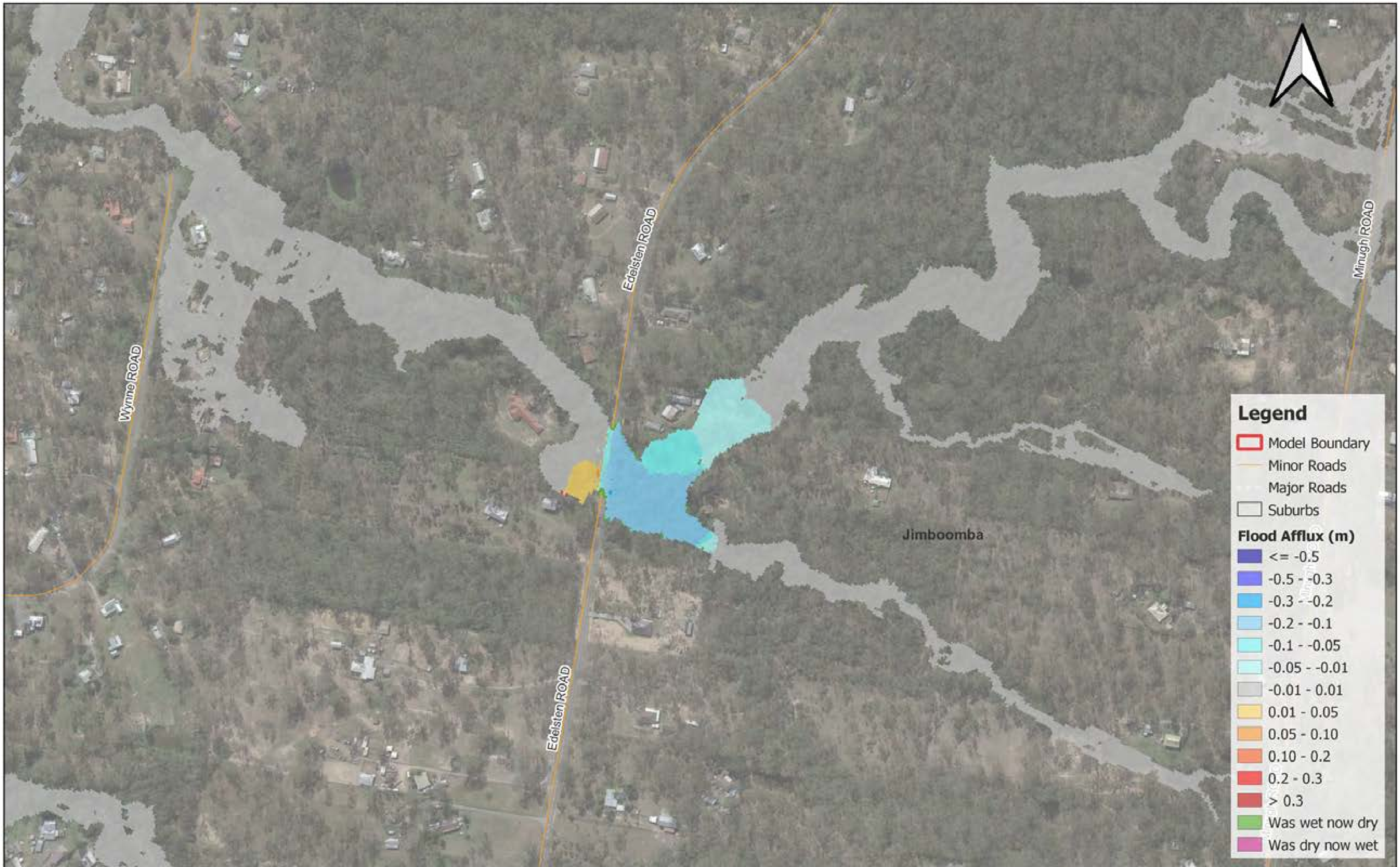
Henderson Creek Flood Study Update
1:500 AEP CC RCP4.5 Flood Hazard (ZQRA)

Appendix H.6.7

M:\Projects\M9000_Logan_City_Council\M9000_083 Henderson Ck FS 2022\05 Design\QGIS\Workspaces\M9000_083-WOR-001-A-Henderson Ck_figure_base - CC.qgz

Appendix I:

Mitigation Option Afflux Maps



R	DETAILS	DATE
1	Final Issue	20-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	20-07-2023

NOTES:

N

0 0.1 0.2 km

SCALE @ A3 - 1:4,000
GDA2020 / MGA zone 56

DISCLAIMER
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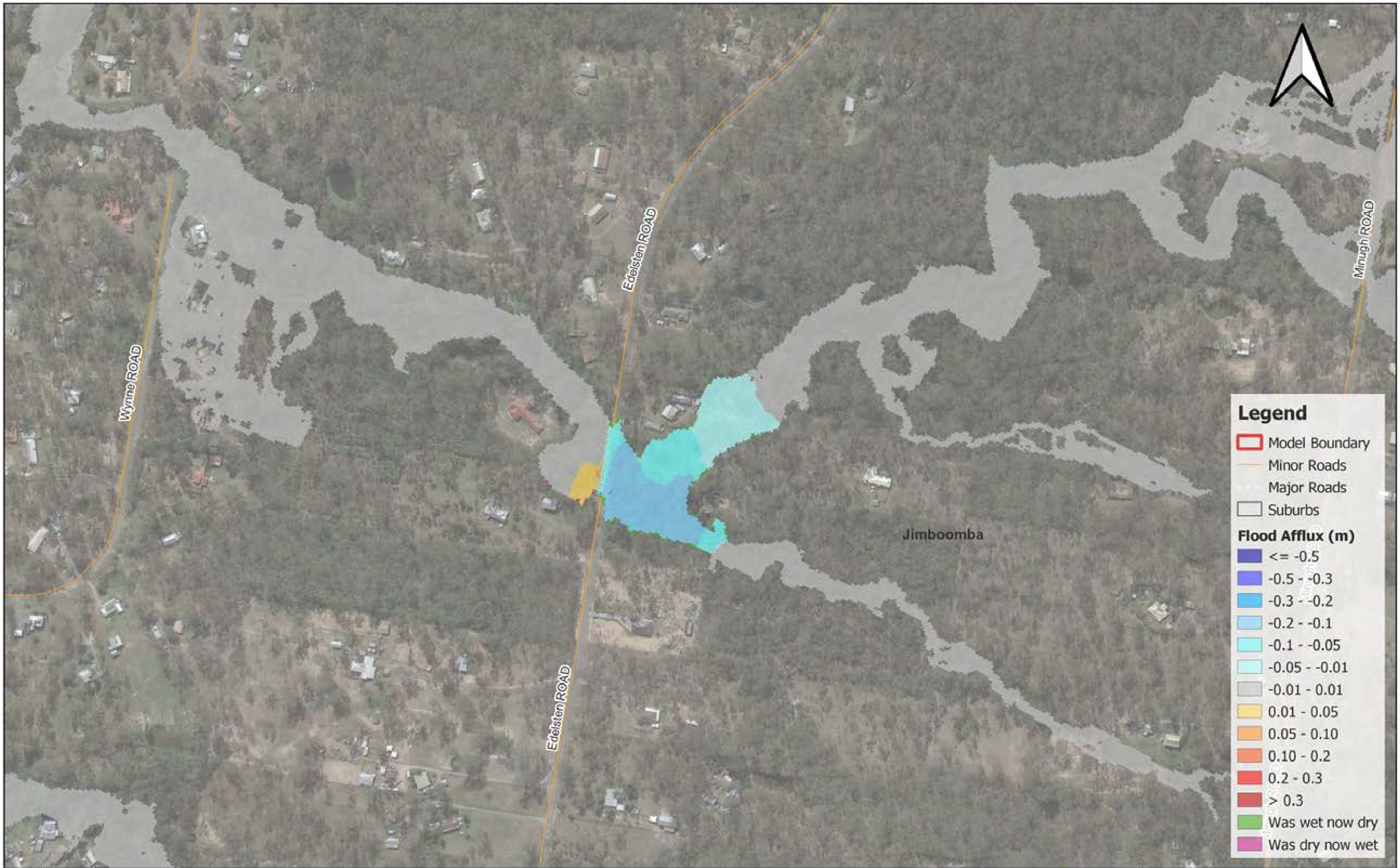
Appendix I.1.1

Henderson Creek Flood Study Update
Structural Mitigation
Edelsten Road
1:5 AEP CC RCP4.5 Flood Afflux

