MOREHUMAN OAKDALE PTY LTD

Oakdale Planning Proposal

Flood Constraints Assessment

Rev B

March 2025

rp311015-00728rg_crt250314-Oakdale PP Flood Constrains Assessment

Project No. 311015-00728

Oakdale Subdivision Planning Proposal – Flood Constraints Assessment

Rev	Description	Originator	Reviewer	Approver	Revision Date
A	Draft Report	IW / RG Isaiah Wibowo / Roy Golaszewski	CT Chris Thomas		6/03/2025
B	Final Report	IW / RG Isaiah Wibowo / Roy Golaszewski	CT Chris Thomas	Chris Thomas	17/03/2025

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Appendices

1. Introduction

MoreHuman Oakdale Pty Ltd (MoreHuman Oakdale) is planning to lodge a Planning Proposal that seeks to rezone land at 1838 Barkers Lodge Road, and 1455 and 1475 Burragorang Road, Oakdale, from RU1 Primary Production to R2 Low Density Residential to permit future housing. The location of the site is shown in **Figure 1-1**.

A Master Plan for the development prepared by Cottee Parker Architects Pty Ltd shows that the proposal is for the rezoning of land to allow the creation of 186 new residential allotments that typically range in size between 300 m^2 and 1385 m^2. Vehicular access to the development is proposed via Barkers Lodge Road from the west and Burragorang Road from the north. The Master Plan is included as **Appendix A**.

A report titled, '*Water Cycle Management Strategy Report, Oakdale Planning Proposal – 1838 Barkers Lodge Road, Oakdale, NSW*', was prepared for the planning proposal by Colliers International Engineering & Design (NSW) Pty Ltd (**Colliers**). The report is dated 14th March 2024 and is referred to as the 2024 WCMS. It was submitted to Wollondilly Shire Council (**Council**) along with a planning proposal report prepared by Gyde Consulting (**Gyde**) dated 16th May 2024.

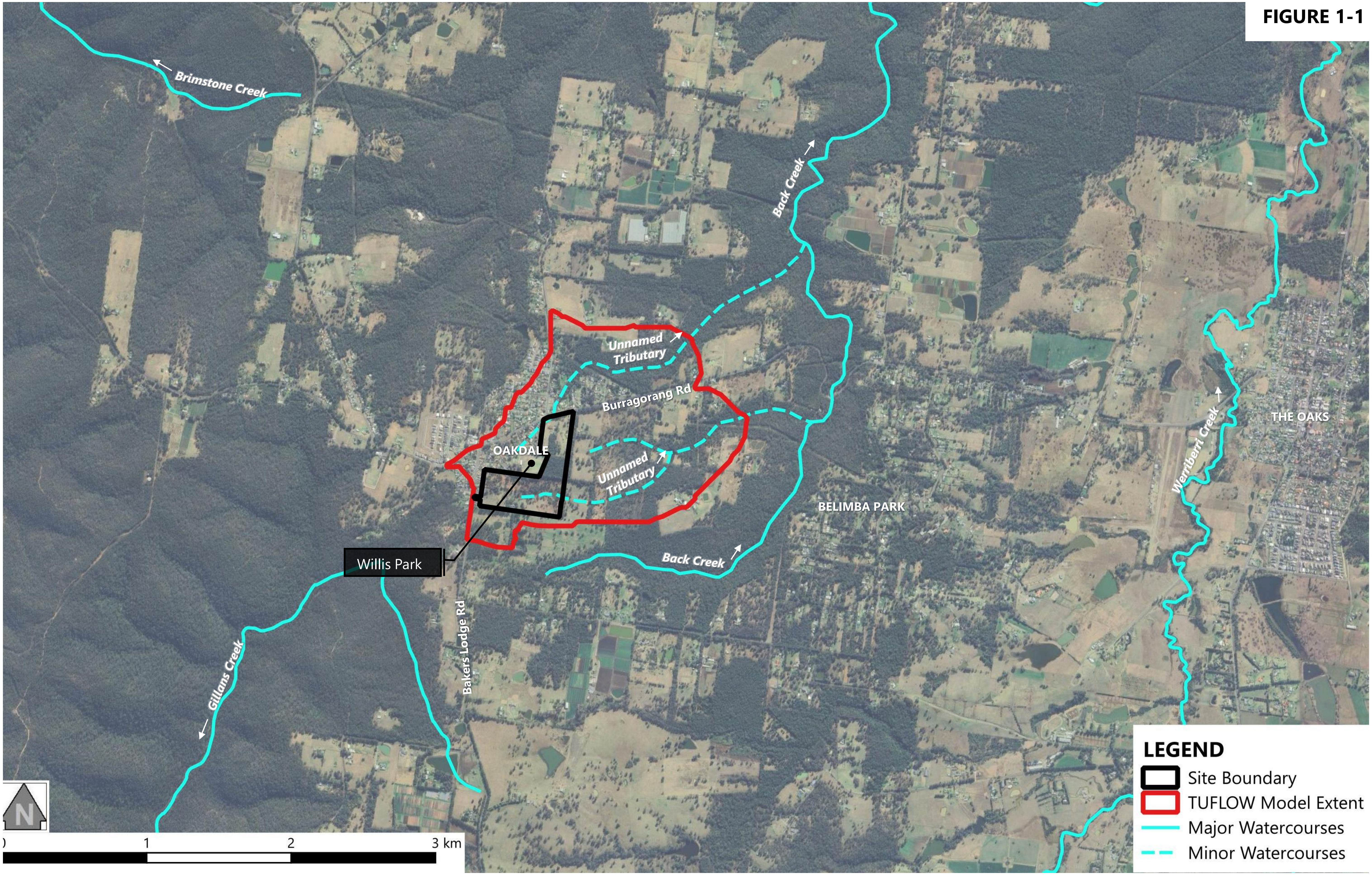
In reviewing the draft planning proposal submission, Council sought advice from the Biodiversity, Conservation and Sciences Group (**BCS**) of the NSW Department of Climate Change, Energy, the Environment and Water (**DCCEEW**). The advice provided by BCS is detailed in a letter dated the 25th July 2024 which is enclosed as **Appendix B**. A subsequent meeting was held with Council on the 8th November 2024 to discuss the planning proposal.

In recognition of the issues raised by BCS, MoreHuman Oakdale engaged Worley Consulting to prepare a flood impact and risk assessment (**FIRA**) for the purpose of attending to issues not fully addressed by Colliers. The FIRA is to address the comments received from BCS (refer **Appendix B**) and Council. The comments include the following.

- Provision of updated modelling results that are based on the use of updated versions of the hydrologic and hydraulic models developed for Council as part of the '*Wollondilly Shire Wide Flood Study*' (in draft, 2024).
- Provision of results for a range of design events including the 1% and 1 in 500 Annual Exceedance Probability (**AEP**) floods and the Probable Maximum Flood (**PMF**).
- Preparation of a development constraints assessment that includes delineation of major flow paths and flood function mapping, i.e., mapping of areas of floodway, flood storage and flood fringe.
- An assessment of flood risks and flood emergency response.
- Responses to the items raised by BCS and Council.

This report documents the findings of the investigations undertaken by Worley Consulting and serves as a development constraints assessment for the Oakdale Subdivision Planning Proposal.

FIGURE 1-1



LEGEND

- Site Boundary
- TUFLOW Model Extent
- Major Watercourses
- Minor Watercourses

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SITE LOCATION

2. Description of the Site

The development site is situated in the rural town of Oakdale which is located in the central region of the Wollondilly Shire Local Government Area (**LGA**). As shown in **Figure 1-1**, the site is located at the intersection of two major roads that pass through the town, namely Burragorang Road and Barkers Lodge Road.

There are a number of watercourses local to the site, including two unnamed tributaries of Back Creek, which is a tributary of Werriberri Creek, and which flow through the site. As shown in **Figure 1-1**, one unnamed tributary originates within the site and flows east toward its confluence with Back Creek. The second tributary originates near Willis Park before flowing north-east through the site and across Burragorang Road.

Orthophoto mapping for the site obtained via the NSW Government SIXmaps website (maps.six.nsw.gov.au) is reproduced in **Plate 2-1**. The mapping shows the alignment of the two unnamed watercourses, as well as three existing farm dams that are located within the site. Two of these farm dams are located along the southernmost watercourse.

Topographic data for the area derived from Light Detection and Ranging (LiDAR) survey was sourced from the online ELVIS portal which is provided free of charge by Geoscience Australia. The LiDAR data was flown in 2019 and comprises land surface elevations sampled at 1 metre spacing which have been used to create a 1m x 1m gridded Digital Terrain Model (**DTM**).

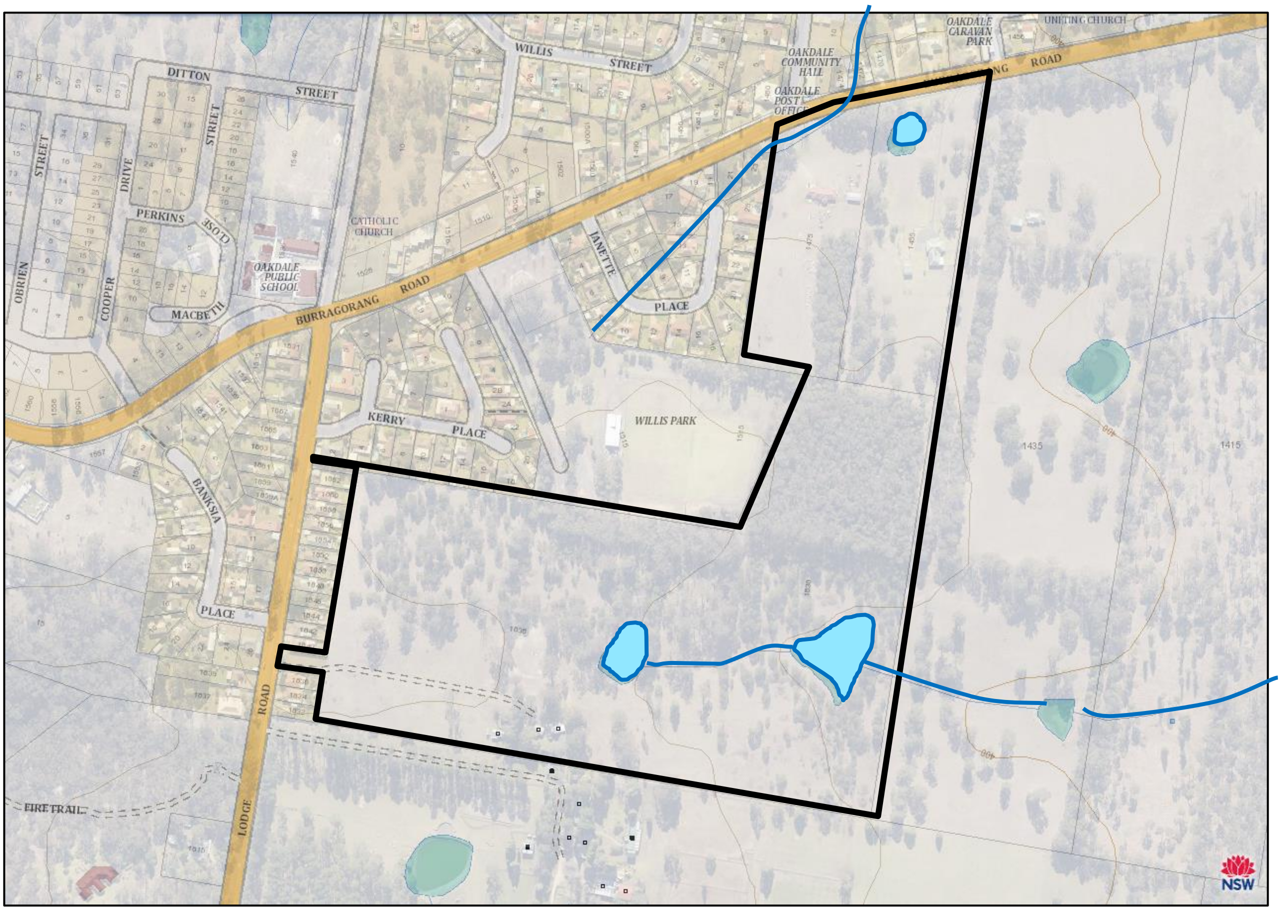


Plate 2-1 Orthophoto mapping of the site extracted from the NSW Government SIXmaps website
(*website address: maps.six.nsw.gov.au*)

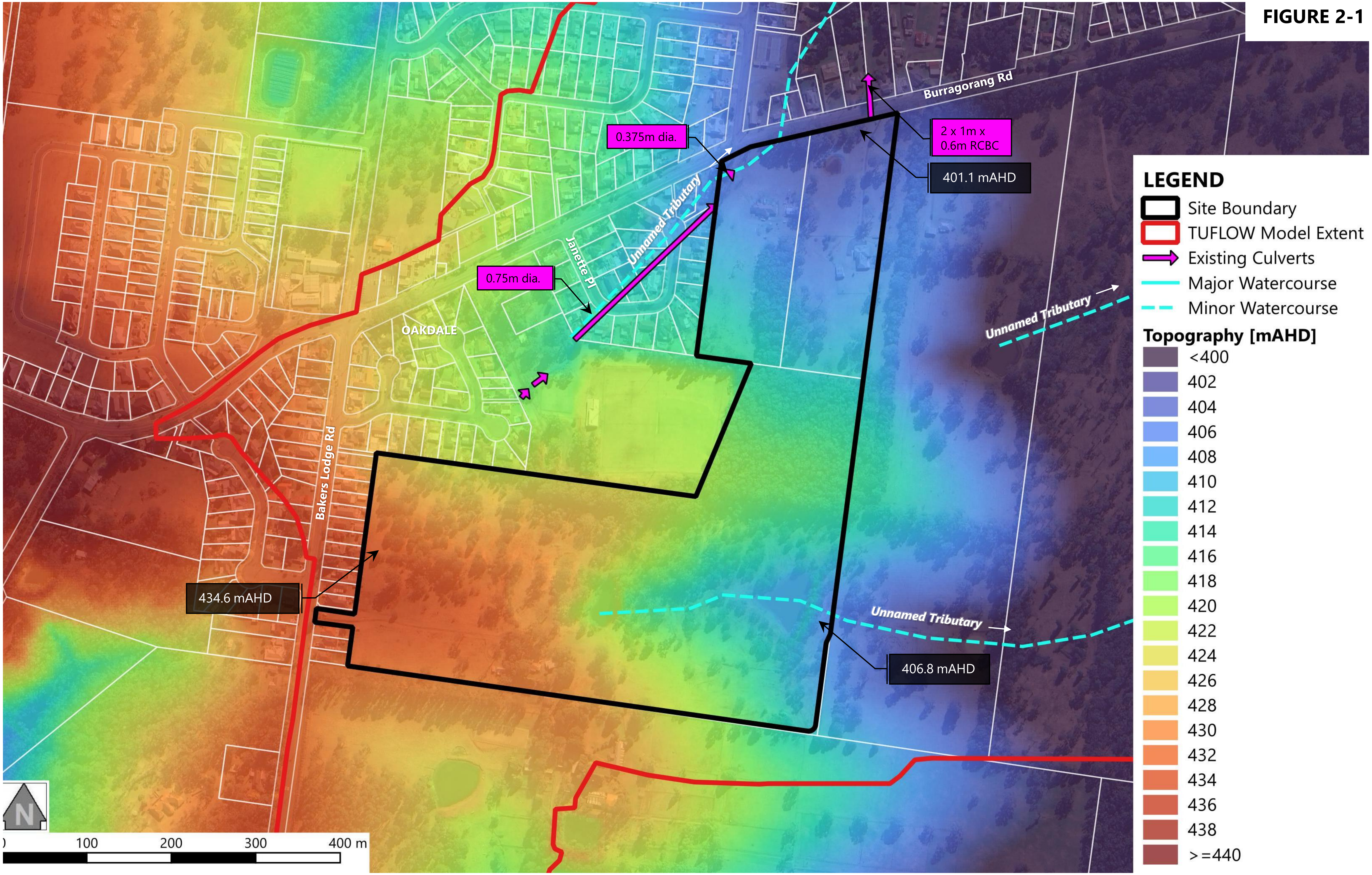
Elevations in the vicinity of the site are shown in **Figure 2-1** based on the 2019 LiDAR. The LiDAR DTM indicates that elevations are highest in the western part of the site near Bakers Lodge Road (refer **Figure 2-1**). As shown, elevations reach 434.6 mAHD at this location, before grading down to the north toward Willis Park, and to the east toward the unnamed tributary and farm dams.

The topographic mapping also shows that there is a high point that separates 1838 Barkers Lodge Road, from 1455 and 1475 Burragorang Road (refer **Figure 2-1**). Elevations across 1455 and 1475 Burragorang Road are generally the lowest in the site, reaching 401.1 mAHD along the northern boundary and adjacent to Burragorang Road.

The locations and sizes of all cross-drainage structures, and the local stormwater pipe network, is shown in **Figure 2-1**. The following key drainage features are shown in the figure.

- Two 0.5 metre diameter (**DIA**) reinforced concrete pipe (**RCP**) culverts which are located to the west of Willis Park.
- Existing 0.75 metre DIA. RCP culvert that commences near the north-west corner of Willis Park and which runs underground beneath properties that front Janette Place. The outlet of the pipe is located along the western boundary of the site.
- Existing 0.375 metre DIA. RCP culvert beneath the private driveway on 1455 Burragorang Road.
- Two 1 metre by 0.6 metre reinforced concrete box culverts (**RCBC**) that convey runoff beneath Burragorang Road.

FIGURE 2-1



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EXISTING TOPOGRAPHY ACROSS THE SITE

3. Background

3.1 Planning Proposal

Information provided to Worley Consulting indicates that the Oakdale Planning Proposal has previously been submitted to Council as a draft for review. The Planning Proposal report submitted by Gyde Consulting and dated 16th May 2024, references the following reports that are relevant to surface water and flooding.

- Preliminary Site Investigation, prepared by Geo-Environmental Engineering (refer Appendix L of the PP Report).
- Watercourse Assessment, prepared by Travers Bushfire and Ecology (refer Appendix L of the PP report).
- '*Water Cycle Management Strategy Report, Oakdale Planning Proposal – 1838 Barkers Lodge Road, Oakdale, NSW*' A '*Water Cycle Management Strategy Report, Oakdale Planning Proposal – 1838 Barkers Lodge Road, Oakdale, NSW*' (Colliers, 14th Match 2024).

In reviewing the draft Planning Proposal submission, Wollondilly Shire Council (Council) sought advice from the Biodiversity, Conservation and Sciences Group (**BCS**) of the NSW Department of Climate Change, Energy, the Environment and Water (**DCCEEW**). Th e advice provided by BCS is outlined in a letter dated 25th July 2024. A copy of the letter is included as **Appendix B**.

BCS made the following recommendations following its review of the 2024 WCMS Report.

- Address the full range of flood risk. To achieve this, flood behaviour would be examined for a range of events. Typical events examined may include the 10% or 5%, 1%, 0.5% or 0.2% AEP and probable maximum flood (PMF) for both existing and developed scenarios.
- Identify the constraints that flood places on the land (floodways, flood storage, flood hazard and emergency response issues) determined for a number of events, typically 10% or 5%, 1%, 0.2% or 0.5% AEP and PMF
- Identify the impact of the development on flooding and on the existing and future community for the full range of flooding.
- Identify how these impacts can be managed to minimise the growth in risk to the community due to the development. This includes details of any management measures to be implemented to minimise the impacts and risks posed to the existing and future community due to development.
- Address climate change impacts.

A subsequent meeting was held with Council on 8 November 2024 to discuss the Planning Proposal. The only recorded outcomes relevant to flooding and surface runoff are:

- updated Flood impact and Risk Assessment should utilise the most up to date flood study (draft Wollondilly Shire Wide Flood Study 2024) and include modelling of the PMF; and,
- stormwater basins should be within residential-zoned areas and will require 2-years maintenance and a 20-year maintenance contribution if dedicated to Council.

3.2 Wollondilly Shire Wide Flood Study (in draft, 2023)

Council previously engaged Worley Consulting to undertake the Wollondilly Shire Flood Study; Broad Scale Assessment Project (in draft, 2023). This study involves the development of WBNM hydrologic and TUFLOW hydraulic models to assess flood behaviour on a shire-wide level, including the local catchment draining through Oakdale to Back Creek and Werriberri Creek.

Worley Consulting is also in the process of developing a more detailed Flood Study for Bargo and Yanderra, The Oaks, Tahmoor, Thirlmere, Appin, and Mount Hunter.

The hydrologic and flood modelling from these studies has been used as a base for further investigations for the Oakdale Planning Proposal.

3.3 Wollondilly Shire Council Development Control Plan 2016

Part 8 of the Wollondilly Shire Council Development Control Plan 2016 (**2016 DCP**) outlines the objectives and controls that relate to development proposed on flood prone land within the LGA

4. Existing Flood Conditions

4.1 Approach

In accordance with the request from Council made during the meeting held on 8 November 2024, the modelling undertaken for the Oakdale Subdivision Planning Proposal has where possible, utilised the hydrologic and hydraulic models, and the associated inputs and outputs, generated as part of the *'Wollondilly Shire Wide Flood Study'* (in draft, 2024). However, due to the broad scale nature of the Council study, the hydrologic model (WBNM) and the hydraulic model (TUFLOW) have required refinement to ensure they are suitable for the local scale investigations necessary for this project.

An overview of the modelling approach adopted for this study is outlined below.

- Refinement of the broad scale WBNM hydrologic model and TUFLOW hydraulic models.
- Use of the refinement WBNM hydrologic model to complete a critical storm duration assessment for the 1% and 1 in 500 AEP design events and the PMF, in accordance with Australian Rainfall and Runoff 2019 (**ARR 2019**).
- Use of the local scale TUFLOW hydraulic model to simulate the 1% and 1 in 500 AEP design events and the PMF for existing conditions.

The following is an overview of the key modelling outputs documented in this section.

- WBNM hydrologic modelling results (refer **Section 4.2**).
  - Findings of the critical duration assessment
  - Peak flow distributions – 1% and 1 in 500 AEP events, and the PMF
  - Validation against the draft Shire Wide Flood Study (2024)
- TUFLOW hydrologic modelling results (refer **Section 4.2**).
  - Peak flood levels and extents, depths, and flow velocities.
  - Provisional flood hazards based on the ARR 2019 hazard curves.
  - Flood function mapping - floodway, flood storage and fringe.

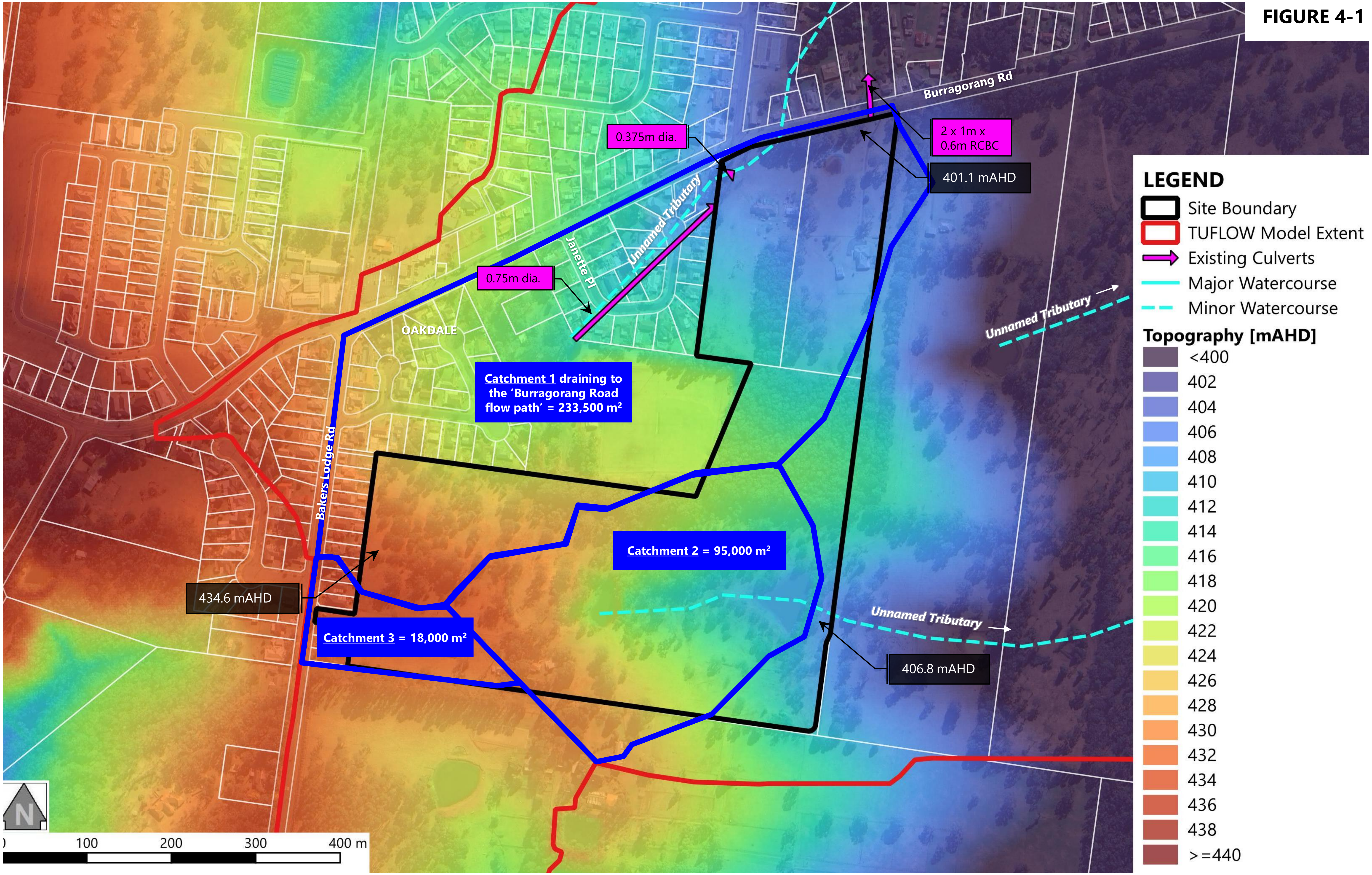
4.2 Catchment Description

The local catchment that drains to the site is shown in **Figure 4-1**. As shown, the catchment can be divided into several smaller subcatchments that direct runoff to the following three locations:

1. To the unnamed tributary that flows through the northern site boundary and along/through Burragorang Road. This flow path is referred to as the Burragorang Road flow path herein (refer <u>Catchment 1</u> on **Figure 4-1**).
2. To the unnamed tributary that flows east through the southern half of the site. This catchment also directs runoff to two existing farm dams (refer <u>Catchment 2</u> on **Figure 4-1**).
3. To the south towards the upper reaches of Back Creek (refer <u>Catchment 3</u> on **Figure 4-1**).

