304001010

# Tuggerah Gateway Flood Assessment Report

## Scentre Group

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## Document History

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| 01 | 4/08/2021 | Draft for project ream review | Zac McCosker | Josh Atkinson |
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*This document contains information about Stantec, particularly about the culture of our organisation and our approach to business, which would be of value to our competitors.  We respectfully request, therefore, that it be considered commercially sensitive.*

*In line with our Quality System, this document has been prepared by Jacob Lee and reviewed by Frank Guo and signed off by Frank Guo.*


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# 1 Introduction

## 1.1 Background

On behalf of Scentre Group, this Flooding Assessment supports a Planning Proposal and Structure Plan prepared by Urbis. The Planning Proposal facilitates the proposed amendment to the Local Environmental Plan at the Tuggerah Gateway Site, known as Lot 2 DP1056960 and Lot 3 DP1084221, which will enable residential, mixed-use and recreational land uses.

The site is approximately 41.6 hectares and is currently zoned RU6 Transition, B4 Mixed Use and E2 Environmental Conservation.

The Planning Proposal seeks to rezone land comprising (part) Lot 2 in DP 1056960 and Lot 3 in DP 1084221 from RU6 Transition to R1 General Residential. The B4 Mixed Use zone in the north-east of the site and E2 Environmental Conservation zone in the south-east is to be retained.

The long-term development yield capable of being accommodated on the site comprises of more than two thousands of dwellings including a mix detached housing lots, medium density townhouses/terraces, apartments and seniors living. Consistent with the Structure Plan, the future development of the site is to be staged in accordance with market demand and infrastructure requirements. In the short-term employment uses in the form of bulky goods / large format retailing will be prioritised in part of the B4 Mixed Use zone. In the longer term this area is envisaged as a mixed-use precinct.

## 1.2 Response to Review RFIs

This report has been prepared with consideration of numerous discussions held with Council and DPE (BCD Division) on biodiversity and flooding matters post Gateway Determination.

The submitted documents achieves the following outcomes and confirms:

- that the proposed flood mitigation works have reasonably avoided the impacts to high biodiversity values
- that the design of the flood mitigation works is capable of avoiding adverse impact on the Melaleuca Bioconvexa on the northern boundary of the site.
- that the proposed channel design that balances flood and ecological management including re-creating wildlife corridors with consideration given to strategy 6.1-6.5 of the Central Coast Regional Plan 2041, as well as supporting open space and recreation values
- that the flood study, civil/stormwater drawings, BCAR/ecological report, landscape concepts are all in alignment.

Given the importance of the raised matters and to enable greater certainty in the development outcome, detailed design testing and documentation has been prepared which should provide added comfort and certainty to Council and BCD. We have tested the design to a level that would ordinarily be expected in a Development Application submission.

The site planning and design incorporates the following key shifts since the original Planning Proposal submission (and that referenced in the BCD letter dated 23 June):

- Removal of one large stormwater basin and the incorporation of three smaller basins in the WSUD corridor, which in turn results in terraced gabion walls that have an overall reduction in wall height.
- Slight reshaping of the riparian corridor southward (adjacent to the north western corner of the MU1 zoned land) to create a substantial setback to the Melaleuca Biconvexa along Wyong Road as well as incorporating space for additional replenishment planting

- Movement of the flood storage arrangement to enable a future larger area of usable public open space that is sited out of high flood hazard areas
- An enlargement of the central open space (to the west and south) on the R1 zoned land, which after testing an indicative landscape concept, confirms that it would align with Council's park design requirements.
- Ensure there is alignment in all technical documentation - for example the roughness of the corridors to align with the landscaping layout / cross-sections as well as the stormwater infrastructure/civil design. The flood modelling has been undertaken against a detailed, technical riparian and waterway corridor documentation (which has been designed to be as naturalised in amenity) to ensure the outcome is robust.

This report should be read in association with the following documentation:

- Biodiversity Certification Assessment Report, prepared by Ecological
- Civil/stormwater drawing set, prepared by IDC
- Indicative landscape concept sketches and cross sections within the Urban Design Report, prepared by Urbis

## 1.3 Study Area

The proposed development site is located within the Mardi Creek catchment which is part of the greater Wyong River catchment. The Site is bounded by Pacific Highway to the west, Wyong Road to the north and bushland to the south.

The proposed development is generally divided by two flow paths, with Mardi Creek passing through the northern portion of the site and a waterway flowing south to east, joining Mardi Creek within the site. The ground levels in the site vary from 8 mAHD in the northeast corner to 74 mAHD in the southeast corner with an average slope of approximately 20%. A concept site layout plan is shown in Appendix A. The proposed development site overlaying the imagery and existing topography is provided in **Figure 1-1**.

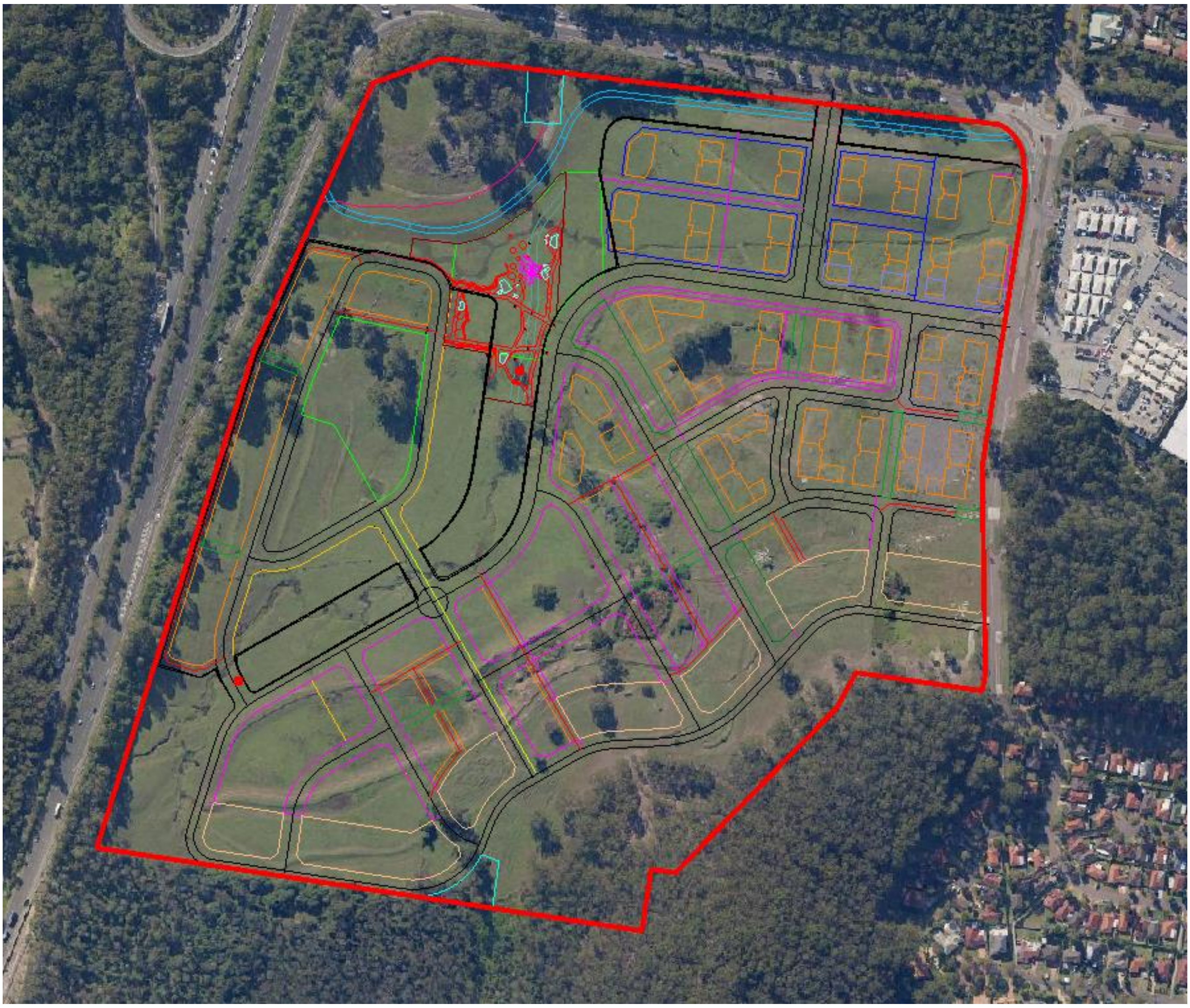


Figure 1-1 Proposed Development Layout

# 2 Available Data

## 2.1 Topographic Data

### 1.3.1 Aerial Laser Scanning (ALS) Survey

ALS data was sourced from the Wyong River Catchment Floodplain Risk Management Study and Draft Plan TUFLOW model provided by Council. The dataset was captured in 2014 and was overlayed with streams from the 2007 dataset during the above study.

## 2.2 Previous Studies

### 2.2.1 Wyong River Catchment Floodplain Risk Management Study and Draft Plan

The *Wyong River Catchment Floodplain Risk Management Study and Draft Plan* was prepared by Catchment Simulation Solutions (CSS), in 2020 to quantify the nature and extent of the existing flooding problem an evaluate options that could be potentially implemented to manage the flood risk. This study built upon previous work including the Lower Wyong River Floodplain Risk Management Study and Lower Wyong River Floodplain Risk Management Plan by Paterson Consultants completed in 2010.

Council provided the hydrological and hydraulic models used to develop the Wyong River Catchment Floodplain Risk Management Study and Draft Plan for use in this report.

## 2.3 Use of Previous Studies in the Report

The reference detailed in **Section 2.2.1**, has been utilised in this report to provide key details of existing stormwater quality assets and channel modifications in the Wyong River Catchment.

The provided models, (hydrological and hydraulic) were reviewed and used as a base case in this assessment.

The reference detailed in **Section 2.2.1** was utilised to validate modelling results from this study.

# 3 Hydrology

## 3.1 Catchment Description

The proposed development site is located within the lower part of the Mardi Creek catchment. The Mardi Creek catchment is approximately 500 ha in area and extends from the Tuggerah in the east to Mardi Dam in the west. A diverse coverage typifies the catchment, ranging from dense bushland near to Mardi Dam, rural residential land with low/medium density residential and industrial areas closer to Tuggerah.

Mardi Creek catchment forms the parts of the southern portion of the greater Wyong River Catchment. The Wyong River Catchment is approximately 440 $km^2$ and extends broadly from the Olney State Forest in the west to Tuggerah Lake in the east.

Mardi Creek generally runs in an easterly direction, flowing through the northern portion of the site and exiting the site via a number of culverts.

## 3.2 Hydrological Model Selection

The computer model XPRAFTS was adopted for the hydrological modelling in this study. This model was provided by Council for use in this study. This model was considered appropriate for the task of modelling the study area given its ability to model a wide range of catchment characteristics and its local development. The model allowed peak flows to be established at various locations throughout the subject site.

## 3.3 Model Input

To assess shorter duration storms (10 to 180 minute) on local catchments (refer Figure 3-1), the supplied XPRAFTS model was modified with the supplied Lower Wyong IFD being implemented across the model. All catchment parameters and longer duration storms were modelled consistent with Council's model and the model parameters have been included in **Table 3-1.** This is considered a conservative approach, common in investigations completed using ARR 87

Table 3-1 Hydrological Model Parameters

| Parameter | Value |
|---|---|
| **Initial Loss** | 0 mm/hr |
| **Continuing Loss** | 0 mm/hr |


Figure 3-1 Local Catchment Plan

# 4 Flood Modelling

## 4.1 Selection of Hydraulic Model

The TUFLOW 2D model was used in the hydraulic assessment of the study area. A 2D model was selected to model the floodplain in order to better represent the complex hydraulics associated with floodplain areas and ensure that all ‘break out’ flows are included in the modelling.

### 4.1.1 Model Review

Upon review of the provided TUFLOW model, a number of issues were identified, shown below with the action taken to rectify noted below each point.

- Inflow on site was inputting a total hydrograph instead of local - This was changed to a local inflow.
- A number of culverts were unsteady - Storage was increased on SX connection points. Still some instability noted.
- Culverts connected to the S channels (S channels are modelled channels that are steep can have super critical flows) downstream of the site were incorrectly setup. This was causing crossings to be cut out of the DEM. This was occurring at the intersection of Gavenlock and Anzac Roads and alongside the Pacific Highway until approximately Johnson Road - Culvert setup modified to ensure all identified crossings local to the development site remained in the DEM.

## 4.2 Model Set Up

### 4.2.1 Model Geometry and Boundary Conditions

The TUFLOW model was established over an 8 meter grid as previously modelled, with elevations extracted from the topographic data discussed in Section 2-1. The model extent was determined based on review of the topography of the study area and review of the previous flood studies to ensure that significant hydraulic controls and flow break out points are included to establish tailwater conditions downstream of the site.

The outlet boundary condition for the TUFLOW model was as used in the provided model.

Inflow hydrographs from the RAFTS model were applied to the upstream and internal catchments, ensuring enough routing time/distance, to allow the model to stabilise and accurately predict flooding behaviour at the site. The hydraulic model schematisation for the TUFLOW model is provided in **Appendix B**

### 4.2.2 Materials Mapping and Roughness

Parameters used in the provided modelling were adopted for this study. The materials values are provided in Table 4-1.

Table 4-1 Roughness Values

| Material | Manning’s Value |
| --- | --- |
| **Buildings** | 1.0 |
| **Roads and Pavement** | 0.03 |
| **River** | 0.03 |
| **Rural Trees** | 0.2 |
| **Maintained Grass** | 0.04 |

| Material | Manning's Value |
|---|---|
| **Creeks** | Depth varying: 1m deep – 0.08,<br>3.5m deep – 0.1 |
| **Urban Trees** | 0.02 |
| **Proposed Channel** | 0.04 |
| **Cleared floodplain** | 0.08 |
| **Proposed Channel** | 0.035 |
| **Proposed Riparian corridor** | 0.05 |
| **Proposed Water Body** | 0.06 |
| **Proposed Recreational Area** | 0.08 |

#### 4.2.3 Climate Change

A sensitivity test for climate change was included in the 1% AEP rainfall event as per the methodology adopted in Council's study. The rainfall intensities were increased by 30% to account for the anticipate effects of climate change in the year 2100.

#### 4.2.4 Structures and Blockage

An ARR blockage assessment was undertaken for the site drainage structures. A 15% blockage factor was calculated according to the ARR procedure (refer Appendix E for the detail of the assessment). Based on the analysis, a 0% conduit blockage will be required for all storms up to the 0.5% AEP. However, the 15% blockage factor was adopted and applied to the proposed case modelling and cross drainage sizing in all simulated design storm AEP as a conservative measure. To assess the worst case of impacts from the development within the site as well as to the downstream properties, both unblocked and 15% blocked cases were modelled and final results shown in Appendix C and Appendix D are derived from the maximum envelop of the two scenarios.

#### 4.2.5 Model Calibration

As this model was provided by Council no model calibration was undertaken. A comparison between the provided and base case runs was performed. This comparison (refer **Figure 4-1**) showed minimal changes in flood levels between the two models. Differences shown can be attributed to the points noted in **Section 4.1.1** and variations in model versions. The largest variation in water level is adjacent and downstream of where the S channels were incorrectly modelled.

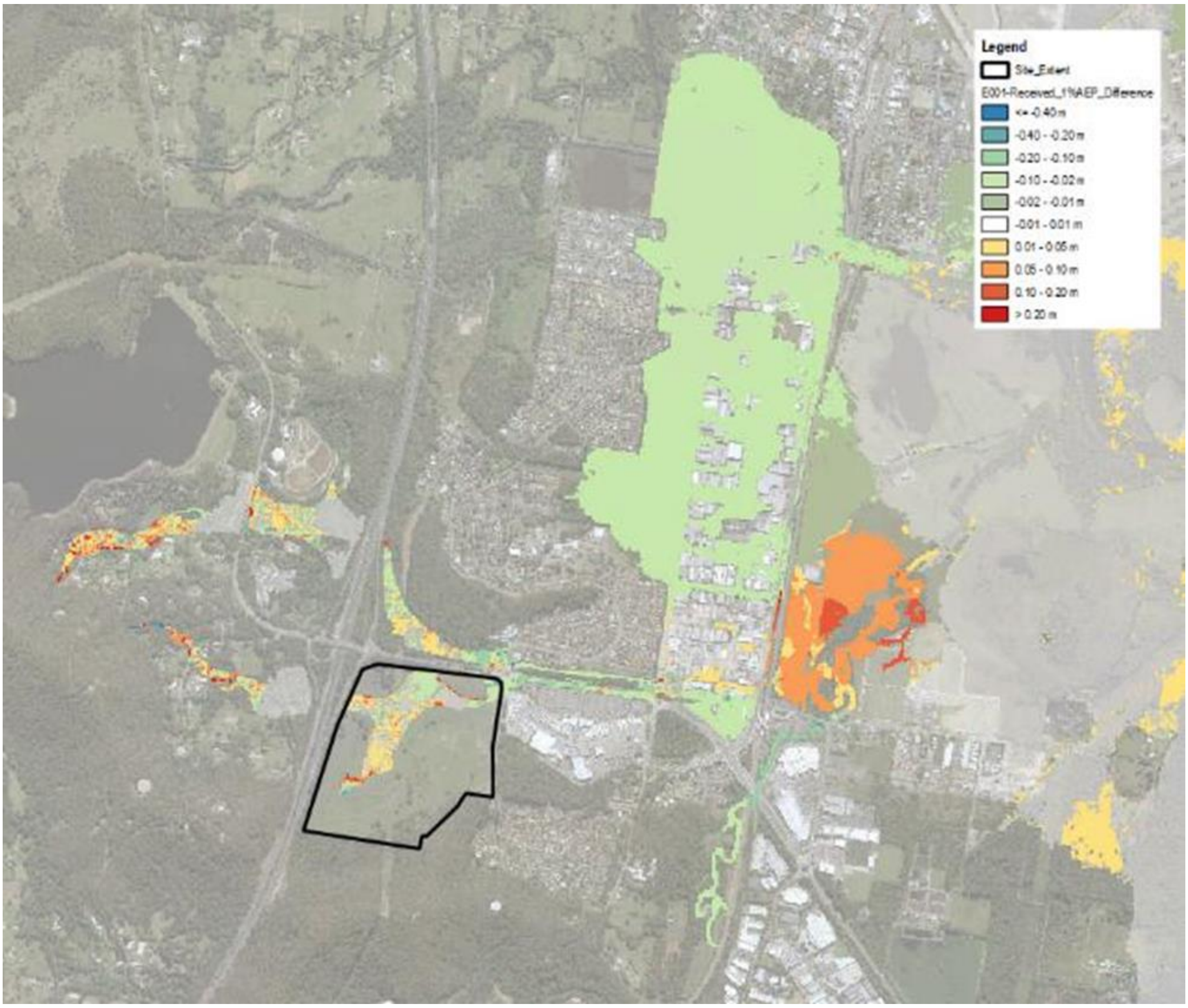



Figure 4-1 Stantec base case – provided 1% AEP WSL difference

### 4.2.6 Critical duration

It should be noted that multiple storm durations were simulated from the 10 minutes to 2160 minutes in the previous submission. However, it was determined through the hydraulic model that the 2-hour duration (9 hour for 20% AEP) is the dominant storm duration. This indicates that the majority of the modelled areas specifically within the site and adjacent downstream areas would experience the worst-case flooding at this duration in all modelled storm events i.e. 5% AEP to PMF. As such, the 2-hour critical duration is considered suitable in assessing the flood severity of the study area and was adopted in the post-development scenario including subsequent impacts assessment.

### 4.2.7 Post-development Scenario

- The design surface provided by Infrastructure & Development Consulting (IDC) dated 2 November 2023. This is the latest surface and consistent with the civil design plans;
- Culverts C1, C2 and C3 under proposed roads provided to pass sufficient flow as to ensure the roads are at least flood free (in the blocked scenario) during the 1% AEP event, and a PMF free access above culvert C2 for flood emergency access and evacuation purposes;
- Low flow channel connecting C1 and C2 culverts;
- A formalized channel from culvert C2 to culvert C3 as well as from culvert C3 to the existing culverts under Wyong Road roundabout
- A flood mitigation storage area has been designed in the play area between culvert C2 and culvert C3; and
- Check dams and footbridge crossings have been integrated to enhance flood storage, reduce water velocity, and maintain low flow continuity. Freeboard assessments confirm the residential area remains above the flood planning level.