Appendix I.1.1



R	DETAILS	DATE
1	Final Issue	20-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	20-07-2023

NOTES:

N

0 0.1 0.2 km

SCALE @ A3 - 1:4,000
GDA2020 / MGA zone 56

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Appendix I.1.2

Henderson Creek Flood Study Update
Structural Mitigation
Edelsten Road
1:10 AEP CC RCP4.5 Flood Afflux

Appendix I.1.2

R	DETAILS	DATE
1	Final Issue	20-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	20-07-2023

NOTES:

0 0.1 0.2 km

SCALE @ A3 - 1:4,000
GDA2020 / MGA zone 56

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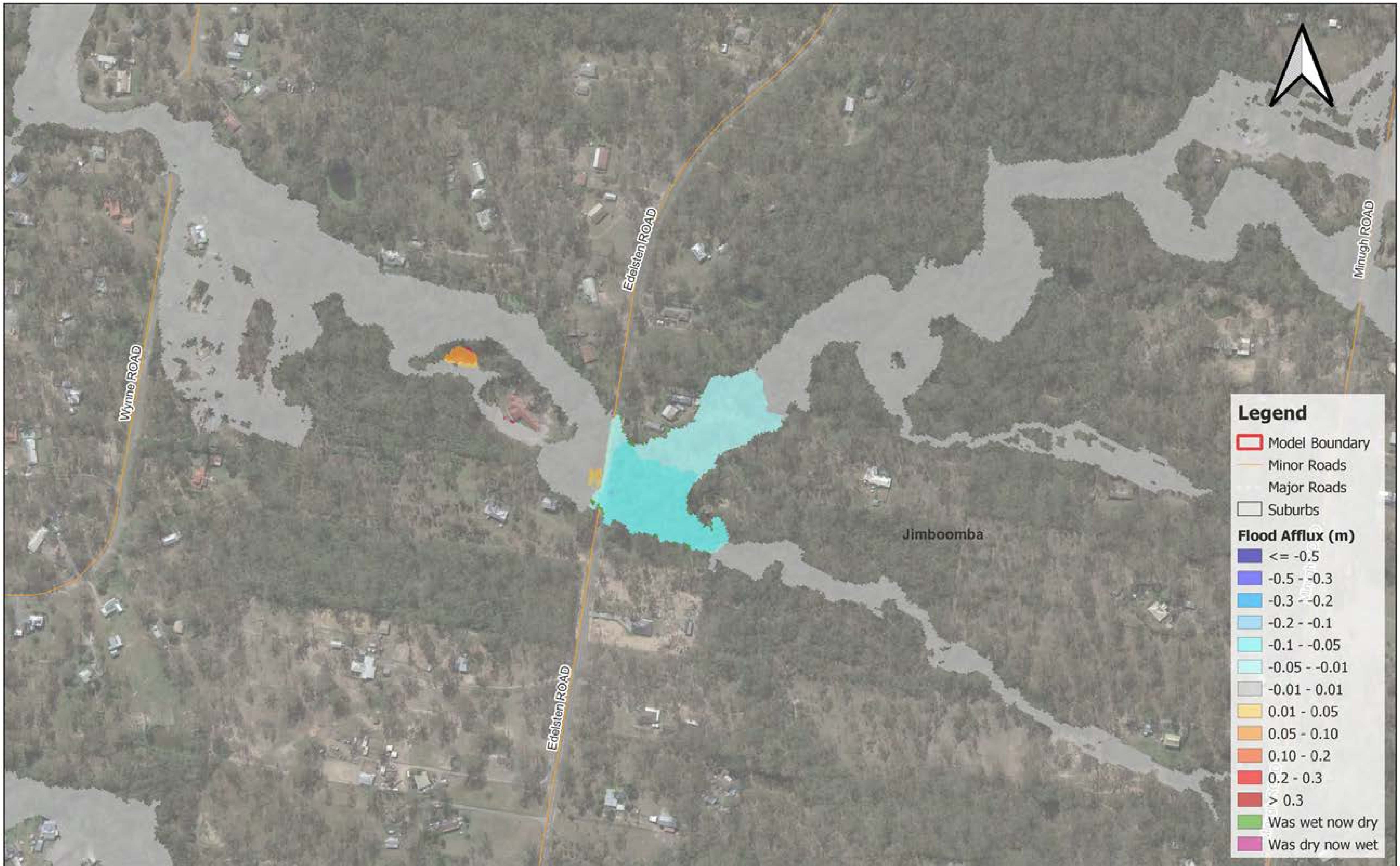
Appendix I.1.3