The total catchment area for each of the above flow paths is 346,500 m^2. Catchment No. 1 is the largest of the three, measuring 233,500 m^2 (refer **Figure 4-1**).

FIGURE 4-1



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LOCAL CATCHMENTS APPLICABLE TO THE SITE

Catchment No. 1 has the highest proportion of urban development with residential lots located along Barkers Lodge Road, Burragorang Road and Janette Place (refer **Figure __**). The other catchments comprise mostly open space with several rural residential buildings.

4.3 WBNM Hydrologic Modelling

4.3.1 WBNM Model Updates

As discussed, the WBNM hydrologic model that was developed as part of the draft Shire Wide Flood Study (2024) was used as the basis for these investigations. However, the WBNM model was development for large catchment scale modelling covering the entire Wollondilly Shire LGA. Consequently, the model is not suitably refined for use in local scale studies such as is required for this Planning Proposal.

The WBNM hydrologic model was therefore updated by undertaking the following.

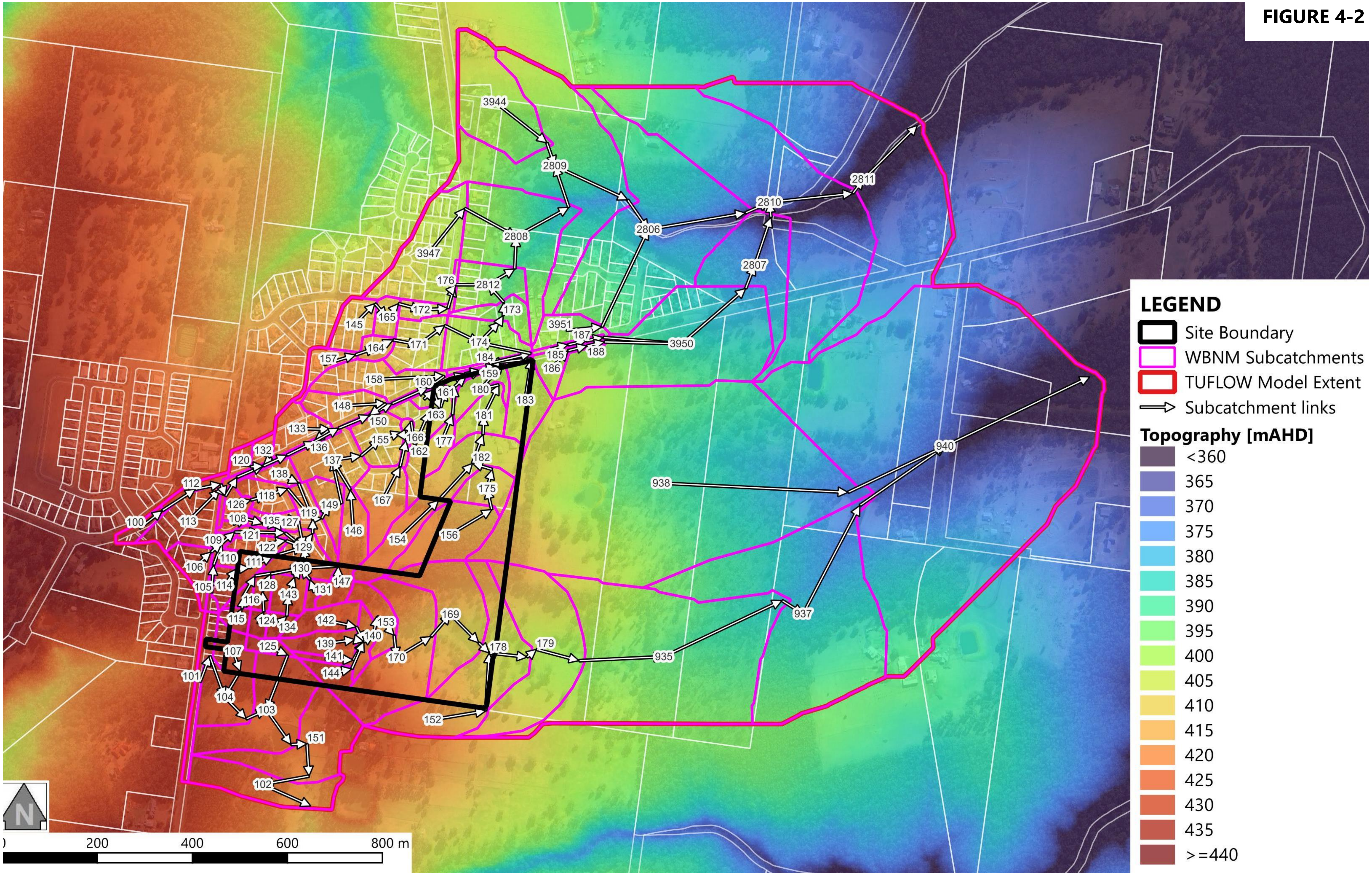
- Refinement of sub-catchment sizes to better represent the flow paths local to the site. The final sub-catchment layout adopted for the local scale WBNM model is shown in **Figure 4-2**.
- Calculation of updated catchment parameters based on analysis of aerial photography and the 2019 LiDAR survey data set. Percentage impervious values were re-calculated for each sub-catchment based on the land use types listed in **Table 4-1**.

Table 4-1 Effective Percentage Impervious by Land Use Type

Material Type	Effective Percentage Impervious
Watercourses	100%
Concrete Open Channels (not used)	100%
Low Density Residential	60%
Medium Density Residential	70%
Large Residential Lot	40%
High Density Residential (not used)	80%
Industrial/Commercial Yard	90%
Open Space / Pastureland	10%
Vegetation – Medium Density	5%
Vegetation – High Density (Forest)	2%
Road Corridor, including roadway and verge	70%
Rail Corridor	50%

No changes were made to the runoff lag and stream routing parameters adopted as part of the Shire Wide Flood Study WBNM model. The adopted values are listed in **Table 4-2**.

FIGURE 4-2



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WBNM HYDROLOGIC MODEL LAYOUT

Table 4-2 Adopted WBNM Runoff Lag and Stream Routing Parameters

WBNM Model Parameter	Parameter Value
Runoff lag factor 'C'	1.6
Impervious runoff lag factor 'C'	0.1
Stream routing factor 'F'	1.0

The layout of the Shire Wide Flood Study WBNM model is shown in **Figures C-1** and **C-2** in **Appendix C**. These figures have been included to allow comparison to the local scale WBNM model.

4.3.2 Design Rainfall

The design rainfall input into the updated WBNM model was consistent with the draft Shire Wide Flood Study WBNM model. Accordingly, the model was set-up in accordance with ARR 2019 with the recommended Intensity-Frequency-Duration (**IFD**) data and ensemble approach for the selection of design storm events and durations. In that regard, ARR 2019 recommends the simulation of an ensemble of ten (10) temporal patterns for each design event and duration to determine a range of plausible flow hydrographs. A single representative design rainfall pattern is then selected which generates a peak flow that is nearest to the average of the ten (10).

The Generalised Short Duration Method (**GSDM**) was applied to determine rainfall intensities and temporal patterns for a local catchment PMF event. The GSDM method is recommended in ARR 2019 for use in catchments with critical durations of up to 6 hours. This is consistent with approach adopted for the Shire Wide Flood Study WBNM model.

4.3.3 Critical Duration Assessment

The WBNM model was used to assess critical storm durations and 'average' temporal patterns. A summary of the selected critical storm durations and temporal patterns are listed in **Table 4-3**.

Table 4-3 Critical Storm Durations and Selected Temporal Patterns

Design Event	Critical Duration (min)	Pattern Set	'Average' Pattern ID
1% AEP	45 min	East Coast (South) - rare	4528
0.2% AEP	45 min	East Coast (South) - rare	4528
PMF	30 min	GSDM	N.A.

The Shire Wide Flood Study (draft, 2024) adopts critical storm durations for the catchment of 60, 180 and 360 minutes. It is understandable that a shorter critical duration has been identified for this study area based on the small catchment size that drains to the north eastern corner of the site.

4.4 Set-up of the Truncated TUFLOW Hydraulic Model

4.4.1 2D Model Domain and Terrain

A truncated version of the Shire Wide Flood Study TUFLOW model was created to cover only the floodplain local to the site. This led to the creation of a localised version of the TUFLOW model with a model area of about 203 ha. The extent of the truncated TUFLOW model is shown in **Figure 4-3**.

A benefit of using a truncated model for this study is that it enabled the grid cell size to be reduced from 6 metres by 6 metres adopted in the Shire Wide TUFLOW model, to 2 metres by 2 metres. This allows an improved representation of the floodplain by allowing additional sampling of the floodplain surface/terrain allowing better representation of flow paths. Accordingly, each square grid cell contains information on ground surface elevation, hydraulic roughness and other parameters as necessary (*e.g., cell blockage and energy losses to represent the hydraulic effects of railings and bridges*). The ground surface elevation is sampled at the centre, mid-sides and corners of each cell from the DTM. For a 2 metre grid this results in DTM elevations being sampled at 1 metre centres.

The 2019 LiDAR data set that was used for the Shire Wide TUFLOW model was again adopted for the truncated model.

The extent and layout of the draft Shire Wide Flood Study (2024) TUFLOW model is shown in **Figure C-3** and **C-4** in **Appendix C**. These figures have been prepared to allow comparison between the two models.

4.4.2 Drainage Infrastructure

Existing drainage infrastructure located along the Burragorang Road, and beneath Janette Place were included in the Shire Wide TUFLOW model and retained in the truncated TUFLOW model (refer **Figure 2-1** and **Figure 4-3**). Invert elevations for the culverts were taken from draft Shire Wide Flood Study (2024) and estimated from the 2019 LiDAR where unavailable.

A 25% blockage factor was adopted for the existing culverts for the 1% AEP flood. An increased blockage factor of 50% was adopted for the culverts for simulation of the 0.2% AEP flood and the PMF.

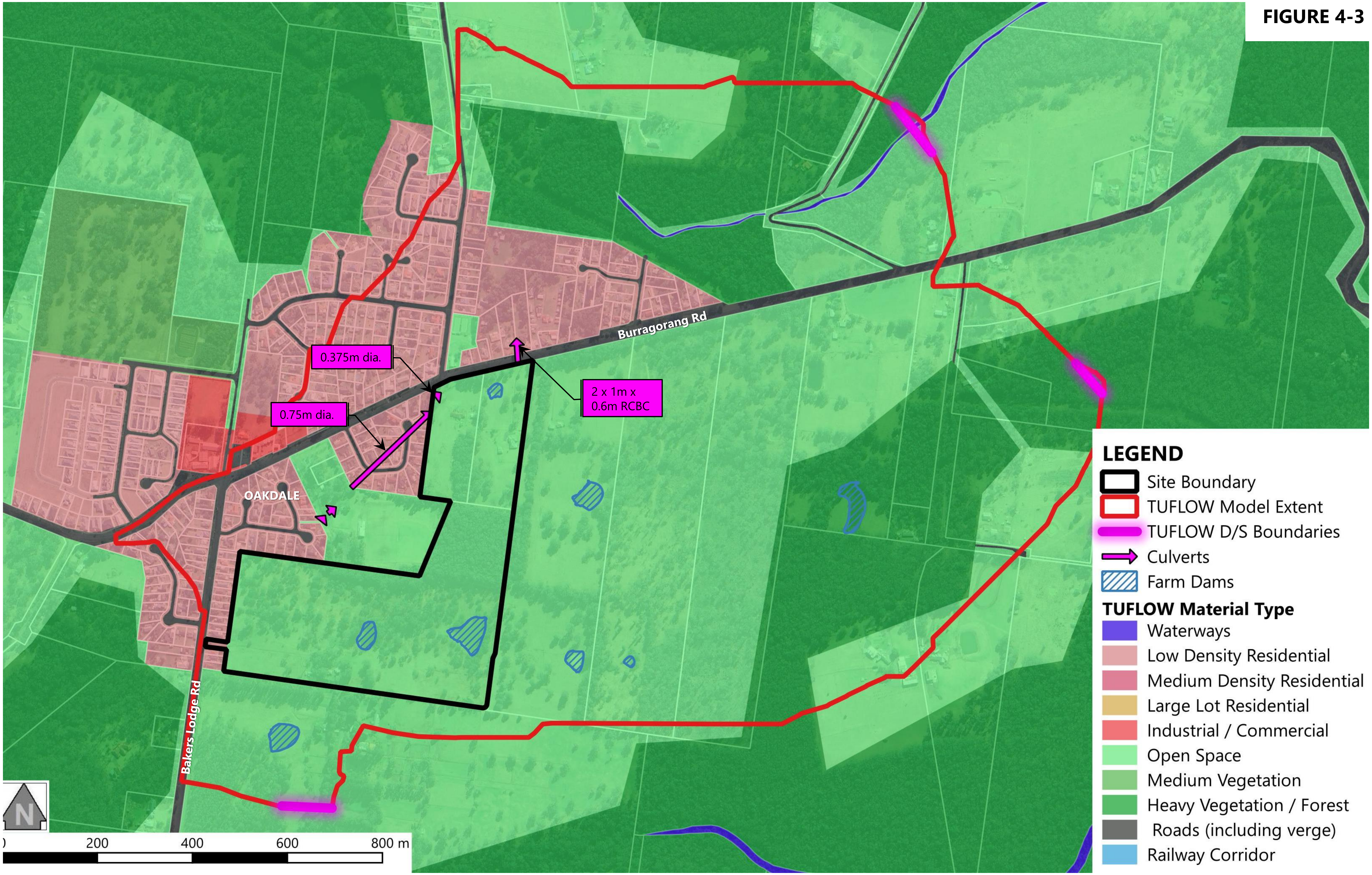
4.4.3 Hydraulic Roughness

Hydraulic roughness coefficients (*Manning's 'n'*) are used to represent the resistance to flow of different surface materials. Hydraulic roughness has a major influence on flow behaviour and is one of the primary parameters that may be altered to achieve calibration of hydraulic models.

Spatial variation in hydraulic roughness is represented in TUFLOW by delineating the floodplain into zones of similar hydraulic properties. The hydraulic roughness zones adopted for the draft Shire Wide Flood Study (2024) are based on consideration of aerial photography, land use zoning, and site observations. Manning's 'n' values assigned to each zone were determined based on-site observations and previous experience, with reference to values recommended in the literature (*e.g., Chow 1959*). As resistance to flow due to surface and form roughness varies with depth (*e.g., Chow 1959, ARR 1987*), variable depth-dependent hydraulic roughness values have been adopted.

Manning's 'n' roughness coefficients adopted in the Shire Wide TUFLOW model and retained in the truncated model are listed in **Table 4-4**, with the delineation of hydraulic roughness zones (*Material Types*) shown in **Figure 4-3**. Below 'Depth 1' the first Manning's 'n' value is applied, while above 'Depth 2' the second Manning's 'n' value is applied. At depths between 'Depth 1' and 'Depth 2' Manning's values are determined by linear interpolation.

FIGURE 4-3



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MODEL AND MATERIAL ROUGHNESS FOR THE TRUNCATED TUFLOW MODEL

This approach attempts to account for relatively rough conditions close to the ground surface (*e.g., small retaining walls, garden beds, rockeries in residential areas*) compared to a lower roughness applied to the remainder of the water column.

Table 4-4 Adopted Manning's 'n' Hydraulic Roughness Coefficients

Model Material	Depth 1 (m)	Manning's 'n' Value 1	Depth 2 (m)	Manning's 'n' Value 2
Watercourses	0.5	0.10	2.0	0.04
Buildings	-	3.00	-	-
High Density Residential	0.3	0.20	1.5	0.10
Low-Med Density Residential	0.2	0.10	0.6	0.06
Industrial/Commercial Yard	0.1	0.10	0.3	0.06
Open Space	0.1	0.06	0.3	0.04
Vegetation – Medium Density	0.15	0.16	0.5	0.08
Road Corridor	0.05	0.05	0.10	0.03
Rail Corridor	0.1	0.16	0.3	0.08

4.4.4 Boundary Conditions

Normal-depth downstream boundary conditions were applied to the two unnamed watercourses at the edge of the model to the east of the site. A third boundary condition was added to the south of the site, as shown in **Figure 4-3**. In TUFLOW, normal-depth boundary conditions utilise the Manning's equation to estimate flow depth and velocity based on bed slope and roughness, ensuring realistic and smooth flow transitions at model outflow boundaries.

4.4.5 Inflows

A 'rainfall on the grid' modelling approach was adopted for the truncated TUFLOW model to better represent the localised flow paths that could form in the vicinity of the site. This approach differs to the Shire Wide Flood Study TUFLOW model which inputs flow hydrographs extracted from the WBNM hydrologic model as 'surface area' local inflows.

4.4.6 Validation of Predicted 1% AEP Levels

As discussed above, the truncated TUFLOW model relied upon for this study is based on an updated version of the TUFLOW model developed as part of the Shire Wide Flood Study (draft, 2024). A comparison between peak flood levels predicted for the 1% AEP event using the truncated and original TUFLOW models, is presented in **Figure 4-4**. The mapping shows that the truncated model predicts peak 1% AEP flood levels in the vicinity of the site that are typically within +/- 0.1 metres of those documented in the Shire Wide Flood Study (draft, 2024).

The inset on **Figure 4-4** also shows that the truncated model predicts similar flood levels along the flow path that runs through the northern corner of the site and along Burragorang Road. This flow path is particularly important to the development given it will have the potential to influence the lot layout and require cross-drainage infrastructure along the entry/exit roads from Burragorang Road.

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NOTES:

1. 1% AEP modelling undertaken for the Shire Wide Flood Study (draft, 2024) adopts 60, 180 and 360 minute storm durations. The modelling undertaken for the Oakdale Planning Proposal is based on a truncated version of the TUFLOW model and a storm duration of 45 minutes.
2. Yellow mapping shows the peak 1% AEP flood extent predicted using the truncated TUFLOW model.

VALIDATION TO THE DRAFT SHIRE WIDE FLOOD STUDY RESULTS
[1% AEP FLOOD LEVELS AND EXTENTS]

It is noted that the differences observed between the truncated and original 1% AEP results are attributed to the following:

- changes in model grid cell size from 6 metres by 6 metres to 2 metres by 2 metres.
- change to rainfall on the grid modelling.

4.5 TUFLOW Hydraulic Model Results

The truncated TUFLOW model developed as part of this study was used to simulate the 1% AEP, 1 in 500 AEP and PMF events. The results of the modelling are presented in the following sections.

4.5.1 Peak Flood Levels and Extents

Peak flood levels and extents for the 1% AEP, 1 in 500 AEP and PMF events are presented in **Appendix D** as **Figures D-1** to **D-6** for existing conditions. The flood mapping shows that most of the site will remain flood free during events up to and including the PMF. This is expected given the location of the site at the top of the Back Creek catchment. The site is most flood prone adjacent to Burragorang Road where floodwaters enter the site via:

- the existing 0.75 metre DIA. RCP culvert that runs beneath Janette Place, and
- an overland flow path that runs along Janette Place before discharging through 23 and 26 Janette Place and into the site (refer **Figures D-1**, **D-3** and **D-5**).

The modelling results for events up to and including the 1 in 500 AEP flood show that the flow path crosses into the Burragorang Road reserve where it is largely contained within the table drain that runs adjacent to it on the southern site. The floodwaters are predicted to then overtop Burragorang Road, or flow through two existing 0.6 metre RCB culverts that run beneath Burragorang Road and continue north toward the unnamed Back Creek tributary.

Additional details for the Burragorang Road flow path, including peak flood levels and flow magnitudes, are listed below in **Table 4-5**.

Table 4-5 Northern Burragorang Road Flow Path

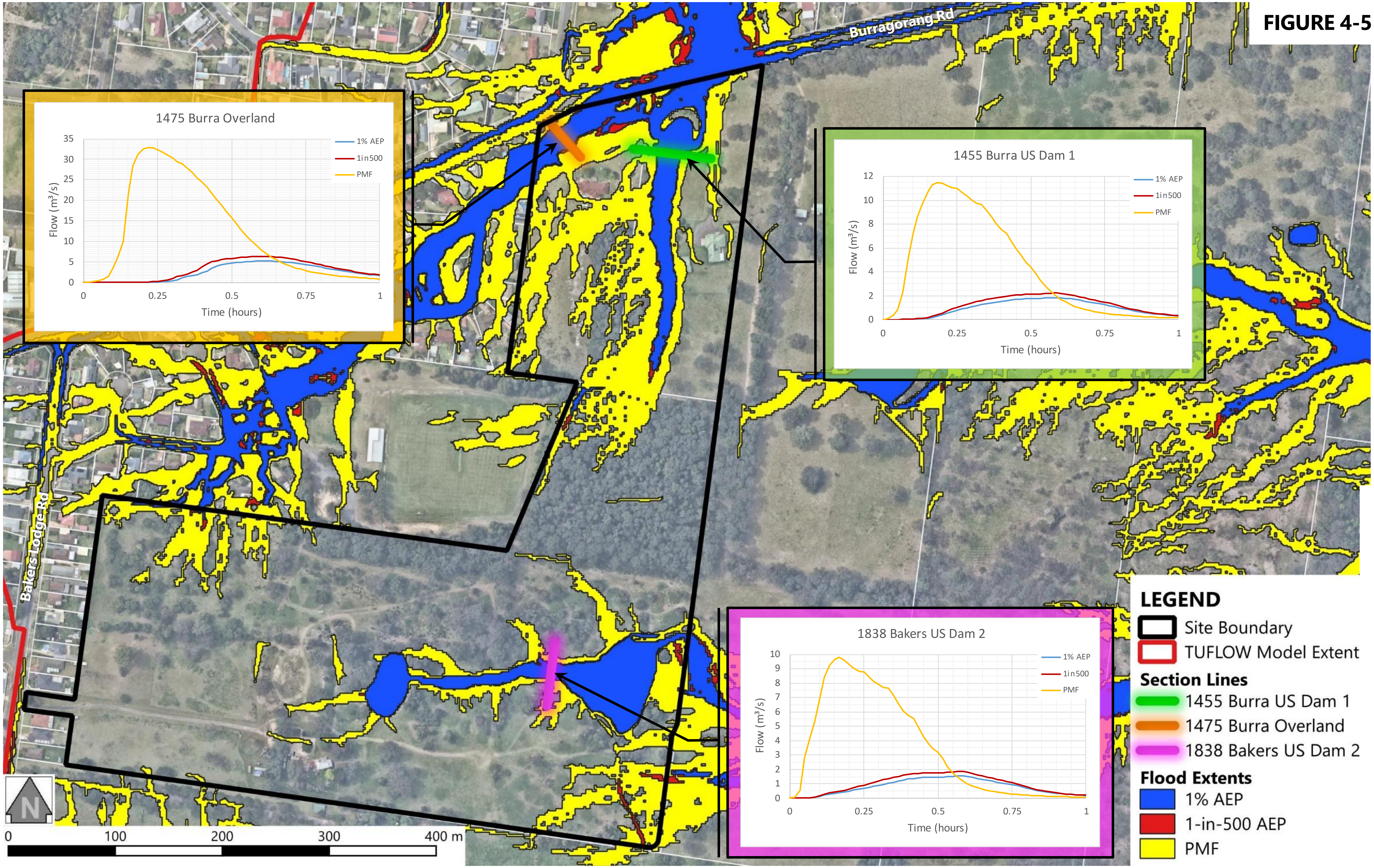
Design Event	Peak Flow Entering Site (m^3/s)	Peak Flood Level (mAHD)	
		Western Site Boundary / Maximum Level	Northern Boundary / Minimum Level
1% AEP	5.5	406.60	401.88
1 in 500 AEP	6.2	406.66	401.92
PMF	33.0	407.12	402.11

Other minor flow paths are also present within the site as shown in **Figure 4-5**. These flow paths are typically aligned with the existing farm dams and are predicted to convey less than 2.5 m^3/s and 11.5 m^3/s during a 1% AEP flood and PMF event, respectively.

4.5.2 Peak Flood Depths and Flow Velocities

The following mapping of peak flood depths and flow velocities for the adopted design events is presented in **Appendix E** and **Appendix F**:

- **Figures E-1** to **E-6** for flood depth mapping, and
- **Figures F-1** to **F-6** for flow velocities.



Note: *All event extents have been filtered to remove depths below 0.15 m and VxD below 0.025 sq.m/s*

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PREDICTED FLOW DISTRIBUTIONS ALONG THE MAIN FLOW PATHS WITHIN THE SITE

The model results shown in the mapping indicate that flow velocities are highest along the Burragorang Road flow path to the north of the site. Accordingly, flow velocities of up to 1.84 m/s and 2.85 m/s are predicted along this flow path and within the site during the 1% AEP and PMF events, respectively.

Flow velocities elsewhere within the site are typically less than 1.0 m/s and 2.0 m/s during the 1% AEP and PMF events, respectively.

4.5.3 Flood Hazards

The personal danger and physical property damage caused by a flood varies both in time and place across the floodplain. Accordingly, the variability of flood patterns across the floodplain over the full range of floods needs to be understood by flood prone landholders and floodplain risk managers.

Representation of the variability of flood hazard across the floodplain provides floodplain risk managers with a tool to assess the existing flood risk and to determine the suitability of land use and future development. The hazard associated with a flood is represented by the static and dynamic energy of the flow, which is in essence, the depth and velocity of the floodwaters. Therefore, the flood hazard at a particular location within the floodplain is a function of the velocity and depth of the floodwaters at that location.

Guideline 7.3 – Flood Hazard of '*Handbook 7 – Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia*' of the Australian Disaster Resilience Handbook Collection (*2017*) presents a set of hazard curves which assess the vulnerability of people, vehicles and buildings to flooding based on the velocity and depth of flood flows. These curves have been adopted to define flood hazard in this study and are reproduced in **Plate 4-1**.