A concept plan of the proposed features is presented in **Figure 4-2**. It is noted that the detailed configuration of the proposed culverts may be subject to further revisions during the detailed design phase, such as the integration of low flow and high flow culvert elements.

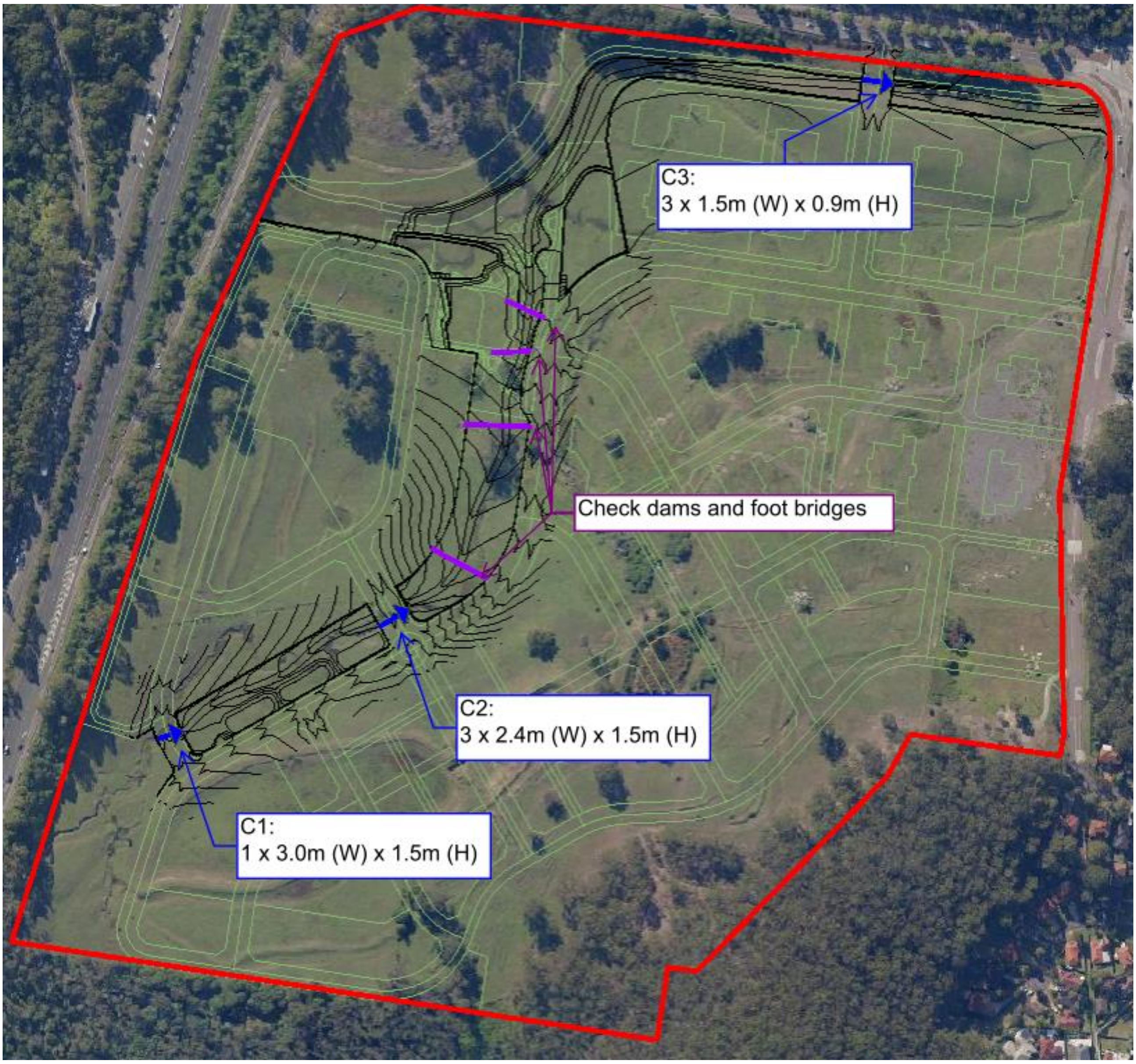



Figure 4-2 Proposed design and mitigation features

## 4.3 Model Results

### 4.3.1 Pre-Development Scenario

The model set up for the pre-development scenario was run for the 20%, 5% and 1% AEP design events and the PMF. The pre-development simulation results are presented in **Appendix C**.

Peak flood depths of up to 0.8 m and 1.5 m are predicted in the vicinity of the site in a 1% AEP design event and PMF, respectively. Peak flow velocities of up 2 m/s and 3 m/s are predicted in the creek beds near the proposed development site in a 1% AEP design event and PMF, respectively. These values are consistent with the observed scour at these locations. Some sections of the main waterway can be considered to contain high hazard (based on hazard classification in **Figure 5-1**).

To the west of the site floodwaters are restricted by the current culvert under Pacific Motorway that discharges into the development site. This culvert appears to have a capacity of a 20% AEP with a peak discharge of approximately 4 $m^3/s$. This detention does not appear to be impacting any habitable dwellings. It is noted that this area is currently mapped as Precinct 3 – Flood Storage, in Councils online mapping.

### 4.3.2 Post-Development Scenario

The post-development scenario was run for the 20%, 5% and 1% AEP design events and the PMF. The flood results map for the post-development scenario are shown in **Appendix C** as well as the impact maps which are provided in **Appendix D** for the 1% AEP design event. Flood results were generally comparable with the pre-development scenario in terms of extents, depths and velocities. Flood depths and velocities have increased on site due to filling reducing and concentrating the flood extents. The filling of areas for subdivision has resulted in minimisation of flood extents in these locations and as a result all proposed lots are flood free up to and including the 1% AEP event. Flood extents, depths and velocities have slightly increased in the waterways and reduced on Wyong Road the road external to the site.

During the pre-lodgement meeting, Council raised the prospect of TNSW upgrading the existing undersized culvert under Pacific Motorway. As mentioned previously, this culvert currently causes detention to occur on the western side of the motorway. Given that areas downstream of the site are impacted during existing case flooding, any upgrades to the existing infrastructure under the motorway have the potential to exacerbate flooding at downstream properties. Due to the proposed development, it is anticipated that if this culvert was upgraded, additional detention could be included in the areas designated for drainage reserve, however impacts may still be noticed downstream of the site.

Currently this culvert will flow into a proposed drainage reserve that covers Mardi Creek until it discharges from the site via the existing culverts under Wyong Road. Mardi Creek, as identified via the NSW Hydrospatial data stream order layers will sit within the proposed designated drainage reserve.

The proposed culverts are designed to cater for the 1% AEP flow with sufficient freeboard. Culvert C2 is proposed to be PMF free for flood emergency access. PMF floodwaters at culvert C1 and C3 overtops onto the proposed residential area. However, the flows overtopping culvert C1 and C3 are low in velocity, shallow in depth and are generally within H1 hazard category (refer **Figure 5-1** for description). The remaining development area is generally PMF immune. Additionally, an area of Wyong Road near the site is flood free up to the 1% AEP due to the improved conveyance within the waterway through the proposed channel works and additional storage provided on site.

# 5 Floodplain Management

## 5.1 Flooding Impacts

In this proposal, all lots and roads are to be raised above the flood planning level and some areas of the floodplain will be required to be filled. Generally, the development meets the following requirements:

- There is no significant increase in flood levels up to and including the PMF event;
- There are no significant impacts upon flood behaviour on other properties; and
- There is no increase in risk to life up to and including the PMF event.

Impact maps for the proposed development are presented in **Appendix D**. The results indicate that, despite some PMF water level increases, the flood extents are reduced on Wyong Road in the 20%, 5% and 1% AEP events. The existing overtopping of the road no longer occurs during events up to and including 1% AEP storms due to the proposed development.

The existing overland sheet flow within the north-eastern portion of the site are directed towards Mardi Creek downstream of the Wyong Road culverts as a result of the development fill as well as the proposed improved conveyance established within Mardi Creek via the proposed drainage culverts. This creates a flood free area for the proposed residential lots as well as 20%, 5% and 1% AEP flood free access along Wyong Road, specifically to the adjacent to the Westfield Tuggerah site (i.e. to the east of the site).

In the PMF event, the results demonstrate that:

- There are up to 28 mm increases are shown on Woodbury Park Drive;
- Approximately 140 mm decreases on Tonkiss Street;
- Approximately 100 mm increase as well as approximately 50 mm decreases in flood level on eastern parts of Wyong Road;
- The worst hazard category along Wyong Road remains a H5 category;
- The flood benefit (up to 50 mm decrease in levels) along Wyong Road, adjacent to Westfield Tuggerah has resulted in an improved hazard in some locations.

The proposed development results in a significant area of flood improvement along Wyong Road as well as the habitable areas within the site whilst creating impacts in other areas. It should be noted that in all design storm modelled as part of this study, the flood impacts are mainly within the waterway or creek riparian areas or areas already experiencing severe flooding in the current state (i.e. along Wyong Road near the round-about north-east of the site boundary). It has been demonstrated through the hydraulic assessment results that the proposed development will improve the flooding impacts currently experienced by the community within the area. Therefore, the impacts as a result of the development in terms of flooding are not considered detrimental as:

- It will not result in any increase risk to life that is any worse than the present state; and
- The risk from the predicted flood behaviour is considered low in terms of endangering the life of a person;
- The impacts to flooding will not cause any severe damages or loss to private or public property to what can be reasonably managed;
- The design incorporated as part of the proposed development has resulted in safer existing roads (Wyong Road) as well as creating safer habitable areas within the site, which suits the existing site uses (zoned RU6 Transition and B4 Mixed Use); and therefore

- It aligns with the NSW Flood Prone Land Policy, NSW Floodplain Development Manual (2005) and Chapter 3.3 Floodplain Management of the Central Coast Development Control Plan (DCP) objectives.

## 5.2 Floodplain Storage

Floodplain storage has been calculated for the proposed and existing scenarios using the TUFLOW hydraulic model for the site. There is an increase in floodplain storage in the proposed scenario when compared to the existing. The comparison of the existing and proposed scenarios is provided below in **Table 5-1**

Table 5-1 Comparison between Existing and Proposed Scenario Floodplain Storage Site(m3)

| Scenario | 100 year ARI | PMF |
|---|---|---|
| **Existing** | 18,256 | 50,512 |
| **Proposed** | 19,497 | 69,760 |

*Floodplain storage will be refined with detailed design surface during the DA stage

## 5.3 Flood Hazard

Provisional hazards have been calculated according to the criteria provided in the Australian Disaster Resilience Handbook Collection Guideline 7-3 (2017) Figure 6, shown in **Figure 5-1**

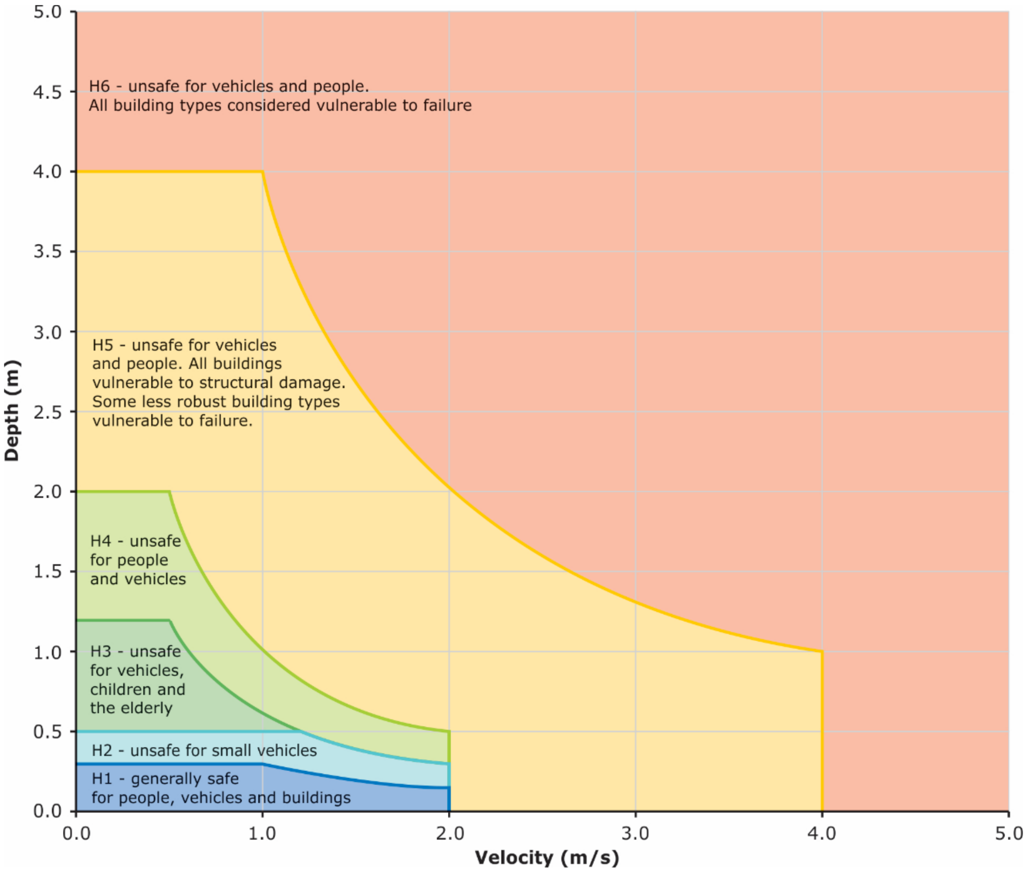



Figure 5-1 General Hazard Curves (reproduced from AIDR, 2017)

**Table 5-2** is a reproduction of Table 2 in Guideline 7-3 which outlines the vulnerability thresholds classification limits.

Table 5-2 Combined hazard curves thresholds

| Hazard Vulnerability Classification | Classification Limit (D and V in combination) m2/s | Limiting still water depth (D) m | Limiting velocity (V) m/s |
|---|---|---|---|
| H1 | D*V<0.3 | 0.3 | 2.0 |
| H2 | D*V<0.6 | 0.5 | 2.0 |
| H3 | D*V<0.6 | 1.2 | 2.0 |
| H4 | D*V<1.0 | 2.0 | 2.0 |
| H5 | D*V<4.0 | 4.0 | 4.0 |
| H6 | D*V>4.0 | - | - |

Hazards are mapped according to these criteria for flood waters across the site and are included in **Appendix D**. During the pre-development scenario, the site exhibits a range of hazard categories from H1 to H5. Isolated areas of the H5 category are contained within the watercourses adjacent to culvert inlets.

## 5.4 Flood Risk

Flood hazard mapping has been developed for both pre-development and post-development conditions across the site. Refer to Appendix D for hazard maps of the site and local area.

## 5.5 Development Controls

The site is identified in Central Coast Councils (CCC), online mapping as being impacted by Flood Precincts 1, 2 and 3. Respectively these precincts relate to the probably maximum flood, flood planning areas and flood storage.

### 5.5.1 Finished Flood Levels

It is proposed that all lots will be constructed with a finished floor level above the flood planning level. Due to the existing and developed topography constraints, this will vary across the development site with final levels to be determined during future development approvals.

### 5.5.2 Flood Compatible

All proposed stages are generally located entirely outside of the existing PMF flood extents. In cases where development does occur within PMF flood affected areas, these locations will be filled to provide the required immunity.

### 5.5.3 Flood Affectation (No Adverse Impact on Adjoining Properties)

It is considered that there are no detrimental impacts up to and including the PMF event. There is no substantial increase in flood levels, no significant impact on flood behaviour for neighbouring properties, and no elevated risk to human life.

### 5.5.4 Evacuation and Safe Access

Flood modelling results demonstrate that habitable floor levels can be located at or above the PMF. Regardless of the short duration (i.e. peak at approximately 2 hours) of the flood, a PMF immune access is provided even at the peak of the storm as part of the development for the entire proposed residential areas through Tonkiss Street. PMF access for potential evacuation to five of the following evacuation centres (taken from the Wyong Shire Flood Emergency Sub Plan, 2013) is provided through Tonkiss Street:

- Diggers @ The Entrance, 315 The Lake Entrance Rd, The Entrance;
- The Bay Sports Club, 5 Bias Ave, Bateau Bay;
- The Entrance Leagues Club, 3 Bay Village Road, Bateau Bay;
- Toukley RSL Club, Holmes Ave, Toukley (corner of Main Road); and
- Tuggerah Lakes Golf Club, Shelley Beach Road, Shelley Beach.

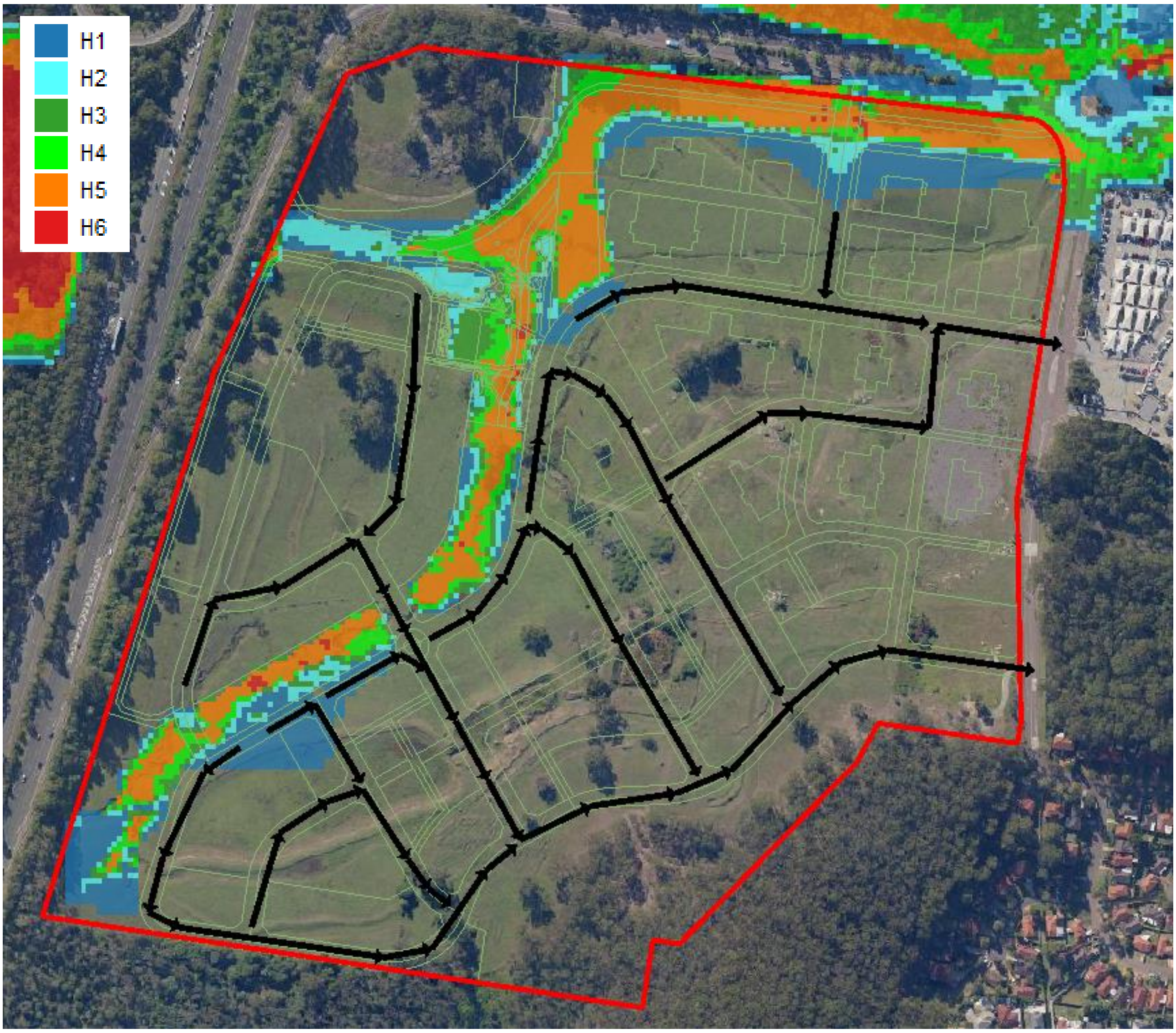



Figure 5-2 Proposed PMF immune access and evacuation (evacuation route: black arrow, PMF Hazard: background)

