# Water Cycle Management Strategy Report, Oakdale Planning Proposal

**1838 Barkers Lodge Road, Oakdale, NSW**

For Morehuman Oakdale ATF MH Property No. 3, 14th March 2024

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This report has been prepared by Colliers International Engineering & Design (NSW) Pty Ltd and has undergone a quality assurance review. The signatures above confirm review completion.

## Acknowledgement of Country

Colliers International Engineering & Design (NSW) Pty Ltd acknowledges the traditional custodians of the land in Wollondilly, the Tharawal people. We acknowledge the living culture and spiritual connections to the land for the Tharawal people, and pay our respects to elders' past, present, and emerging and we acknowledge the cultural significance of the Appin region to the Aboriginal people.

## Abbreviations

| | |
|---|---|
| AEP | Annual Exceedance Probability |
| ARI | Annual Recurrence Interval |
| DCP | Development Control Plan |
| ILP | Indicative Layout Plan |
| IWM | Integrated Water Management |
| LBP | Land Budget Plan |
| LiDAR | Light Detection and Ranging |
| NorBE | Neutral or Beneficial Effect |
| PET | Potential Evapotranspiration |
| PMF | Probable Maximum Flood |
| PMP | Probable Maximum Precipitation |
| QGIS | Quantum Geographic Information System |
| TIN | Triangulated Irregular Network |
| WSC | Wollondilly Shire Council |
| WSUD | Water Sensitive Urban Design |

# 1. Introduction

## 1.1 Background

Colliers International Engineering & Design (NSW) have been engaged by Morehuman Oakdale Pty Ltd Atf MH Property No.3 (MH Property No.3) to prepare a Water Cycle Management Strategy Report to support the Oakdale Planning Proposal for development at 1838 Barkers Lodge Road and 1455-1475 Burragorang Road, Oakdale, NSW (Lots 1, 2 and 6 on DP734561).

The Planning Proposal seeks to amend Wollondilly Local Environmental Plan 2011 to rezone the Site and facilitate future local housing with consideration of the environmental values of the Site.

As part of the planning proposal a Water Cycle Management Plan (WCMP) is required to assess key flooding and stormwater management risks and address the requirements of the Wollondilly Shire Council (WSC) Development Control Plan.

## 1.2 Proposed Development

The proposed development will include a mix of low-density residentials zoned R2, and some portions of land zoned C2 – Environmental Conservation and C3- Environmental Management to enhance and protect the environmental values of the Site. The proposed zoning plan and road layout are shown in Appendix A.1 & B.1 respectively.

## 1.3 Scope

This report addresses the stormwater management strategy for the proposed West Wilton Precinct. The Water Cycle Management Plan for this Planning Proposal has been developed in accordance with the Wollondilly Shire Council's (WSC) control documents and specifications. The scope of works is as follows:

1. Preparation of a WCMP that assesses whether the Site is subject to flooding as defined in the Wollondilly Shire Council Engineering Design Guide;
2. Ensure the WCMP is developed in accordance with the objectives and controls outlined within the Wollondilly Shire Council Integrated Water Management Policy (IWMP) such that the development is compatible with the flood behaviour, flood hazard and flood emergency management;
3. Prepare flood modelling for the 1% AEP storm event and issue modelling files and mapping results to the City of Wollondilly;
4. Build the proposed development into the hydraulic model and compared pre- and post- development to determine the extent of flood impacts;
5. Define the planning flood design requirements for development and the anticipated urban built form;
6. Indicative Water Quality treatment train assessment in accordance with Wollondilly Shire Council Development Control Plan (WSCDCP);
7. Provision of high-level recommendations for detention basin sizes and layout; and
8. Liaise with and attend meetings with Wollondilly Shire Council and respond to questions during the rezoning assessment phase as required.

It is noted that this is a high-level report for the purposes of site rezoning and answering the NSW Government call for efficient land supply. It is acknowledged that further detailing of hydrology, hydraulics, basin sizing and optimisation, water quality and underground stormwater drainage will be required as the project progresses.

## 1.4 Objectives

The objective of this report is to:

- Undertake a Water Cycle Management Strategy for the purposes of the proposed land zoning;
- Undertake a preliminary flood assessment – hydrologic and hydraulic modelling, to determine existing conditions flood behaviour and the potential impacts of the rezoning;
- Prepare a high-level water quality assessment of the site in accordance with Wollondilly Shire Council's Integrated Water Management Strategy and Policy (IWMS); and
- Identify and undertake high-level concept layout of detention basins and bioretention basins that may be required for water quantity and quality management purposes.

# 2. Data Collation and Review

Relevant available information from the Client, Project Team, Council and external sources was compiled, reviewed, and assessed, with the aim of obtaining a full understanding of the project proposal and goals, collating data required for the Water Cycle Management Plan and identifying any outstanding data required.

## 2.1 Guidelines and Previous Studies

Available guidelines reviewed and adopted for this study include the following:

- WSC Water Sensitive Urban Design (WSUD) Guidelines (WSC 2020)
- NSW MUSIC Modelling Guidelines (BMT WBM, 2015)
- WSC Development Control Plan (DCP) (WSC 2016)
- WSC Integrated Water Management Policy and Strategy (WSC, 2020)
- Australian Rainfall and Runoff: A Guide to Flood Estimation (Commonwealth of Australia, Geoscience Australia, 2019)
- The Wollondilly Shire Flood Study Broad Scale Assessment (Advisian, 2021)

The site is situated within Wollondilly Shire Council Local Government Area and is therefore subject to the WSC DCP.

The Wollondilly Shire Flood Study Broad Scale Assessment was used to determine the basis of the flood extents at the site, however, as discussed later in this report, the LGA wide Flood Study is not appropriate for this assessment and therefore a new site-specific model was created.

# 3. Water Quality Management Strategy

## 3.1 Wollondilly Shire Council WSUD Design Guidelines

The WSC Water Sensitive Urban Design Guidelines (Wave Consulting, 2021), 'The WSUD Guidelines', were released in conjunction with the WSC Integrated Water Management (IWM) Strategy in January 2021. The vision outlined in the IWM strategy is to maintain pristine creeks and rivers to be swimmable and ecologically rich and diverse. The IWM Strategy is supported by the WSUD Guidelines, which integrate urban water cycle management with urban planning with the aim of mimicking natural systems to minimise negative impacts on the natural water cycle and receiving waterways (Wave Consulting, 2021).

The WSUD Guidelines (2021) outline the key principles as follows:

a) Protect and enhance natural water systems within urban environments.
b) Integrate stormwater treatment into the landscape, maximising the visual and recreational amenity of developments.
c) Improve the quality of water draining from urban developments into receiving environments.
d) Reduce runoff and peak flows from urban developments by increasing local detention times and minimising impervious areas.
e) Minimise drainage infrastructure costs of development due to reduced runoff and peak flows.

These principles speak to the aspirations held by the Wollondilly Community Strategic Plan (CSP), which provides a clear mandate to protect and maintain the environment.

The flow and volume of stormwater and the pollutants contained therein, can be one of the largest contributors to water degradation if not managed. As such, the WSUD Guidelines have outlined a suite of seven recommended actions to retain stormwater on-lot or within the catchment as much as possible. The remaining runoff that is not retained within the catchment is to be treated to best practice.

## 3.2 Objectives and Targets

The objectives of the WSC WSUD Guidelines and IWM Strategy are threefold:

1. Achieve a zero impact of stormwater on local waterways;
2. Achieve a zero impact of wastewater on local waterways; and
3. Use water to support sustainable development.

To achieve a zero impact, the policies require runoff from impervious surfaces to be reduced to a near natural condition and it is through the suite of seven recommended actions outlined within the Guidelines that this can be achieved.

In particular,

- Maximising use of rainwater tanks on a lot-scale basis reduces run-off and pollutants and reduces potable water use; and
- Runoff from impervious roads and pavements can be reduced by using central swales for retention and treatment.

The WSUD Guidelines also state that it is expected that a 79% reduction in impervious flows would be as close as possible to a zero-impact scenario, and it is not practical or appropriate to reduce runoff to zero (Wave Consulting, 2021).

Zero impact also refers to the impact of wastewater discharge, however, this report will address only the impacts of stormwater runoff.

Sections 4.2.1, 4.2.2 and 4.3 of the WSUD Guidelines (2021) provides tables of requirements to meet the WSUD zero impact targets. Since the proposal is a subdivision of greater than 10+ lots, all targets outlined will apply. Items of particular relevance to the Water Cycle Management Plan, are outlined in Table 3-1 below.

*Table 3-1 Summary of Sections 4.2 and 4.3 of WSC WSUD Guidelines, as they pertain to this Water Cycle Management Plan*

| Requirements | 10+ lots or 2500+ $m^2$ | Addressed at Rezoning Stage |
|---|---|---|
| Reduce stormwater runoff to an equivalent of between 2.5 and 3 ML / year / 1 hectare of urban area | Yes | Yes |
| Reduce potable water use by > 70% compared to business as usual | Yes | No<br>Potable water analysis to be undertaken as part of the Water and Sewer Design[1] |
| Ensure smart tank technology could in the future be integrated into residential, commercial, and industrial developments. | Yes | No<br>Analysis to be undertaken at DA Stage |
| Prepare an Integrated Water Plan, including who owns and maintains all associated assets, and where all impervious surfaces drain to. See section 8.2 Early Planning for requirements. | Yes | Yes, partially[2] |
| Use Council MUSIC template model to demonstrate how the outcomes of this policy will be achieved. | Yes | Yes - Adopted |
| Design and build streetscapes in new subdivisions to achieve zero impact. | Yes | Yes |
| For developments where demand is greater than 5 ML/year demonstrate how this water will be sourced through rainwater, stormwater, or recycled water. | Yes | No<br>Potable water demand to be addressed within the Water and Sewer Design[1] |
| Routine monitoring of WSUD effectiveness should be undertaken on an ongoing basis. | Yes | No<br>Maintenance schedules to be provided as required by Council Policy at Detailed Design. |

*Table continued next page*

| | | |
|---|---|---|
| Monitoring of waterways to demonstrate downstream waterway of urban development is of a similar condition / quality to designated reference stream. | Yes | No<br>Part of ongoing monitoring and maintenance |
| **Subdivision Specific** | | |
| Road reserve to be designed to filter and convey more stormwater runoff | Yes | Yes |
| Median reserve to be designed and constructed to maintain stormwater runoff and may need to be increased from 5m to 7m, with a swale that has a 2m base. | Yes | Yes<br>Although further details and analysis to be undertaken at DA |

[1] Note that Water and Sewer Design to be undertaken at DA Stage and will involve analysis of the water supply and consumption associated with the rainwater tanks.

[2] Analysis of the smart tank technology will require individual residential, commercial, and industrial lot owners to submit separate DA applications for rainwater tanks including smart tanks.

[3] Note that Environmental and Cultural Heritage Considerations, preliminary construction, operations and maintenance requirements and funding opportunities are not addressed within this report.

## 3.3 Water Quality Management Objectives

This Water Cycle Management Plan will demonstrate that at this preliminary Planning Application Stage, that a Regional Scale focus will sufficiently manage the stormwater quality and runoff requirements, with the detailed design to be addressed at Development Application, when more detail is available at a street- and lot-scale. At DA stage, rainwater tanks, bioretention systems and tree pits can be considered for incorporation into the treatment train.

At Planning Application Stage for the purposes of Rezoning Approval, it is proposed to present a strategy that incorporates Regional Scale WSUD elements such as:

- Rainwater Tanks
- Bio-retention basins
- Detention Basins

The MUSIC model will incorporate rainwater tanks, bioretention and detention systems at a high-level, but the detailing of these items will occur later in the project.

## 3.4 Pollutant Reduction Targets

The WSC WSUD Guidelines are used to assess performance against the Stormwater Quality Targets. The stormwater quality targets are outlined in Table 3-2.

*Table 3-2 Stormwater Quality PerformanceTargets. Source: WSC Engineering Design and Construction Guidelines*

| Pollutant | Stormwater Management Objective % Reduction |
|---|---|
| Gross Pollutants (>5mm) | 70 |
| Total Suspended Solids (TSS) | 80 |
| Total Phosphorus (TP) | 45 |
| Total Nitrogen (TN) | 45 |

## 3.5 Water Quality Management Strategy

The adopted stormwater quality management strategy includes provision of a treatment train to treat surface runoff to the drainage network for the fully developed conditions. The treatment system is a mixture of distributed and end-of-line features that can be integrated within the landscape and open space areas and distributed throughout the catchment, such as rainwater tanks, vegetated swales, infiltration trenches or tree-pits, or they can be concentrated in centralised locations as end-of-line treatments, such as bio-retention basins.

The following water quality control assets are proposed for implementation within the development:

a. Distributed rainwater tanks – for collection of runoff from roofs and re-use of water for irrigation and household use;
b. Distributed proprietary Gross Pollutant Traps (GPTs) - for removal of coarse sediment and large debris, reducing maintenance obligations and pollutant loads on the tertiary treatment controls. These will typically be sized for the 3–6-month flow and will be located upstream of the bioretention basins;
c. End-of-line bioretention systems for capture of finer sediment and treatment of nutrients. These may be distributed treatment systems such as vegetated swales, or end-of line such as bio-retention basins.
d. Detention basins, to replicate the requirement of water quantity as detailed in section 5 of the report.

## 3.6 Methodology

The stormwater quality management modelling was conducted using the industry-standard MUSIC Model (Model for Urban Stormwater Improvement Conceptualisation) Version 6.3. WSC provided a MUSIC template for use, which was adopted for modelling the site.

The following methodology was employed for the analysis:

- The existing scenario was modelled as agricultural land with 0% impervious fraction.
- For the proposed scenario, the entire site was included in the model, assuming a ratio of 15 dwellings per hectare (nominal), with a typical surface split as follows:
    - Road, including verge: 25%
    - Roof (assuming a typical roof area of 215 m$^2$): 32.5%
    - Ground: 42.5%

It is understood that detailed modelling of the full precinct will be completed at the Development Application (DA) stage to optimize the water quality treatment train approach and sizing. However, at this stage, considering that no open space has been accounted for in the catchment split, it is understood that the model presented is conservative and fit for purpose.

## 3.7 Hydrologic Data Inputs

Wollondilly Shire Council's MUSIC template uses 6-minute rainfall and monthly Potential Evapotranspiration (PET) data from Rainfall Station No. 066164 – Rookwood Station. The data was based on the timeseries 01/01/1974 12:00 AM to 01/01/1984 11:54 PM. Rainfall and PET for the period are presented in Figure 3-1 below.