Henderson Creek Flood Study Update
Structural Mitigation
Edelsten Road
1:20 AEP CC RCP4.5 Flood Afflux

Appendix I.1.3



#	DETAILS	DATE
1	Final Issue	20-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	20-07-2023

NOTES:

N

0 0.1 0.2 km

SCALE @ A3 - 1:4,000
GDA2020 / MGA zone 56

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Appendix I.1.4

Henderson Creek Flood Study Update
Structural Mitigation
Edelsten Road
1:50 AEP CC RCP4.5 Flood Afflux

Appendix I.1.4

#	DETAILS	DATE
1	Final Issue	20-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	20-07-2023

NOTES:

N

0 0.1 0.2 km

SCALE @ A3 - 1:4,000
GDA2020 / MGA zone 56

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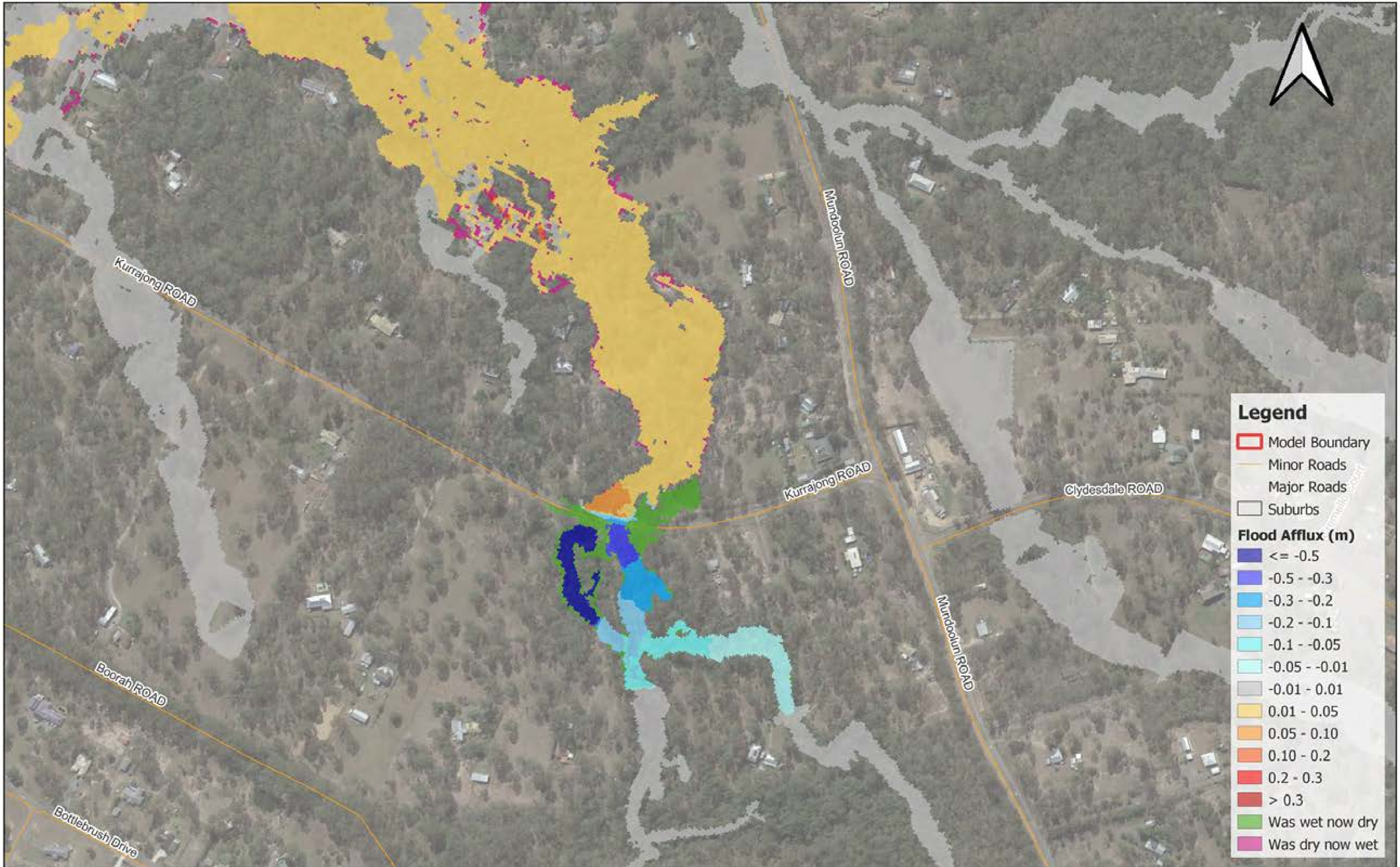
Appendix I.1.5