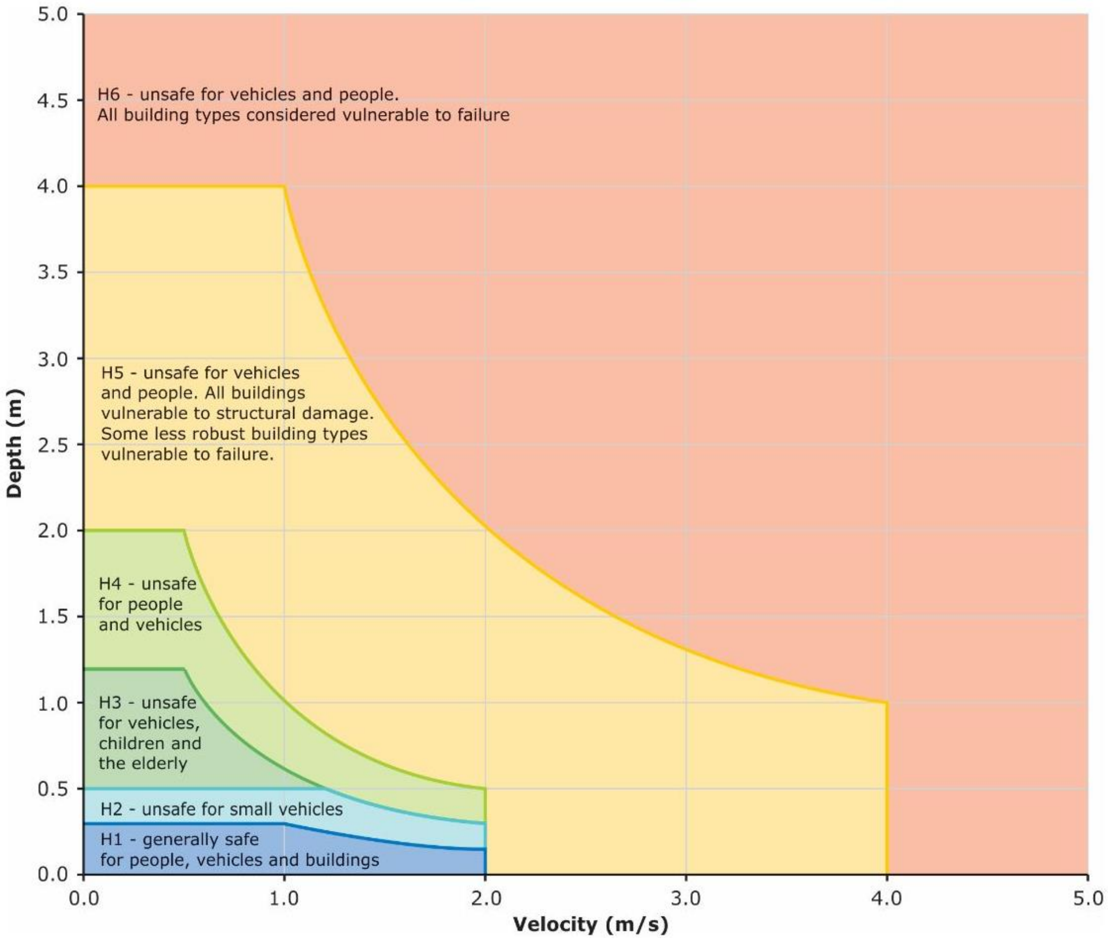


Plate 4-1 Flood Hazard Hydraulic Criteria (Handbook 7 – Managing the Floodplain 2017)

The modelling results for the 1% AEP, 1 in 500 AEP and PMF events were used to prepare provisional flood hazard mapping for the site. As shown in **Figures G-1** to **G-4**, flood hazards are predicted to be in the lowest category H1 across the majority of the site during a 1% AEP and 1 in 500 AEP events. In that regard, only a small extent of the Burragorang Road flow path and the farm dams are predicted to exceed H1 and reach as high as H4.

During the PMF, flood hazards across the site and local floodplain are predicted to range between H1 and H5. As show in **Figure G-5**, H5 hazards are predicted to occur along the Burragorang Road flow path and along Burragorang Road itself.

4.5.4 Hydraulic Categories / Flood Function

The hydraulic category or flood function for a site identifies the potential for development to impact on existing flood behaviour. The NSW Government's '*Floodplain Development Manual*' (*2005*) divides flood prone land into three hydraulic categories; namely Floodway, Flood Storage and Flood Fringe.

The NSW Government's *Flood Risk Management Manual: The Policy and Manual for the Management of Flood Liable Land* (2023) includes *Floodplain Risk Management Guideline FB02*, titled 'Flood Function'. Guideline FB02 offers advice on delineating floodways, flood storage areas, and flood fringe zones based on their flood function. It also provides a recommended methodology for floodway delineation, drawing on the approach and criteria originally proposed by Thomas et al. (2012).

The results discussed in the preceding sections and presented in **Appendix D** to **G**, indicate that flooding across the site is categorised by shallow depths and low flow velocities that are typically less than 0.5 metres and 1.0 m/s during floods up to and including a 1 in 500 AEP event, respectively. This is also supported by **Figure 4-5** which shows that peak flows throughout the site are predicted to be less than 6.2 m^3/s during floods up to and including the 1 in 500 AEP event.

The Burragorang Road flow path is the most significant, conveying the largest flows and highest flow velocities. This flow path enters the site from Janette Place before discharging toward and then over Burragorang Road. The floodway corridor was delineated for the Burragorang Road flow path based on application of the '*conveyance method*' documented in Guideline FB02. This approach recommends that the floodway be delineated based on a review of flow distributions to identify the floodplain width required to convey 80% of the total local flow. Flow distributions were analysed for the 1% AEP and 1 in 500 AEP results to delineate the floodway corridor along this flow path.

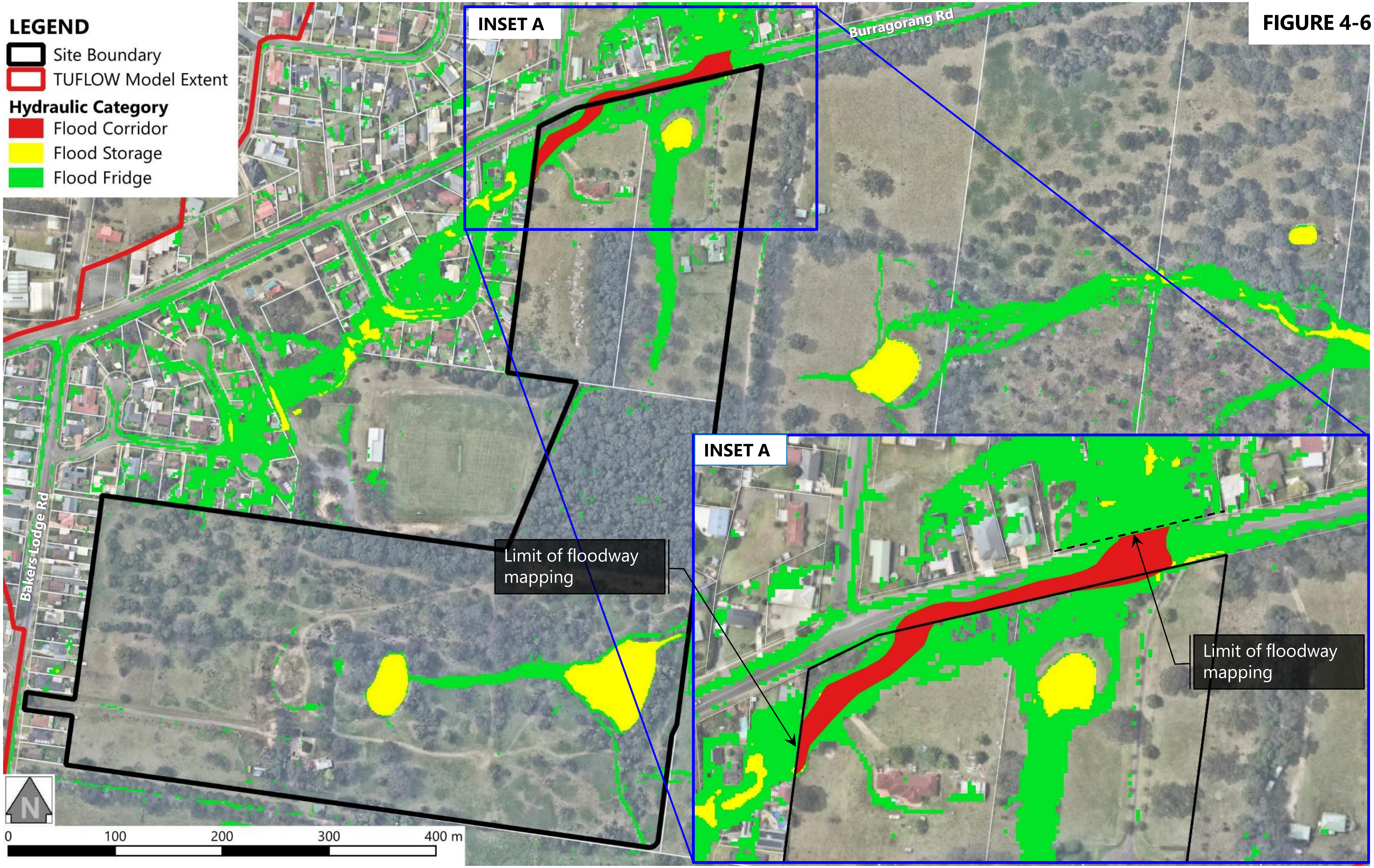
Flood function mapping for the site is presented in **Figures 4-6** for the 1% AEP flood. As shown, a floodway corridor has been mapped only for the Burragorang Road flow path, with the remainder of the site mapped as flood storage and fringe. A depth threshold of 0.3 metres was adopted for mapping flood fringe.

4.5.5 Consideration of Climate Change

The letter issued by BCS dated 15th July 2024, includes a recommendation stating that the impact of climate change be considered. In general, climate change is predicted to result in more frequent flooding and higher flood levels due to increases in the intensity and frequency of flood-producing rainfall events. Sea level rise is also predicted to lead to higher tidal levels. However, increased tidal levels would not contribute to any change in the vicinity of the site.

Section 2.6.2 of Guideline FB01 which is one of the supporting documents that form the Toolkit for the recently published NSW *Floodplain Risk Management Manual* (2023), provides some guidance on how climate change should be considered for new development. The guideline advocates a practical approach for studies completed under the Floodplain Management Program whereby the 1 in 200 AEP and/or 1 in 500 AEP design events are used as proxies for understanding the potential impact of climate change. This is based on the 1 in 200 and 1 in 500 AEP events typically having in the order of 15% and 30% more rainfall than the current estimate of the rainfall required to generate a present day 1% AEP flood.

FIGURE 4-6



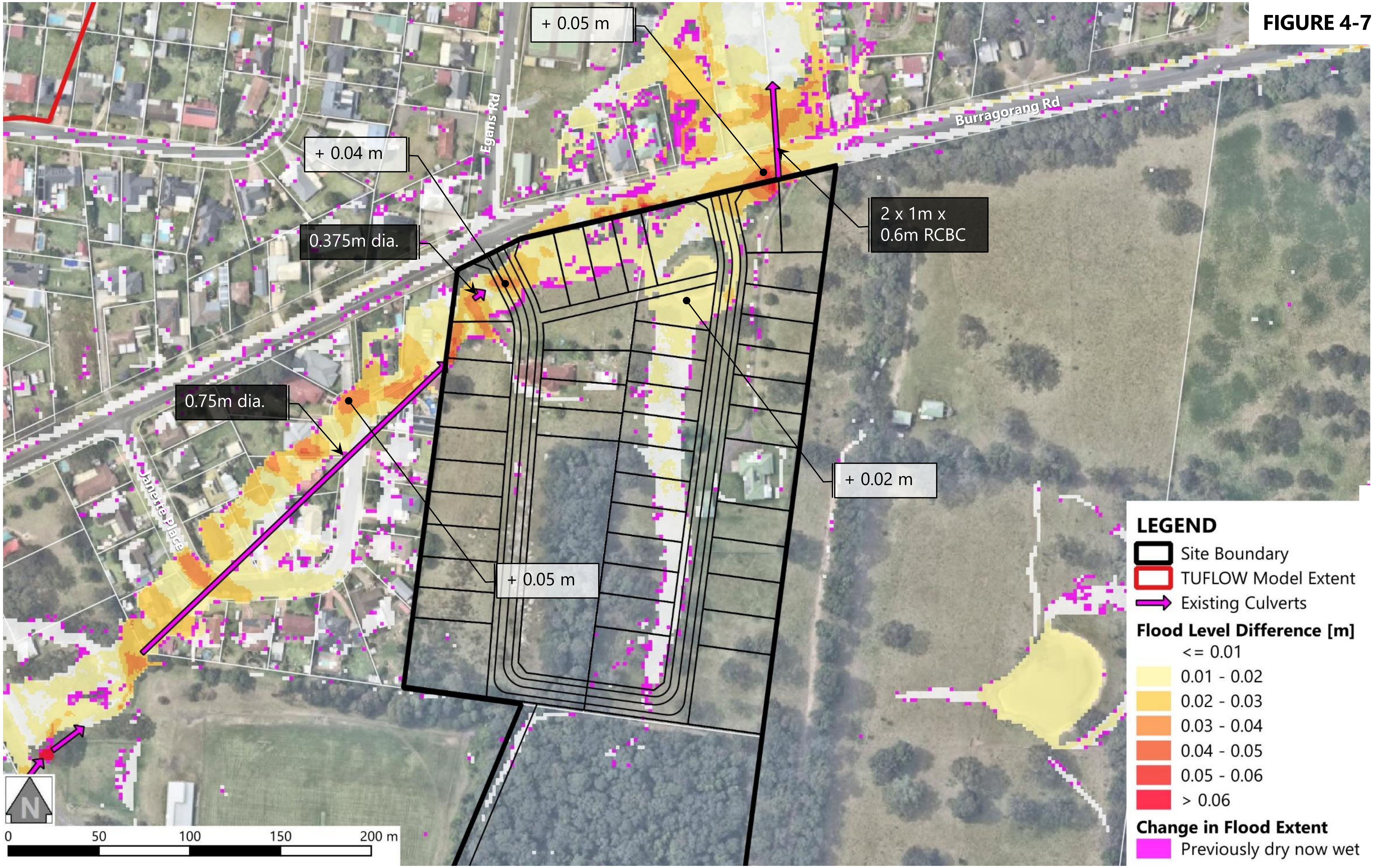
Prepared by:

worley consulting

HYDRAULIC CATEGORY / FLOOD FUNCTION MAPPING – 1% AEP EVENT

It is considered appropriate to adopt the 1 in 500 AEP event as a proxy for climate change for this study, and for it to be used to characterise the potential impact of climate change on flooding.

Predicted flood levels and extents for the 1 in 500 AEP flood are presented in **Figure D-3** and **D-4** in **Appendix D**. The differences in flood levels between this climate change scenario and the present day 1% AEP flood are presented in **Figure 4-7** and **Figure 4-8**. The flood level difference mapping shows that climate change could lead to flood level increases that range between typically range between 0.01 to 0.06 metres across the site. The differences mapping also shows the change to predicted flood extents via the purple coloured inundation.



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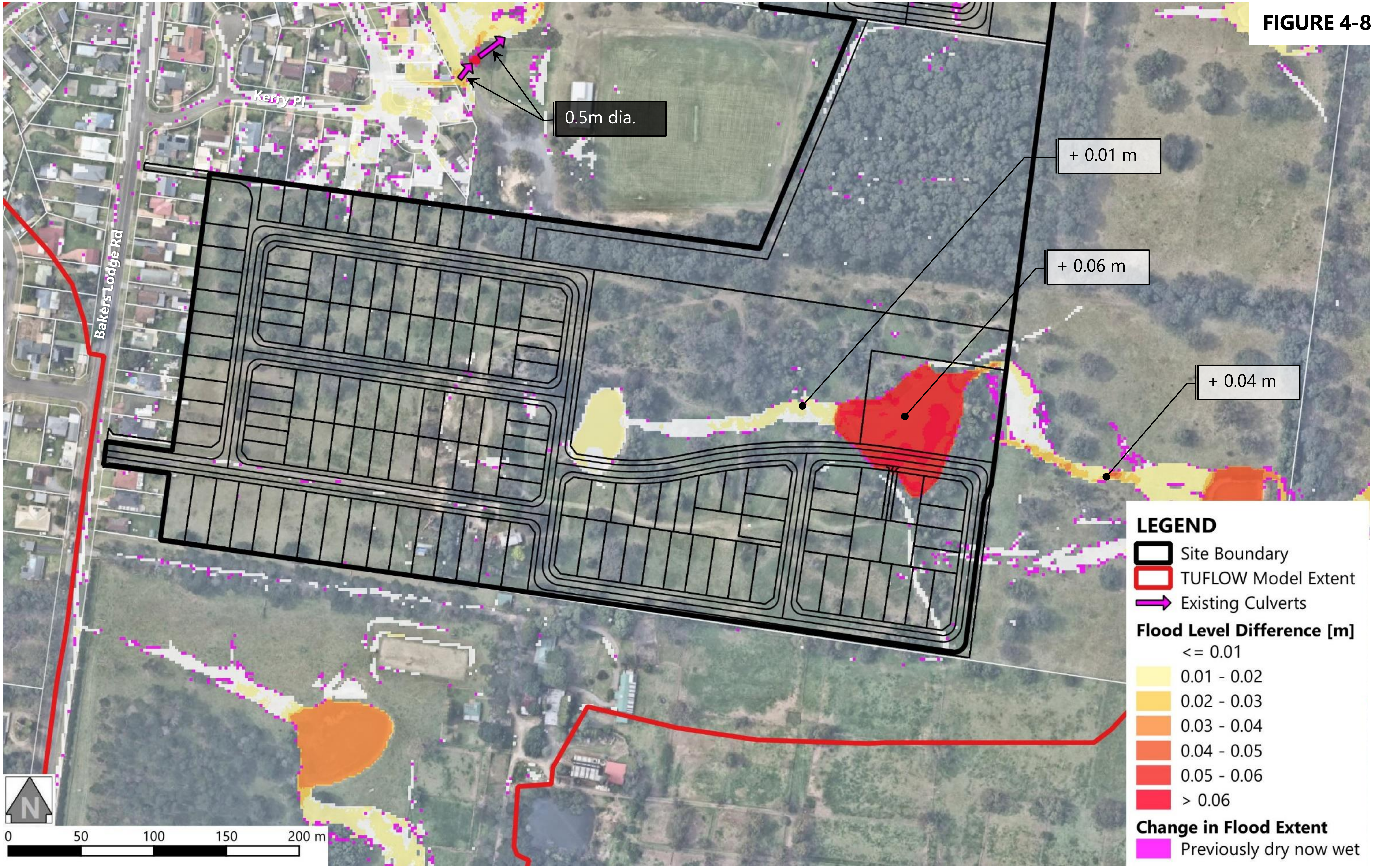
worley consulting

1-IN-500 AEP MINUS 1% AEP FLOOD LEVEL

[CLIMATE CHANGE DIFFERENCE MAPPING]

FIGURE 4-8



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worley consulting

1-IN-500 AEP MINUS 1% AEP FLOOD LEVEL

[CLIMATE CHANGE DIFFERENCE MAPPING]

5. Development Constraints Assessment

5.1 Approach

A traditional Flood Impact Assessment (**FIA**) is not possible at this rezoning stage because the proponent has not completed the necessary masterplanning for the site to developed post-development landform. The client understands that an FIA that includes post-development modelling will be required as part of future development applications.

In lieu of post-development modelling, and in recognition of the information available at this stage, it is proposed that a development constraints assessment be completed that identifies the flood constraints that will need to be overcome to allow development of the site and ensure that any future development does not result in adverse impacts on adjoining properties. This includes modifications to the proposed lot layout to accommodate the Burragorang Road flow path, advice on the location of detention basins, and a review of flood risks and emergency response.

An assessment of the potential flood constraints will facilitate development of a lot layout and post-development landform that will result in no off-site impacts.

5.2 Review of the Proposed Lot Layout

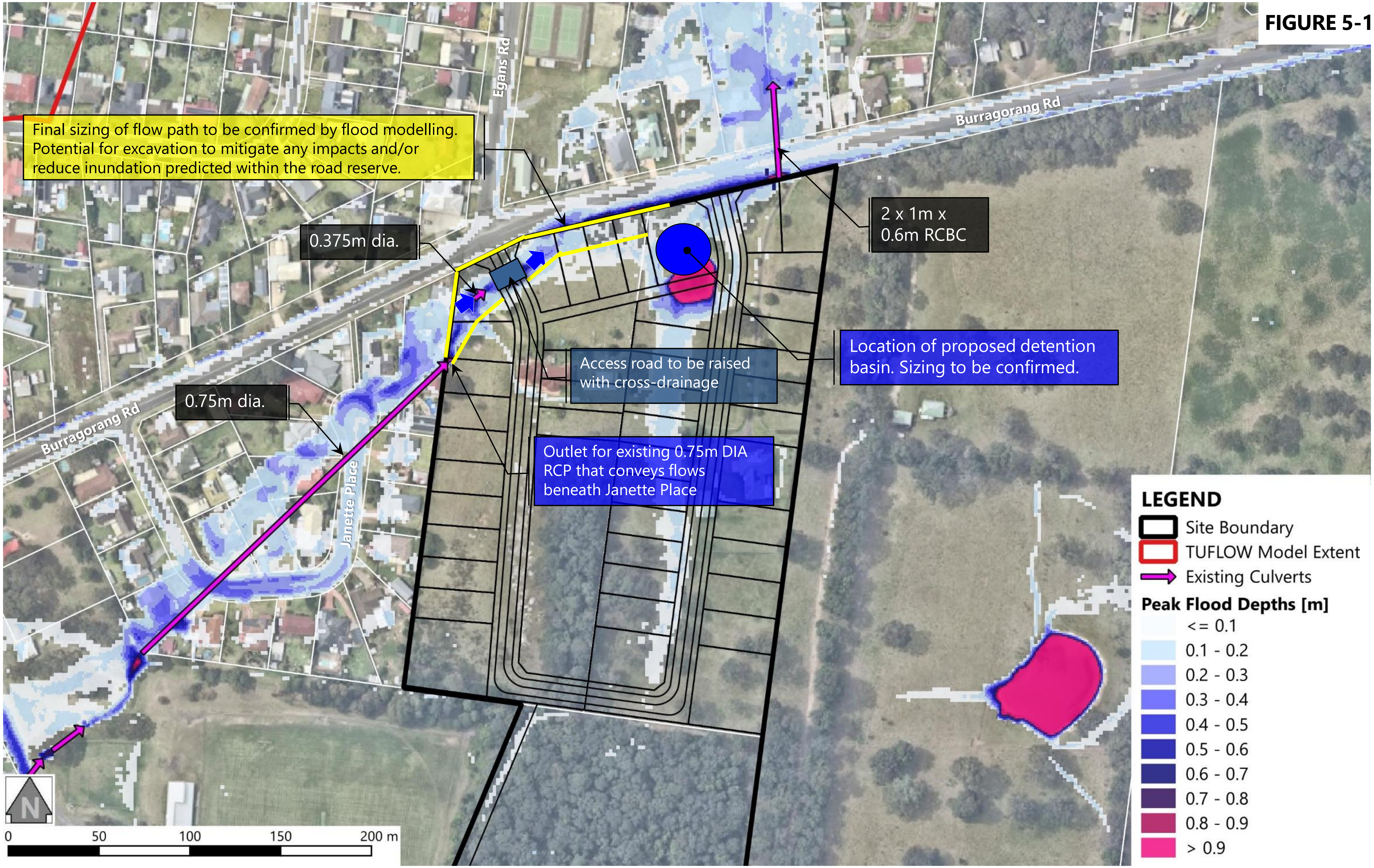
A preliminary lot layout for the development was reviewed against the model results generated for existing conditions. The lot layout and proposed development extents were found to be appropriate in the southern half of the site where the development will not encroach into the existing farm dams and associated flow paths. The northern half of the site is however affected by the Burragorang Road flow path (refer **Figure E-1**). As discussed in **Section 4.5**, the Burragorang Road flow path conveys runoff from catchments upstream of the site to Burragorang Road and onwards. It is important that the proposed lot layout is structured so that this flow path is retained along its current alignment and extent. This will ensure that the development does not lead to any obstructions that could cause off-site flood level increases, and/or lead to a redistribution of flows to new areas.

It is recommended that the lot layout be modified adjacent to Burragorang Road to allow land to be reserved for the safe passage of floodwaters. This should be based on considering floods up to and including the 1 in 500 AEP event to ensure there are no significant impacts on adjoining properties. It is also recommended that modelling be undertaken for the PMF event to ensure the development does not result in an increase in the potential risks to those that might seek to evacuate the area in the occurrence of a very rare flood.

The extent of the site that is recommended to be reserved for flow conveyance is shown in **Figure 5-1**. Minor excavation could be undertaken along this flow path to reduce any potential impacts caused by the development. This excavation could also act to reduce the frequency of floodwater overtopping Burragorang Road by removing a proportion of the flow that would otherwise enter the road reserve. The benefits afforded by this proposal would be subject to detailed modelling.

5.3 Locations of Detention Basins

The 2024 WCMS indicates that two detention basins are to be incorporated into the development. The basins are required to mitigate any increased flows associated with the urbanisation of the site. In that regard, the basins would be designed to ensure the peak flows leaving the site during post-development conditions would not exceed the magnitudes predicted for pre-development conditions for the full range of standard storm events; i.e., 50%, 20%, 10%, 5% and 1% AEP storms.



Prepared by:

worley consulting

NOTES:

1. The modified lot layouts and concept design for flood management has not been tested using the two-dimensional TUFLOW model. Accordingly, the lot sizes and flow paths are indicative only and subject to refinement following post-development modelling.
2. Results for the 1% AEP 45min duration are superimposed on the figure.

PROPOSED LOT AMENDMENTS TO ALLOW PASSAGE OF THE BURRAGORANG ROAD FLOW PATH - PEAK 1% AEP 45 MINUTE FLOOD DEPTHS

The detention basin on the southern half of the site is to be located within the footprint of the existing farm dam as shown in **Figure 5-2**. All outflows from the detention basin, including low flows and spillway overflows, will be directed into the existing flow path thereby limiting any possible flow re-distribution and reducing the potential for downstream impacts.

It is recommended that the northern detention basin be positioned close to the existing farm dam that is located to the south of Burragorang Road. As shown in **Figure 5-1**, the detention basin could be positioned a short distance north of the existing farm dam within the identified lot. It is recommended that the detention basin be designed to mimic the existing flow path and flow distributions as much as possible. This would prevent any changes to flow distributions at the outlet that could lead to changes downstream at Burragorang Road and the residential properties downstream. This will need to be assessed during post-development modelling.

5.4 Flood Emergency Response Strategy

During a flood emergency there are two primary response options available as follows.

1) Evacuation: horizontal evacuation of people to an area outside of the effects of flooding that has adequate facilities to maintain their safety. Evacuation must be achieved before the evacuation route is cut by floodwaters.
2) Shelter-in-place: the movement of occupants to, or sheltering of occupants in, a building that provides safe refuge above the PMF level on or near the site.

Evacuation is generally considered the preferred emergency response strategy for flooding. However, in some situations it may not be possible to evacuate, or it may be more hazardous to do so than to shelter-in-place. This is especially the case where 'flash flooding' leaves very little time for evacuation and can result in isolation with very little notice (DPE 2022). Flash flooding typically refers to scenarios where the flood warning time and flood duration are both less than six hours[1].

The development site is in the upper reaches of the Back Creek catchment. As a result any flooding that occurs at the site will be short duration flash flooding. As discussed in **Section 4.3.3**, the critical storm duration for the site has been determined to be 45 minutes for the 1% and 1 in 500 AEP floods, and 30 minutes for the PMF.

