

Bushfire Hazard Assessment and Management Plan

1-23 Crowson Lane, Munruben

Prepared for OneFin Ops Pty Ltd

LOGAN CITY COUNCIL

APPROVED NEGOTIATED DOCUMENT

This is an approved document for Development Application

MCUI/60/2023

Prepared by:

Green Tape
SOLUTIONS

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Document Records - Quality

TITLE	Bushfire Hazard Assessment and Management Plan for 1-23 Crowson Lane Munruben
FILED AS	PR22301_BHAMP_1-23 Crowson Lane Munruben

Revision	Date	Prepared by (name/title)	Reviewed by (name/ title)	Approved by (name/title)
Version A	15/11/2022	Mark McVeigh, Ecologist	Richard Hanson, Senior Ecologist	Client
Version B	13/9/ 2023	Richard Hanson, Senior Ecologist	Richard Hanson, Senior Ecologist	Client

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I Introduction

1.1 Background

Green Tape Solutions was engaged by Onefin Ops Pty Ltd to prepare a Bushfire Hazard Assessment and Management Plan (BHAMP) for a site located at 1-23 Crowson Lane, Munruben (described as Lot 1 on SP231913) (the 'site').

This report has been prepared for a development application for a Material Change of Use (MCU) for the construction of a childcare centre. The site currently supports an existing detached dwelling house and associated outbuildings and structures, including sheds and a swimming pool. Access to the proposed childcare centre shall be provided via a driveway connecting to Crowson Lane.

The development has been designed to primarily utilise existing cleared areas; however, some removal of vegetation shall be required. The proposed development layout is provided in **Appendix 1**.

1.2 Site Description

The site is located on a single lot comprising a total area of approximately 18,320 m² (1.83 ha) within the Logan City Council (LCC) local government area (**Figure 1**). The site is bounded by highway infrastructure and vegetated, undeveloped land to the south and east, with rural residential lots to the north and west.

The eastern portions of the property have been historically cleared of native vegetation. Remnant native canopy vegetation has been retained within the western portion of the site. The vegetation on site and surrounding rural residential lots contain managed lawn understories of grassland maintained through regular mowing/slashing. A more detailed description of the vegetation communities within and surrounding the site is provided in **Section 3.1.2**



Figure 1 Site location (Source: Queensland Globe).

1.3 Scope of Work

The purpose of this BHAMP is to provide a site-specific assessment of bushfire hazard and to assess compliance of the proposed development with the outcomes sought by the Logan City Planning Scheme 2015 (version 9), in particular the assessment benchmarks outlined in the Bushfire Hazard Overlay Code. The BHAMP also provides a plan for bushfire risk management including building construction requirements, asset protection zones, fuel management, access requirements and emergency responses measures. Recommendations are consistent with legislative requirements to reduce the risk to life and property.

1.4 Qualifications and Experience

The Queensland Fire and Emergency Service (QFES) *Bushfire Resilient Communities Technical Reference Guide for the State Planning Policy State Interest 'Natural Hazards, Risk and resilience – Bushfire' October 2019* ('BRC Technical Guide') (QFES, 2019) provides guidance on suitably qualified people for assessments identified in the BRC Technical Guide. This guidance includes the following recommendations:

- Fine-scale assessment of vegetation communities in accordance with the 'Vegetation Hazard Class' assessment methodology be undertaken by a suitably qualified person with experience in botanical survey methods; and

- Applicant-initiated assessments and reports be prepared or peer-reviewed by suitably qualified and experienced people with degree (AQF Level 8) qualifications in environmental science, environmental management (or an equivalent discipline), demonstrated experience in botanical surveys and spatial analysis methods, including use of geographic information systems (GIS) software); demonstrated experience in the assessment of bushfire hazard and risks or technical qualifications in environmental science, environmental management (or and equivalent discipline) and demonstrated relevant industry experience in the assessment of bushfire hazard and risks for a minimum of five years.

The author of this report meets QFES' criteria as follows:

- possesses knowledge and experience in applying relevant legislation, plans, policies, standards and guidelines relating to bushfire hazard and fire ecology relating to Queensland requirements and South-east Queensland conditions;
- has knowledge, experience in botanical survey methods and GIS analysis and at least 5 years' experience in undertaking bushfire hazard assessment and preparing bushfire management plans, including experience in undertaking fine-scale assessment of vegetation communities and application of the QFES Bushfire Hazard Assessment methodology outlined in the BRC Technical Guide; and
- has qualifications and experience in the field of ecology, environmental management or similar to assess and protect site-based and strategic biodiversity values relating to South-east Queensland.

2 Bushfire Regulatory Framework

Given that bushfire hazard can cause harm to people and social wellbeing, damage to property and impacts to the economy and environment, the management of bushfire hazard in Queensland is considered an integral component of land use planning and development decisions.

There are three regulatory mechanisms/instruments applicable to the site that regulate development to avoid and mitigate potential impacts associated with bushfire hazard:

- State Planning Policy (SPP) and associated guidelines (Department of Infrastructure, Local Government and Planning (DILGP), July 2017);
- Logan City Planning Scheme 2015 (version 9) (Logan City Council, 2023); and
- Australian Standard AS3959:2018 – Construction of Buildings in Bushfire-prone Areas (Standards Australia, 2018).

2.1 State Planning Policy (SPP)

The SPP identifies the Queensland Government's policies about matters of state interest in land use planning and development (Department of Infrastructure, Local Government and Planning (DILGP), July 2017). The SPP is a broad and comprehensive statutory planning instrument. It sits above regional plans, standard planning scheme provisions and local government planning schemes within the hierarchy of planning instruments outlined in the *Planning Act 2016*.

The SPP is supported by the following guidance material:

- The SPP state interest guidance material - Natural hazards, risk and resilience - Bushfire ('SPP guidance') (DSDMIP, 2019), which provides further context to the SPP and explains how the SPP policies can be applied, in particular for local government when making or amending local planning instruments. The SPP guidance is also intended to assist assessment managers and practitioners in applying the SPP assessment benchmarks when state interests have not been integrated into the local planning scheme (where applicable).
- The 'Bushfire Resilient Communities – Technical Reference Guide for the State Planning Policy State Interest - Natural Hazards, Risk and Resilience – Bushfire ('BRC Technical Guide') (QFES, 2019), which provides technical guidance and policy positions of the Queensland Fire and Emergency Services (QFES). It includes procedures for undertaking a bushfire hazard assessment (BHA), calculating asset protection zones and preparing a Bushfire Management Plan.

The SPP assessment benchmarks outlined in Part E of the SPP and Section 4.0 of the SPP guidance apply to development to the extent that the development is assessable against a planning scheme and only to the extent that the planning scheme is inconsistent with the SPP.

The SPP is also supported by a state-wide map of bushfire prone areas (BPA) (also referred to as 'bushfire hazard area') that was developed based on the CSIRO modelling of potential fireline intensity using the methodology described by Leonard *et al.* (2014). The BPA mapping identifies areas of Very High (>40,000 kW/m), High (20,000 – 40, 000 kW/m) and Medium (4,000 – 20,000 kW/m) Potential Bushfire Intensity. The Potential Impact Buffer includes all land within 100 metres of any area with a

potential fireline intensity greater than 4,000 kW/m (i.e. medium, high or very high bushfire hazard/potential bushfire intensity). This mapping triggers assessment against the State Planning Policy Assessment Benchmarks.

An excerpt from the SPP Assessment Benchmark – BPA mapping published on the SPP Interactive Mapping System (IMS) is provided in **Figure 2**. The site is mapped as being in the Potential Impact Buffer. In addition, land on surrounding lots is mapped as containing areas of Medium Potential Bushfire Intensity and Potential Impact Buffer.