## 5.6 Climate Change Sensitivity

The climate change sensitivity results indicate that 5 to 33 mm increase of water level are predicted within the surrounding site area. It is believed that a typical 500 mm freeboard above the 1% AEP level would be adequate to cover the climate change impacts. Flood impacts due to climate change is shown in **Figure 5-3.**

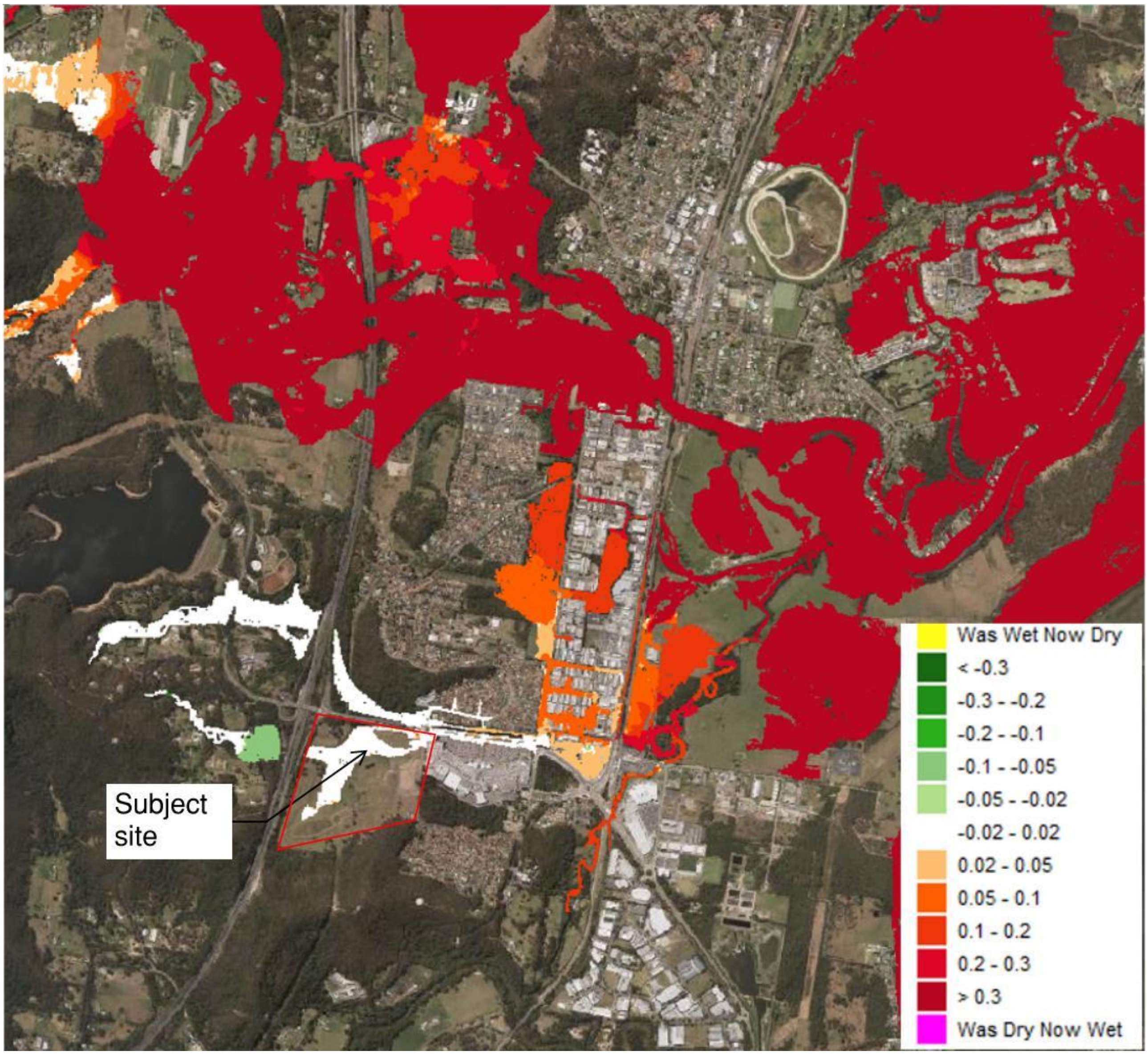



Figure 5-3 Climate Change impacts

## 5.7 Section 9.1 Directions

The proposal is consistent with the ministerial directions issued under section 9.1 of the *Environmental Planning and Assessment Act 1979* (the Section 9.1 directions). Direction 4.1 of the Section 9.1 directions pertains to flooding, and the consistency of the proposal against this direction is summarised in **Table 5-3**.

Table 5-3 Consistency with Section 9.1 Direction 4.1

| Direction 4.1 clause reference | Requirement | Consistency |
|---|---|---|
| **4.1 (2)** | A planning proposal must not rezone land within the flood planning area from Recreation, Rural, Special Purpose or Conservation Zones to a Residential, Employment, Mixed Use, W4 Working Waterfront or Special Purpose Zones. | No residential, business, industrial, special use or special purpose zone is proposed within the developed flood planning area. |

| Direction 4.1 clause reference | Requirement | Consistency |
|---|---|---|
| **4.1 (3)** | A planning proposal must not contain provisions that apply to the flood planning area which: | The below requirements apply to the flood planning area, which is identified as the 1%AEP flood level with 500mm freeboard. |
| **4.1 (3)(a)** | permit development in floodway areas | No development is proposed within a floodway area. |
| **4.1 (3)(b)** | permit development that will result in significant flood impacts to other properties | The development results in no offsite impacts during the 1% AEP flood.<br>It is no considered a significant flood impacts that PMF water increases ranging from 1mm to 7mm beyond the accuracy limit of TUFLOW. Additionally, the flood behaviour, hazard level and timing of the flood remain unaltered. |
| **4.1 (3)(c)** | permit development for the purposes of residential accommodation in high hazard areas | No residential accommodation is proposed in high hazard areas. |
| **4.1 (3)(d)** | permit a significant increase in the development and/or dwelling density of that land | A significant increase in development and/or dwelling density is not proposed below the flood planning level. |
| **4.1 (3)(g)** | are likely to result in a significantly increased requirement for government spending on emergency management services, flood mitigation and emergency response measures, which can include but are not limited to the provision of road infrastructure, flood mitigation infrastructure and utilities | The site has reliable flood evacuation access during the 1%AEP event, and therefore is unlikely to result in a significantly increased requirement for emergency services expenditure / infrastructure. |
| **4.1 (4)** | A planning proposal must not contain provisions that apply to areas between the flood planning area and probable maximum flood to which Special Flood Considerations apply which: | The below requirements apply to areas above the flood planning area and below the probable maximum flood (PMF). |
| **4.1 (3)(a)** | permit development in floodway areas | No development is proposed within a floodway area. |
| **4.1 (3)(b)** | permit development that will result in significant flood impacts to other properties | The development results in an increase of the PMF in a localised area across the adjacent Wyong Road and Woodbury Park Drive but reduces the PMF along Wyong Road to the east of the site (refer flood impact maps in Appendix D).<br>The increases in flood depth are between 21mm to 27mm, which are not considered significant in the context of the rarity of the event. Noting that the PMF is typically used to inform flood emergency risk and evacuation strategy. The roads and lots impacted in the PMF are also already liable to flooding in the pre-developed PMF<br>The increased flood levels do not result in an increase to the maximum flood hazard category across Wyong Road, and so flood evacuation access reliability of the road is not likely to be affected. |
| **4.1 (3)(c)** | permit a significant increase in the dwelling density of that land | A significant increase in development and/or dwelling density is not proposed below the PMF. |

| Direction 4.1 clause reference | Requirement | Consistency |
|---|---|---|
| **4.1 (3)(e)** | are likely to affect the safe occupation of and efficient evacuation of the lot, or | The increased flood levels do not result in an increase to the maximum flood hazard category across Wyong Road, and so flood evacuation access reliability of the road is not likely to be affected. |
| **4.1 (3)(f)** | are likely to result in a significantly increased requirement for government spending on emergency management services, and flood mitigation and emergency response measures, which can include but not limited to road infrastructure, flood mitigation infrastructure and utilities. | The increased flood levels do not result in an increase to the maximum flood hazard category across Wyong Road and Woodbury Park Drive, and so flood evacuation access reliability of the road is not compromised.<br>It is therefore considered unlikely that the development will result in significantly increased requirement for government spending on emergency management services, and flood mitigation and emergency response measures. |

# 6 Conclusions

Based on the modelling undertaken to date, it can be concluded that:

- Despite some PMF water level increases and the flood extents are reduced on the Wyong Road in the 20%, 5% and 1% AEP.
- The existing overtopping is eliminated up to and including 1% AEP storms due to the proposed development.
- A flood free area for the proposed residential lots as well as 20%, 5% and 1% AEP flood free access along Wyong Road adjacent to the Westfield Tuggerah site is established as a result of the development fill as well as the proposed improved conveyance established within Mardi Creek via the proposed drainage culverts;
- All habitable floor levels can be located at or above the PMF;
- A PMF immune access is provided as part of the development for the entire proposed residential areas through Tonkiss Street. While 1% AEP flood free access are designed at other crossings;
- The flooding on Wyong Road is significantly improved on Wyong Road and Tonkiss Street due to the proposed development;
- PMF impacts on Woodbury Park Drive and other parts of Wyong Road are not considered detrimental as:
  - It will not result in any increase risk to life that is any worse than what it currently is;
  - The risk from the predicted flood behaviour is considered low in terms of endangering the life of a person;
  - The impacts to flooding will not cause any severe damages or loss to private or public property to what can be reasonably managed; and therefore;
  - The design incorporated as part of the proposed development has resulted in safer existing roads (Wyong Road) creating safer habitable areas within the site, which suits the existing site uses (zoned RU6 Transition and B4 Mixed Use); and therefore
  - It aligns with the NSW Flood Prone Land Policy, NSW Floodplain Development Manual (2005) and Chapter 3.3 Floodplain Management of the Central Coast Development Control Plan (DCP) objectives.

The proposed development at the site is consistent with the principals and objectives of the *Development Control Plan 2013 – Development Controls for Wyong Shire, the Section 9.1 Ministerial Direction* on flooding, and the *NSW Floodplain Development Manual* as the proposal allows for efficient and productive use of an area of low flood risk, while appropriately managing the impacts to the environment and flood safety.

# 7 Appendices

# Appendix A:
CONCEPT LAYOUT

We design with community in mind

## LEGEND

- Tuggerah Gateway Site

### LAND USE

- Detached Homes - Large Lots
- Detached Homes - Standard Lot
- Townhouse/Duplex
- Terrace Homes
- Low-Medium Rise Apartment ( up to 4 storeys)
- Medium Rise Apartment (up to 6 storeys)
- Medium Rise Apartment (up to 6 storeys with a portion up to 8 storeys)
- Independent Living Unit (up to 6 storeys with a portion up to 8 storeys)
- Retail Bulky Goods (up to 2 retail storeys) / Future Mixed Use (up to 12 storeys)
- Utilities (Transmission Line)

### OPEN SPACE & PUBLIC DOMAIN

- Conservation Area
- Rocky Outcrop
- Riparian Corridor
- Natural Low Land Corridor
- Active Open Space 1 - Central Green
- Active Open Space 2 - Hillside Park
- Linear Park
- Pedestrian Links
- Mardi Creek
- Water Basin
- Secondary Landscape Node

### STREET NETWORK

- Collector Street - 20m
- Boulevard -21m
- Local Street - 16m
- Local Street Green - 14.5m
- Perimeter Street - 14.5m
- Laneway - 8m
- Primary Intersection
- Secondary Intersection
- Left-In Left Out Intersection

### ACTIVE TRANSPORT

- Shared Pedestrian/ Cycleway
- Pedestrian Way


URBIS

# TUGGERAH GATEWAY PRECINCT

## STRUCTURE PLAN

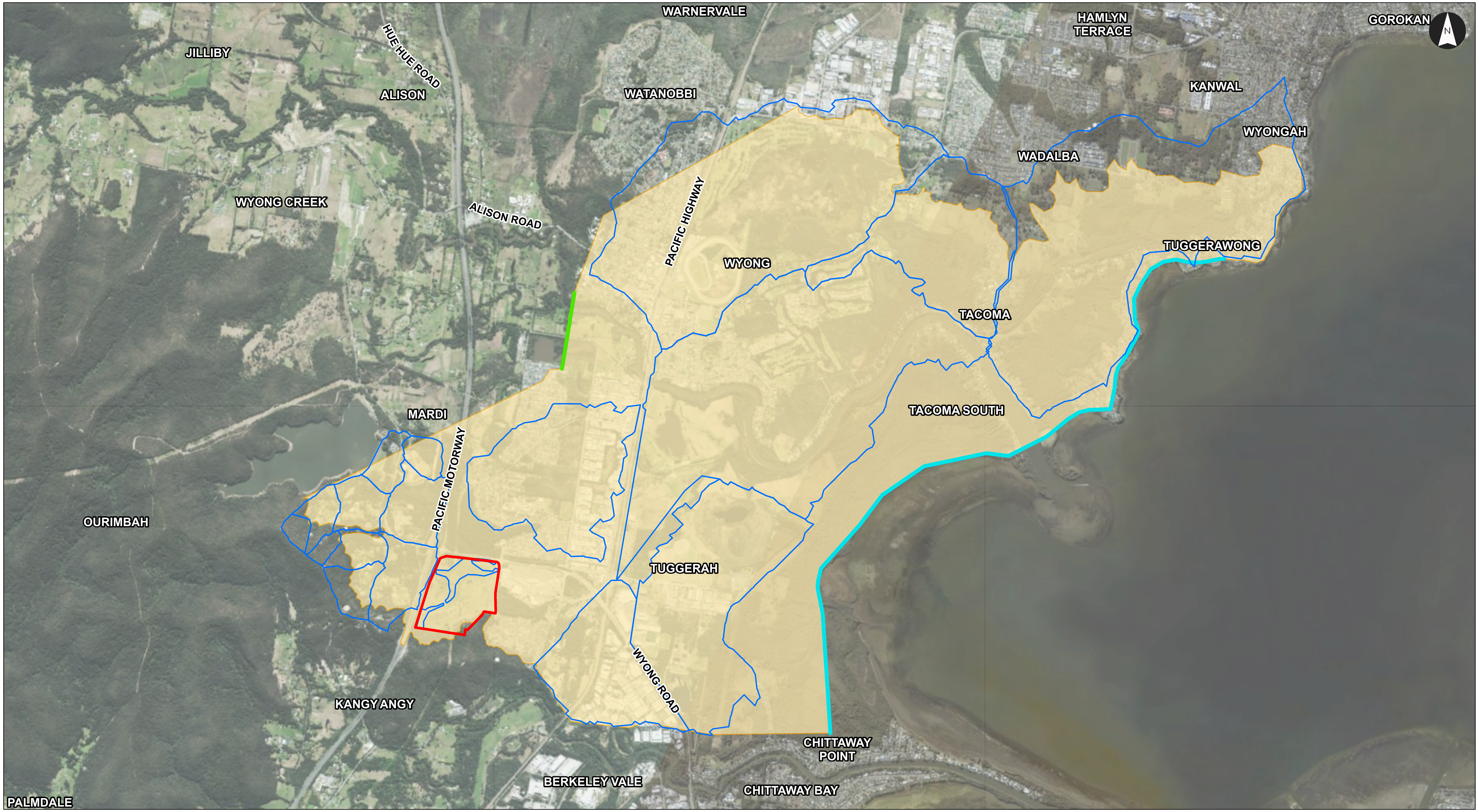
1:5,000 @ A3

**DATE:** 03 MAY 2023
**JOB NO:** P0033029
**REV:** 1

# Appendix B:

TUFLOW SCHEMATIC

We design with community in mind




# TUFLOW Schematic

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

**Legend**

- Site Boundary
- 2d_bc inflows
- Downstream Boundary
- 2d_sa inflows
- Model Extent

*Project Code: 8202120301-GS-030*
*Drawn By: MMM, Checked By: AES*
*Rev: 02*
*Date: 2023-06-15*

Stantec SCENTRE GROUP

*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*

0 500 1,000 1,500 2,000 Metres
Scale at A3: 1:35,000

# Appendix C:
WATER LEVEL DEPTH VELOCITY

We design with community in mind


# Existing Flood Extent
# 20% AEP

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

*Project Code: 8202120301-GS-003*
*Drawn By: MMM, Checked By: AES*
*Rev: 02*
*Date: 2023-05-31*

Stantec

SCENTRE GROUP

**Legend**

- Site Boundary
- Watercourse
- 0.5m Flood Height Contour (m AHD)
- Cadastre

**Flood Depth (m)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- 1.25 - 1.50
- > 1.50

*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

0 50 100 150 200 250 Metres

Scale at A3: 1:5,000

NEWCASTLE
TUGGERAH
SYDNEY


# Existing Flood Extent 5% AEP

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

Project Code: 8202120301-GS-001
Drawn By: MMM, Checked By: AES
Rev: 02
Date: 2023-05-31

**Legend**

- Site Boundary
- Watercourse
- 0.5m Flood Height Contour (m AHD)
- Cadastre

**Flood Depth (m)**

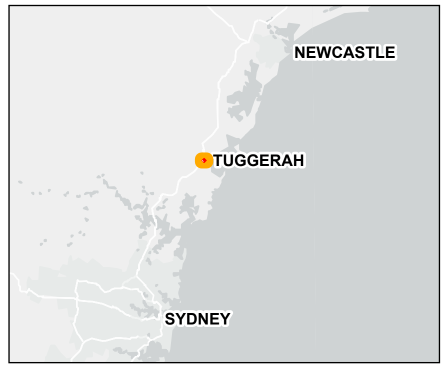
- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- 1.25 - 1.50
- > 1.50

*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

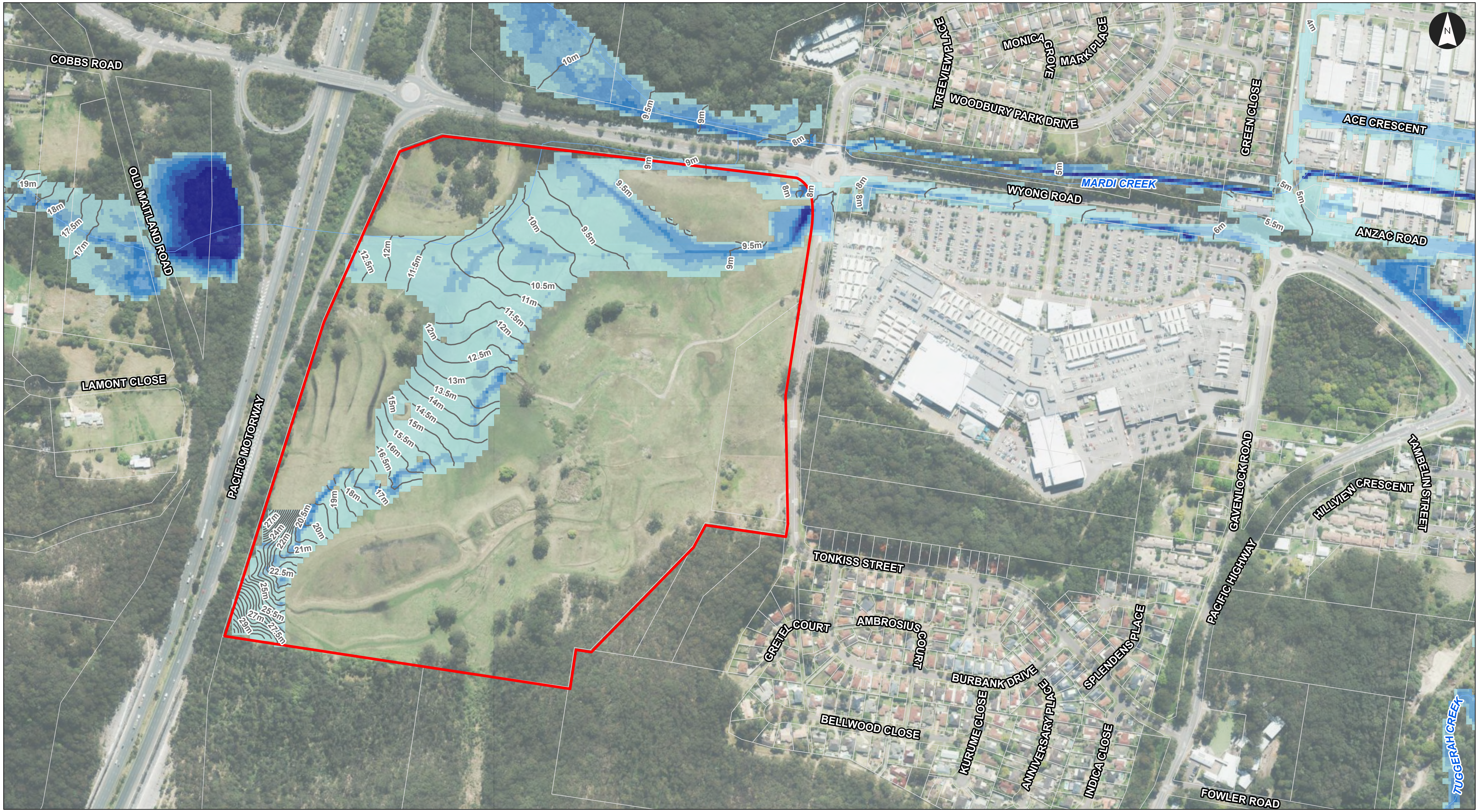
0 50 100 150 200 250 Metres

Scale at A3: 1:5,000




Stantec

SCENTRE GROUP




# Existing Flood Extent 1% AEP

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

Project Code: 8202120301-GS-001
Drawn By: MMM, Checked By: AES
Rev: 02
Date: 2023-05-31