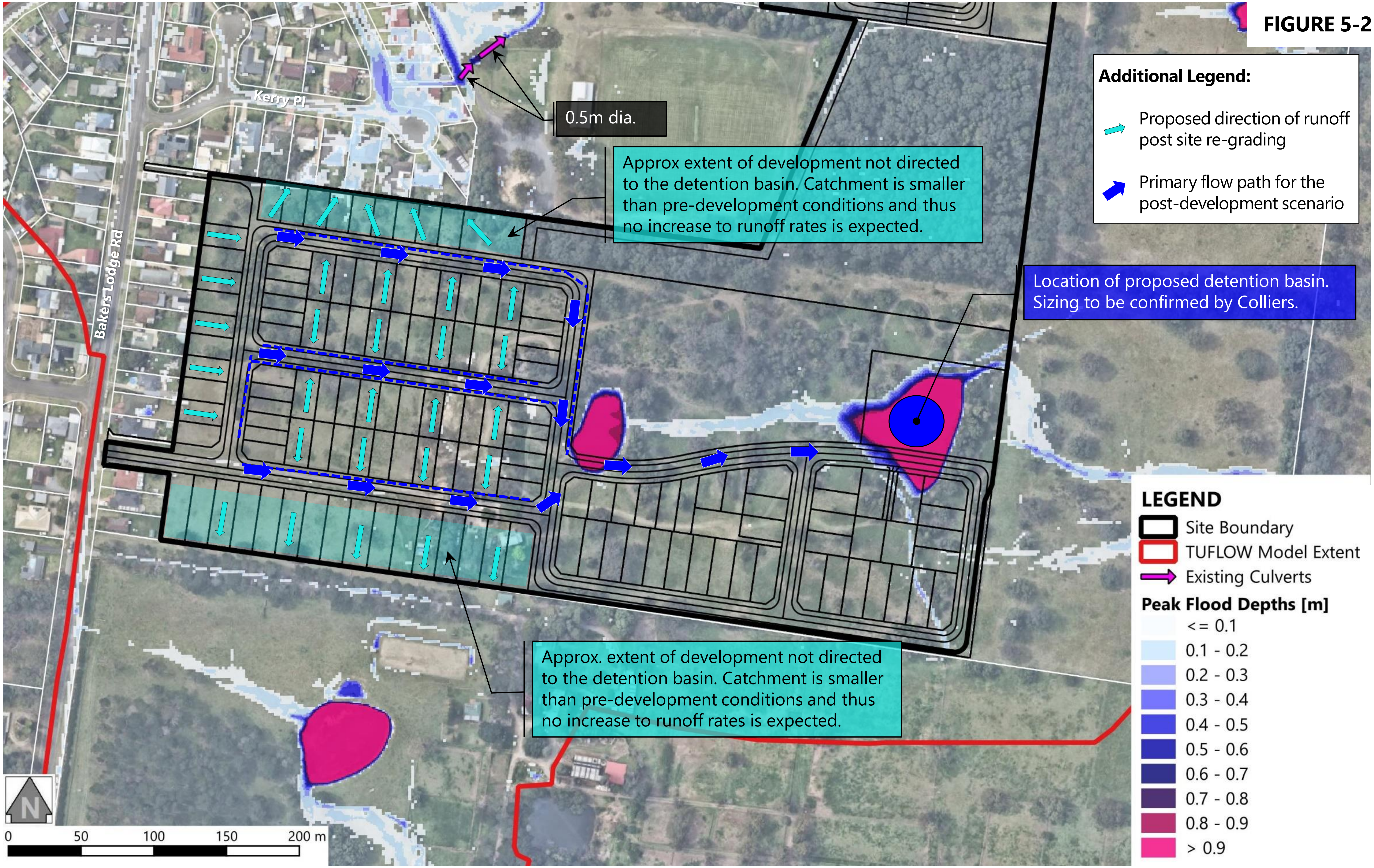
Short duration storms of less than 1 to 2 hours typically result in flash flooding that is categorised by:

- a fast rate of rise that gives little opportunity for advanced warning, and,
- short durations of inundation that typically recede within 30 to 60 minutes.

These flooding characteristics can be observed in the flow hydrographs presented in **Figure 4-5** which show that flows during a PMF event rise and fall within 0.75 hrs (45 minutes) from the start of the rainfall event.

Based on the above, it is recommended that a shelter in place strategy be adopted for the site. This approach considers the hazard mapping contained in **Appendix D** which shows that most of the site and areas proposed for development, would remain dry or experience low hazard flooding of up to H1 during a PMF event. It is noted that this is contingent on the Master Plan being developed based on the recommendations provided previously regarding the lot layout (refer **Section 5.2**) and basin locations (refer **Section 5.3**).

[1] Flash flooding as defined in Emergency Planning and Response to Protect Life in Flash Flood Events (2018) AFAC (Australasian Fire and Emergency Service Authorities Council)



Prepared by:

worley consulting

NOTES:

1. The modified lot layouts and concept design for flood management has not been tested using the two-dimensional TUFLOW model. Accordingly, the lot sizes and flow paths are indicative only and subject to refinement following post-development modelling.
2. Results for the 1% AEP 45min duration are superimposed on the figure.

REVIEW OF LOT LAYOUTS AND DETENTION BASIN LOCATIONS FOR SOUTHERN HALF OF THE DEVELOPEMNT - PEAK 1% AEP 45 MINUTE FLOOD DEPTHS

The flood modelling results also shows that the southern half of the development site would not be at risk of isolation during events up to and including the PMF, with evacuation by vehicle and/or foot possible to Bakers Lodge Road. It is possible that vehicular evacuation could be cut for the northern half of the development site for short periods of up to 3 hours during a PMF event. Evacuation by foot would however still be possible to the southern half of the development site via the proposed pedestrian/fire access trail (refer **Appendix A**).

6. Response to BCS Submission and Planning Requirements

6.1 Response to BCS Submission

As discussed in **Section 2**, a letter submission dated 25th July 2024 was received from the Biodiversity, Conservation and Sciences Group (**BCS**) of the NSW Department of Climate Change, Energy, the Environment and Water (**DCCEEW**). The letter was issued in response to the draft planning proposal and the 2024 WCMS report prepared by Colliers.

The recommendations raised in the BCS letter are listed below. A response to each item is added with commentary outlining how and where in the report the recommendation has been addressed.

<u>Recommendation 1</u> - Address the full range of flood risk. To achieve this, flood behaviour would be examined for a range of events. Typical events examined may include the 10% or 5%, 1%, 0.5% or 0.2% AEP and probable maximum flood (PMF) for both existing and developed scenarios.

This report includes modelling for the 1% AEP, 1 in 500 AEP and PMF events. Modelling for floods smaller than the 1% AEP event were not included based on an initial review of the 2024 WCMS and the *Wollondilly Shire Wide Flood Study* (in draft, 2024) indicating that flooding local to the site was minor during the 1% AEP flood and categorised as exhibiting H1 low flood hazards at the site. Accordingly, modelling of more frequent events would offer little value to the study and the development.

Post-development modelling was not possible at this rezoning stage due to the post-development landform having not been prepared. MoreHuman has been advised that post-development modelling will be required, particularly for the northern half of the site where the development has the potential to impact the flow path that runs adjacent to Burragorang Road. As discussed in **Section 5.2**, it is Worley Consulting's recommendation that the development layout be "pulled-back" from Burragorang Road to avoid reducing the conveyance capacity of this overland flow path. It is also recommended that shallow excavation be incorporated into the development proposal to formalise the flow path, which would also serve to reduce the frequency of inundation along the Burragorang Road corridor.

It is expected however, that the development can be designed to ensure it does not '*significantly increase the 5% AEP and 1% AEP flood levels or peak flood flow velocities on adjacent properties*', as required by the Wollondilly Shire DCP (2016).

<u>Recommendation 2</u> - Identify the constraints that flood places on the land (floodways, flood storage, flood hazard and emergency response issues) determined for a number of events, typically 10% or 5%, 1%, 0.2% or 0.5% AEP and PMF

Flood hazard mapping has been prepared for the 1% AEP, 1 in 500 AEP and PMF events as is discussed in **Section 4.5.3** and presented in **Figures G-1** to **G-6** in **Appendix G**.

Hydraulic category or flood function mapping has been prepared for the site for the 1% AEP flood in accordance with the flow conveyance methodology outlined in *Floodplain Risk Management Guideline FB02*, titled 'Flood Function'. As discussed in **Section 4.5.4**, the floodway corridor was delineated along the Burragorang Road flow path based on consideration of flow distributions for the 1% and 1 in 500 AEP flood events (refer **Figure 4-5**).

Emergency response for the site is discussed in **Section 5.4**. A shelter in place strategy is proposed recognising that the site and surrounds are impacted by flash flooding which results in a very fast rise and fall in flood levels. This also is based on the hazard mapping presented in **Appendix G** which shows that <u>most</u> of the site and areas proposed for development, would remain dry or only experience low hazard flooding of up to H1 during a PMF event. It is noted that this is contingent on the Master Plan being developed based on the recommendations provided previously regarding the lot layout (refer **Section 5.2**) and basin locations (refer **Section 5.3**).

The flood modelling results also show that the southern half of the development would not be at risk of isolation during events up to and including the PMF, with evacuation by vehicle and/or foot possible to Bakers Lodge Road. It is possible that vehicular evacuation could be cut for the northern half of the development site for short periods of up to 3 hours during a PMF event. Evacuation by foot would however still be possible to the southern half of the development site via the proposed pedestrian/fire access trail (refer **Appendix A**).

***Recommendation 3* - Identify the impact of the development on flooding and on the existing and future community for the full range of flooding.**

A response to this recommendation is best considered with reference to the response provided above for Recommendation 1. In that regard, it is acknowledged that post-development modelling will be required once a post-development landform has been created for the subdivision.

Notwithstanding, the review undertaken for this report indicates that the proposed subdivision can be designed to ensure the development does not '*significantly increase the 5% AEP and 1% AEP flood levels or peak flood flow velocities on adjacent properties*', as required by the Wollondilly Shire DCP (2016).

***Recommendation 4* - Identify how these impacts can be managed to minimise the growth in risk to the community due to the development. This includes details of any management measures to be implemented to minimise the impacts and risks posed to the existing and future community due to development.**

A response to this recommendation is best considered with reference to the response provided above for Recommendation 1 which references the recommendation made in **Section 5.2** for the proposed lots to be "pulled-back" from Burragorang Road to allow for the safe passage of flood flows. This flow path has been identified as locally significant locally with there being potential for any blockage to impact downstream properties on the northern side of Burragorang Road.

It is understood that MoreHuman is receptive of these recommendations and as such, has updated the Masterplan (refer **Appendix A**) to conceptually include a proposed overland flow path. Post-development flood modelling could be undertaken to confirm the required dimensions of the flow path, and any benefit that excavation along its alignment could afford in the way of reducing the frequency of flood affectation within the Burragorang Road corridor.

***Recommendation 5* - Address climate change impacts.**

Climate change is addressed in **Section 4.5.5** of the report and **Figure 4-7** and **4-8**.

6.2 Response to Part 8 of the 2016 DCP

Part 8 of Volume 1 of the 2016 DCP outlines the objectives and controls that apply to development on flood prone land. Table C in Section 8.2 provides '*development controls which apply to flood affected land including overland flow flooding*'.

The 2016 DCP indicates that the following points are relevant to the site.

- The applicable land use category for the proposed development is 'subdivision' (refer Table A of Section 8.2).
- The flood risk precinct applicable to the site is 'Medium Flood Risk Precinct' (refer Table B of Section 8.2).

Table C of Section 8.2 lists the following controls as being applicable to the site based on the above classifications. A response to each control is also provided.

SS2 – Structural Soundness *– Any permitted structure (including foundations and support) must require information to be provided by a competent engineer indicating that the structure can withstand the likely conditions experienced during the PMF without suffering Structural Failure.*

Although post-development modelling has not yet been completed, the existing conditions flood characteristics presented in Appendix D to G indicate that the structural soundness of foundations and support structures will not be an issue for the development. This is based on the relatively low flow magnitude of 33 m^3/s predicted for the critical duration PMF event, and the low H1 hazards across most of the site.

As discussed in **Section 5.2**, it is also recommended that the development layout be modified to ensure that no physical features are included along the Burragorang Road flow path that could serve as obstructions to the flow and cause localised turbulence during flooding. This is the most hazardous flow path that could impact the structural soundness of foundations and support structures.

HY2 – Flood Affectation *– Fencing must be compatible with the nature of flooding and be designed to pass flood flows during flood events up to the Flood Planning Level.*

Requirement is noted and can be adopted for the three identified flow paths (refer **Section 4.5.1**).

HY3 *– Any permitted development must require adequate information to be provided by a competent engineer indicating that the proposed development will be unlikely to significantly increase the 5% AEP and 1% AEP flood levels or peak flood flow velocities on adjacent properties.*

Based on the analysis completed for this report, Worley Consulting is confident that the proposed modifications to the development layout as recommended in **Section 5.2** and **Section 5.3**, will result in the development being *'unlikely to significantly increase the 5% AEP and 1% AEP flood levels or peak flood flow velocities on adjoining properties'*. Post-development modelling is proposed to confirm this once a post-development landform and the detention basin designs are available.

HY4 *– Any permitted filling of land in Floodway areas must require compensatory works such as excavated floodway to be provided to ensure that there is no adverse effect on flood levels.*

Hydraulic category mapping for the site is discussed in **Section 4.5.4** and presented in **Figure 4-6**. As shown, a floodway corridor has been mapped only for the Burragorang Road flow path, with the remainder of the site mapped as flood storage and fringe.

As discussed in **Section 5.2**, it is recommended that the development extent be offset from Burragorang Road to retain the required flow path for the floodway. It is proposed that the potential for excavation of the flow path also be investigated to potentially reduce the frequency of flood affectation within the Burragorang Road corridor.

The only filling that may be required within the designated floodway is to raise the access road from Burragorang Road. The raised access would be designed with adequate cross-drainage to mitigate any impacts or loss in flow conveyance.

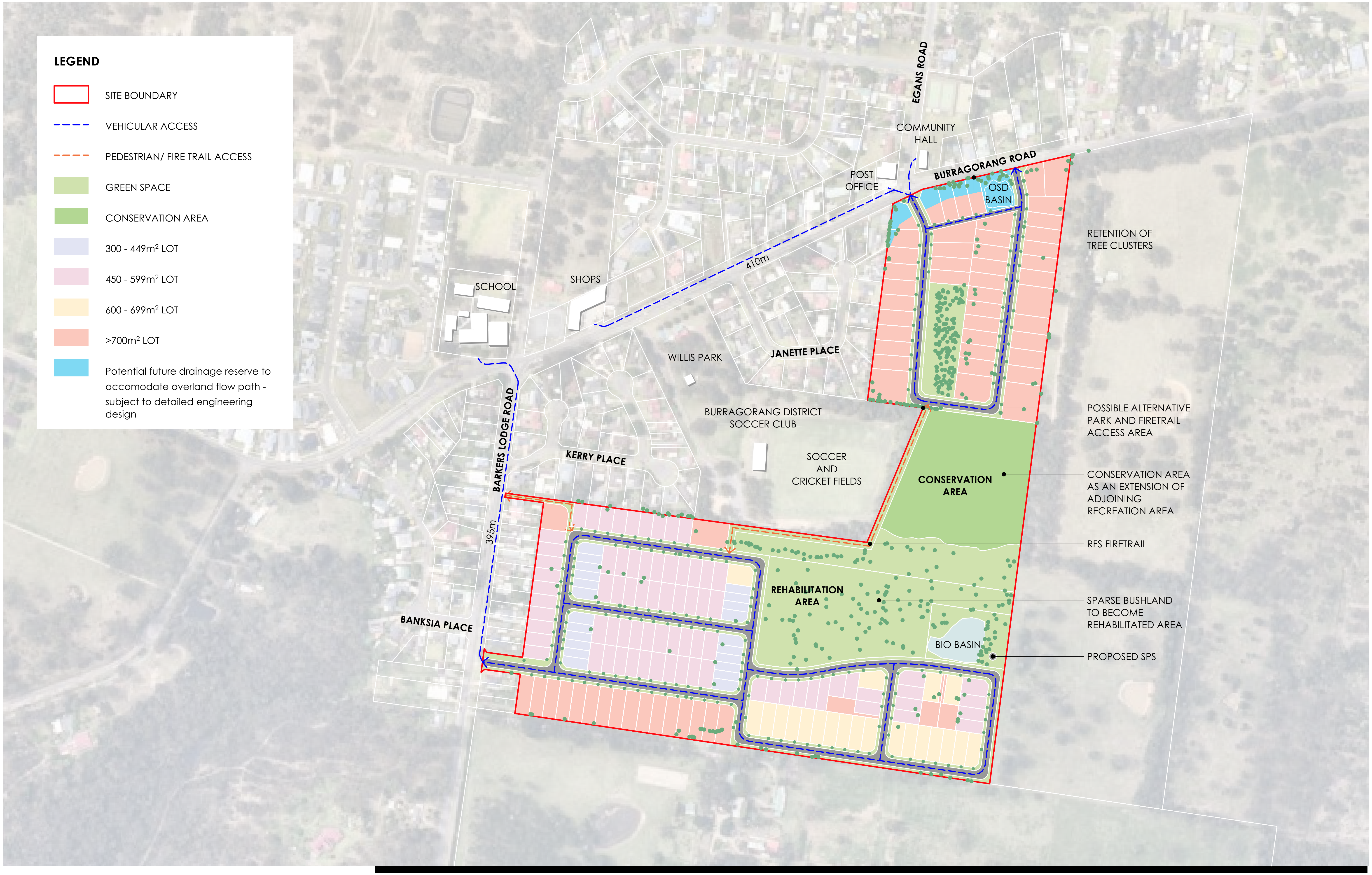
HY5 *– Subdivision of land in Floodway areas must not be permitted unless the applicant is able to demonstrate that a significantly better outcome in terms of flood risk is achieved.*

Refer to the response above to HY4.

7. References

- Australian Emergency Management Institute (2013), '*Managing the floodplain: a guide to best practice in flood risk management in Australia*'.
- Australian Institute for Disaster Resilience (2017), '*Australian Disaster Resilience Handbook 7: Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia*'; © Commonwealth of Australia 2017, third edition.
- Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) (2019), '*Australian Rainfall and Runoff: A Guide to Flood Estimation*', © Commonwealth of Australia (Geoscience Australia), (ARR 2019)
- Bureau of Meteorology (2003), '*The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method*'.
- CSIRO and Bureau of Meteorology (2015), 'Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report'.
- Institution of Engineers Australia (1987), '*Australian Rainfall and Runoff: A Guide to Flood Estimation*', Volume 1, Editor-in-chief D.H. Pilgrim, Revised Edition 1987 (ARR 1987)
- IPCC (Intergovernmental Panel on Climate Change) (2013), '*Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*', Stocker, T.F., and others (Eds.), Cambridge University Press, Cambridge, UK and New York, NY, USA.
- MoreHuman Oakdale Pty Ltd (2024), '*Water Cycle Management Strategy Report, Oakdale Planning Proposal*', prepared by Colliers International Pty Ltd
- New South Wales Government (2005), '*Floodplain Development Manual: the management of flood liable land*', ISBN 07313 0370 9.
- NSW Department of Planning and Environment (2023), '*Flood Risk Management Manual: The policy and manual for the management of flood liable land*', ISBN 978-1-923076-17-4.
- NSW Department of Planning, Housing and Infrastructure (2024), '*Shelter in place guideline for flash flooding*', DPHI-MC-SD-V1.0
- Wollondilly Shire Council (2016), '*Wollondilly Shire Council Development Control Plan*', prepared by Wollondilly Shire Council.
- Wollondilly Shire Council (in draft 2023), '*Wollondilly Shire Flood Study; Broad Scale Assessment*', prepared by Worley Consulting (formerly Advisian).

Appendix A. Planning Proposal Masterplan prepared by Cottee Parker Architects Pty Ltd



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2. Cottee Parker Architects Pty Ltd asserts copyright of this drawing. It may not be used, retained or copied without permission.

OAKDALE

BARKERS LODGE ROAD AND BURRAGORANG ROAD, OAKDALE

CLIENT - MOREHUMAN PROPERTY GROUP

TITLE

MASTERPLAN

	JOB No	DWG No	ISSUE
PRELIMINARY	NA	SK0100	

Appendix B. BCS Letter Dated 25th July 2024

Department of Climate Change, Energy, the Environment and Water

NSW GOVERNMENT

Your ref: CM 13014
Our ref: DOC24/459837

Ms Sara Mehryar
Assistant Strategic Planner, Sustainable Growth
Wollondilly Shire Council

By email: sara.mehryar@wollondilly.nsw.gov.au

Dear Ms Mehryar

I refer to your letter dated 11 June 2024 seeking advice from the Biodiversity, Conservation and Science Group (BCS) of the NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW) on a draft Planning Proposal for 1838 Barkers Lodge Road, and 1455 and 1475 Burragorang Road, Oakdale (proposal).

BCS understands that Council is seeking early feedback on preliminary notification documents for the proposal, which seeks to amend the *Wollondilly Local Environmental Plan 2011* to enable low density residential development for approximately 208 lots.

BCS has reviewed the information provided and recommends that:

- consideration be given to further avoidance of impacts to threatened ecological communities and threatened species habitat, including critically endangered ecological communities which are also Serious and Irreversible Impact entities
- the proposal addresses urban heat mitigation
- a flood impact and risk assessment be undertaken in accordance with the Flood Risk Management Manual and its supporting flood risk management guidelines, with particular attention to Flood Impact and Risk Assessment (LU01) and Support for Emergency Management Planning (EM01)
- the proposal addresses Ministerial Direction 4.1 Flooding.

Detailed BCS comments are provided at Attachment A.

If you have any further questions about this issue, please contact Dana Alderson, Senior Project Officer Planning at dana.alderson@environment.nsw.gov.au.

Sincerely

S. Harrison

25/07/2024

Susan Harrison
Senior Team Leader Planning Greater Sydney
Regional Delivery
Biodiversity, Conservation and Science

Attachment A

BCS) advice - draft Planning Proposal for 1838 Barkers Lodge Road, and 1455 and 1475 Burragorang Road, Oakdale.

BCS has reviewed:

- *Planning Proposal P-22086 1838 Barkers Lodge Road, 1455 Burragorang Road & 1475 Burragorang Road, Oakdale* prepared by Gyde Consulting dated 16 May 2024 (PP report)
- *Oakdale Rezoning Project Biodiversity Development Assessment Report* prepared by Biosis dated 25 March 2024 (BDAR)
- *Strategic Bushfire Study Barkers Lodge Road Oakdale Planning Proposal* prepared by Black Ash Bushfire Consulting dated 27 March 2024 (Bushfire report)
- *Vegetation Management Plan* prepared by Restore dated 22 March 2024 (VMP)
- *Water Cycle Management Strategy Report, Oakdale Planning Proposal* prepared by Colliers dated 14 March 2024 (WCMS report).

Biodiversity

The site contains critically endangered ecological communities (CEECs) and habitat for several threatened species. This includes Shale Sandstone Transition Forest in the Sydney Basin Bioregion (SSTF) and Sydney Turpentine Ironbark Forest (STIF) which are both CEECs under the *Biodiversity Conservation Act 2016* (BC Act). The proposal involves direct and indirect impacts to these CEECs (refer Figure 15 of the BDAR), as well as threatened species habitat.

As much of the site is mapped on the Biodiversity Values Map, future development under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) will trigger the Biodiversity Offsets Scheme and require preparation of a Biodiversity Development Assessment Report (BDAR).

These CEECs are also Serious and Irreversible Impact (SAII) entities pursuant to clause 6.7 of the *Biodiversity Conservation Regulation 2017*. For Part 4 development, a decision maker must not grant approval if they determine the proposal is likely to have a serious and irreversible impacts (SAII) on biodiversity values.

Direct impacts and proposed land use zoning

The proposal will result in the removal of 6.82ha of native vegetation, including 3.07ha of CEECs as well as habitat for the threatened Cumberland Plain Land Snail, Powerful Owl and Southern Myotis. Only some retention of vegetation is proposed in the C2 Environmental Conservation zone, as vegetation in the C3 Environmental Management zone will be managed by clearing/thinning for asset protection and open space purposes.

The BDAR acknowledges that biodiversity values within the C3 zone will be impacted through management as an Inner Protection Area (Figure 16, Bushfire report, p.55). The canopy and understorey will be limited and will resemble mown lawn and gardens rather than a native vegetation community. Refer to page 107 of *Planning for Bushfire Protection 2019* (PBP). Further, the C3 zone under the *Wollondilly LEP 2011* permits a range of permissible uses, many of which are not consistent with biodiversity conservation.

The BDAR states that it has conservatively assumed that all existing vegetation within the development footprint will be removed (p.73). BCS considers that there is opportunity for further avoidance of direct biodiversity impacts, and the creation of a larger C2 zoned conservation area that is less awkwardly shaped, and which is more likely to have successful outcomes for the retention of biodiversity values in the long term. Furthermore, BCS recommends that the proposal commit to retaining existing vegetation within the development footprint, particularly hollow-bearing trees (HBTs).

Indirect impacts

The BDAR states that "indirect impacts are not expected to occur as a result of the proposal, and will be avoided through the mitigation measures provided in Section 7" (p.83).

BCS advises that indirect impacts may result from the proposal as follows.

The areas of retained native vegetation within the C2 and C3 zones will be subject to indirect impacts including, but not limited to, weed infestations, stormwater runoff and an increase in use for walking and other passive recreation purposes. This is amplified by the elongated shape of the C-zoned lands, and large edge-area ratio.

In addition, BCS notes that the voluntary planning agreement (VPA) proposes improvements to open space and community facilities including new flood lighting in the adjoining Willis Park. As these works are required due to the additional population generated by the proposal, indirect impacts on the retained vegetation in the C2 and C3 land should be included in the assessment of impacts on biodiversity resulting from the rezoning. Any impacts of these works on biodiversity values off site should also be addressed.

Future development applications will be required to consider the above indirect impacts, including whether indirect impacts will contribute to SAII. Mitigation measures must be applied to all indirect impacts from works both within and off site related to the proposal.

Management of retained vegetation

BCS understands that it is proposed that management of retained native vegetation will occur under a vegetation management plan (VMP) linked to a community title scheme, with a section 88B instrument under the NSW *Conveyancing Act 1919*. Previous advice provided by BCS dated 26 September 2022 suggested that there were several options for the management of the conservation land. The proponent should justify why these other options are not supported.

In relation to the proposal's VMP, a map of the Vegetation Management zones (VMZs) should be provided to clearly show the location of the VMZs.

The BDAR emphasises that avoidance of impacts for the proposal has included 'redesign of subdivision to retain remnant native vegetation and hollow-bearing trees with a proposed C2 and C3 zoning' (p.66). As such the proposal must ensure that HBTs are retained within the C2 and C3 land. BCS recommends the VMZ mapping shows the location of HBTs to be retained, and Table 2-1 'VMP management zones and objectives' be updated to identify which VMZs contain HBTs and clearly state that they are to be retained. This is important to ensure that HBTs are retained when the 25% canopy removal occurs for the purpose of creating APZs.