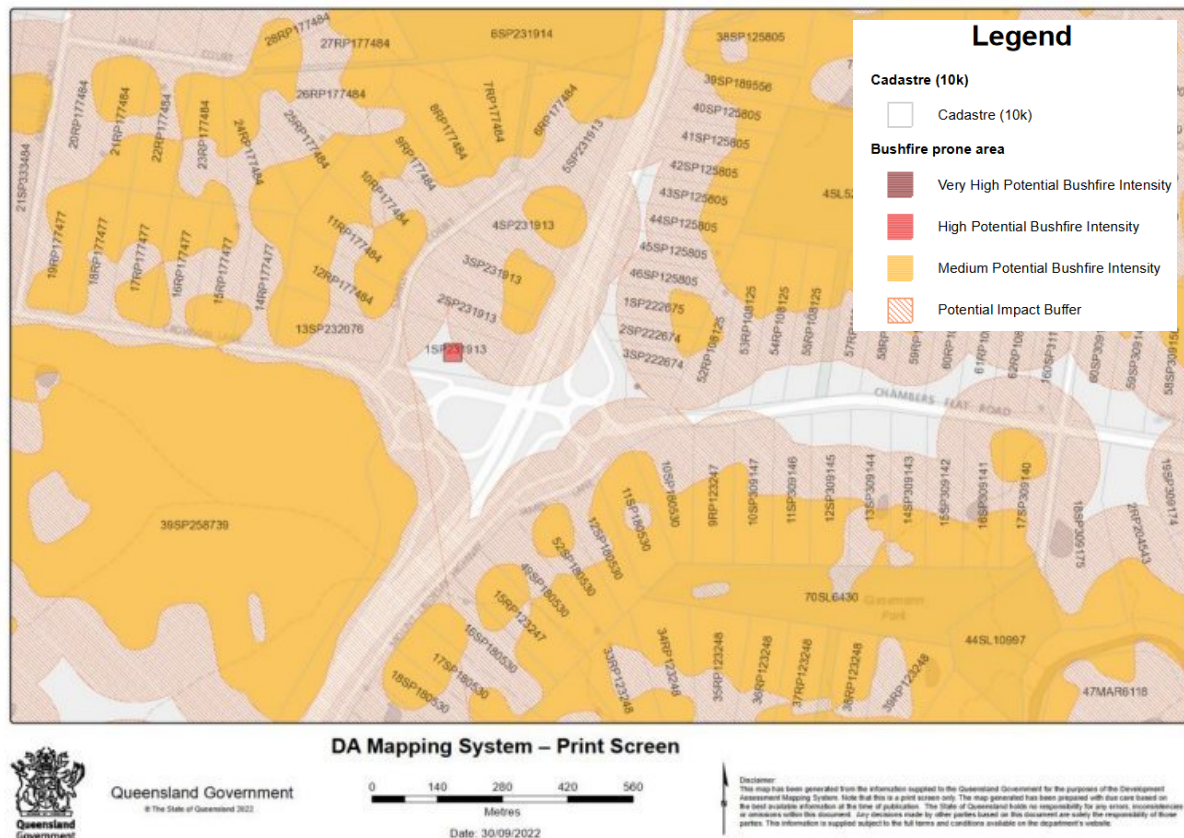


Figure 2 Excerpt from DSDMIP SPP IMS – Bushfire prone area (Source: DSDMIP SPP IMS).

2.2 Logan City Planning Scheme 2015

The site is located within the Logan City local government area and is subject to the provisions of the Logan City Planning Scheme 2015 (version 9). The planning scheme's Bushfire Hazard Overlay maps the site as being in the Potential Impact Buffer. Land on surrounding lots is mapped as containing areas of Medium Potential Bushfire Intensity and Potential Impact Buffer. An excerpt from the overlay map identifying the mapped bushfire hazard areas in relation to the proposed development site is shown in **Figure 3**.

Logan City Council's Bushfire Hazard Overlay mapping designates bushfire prone areas for the purposes of Section 12 of the *Building Regulation 2006*. The provisions of the Building Code of Australia

(BCA) or Queensland Development Code (QDC) are applicable to any building assessment work in a designated bushfire prone area.

The Logan City Planning Scheme 2015 Bushfire Hazard Overlay Code notes that a site-based assessment may be used to ground-truth the extent of hazardous vegetation and the extent and nature of the bushfire hazard area (bushfire prone area), but does not specify acceptable methodologies.

The site-specific bushfire assessment provided in this plan has been undertaken in accordance with the BRC Technical Guide (Queensland Fire and Emergency Services (QFES), 2019).

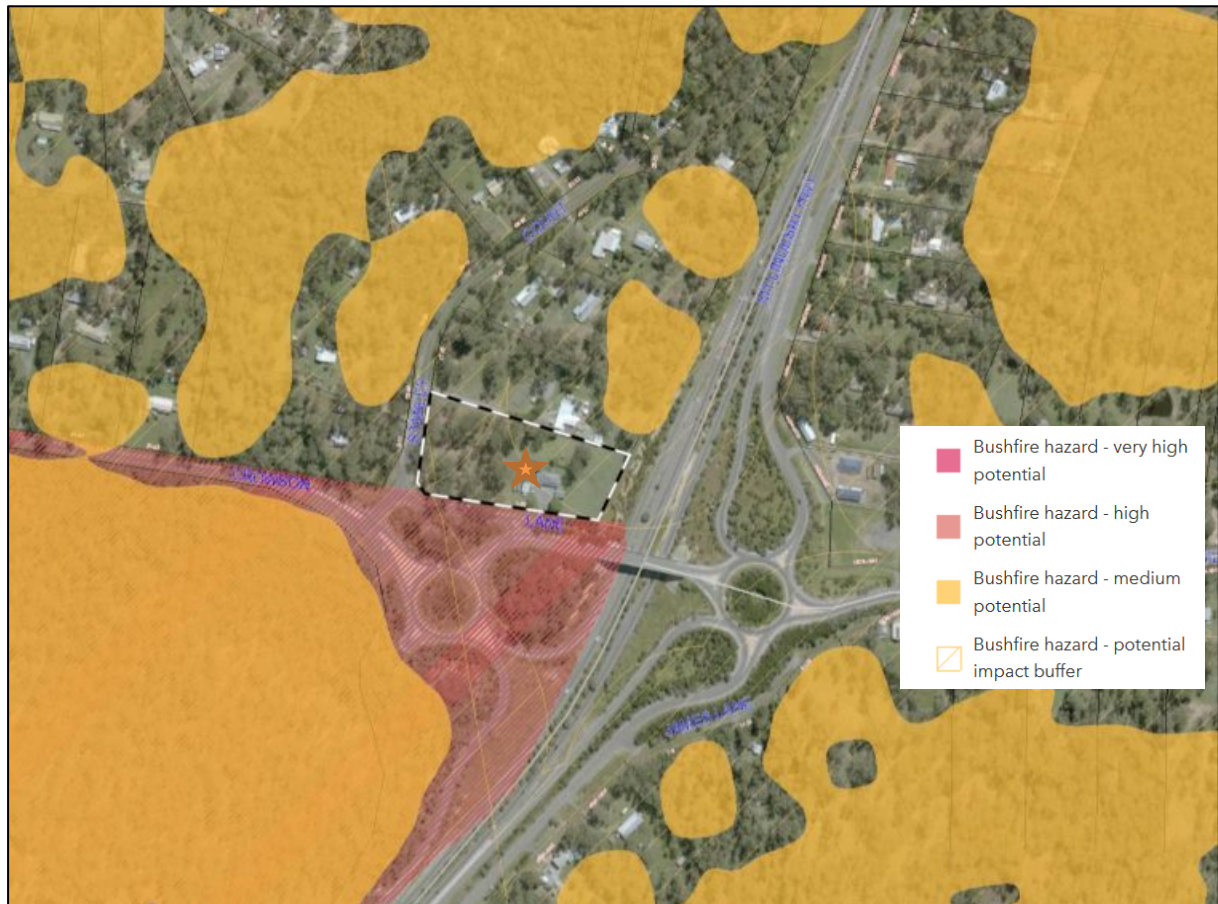


Figure 3 Excerpt from Logan City Planning Scheme 2015 – Bushfire Hazard overlay (Source: LCC, 2023).