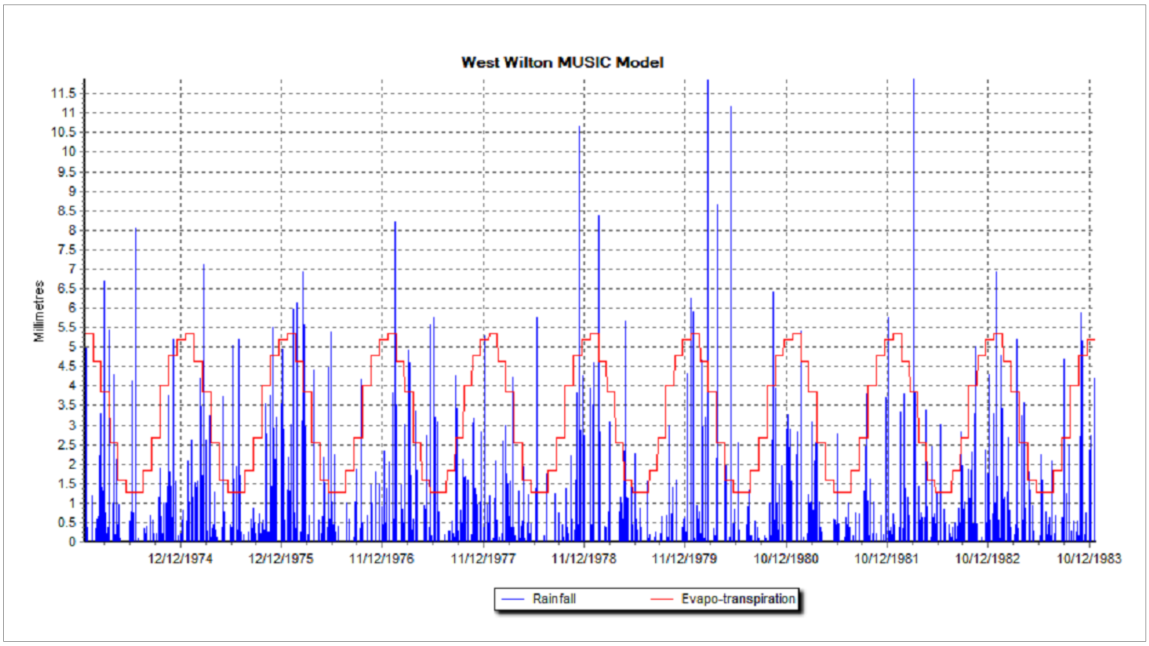


*Figure 3-1 Rainfall and PET graph from the WSC Template in MUSIC*

## 3.8 Source Node Data Inputs

Source Node parameters were adopted from WSC's MUSIC template (Wave Consulting, 2021). The following table summarises the source node inputs used within the MUSIC model.

*Table 3-3 Stormwater Quality parameters – Source Nodes*

| Land use Category | | Total Suspended Solids (mg/L $Log_{10}$) | | Total Phosphorus (mg/L $Log_{10}$) | | Total Nitrogen (mg/L $Log_{10}$) | |
|---|---|---|---|---|---|---|---|
| | | Storm Flow | Base Flow | Storm Flow | Base Flow | Storm Flow | Base Flow |
| Residential Areas | Mean | 2.15 | 1.20 | -0.60 | -0.85 | 0.30 | 0.11 |
| | Std Dev | 0.32 | 0.17 | 0.25 | 0.19 | 0.19 | 0.12 |
| Roof Areas | Mean | 1.30 | 1.10 | -0.89 | -0.82 | 0.30 | 0.32 |
| | Std Dev | 0.32 | 0.17 | 0.25 | 0.19 | 0.19 | 0.12 |
| Sealed Road Areas | Mean | 2.43 | 1.20 | -0.30 | -0.85 | 0.34 | 0.11 |
| | Std Dev | 0.32 | 0.17 | 0.25 | 0.19 | 0.19 | 0.12 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Mixed Use/ Residential Areas | Mean<br>Std Dev | 2.20<br>0.32 | 1.10<br>0.17 | -0.45<br>0.25 | -0.82<br>0.19 | 0.42<br>0.19 | 0.32<br>0.12 |

## 3.9 Catchment Details

The proposed development site has been divided into two sub-catchments as shown in Figure 3-2 based on the 1m LIDAR data and following the approach adopted in Section 5. The site was assumed to be all Mixed Residential area with three main categories for modelling. The impervious percentage of each of the land uses is detailed below in Table 3-4.

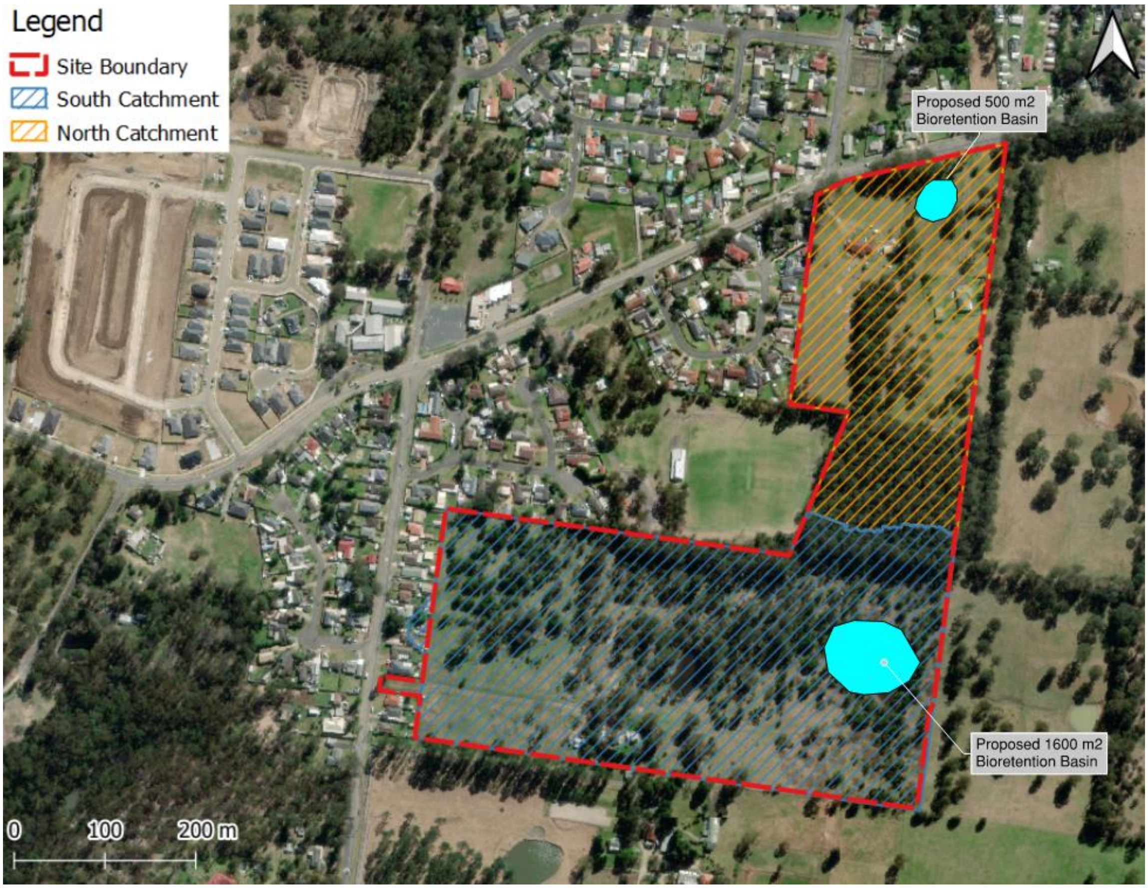


*Figure 3-2: Catchment Plan*

*Table 3-4: Catchment Split Details*

| Catchment ID | Total Area [Ha] | Road (70% Impervious) [Ha] | Roof (100% Impervious) [Ha] | Ground (30% Impervious) [Ha] |
|---|---|---|---|---|
| North | 5.97 | 1.493 | 1.940 | 2.537 |
| South | 16.73 | 4.183 | 5.437 | 7.110 |

These values match the assumptions adopted elsewhere in Wollondilly Shire Council.

This high-level analysis is considered sufficient at Planning Proposal Phase, a more detailed analysis will be undertaken for DA stage.

## 3.10 Treatment Train

The stormwater design for the development will use a combination of at-source conveyance controls, such as rainwater tanks and end-of-line features such as gross pollutant traps, bio-retention and detention basins to treat the stormwater runoff from the site. The treatment trains proposed for this development are detailed in Sections 3.10.1 through 3.10.3 inclusively.

### 3.10.1 Rainwater Tanks

Rainwater tanks are proposed for each dwelling as part of the treatment train and BASIX requirements. The WSC rainwater tank recommendations are detailed in Table 3-5 below. For the purposes of preliminary modelling, an average roof size of 215 $m^2$ was adopted using the roof catchment split as previously detailed in Table 3-4. The adopted roof size corresponds to a 8,000 L rainwater tank size.

The size and number of rainwater tanks can be further refined at DA stage, when the details of lot and roof sizing within the precinct become available.

*Table 3-5 Rainwater tanks recommended in Council WSUD Guidelines*

| Size of roof (sqm) | Minimum size of rainwater tank (litres) |
|---|---|
| 100 | 400 |
| 200 | 8,000 |
| 300 | 12,000 |
| 500 | 20,000 |
| 1,000 | 40,000 |
| 5,000 | 200,000 |

The WSC WSUD Guidelines (2021) *Section 4.4 Water demand baseline and targets,* as outlined in Table 3-6, have provided water consumption and supply figures as sourced from the Sydney Water Wave Conservation Report (2018), Sydney Water Daily Water Use Report, Smart Water Melbourne Residential Water Use Study (2013), and Green Building Council of Australia Potable Water Calculator (2015).

Accordingly, the internal daily re-use rate for the modelling of the site has been adopted as 252L/day, which is the average rainwater tank supply rate/household as outlined in Table 3-6 below. As discussed in Section 3.9, a 50% reduction in the number of tanks was adopted to account for owner non-compliance (this is shown within the MUSIC model as roofs bypassing RWT). To be conservative, the tanks were modelled as half full at the start of the storm event.

*Table 3-6 Water demand baseline and targets in Council WSUD Guidelines*

<table>
<tr><th>Development Type</th><th>Average potable water use – baseline (litres/day)</th><th>Average water efficiency saving (litres/day)</th><th>Average rainwater tank supply (litres/day)</th><th>Average WSC potable target (litres/day)</th></tr>
<tr><td>1 household</td><td>620</td><td>180</td><td>252</td><td>185</td></tr>
<tr><td>Commercial<br>(1 ha area) *</td><td>6,800</td><td colspan="3">80% less potable water use<br>1,200</td></tr>
<tr><td>Industrial<br>(1 ha area) *</td><td>7,700</td><td colspan="3">80% less potable water use<br>1,800</td></tr>
</table>

### 3.10.2 Gross Pollutant Traps

Gross Pollutant Traps (GPTs) are proposed upstream of all bioretention systems. An example proprietary GPT such as the Ocean Protect Vortechs is illustrated below in Figure 3-3 and is an example of a system that is a high-performance GPT that effectively removes fine sediment, oil and grease as well as floating and sinking debris.

For modelling purpose and aiming to ensure the correct sizing of the end of line treatment, GPT has not been included in the model.

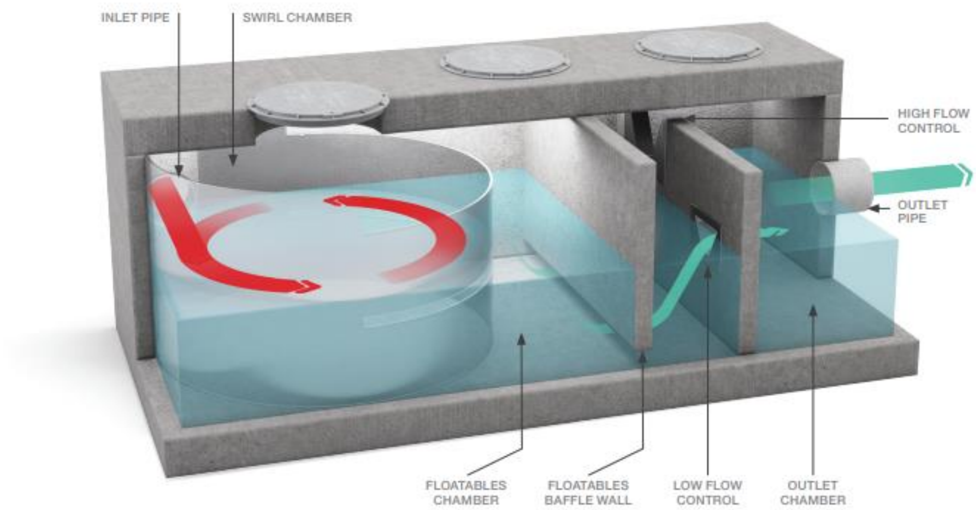


*Figure 3-3 Ocean Protect Vortech*

The performance criteria of the Ocean Protect Vortech is outlined in Table 3-7.

*Table 3-7 Gross Pollutant Trap capture efficiency table*

| Pollutant | Capture Efficiency |
|---|---|
| Gross Pollutant (>50µm) | 100% |
| Total Suspended Solids (TSS) | 80% |
| Total Phosphorous (TP) | 30% |
| Total Nitrogen (TN) | 0% |

### 3.10.3 Bioretention Basins

It is proposed to incorporate two bioretention systems as end-of-line treatment serving to each the two defined catchments.

The system will be collocated within the proposed detention basin and will be provided with a high flow bypass to convey flows in excess of the 1 in 3 Month AEP.

Figure 3-4 shows a typical section of the bioretention basin adopted for this study.

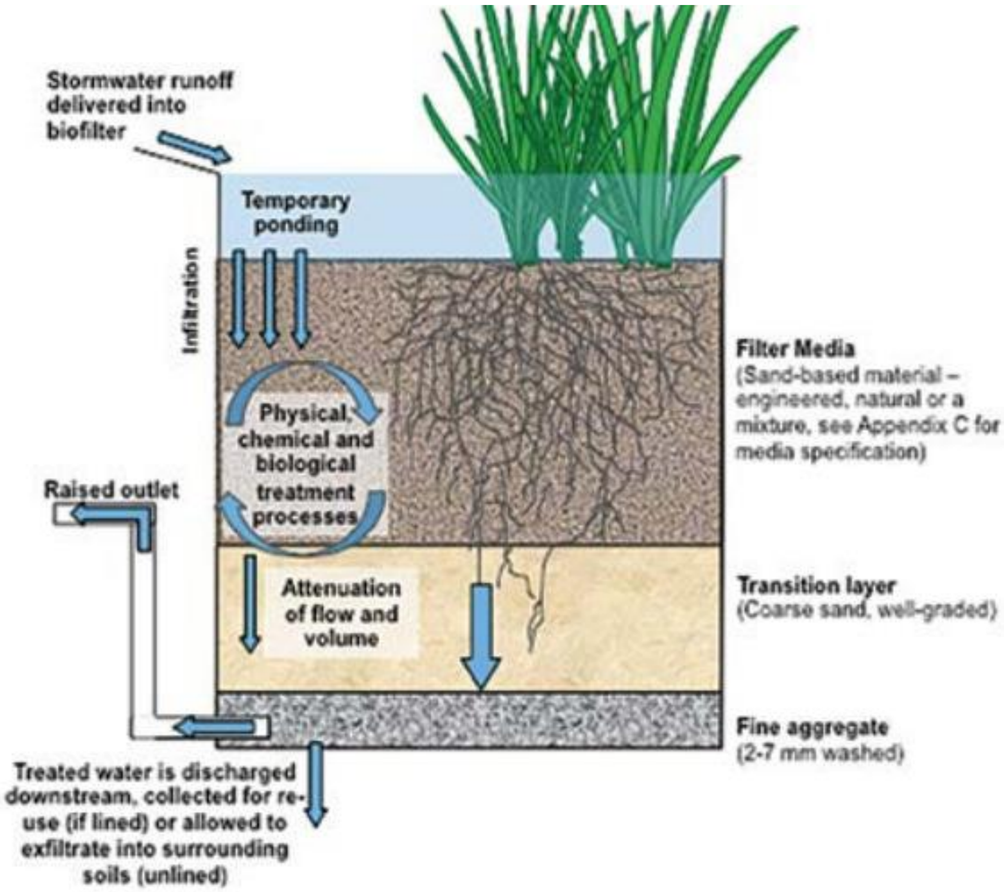


*Figure 3-4 Bioretention system schematic*

The design parameters adopted for the bioretention systems are shown below in Table 3-8.