Henderson Creek Flood Study Update
Structural Mitigation
Edelsten Road
1:100 AEP CC RCP4.5 Flood Afflux

Appendix I.1.5



R	DETAILS	DATE
1	Final Issue	20-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	20-07-2023

NOTES:

0 0.1 0.2 km

SCALE @ A3 - 1:4,000
GDA2020 / MGA zone 56

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Appendix I.2.1

Henderson Creek Flood Study Update
Structural Mitigation
Kurrajong Road
1:5 AEP CC RCP4.5 Flood Afflux

Appendix I.2.1

R	DETAILS	DATE
1	Final Issue	20-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	20-07-2023

NOTES:

N

0 0.1 0.2 km

SCALE @ A3 - 1:4,000
GDA2020 / MGA zone 56

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Appendix I.2.2

Henderson Creek Flood Study Update
Structural Mitigation
Kurrajong Road
1:10 AEP CC RCP4.5 Flood Afflux

Appendix I.2.2

R	DETAILS	DATE
1	Final Issue	20-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	20-07-2023

NOTES:

N

0 0.1 0.2 km

SCALE @ A3 - 1:4,000
GDA2020 / MGA zone 56

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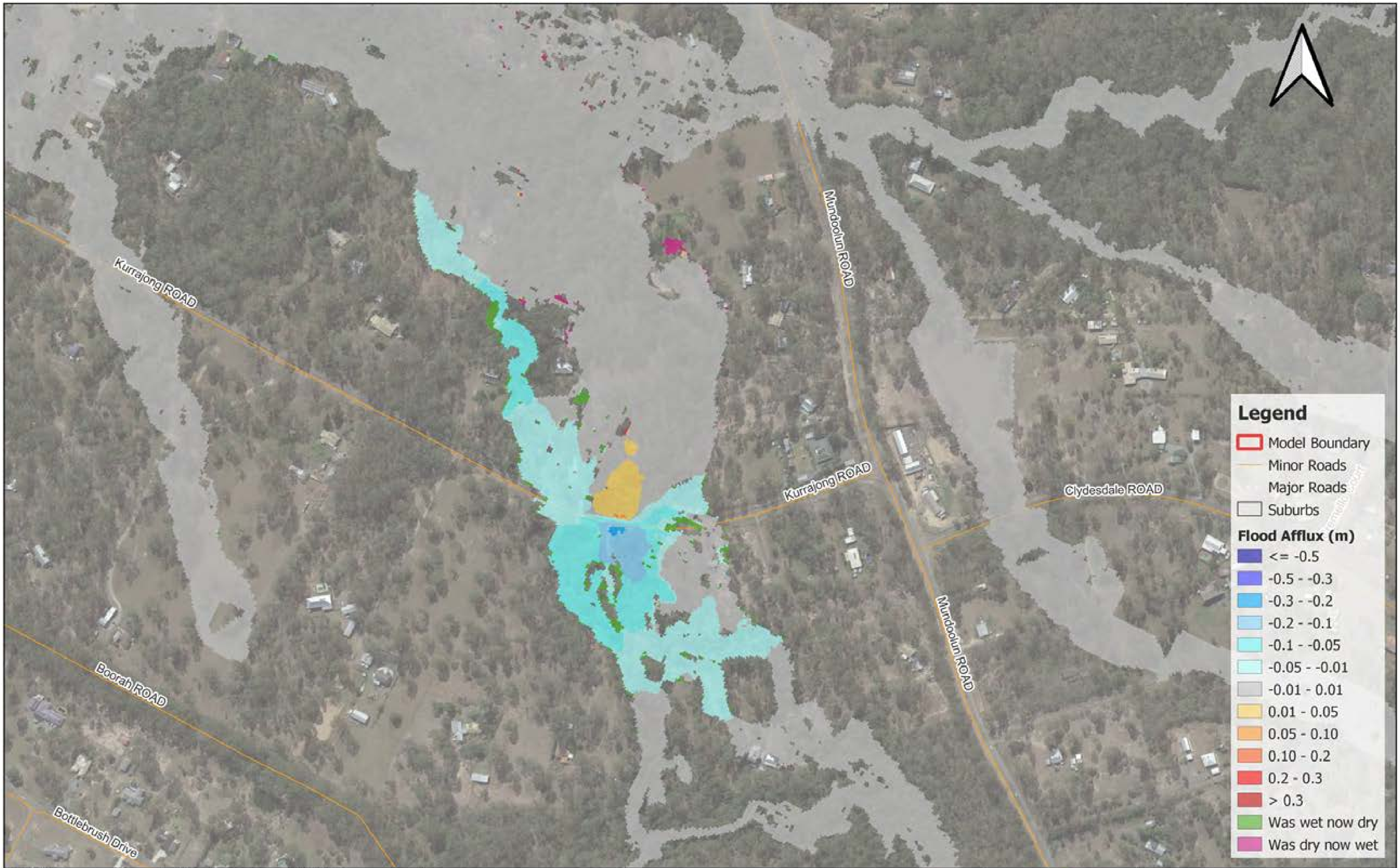
Appendix I.2.3