2.3 AS3959:2018 Construction of Buildings in Bushfire Prone Areas

The Australian Standard AS3959:2018 *Construction of Buildings in Bushfire-Prone Areas* (Standards Australia, 2018) specifies the requirements for the construction of buildings in bushfire-prone areas in order to improve their resistance to bushfire attack. AS3959:2018 applies to those areas where a regulated map (i.e. a planning scheme overlay map) identifies an area as a bushfire prone area (or similar), requiring calculation of Bushfire Attack Level (BAL) in accordance with a methodology outlined in the standard.

AS3959:2018 thus prescribes the construction details for buildings depending on the calculated BAL. The detailed requirements relating to construction methods and materials are typically dealt with as part of building design and enabled via private certification in accordance with the Building Code of Australia.

3 Bushfire Hazard Assessment

A site-specific bushfire hazard assessment (BHA) for the site has been undertaken in accordance with the methodology outlined in the 'Bushfire Resilient Communities' (BRC) technical document (QFES, 2019). The methodology underpinning the BHA process consists of three stages:

1. An assessment to verify the reliability of existing BPA mapping over the site and land surrounding the site (the 'assessment area').
2. A hazard assessment involving field investigations to ground-truth the accuracy of the BPA mapping for the site, where required. The hazard assessment area must include the development area and all land within 150 metres of the development footprint.
3. Using the results of the site-specific assessment, the asset protection zone width needed to achieve the requisite radiant heat flux levels is calculated using the SPP Bushfire asset protection zone (APZ) width calculator or Method 2 of AS3959:2018.

Where the precision and/or accuracy of BPA mapping or map input datasets are insufficient (e.g. where there has been changes in land use and vegetation cover within the assessment area), the process enables applicants to create a local-scale BPA map based on the results of the site investigation and to apply modified input variables that reflect changes that have occurred over time. The BHA process adapts the method used to generate the state-wide BPA mapping, described in Leonard *et. al.* (2014) with further refinement to allow for the downgrade and/or filtering of small patches and narrow corridors where needed in accordance with contemporary mapping rules outlined in the BRC technical guide and Leonard and Opie (2017).

Where effective fuel loads have been reduced based on patch size and isolation in accordance with the patch and corridor filtering rules outlined in 4.2.6 of the QFES BRC technical guide, reduced effective fuel loads can be used as inputs into a Method 2 Bushfire Attack Level (BAL) assessment.

The assessment has been based on vegetation existing within, adjacent and nearby to the site including any areas subject to revegetation or regrowth, which have been assessed as if these areas have reached their mature state.

3.1 Hazard Assessment

The following steps have been undertaken to assess spatial factors that contribute to potential bushfire intensity for the site and surrounding land:

- **Step 1: Identification of Fire weather severity**

Identification of all Forest Fire Danger Index (FFDI) values estimated at a 1:20 year (5%) Annual Exceedance Probability (AEP) using the Bushfire Hazard Area – Bushfire Prone Area – Inputs dataset from the Queensland Government data portal.

- **Step 2: Identification of Vegetation Hazard Classes**

Assessment of vegetation communities to identify the relevant vegetation hazard classes (VHCs) using a combination of remnant and pre-clearing regional ecosystem maps, high-resolution aerial imagery and a ground-truthed assessment of vegetation present within the site and within the required 150 m assessment area.

- **Step 3: Slope assessment**

Identification of site slope and effective slope, and determination of whether proposed buildings are upslope or downslope of hazardous vegetation using Bushfire Hazard Area – Bushfire Prone Area – Inputs dataset from the Queensland Government data portal and 1 m LiDAR-derived contour data.

- **Step 4: Remodeling of bushfire hazard and calculation of potential fireline intensity** - Where a change to the distribution, extent and/or classification of VHCs within the assessment area is proposed, remodeling of bushfire hazard is undertaken to determine how the changes to VHCs and associated fuel loads affect potential fireline intensity. Potential fireline intensity is to be calculated in accordance with the method outlined in Leonard *et al.* (2014).

VHCs and associated potential fuel loads are in accordance with Leonard *et al.* (2017), as provided in the BRC Technical Guide and SPP Bushfire APZ width calculator published by the Queensland Fire and Emergency Services (QFES).

Relevant spatial datasets published by the QFES were accessed via the Queensland Spatial Catalogue (QSpatial) and the Catalyst Fire Management System (Queensland Fire and Emergency Services, 2020).

3.1.1 Step 1 – Fire Weather Severity

South-east Queensland has a subtropical climate with warm humid summers and mild winters and is subject to influence from monsoonal climate systems and easterly troughs. Seasonality is not pronounced; however the ‘wet’ season generally occurs during the December – April period. The fire danger season usually occurs from spring to mid-summer (August/September to December) with the greatest danger after a dry winter and spring and when deep, low-pressure systems near Tasmania bring strong, hot and dry westerly winds to the coastal districts (Bureau of Meteorology, 2021). Severe bushfire weather is characterised by days with high temperatures over 35 degrees, low relative humidity and winds from the north to north-west.

The Forest Fire Danger Index (FFDI) provides an annual accumulated index of fire weather severity (i.e. the potential danger of a bushfire) based on a combination of vegetation dryness, air temperature, wind speed and humidity. The relevant FFDI for the site was derived from the Fire Weather Severity (Forest Fire Danger Index) raster provided as part of the Bushfire Hazard Area – Bushfire Prone Area – Inputs dataset.

The FFDI for the site and surrounding land is 55.

3.1.2 Step 2 - Vegetation Hazard Classes and Potential Fuel Loads

3.1.2.1 Vegetation Hazard Classes

Different types of vegetation communities determine the rate at which dry fuel accumulates. Some vegetation communities protect fuel from drying out in all but extreme bushfire seasons and can then be susceptible to very destructive bushfires. Alternatively, vegetation communities may expose fuels to drying and therefore be frequently available for burning. Frequent bushfires can result in the development of bushfire-tolerant grassy woodlands or grasslands and less destructive bushfire behaviour.

Vegetation Hazard Classes (VHCs) provided within the Bushfire Prone Area – Vegetation hazard class – South east Queensland spatial dataset were reviewed for the site and surrounding land (**Figure 4**). The following VHCs are mapped within the required 150 m assessment area:

- 10.1 – Spotted gum dominated open forests;
- 16.1 – Eucalyptus dominated forest on drainage lines and alluvial plains;
- 39.2 – Low to moderate tree cover in built-up areas;
- 41.4 – Discontinuous low grass or tree cover; and
- 42.6 – Nil to very low vegetation cover.

The reliability of State-mapped VHCs was assessed through:

- review of Vegetation management remnant and pre-clearing regional ecosystem (RE) mapping published by the Department of Resources (DoR);
- an assessment of existing vegetation undertaken by Green Tape Solutions in October 2022 as part of site investigations to support preparation of a BHAMP.

DoR's RE mapping shows vegetation is identified as containing the following REs:

- RE 12.9-10.19a - *Corymbia henryi* and/or *Eucalyptus fibrosa* subsp. *fibrosa* open forest.; and
- RE 12.9-10.2/12.9-10.12/12.9-10.7 - *Corymbia citriodora* subsp. *variegata* +/- *Eucalyptus crebra* open forest on sedimentary rocks / Mixed woodland usually containing *Corymbia intermedia*, *Angophora leiocarpa* and at least the presence of *Eucalyptus seeana* on sedimentary rocks / *Eucalyptus crebra* +/- *E. tereticornis*, *Corymbia tessellaris*, *Angophora* spp. and *E. melanophloia* woodland on sedimentary rocks.
- RE 12.3.3/12.3.3d - *Eucalyptus tereticornis* woodland on Quaternary alluvium / *Eucalyptus moluccana* woodland

The site assessment determined that vegetation within the 150 m assessment area consists of a mosaic of native vegetation, landscape vegetation (including streetscape vegetation) and areas of maintained grassland/lawn with low tree cover. The site has been predominantly cleared, with some retained native canopy vegetation in the western half of the site. Vegetation adjacent to and within proximity of the development consists of two (2) site-verified communities.