Design principles

BCS previously advised that the proposal should be consistent with the following design principles to respond to the biodiversity values on the site:

Principle	**BCS comment**
Prevent fragmentation of conservation land through a minimum lot size which does not allow further subdivision (other than to subdivide off conservation land from development land).	The proposal includes a minimum lot size of 5ha for the C2 land, and 4000sqm and 5ha for the C3 land which will prevent further subdivision of the land. It is noted however that the conservation land is awkwardly shaped, with long fingers of retained vegetation and a large edge-area ratio.
Prevent impacts from development on conservation land by: - ensure active open space is provided within the development land - provide buffers to conservation land within the development via a perimeter road, shared cycle/pedestrian paths or open space - ensure stormwater and effluent systems do not discharge into existing or proposed conservation land	- No active open space is proposed within the development land, though embellishments are to be made to the adjoining sportsfields. Passive open space is provided in the C3 land. - Some instances where buffers are not provided. - Stormwater in the south of the precinct will be directed to a stormwater detention basin situated in the C3 land, location of discharge point is not known. - APZs proposed in C3 land.

- ensure APZs sited on development land - retention of existing vegetation within development land for amenity and urban cooling.	- The BDAR states that all existing vegetation within the development footprint will be removed. Mitigation of urban heat has not been addressed in the PP report.

Urban heat mitigation

As noted above, BCS recommends that the proposal commit to retain vegetation within the development footprint, not only for biodiversity but also canopy cover to improve amenity and provide shade for urban heat mitigation. The small lots proposed are unlikely to be large enough to accommodate planting of new shade trees, and retention of existing mature trees is an easy way to ensure immediate shading of the new development.

BCS recommends the proposal address urban heat mitigation with reference to the *Wollondilly Urban Tree Canopy Plan and Landscape Strategy* (McGregor Coxall, December 2020).

Flooding

At pre-scoping stage, BCS recommended preparation of a flood impact and risk assessment (FIRA) if the site is flood affected. BCS has reviewed section 4 'Flood assessment' of the WCMS report and notes that it outlines the methodology undertaken for the flood assessment. Appendix D of the WCMS report provides flood maps for the 1% AEP existing and developed scenarios.

Section 4 of the WCMS report does not provide adequate information about flood risk, constraints and impacts. The assessment is limited to the 1% AEP as provided in Appendix D. It is unclear from the information in the WCMS report whether the proposal is consistent with Ministerial Direction 4.1 Flooding.

A flood impact and risk assessment (FIRA) should be undertaken in accordance with the Flood Risk Management Manual and its supporting flood risk management guidelines, with particular attention to Flood Impact and Risk Assessment (LU01) and Support for Emergency Management Planning (EM01). The deliverables of the FIRA should be in general accordance with Table 6 of the guideline. The FIRA must consider the compatibility of the proposed development with the flood function and behaviour of the land. The FIRA should provide detailed consideration and recommendations for flood related development controls. The FIRA should be undertaken by qualified engineers who have experience and advanced skills in catchment hydrology and floodplain hydraulics and have a good working knowledge of flood risk management practices and guidance in NSW.

As such, BCS recommends the WCMS report be updated as follows:

- address the full range of flood risk. To achieve this, flood behaviour would be examined for a range of events. Typical events examined may include the 10% or 5%, 1%, 0.5% or 0.2% AEP and probable maximum flood (PMF) for both existing and developed scenarios
- identify the constraints that flood places on the land (floodways, flood storage, flood hazard and emergency response issues) determined for a number of events, typically 10% or 5%, 1%, 0.2% or 0.5% AEP and PMF
- identify the impact of the development on flooding and on the existing and future community for the full range of flooding
- identify how these impacts can be managed to minimise the growth in risk to the community due to the development. This includes details of any management measures to be implemented to minimise the impacts and risks posed to the existing and future community due to development
- address climate change impacts.

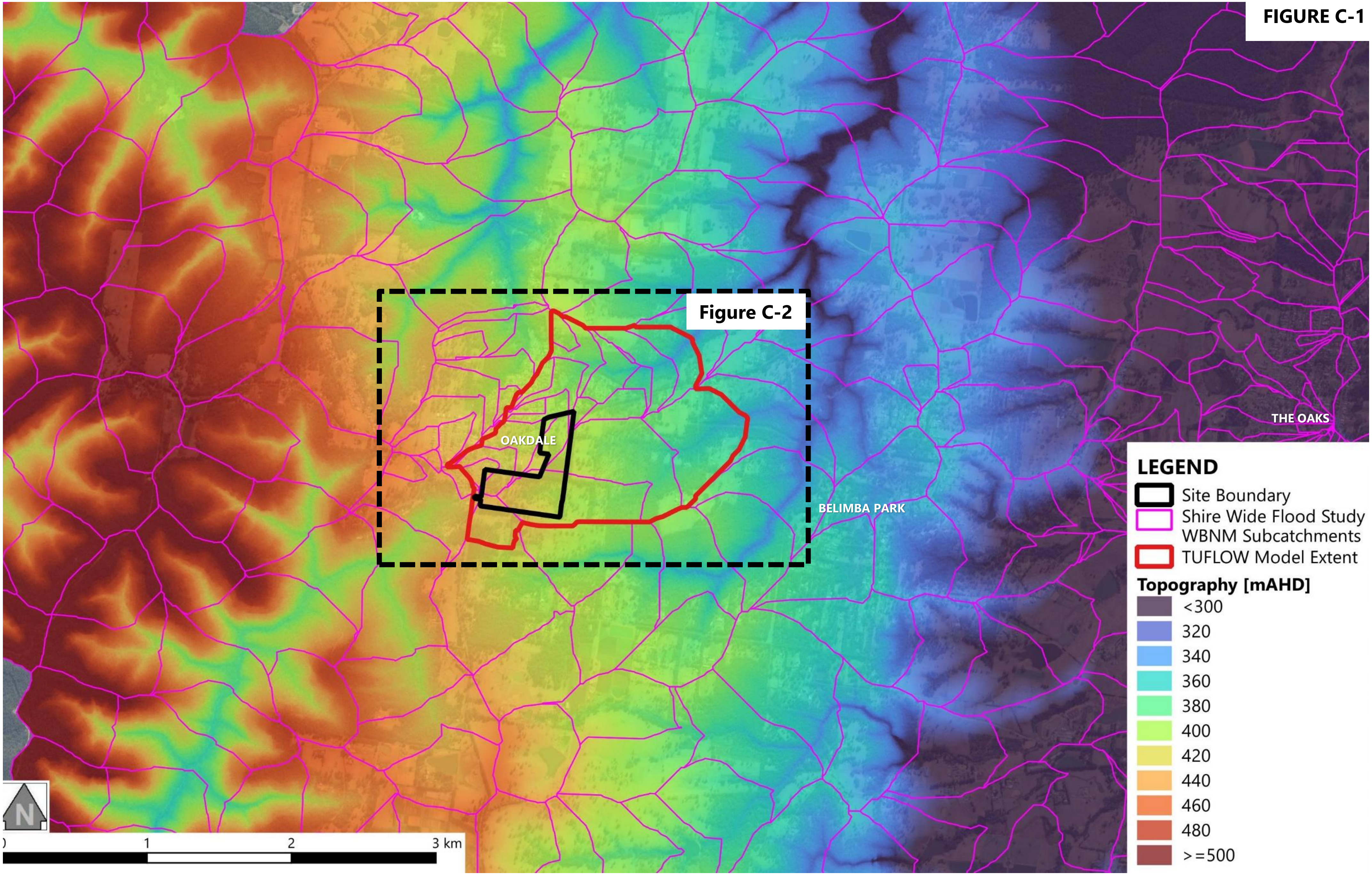
BCS also provides the following comments on the 1% AEP flood maps provided in Appendix D:

- The maps of the post-development scenario should show the proposed zoning as depicted in Figure 10 of the PP Report instead of the existing undeveloped scenario
- The flood hazard maps (Figures B003 and C003) may require revision as areas shown in Figures B001 and C001 that have flood depth greater than 1m are categorised H1
- Appendix D shows adverse impacts on the downstream community particularly north of Burragorang Road. These impacts should be addressed and mitigated as part of the planning proposal.

The proposal should be updated following the completion of the above flood assessment to address consistency with Direction 4.1.

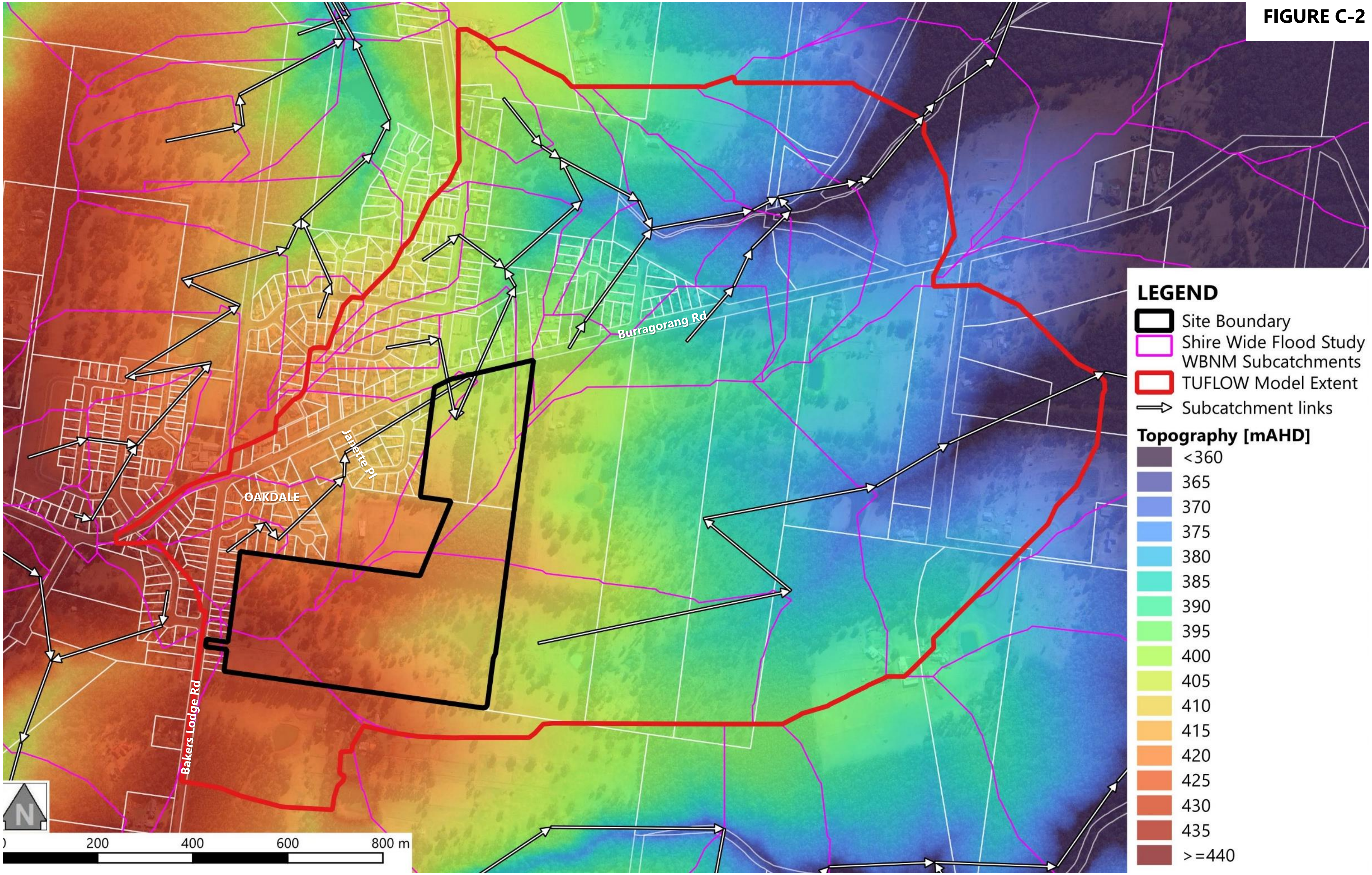
END OF SUBMISSION

Appendix C. Shire Wide Flood Study Models – WBNM and TUFLOW



Prepared by:

SHIRE WIDE FLOOD STUDY
WBNM MODEL SCHEMATIC

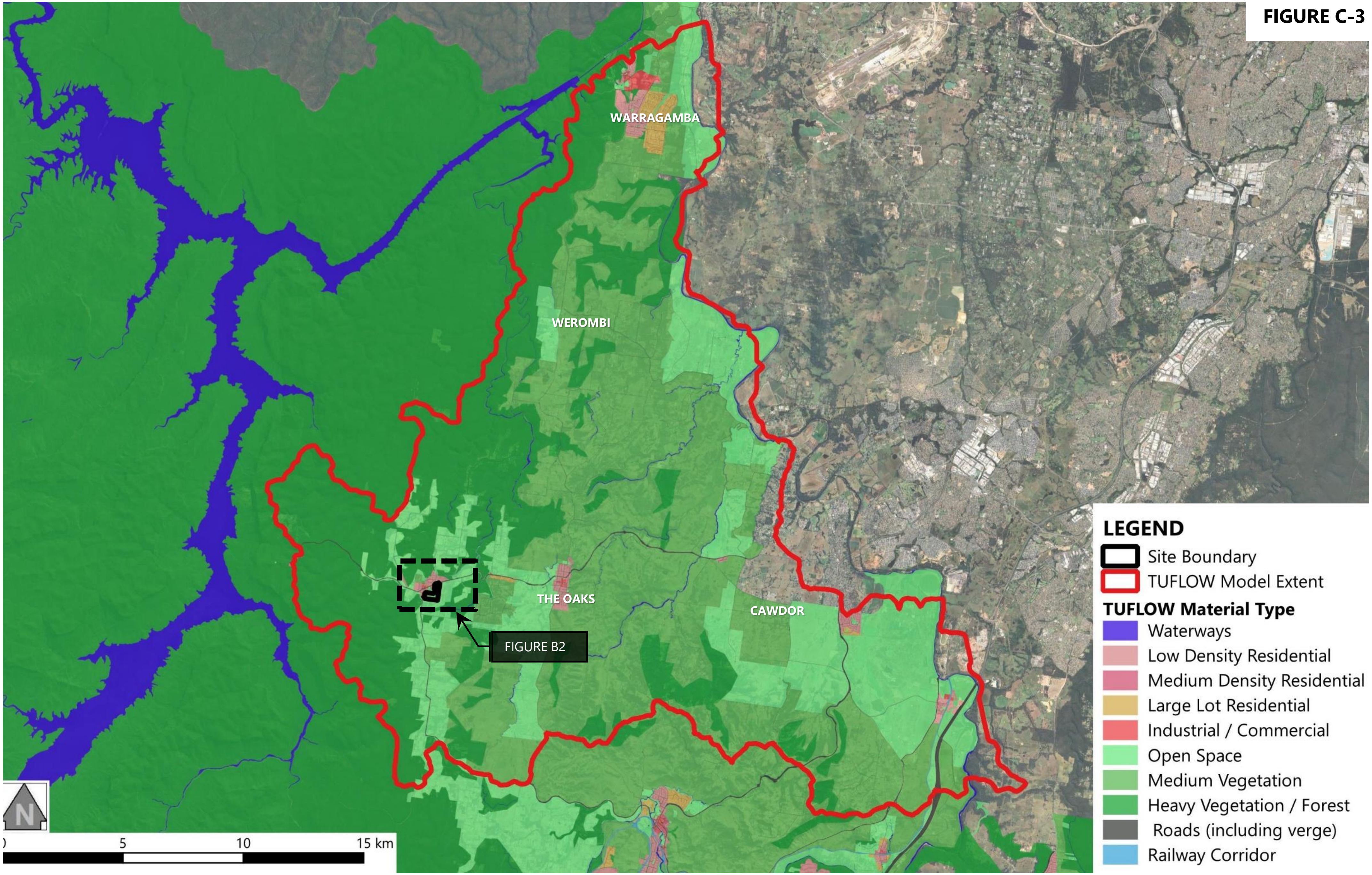


Prepared by:

worley consulting

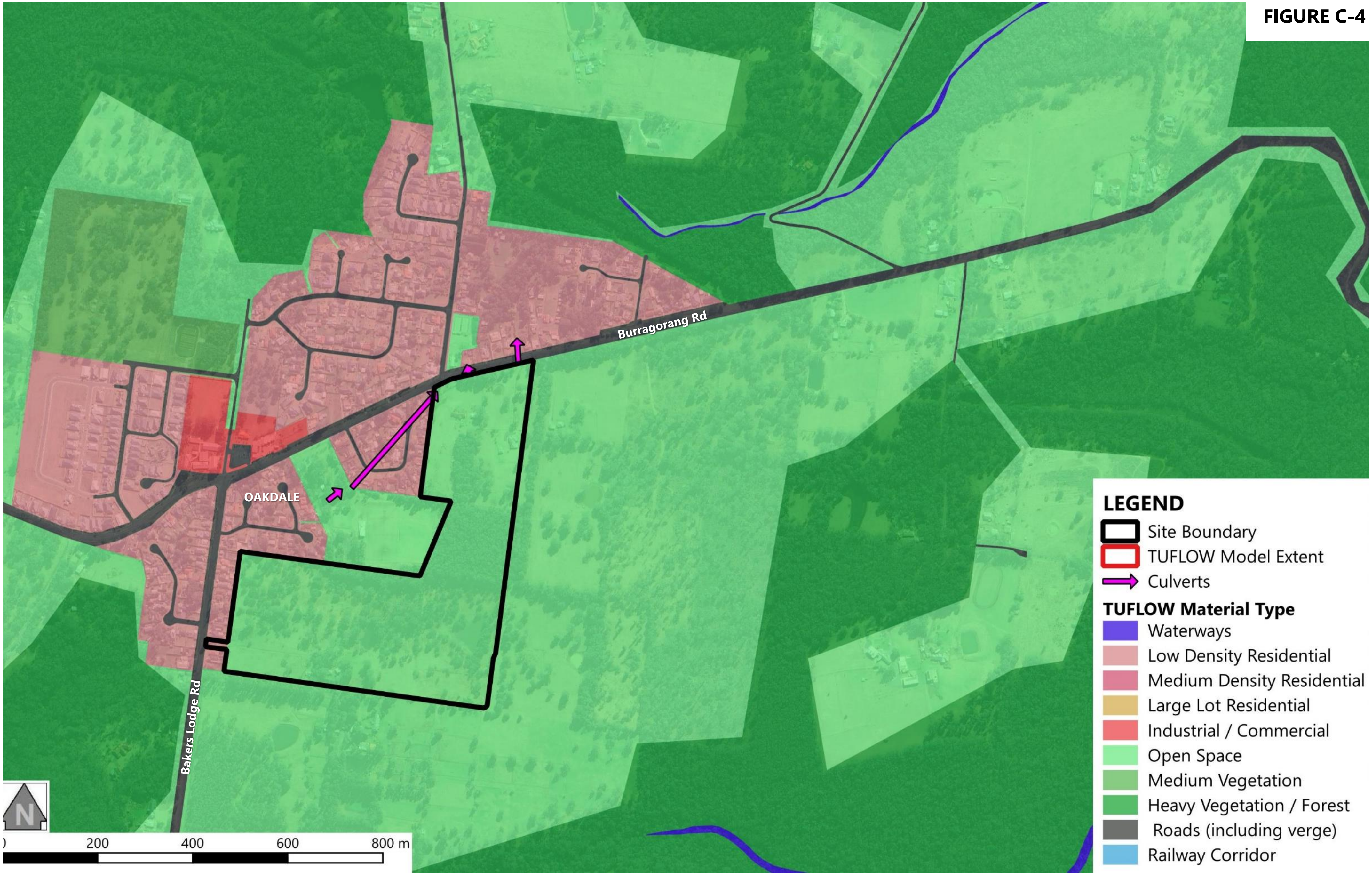
SHIRE WIDE FLOOD STUDY
WBNM MODEL SCHEMATIC [SITE]

FIGURE C-3



Prepared by:

SHIRE WIDE FLOOD STUDY
TUFLOW MODEL SETUP

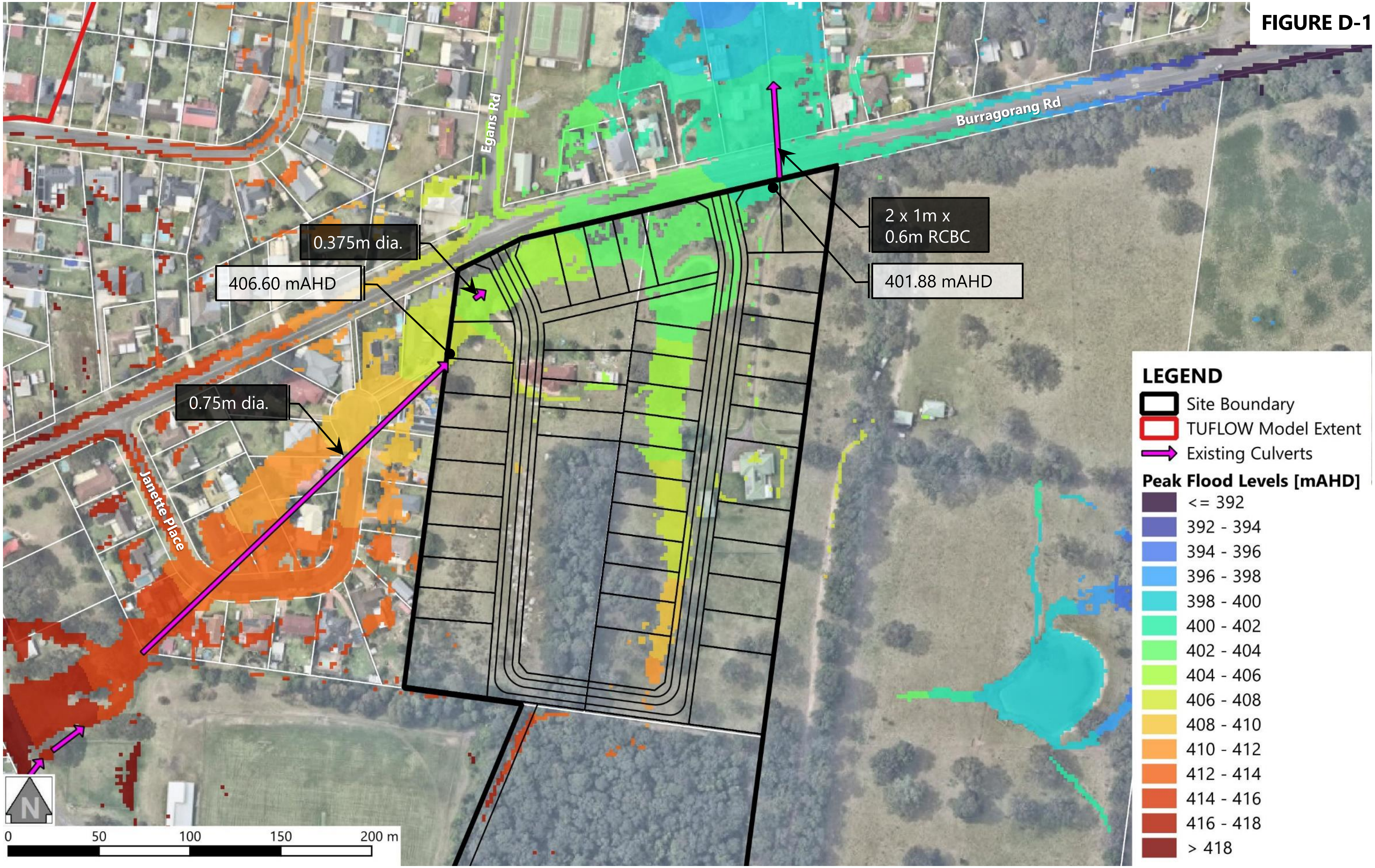


Prepared by:

worley consulting

SHIRE WIDE FLOOD STUDY
TUFLOW MODEL SETUP [SITE]

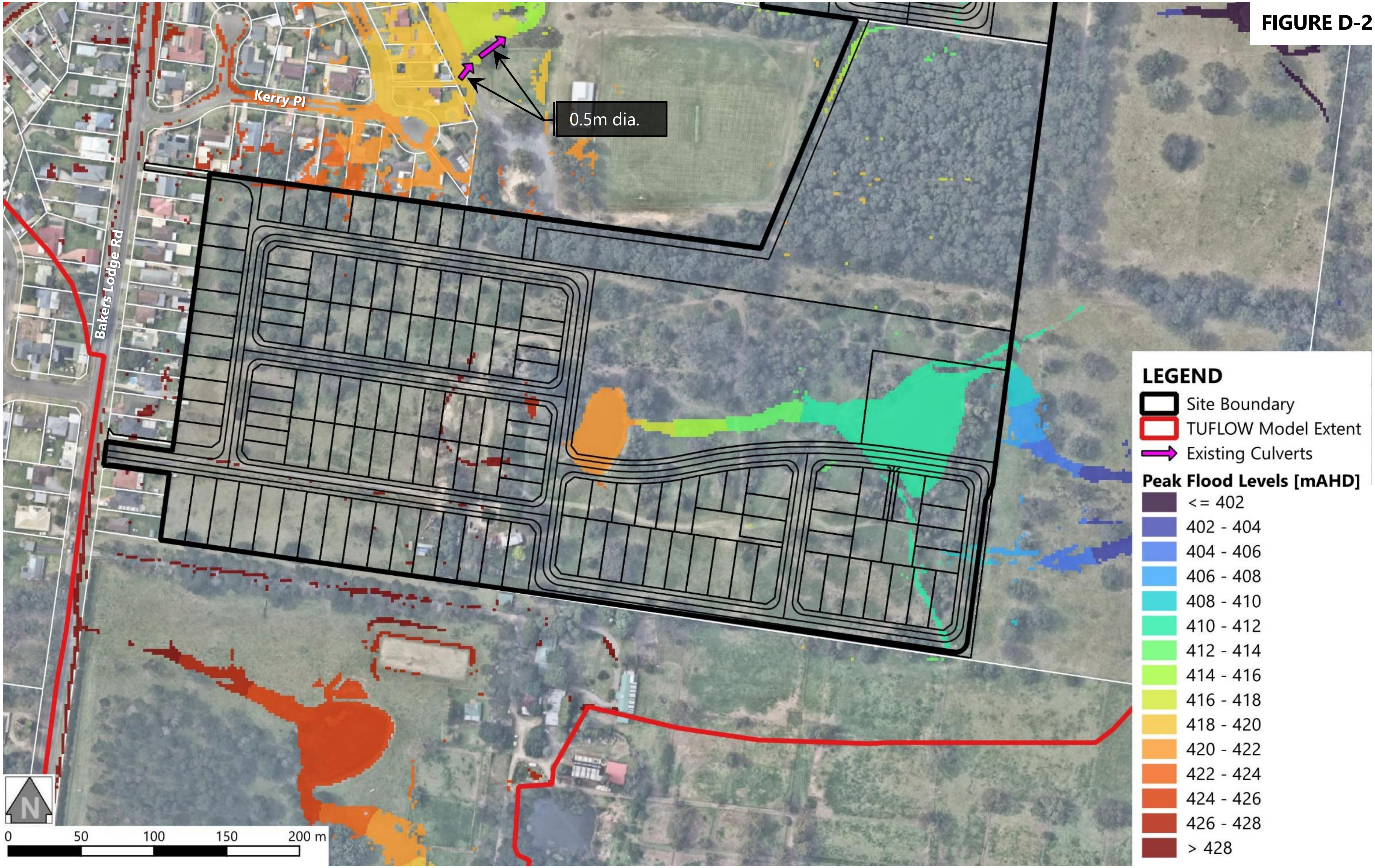
Appendix D. Existing Conditions Flood Levels and Extents Mapping