Henderson Creek Flood Study Update
Structural Mitigation
Kurrajong Road
1:20 AEP CC RCP4.5 Flood Afflux

Appendix I.2.3



R	DETAILS	DATE
1	Final Issue	20-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	20-07-2023

NOTES:

0 0.1 0.2 km

SCALE @ A3 - 1:4,000
GDA2020 / MGA zone 56

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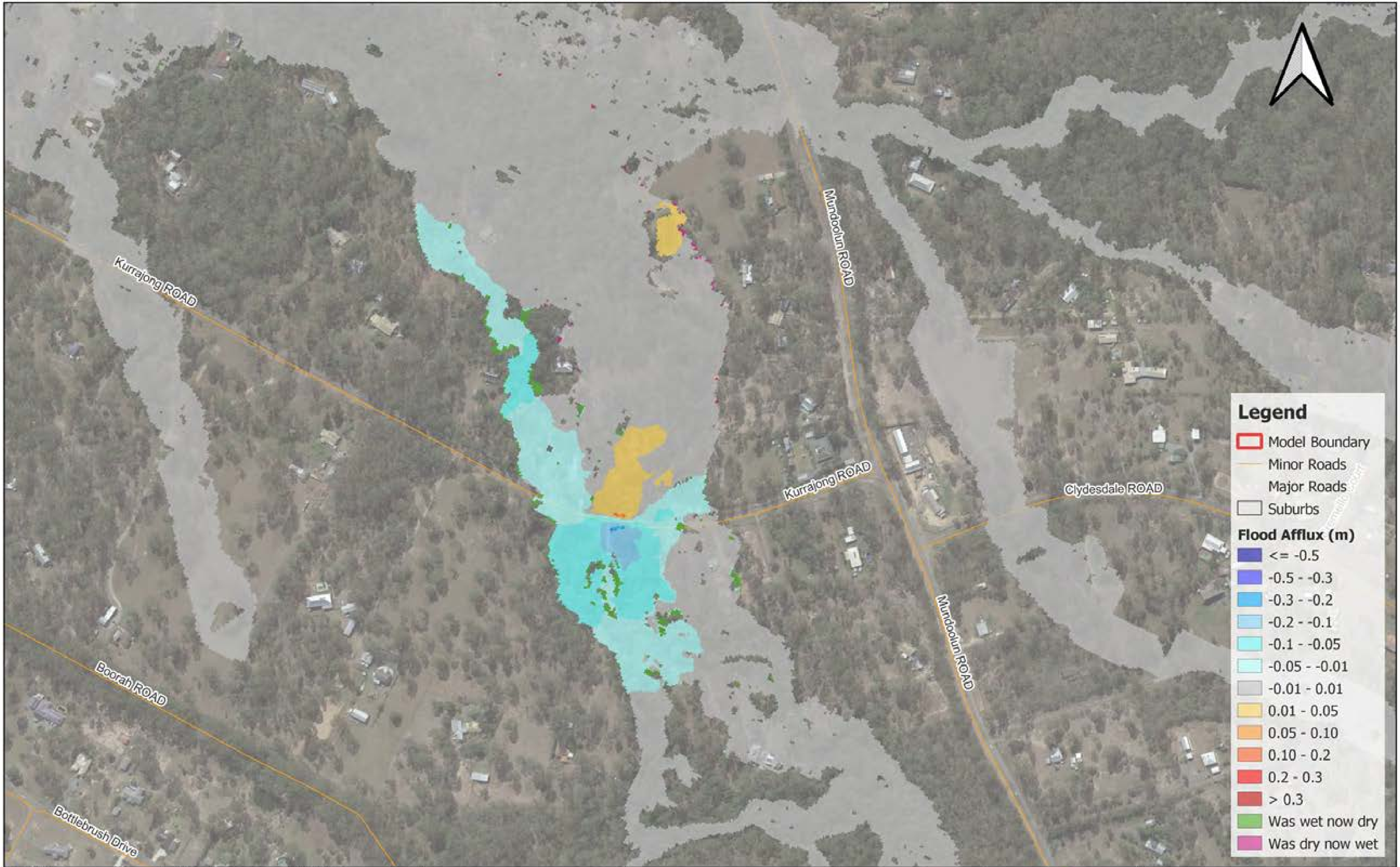
Appendix I.2.4