- **Vegetation community 1 – Landscape vegetation**

Vegetation within the site and on adjacent rural residential lots consists primarily of a mix of native canopy trees such as spotted gum (*Corymbia citriodora*) and Qld blue gum (*Eucalyptus tereticornis*) and exotic landscape vegetation such as mango (*Mangifera indica*) and jacaranda (*Jacaranda mimosifolia*) with a managed lawn understory.

Landscape vegetation within the 150 m assessment area has been classified as **VHC 39.2** - Low to moderate tree cover in built-up areas.

- **Vegetation community 2 – Spotted gum open woodland**

Remnant native vegetation associated with retained vegetation patches to the south conforms to a spotted gum open woodland. The ground-truthed vegetation assessment determined that this vegetation is composed of mostly spotted gum (*Corymbia citriodora*), narrow-leaved ironbark (*Eucalyptus crebra*), Qld blue gum (*Euclayptus tereticornis*) and pink bloodwood (*Corymbia intermedia*). Non-native species (*) within this community include devil's fig (*Solanum torvum**) and lantana (*lantana cammara**). This community is currently in various stages of regrowth and some areas are proposed for clearing under the Priority Development Area to the south.

This community is mapped as Category B (remnant) vegetation. The community likely conforms to regional ecosystem (RE) 12.9-10.2 *Corymbia citriodora subsp. variegata* +/- *Eucalyptus crebra* open forest on sedimentary rocks.

The spotted gum open woodland community on adjoining land has been classified as **VHC 10.2** spotted gum dominated woodlands.

Non-vegetated areas (roads, footpaths and buildings) and low-threat vegetation (including grassland maintained in a minimal fuel condition, maintained lawns, maintained public reserves and parklands and cultivated gardens) within the 150 m assessment area have been classified as VHC 42.6 – Nil to very low vegetation cover. These areas have been excluded from the BAL assessment as they meet the criteria for exclusion as low threat vegetation.

Figure 5 depicts the location of ground-truthed VHCs within the 150 m assessment area.



Plate 1 Vegetation Community 2 – south



Plate 2 Clearing in the PDA to the south



**Plate 3 Vegetation Community 1 – canopy trees
with a managed understory on site**



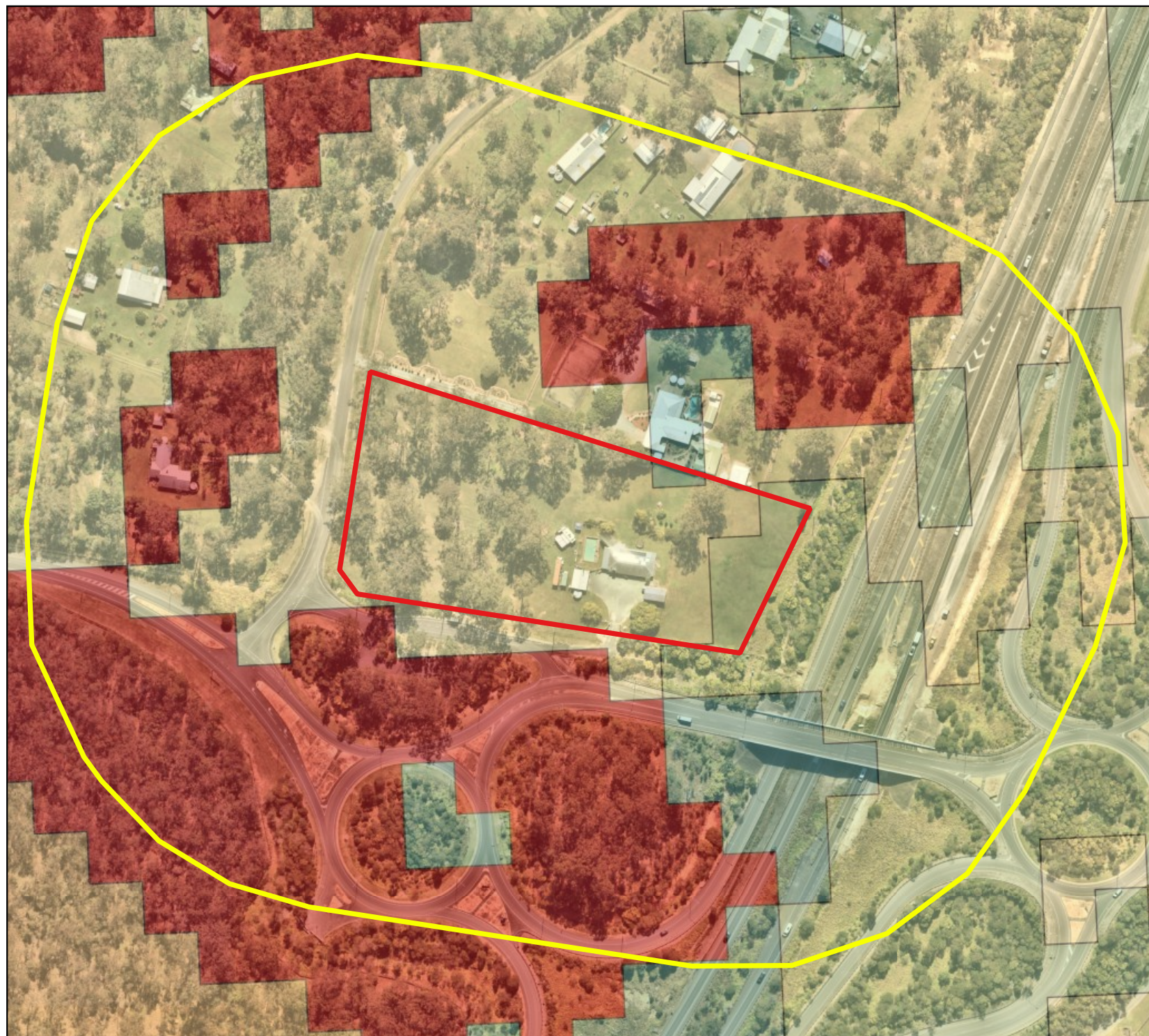
**Plate 4 Vegetation Community 1 – canopy trees
with a managed understory**



Plate 5 Adjacent property



Plate 6 Development area



**Figure 4: State mapped
Vegetation Hazard Class**

Project: PR22301_1-23 Crowson Lane,
Manruben.

Lot Boundary

Bushfire Assessment Area

SE Qld VHC Fixed Geometry

10.1 Spotted gum dominated open forests

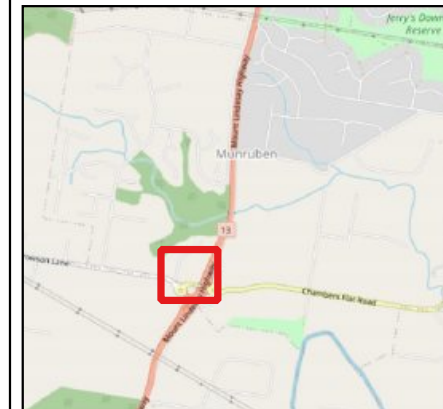
16.1 Eucalyptus dominated forest
on drainage lines and alluvial plains

16.2 Eucalyptus dominated woodland
on drainage lines and alluvial plains

39.2 Low to moderate tree cover
in built-up areas

41.4 Low grass or tree cover
in built-up areas

42.6 Nil to very low vegetation cover



Notes:

- Survey Data by Green Tape Solutions
- Site Infrastructure and Impact Areas from Client
- Base map Copyright (c) Esri and its data suppliers.