**Legend**

- Site Boundary
- Watercourse
- 0.5m Flood Height Contour (m AHD)
- Cadastre

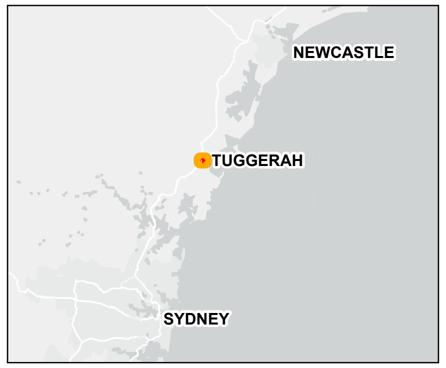
**Flood Depth (m)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- 1.25 - 1.50
- > 1.50

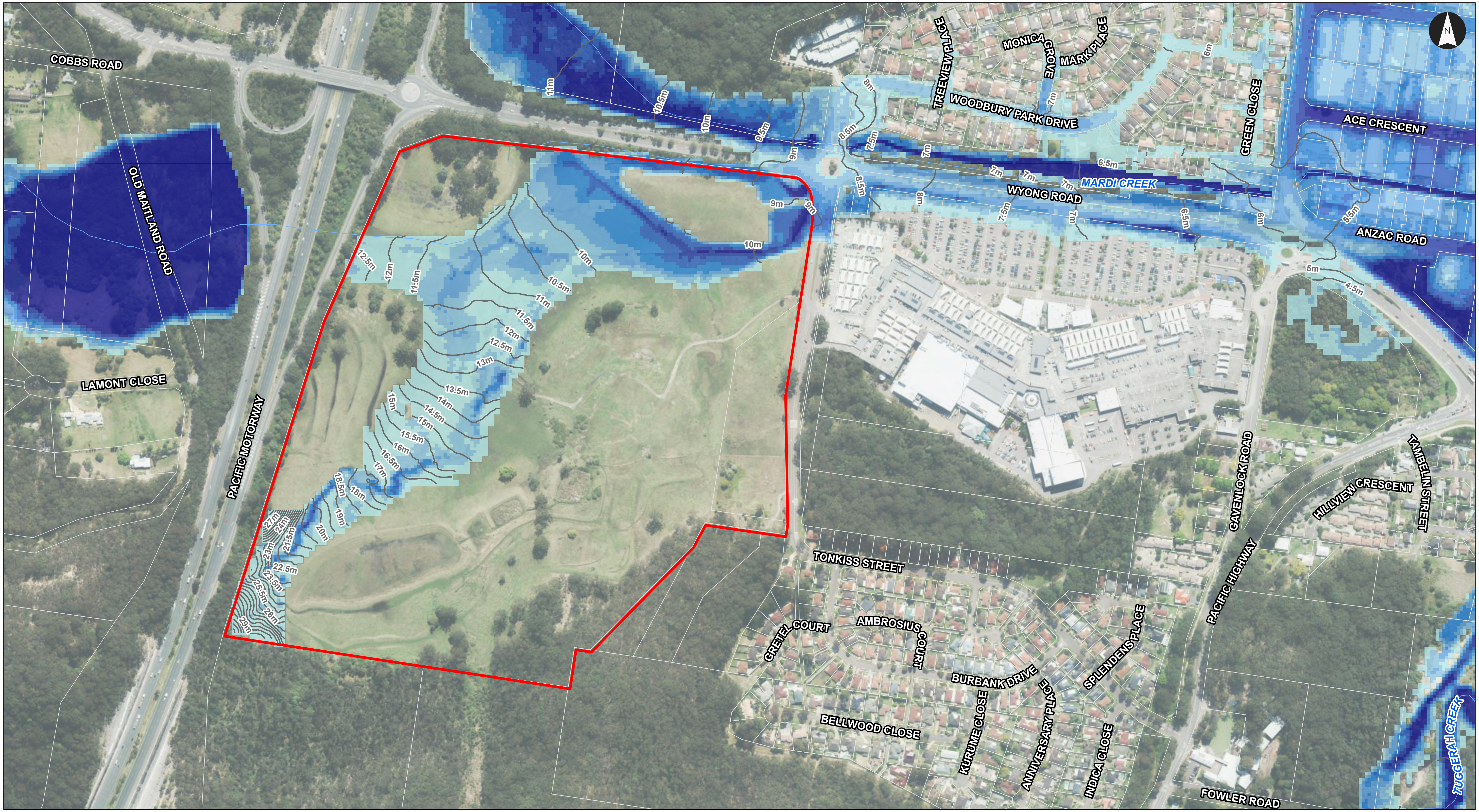
*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

0 50 100 150 200 250 Metres
Scale at A3: 1:5,000




Stantec
SCENTRE GROUP




# Existing Flood Extent PMF

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

Project Code: 8202120301-GS-004
Drawn By: MMM, Checked By: AES
Rev: 02
Date: 2023-05-31

**Legend**

- Site Boundary
- Watercourse
- 0.5m Flood Height Contour (m AHD)
- Cadastre

**Flood Depth (m)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- 1.25 - 1.50
- > 1.50

*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

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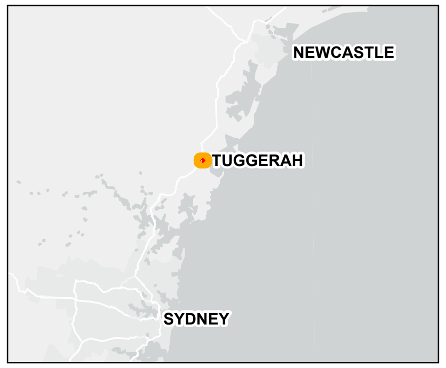
Scale at A3: 1:5,000




Stantec

SCENTRE GROUP


# Existing Flood Velocity 20% AEP

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

*Project Code: 8202120301-GS-005*
*Drawn By: MMM, Checked By: AES*
*Rev: 02*
*Date: 2023-05-31*

**Legend**

- Site Boundary
- Watercourse
- Cadastre

**Flood Velocity (m/s)**

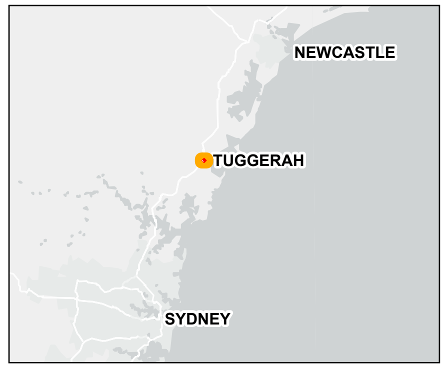
- 0 - 1
- 1 - 2
- 2 - 3
- > 3

*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

0 50 100 150 200 250 Metres

Scale at A3: 1:5,000




Stantec

SCENTRE GROUP


# Existing Flood Velocity 5% AEP

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

*Project Code: 8202120301-GS-006*
*Drawn By: MMM, Checked By: AES*
*Rev: 02*
*Date: 2023-05-31*

**Legend**

- Site Boundary
- Watercourse
- Cadastre

**Flood Velocity (m/s)**

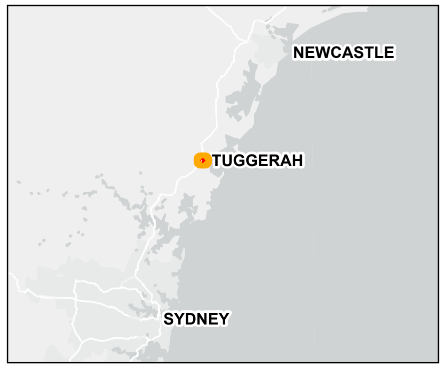
- 0 - 1
- 1 - 2
- 2 - 3
- > 3

*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

0 50 100 150 200 250 Metres

Scale at A3: 1:5,000




Stantec

SCENTRE GROUP


# Existing Flood Velocity 1% AEP

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

*Project Code: 8202120301-GS-005*
*Drawn By: MMM, Checked By: AES*
*Rev: 02*
*Date: 2023-05-31*

**Legend**

- Site Boundary
- Watercourse
- Cadastre

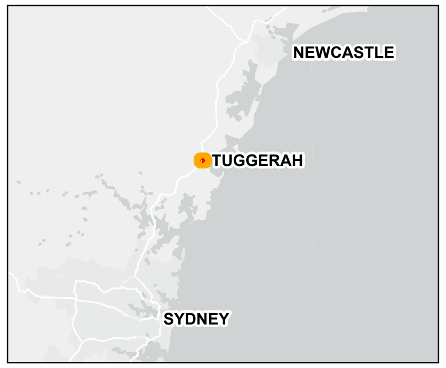
**Flood Velocity (m/s)**

- 0 - 1
- 1 - 2
- 2 - 3
- > 3

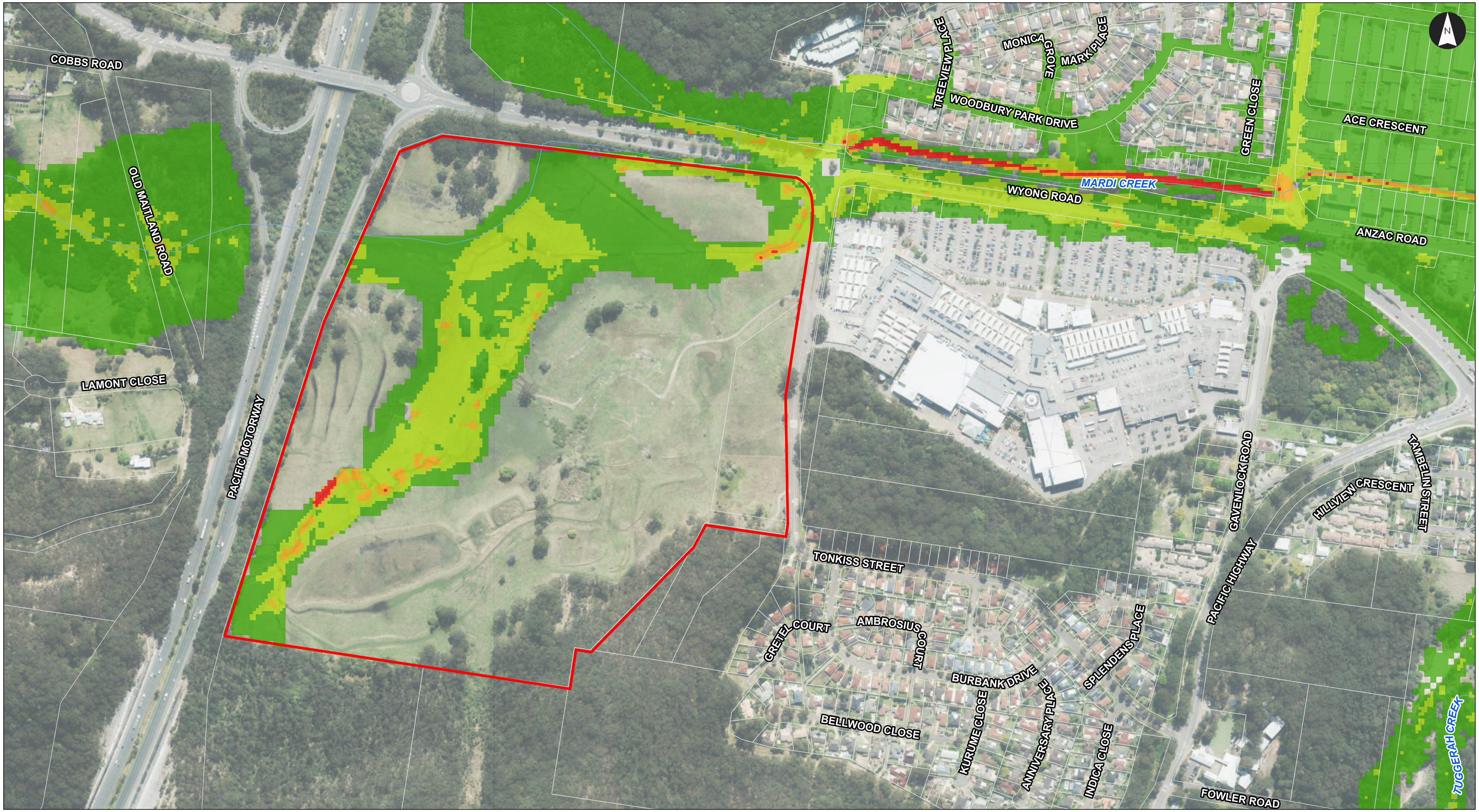
*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

0 50 100 150 200 250 Metres
Scale at A3: 1:5,000




Stantec
SCENTRE GROUP




# Existing Flood Velocity PMF

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

*Project Code: 8202120301-GS-008*
*Drawn By: MMM, Checked By: AES*
*Rev: 02*
*Date: 2023-05-31*

**Legend**

- Site Boundary
- Watercourse
- Cadastre

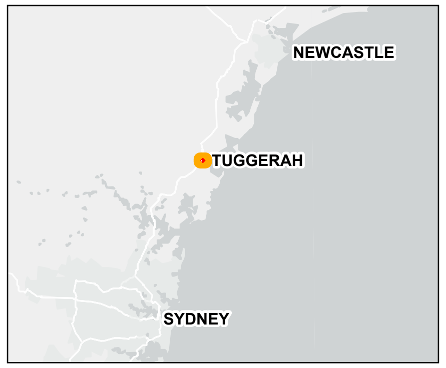
**Flood Velocity (m/s)**

- 0 - 1
- 1 - 2
- 2 - 3
- > 3

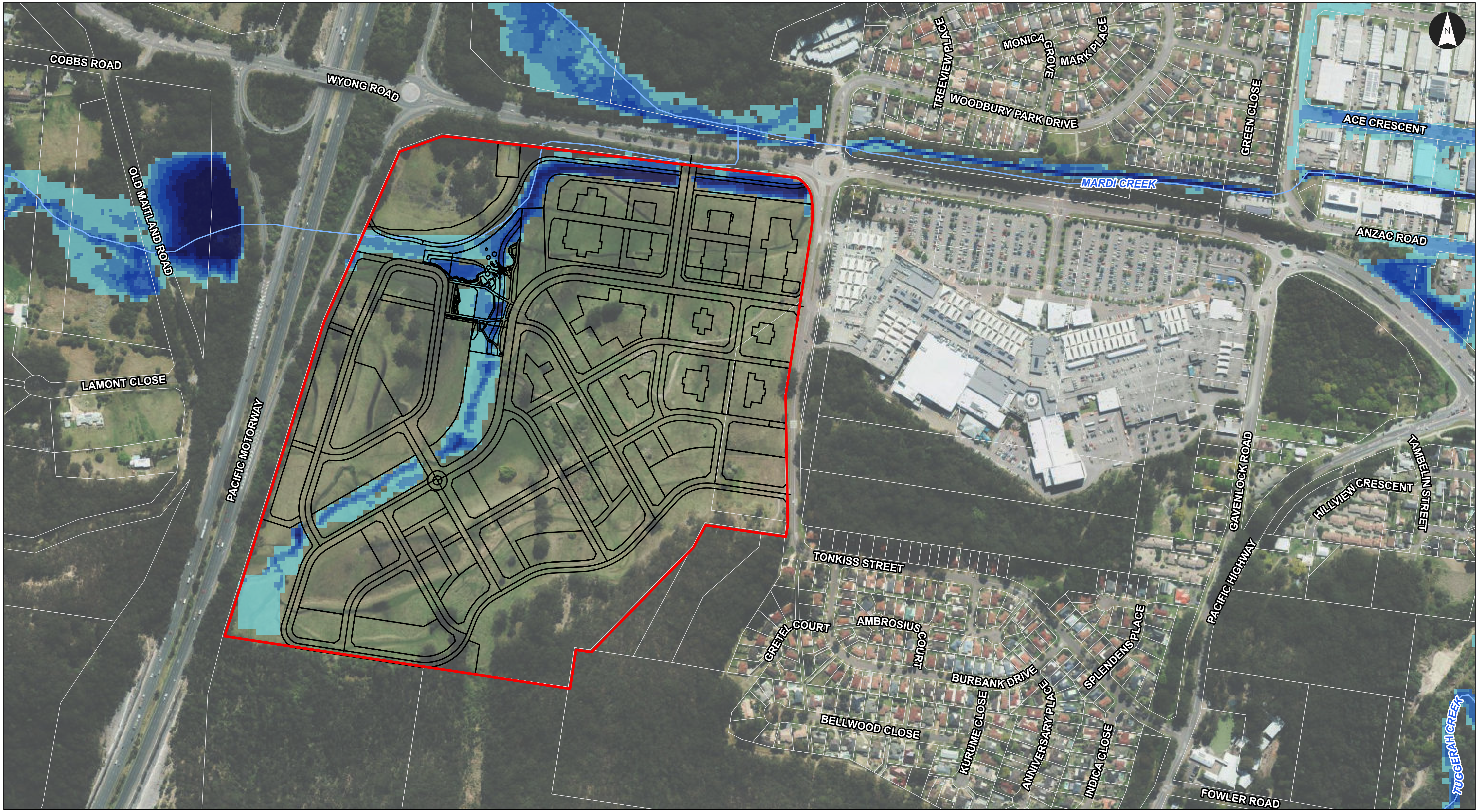
*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

0 50 100 150 200 250 Metres
Scale at A3: 1:5,000




Stantec
SCENTRE GROUP




# Proposed Flood Extent
## 1% AEP

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

*Project Code: 8202120301-GS-013*
*Drawn By: JML, Checked By: MMM*
*Rev: 04*
*Date: 2024-02-19*

**Legend**

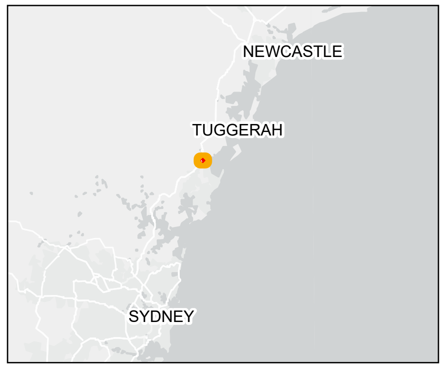
- Site Boundary
- Proposed Lot Layout
- Watercourse
- Cadastre