Within the MUSIC model, the basin surface area (the surface area at the extended detention depth) was set equal to the filter media area (basin invert area). This is a conservative approach as in reality; all basins are likely to have side slopes of at least 1V:4H meaning the surface area will be greater than the filter media area. However, this simplified approach is appropriate at this stage as it allows for optimisation of bioretention design in later detailed design stages.

The proposed basins have been modelled with low flow links to the system and high flow bypass to the detention basin. The high flow bypass value has been estimated from the hydraulic modelled and set in the Music node as detailed in Table 3-8.

*Table 3-8 Bioretention Basin Parameters adopted in MUSIC*

| Parameters | WCC Requirement | Value |
|---|---|---|
| Pre-treatment / Inlet Protection | Required | GPT upstream of all bioretention (See above) |
| Extended Detention Depth | 0.2m Minimum | 0.3m |
| Filter Media Depths | Typically, 0.6m 0.3m-0.6m acceptable | 0.6m |
| Filter Media | Loamy Sand | Loamy Sand |
| Filter Media Permeability (Saturated Hydraulic Conductivity) (mm/hr) | 180-300 mm/hr | 200 |

| | | |
|---|---|---|
| TN Content (mg/kg) | | 400 |
| Orthophosphate Content (mg/kg) | | 40 |
| Exfiltration Rate (mm/hr) | | ½ of 180 mm/hr Sandy Loam |
| Impervious Base Liner | | NO |
| Overflow Pit | Overflow pit or other controlled overflow required | 1:3 Month AEP High-flow bypass North Basin:270 l/s South Basin:770 l/s |
| Submerged Zone | | 0.3 m |

### 3.10.4 Detention Basin

Two detention basins were adopted within the MUSIC model to attenuate flows. The detention basin node performs no water quality treatment function and has not been sized via MUSIC. The flow detention strategy is discussed more fully in Section 5

## 3.11 MUSIC Model

The MUSIC model layout adopted for the proposal is provided in Figure 3-5 below.

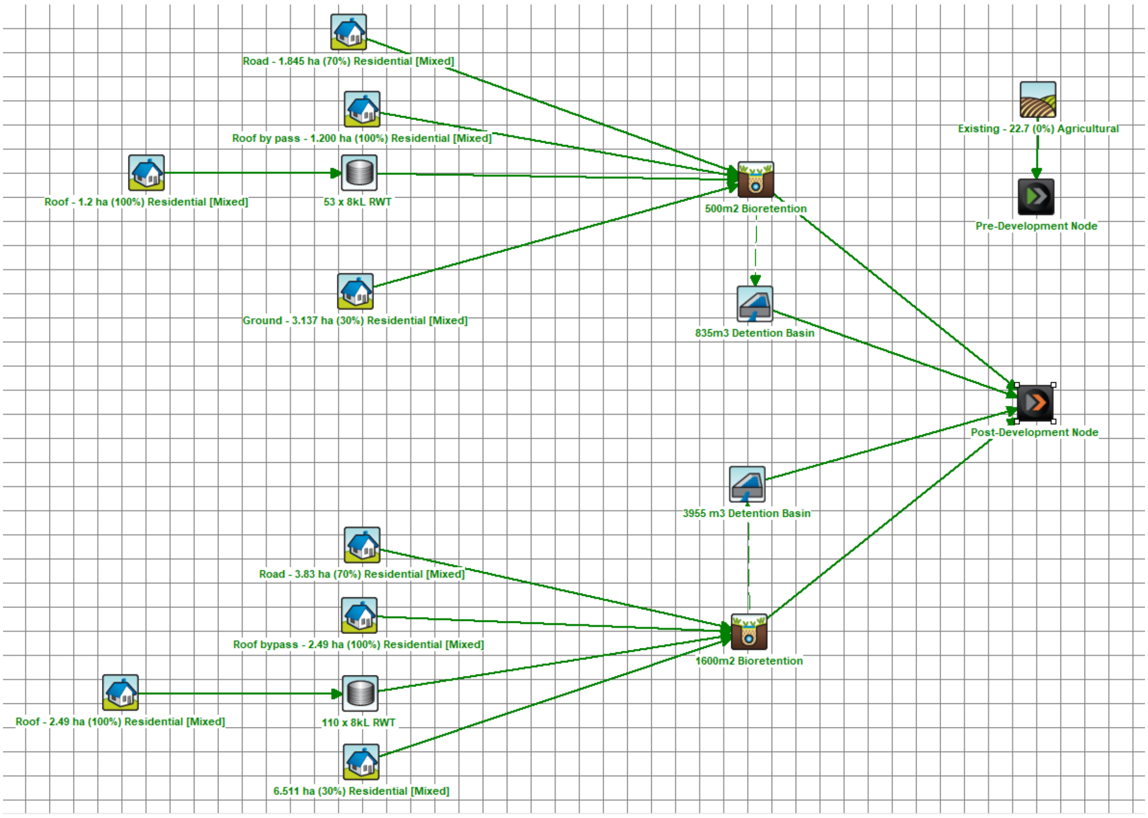


*Figure 3-5 Post development MUSIC model*

## 3.12 Music Model Results – NorBe

Wollondilly Shire Council's DCP requires that the Neutral or Beneficial Effect (NorBE) performance criteria be achieved.

This comparison was undertaken as outlined in Section 3.6 and was compared to an undeveloped agricultural node of the same size.

The results demonstrate that the mean annual loads have been reduced from the predevelopment conditions by more than 50%, satisfying the NorBE requirements across all pollutants.

The analysis of the water quality results are outlined below in Figure 3-6.

| | Sources | | Residual Load | | % Reduction | |
|---|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | Pre | Post |
| **Flow (ML/yr)** | 78.8 | 193 | 78.8 | 58.5 | 0 | 69.7 |
| **Total Suspended Solids (kg/yr)** | 13500 | 38100 | 13500 | 3520 | 0 | 90.8 |
| **Total Phosphorus (kg/yr)** | 38.9 | 78.6 | 38.9 | 12.3 | 0 | 84.4 |
| **Total Nitrogen (kg/yr)** | 262 | 553 | 262 | 148 | 0 | 73.2 |
| **Gross Pollutants (kg/yr)** | 0 | 4480 | 0 | 0 | 0 | 100 |

*Figure 3-6 MUSIC model results*

The preliminary assessment of Water Quality measures undertaken for the site shows that the treatment train of distributed rainwater tanks in combination with end-of-line bioretention and detention basins will be sufficient to satisfy the water quality targets set by WSC Guidelines.

The details of the water quality treatment train is subject to further detailed design and modelling at DA stage. It is expected that further design iterations would result in the size of the water treatment being smaller than the nominated areas, owing to the result exceeding that of the Stormwater Management Objectives, as well as the aforementioned characteristics of the catchment.

# 4. Flood Assessment

The following provides a definition of the flood characteristics around the site for the existing and preliminary post development scenario for the 1% Annual Exceedance Probability (AEP) rainfall event. The analysis utilizes hydrologic and hydraulic modelling to define the flooding characteristics of the overland flow paths and the resulting flood behaviours including flood depth, velocities and hazard.

## 4.1 Existing Flood Information

Oakdale Precinct lies within the catchment of the draft Wollondilly Shire Council Flood Study – Broad Scale Assessment (WSC-FS) that was undertaken by Advisian in 2021 on behalf of Wollondilly Shire Council. The flood study includes portions of the Georges River, Wollondilly River, and Nepean River catchments. The proposed development site lies within the Nepean River catchment, and the flood study will be used to inform the flood behaviour at the site.

The Flood Study utilised a WBNM hydrologic engine, as well as the hydraulic software, TUFLOW for the 1D/2D hydraulic analysis. The catchment area covered by the modelling was approximately 800km$^2$, and included the towns and villages of Appin, Silverdale, The Oaks, Oakdale, Douglas Park, Wilton, Tahmoor, and Thirlmere. The Broad Scale Assessment utilised ARR2019 rainfall patterns and incorporated a 6m grid cell size. According to this flood study and as detailed by council in the pre lodgement the application site is subject within flood affected area as shown in Figure 4-1. Further assessment of the flood extend indicated that the source of flooding is the local catchment located upstream of the development site and that the site was not subject to regional flooding.

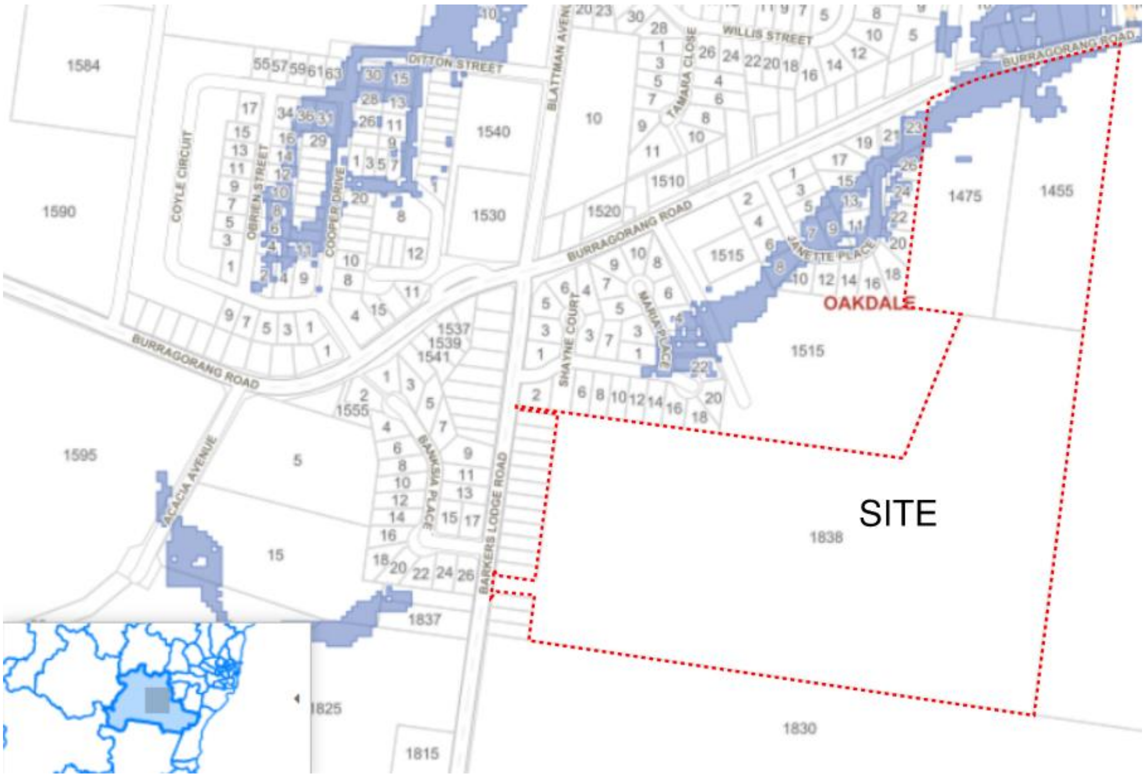


*Figure 4-1: Existing Flood Extent. Source: WSC GIS*

In correspondence with Colliers Engineering and Design, WSC Flood Engineers indicated that the existing model was too coarse for being used for a development impact assessment and that a local scale model was required to be built. Following a flood application form Advisian provided the following information that was used to build the local model:

- Local Stormwater Infrastructure
- Materia (Roughness) Map
- Catchment Map
- PMF Flood Extent
- 1% & 10% AEP Flood Extent

## 4.2 Hydrologic Modelling

Following the methodology used in the WSC-FS, hydrologic modelling of the catchment has been carried out using WBNM software (2019 version) developed jointly by the University of Wollongong, Rienco Consulting and Balance R&D. Australian Rainfall and Runoff 2019 (ARR2019) methodology was used for this assessment. The WBNM model was run using the Storm Injector software. The parameters implemented in the model are consistent with the ones outlined in WSC-FS.

### 4.2.1 Catchments

The catchments were delineated using the information provided by council in conjunction with the results of a topographic analysis based on Digital Elevation Model (DEM) of Australia derived from LiDAR 1 Metre Grid. The sub catchment including portions of the site, have been split into further sub catchment using the site boundary. The resulting catchment layout is shown in Figure 4-2.

The entire model has been represented by 26 sub-catchments. Fraction impervious has been calculated as mean value for each sub catchment using the WSC-FS information as shown in Table 4-2. A fraction impervious of 70% has been adopted for the post development scenario. A summary of the catchment areas and impervious values are provided in TABLE!!!@#.

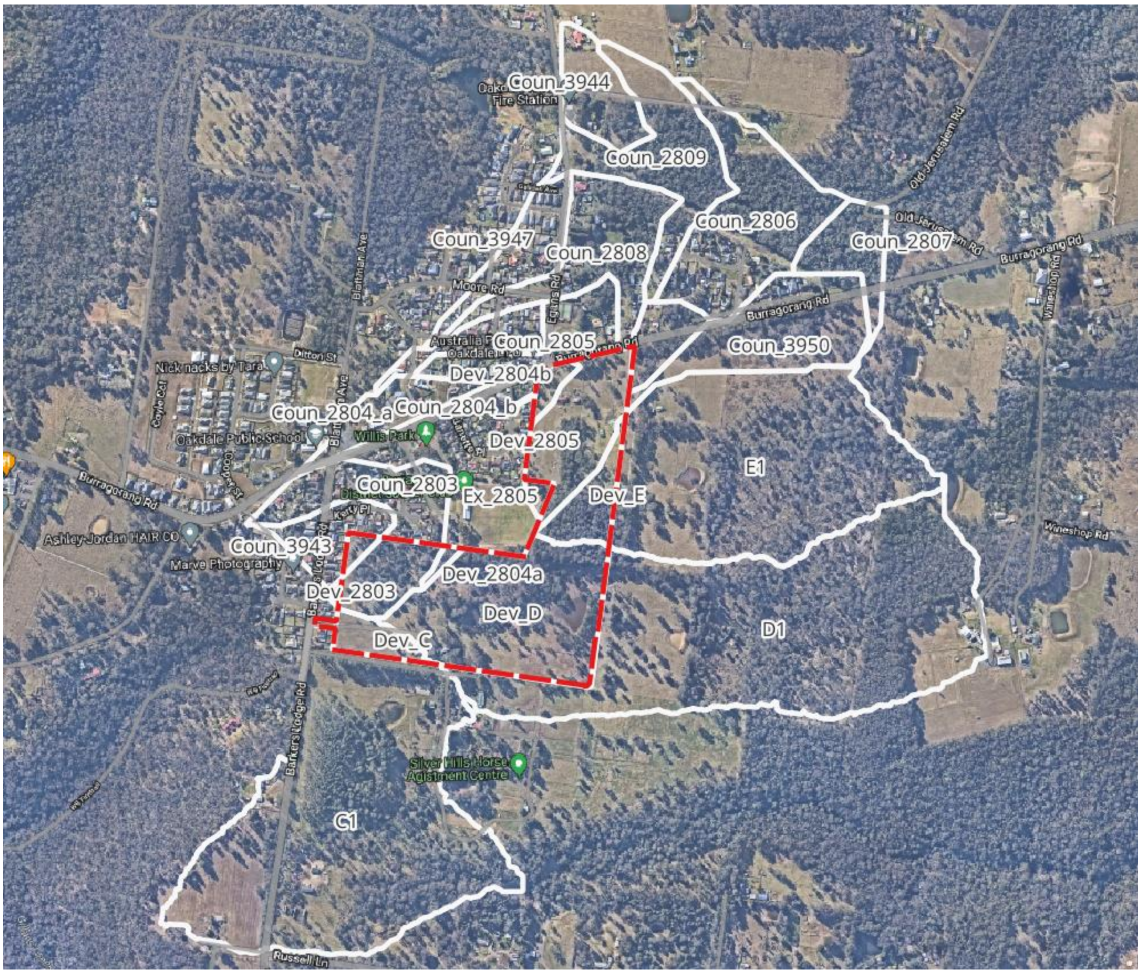


*Figure 4-2: Existing Catchment Plan*

A summary of the catchment areas and impervious values for the catchments relating to the site are provided in Table 4-1.