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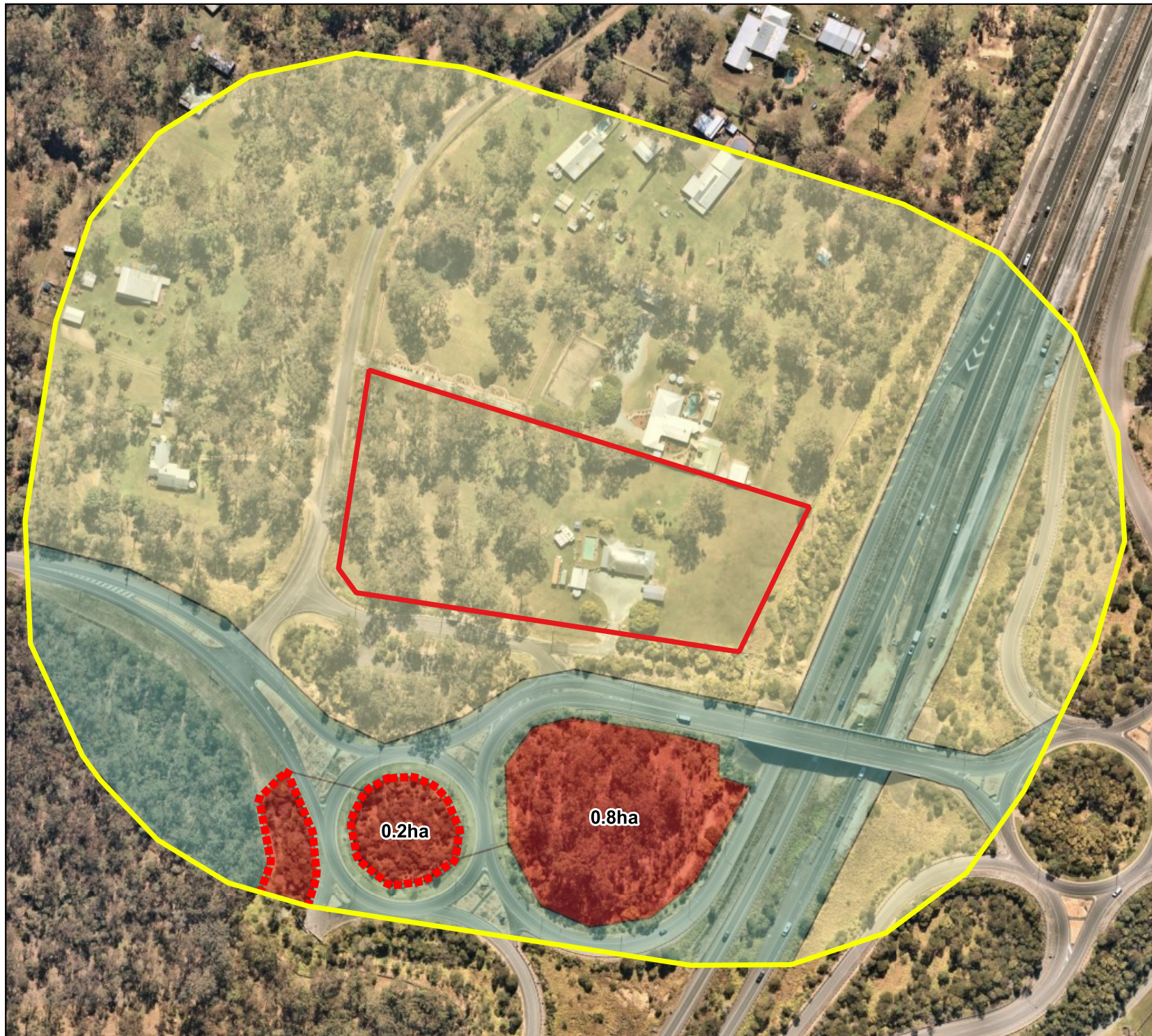
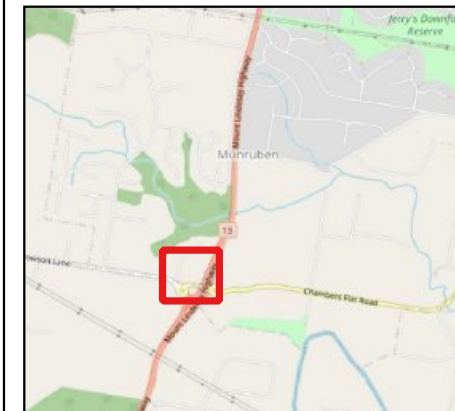


Figure 5: Ground truthed VHC

Project: PR22301_1-23 Crowson Lane, Manruben.

- Lot Boundary
 - Bushfire Assessment Area
 - Patch filtering
- Vegetation Hazard Class**
- 10.2 Spotted gum dominated open woodland
 - 39.2 Low to moderate tree cover in built-up areas
 - 42.6 Nil to very low vegetation cover



Notes:
 - Survey Data by Green Tape Solutions
 - Site Infrastructure and Impact Areas from Client
 - Base map Copyright (c) Esri and its data suppliers.

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3.1.2.2 Potential Fuel Loads

Fuel loads have been allocated for each VHC to represent the long-unburnt condition that would be typically exhibited 10 years after fire. In accordance with the values provided in Figure 14 of the BRC Technical Guide (QFES, 2019a), the potential fuel load values for ground-truthed VHCs within and surrounding the site are as provided in **Table 1**.

Table 1: Potential fuel loads for classified vegetation within 150 m assessment area.

VHC		Total potential surface fuel load (t/ha)	Total overall potential fuel load (t/ha)	Prone type ¹		Fuel continuity ²	
10.2	Spotted gum dominated woodlands	17.0	18.0	1	Bushfire-prone – Forest or shrub fires	1	Continuous
39.2	Low to moderate tree cover in built-up areas	5.0	8.0	3	Non-bushfire prone – Low hazard	2	Discontinuous
42.6	Nil to very low vegetation cover	2.0	2.0	3	Non-bushfire prone – Low hazard	2	Discontinuous

3.1.3 Step 3 - Site and Effective Slope

Two slope input parameters are required for the estimation of fire behaviour and separation. Site slope is the slope of the ground between the edge of the proposed development (or site boundary) and the edge of hazardous vegetation. Effective slope refers to the slope of the land beneath hazardous vegetation. Effective slope is the more important parameter as it has a direct influence on the potential rate of fire spread, fuel consumption and thus, potential fireline intensity. For each vegetation hazard class, the effective slope is determined by assessing the slope beneath classified vegetation (in degrees) which most influences bushfire behaviour and the relative position of land supporting hazardous vegetation in relation to the development i.e. upslope or downslope. Where there is more than one slope beneath classified vegetation, each slope should be individually assessed, and the worst-case scenario adopted.

The topography of the site and surrounding land is relatively flat with a slight downwards slope to the south. Slope measurements have calculated using LiDAR-derived 1 metre contour data published by the Department of Resources and verified by site measurement. The site slope and effective slope angles for all hazardous vegetation within the assessment area have been calculated and are shown in **Table 2**.

¹ Prone type taken from Figure 14 of the QFES BRC Technical Guide.

² Fuel continuity type taken from Figure 14 of the QFES BRC Technical Guide.

Table 2: Slope angles for assessable fire runs to the development site

Slope location in relation to development area	Max effective slope (degrees)	Max site slope (degrees)	Fire run in relation to development	Fire run scale
South	3.15	1	Downslope	Short fire run
South West	3.43	1	Downslope	Fully developed fire

3.1.4 Step 4 - Remodelling of Bushfire Hazard

Given that site-specific assessment determined that VHCs provided within the BPA – VHC – South east Queensland spatial dataset do not entirely reflect the ground-truthed VHCs, remodelling of bushfire hazard has undertaken to determine how the changes to VHCs and associated fuel loads affect potential fireline intensity. Potential fireline intensity has been calculated in accordance with the method outlined in Leonard *et. al.* (2014).