**Flood Depth (m)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- 1.25 - 1.50
- > 1.50

*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

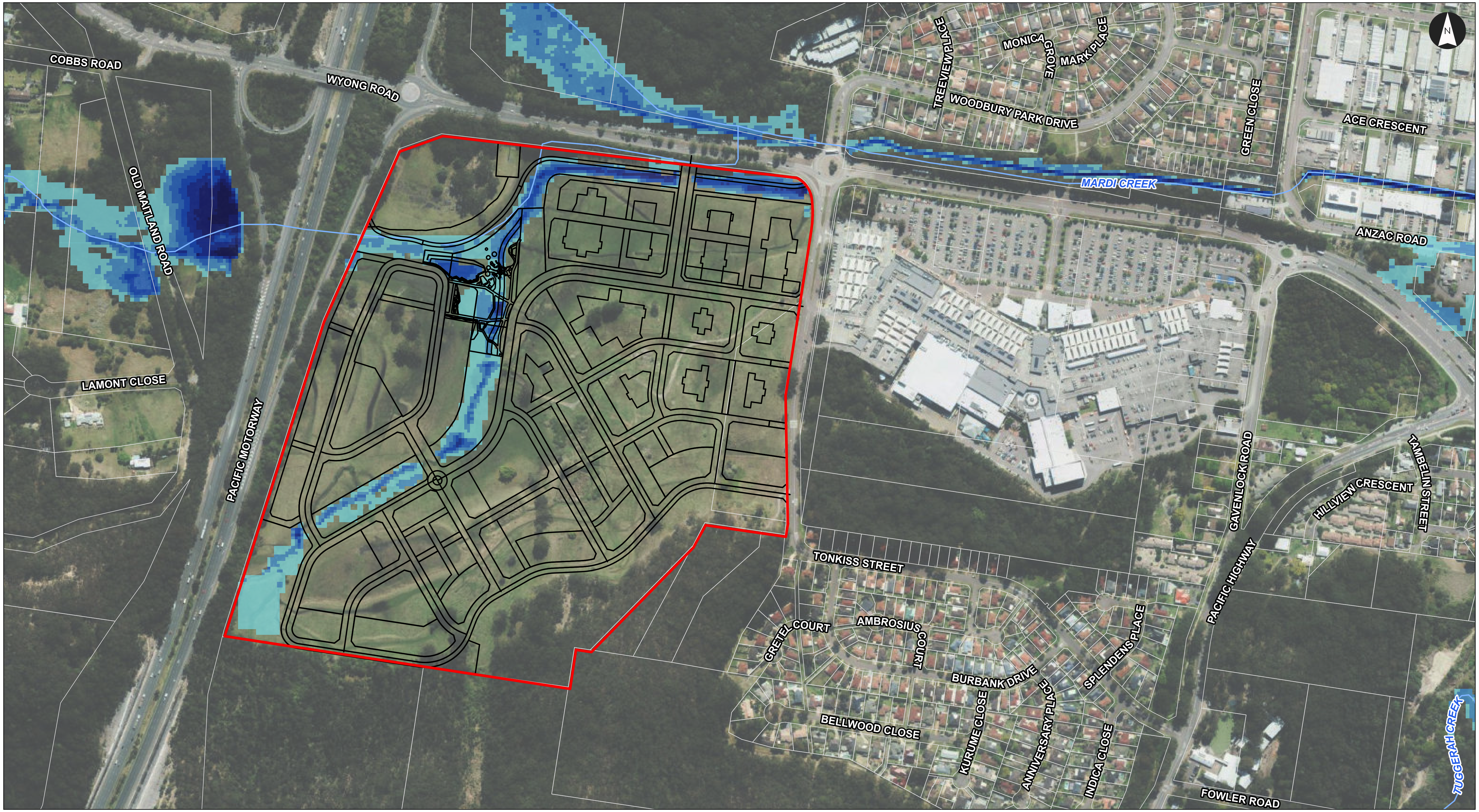



0 50 100 150 200 250 Metres

Scale at A3: 1:5,000

Stantec

SCENTRE GROUP




# Proposed Flood Extent
## 5% AEP

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

*Project Code: 8202120301-GS-014*
*Drawn By: JML, Checked By: MMM*
*Rev: 04*
*Date: 2024-02-19*

Stantec
SCENTRE GROUP

**Legend**

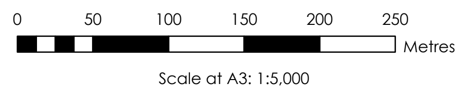
- Site Boundary
- Proposed Lot Layout
- Watercourse
- Cadastre

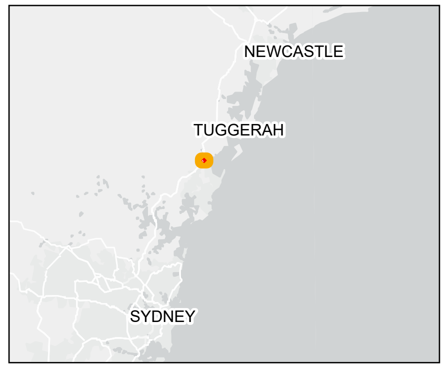
**Flood Depth (m)**

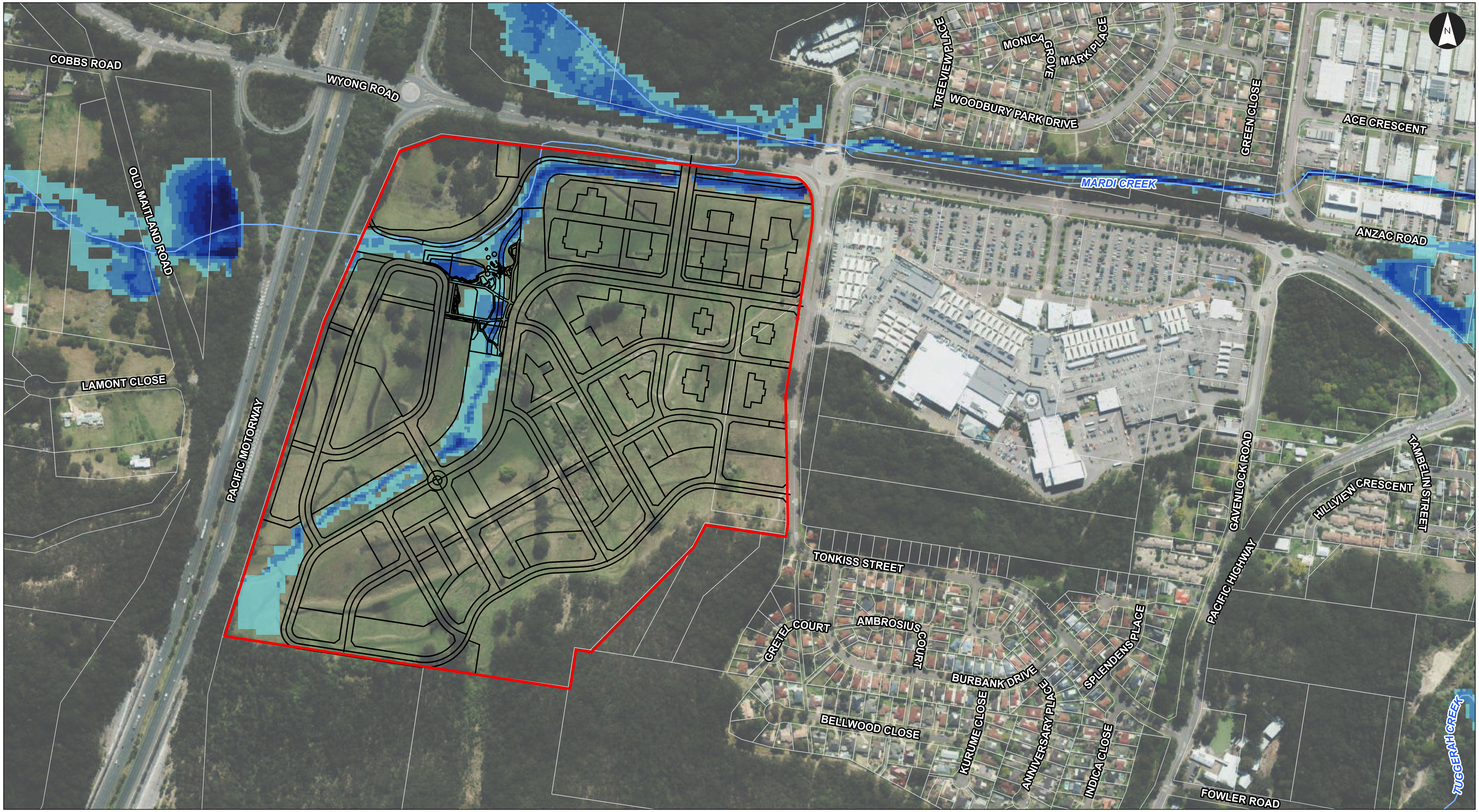
- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- 1.25 - 1.50
- > 1.50

*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*






# Proposed Flood Extent
## 20% AEP

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

*Project Code: 8202120301-GS-015*
*Drawn By: JML, Checked By: MMM*
*Rev: 04*
*Date: 2024-02-19*

Stantec | SCENTRE GROUP

**Legend**

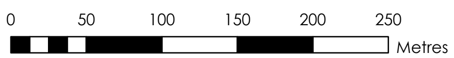
- Site Boundary
- Proposed Lot Layout
- Watercourse
- Cadastre

**Flood Depth (m)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- 1.25 - 1.50
- > 1.50

*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

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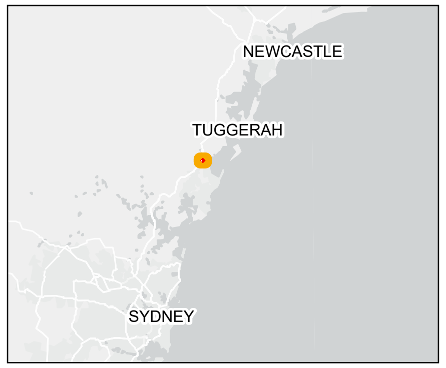
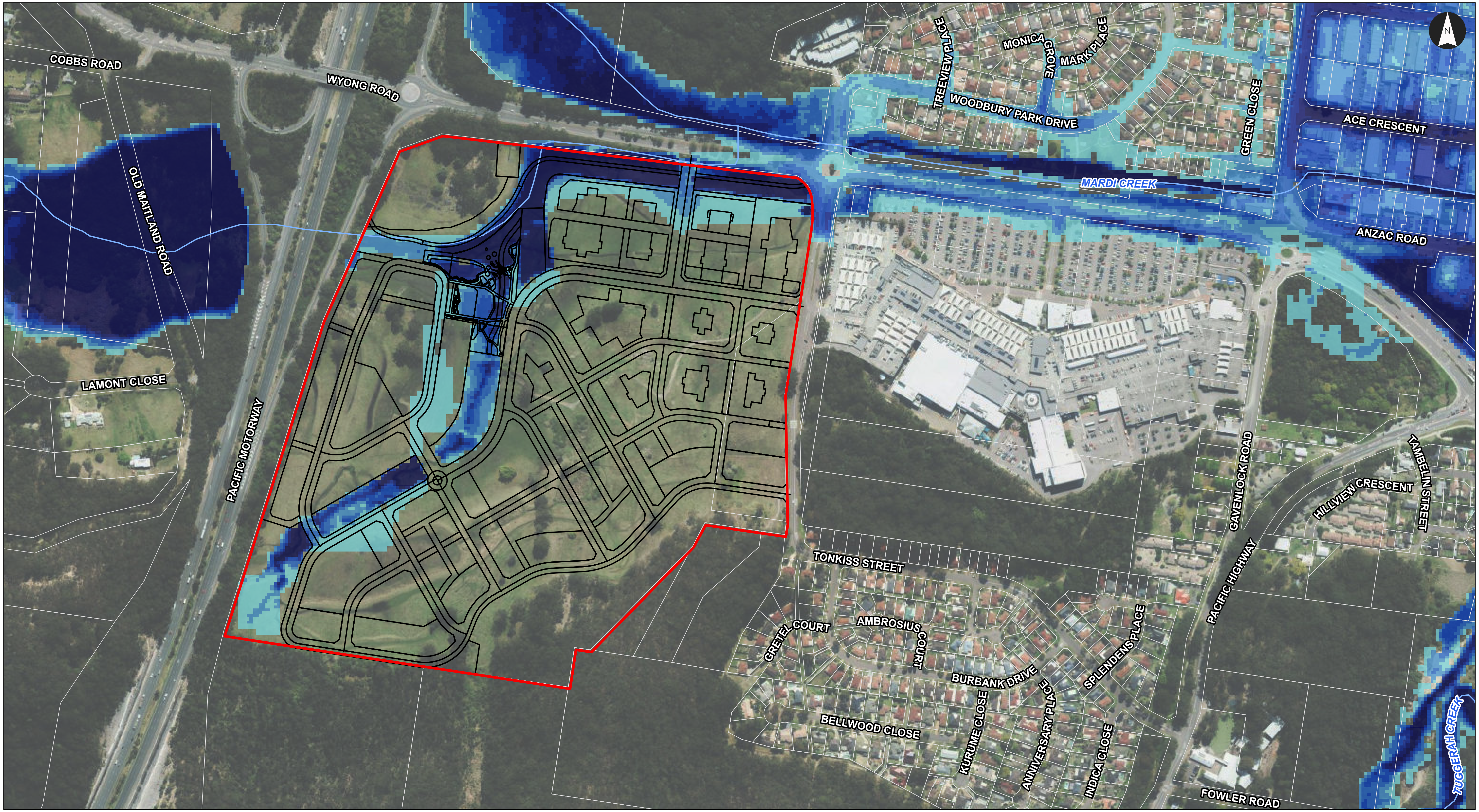





# Proposed Flood Extent PMF

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

*Project Code: 8202120301-GS-016*
*Drawn By: JML, Checked By: MMM*
*Rev: 04*
*Date: 2024-02-19*

Stantec
SCENTRE GROUP

**Legend**

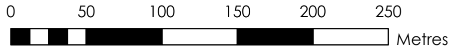
- Site Boundary
- Proposed Lot Layout
- Watercourse
- Cadastre

**Flood Depth (m)**

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- 1.25 - 1.50
- > 1.50

*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

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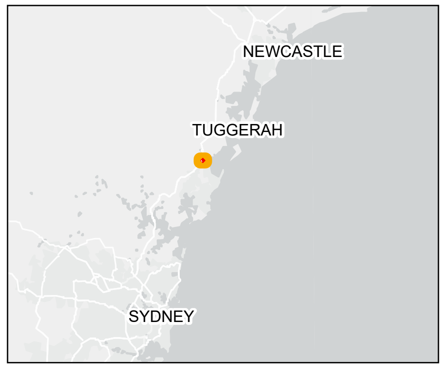
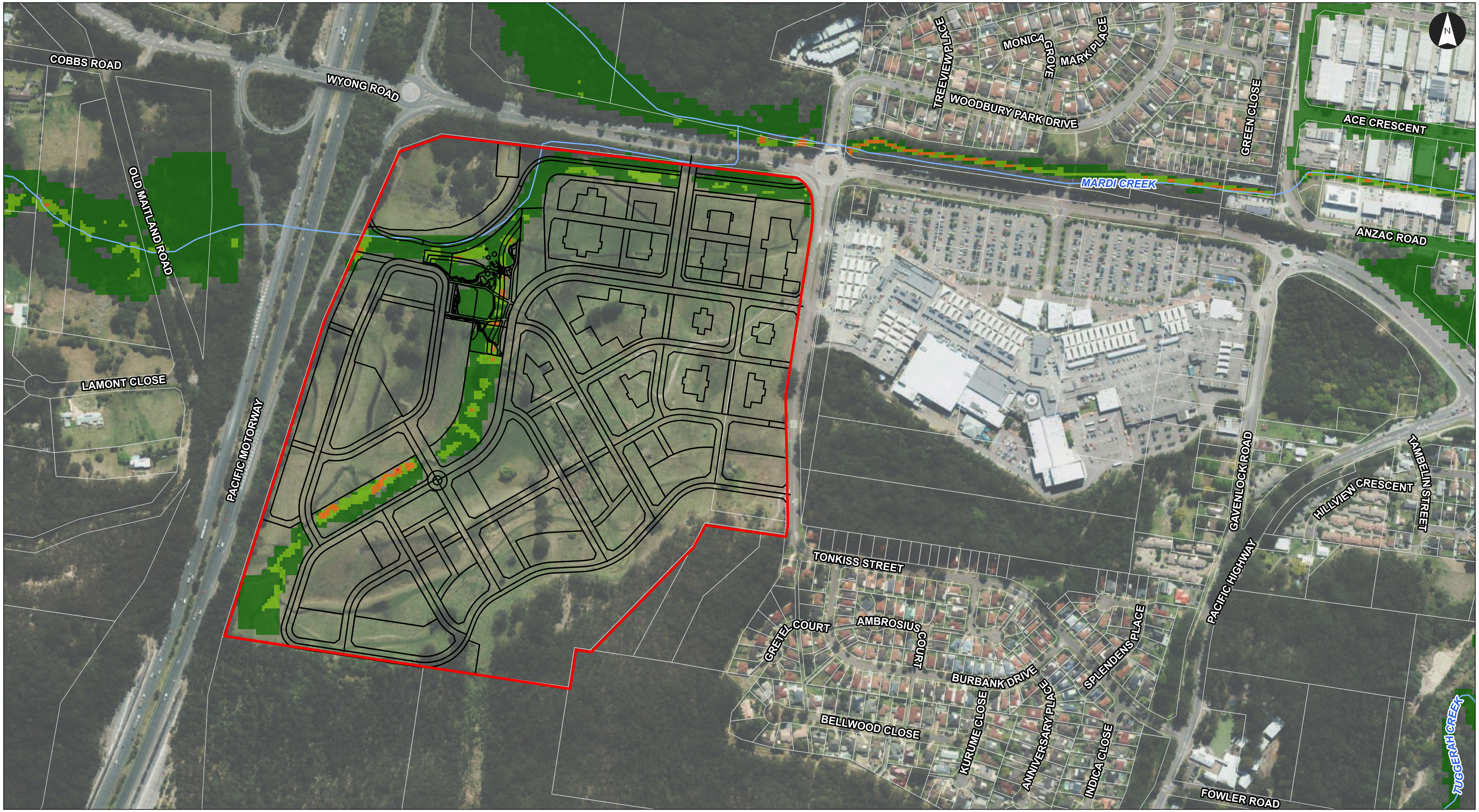





# Proposed Flood Velocity 1% AEP

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

*Project Code: 8202120301-GS-017*
*Drawn By: JML, Checked By: MMM*
*Rev: 04*
*Date: 2024-02-19*

**Legend**

- Site Boundary
- Proposed Lot Layout
- Watercourse
- Cadastre

**Flood Velocity (m/s)**

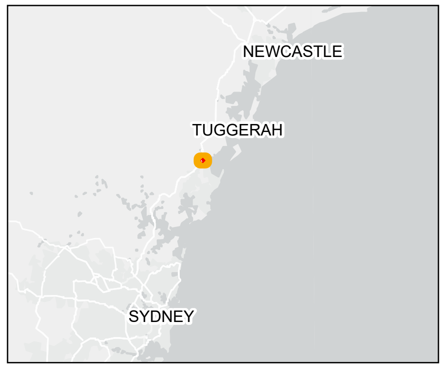
- 0 - 1
- 1 - 2
- 2 - 3
- > 3

*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

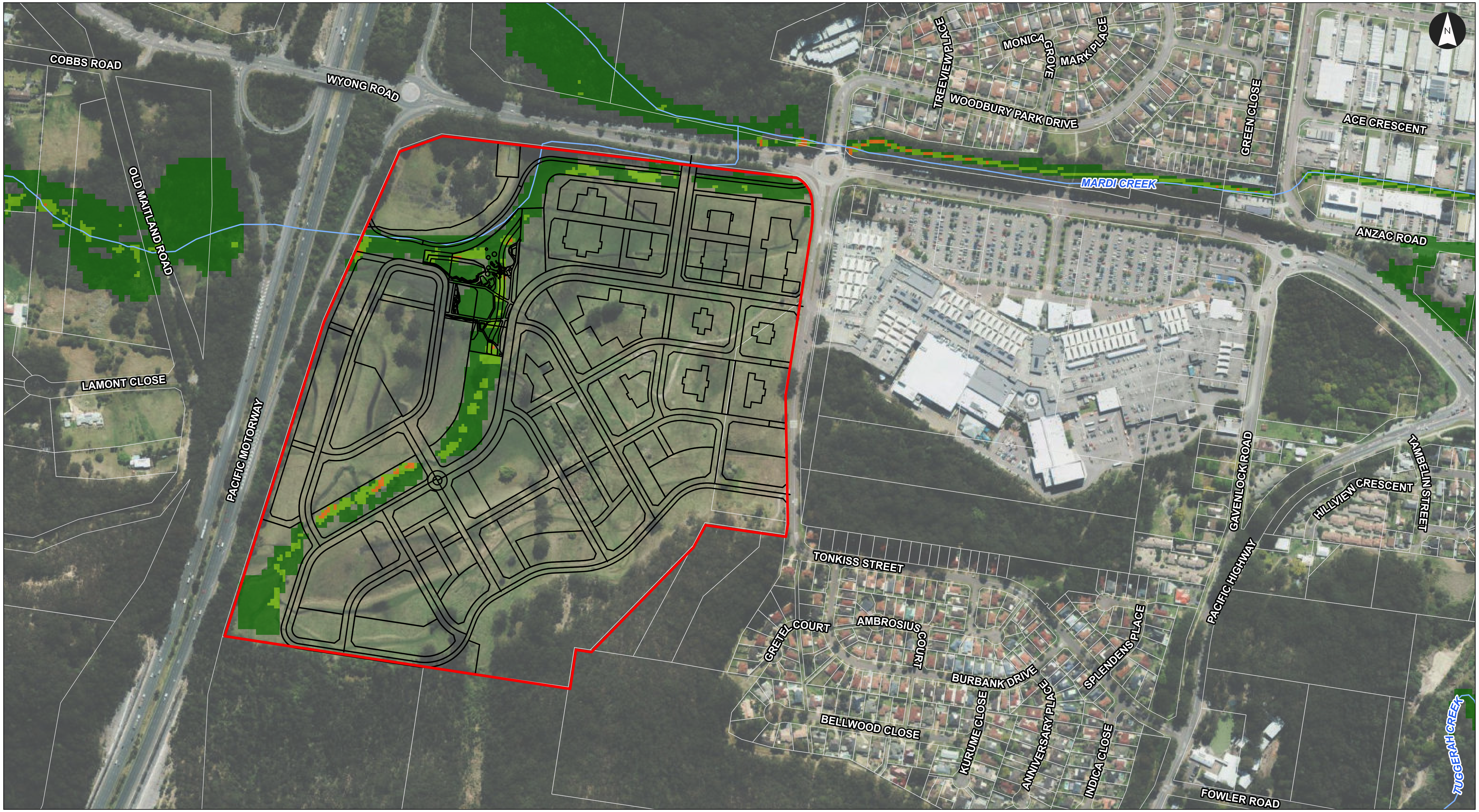
*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