Henderson Creek Flood Study Update
Structural Mitigation
Kurrajong Road
1:50 AEP CC RCP4.5 Flood Afflux

Appendix I.2.4



R	DETAILS	DATE
1	Final Issue	20-07-2023

DRAWN	ZL	CHECKED	KM
APPROVED	MP	DATE	20-07-2023

NOTES:

N

0 0.1 0.2 km

SCALE @ A3 - 1:4,000
GDA2020 / MGA zone 56

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Appendix I.2.5

Henderson Creek Flood Study Update
Structural Mitigation
Kurrajong Road
1:100 AEP CC RCP4.5 Flood Afflux

Appendix I.2.5

Appendix J:

Cost Estimates

Estimate Summary

Project name:	**Edelston Road Crossing**
Project description:	**Stormwater culvert upgrade (7 x 2400mm x 1800mm RCBC)**
Client:	**Logan City Council**
Estimated by:	**Braeden Alexanderson (Civil Engineer)**
Reviewed By	**Andrew O'Keeffe**
Date:	**12/05/2023**
Notes:	**Assumptions:** **- Construction duration of 16 weeks, does not account for inclement weather delays** **- Staging of culvert construction to maintain traffic access through arterial road** **- 2 x traffic controller, ute and signage for duration of works** **- All works to take place during normal working hours** **- Culvert on skew with road alignment** **- Guardrail incorporated in new road design** **- Anticipated road reconstruction area 300m2** **Exclusions:** **- Service alterations or relocations**

PROFESSIONAL FEES & SERVICES	**21%**	**$**	**342,445**
Project Management		$	47,520
PMU Order of Costs		$	-
Estimation		$	-
Project Investigations		$	10,000
Community/Public Consultation		$	500
Project Design		$	-
Engineering Survey		$	38,000
Survey Services - Cadastral Survey		$	-
Survey Services - Hydrographic Survey		$	-
Materials Testing		$	30,000
Documentation & Tendering Process		$	10,000
Fees and Approvals		$	19,675
Locating Utilities/Underground Services		$	15,450
Outsourced Services		$	75,000
Project Planning		$	-