Potential fireline intensity (PFI) is a standard measure of the rate at which an advancing fire would consume fuel energy per unit time per unit length of the fire front. This metric combines potential fuel load (PFL), maximum landscape slope (slope) and fire weather severity (FFDI) to provide a potential fireline intensity metric. The potential fireline intensity (PFI) is represented as the following equation:

$$PFI = 0.62 PFL^2 \times FFDI \exp (0.069 \times \text{slope})$$

Where: *PFI* = Potential fire line intensity (kW/m), *PFL* = Potential fuel load (tonnes / ha), *FFDI* = Potential severe fire weather (FFDI) and *Slope* = Max slope

Table 3 shows the potential fireline intensity ranges (in kilowatts per metre) and the corresponding potential bushfire hazard classes.

Table 3: Potential fireline intensity ranges and bushfire hazard classes

Potential Fireline Intensity (kW/m)	Potential Bushfire Hazard Class
40,000+ kW/m	Very high
20,000 – 40,000 kW/m	High
4,000–20,000 kW/m	Medium
0 – 4,000 kW/m	Low/Not bushfire prone

Section 4.2.6 of the QFES BRC technical guide provides a series of mapping rules ('patch and corridor filtering') for modifying the potential fireline intensity of bushfire-prone areas to reflect the likelihood of lower potential fireline intensities in smaller vegetation patches and narrow vegetated corridors. These rules are applied as follows:

1. Remove patches of continuous fuel < 1 ha in area that are surrounded by either no fuel or non-continuous fuel and are further than 100 m from any other continuous fuel patch greater than 2 ha;
2. Downgrade the effective fuel load of small patches of continuous fuel measuring a. 1 – 2 ha – downgrade by 66% and b. 2 – 3 ha – downgrade by 50 % if the patch is surrounded by either non-continuous fuel or a low-hazard vegetation or land-use type and if the patch is further than 100m from any other continuous -fuel vegetation patch greater than 2 ha; and
3. Remove narrow corridors and area of continuous fuel that are less than 50 m in width.
4. Remove patches less than 0.5 hectare

Figure 6 depicts fuel patches (classified as VHC 10.2) to the south and south-west of the site in relation to other small continuous-fuel patches within 100 m. Patch and corridor filtering has been applied to these patches, as follows:

- The patch within the smaller central roundabout has a total patch area of 0.2 ha and thus meets patch filtering rule 4. This patch has been excluded from further assessment
- The small area of vegetation in the south west extending out from the PDA area is less than 50m wide and unlikely to hold a full fire front and is filtered out under rule 3.

The potential fireline intensity was calculated for bushfire-prone vegetation within 150 m of the site using the inputs from Steps 1 - 3. In accordance with Section 7.6 of the BRC Technical Guide, fireline intensity, radiant heat flux and bushfire attack level is not required to be calculated for non-bushfire prone (i.e. VHCs with a prone type of 2) or low hazard VHCs (i.e. VHCs with a prone-type of 3), therefore VHCs 39.2 and 42.6 have been excluded from calculation of potential fireline intensity. Potential fireline intensity for bushfire-prone vegetation is provided in **Table 4**.

Table 4: Potential fireline intensity for classified VHCs within 150 m assessment area

Location of classified vegetation in relative to development area	VHC	Status	Effective slope – average slope beneath bushfire-prone vegetation in relation to development (degrees)		Fire weather severity (FFDI)	Potential fireline intensity (PFI)	Potential bushfire hazard class
South	10.2	Remnant	3.15	Downslope	55	12,247 kW/m	Medium

The results of the potential fireline intensity calculation for bushfire-prone vegetation within the assessment area show that vegetation to the south of the site (VHC 10.2) has a potential bushfire hazard class of 'medium'. All other vegetation within 150 m of the development site is not classified as bushfire-prone and therefore, calculation of radiant heat flux/bushfire attack level (BAL) is not applicable.

Section 5 outlines the requirements for management and mitigation of bushfire hazard for the bushfire-prone vegetation within the site.

3.2 Radiant Heat Exposure and Bushfire Attack Levels

Bushfire attack levels (BALs) are used to quantify the levels of attack (radiant heat exposures/flux) that built structures may experience during a fire event. The BAL is defined as 'a means of measuring the severity of a building's potential exposure to ember attack, radiant heat and direct flame contact, using increments of radiant heat expressed in kilowatts per metre squared, and the basis for establishing the requirements for construction to improve protection of building elements from attack by bushfire' (Standards Australia, 2018).

AS3959:2018 adopts six BAL categories, which are based on the level of radiant heat flux to which buildings may be exposed to during a bushfire event. This level of heat flux generally relates to the type of vegetation, effective slope and how far a building is from hazardous vegetation. BALs apply to buildings and any attached or adjacent structure within 6 m of the building.

The BRC Technical Guide requires that radiant heat exposure/bushfire attack levels (BALs) are calculated using either the SPP Bushfire APZ calculator (QFES, 2019b), which is the preferred method or Method 2 of AS3959:2018. Where Method 2 is used, the following inputs are to be used:

- site-specific values for FFDI (Step 1)
- ground-truthed VHCs (Step 2) and their associated fuel loads (provided in Figure 14 of the BRC Technical Guide); and
- site and effective slopes (Step 3).

The Flamesol Method 2 Minimum Distance calculator has been used to calculate the minimum separation distance required between the development and bushfire-prone vegetation for each BAL. These results are provided in **Appendix 2** and **Figure 6** and summarised in **Table 5**.

Table 5: Determination of Bushfire Attack Level (BAL) minimum separation distances for bushfire-prone vegetation.

Bushfire attack level (BAL) →	BAL-Flame zone (FZ)	BAL-40	BAL-29	BAL-19	BAL-12.5	BAL-10
South	0 - <13.4 m	13.4 - <18 m	18- < 26.1 m	26.1 - <36.4 m	36.4 - < 42.9m	42.9 - < 100m

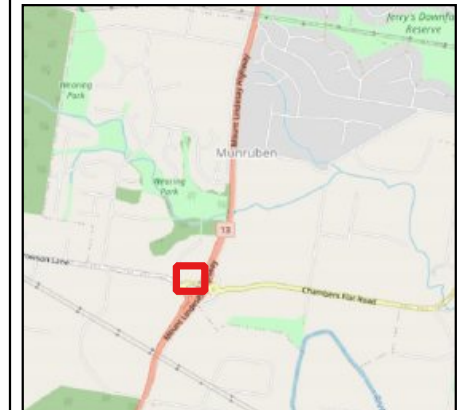
The Logan City Planning Scheme 2015 specifies that buildings are to be separated from hazardous vegetation such that they achieve a maximum radiant heat flux of 29 kW/m² (BAL-29). However, in this case, the development is for a childcare centre, which is a 'vulnerable use'. Section 9.4 of the QFES Bushfire Resilient Communities document states that vulnerable uses are to be sited so they achieve a radiant heat flux of no more than 10 kW/m². To achieve this outcome, the development footprint (buildings, play areas, car parking) will need to be sited at least 42.9m from retained vegetation to the south of the site (**Appendix 2**, Method 2 model output). The proposed new development footprint area achieves this setback and is thus compliant with this requirement for a vulnerable use.



Figure 6: Bushfire Attack Level

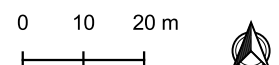
Project: PR22301_1-23 Crowson Lane, Munruben.

- Lot Boundary
- Hazardous vegetation edge
- Hazardous Vegetation
- Asset Protection Zone
- Bushfire Attack Level**
- Flamezone
- 40
- 29
- 19
- 12.5



Notes:
 - BAIs by Green Tape Solutions
 - Site Infrastructure and Impact Areas from Client
 - Base map Copyright (c) Esri and its data suppliers.

Created By: RH
 Date: 13/9/2023
 Version: 2



Green Tape
 SOLUTIONS

4 Bushfire Management Plan

The SPP requires that where it is not possible to avoid a bushfire prone area, development mitigates bushfire risk to people and property to an acceptable or tolerable level. This can be achieved through development design and siting, hazard reduction practices and emergency mitigation measures for any buildings bordering potentially bushfire-susceptible vegetation. These practices and measures include fuel reduction and management, road infrastructure to provide safe access and egress, appropriate building design and construction standards, procedures for fighting bushfires and fire intensity reduction management measures.