*Table 4-1: TUFLOW model Sub-Catchment Summary*

| Subarea Name | D/S Subarea | Area [ha] | Existing Imp Fraction | Proposed Imp Fraction |
|---|---|---|---|---|
| Dev_C | C1 | 1.326 | 10.0 | 70.0 |
| C1 | Point_1 | 29.851 | 5.0 | - |
| Coun_3947 | Coun_2808 | 3.212 | 61.1 | - |
| Dev_2804a | Coun_2805 | 0.233 | 49.0 | 70.0 |
| Coun_3943 | Coun_2803 | 2.48 | 55.5 | - |
| Dev_3943 | Coun_2803 | 0.352 | 55.5 | 70.0 |
| Coun_2803 | Coun_2804 | 4.44 | 36.7 | - |
| Dev_2803 | Coun_2804 | 2.57 | 36.7 | 70.0 |
| Coun_2804 | Coun_2805 | 9.05 | 49.0 | - |
| Coun_3948 | Coun_2805 | 2.16 | 60.8 | - |
| Dev_2804b | Coun_2805 | 0.59 | 49.0 | 70.0 |
| Coun_2805 | Coun_2808 | 3.77 | 28.5 | - |
| Ex_2805 | Dev_2805 | 1.98 | 28.5 | - |
| Dev_2805 | Coun_2808 | 4.73 | 28.5 | 70.0 |
| Coun_2808 | Coun_2809 | 6.42 | 44.9 | - |
| Coun_3944 | Coun_2809 | 3.16 | 6.8 | - |
| Coun_2809 | Coun_2806 | 7.14 | 12.2 | - |
| Coun_3951 | Coun_2806 | 1.86 | 41.8 | - |
| Coun_2806 | Point_3 | 8.98 | 25.6 | - |
| Dev_E | E1 | 2.01 | 5.0 | - |
| E1 | Point_2 | 22.41 | 10.0 | - |
| Dev_D | D1 | 10.85 | 10.0 | 70.0 |
| D1 | Point_2 | 31.50 | 5.0 | - |
| Coun_3950 | Coun_2807 | 6.82 | 20.9 | - |
| Coun_2807 | Point_3 | 2.85 | 7.3 | - |
| Point_1 | Out | 0.01 | 0.0 | - |
| Point_2 | Out | 0.01 | 0.0 | - |
| Point_3 | Out | 0.01 | 0.0 | - |
| Out | SINK | 0.01 | 0.0 | - |
| Total | | 170.767 | | |

### 4.2.2 Rainfall Depths and Losses

Rainfall depths were obtained from the Bureau of Meteorology (BOM) Intensity-Frequency-Duration (IFD) website via Storm Injector. Rainfall losses were applied as variables in accordance with Table 5-2 of the WSC-FS.

Three durations (60, 180, 360 minutes) with 10 temporal patterns each were simulated. For the purpose of this preliminary assessment, only the 1% Annual Exceedance Probability (AEP) rainfall event was considered.

## 4.3 Hydraulic Model Setup

Hydraulic modelling has been carried out using TUFLOW software developed by BMT WBM. TUFLOW is a computational engine that provides one-dimensional (1D) and two-dimensional (2D) solutions for the free-surface flow equations to simulate flood and tidal wave propagation. The Heavily Parallelised Compute (HPC) computational method has been applied using 2020-10-AA version of TUFLOW. Modelling assumptions and outcomes are described below.

### 4.3.1 Topography

The existing scenario TUFLOW model topography is based upon a combination of 2011 LiDAR information and detailed site survey.

The catchment has been represented using a 2m hydraulic grid size.

### 4.3.2 Inflow

Inflows have been incorporated into the model setup using inflow polygons (2d_sa) to read in the inflow hydrographs from the WBNM hydrology model as TS1 files.

### 4.3.3 Material - Roughness

The material map has been created using the information provided by WSC and the addition of polygons in the missing areas in accordance with WSC-FS, the resulting map is shown in Figure 4-3. Associated roughness values were extracted from WSC-FS and are presented in Table 4-2.

*Table 4-2: Model Roughness Values*

| Adopted Material Types | Material Type | Effective Percentage Impervious | Effective Percentage Impervious |
|---|---|---|---|
| 101 | Waterways | 1 | 100 |
| 201 | Low Density Residential Lots | 0.6 | 60 |
| 202 | Medium Density Residential Lots | 0.7 | 70 |
| 204 | Large Lot Residential | 0.4 | 40 |
| 205 | Industrial/Commercial | 0.9 | 90 |
| 301 | Open Space | 0.1 | 10 |
| 302 | Medium Vegetation | 0.05 | 5 |
| 303 | Heavy Vegetation/Forest | 0.02 | 2 |
| 401 | Roads (Including Verge) | 0.7 | 70 |
| 402 | Railway Corridor | 0.5 | 50 |

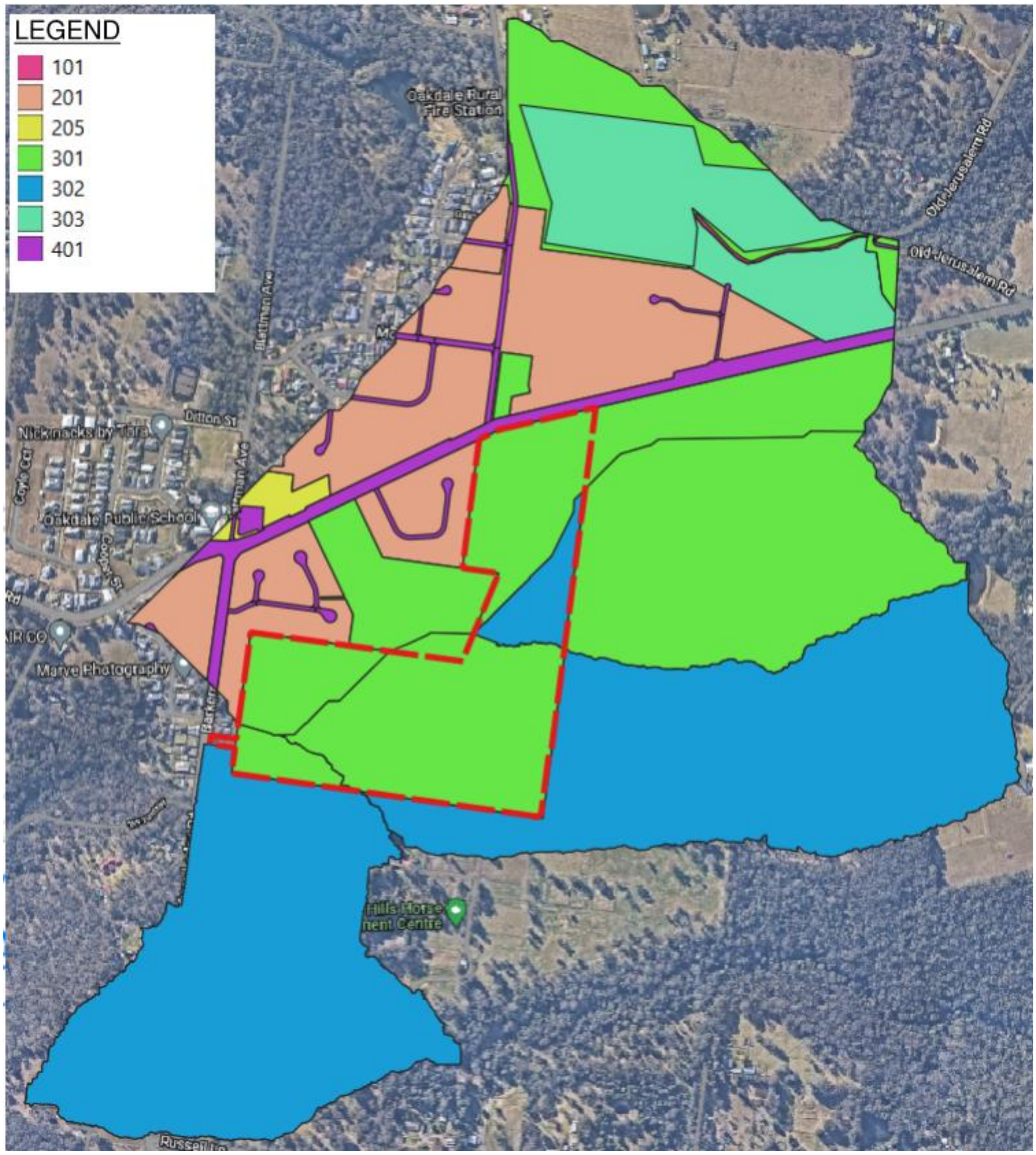


*Figure 4-3: TUFLOW Material Model Layout for Existing Scenario E02*

#### 4.3.3.1 Boundary

The TUFLOW model has been extended past the boundary of the site to capture the effect of the flows leaving the site on downstream properties. Three water level vs. flow (HQ) boundary have been established considering the average slope of the streamline up to that point. The parameter b has been estimated for each HQ boundaries with values between 0.03 and 0.05 as shown in Figure 4-4.

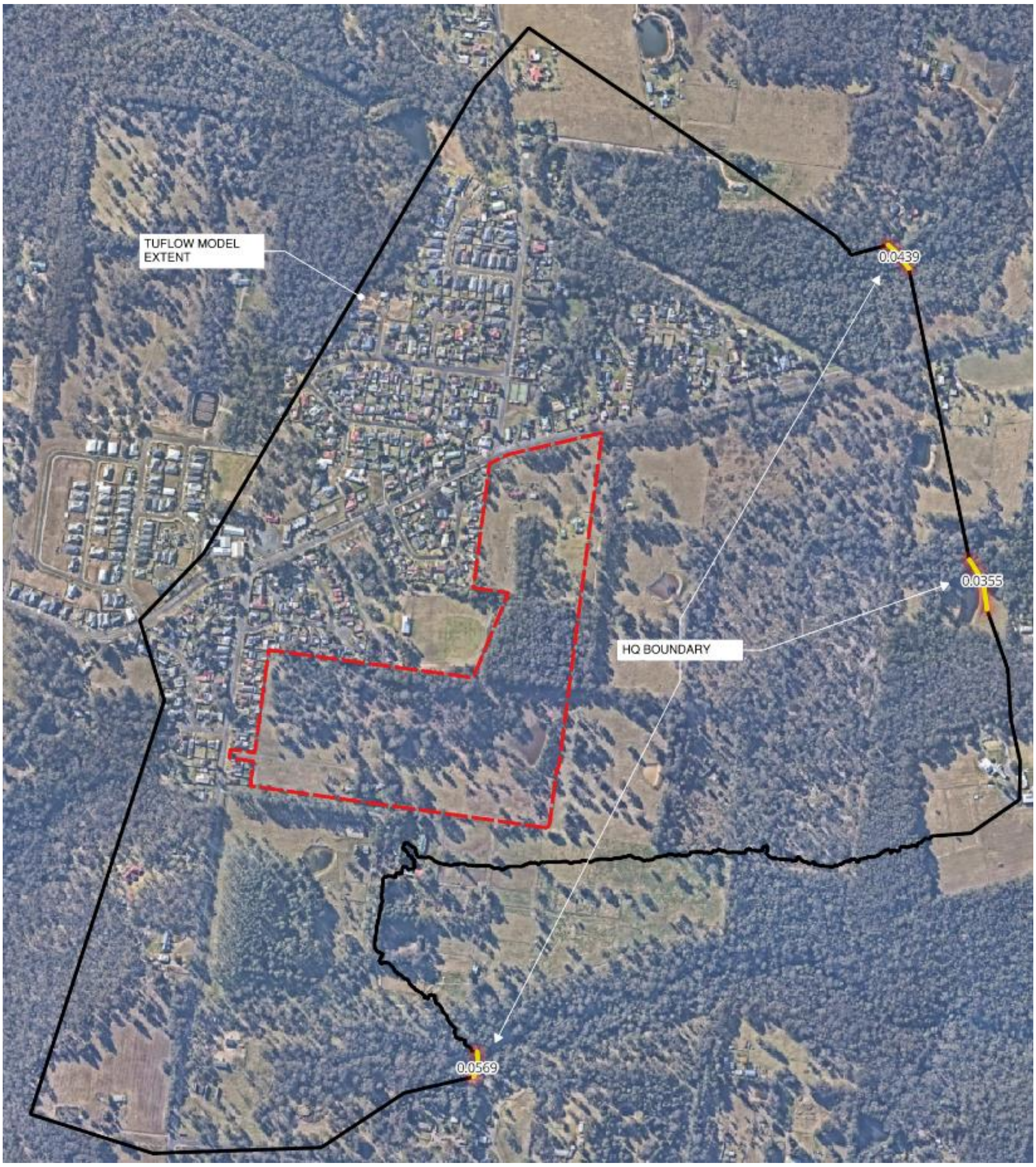


*Figure 4-4: TUFLOW Model extent and Boundary Conditions.*

#### 4.3.3.2 Stormwater Network

Stormwater infrastructure has been included in the model following the indicative sketch provided by Advisian. Refer Appendix C.1.

## 4.4 Modelling Scenarios

A summary of the modelling scenarios assessed as part of this investigation are outlined below:

### 4.4.1 Existing (E02)

The existing scenario has been prepared to evaluate the current conditions of the site and demonstrate compliance with the results from WSC-FS. The model has been run with no modification to what was described in the previous sections. Results from the Existing Scenario have been included in Appendix II.

WSC-FS 1% AEP flood extent has been compared with the results obtained from Colliers TUFLOW model and is presented in Figure 4-5. As can be seen, E02 model results reproduce with good grade of accuracy the flood extent provided by WSC in the main overland flow path to the north. It is noted that Colliers model show additional wet cell areas which are results of the refinement of the catchments and grid cell size. The additional overland flow path that appears to the South and East of the development, are result of the catchment included in E02 that were not present in WSC-FS model. These were added to consider the overall impact of the development in the surrounded areas.