0 50 100 150 200 250 Metres

Scale at A3: 1:5,000




Stantec SCENTRE GROUP




# Proposed Flood Velocity 5% AEP

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

*Project Code: 8202120301-GS-018*
*Drawn By: JML, Checked By: MMM*
*Rev: 04*
*Date: 2024-02-19*

Stantec
SCENTRE GROUP

**Legend**

- Site Boundary
- Proposed Lot Layout
- Watercourse
- Cadastre

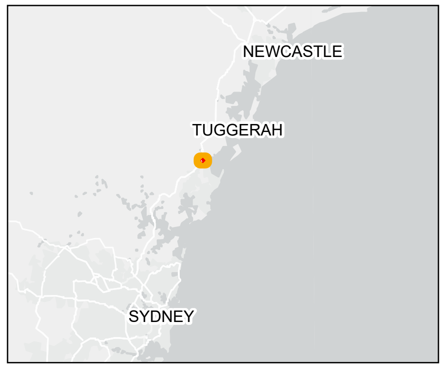
**Flood Velocity (m/s)**

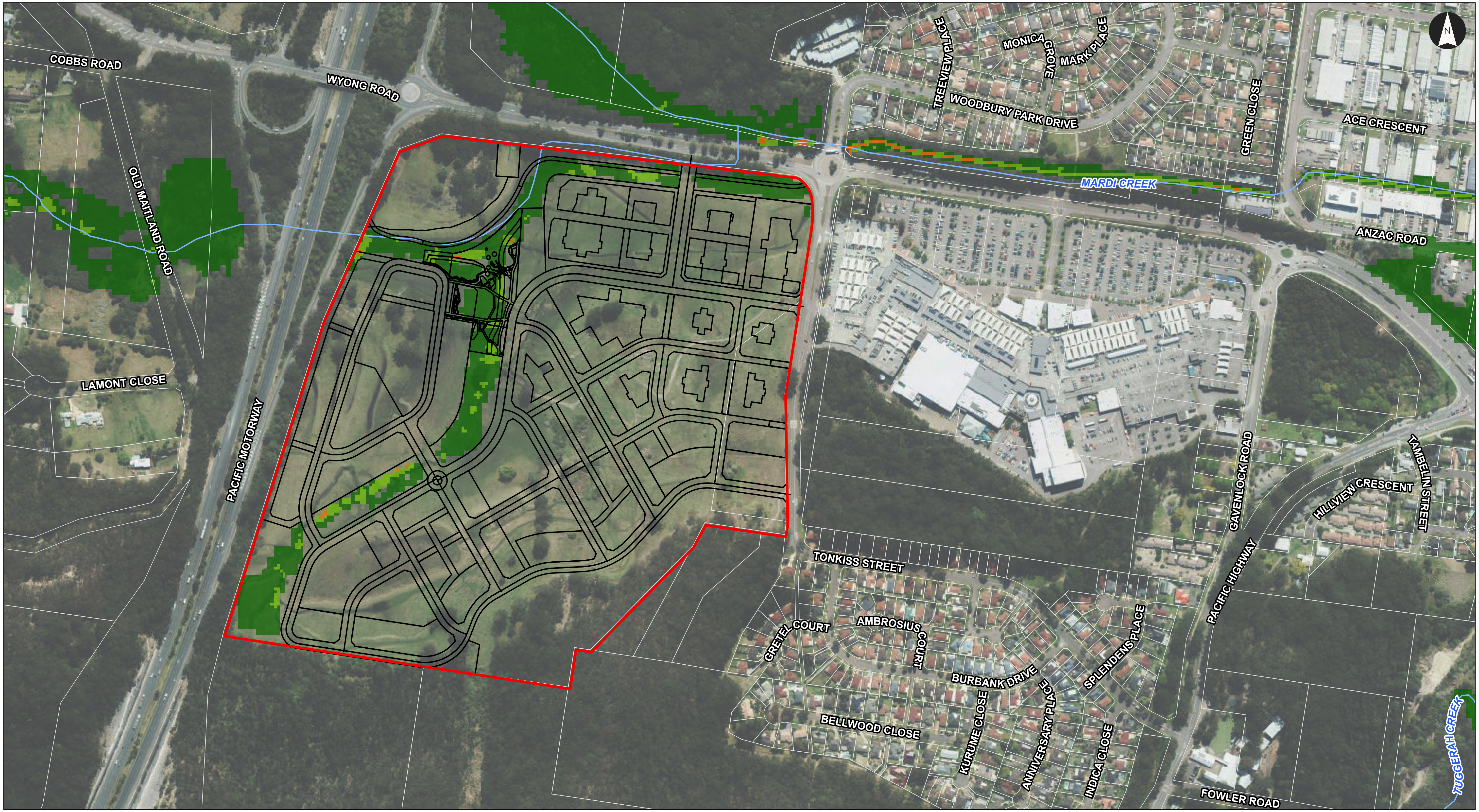
- 0 - 1
- 1 - 2
- 2 - 3
- > 3

*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

0 50 100 150 200 250 Metres
Scale at A3: 1:5,000






# Proposed Flood Velocity 20% AEP

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

*Project Code: 8202120301-GS-019*
*Drawn By: JML, Checked By: MMM*
*Rev: 04*
*Date: 2024-02-19*

**Legend**

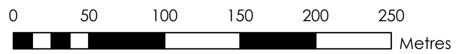
- Site Boundary
- Proposed Lot Layout
- Watercourse
- Cadastre

**Flood Velocity (m/s)**

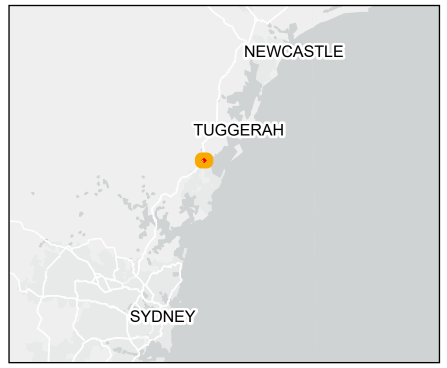
- 0 - 1
- 1 - 2
- 2 - 3
- > 3

*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*




Scale at A3: 1:5,000

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# Proposed Flood Velocity PMF

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

*Project Code: 8202120301-GS-020*
*Drawn By: JML, Checked By: MMM*
*Rev: 04*
*Date: 2024-02-19*

**Legend**

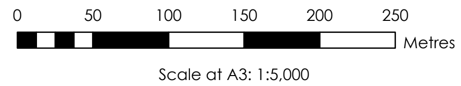
- Site Boundary
- Proposed Lot Layout
- Watercourse
- Cadastre

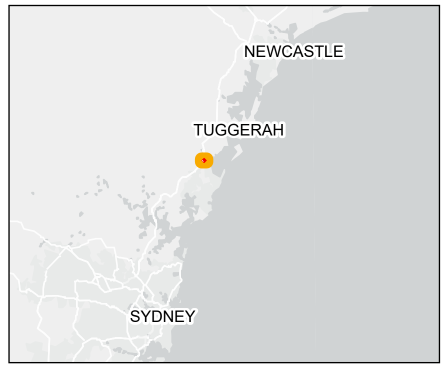
**Flood Velocity (m/s)**

- 0 - 1
- 1 - 2
- 2 - 3
- > 3

*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

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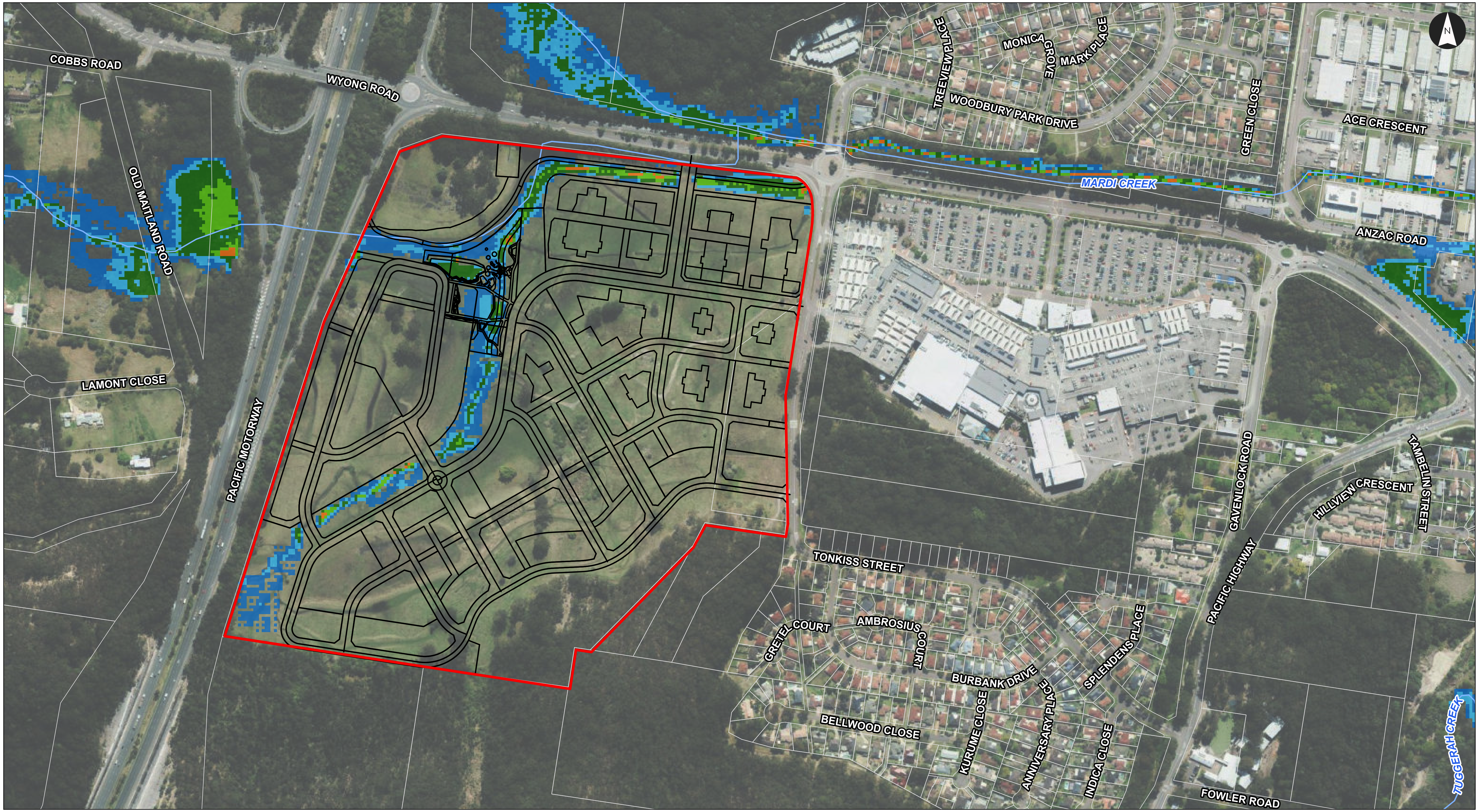
# Appendix D:

FLOOD IMPACT AND HAZARD

We design with community in mind




# Proposed Flood Hazard 20% AEP

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

*Project Code: 8202120301-GS-023*
*Drawn By: JML, Checked By: MMM*
*Rev: 05*
*Date: 2024-02-19*

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SCENTRE GROUP

**Legend**

- Site Boundary
- Proposed Lot Layout
- Watercourse
- Cadastre

**Flood Hazard**

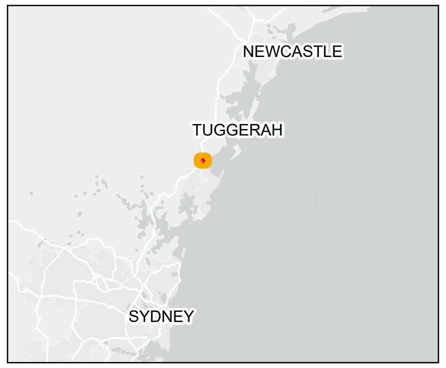
- H1 - Generally safe for vehicles, people, buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children, and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for behicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles people. All building types considered vulnerable to failure

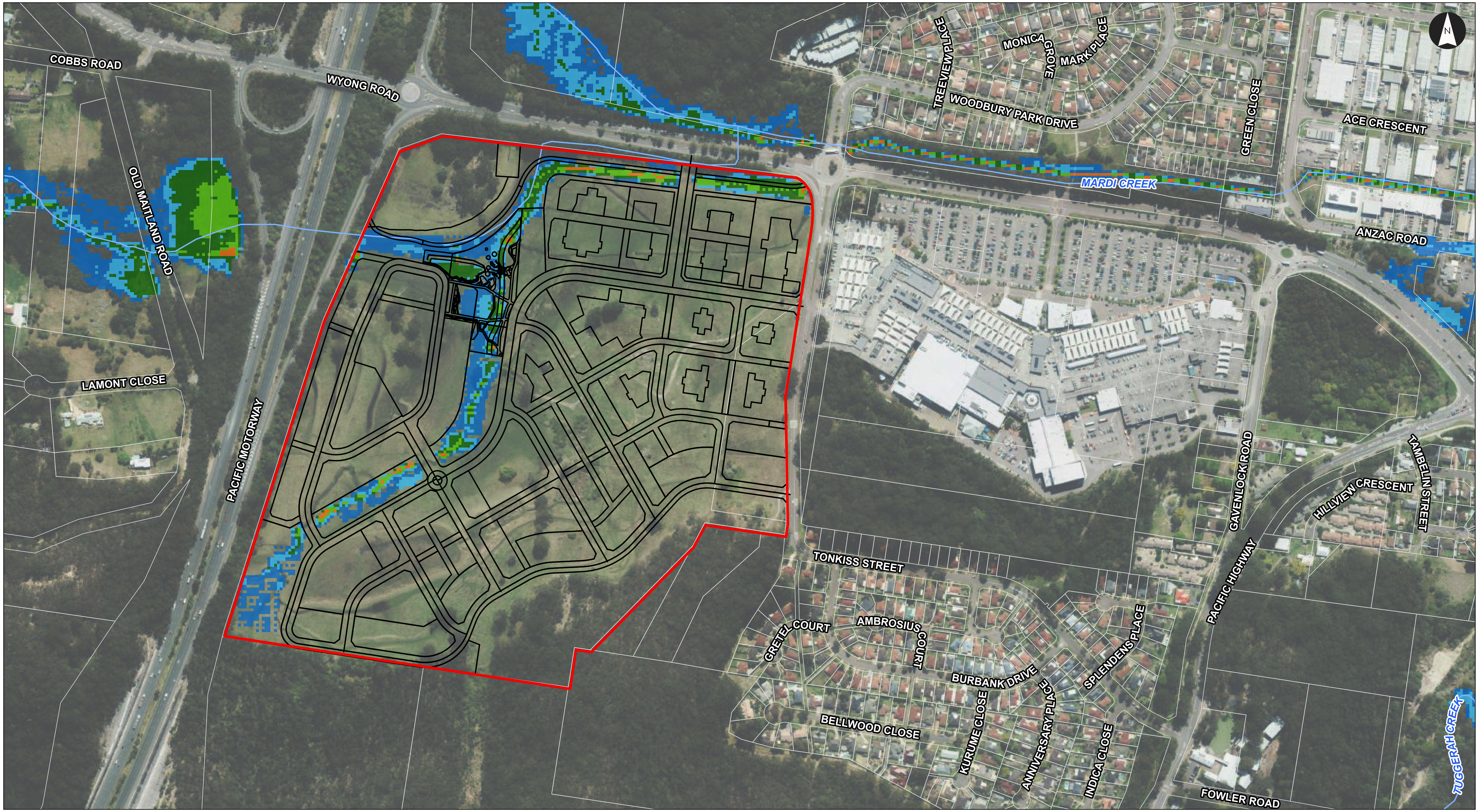
*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

0 50 100 150 200 250 Metres

Scale at A3: 1:5,000






# Proposed Flood Hazard 5% AEP

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

*Project Code: 8202120301-GS-022*
*Drawn By: JML, Checked By: MMM*
*Rev: 05*
*Date: 2024-02-19*

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SCENTRE GROUP

**Legend**

- Site Boundary
- Proposed Lot Layout
- Watercourse
- Cadastre

**Flood Hazard**

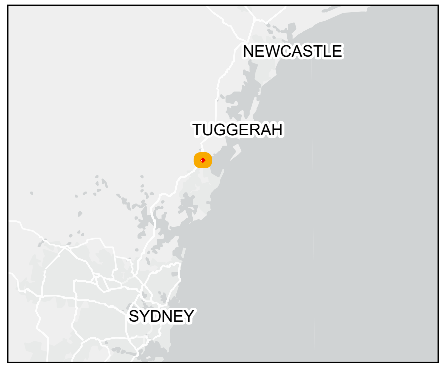
- H1 - Generally safe for vehicles, people, buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children, and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for behicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles people. All building types considered vulnerable to failure