Risk Management		$	**5,000**
Strategic Forward Planning		$	**-**
Specification Stage		$	**-**
As Constructed Data Work (Field Work)		$	**5,000**
As Constructed Data Work (Office Work)		$	**5,000**
Post Design Work		$	**40,650**
Superintendents Representative		$	**40,650**
CONSTRUCTION WORK	**50%**	**$**	**813,057.00**
Construction Supervision		$	**38,717**
Preliminaries		$	**82,048**
Demolition		$	**70,820**
Service Alteration		$	**-**
Environmental Control		$	**5,080**
Traffic Control		$	**145,201**
Earthworks		$	**2,050**
Roadworks (Roads & Carparks)		$	**28,769**
Concrete Slabs		$	**-**
Pathways		$	**-**
Bridges and Culverts (Bridges and Major Culverts)		$	**-**
Road Inventory (Street Furniture)		$	**20,741**
Site Improvements Other		$	**-**
Soft Streetscape (Street Plantings)		$	**10,000**
Underground Stormwater Construction		$	**369,631**
Aboveground Channels (Channels)		$	**40,000**
Stormwater Quality Improvement Device		$	**-**
Lakes and Basins		$	**-**
Weirs and Floodgates		$	**-**
Alert Warning System		$	**-**
Seaway and Foreshore		$	**-**
Parking Area (Multideck Car Park)		$	**-**
Buildings		$	**-**
Swimming Facility		$	**-**
Weighbridge		$	**-**
Restoration		$	**-**
Remedial Works		$	**-**
OTHER	**0%**	**$**	**-**
Land/ Property Acquisition		$	**-**
Non Capital Costs		$	**-**
PROVISIONAL ALLOWANCE	**29%**	**$**	**462,201**
Provisional Amount (Contingency)		$	**462,201**
TOTAL COSTS =	**100%**		**$1,617,703**

Estimate Summary

Project name:	**Kurrajong Road Crossing**
Project description:	**Stormwater culvert upgrade (9 x 2000mm x 2200mm RCBC)**
Client:	**Logan City Council**
Estimated by:	**Braeden Alexanderson**
Reviewed By	**Andrew O'Keeffe**
Date:	**12/05/2023**

Notes:

Assumptions:
- Construction duration of 16 weeks, does not account for inclement weather delays
- Staging of culvert construction to maintain traffic access through arterial road
- 2 x traffic controller, ute and signage for duration of works
- All works to take place during normal working hours
- Anticipated road reconstruction area 200m2

Exclusions:
- Service alterations or relocations

PROFESSIONAL FEES & SERVICES	**22%**	**$**	**335,568**
Project Management		$	47,520
PMU Order of Costs		$	-
Estimation		$	-
Project Investigations		$	10,000
Community/Public Consultation		$	500
Project Design		$	-
Engineering Survey		$	38,000
Survey Services - Cadastral Survey		$	-
Survey Services - Hydrographic Survey		$	-
Materials Testing		$	30,000
Documentation & Tendering Process		$	10,000
Fees and Approvals		$	19,298
Locating Utilities/Underground Services		$	15,450
Outsourced Services		$	75,000
Project Planning		$	-

Risk Management		$	5,000
Strategic Forward Planning		$	-
Specification Stage		$	-
As Constructed Data Work (Field Work)		$	5,000
As Constructed Data Work (Office Work)		$	5,000
Post Design Work		$	37,400
Superintendents Representative		$	37,400
CONSTRUCTION WORK	**49%**	**$**	**747,533.64**
Construction Supervision		$	35,597
Preliminaries		$	82,048
Demolition		$	39,070
Service Alteration		$	-
Environmental Control		$	5,080
Traffic Control		$	145,201
Earthworks		$	1,700
Roadworks (Roads & Carparks)		$	22,395
Concrete Slabs		$	-
Pathways		$	-
Bridges and Culverts (Bridges and Major Culverts)		$	-
Road Inventory (Street Furniture)		$	23,561
Site Improvements Other		$	-
Soft Streetscape (Street Plantings)		$	10,000
Underground Stormwater Construction		$	352,882
Aboveground Channels (Channels)		$	30,000
Stormwater Quality Improvement Device		$	-
Lakes and Basins		$	-
Weirs and Floodgates		$	-
Alert Warning System		$	-
Seaway and Foreshore		$	-
Parking Area (Multideck Car Park)		$	-
Buildings		$	-
Swimming Facility		$	-
Weighbridge		$	-
Restoration		$	-
Remedial Works		$	-
OTHER	**0%**	**$**	**-**
Land/ Property Acquisition		$	-
Non Capital Costs		$	-
PROVISIONAL ALLOWANCE	**29%**	**$**	**433,241**
Provisional Amount (Contingency)		$	433,241
TOTAL COSTS =	**100%**		**$1,516,343**

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P: 07 3221 7174
Lvl 2, 500 Queen Street, Brisbane QLD 4000 | PO Box 10183 Brisbane QLD 4000