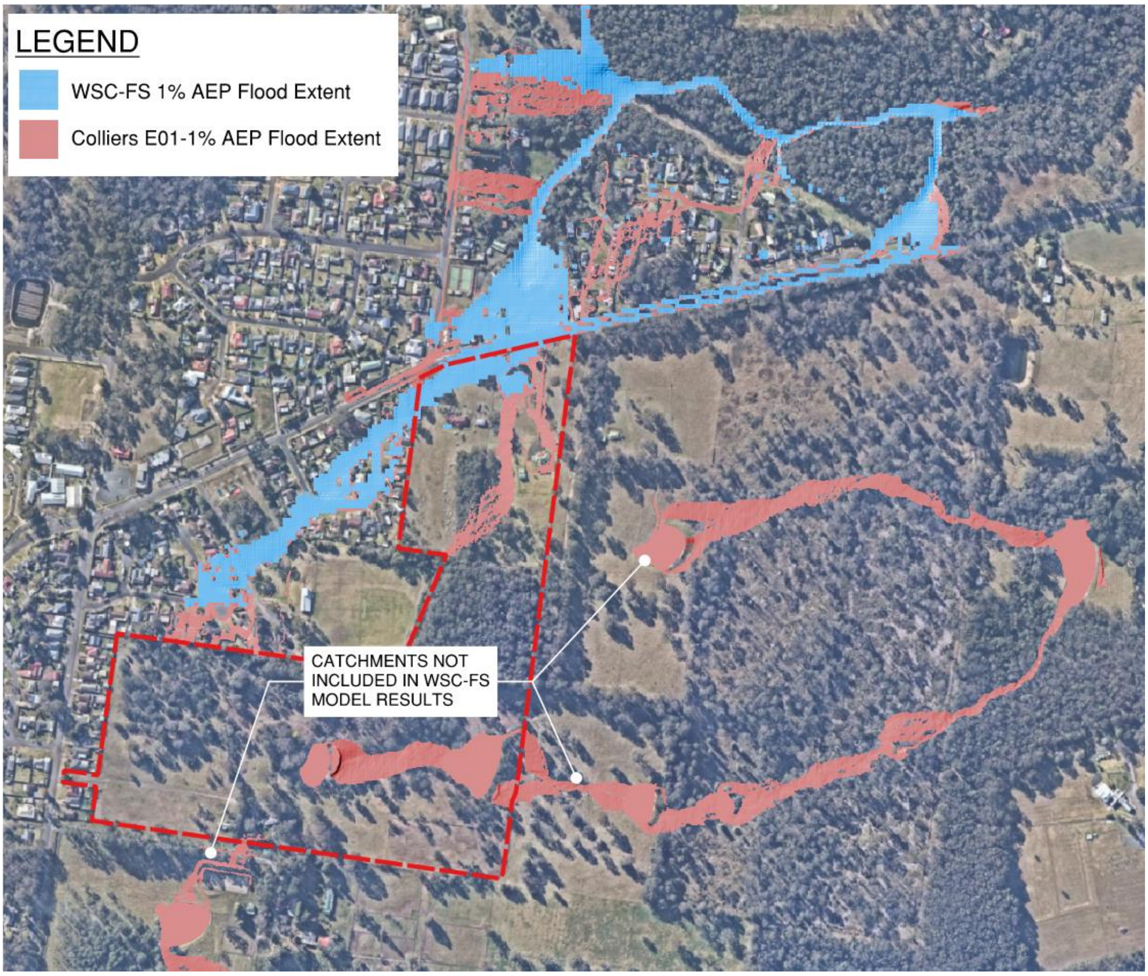


*Figure 4-5: TUFLOW Flood extent comparison*

### 4.4.2 Proposed Scenario (P01)

This scenario has been developed to conduct a preliminary assessment of the impacts resulting from future modifications on the site. The model is constructed from E02 and incorporates the following modifications:

- Inclusion of preliminary design topography

- Replacement of catchment polygons within the site with mitigated flows applied at the selected discharge point, as described in Section 5 and Tables 5.5 and 5.8
- Update of material files (roughness) to reflect the proposed changes for the site.

## 4.5 TUFLOW Model Results

The assessment was conducted in accordance with WSC-FS, considering three storm durations (60, 180, and 360 minutes) with 10 different patterns each to define the critical storm. The critical storm, defined as the maximum of the median for each duration, was selected to represent flood behaviour in the simulated scenarios.

The results of the hydraulic assessment are presented as a series of flood maps illustrating flooding characteristics, including flood depth, velocities, and hazards, for both existing and proposed scenarios. Additionally, a flood afflux map was prepared to identify the impacts of proposed changes in site hydrology and terrain modifications. Refer to Appendix D.1 for Flood Mapping.

Analysis of the afflux map reveals a reduction in flows at the south and north boundaries of the site portion with access through Barkers Lodge Road, primarily due to the relocation of catchments to the southern basin. Downstream of the southern basin outlet, minor afflux of up to 60mm is visible. It is noted that the analysis prepared as part of Section 5 indicated that the proposed basin can accommodate the flows and reduce peak flows to predevelopment levels. Further investigation of this afflux indicates that the expected peak flows of the local catchment for both the existing and proposed scenarios are for durations below 60 minutes, which haven't been captured in the flood modelling assessed events. Additionally, it is expected that this minor afflux will disappear once a more detailed analysis takes place at the DA stage.

Along the frontage of the site with access through Burrogorrang Road, a redistribution of flows is observed, driven by the formalization of site access and diversion of incoming flows from the western boundary. Further refinement of this already flood-affected area will be necessary at the DA stage once the interface within the private and public domain is defined.

Based on these observations, it can be concluded that flooding does not present an impediment to the approval of the rezoning proposal.

# 5. Water Quantity Management Strategy

The objective of this component of the study is to investigate the potential impact that the proposed development will have on peak flows discharging downstream of the site and any associated impacts of the proposed layout.

## 5.1 Hydrological modelling

Modelling has been carried out using WBNM for the 63.2%, 50%, 20%, 10%, 5%, 2% and 1% Annual Exceedance Probability (AEP) storm events. The following scenarios have been investigated:

- Current C01
- Mitigated M01

### 5.1.1 Current Scenario (C01)

Following the catchment delineation discussed in section 4.2.1, C01 sub-catchments have been delimited to the extent of the site boundary to isolate the flow contributions from the site to the proposed point of discharge (outlets) as shown in Figure 5-1 with selected sub-catchment parameters in Table 5-1.

*Table 5-1: C01 Sub-catchment Parameters*

| Outlet | Sub-catchment | Area (ha) | % Imp |
|---|---|---|---|
| North | Dev_2805 | 4.73 | 10 |
| | Dev_2804b | 0.59 | 10 |
| South | Dev_D | 10.85 | 0 |

WBNM was simulated for events from 63.2% to 1% AEP and for durations of 15 minutes to 3 hours. The peak discharge values for the critical storm found from the modelling are summarised in Table 5-2.

*Table 5-2: Existing Catchment Peak Flows [$m^3/s$]*

| Outlet | Design Event [% AEP] | | | | | | |
|---|---|---|---|---|---|---|---|
| | 63.2 | 50 | 20 | 10 | 5 | 2 | 1 |
| North | 0.32 | 0.38 | 0.62 | 0.83 | 1.04 | 1.37 | 1.63 |
| South | 0.53 | 0.63 | 1.01 | 1.33 | 1.68 | 2.22 | 2.65 |

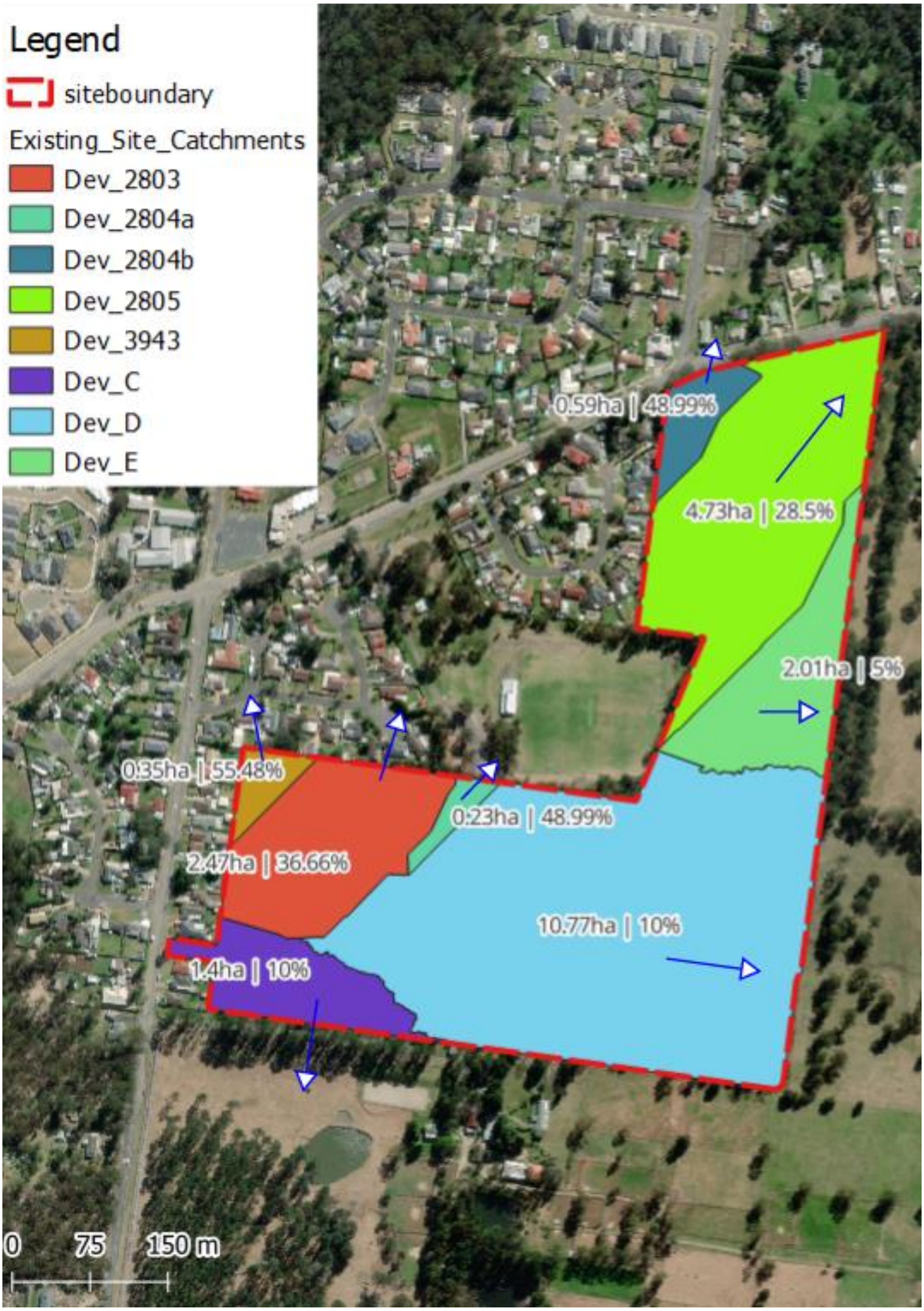


*Figure 5-1: C01 Catchment Plan*

### 5.1.2 Mitigated Scenario (M01)

For M01, the entire site has been grouped into two catchments based on the intended point of discharge. M01 catchment plan is depicted in Figure 5-2 with sub-catchment parameters in Table 5-3.

*Table 5-3: M01 Sub-catchment Parameters*

| Outlet | Sub-catchment | Area (ha) | % Imp |
|---|---|---|---|
| North | Dev_2805 | 5.84 | 70 |
| South | Dev_D | 15.3 | 70 |

Two detention basins have been proposed to attenuate peak flows discharging from the site to achieve non-worsening at the outlets of the site overall and meet legal point of discharge requirements. For the purpose of the modelling the following assumptions have been made:

- Internal stormwater network and grading will be designed such as all runoff from the site up to the 1% AEP will be directed to the detention basins.
- No external catchment will be directed to the basins.
- Noting that Dev_E has been reduced in size with no changes in imperviousness, it has not been considered in the analysis.


*Figure 5-2: M01 Catchment Plan*

#### 5.1.2.1 North Basin

The details of the northern detention basin are summarised in Table 5-4.

*Table 5-4: Storage and Outlet Details of Detention Basin - North*

| Detention Basin - North | |
|---|---|
| **Stage (m RL)** | **Storage (m3)** |
| 0.00 | 0 |
| 0.2 | 157 |
| 0.4 | 327 |
| 0.6 | 512 |
| 0.8 | 712 |
| 1 | 927 |
| 1.2 | 1158 |
| 1.4 | 1406 |
| 2 | 1671 |
| **Parameter** | **Specification** |
| Pipe Outlet/ Orifice | 1 x 525 mm diameter at 0 m<br>1 x 525 mm diameter at 0.6 m |
| Weir Outlet | 5 m wide at 1.25 m |

A comparison of the critical duration peak flows discharged from the outlet, between the current and mitigated scenario, are presented in Table 5-5. The results show a minor decrease in peak flows for the critical duration across all modelled events is predicted and that the principle of 'no-worsening' is upheld.

*Table 5-5: Comparison of Peak Discharge [$m^3/s$] from the North outlet*

| Scenario | Design Event [% AEP] | | | | | | |
|---|---|---|---|---|---|---|---|
| | 63.2 | 50 | 20 | 10 | 5 | 2 | 1 |
| Current | 0.32 | 0.38 | 0.62 | 0.83 | 1.04 | 1.37 | 1.63 |
| Mitigated | 0.31 | 0.37 | 0.59 | 0.77 | 0.96 | 1.21 | 1.56 |
| Difference | -0.01 | -0.01 | -0.04 | -0.06 | -0.09 | -0.16 | -0.06 |
| Difference [%] | -1.71 | -3.62 | -5.66 | -6.97 | -8.20 | -11.57 | -3.84 |

A summary of the resulting depths predicted in the basin are shown in Table 5-6.

*Table 5-6: Detention Basin Results*

| Parameter | Value |
|---|---|
| 1 % AEP Depth | 1.37 m |
| 1 % AEP Detention Volume | 1312 m3 |

### 5.1.2.2 South Basin

The details of the southern detention basin are summarised in Table 5-7.

*Table 5-7: Storage and Outlet Details of Detention Basin -South*

| Detention Basin - South | |
|---|---|
| **Stage (m RL)** | **Storage (m3)** |
| 0.00 | 0 |
| 0.2 | 627 |
| 0.4 | 1309 |
| 0.6 | 2048 |
| 0.8 | 2847 |
| 1 | 3708 |
| 1.2 | 4633 |
| 1.4 | 5625 |
| 2 | 6686 |
| **Parameter** | **Specification** |
| Pipe Outlet/ Orifice | 1 x 600 mm diameter at 0 m |
| Weir Outlet | 5 m wide at 1.0 m |

A comparison of the critical duration peak flows discharged from the outlet, between the current and mitigated scenarios, are presented in Table 5-8. The results show a minor decrease in peak flows for the critical duration across all modelled events is predicted and that the principle of 'no-worsening' is upheld.

*Table 5-8: Comparison of Peak Discharge [$m^3/s$] from the South outlet*

| Scenario | Design Event [% AEP] | | | | | | |
|---|---|---|---|---|---|---|---|
| | 63.2 | 50 | 20 | 10 | 5 | 2 | 1 |
| Current | 0.53 | 0.63 | 1.01 | 1.33 | 1.68 | 2.22 | 2.65 |
| Mitigated | 0.38 | 0.43 | 0.57 | 0.83 | 1.23 | 1.88 | 2.45 |
| Difference | -0.14 | -0.20 | -0.44 | -0.50 | -0.44 | -0.34 | -0.20 |
| Difference [%] | -27.27 | -31.86 | -43.61 | -37.73 | -26.44 | -15.46 | -7.63 |

A summary of the resulting depths predicted in the basin are shown in Table 5-9.

*Table 5-9: Detention Basin Parameters*

| Parameter | Value |
|---|---|
| 1 % AEP Depth | 1.35 m |
| 1 % AEP Detention Volume | 5355 m3 |

## 5.2 Hydrological modelling Results

As can be seen from Table 5-5 and Table 5-8, the assessment indicates that the proposed basins will effectively mitigate impacts of the proposed change in impervious fraction resulting from the rezoning proposal.