Prepared by:

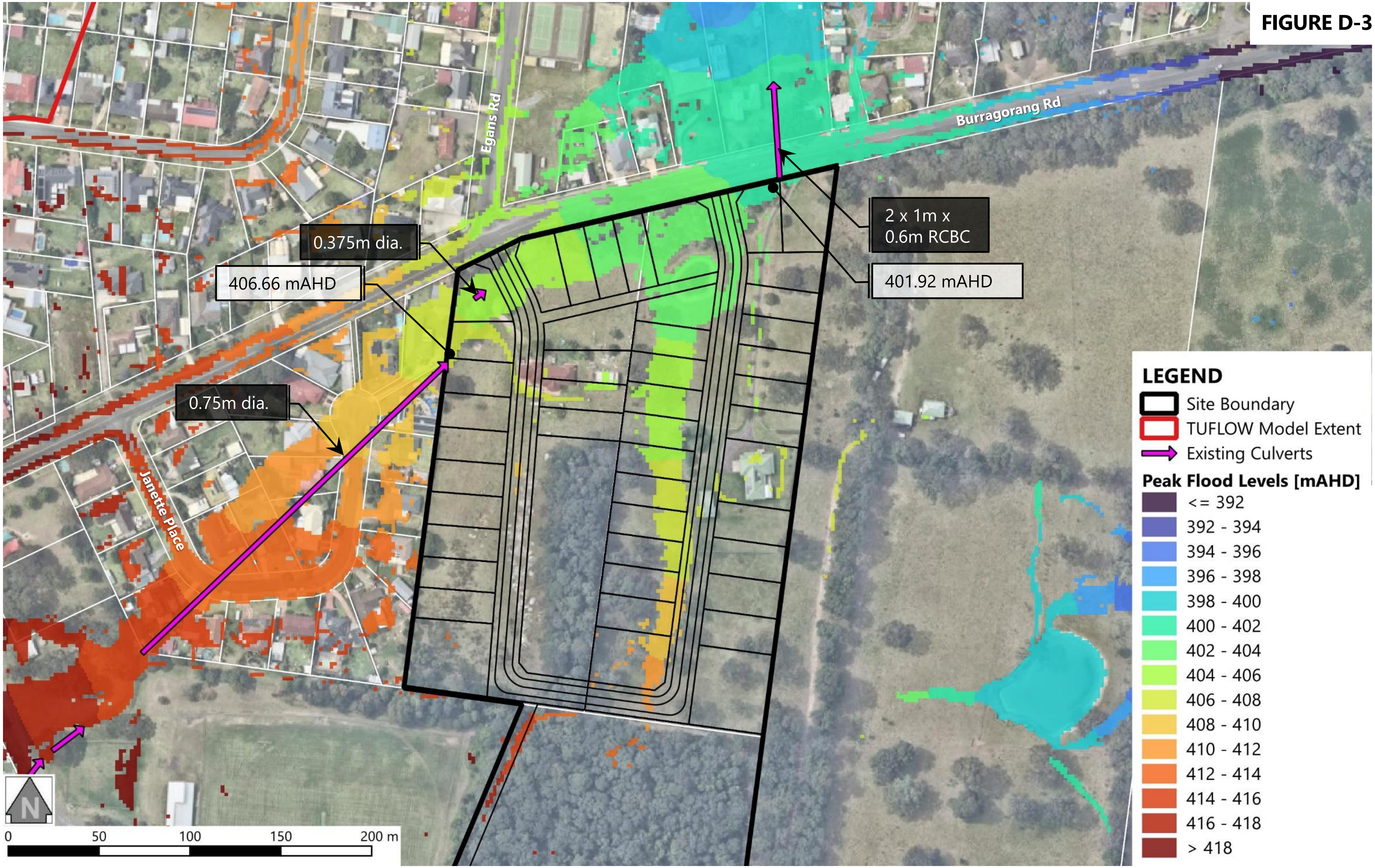
worley consulting

PEAK 1% AEP 45 MINUTE DURATION
FLOOD LEVELS BURRAGORANG ROAD



Prepared by:
worley consulting

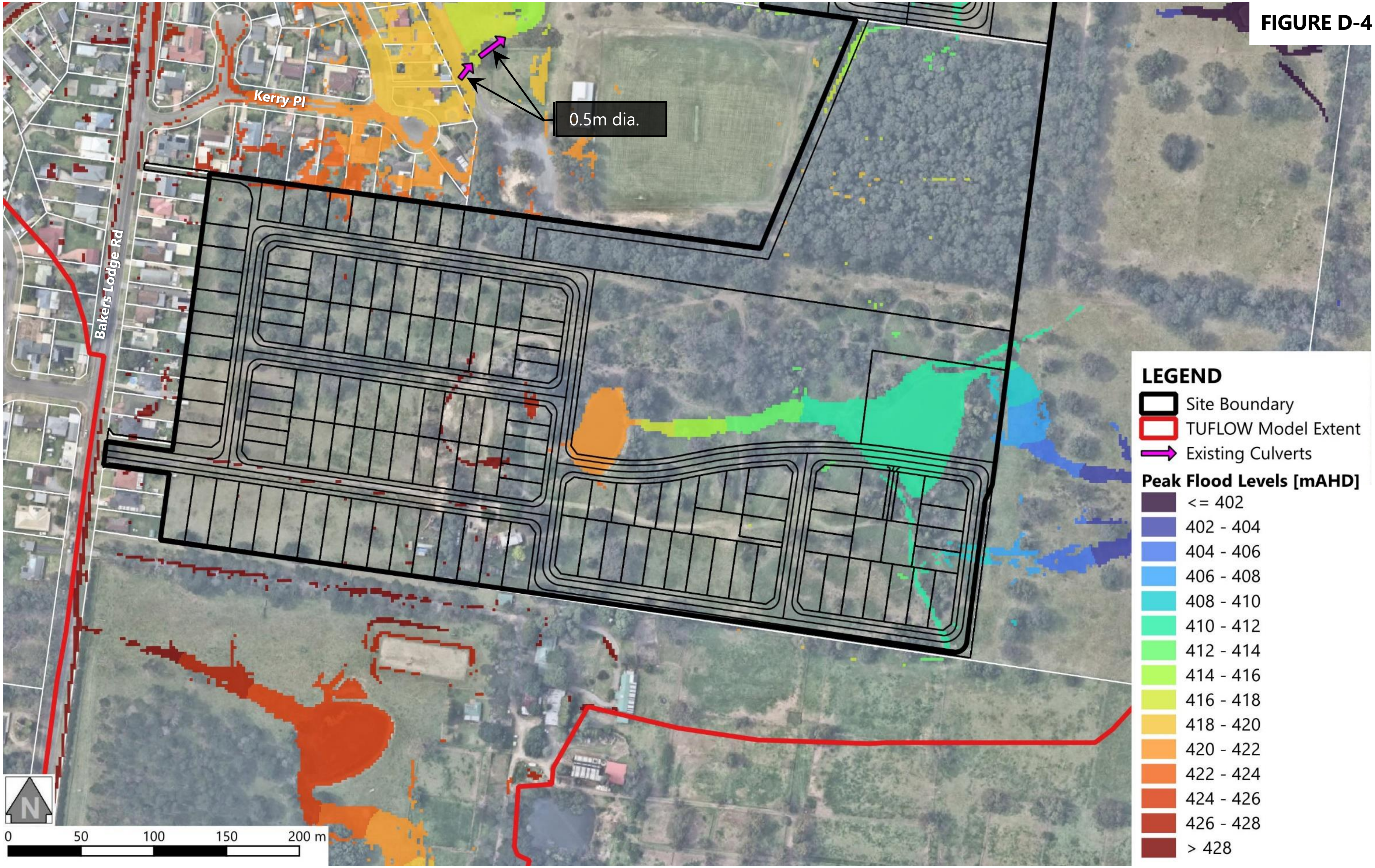
PEAK 1% AEP 45 MINUTE DURATION FLOOD LEVELS BAKERS LODGE ROAD



Prepared by:

worley consulting

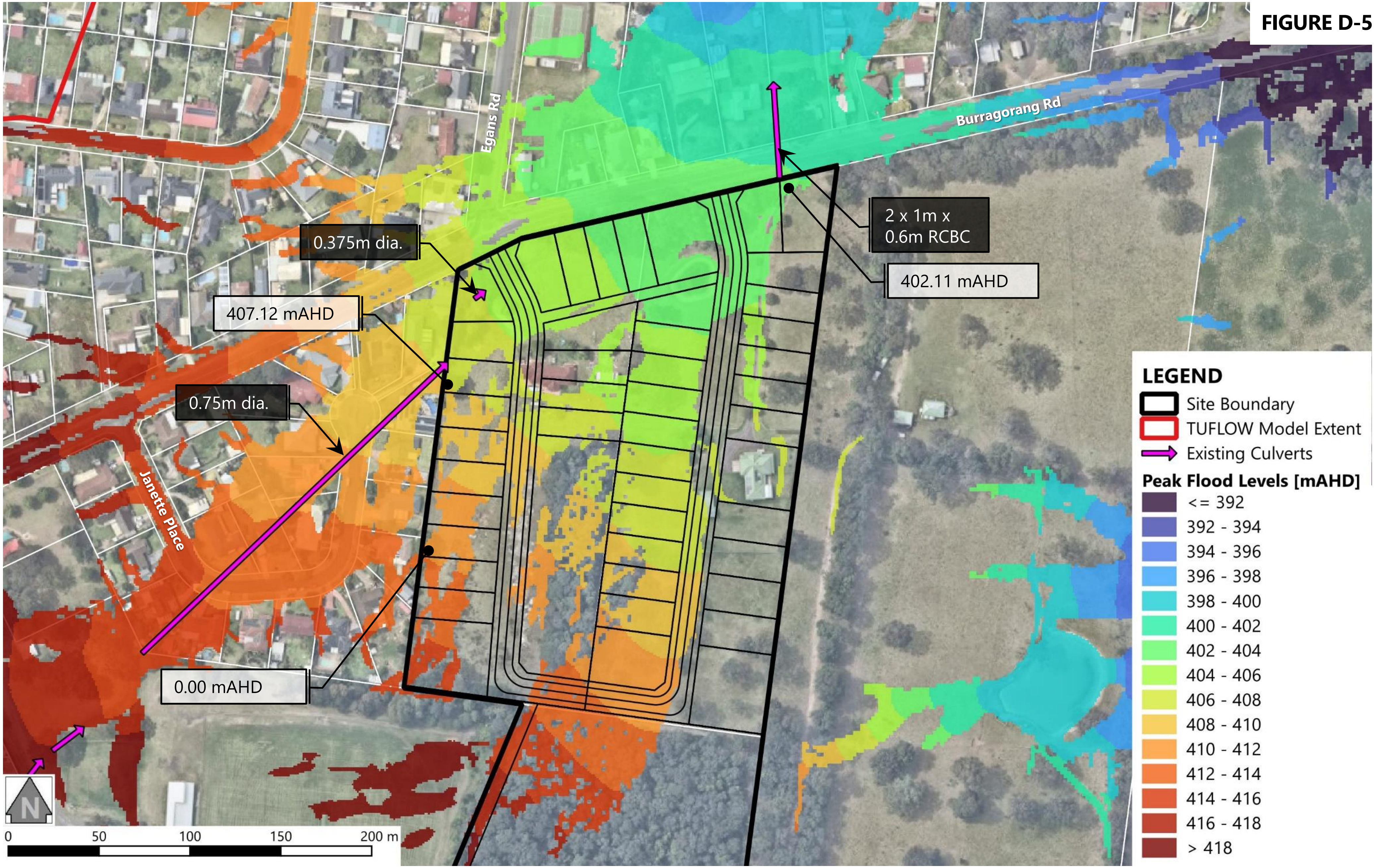
PEAK 1-IN-500 AEP 45 MINUTE DURATION FLOOD LEVELS BURRAGORANG ROAD



Prepared by:
worley consulting

PEAK 1-IN-500 AEP 45 MINUTE DURATION
FLOOD LEVELS BAKERS LODGE ROAD

FIGURE D-5

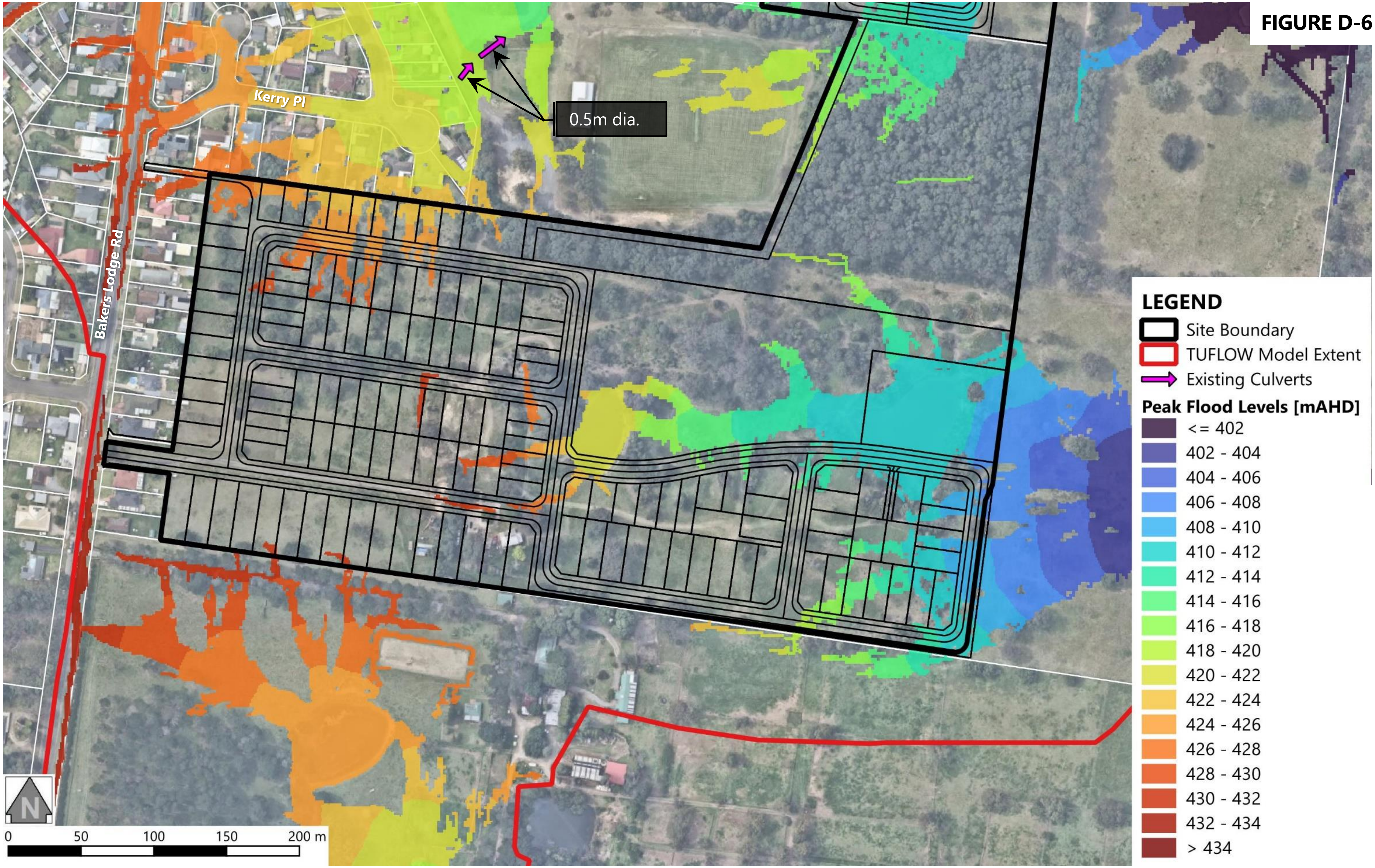


Note: *PMF has been filtered to remove depths below 0.15 m and VxD below 0.025 sq.m/s*

Prepared by:

worley consulting

PEAK PMF 30 MINUTE DURATION
FLOOD LEVELS BURRAGORANG ROAD



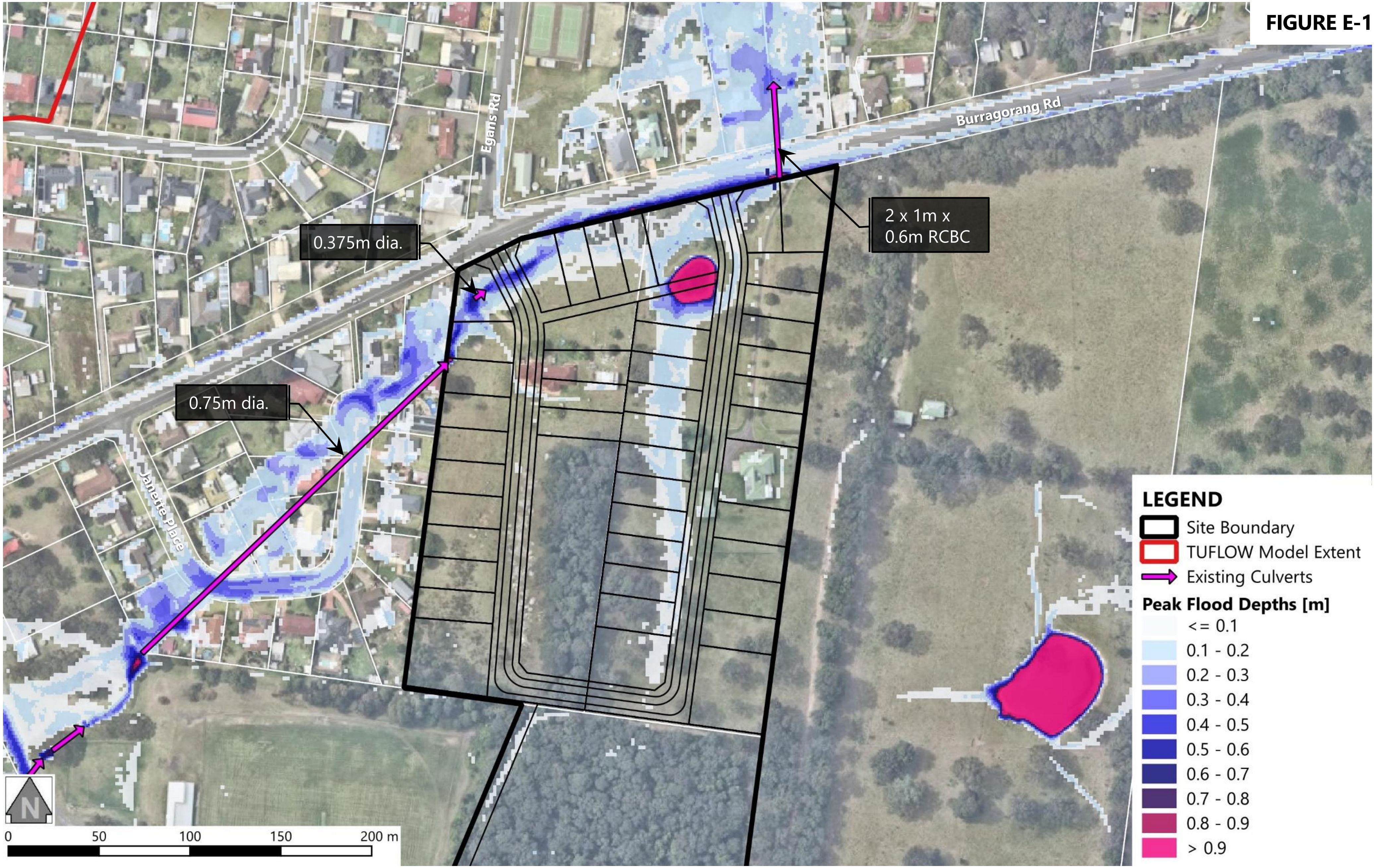
Note: *PMF has been filtered to remove depths below 0.15 m and VxD below 0.025 sq.m/s*

Prepared by:

PEAK PMF 30 MINUTE DURATION
FLOOD LEVELS BAKERS LODGE ROAD

Appendix E. Existing Conditions Flood Depths and Flow Velocity Mapping

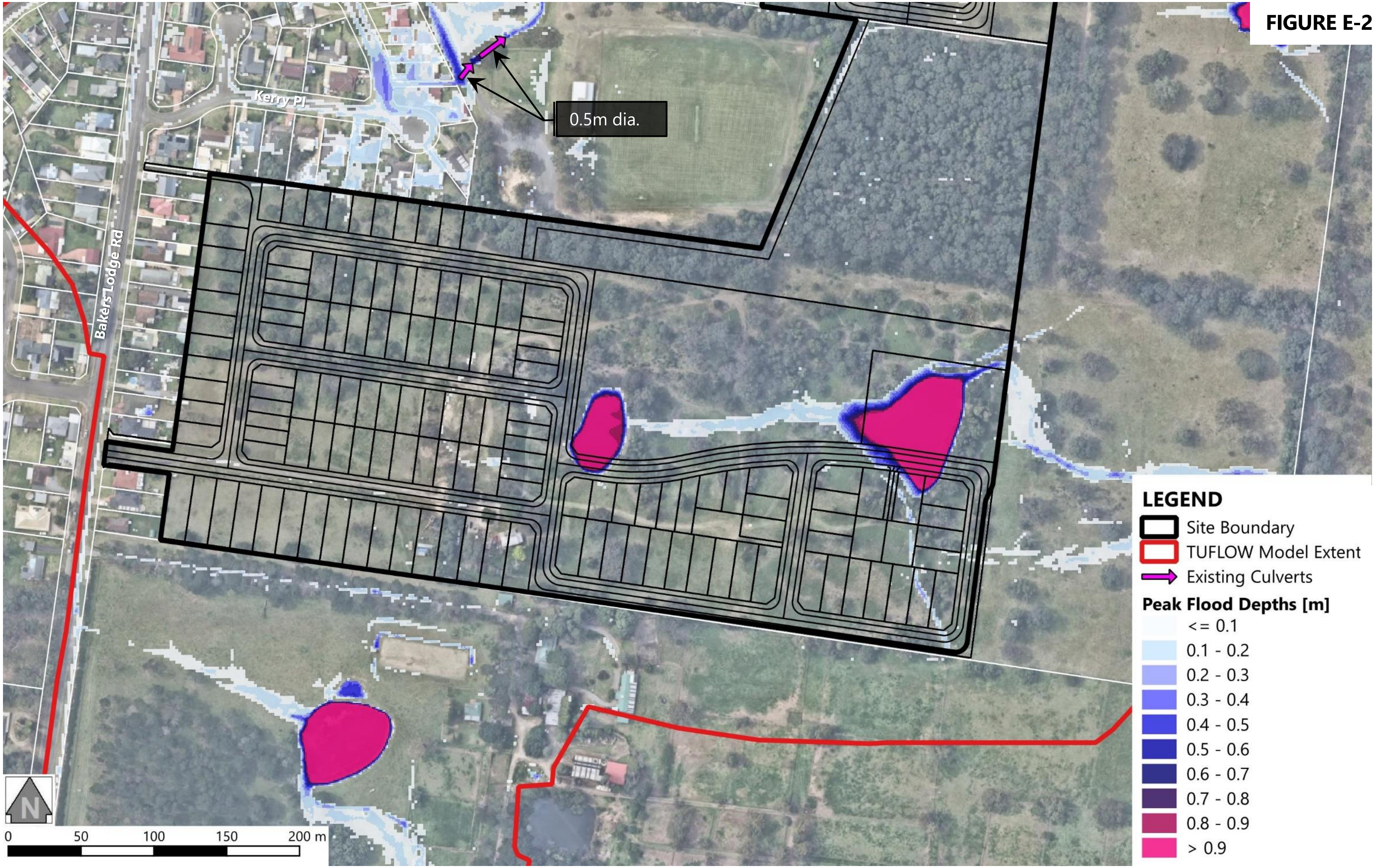
FIGURE E-1



Prepared by:

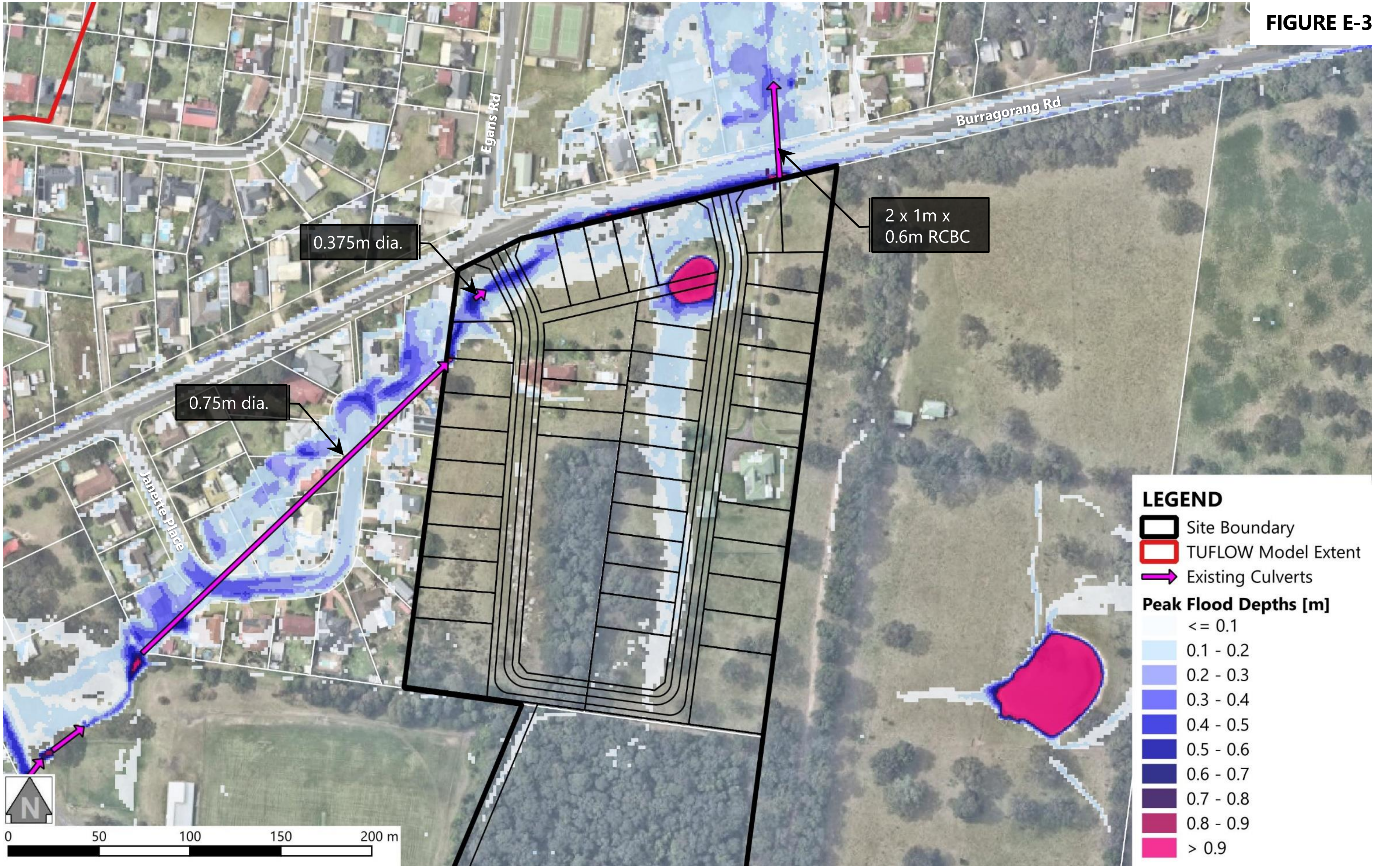
worley consulting

**PEAK 1% AEP 45 MINUTE DURATION
FLOOD DEPTHS BURRAGORANG ROAD**



Prepared by:
worley consulting

PEAK 1% AEP 45 MINUTE DURATION
FLOOD DEPTHS BAKERS LODGE ROAD

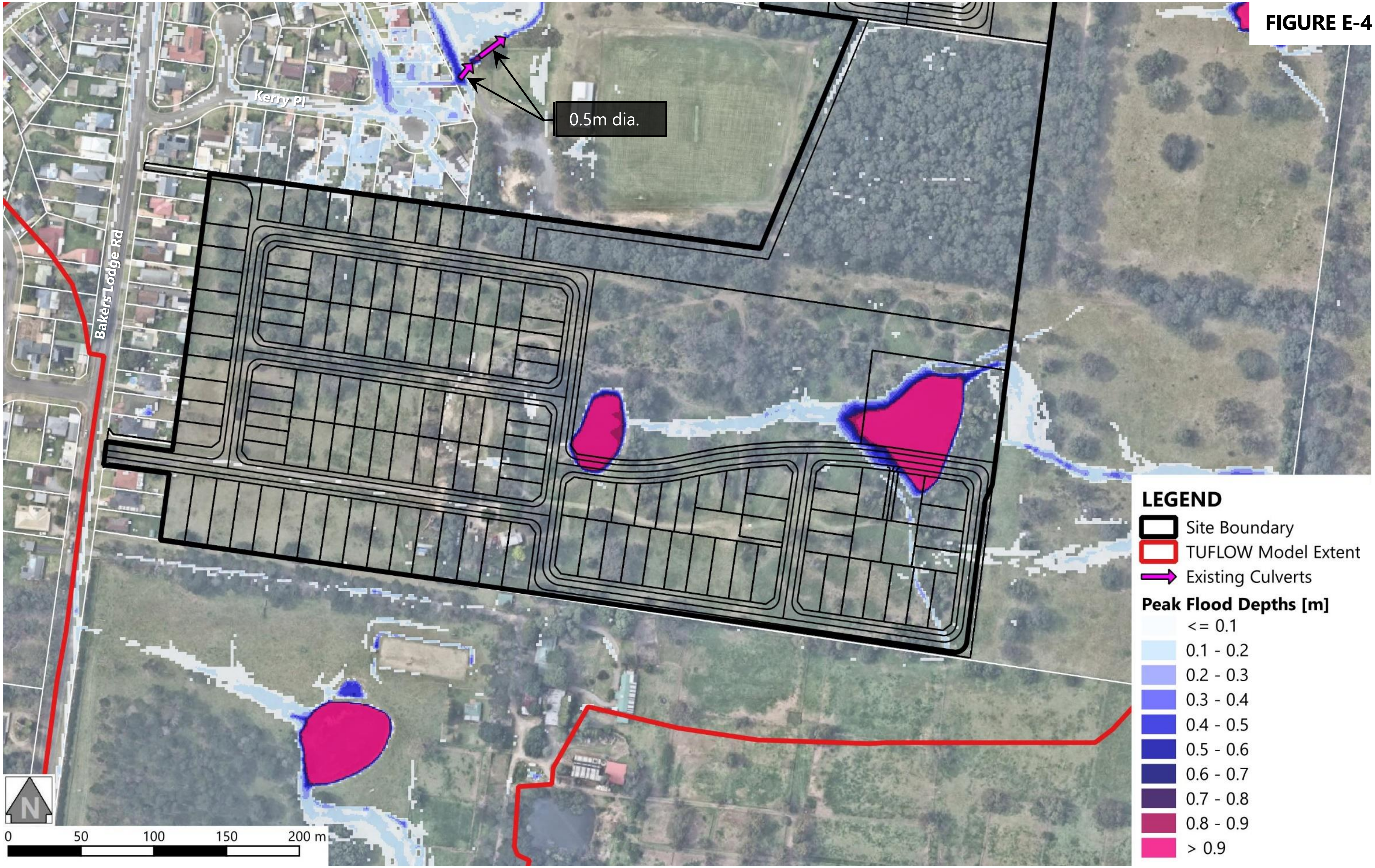


Prepared by:

worley consulting

PEAK 1-IN-500 AEP 45 MINUTE DURATION FLOOD DEPTHS BURRAGORANG ROAD

FIGURE E-4

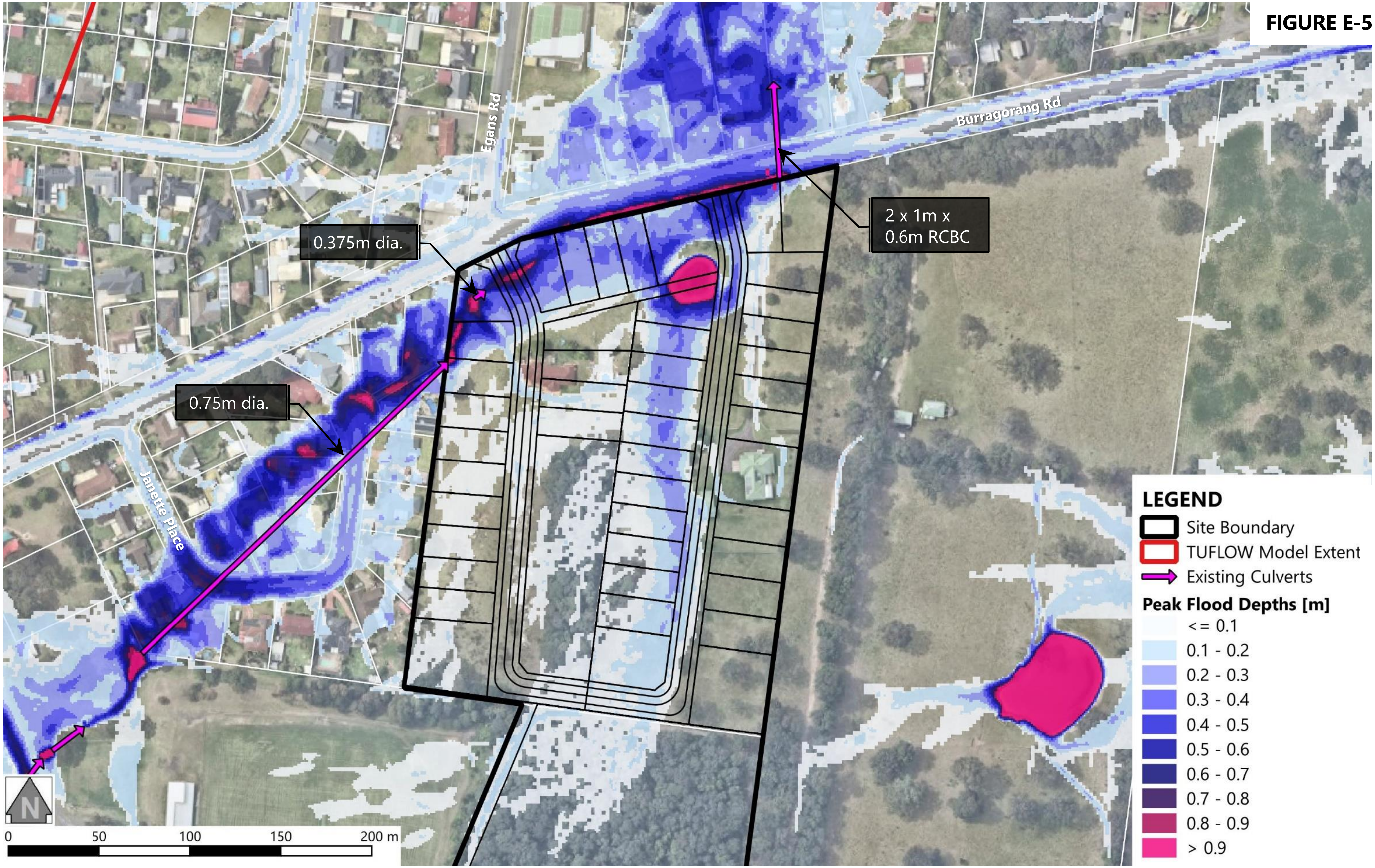


Prepared by:

worley consulting

PEAK 1-IN-500 AEP 45 MINUTE DURATION FLOOD DEPTHS BAKERS LODGE ROAD

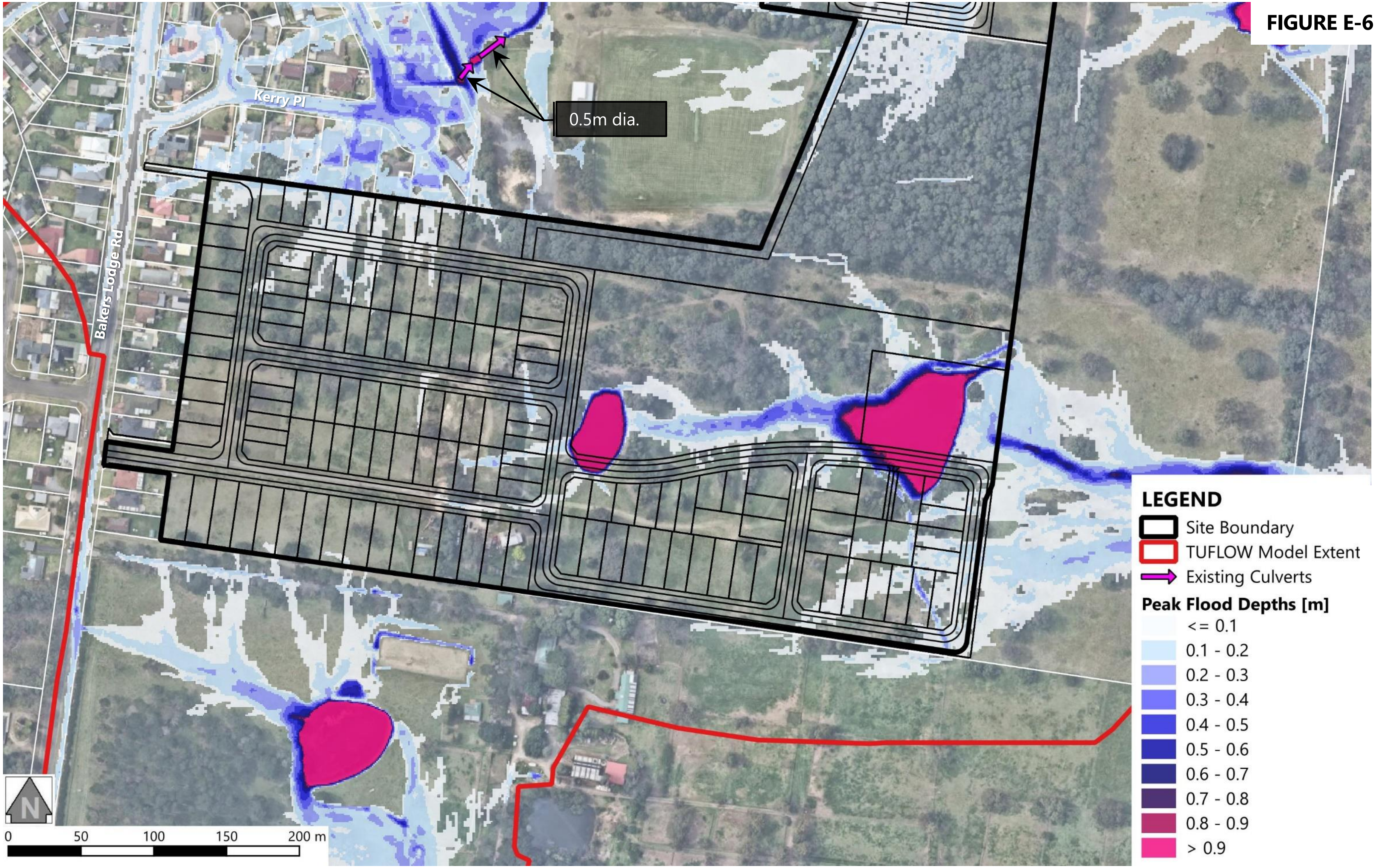
FIGURE E-5



Note: *PMF has been filtered to remove depths below 0.15 m and VxD below 0.025 sq.m/s*

Prepared by:
worley consulting

PEAK PMF 30 MINUTE DURATION
FLOOD DEPTHS BURRAGORANG ROAD



Prepared by:

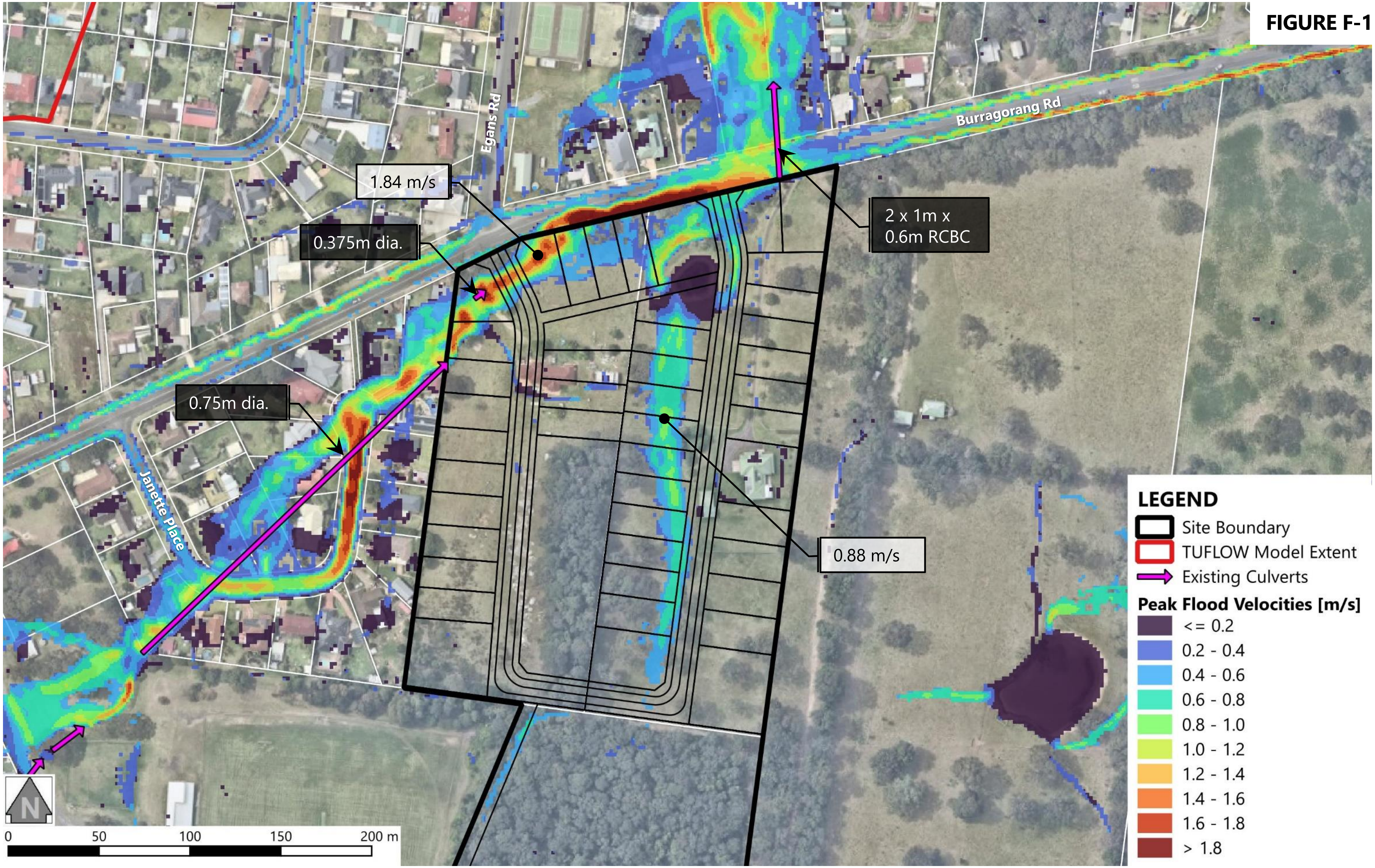
worley consulting

Note: *PMF has been filtered to remove depths below 0.15 m and VxD below 0.025 sq.m/s*

PEAK PMF 30 MINUTE DURATION
FLOOD DEPTHS BAKERS LODGE ROAD

Appendix F. Existing Conditions Flow Velocity Mapping

FIGURE F-1



Prepared by:
worley consulting

PEAK 1% AEP 45 MINUTE DURATION
FLOOD VELOCITIES BURRAGORANG ROAD

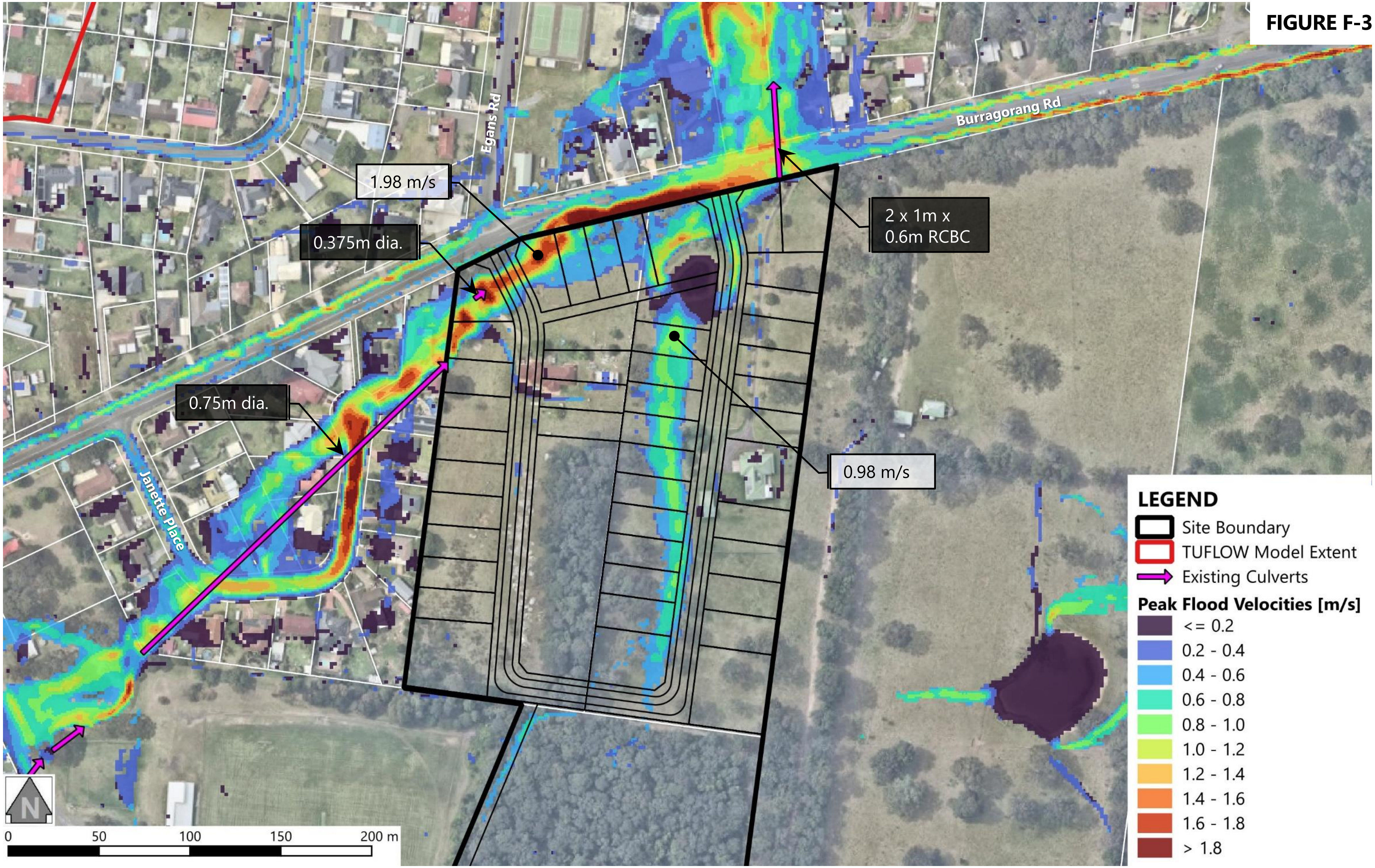
FIGURE F-2

Prepared by:

worley consulting

PEAK 1% AEP 45 MINUTE DURATION FLOOD VELOCITIES BAKERS LODGE ROAD

FIGURE F-3



Prepared by:

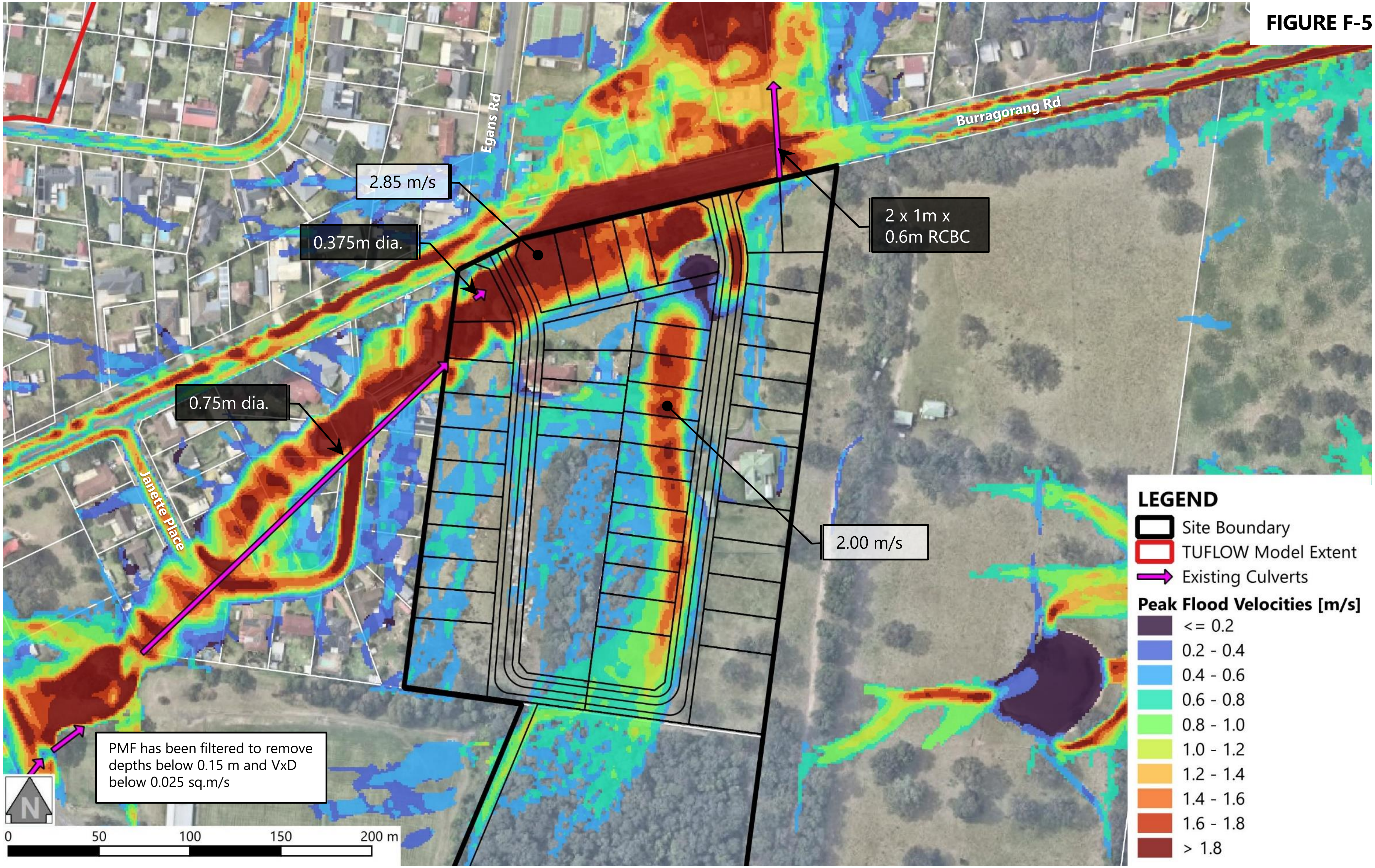
worley consulting

PEAK 1-IN-500 AEP 45 MINUTE DURATION FLOOD VELOCITIES BURRAGORANG ROAD

Prepared by:

worley consulting

PEAK 1-IN-500 AEP 45 MINUTE DURATION
FLOOD VELOCITIES BAKERS LODGE ROAD



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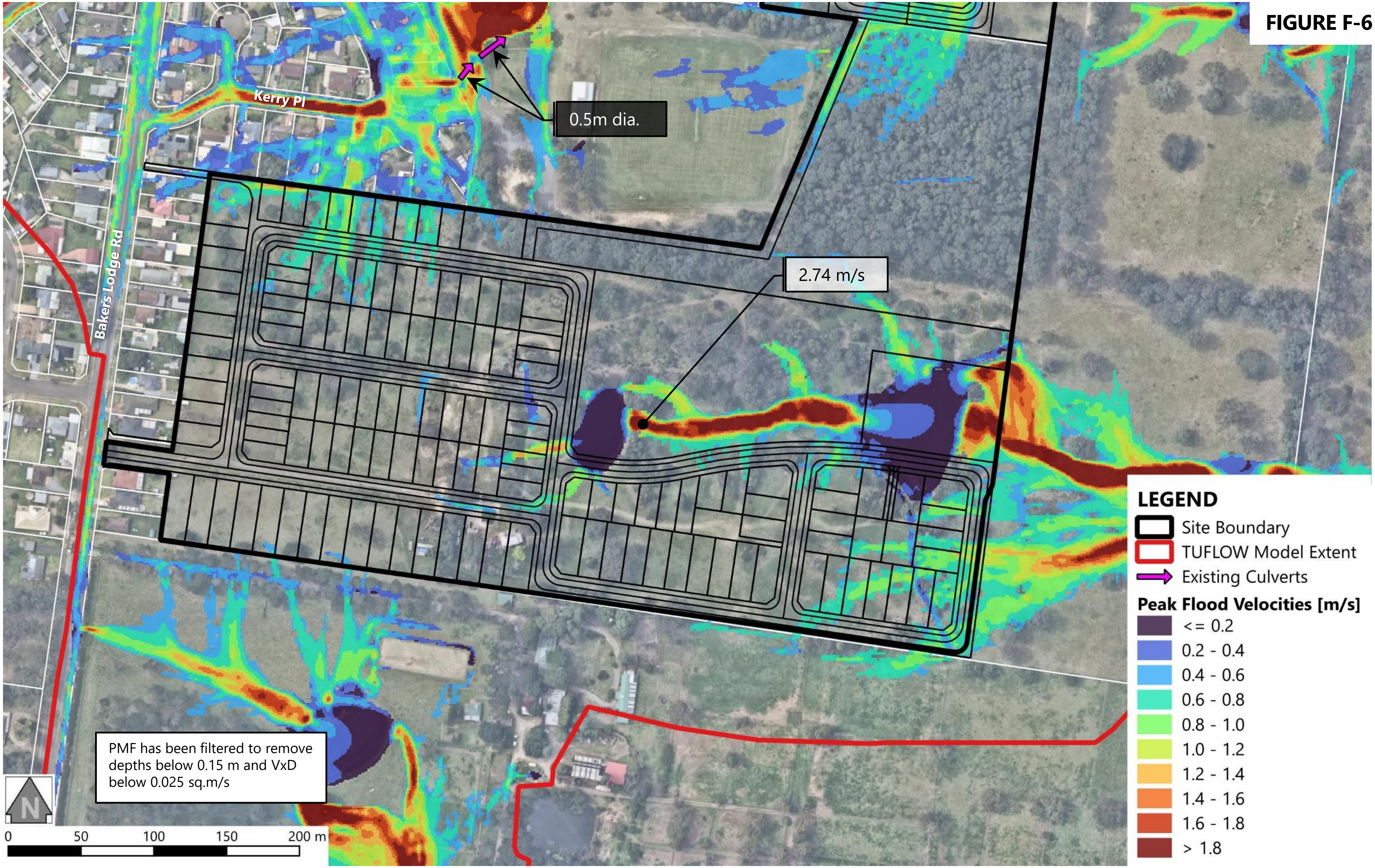
PEAK PMF 30 MINUTE DURATION
FLOOD VELOCITIES BURRAGORANG ROAD