The development does not seek to mitigate bushfire hazard through additional vegetation clearing beyond the development area boundary and shall contain all bushfire management and mitigation measures within the development area.

4.1 Agencies / Persons Responsible

The responsible fire authority is the Queensland Fire and Emergency Services (QFES). It is the responsibility of the proponent to ensure that the relevant measures required by this plan are in place prior to inspection by the Council and the building certifier, and to ensure that the measures are in place prior to enacting the approval. Furthermore, it is the responsibility of the proponent to ensure that a copy of this report is always on hand at the site.

4.2 Owner / Occupier Responsibilities

It is the responsibility of the relevant lot owner to maintain each lot in accordance with the conditions outlined in this report. The owner / occupier responsibilities include:

- An Asset Protection Zone (APZ) is to be established and maintained between buildings and bushfire-prone vegetation. The APZ is to be managed in accordance with the measures outlined in Section 4.5.
- All access routes are to remain clear of obstacles to enable effective emergency vehicle access and egress;
- No burning is to be undertaken on-site without a Permit to Burn as issued by the local Fire Warden (and approval if required, in writing, from Council); and
- The storage or handling of hazardous chemicals on the premises must not result in an unacceptable risk to people, property and the environment. Hazardous chemicals should not present a risk to or impose upon emergency services when responding to an emergency or evacuation.

4.3 Reporting and Auditing

This bushfire report is a controlled working document that is to be updated and revised to reflect adaptive management and constructive feedback. Some sections of the plan may be modified, new procedures may be implemented, and responsibilities altered, depending on feedback and application.

This bushfire report will only ever be modified with the agreement of Logan City Council. This agreement allows for changes to the plan scope, as determined through consultation and the acceptance of the proponent. That is, where further actions are deemed necessary or where actions can be reduced in scope.

4.4 Siting of Buildings

In accordance with the SPP 2017 (and associated guidance material) and the Logan City Planning Scheme 2015 (version 9), the proposed design has considered the key principles when siting development. The relevant clauses that have been considered are:

- Utilising land that is predominantly cleared to minimise ecological impacts to native vegetation;
- Maximising where practicable building frontage setbacks from any hazardous vegetation; and
- Siting of buildings so that elements of the development that are least susceptible to fire are situated closest to the bushfire hazard (e.g. driveways, parking areas and protective landscape treatments).

4.5 Asset Protection Zones

The use of an APZ is the most effective defence against flame and radiant heat and to a lesser extent, ember attack. The APZ incorporates defendable space and allows for managing heat intensities at the building surface. Appropriate vegetation management measures shall be required to manage fine fuels, which have the greatest influence on the spread of a conventional flame front-driven bushfire (Queensland Government and CSIRO, 2020).

Section 9.4 of the QFES Bushfire Resilient Communities document states that vulnerable uses (such as childcare centres) are to be sited so they achieve a radiant heat flux of no more than 10 kW/m². To achieve this outcome, an Asset Protection Zone (APZ) has been established surrounding the child care centre, to ensure that the centre will be able to achieve and maintain a maximum radiant heat exposure of 10kW/m² and a BAL-12.5 construction rating (**Figure 6**).

The APZ will have the following characteristics:

- The APZ is to be maintained as an area that is generally free of flammable material to provide defendable space and for managing heat intensities at the building surface.
- Any fences are to be constructed from non-combustible materials
- Garden beds are not to be located under trees.
- Any trees should have lower limbs removed up to a height of 2 metres above the ground.
- Landscape trees should be spaced so as to avoid the foliage of mature trees overhanging roof lines and gutters.
- Landscaping treatments within the APZ shall comprise only low threat vegetation, including lawn areas managed in a minimal fuel condition (i.e. ≤ 100 mm nominal height as specified in AS3959:2018) and plant species that are of low combustibility (i.e. species with high leaf moisture content, low volatile oil content, absence of shedding bark, low production of leaf litter etc.).

- Plants should also be arranged to minimise vertical and horizontal connectivity of plant material.
- Non-habitable structures such as sheds are permitted in the APZ, as long as they are made from non-combustible materials and are located greater than 6m from any habitable buildings.
- Regular yard maintenance should be undertaken to remove fine fuels and debris, particularly prior to and during the fire season (i.e., late Winter to early Summer). This shall include regular vegetation management and maintenance where necessary and practicable (e.g., brush-cutting, weed removal etc.) and removal of debris and rubbish.

4.6 Access Roads

Access to the childcare centre will be provided via a new driveway from Crowson Lane. This driveway is approximately 40m long and will be sealed. This driveway will provide safe and effective access and egress for emergency vehicles and occupants away from the direction of an approaching bushfire, either to the east or west. The access arrangements do not create any potential entrapment situations.

4.7 Electricity Supply

The proposed development will have access to mains electricity supply. Where practicable, electrical transmission lines will be installed underground.

4.8 Water Supply

The childcare centre will have access to the reticulated water supply.

4.9 Climate Change and Fire Weather – Projections for 2050

Climate change can act in two ways to affect fire behaviour. First, it is likely to exacerbate the fire-weather risk on any given day, leading to increased frequency or intensity of extreme and very extreme fire-weather days particularly within the fire season. Secondly, an increase in the accumulated fire risk over a year might represent a longer fire season and a reduction in the number of days suitable for prescribed burning.

It is recommended to review this document and associated bushfire procedures at the site over the coming decades in response to any potential increases of bushfire risk from climate change.

4.10 Emergency Response Procedures

An onsite fire management and evacuation strategy should be developed and available to implement in the event of an emergency. In the event of a pending fire emergency, assistance is to be obtained by contacting dialling 000.

5 Assessment Against the Bushfire Hazard Overlay Code

The site is mapped with the Logan City Planning Scheme 2015 (version 9) Bushfire Hazard Overlay, which triggers a response to the Bushfire Hazard Overlay Code. An assessment against this code is provided in **Table 6**.

Table 6: Assessment against the Logan City Planning Scheme 2015 (version 9) Bushfire Hazard Overlay Code.

Performance outcomes	Acceptable outcomes	Comments
For accepted development (subject to requirements) and assessable development		
Location, design and siting of development		
PO1 Development is designed to: a. minimise risk of bushfire hazard; b. provide safe premises; c. create efficient emergency access for fire-fighting and other emergency vehicles. <i>Note - Planning scheme policy 6 - Management of bushfire hazard provides guidelines on how to achieve this outcome.</i>	AO1 Development: a. does not increase the number of persons living in, or lots in, the Bushfire hazard area identified on Bushfire hazard overlay map OM-03.00; or b. is on a site that a bushfire hazard assessment prepared in accordance with the methodology in Planning scheme policy 6 - Management of bushfire hazard determines is of low bushfire hazard.	Compliant with AO1 The Bushfire hazard assessment provided in section 3 complies with Planning Scheme Policy 6. The hazard assessment determined that nearby vegetation is considered 'medium' hazard and the development achieves a BAL 12.5 rating and is not subject to radiant heat flux greater than 10 kW/m². Access to the childcare centre will be provided via a new driveway from Crowson Lane. This driveway is approximately 40m long and will be sealed. This driveway will provide safe and effective access and egress for emergency vehicles and occupants away from the direction of an approaching bushfire, either to the east or west.
PO2	AO2 Development is located and constructed:	Compliant with PO2 The Bushfire hazard assessment provided in section 3 complies with Planning Scheme Policy 6. The hazard assessment determined that nearby vegetation is