# 6. Conclusion and Recommendations

The Water Cycle Management Strategy Report presented supports the Oakdale Rezoning Proposal based on high-level assessments conducted for Water Quality, Water Quantity, and Flooding. This initial analysis provided preliminary sizing and locations of proposed water quality treatment train features. The water quality management strategy was developed and modelled in MUSIC, confirming that a combination of rainwater tanks, gross pollutant traps, and bioretention basins meet water quality targets per NorBE requirements for all pollutants.

Flood modelling, utilising industry-standard software TUFLOW, describes flood behaviour, with accompanying flood maps provided in the appendices. Results indicate an overall improvement in local drainage is expected as a result of catchment redistributions and formalisation of detention basins as part of the proposed Zoning Plan. Minor impacts are anticipated in flood behaviour within the site, easily mitigated through incorporation of the internal road plan and an underground drainage network at a later stage.

Although PMF flood modelling was not undertaken for the Planning Proposal, it will be addressed during the DA stage to further enhance Emergency Management Planning. On-site detention basins, sized based on high-level assessments using WBNM, are proposed at the southeast and north end of the site. The assessment indicates that the proposed basins will effectively mitigate the impacts of the proposed change in impervious fraction resulting from the rezoning proposal.

Future analysis will include catchment-specific modelling of water quality and quantity requirements for the site, along with refined flood modelling incorporating stormwater drainage networks, culvert and bridge structures, and detailed feature and level surveys as necessary.

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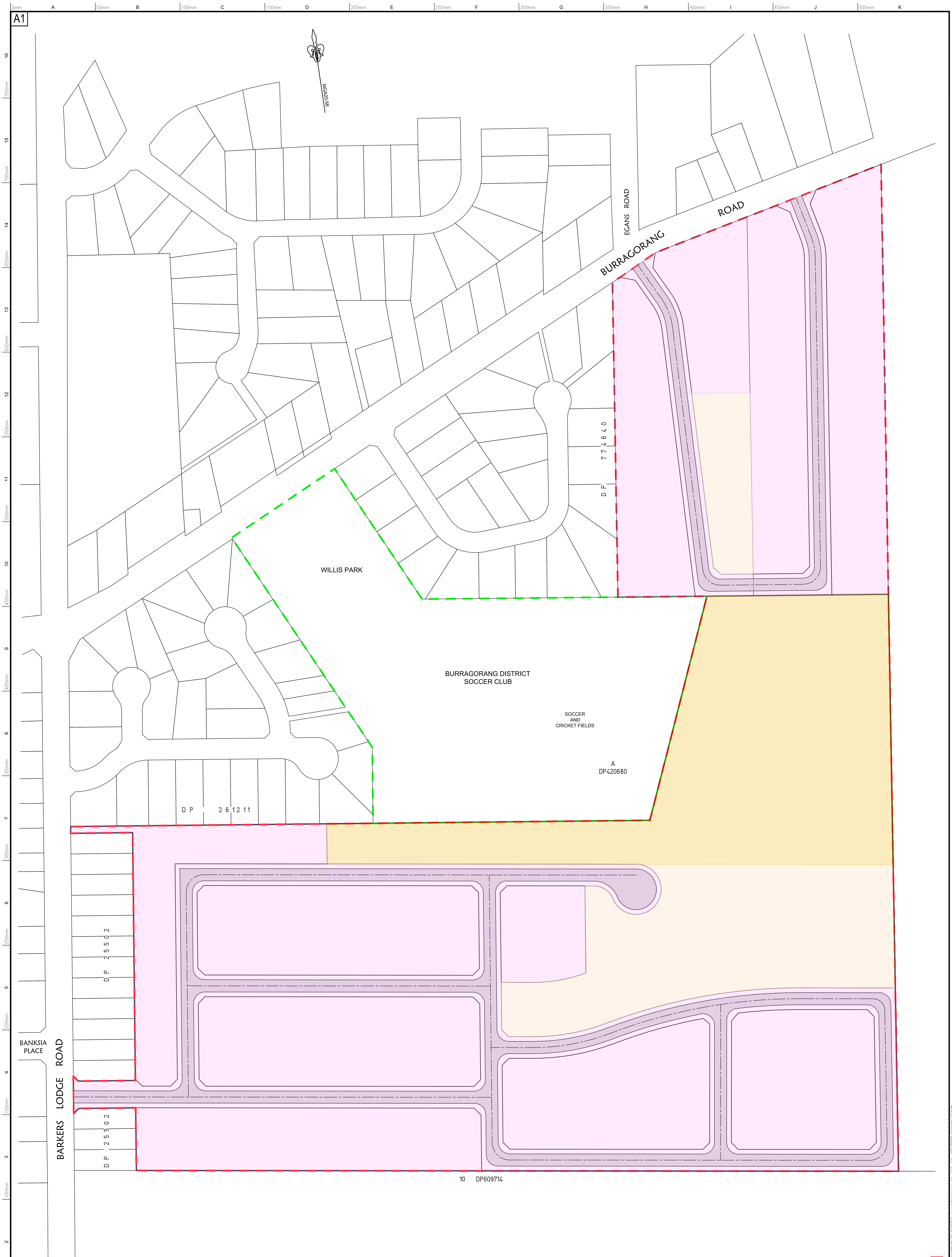
# Appendix

## A.1 Zoning Plan




CONCEPT ENVIRONMENTAL CONSERVATION (C2) ZONING
CONCEPT ENVIRONMENTAL MANAGEMENT (C3) ZONING
CONCEPT RESIDENTIAL (R2) ZONING
CADASTRAL BOUNDARY
EXISTING OPEN SPACE

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SKETCH

| AMEND. | DATE | CALC | DRAFTED | P.M. | CHECKED | APPROVED |
|---|---|---|---|---|---|---|
| 00 | 23-02-2024 | N.P. | G.W.E. | A.H. | | |

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Project:
SKETCH OVER
LOTS 1, 2 & 6 DP734561
BARKERS LODGE ROAD AND BURRAGORANG ROAD,
OAKDALE

Principal:
Scale 1:1250 | Date 11/10/2023 | Council Ref.
Datum AHD | L.G.A. WOLLONDILLY SHIRE COUNCIL
Calc's A.H. | Drawn. G.W.E. | Proj.Man. A.H. | Client Ref:

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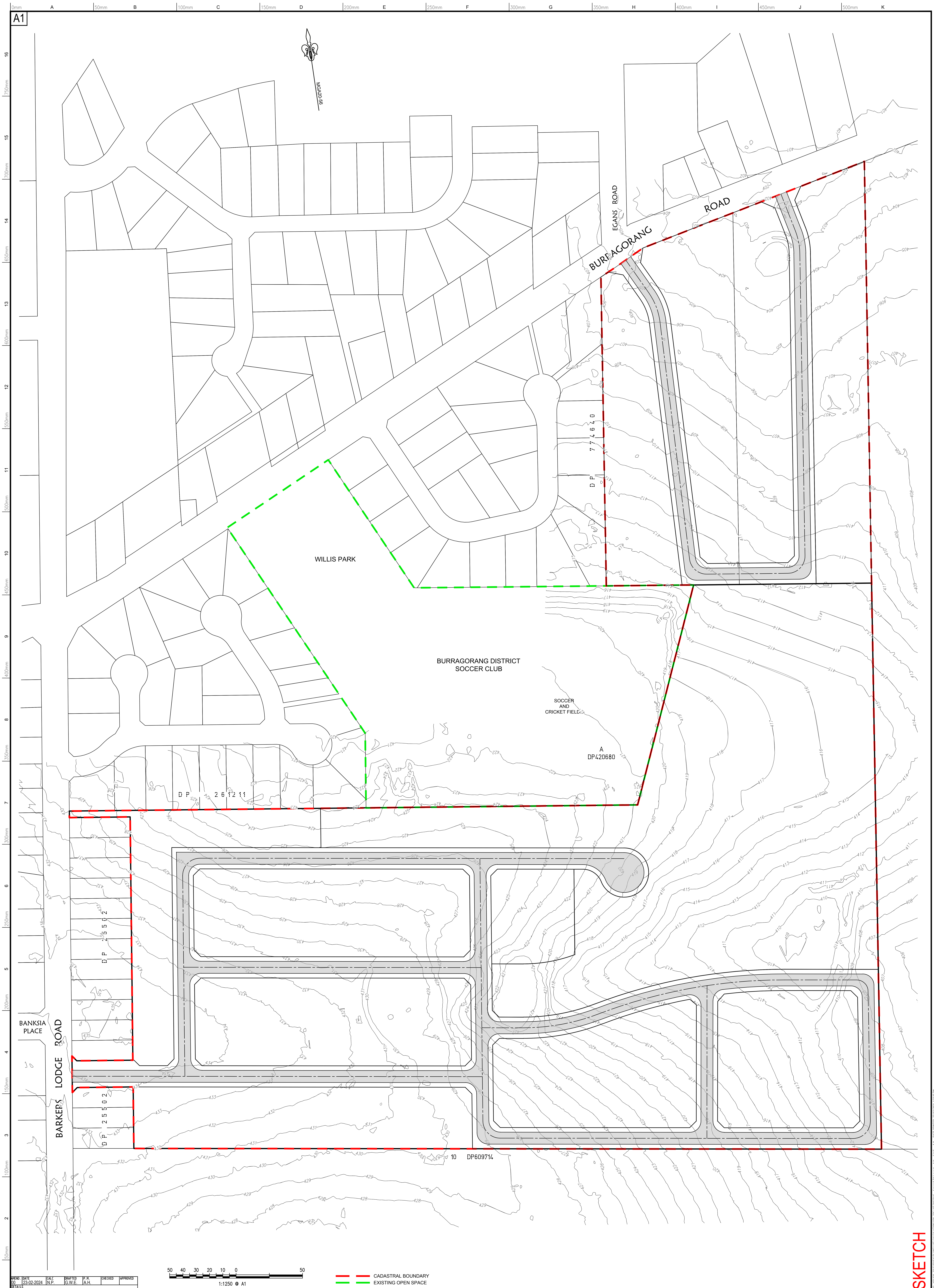
030-22G L07 [00]
- Concept Rd and Zoning

# Appendix

## B.1 Road Layout

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SKETCH OVER
LOTS 1, 2 & 6 DP734561
BARKERS LODGE ROAD AND BURRAGORANG ROAD,
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Principal:

| | | | |
|---|---|---|---|
| Scale 1:1250 | Date 11/10/2023 | Council Ref. | |
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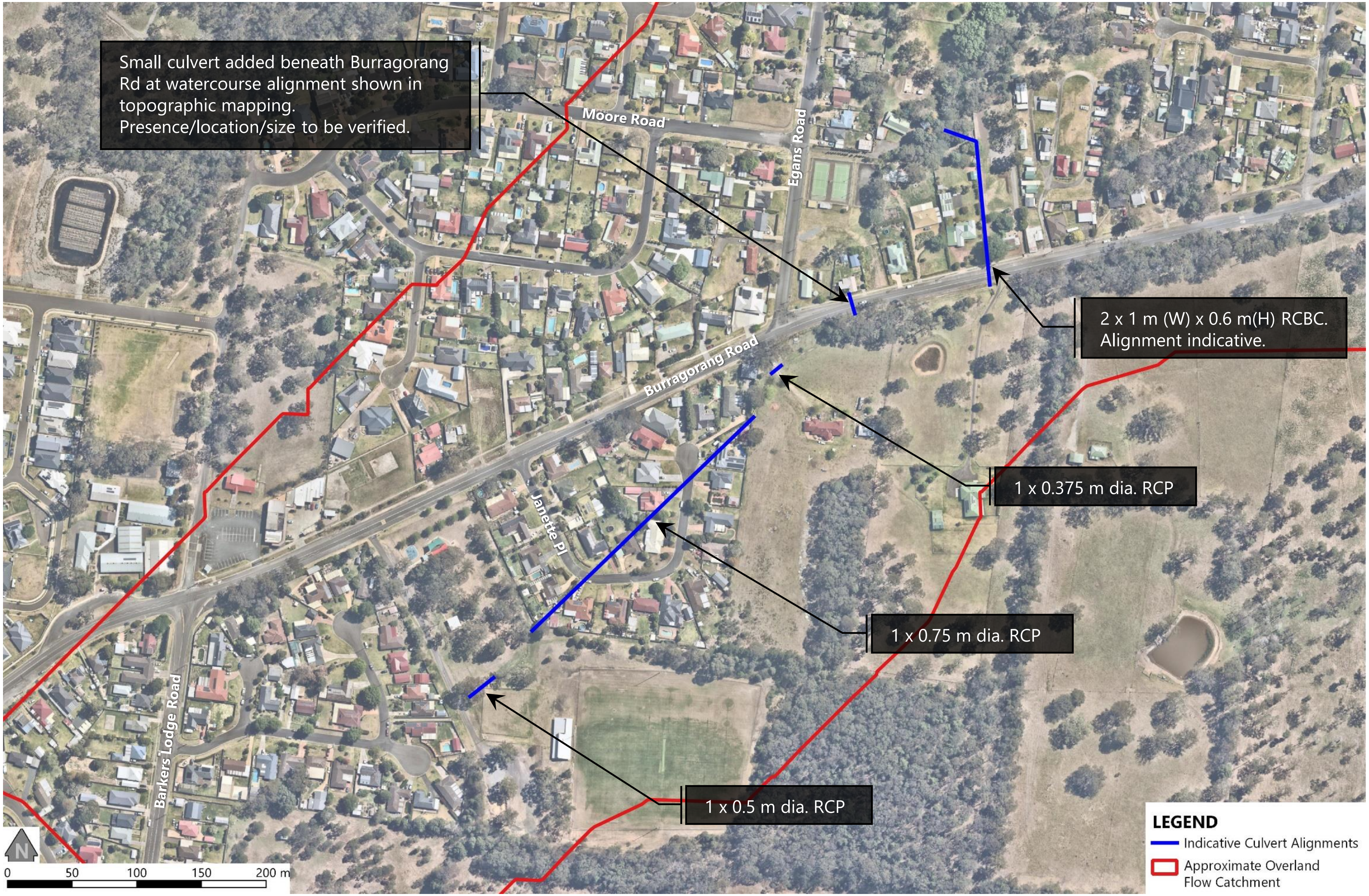
030-22G L07 [00]
- Concept Rd Layout