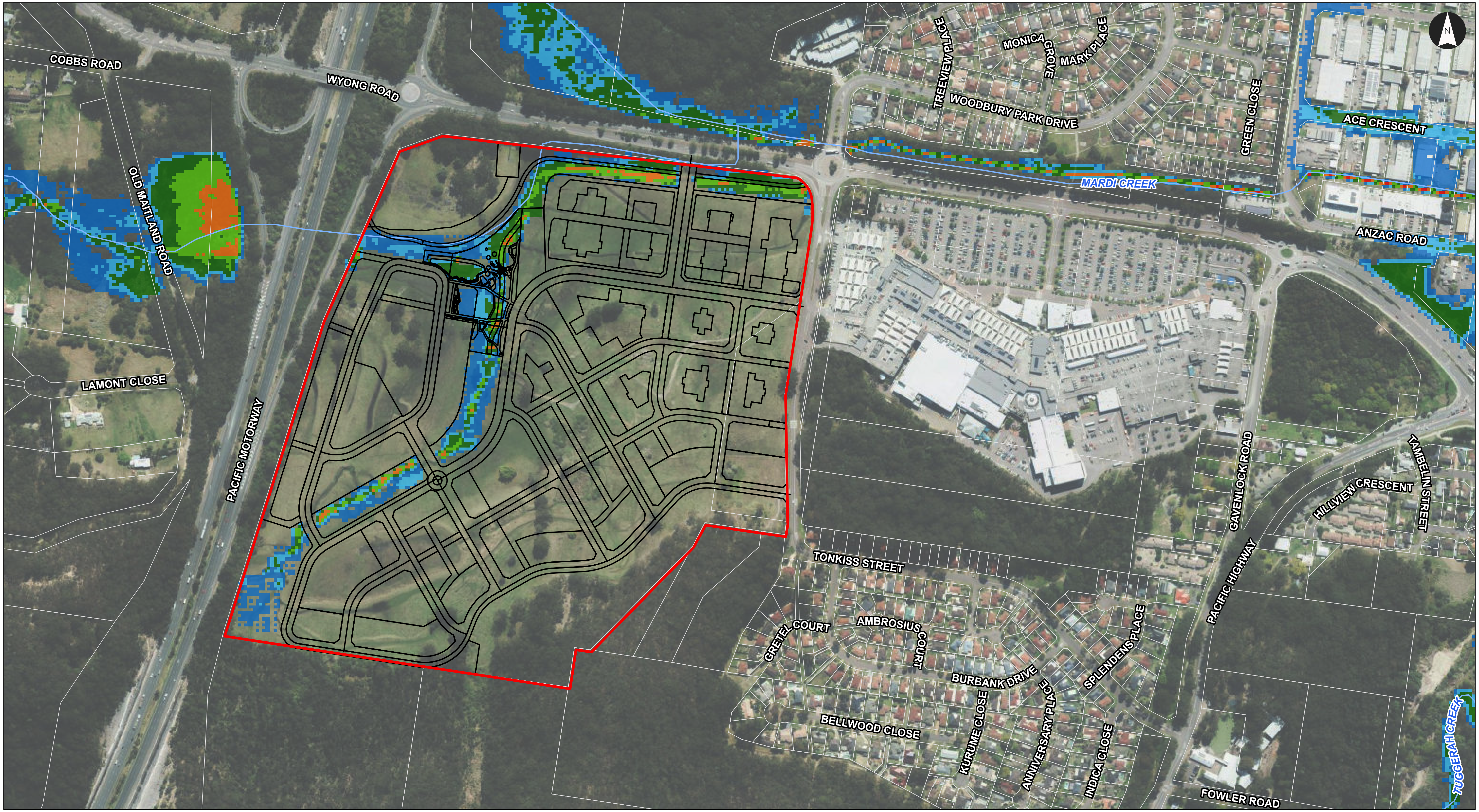
*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

0 50 100 150 200 250 Metres

Scale at A3: 1:5,000






# Proposed Flood Hazard 1% AEP

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

*Project Code: 8202120301-GS-021*
*Drawn By: JML, Checked By: MMM*
*Rev: 05*
*Date: 2024-02-19*

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SCENTRE GROUP

**Legend**

- Site Boundary
- Proposed Lot Layout
- Watercourse
- Cadastre

**Flood Hazard**

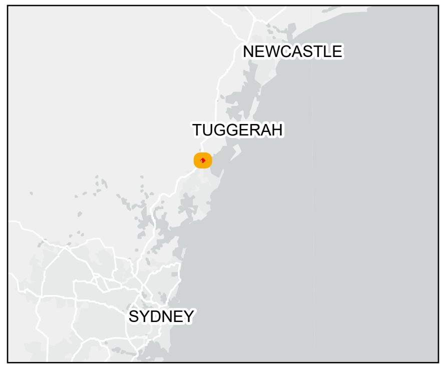
- H1 - Generally safe for vehicles, people, buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children, and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for behicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles people. All building types considered vulnerable to failure

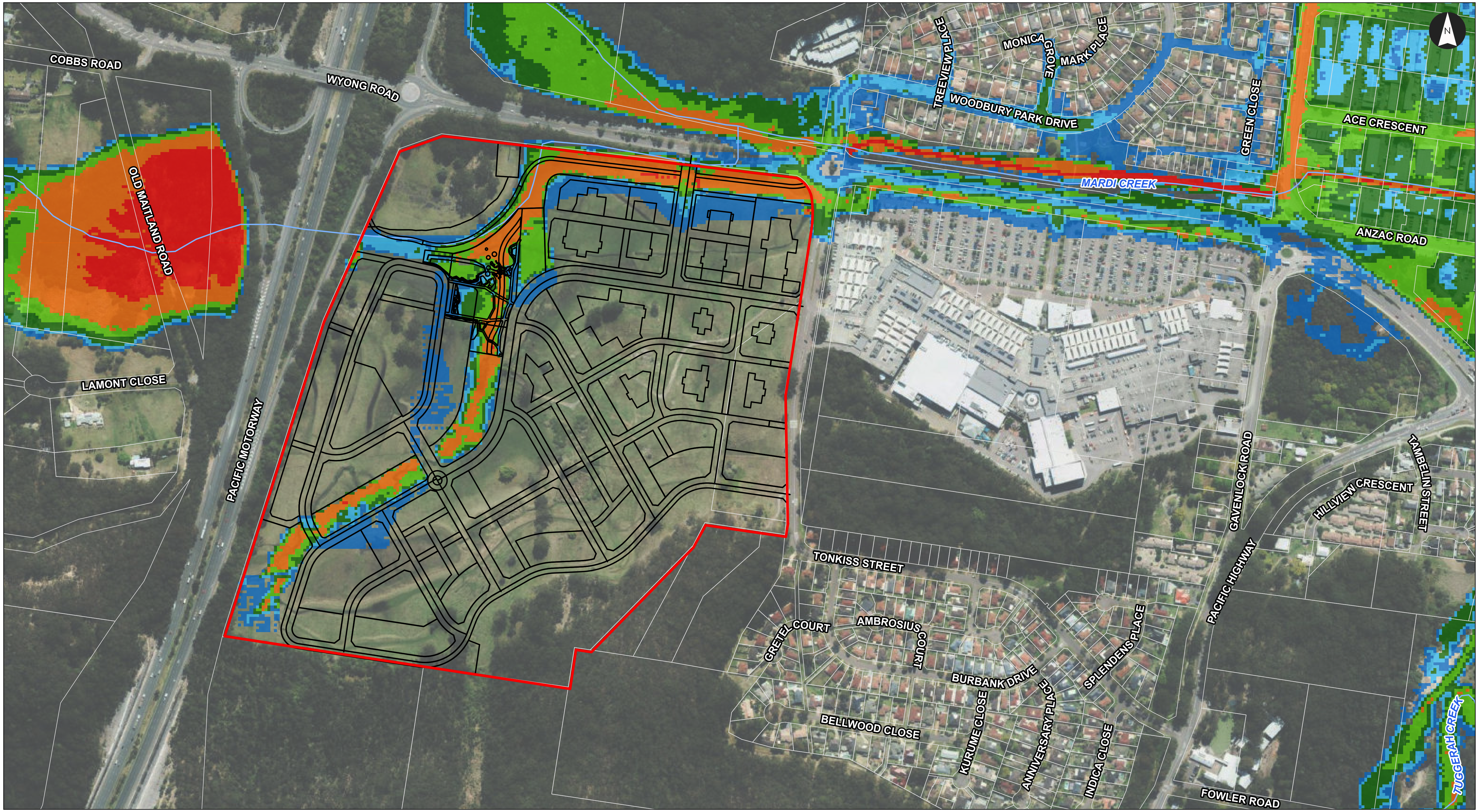
*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

0 50 100 150 200 250 Metres

Scale at A3: 1:5,000






# Proposed Flood Hazard PMF

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

*Project Code: 8202120301-GS-024*
*Drawn By: JML, Checked By: MMM*
*Rev: 05*
*Date: 2024-02-19*

**Legend**

- Site Boundary
- Proposed Lot Layout
- Watercourse
- Cadastre

**Flood Hazard**

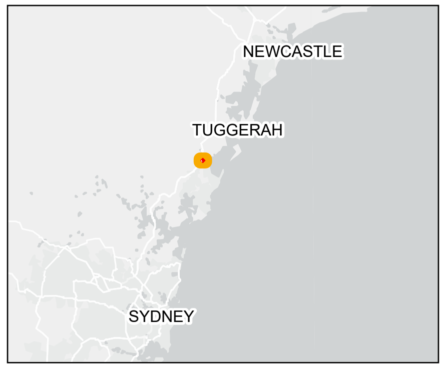
- H1 - Generally safe for vehicles, people, buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children, and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for behicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles people. All building types considered vulnerable to failure

*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

0 50 100 150 200 250 Metres

Scale at A3: 1:5,000

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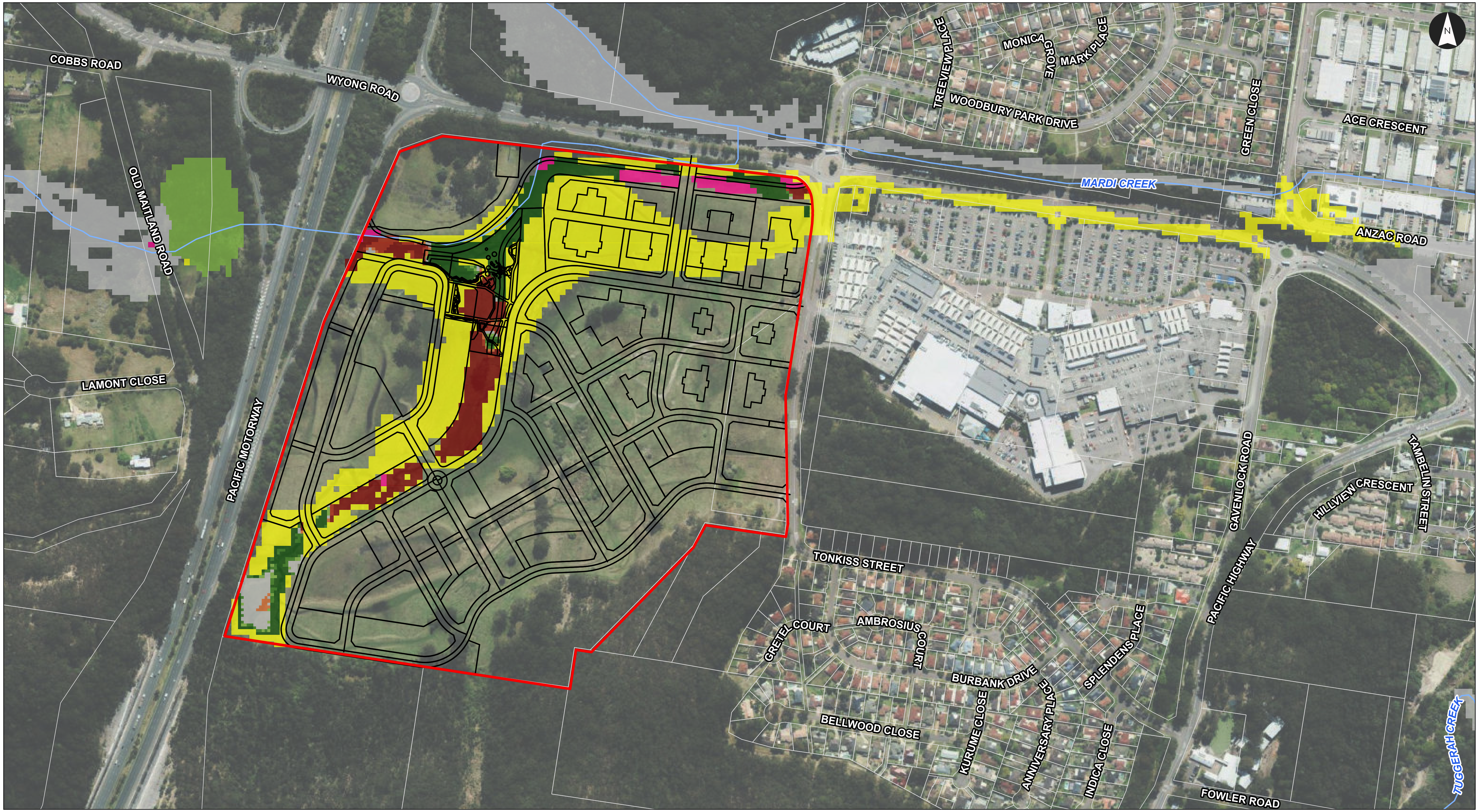


# Flood Impacts 20% AEP

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

*Project Code: 8202120301-GS-027*
*Drawn By: JML, Checked By: MMM*
*Rev: 06*
*Date: 2024-02-19*

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SCENTRE GROUP

**Legend**

- Site Boundary
- Proposed Lot Layout
- Watercourse
- Cadastre

**Change in Flood Levels (m)**

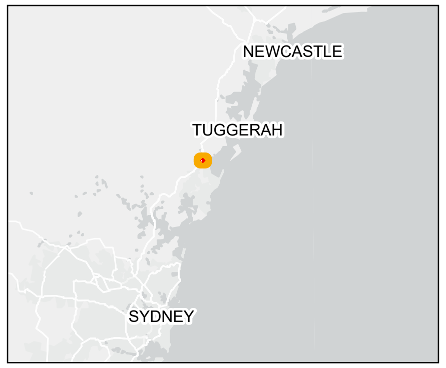
- Was Wet Now Dry
- < -0.1
- -0.1 to -0.05
- -0.05 to - 0.02
- -0.02 to 0.02
- 0.02 to 0.05
- 0.05 to 0.1
- > 0.1
- Was Dry Now Wet

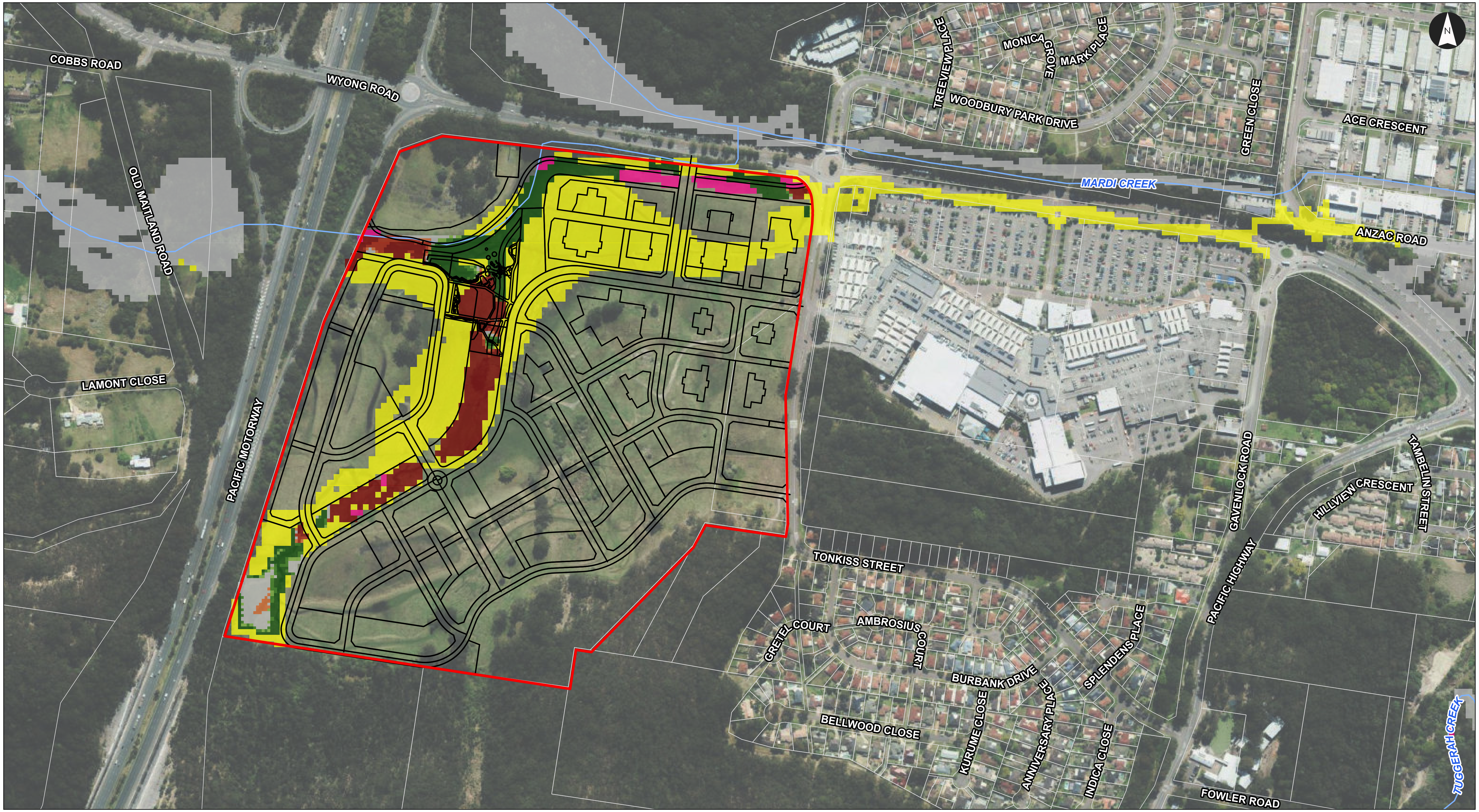
*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

0 50 100 150 200 250 Metres

Scale at A3: 1:5,000






# Flood Impacts 5% AEP

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

Project Code: 8202120301-GS-026
Drawn By: JML, Checked By: MMM
Rev: 05
Date: 2024-02-19

**Legend**

- Site Boundary
- Proposed Lot Layout
- Watercourse
- Cadastre

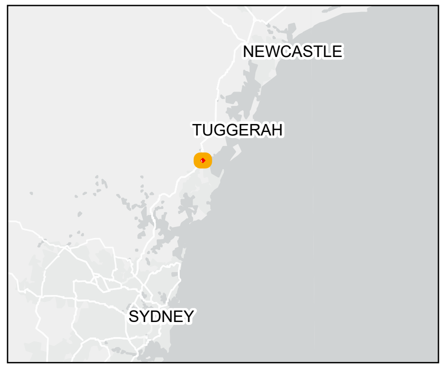
**Change in Flood Levels (m)**

- Was Wet Now Dry
- < -0.1
- -0.1 to -0.05
- -0.05 to - 0.02
- -0.02 to 0.02
- 0.02 to 0.05
- 0.05 to 0.1
- > 0.1
- Was Dry Now Wet

*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

0 50 100 150 200 250 Metres
Scale at A3: 1:5,000

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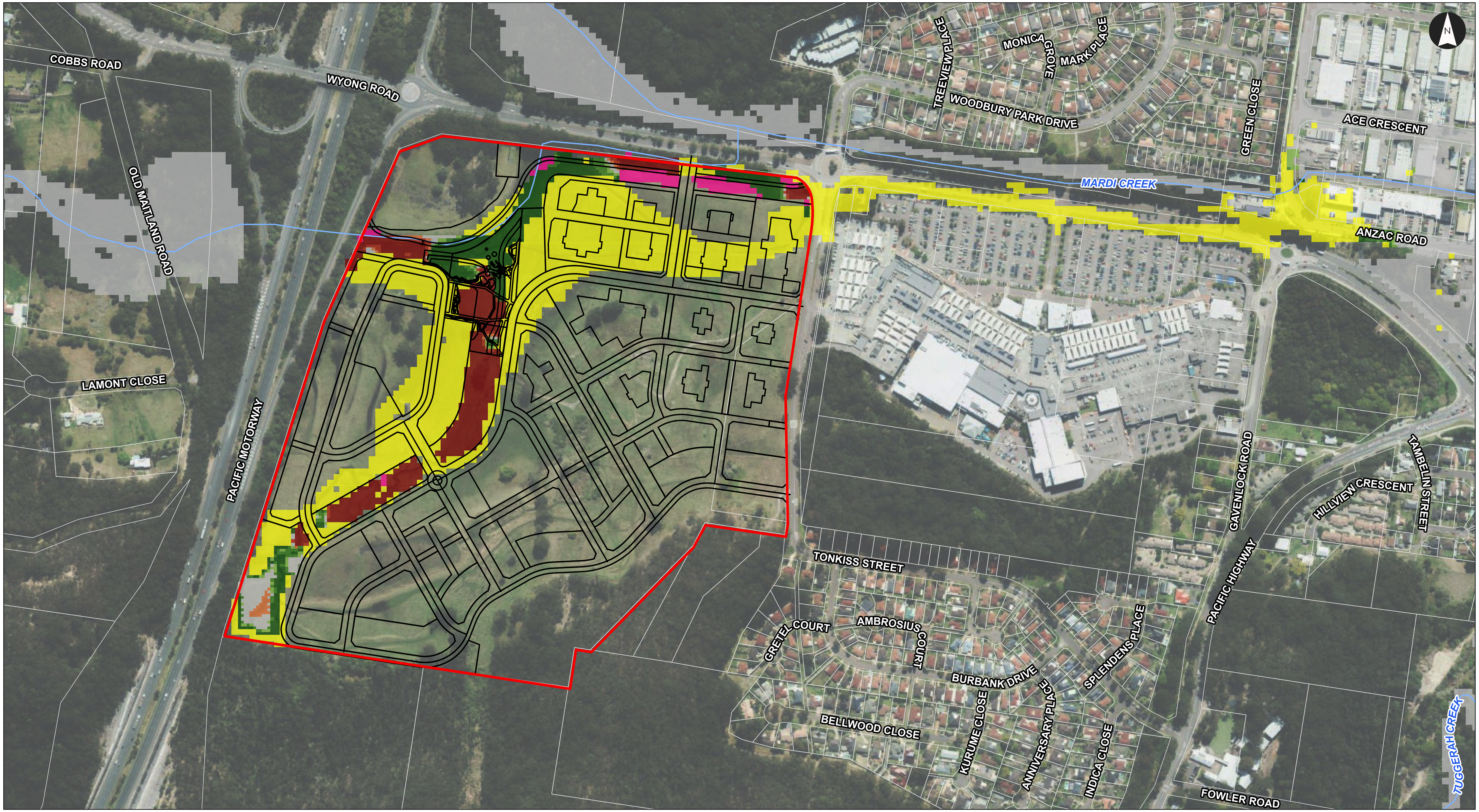