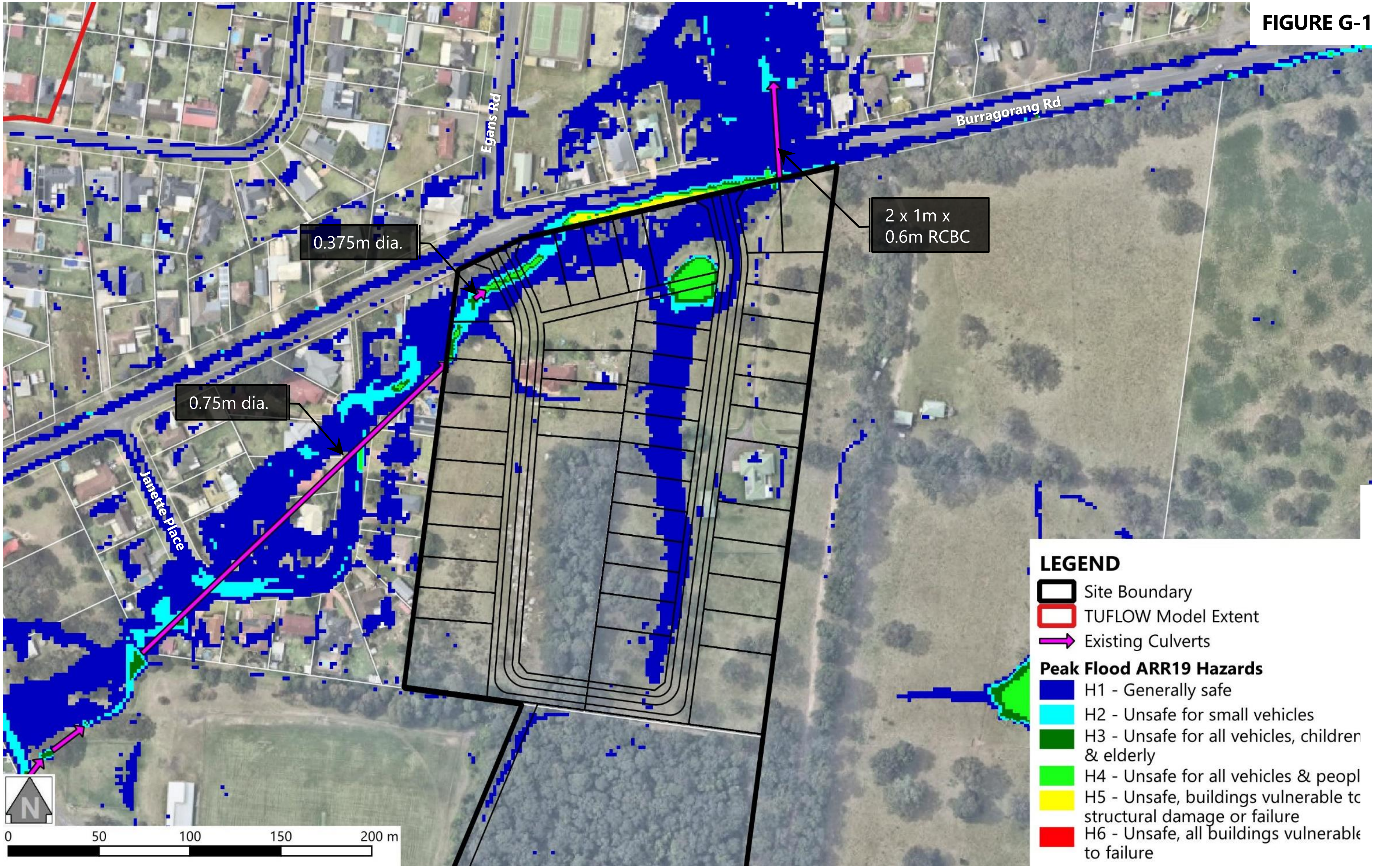
Prepared by:

worley consulting

PEAK PMF 30 MINUTE DURATION
FLOOD VELOCITIES BAKERS LODGE ROAD

Appendix G. Existing Conditions Flood Hazard Mapping

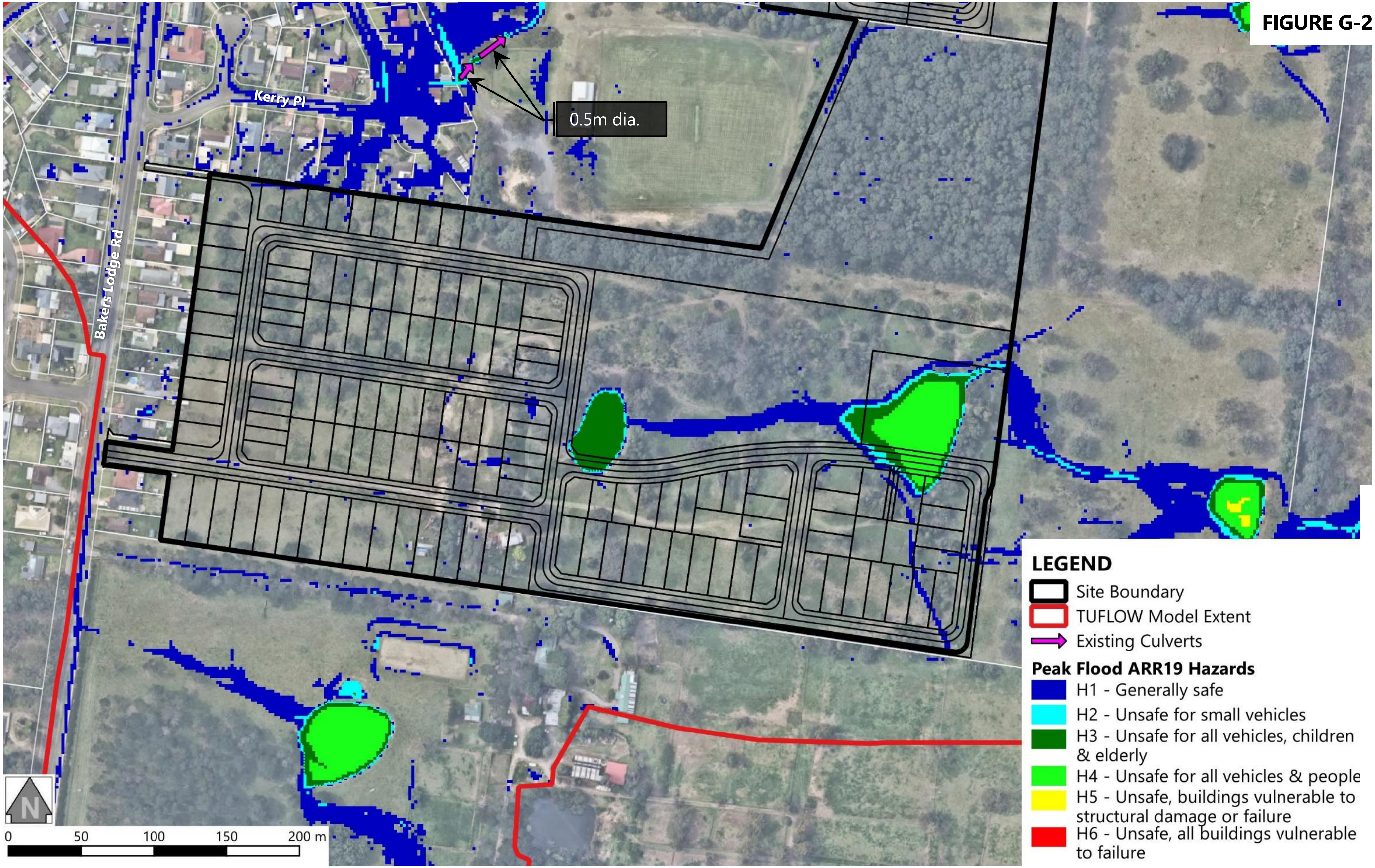
FIGURE G-1



Prepared by:

worley consulting

PEAK 1% AEP 45 MINUTE DURATION
ARR19 HAZARDS BURRAGORANG ROAD

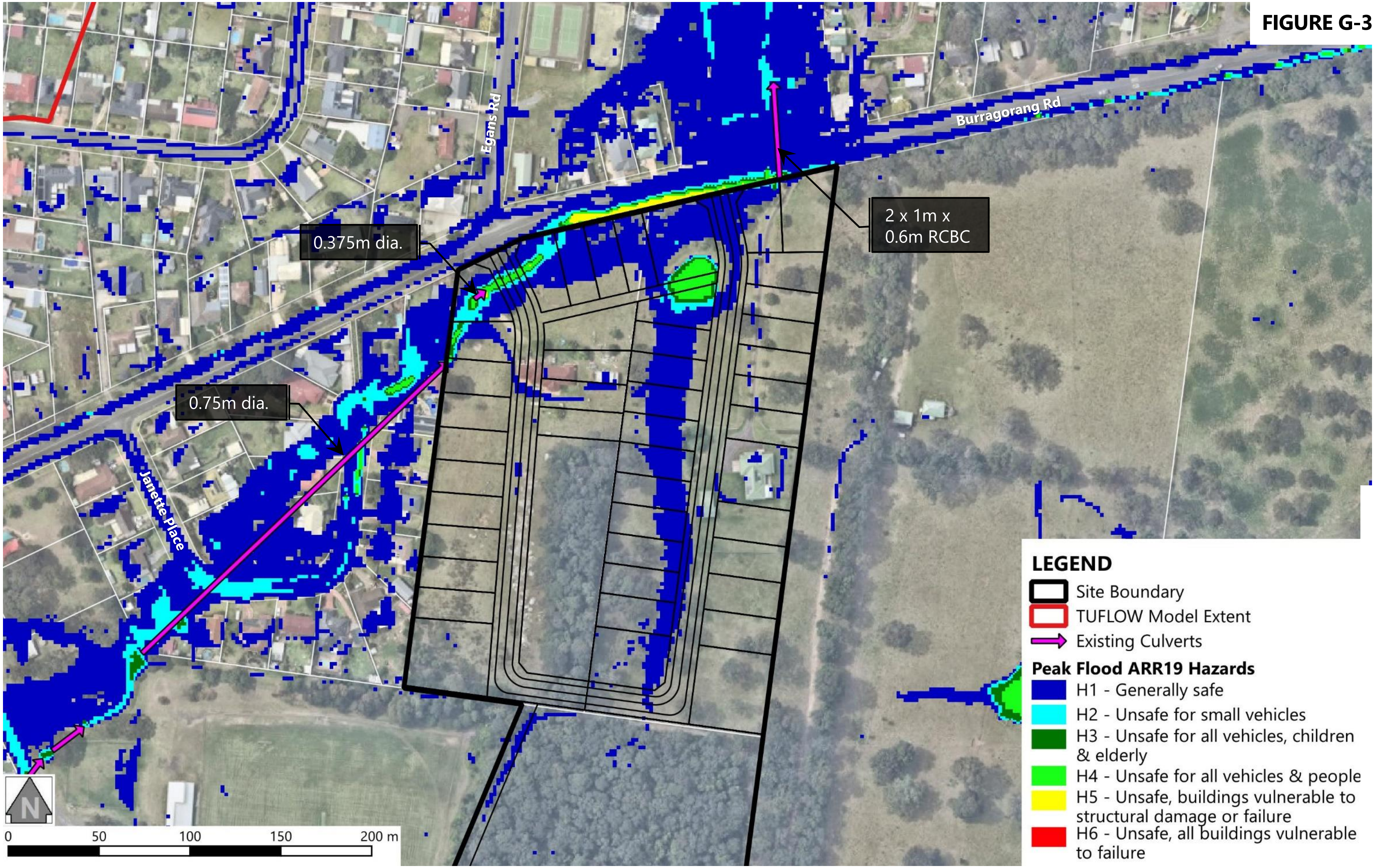


Prepared by:

worley consulting

PEAK 1% AEP 45 MINUTE DURATION
ARR19 HAZARDS BAKERS LODGE ROAD

FIGURE G-3

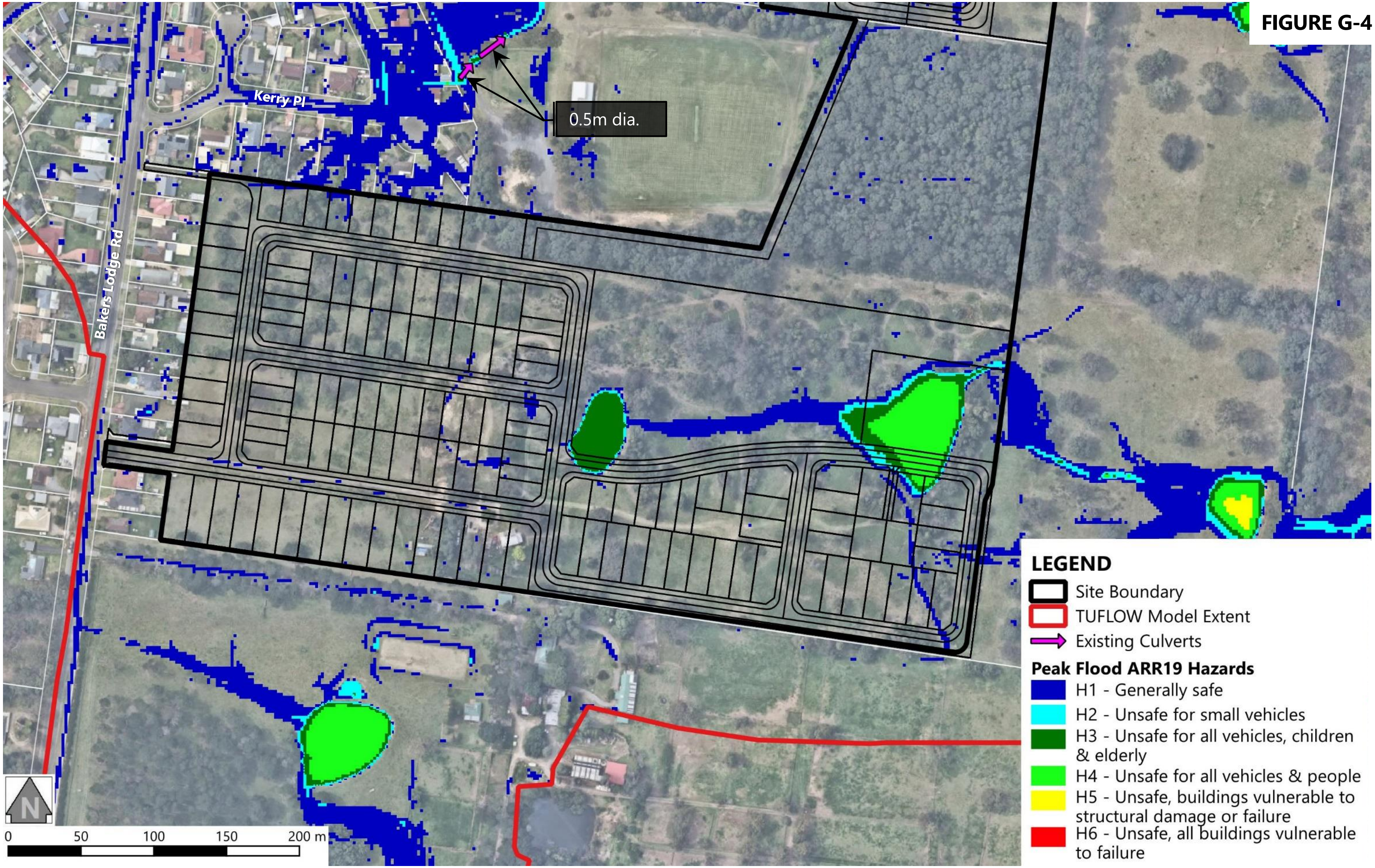


Prepared by:

worley consulting

PEAK 1-IN-500 AEP 45 MINUTE DURATION
ARR19 HAZARDS BURRAGORANG ROAD

FIGURE G-4



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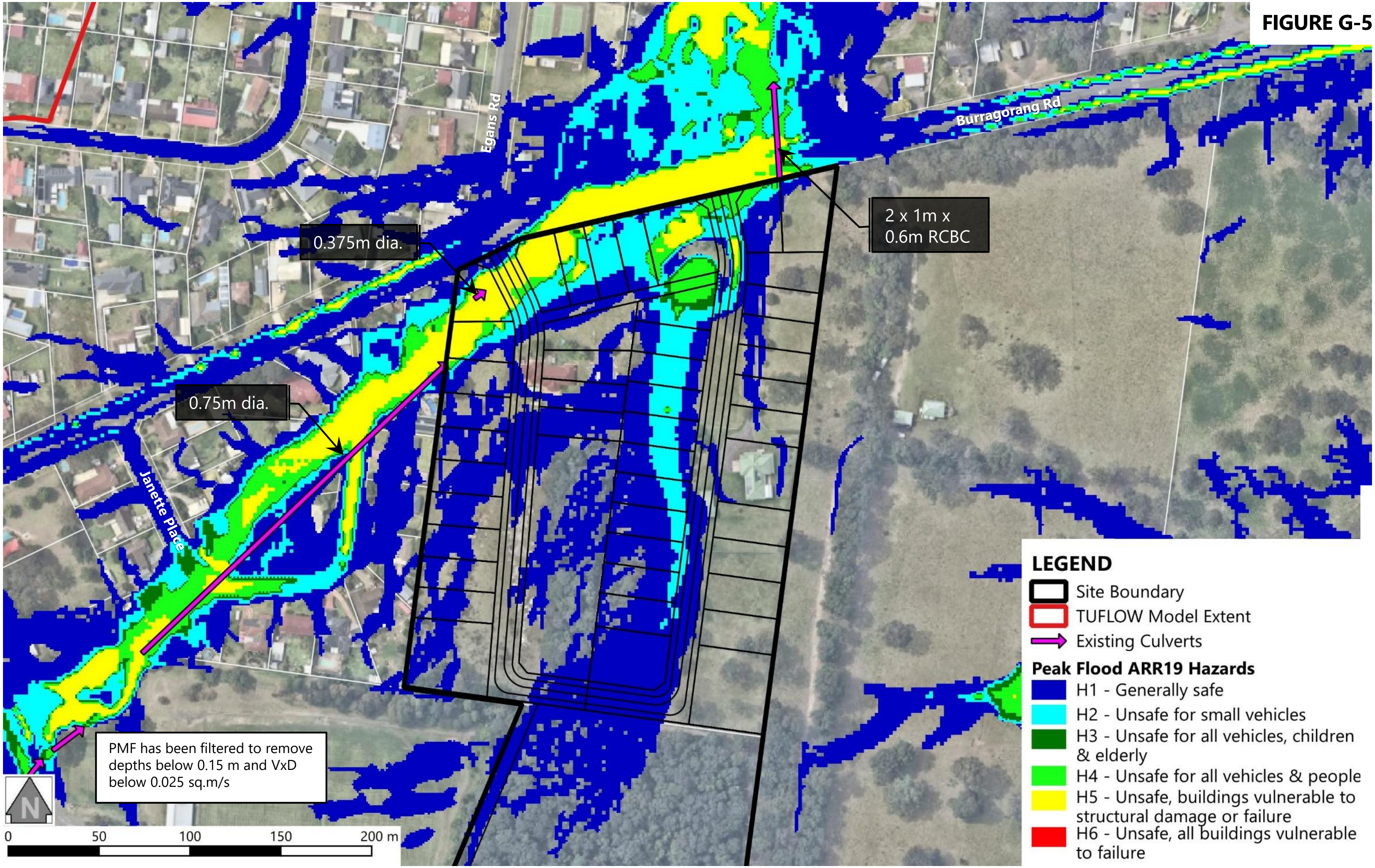
worley consulting

PEAK 1-IN-500 AEP 45 MINUTE DURATION ARR19 HAZARDS BAKERS LODGE ROAD



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worley consulting

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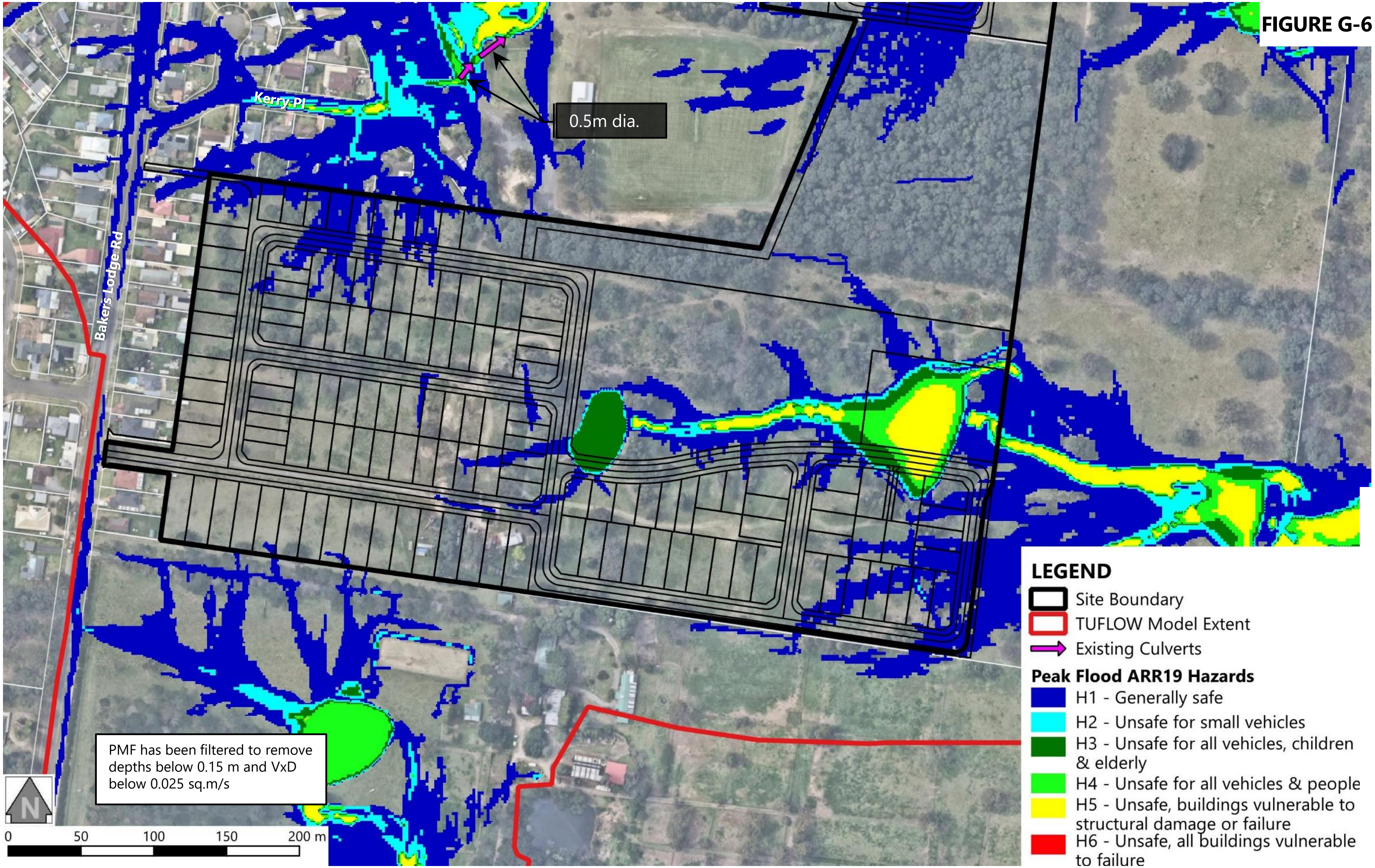

Prepared by:

worley consulting

PEAK PMF 30 MINUTE DURATION
ARR19 HAZARDS BAKERS LODGE ROAD