# Appendix

## C.1 Indicative Culvert Information




Advision
Worley Group

# INDICATIVE CULVERT INFORMATION AT OAKDALE

# Appendix

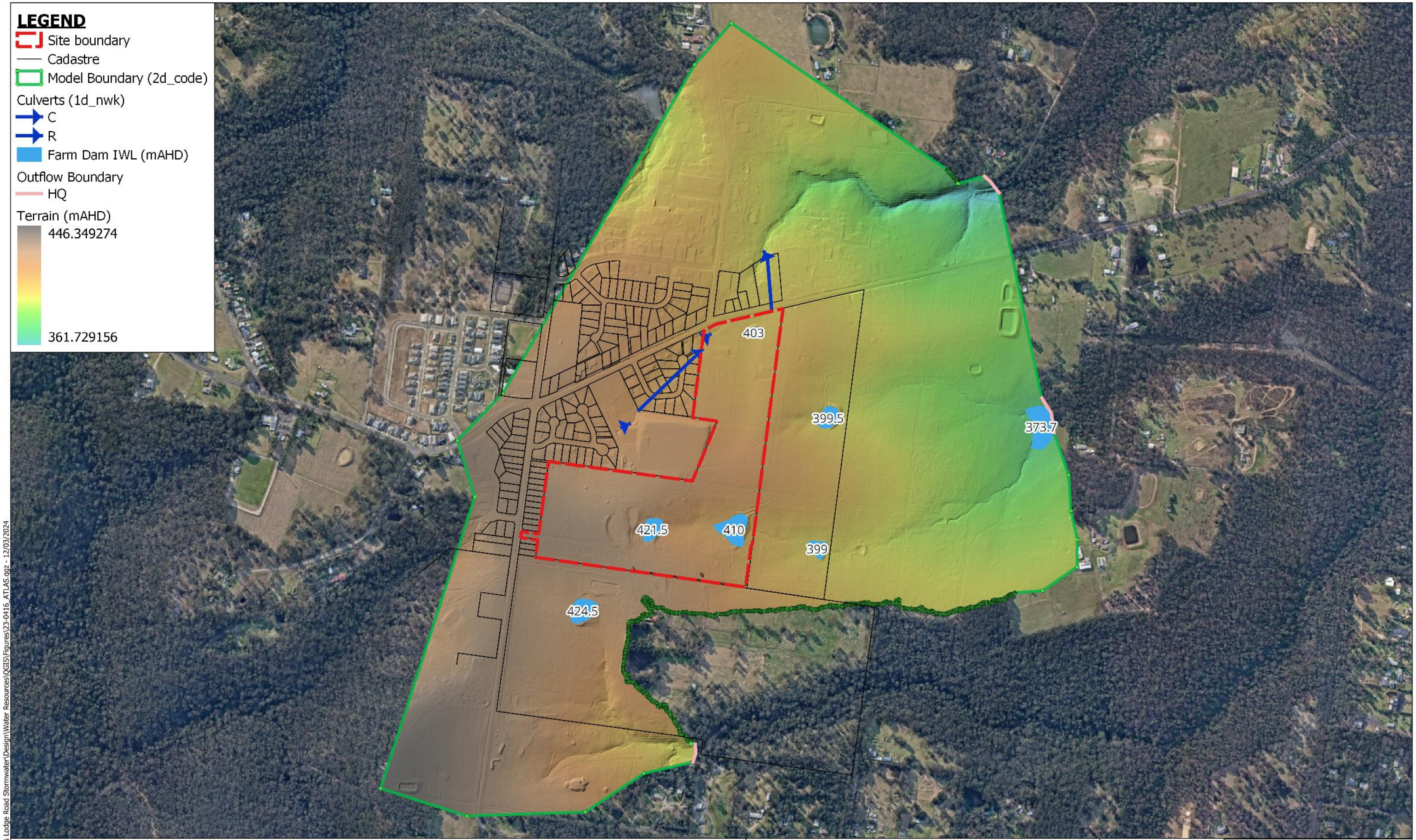
## D.1 Flood Mapping

### I. TUFLOW Model Layout

### II. Existing Scenario Results

### III. Proposed Scenario Results

### IV. Afflux Map

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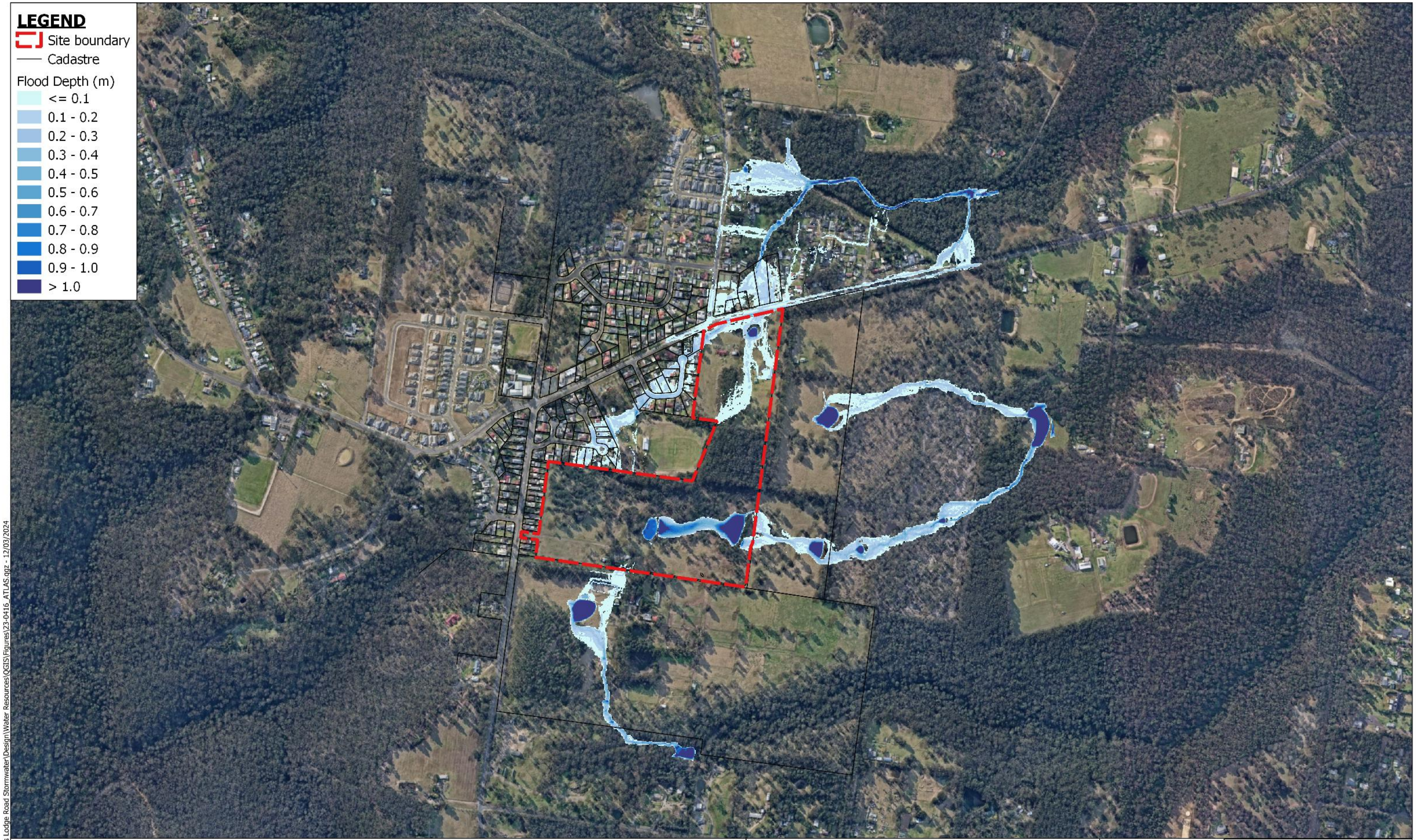
| FIGURE TITLE: | TUFLOW LAYOUT MAP | FIGURE NO: | A |

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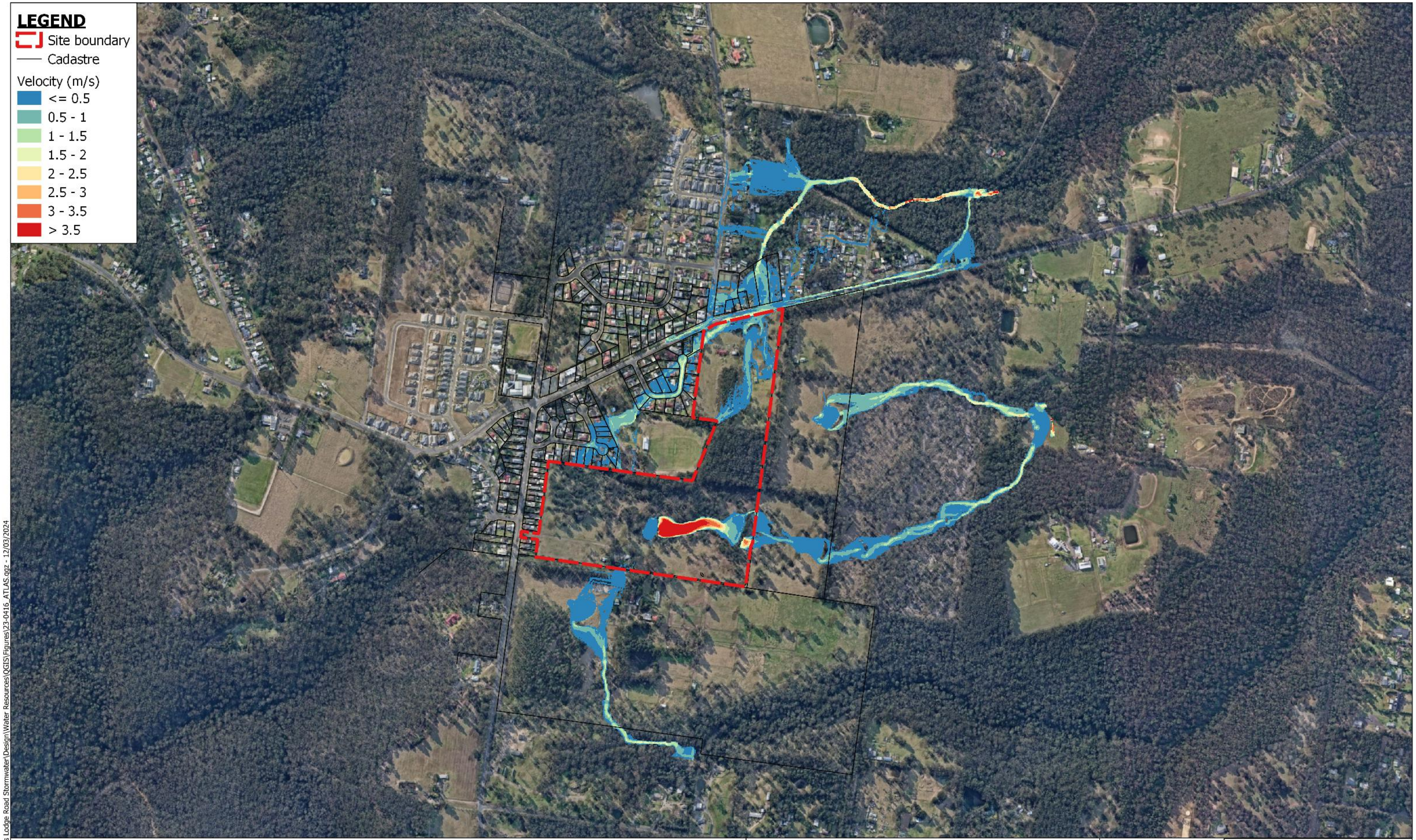
| PROJECT TITLE: | OAKDALE PLANNING PROPOSAL FLOOD ASSESSMENT | PROJECT NO: | 23-0416 |
| FIGURE TITLE: | FLOOD DEPTH MAP - EXISTING (E02) - 1% AEP | FIGURE NO: | B001 |

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| PROJECT TITLE: | OAKDALE PLANNING PROPOSAL FLOOD ASSESSMENT | PROJECT NO: | 23-0416 |
| FIGURE TITLE: | VELOCITY - EXISTING (E02) - 1% AEP | FIGURE NO: | B002 |

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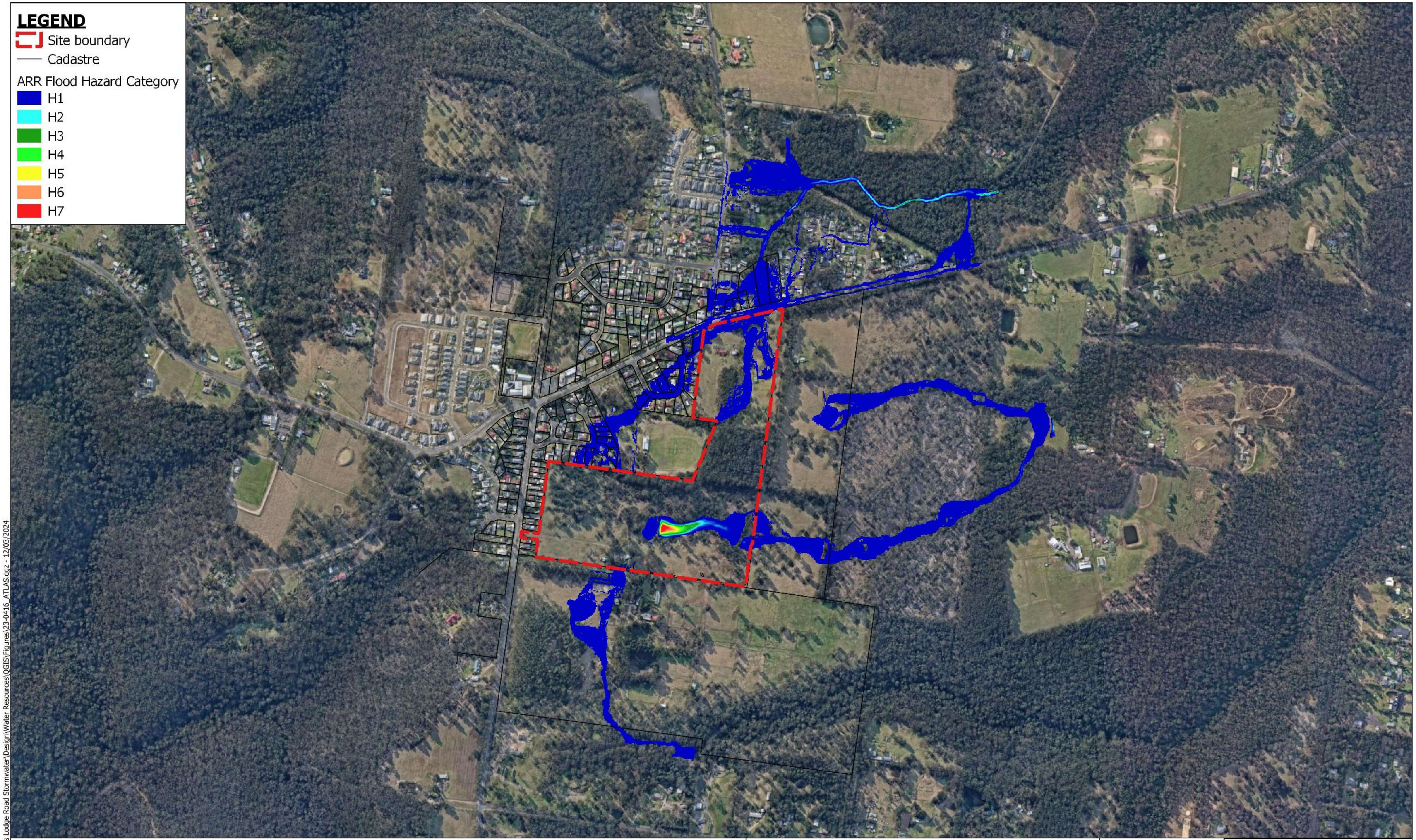