# Flood Impacts 1% AEP

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

Project Code: 8202120301-GS-025
Drawn By: JML, Checked By: MMM
Rev: 05
Date: 2024-02-19

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SCENTRE GROUP

**Legend**

- Site Boundary
- Proposed Lot Layout
- Watercourse
- Cadastre

**Change in Flood Levels (m)**

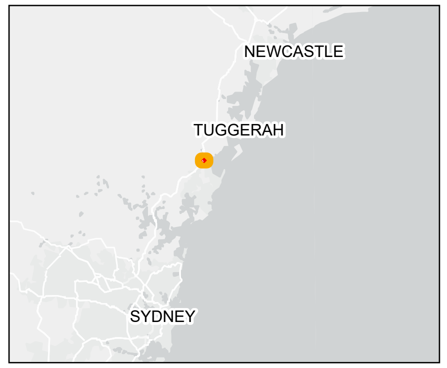
- Was Wet Now Dry
- < -0.1
- -0.1 to -0.05
- -0.05 to - 0.02
- -0.02 to 0.02
- 0.02 to 0.05
- 0.05 to 0.1
- > 0.1
- Was Dry Now Wet

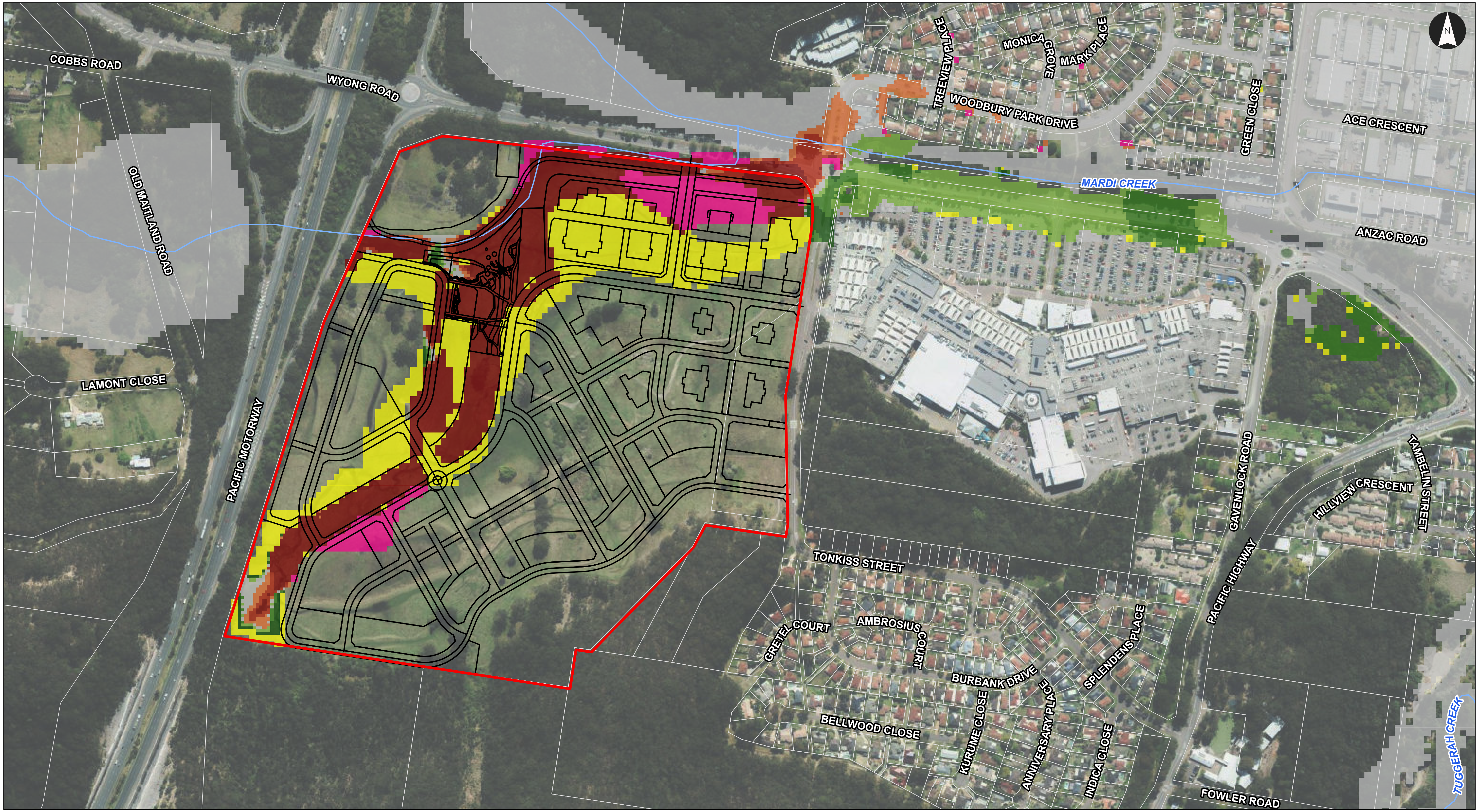
*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

0 50 100 150 200 250 Metres

Scale at A3: 1:5,000






# Flood Impacts PMF

Tuggerah Gateway Shopping Centre
Tuggerah, NSW

Project Code: 8202120301-GS-028
Drawn By: JML, Checked By: MMM
Rev: 05
Date: 2024-02-19

**Legend**

- Site Boundary
- Proposed Lot Layout
- Watercourse
- Cadastre

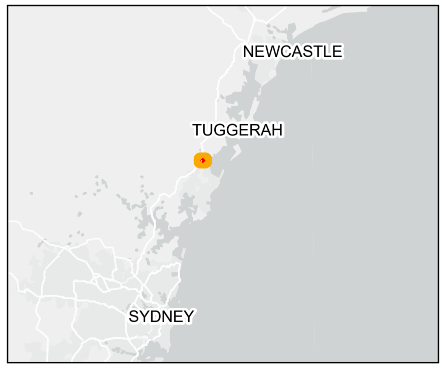
**Change in Flood Levels (m)**

- Was Wet Now Dry
- < -0.1
- -0.1 to -0.05
- -0.05 to - 0.02
- -0.02 to 0.02
- 0.02 to 0.05
- 0.05 to 0.1
- > 0.1
- Was Dry Now Wet

*Notes:*
*1. Map displayed in GDA2020 MGA Zone 56*

*References:*
*1. Aerial imagery (MetroMap, Sept 2022)*
*2. Watercourse (NSW SS)*
*3. Cadastre (NSW, 2022)*

0 50 100 150 200 250 Metres
Scale at A3: 1:5,000

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# Appendix E:

ARR BLOCKAGE ASSESSMENT FORM

We design with community in mind

## BLOCKAGE ASSESEMENT FORM

**STRUCTURE : Tuggerah Gateway Culvert C1, C2 and C3**

**OPENING WIDTH:C1 & C2 = 3 x 2400mm (W) x 1500mm (H)**
**C3 = 3 x 1500mm (W) x 900mm (H)**

### DEBRIS TYPE/MATERIAL/$L_{10}$/SOURCE AREA - *There may be more than one material type to consider!*

| Debris Type/Material | $L_{10}$ | Source Area | How Assessed |
|---|---|---|---|
| Sticks and fallen tree limbs | 1.5 | Inlet: rural grazing some steep forest.<br>Barrel: Grassed land with clay type soil - low transpotability | Aerial photos and Google streetview |

### DEBRIS AVAILABILITY (HML) – *for the selected debris type/size and its source area*

| Availability | Typical Source Area Characteristics | Notes |
|---|---|---|
| **H**igh | • *Dense forest, thick vegetation, extensive canopy, difficult to walk through with considerable fallen limbs, leaves and high levels of floor litter.*<br>• *Streams with boulder/cobble beds and steep bed slopes and banks showing signs of substantial past bed/bank movements.*<br>• *Arid areas, where loose vegetation and exposed loose soils occur and vegetation is sparse.*<br>• *Urban areas that are not well maintained and/or old paling fences, sheds, cars and/or stored loose material etc., are present on the floodplain close to the water course.* | |
| **M**edium | • *State forest areas with clear understory, grazing land with stands of trees*<br>• *Source areas generally falling between the High and Low categories.* | • Rural grazing some steep forest surrounds the site<br>• Proposed area is urban and the waterway will be used a recreational purposes (therefore will be maintained) |
| **L**ow | • *Well maintained rural lands and paddocks, with minimal outbuildings*<br>• *Streams with moderate to flat slopes and stable beds and banks.*<br>• *Arid areas where vegetation is deep rooted and soils resistant to scour*<br>• *Urban areas that are well maintained with limited debris present in the source area.* | |

### DEBRIS MOBILITY (HML) - *for the selected debris type/size and its source area*

| Mobility | Typical Source Area Characteristics | Notes |
|---|---|---|
| **H**igh | • *Steep source area with fast response times and high annual rainfall and/or storm intensities and/or source areas subject to high rainfall intensities with sparse vegetation cover.*<br>• *Receiving streams that frequently overtop their banks.*<br>• *Main debris source areas close to streams* | |
| **M**edium | • *Source areas generally falling between the High and Low categories.* | |
| **L**ow | • *Low rainfall intensities and large, flat source areas.*<br>• *Receiving streams that Infrequently overtop their banks.*<br>• *Main source areas well away from streams* | • Bank does not overtop frequently i.e. small/regular storm events.<br>• Waterway is not mainstream tributary. |

### DEBRIS TRANSPORTABILITY (HML) - *for the selected debris type/size and stream characteristics*

| Transportability | Typical Transporting Stream Characteristics | Notes |
|---|---|---|

## BLOCKAGE ASSESMENT FORM

| | | |
|---|---|---|
| **H**igh | • *Steep bed slopes (> 3%).and/or high stream velocity (V>2.5m/sec)*<br>• *Deep stream relative to vertical debris dimension (D>0.5$L_{10}$)*<br>• *Wide streams relative to horizontal debris dimension. (W>$L_{10}$)*<br>• *Streams relatively straight and free of constrictions/snag points.*<br>• *High temporal variability in maximum stream flows* | |
| **M**edium | • *Streams generally falling between High and Low categories* | • Creek longitudinal slope is approx. 2.5% and meanders with frequent constrictions at culvert crossings. |
| **L**ow | • *Flat bed slopes (< 1%).and/or low stream velocity (V<1m/sec)*<br>• *Shallow stream relative to vertical debris dimension (D<0.5$L_{10}$)*<br>• *Narrow streams relative to horizontal debris dimension.(W<$L_{10}$)*<br>• *Streams meander with frequent constrictions/snag points.*<br>• *Low temporal variability in maximum stream flows* | |

## BLOCKAGE ASSESMENT FORM

### SITE BASED DEBRIS POTENTIAL 1%AEP (HML) - *for the selected debris type/size arriving at the site*

| Debris Potential | Combinations of the Above (any order) | Notes |
|---|---|---|
| $DP_{High}$ | HHH or HHM | |
| $DP_{Medium}$ | MMM or HML or HMM or HLL | |
| $DP_{Low}$ | LLL or MML or MLL | MLM, therefore $DP_{Low}$ selected |

### AEP ADJUSTED SITE DEBRIS POTENTIAL (HML) - *for the selected debris type/size*

| Event AEP | At Site 1% AEP Debris Potential | | | AEP Adjusted At Site Debris potential |
|---|---|---|---|---|
| | $DP_{High}$ | $DP_{Medium}$ | $DP_{Low}$ | |
| **AEP > 5%** *(frequent)* | Medium | Low | Low | Low |
| **AEP 5% - AEP 0.5%** | High | Medium | Low | Low |
| **AEP < 0.5%** *(rare)* | High | High | Medium | Medium |

# Debris Blockage

### MOST LIKELY DESIGN INLET BLOCKAGE LEVEL ($B_{DES}$%) *for the selected debris type/size*

| Control Dimension Inlet Width W (m) | At-Site Debris Potential (Generally) | | |
|---|---|---|---|
| | High | Medium | Low |
| $W < L_{10}$ | 100% | 50% | 25% |
| $W \geq L_{10} \leq 3*L_{10}$ | 20% | 10% | 0% |
| $W > 3*L_{10}$ | 10% | 0% | 0% |

| Event AEP | Bdes % |
|---|---|
| **AEP > 5% *(frequent)*** | Low – 0% |
| **AEP 5% - AEP 0.5%** | Low – 0% |
| **AEP < 0.5% *(rare)*** | Medium – 10% |

*Refer Guideline if opening H<0.33W*

# Barrel Blockage

***The following tables are only relevant to sites subject to a significant debris load of sediment. Where inlet blockage and barrel blockage are both likely, the blockage producing the greatest impact on flood behaviour should be used in design.***

**LIKELIHOOD OF SEDIMENT BEING DEPOSITED IN THE BARREL OR WATERWAY (HML)**

| Peak Velocity Through Structure (m/sec) | Mean Sediment Size Present | | | | |
|---|---|---|---|---|---|
| | Clay/Silt 0.001 to 0.04 mm | Sand 0.04 to 2 mm | Gravel 2 to 63 mm | Cobbles 63 to 200 mm | Boulders >200 mm |
| >= 3 | L | L | L | L | M |
| 1.0 to < 3.0 | L | L | L | M | M |
| 0.5 to < 1.0 | L | L | L | M | H |
| 0.1 to < 0.5 | L | L | M | H | H |
| < 0.1 | L | M | H | H | H |

**Likelihood of Sediment:** Low

**MOST LIKELY DESIGN BARREL BLOCKAGE (Bdes% )** ***for sediment of a particular mean size is then;***

| Likelihood That Deposition Occurs | AEP Adjusted Sediment Potential | | |
|---|---|---|---|
| | High | Medium | Low |
| High | 100% | 60% | 25% |
| Medium | 60% | 40% | 15% |
| Low | 25% | 15% | 0% |

| Event AEP | Bdes % |
|---|---|
| AEP > 5% (frequent) | Low – 0% |
| AEP 5% - AEP 0.5% | Low – 0% |
| AEP < 0.5% *(rare)* | Medium – 15% |

***For modelling blockage mechanism (type, location and timing), refer to Guideline Table 8***

# BLOCKAGE CALCULATIONS - ARR (2016) Book 6 Chapter 6

**Project:** Tuggerah Gateway
**Structure/Drawing:** Upper Culvert - Culv A
**Location & LGA:** South-West
**Designer/Engineer:** SR
**Checked by:** FG/ZM
**Date:** 28/02/2022

User Defined Text & Parameters

Side notes: S=Section, T=Table in ARR Bk6 Ch6

| STEP 1: Setup Details | | |
|---|---|---|
| Catchment Area: | 100 | ha or km2 |
| Source Area (&Landuse): | rural grazing some steep forest | S6.3.3 |
| **Inlet Blockage Data** (floating /non-floating debris) | | |
| Description: | Sticks and fallen tree limbs | |
| How assessed: | Aerial photos and Google streetview | |
| Inlet Clear Width **(W)** | 1.5 | (m) |
| Inlet Clear Height **(D)** | 0.9 | (m) |
| Check W/D<=3 | 1.7 | (m/m) S6.4.4.8 |
| $L_{10}$ | 1.5 | (m) S6.4.4.1 |
| **Barrel Blockage Data** (sediment & bedload) | | |
| Description: | Grassed land with clay type soil - low transpotability | |
| How assessed: | Aerial photos and Google streetview | |
| $D_{50}$ | 50 | (mm) |
| Barrel velocity **(V)** | 2 | (m/s) |

| STEP 2: Debris Potential at Structure for 1% AEP | | | |
|---|---|---|---|
| Blockage Location | Inlet (debris) | Barrel (sediment) | |
| Availability (H,M,L) | M | M | S6.4.4.2 & T6.6.1 |
| Mobility (H,M,L) | L | L | S6.4.4.3 & T6.6.2 |
| Transportability (H,M,L) | M | M | S6.4.4.4 & T6.6.3 |
| Combined Result | MLM | MLM | |
| 1% Debris Potential | LOW | LOW | S6.4.4.5 & T6.6.4 |

| STEP 3: AEP Adjusted Debris Potential (S6.4.4.6 & T6.6.5) | | | |
|---|---|---|---|
| Event AEP(%) [1:yr] | HIGH | MED | LOW |
| >5% [<1:20] | Med | Low | Low |
| 5%-0.5% [1:20 - 1:200] | High | Med | Low |
| <0.5% [>1:200] | High | High | Med |

| STEP 4: Inlet Blockage Level (S6.4.4.7 & T6.6.6) | | | |
|---|---|---|---|
| AEP Adjusted Debris Potential At Structure (Inlet) | | | |
| **Control Dimension** | High | Med | Low |
| $W < L_{10}$ | 100% | 50% | 25% |
| $L_{10} <= W <= 3*L_{10}$ | 20% | 10% | 0% |
| $W > 3*L_{10}$ | 10% | 0% | 0% |

| STEP 5: Likelihood of Sediment Deposition in Barrel (T6.6.7) | | | | | |
|---|---|---|---|---|---|
| Sediment (Type & $D_{50}$) | Clay/Silt | Sand | Gravel | Cobbles | Boulders |
| Structure Velocity (m/s) | <=0.04mm | >0.04-2mm | >2-63mm | >63-200mm | >200mm |
| >=3.0 | *low* | *low* | *low* | *low* | *med* |
| 1.0 to < 3.0 | *low* | *low* | *low* | *med* | *med* |
| 0.5 to < 1.0 | *low* | *low* | *low* | *med* | *high* |
| 0.1 to < 0.5 | *low* | *low* | *med* | *high* | *high* |
| < 0.1 | *low* | *med* | *high* | *high* | *high* |

| STEP 6: Depositional Blockage Levels (T6.6.8) | | | |
|---|---|---|---|
| AEP Adjusted Sediment Potential At Structure (barrel) | | | |
| Likelihood of Deposition | High | Med | Low |
| *high* | 100% | 60% | 25% |
| *med* | 60% | 40% | 15% |
| *low* | 25% | 15% | 0% |

| STEP 7: BLK-DES% | Inlet (Debris) | | Barrel (Sediment) | |
|---|---|---|---|---|
| Event AEP(%) [1:yr] | LOW | STEP 4 | LOW | STEP 6 |
| >5% [<1:20] | Low | 0% | Low | 0% |
| 5%-0.5% [1:20 - 1:200] | Low | 0% | Low | 0% |
| <0.5% [>1:200] | Med | 10% | Med | 15% |

**STEP 8: RISK ASSESSMENT & SENSITIVITY ANALYSIS**

**ASSESS:**

1). Extreme blockage consequences using 2*BDES% (S6.4.4.11)
2). Worse case downstream flooding using "All Clear" case (S6.4.5)

**If CONSEQUENCES HIGH:**

**Flood Study:** Review blockage parameters. Notify asset owner.
**Design:** Review blockage parameters. Mitigate Risk. **(see S6.6)**

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