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CONSULTANT: Colliers

PROJECT TITLE: OAKDALE PLANNING PROPOSAL FLOOD ASSESSMENT

PROJECT NO: 23-0416

FIGURE TITLE: FLOOD HAZARD MAP - EXISTING (E02) - 1% AEP

FIGURE NO: B003

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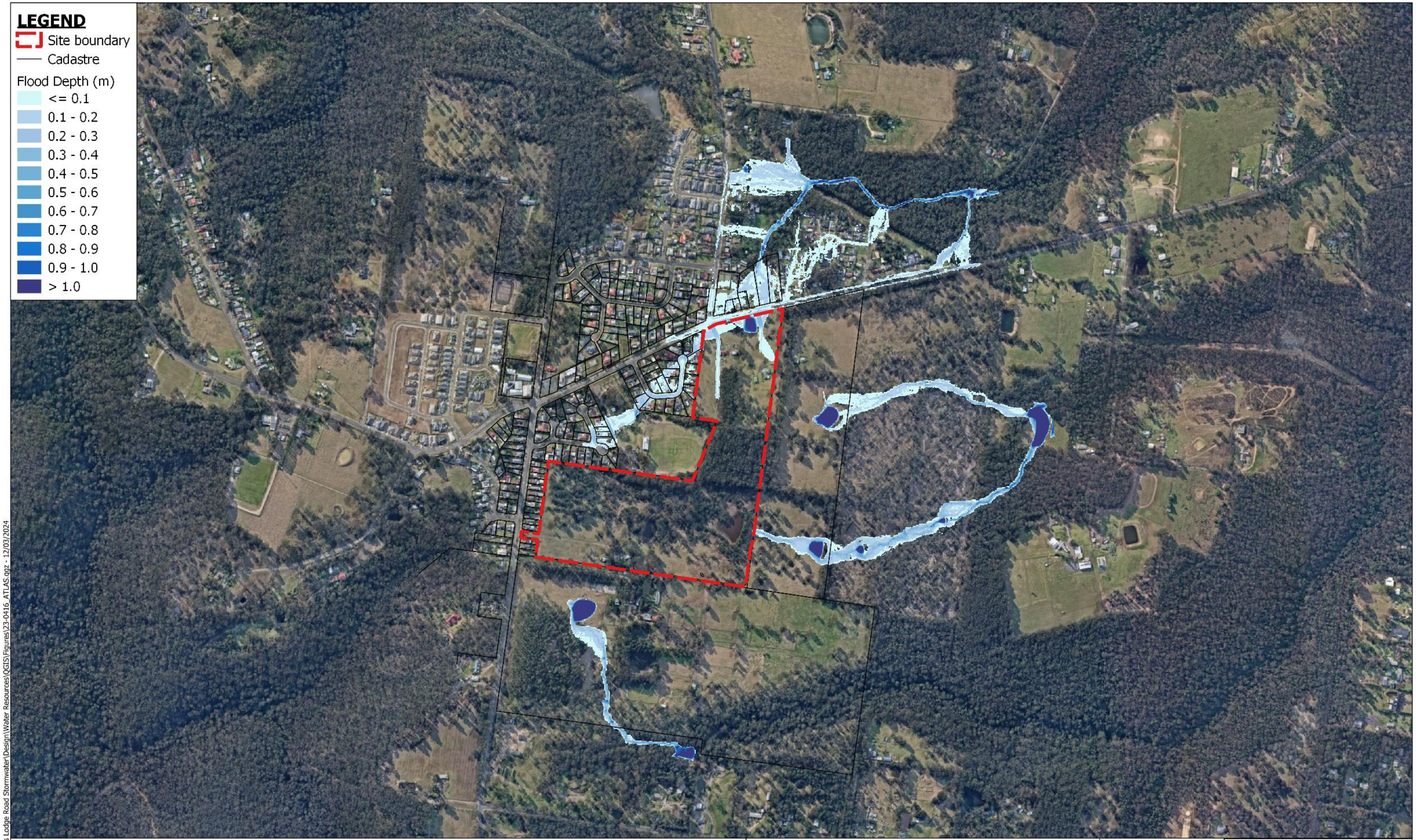


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| FIGURE TITLE: | FLOOD DEPTH MAP - PROPOSED (P01) - 1% AEP | FIGURE NO: | C001 |

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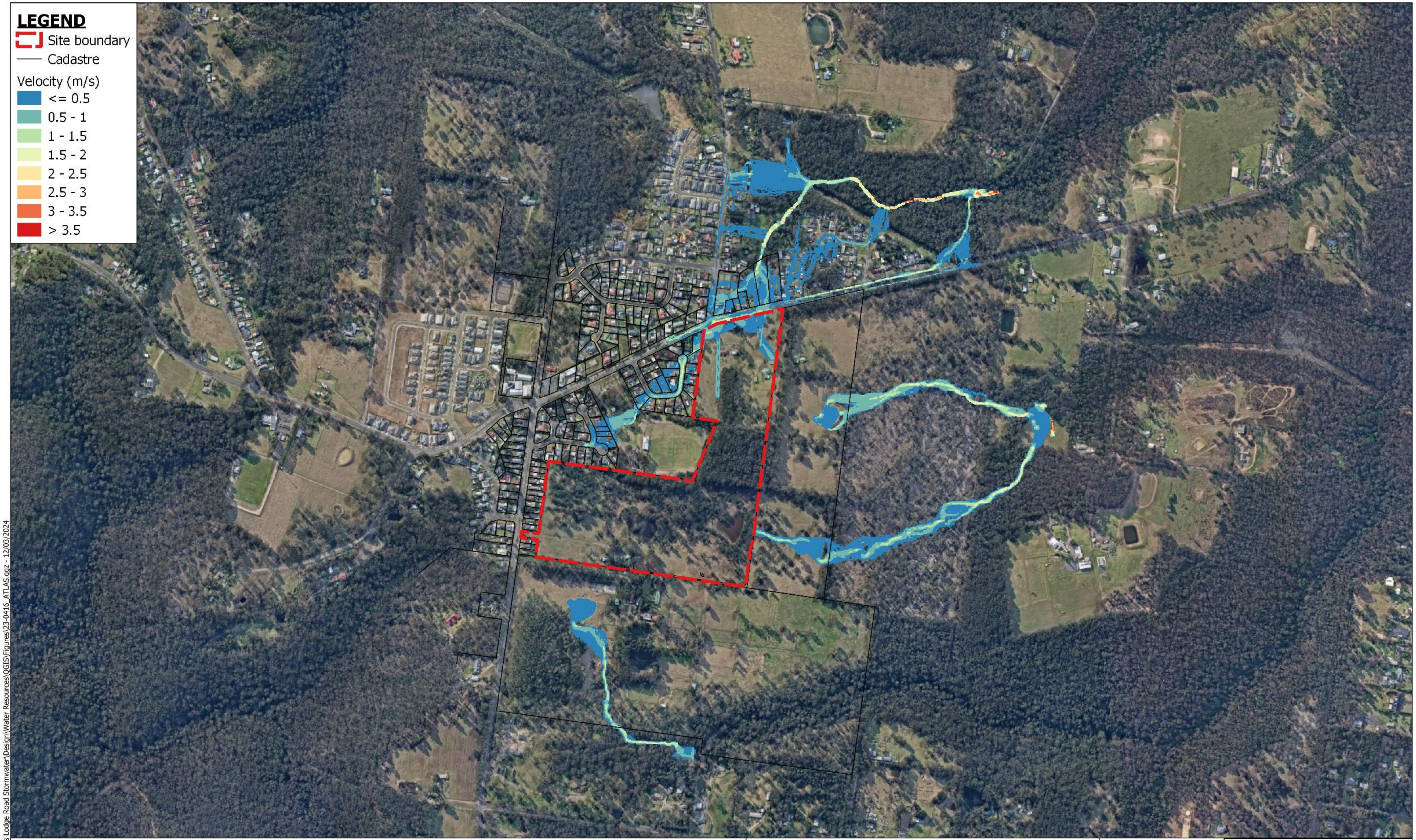


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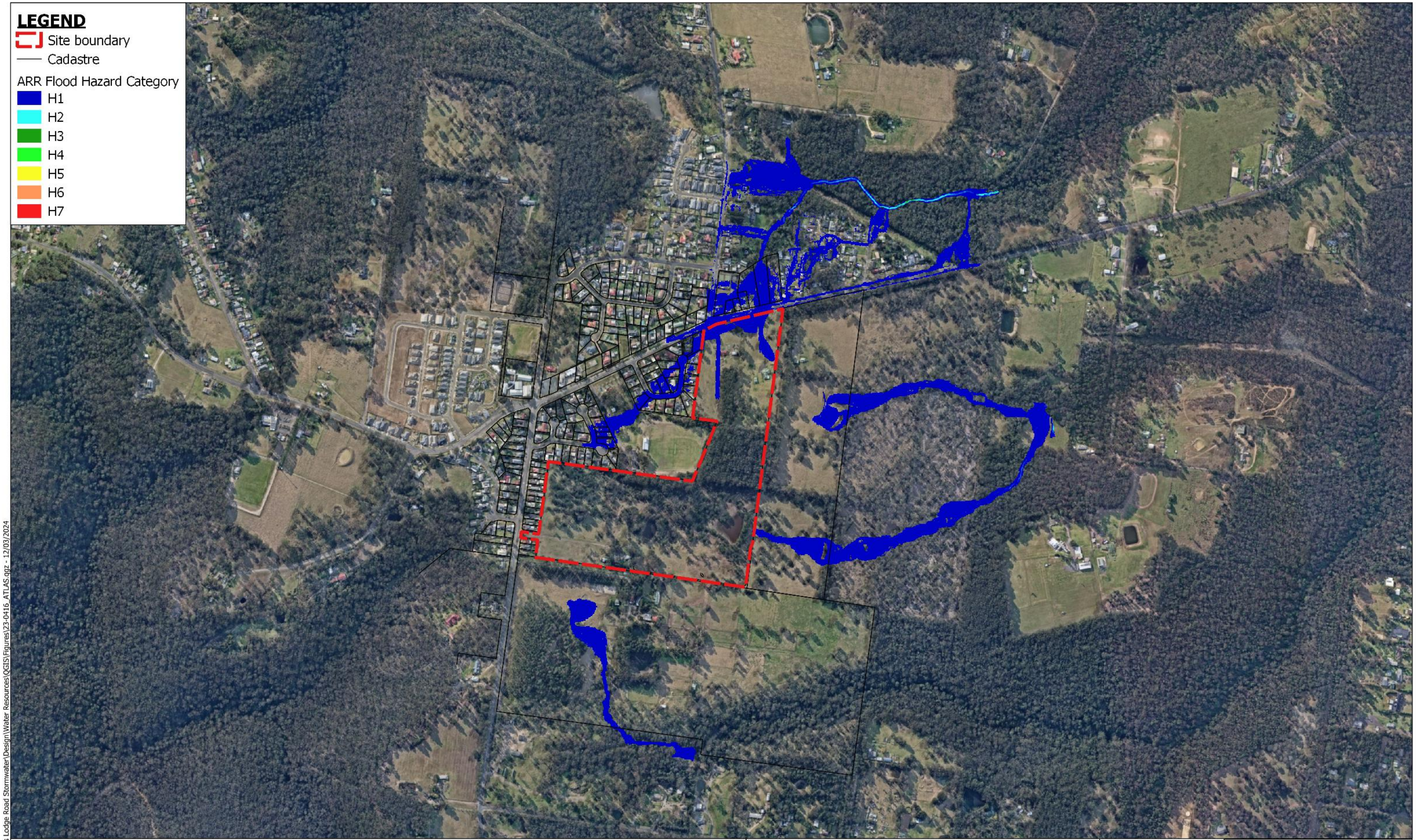
PROJECT TITLE: OAKDALE PLANNING PROPOSAL FLOOD ASSESSMENT

PROJECT NO: 23-0416

FIGURE TITLE: VELOCITY - PROPOSED (P01) - 1% AEP

FIGURE NO: C002

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PROJECT TITLE: OAKDALE PLANNING PROPOSAL FLOOD ASSESSMENT

PROJECT NO: 23-0416

FIGURE TITLE: FLOOD HAZARD MAP - PROPOSED (P01) - 1% AEP

FIGURE NO: C003

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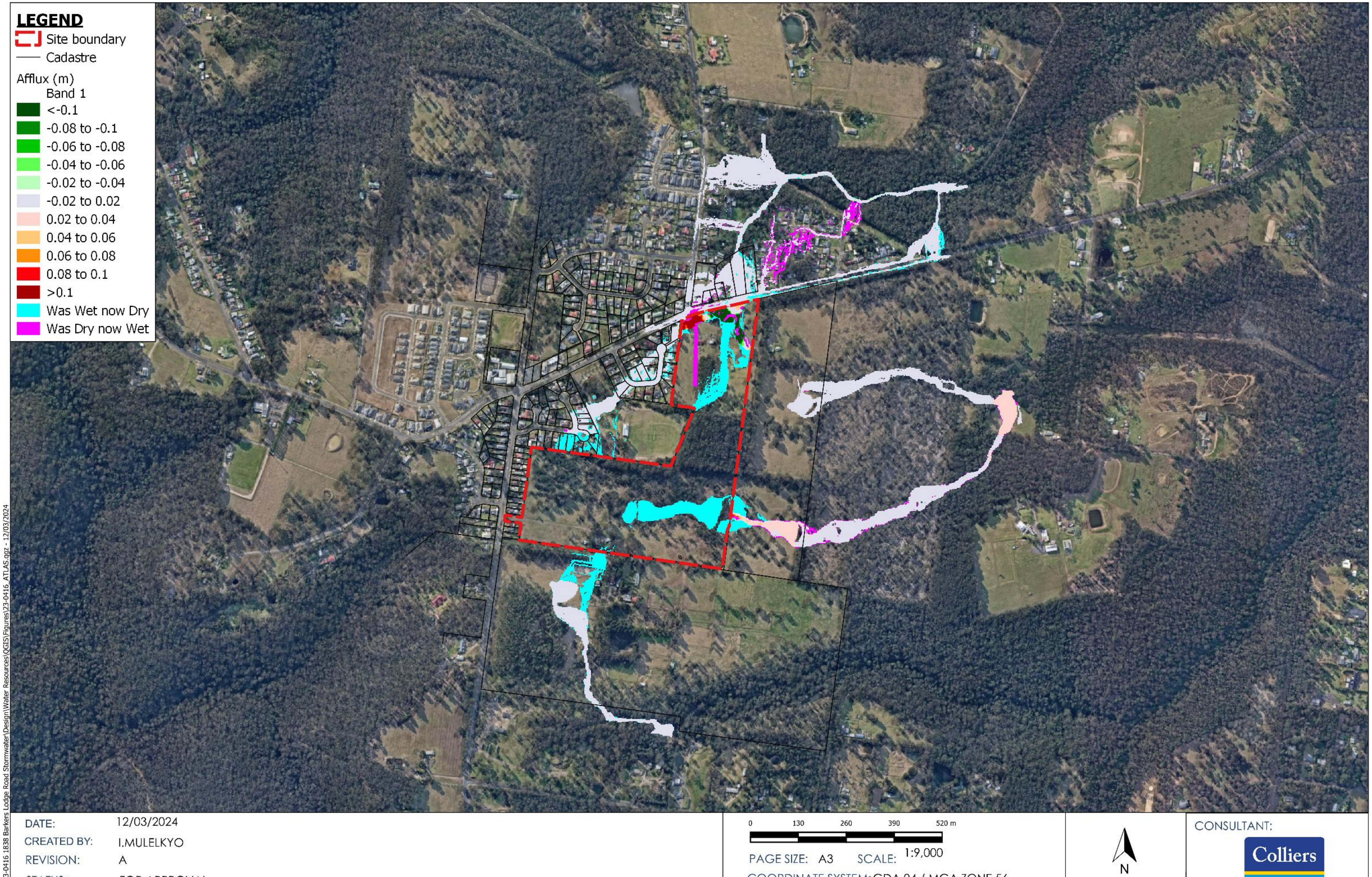


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PROJECT TITLE: OAKDALE PLANNING PROPOSAL FLOOD ASSESSMENT

PROJECT NO: 23-0416

FIGURE TITLE: FLOOD AFFLUX MAP (P01 - E02) - 1% AEP

FIGURE NO: D

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