Development is sited and constructed to minimise the bushfire hazard and maximise the protection of life and property from bushfire. <i>Editor's note - Planning scheme policy 6 - Management of bushfire hazard contains guidance on the preparation of bushfire management plans.</i>	a. where there is no bushfire management plan approved by an existing development approval: i. such that the bushfire attack level is less than or equal to BAL-29; ii. away from the most likely direction of a fire front; iii. so that elements of the development least susceptible to fire are sited closest to the bushfire hazard; iv. such that asset protection zones are sited on land with a slope less than 18 degrees; v. such that asset protection zones are entirely within the boundaries of the private property of the development site; or b. where an approved bushfire management plan directs development to be located. <i>Note - BAL = Bushfire attack level is the radiant heat flux a building will experience during a bushfire and is a measure of heat energy impacting on a surface expressed as kW/m². BAL is calculated from the following factors; vegetation type, fuel loads, distance to vegetation, Forest Fire danger Index (FDI), flame length, fire behaviour/intensity and slope. BAL is used to determine the required construction level of a building and the size of asset protection zones (inner and outer radiation zones). Further information on calculating the BAL can be obtained from AS3959-2009.</i>	considered 'medium' hazard and the development achieves a BAL 12.5 rating and is not subject to radiant heat flux greater than 10 kW/m². The proposed Asset Protection Zone is sited on generally flat land.
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	<i>Editor's note - Asset protection zones are not located on slopes greater than 18 degrees to ensure maintenance is practical, soil stability is not compromised and the potential for crown/canopy fires is reduced.</i>	
PO3 Reconfiguring a lot ensures that lots are designed to minimise bushfire hazard and provide safe sites for people, property and buildings.	AO3 Lots: a. are suitable for people, property and buildings by: i. having a bushfire attack level less than or equal to BAL-29; or ii. containing a development envelope area that has a bushfire attack level less than or equal to BAL-29; b. provide asset protection zones that: i. are located on land with a slope less than 18 degrees; ii. are located on the same lot.	Not Applicable – the proposal is not for a ROL
Vehicular access and fire maintenance trails		
PO4 Access for fire management and evacuation is provided by access that: a. separates premises from adjoining vegetation; b. is safely accessible by fire fighting vehicles;	AO4 Access for fire management and evacuation is provided by vehicular access in the form of a perimeter road: a. with a minimum reserve width of 20 metres;	Compliant with PO4 The public road network separates the childcare building from the hazardous vegetation to the south. The access driveway location and dimensions allows for safe access and turning by fire fighting vehicles. Access to the site will not be prevented by a gate. The access driveway and public road network will provide

c. has regular vehicular access points for bushfire management, response and evacuation; d. has regular vehicle passing and turning areas for bushfire management, response and evacuation; e. allows access at all times for fire fighting vehicles; f. allows for maintenance, burning off and bushfire response; g. has vehicular links to an alternative through road; h. is readily maintained. <i>Editor's note - Planning scheme policy 6 - Management of bushfire hazard provides details on alternative solutions for providing fire management access and evacuation</i>	b. located between the premises and adjoining vegetation; c. with a maximum gradient of 12.5 percent; d. constructed to otherwise comply with section 3.4 - Movement infrastructure standards of Planning scheme policy 5 - Infrastructure; e. that has a layout that does not include a cul-de-sac.	safe and effective access and egress for emergency vehicles and occupants away from the direction of an approaching bushfire, either to the east or west.
Water supply		
PO5 Development has access to adequate water supply for fire fighting purposes.	AO5 Development: a. is connected to a reticulated water supply scheme that has sufficient flow and pressure characteristics for fire fighting purposes at all times with a minimum pressure and flow of 10 litres per second at 200kPa; or b. has an on-site water storage in accordance with Table 8.2.3.3.2 - Water storage for fire fighting,	Compliant with AO5 The development will be connected to the LCC reticulated water supply.

	dedicated or retained for fire fighting purposes that is made of fire resistant materials and is: i. a separate tank; or ii. a reserve section in the bottom part of the main water supply tank. <i>Editor's note - The requirement in AO5 is:</i> <i>- in addition to the requirement for potable water supply/storage in AO2 in Table 9.4.3.3.1 - Infrastructure code: accepted development (subject to requirements) and assessable development.:- reflected in AO5 in Table 9.4.3.3.1 - Infrastructure code: accepted development (subject to requirements) and assessable development.</i>	
For assessable development		
Community infrastructure		
PO6 Community infrastructure is not located in a bushfire hazard area or is able to function effectively during and immediately after a bushfire event.	AO6 Community infrastructure is: a. not located in a Bushfire hazard area identified on Bushfire hazard overlay map OM-03.00; or b. located to ensure that: i. the core services provided by the community infrastructure is able to function effectively during bushfire events;	Not Applicable – the proposal is not for community infrastructure

	ii. access to the community infrastructure is not compromised by bushfire events; iii. the safe storage of valuable records, public records and items of cultural or historic significance is able to be maintained during a bushfire event.	
Hazardous materials		
PO7 Public safety and the environment are not adversely affected by the adverse impacts of bushfire on hazardous materials including fuels, explosives and flammable chemicals manufactured or stored in bulk on premises.	AO7 Hazardous materials: a. storage is in compliance with AS1940 - The storage and handling of flammable and combustible liquids; b. manufacturing does not occur in a Bushfire hazard area on Bushfire hazard overlay map OM-03.00.	Not Applicable – the proposal does not involve storage of hazardous chemicals.

6 Conclusion

This report has been prepared to provide a site-specific bushfire hazard assessment and management plan for a proposed childcare centre at 1-23 Crowson Lane, Munruben. The bushfire assessment has been undertaken in accordance with a contemporary methodology i.e. the methodology outlined in the QFES *Bushfire Resilient Communities* Technical Reference Guide (QFES, 2019) and utilises QFES-published inputs (FFDI and fuel loads) for hazardous vegetation classified in accordance with the QFES vegetation hazard classification system.

The results of the assessment show that vegetation associated with the eucalypt forest (VHC 10.2) to the south of site has a potential bushfire hazard class of 'Medium'. All other vegetation within 150 m of the development site is not classified as bushfire-prone and therefore, calculation of radiant heat flux/bushfire attack level (BAL) is not applicable.

The proposed childcare centre is defined as a 'vulnerable use'. Section 9.4 of the QFES Bushfire Resilient Communities document states that vulnerable uses are to be sited so they achieve a radiant heat flux of no more than 10 kW/m². To achieve this outcome, the development footprint (buildings, play areas, car parking) will need to be sited at least 42.9m from retained vegetation to the south of the site. The proposed new development footprint area achieves this setback and is thus compliant with this requirement for a vulnerable use. A bushfire Asset Protection Zone (APZ) is also proposed around the building to achieve this outcome. Regular fuel maintenance within the APZ will be required by the site manager to ensure ongoing protection of the structure and occupants.

Access to the childcare centre will be provided via a new driveway from Crowson Lane. This driveway is approximately 40m long and will be sealed. This driveway will provide safe and effective access for emergency vehicles and safe egress for occupants away from the direction of an approaching bushfire, either to the east or west, via the public road network. In addition, the public road network separates the childcare building from the hazardous vegetation to the south, acting as a buffer area. The childcare centre will have access to the reticulated water supply for fire fighting purposes.

The proposed development complies with *State Planning Policy 2017* Natural Hazards, Risk and Resilience Assessment Benchmarks and the *Logan Planning scheme 2015* Bushfire Hazard Overlay Code.

7 References

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Appendix 1

Proposed Development Layout

MUNRUBEN CHILDCARE

DEVELOPMENT APPLICATION

1-23 CROWSON LANE MUNRUBEN QLD 4125

FOR: ONEFIN OPS PTY LTD



ARTIST IMPRESSION ONLY

DRAWING LIST

SHEET	DRAWING NAME
22797_DA-000_C	COVERPAGE
22797_DA-010_C	DESIGN INTENT
22797_DA-020_B	SITE CONTEXT AND ANALYSIS
22797_DA-100_B	OVERALL SITE PLAN
22797_DA-110_D	SITE PLAN
22797_DA-130_C	FLOOR PLAN
22797_DA-200_C	ELEVATIONS - 1
22797_DA-201_C	ELEVATIONS - 2
22797_DA-300_C	SECTIONS
22797_DA-400_C	PERSPECTIVES
22797_DA-900_C	MATERIAL PALETTE

DA ISSUE

NOT FOR CONSTRUCTION

11/09/2023

LIGHT TEXTURED BRICK



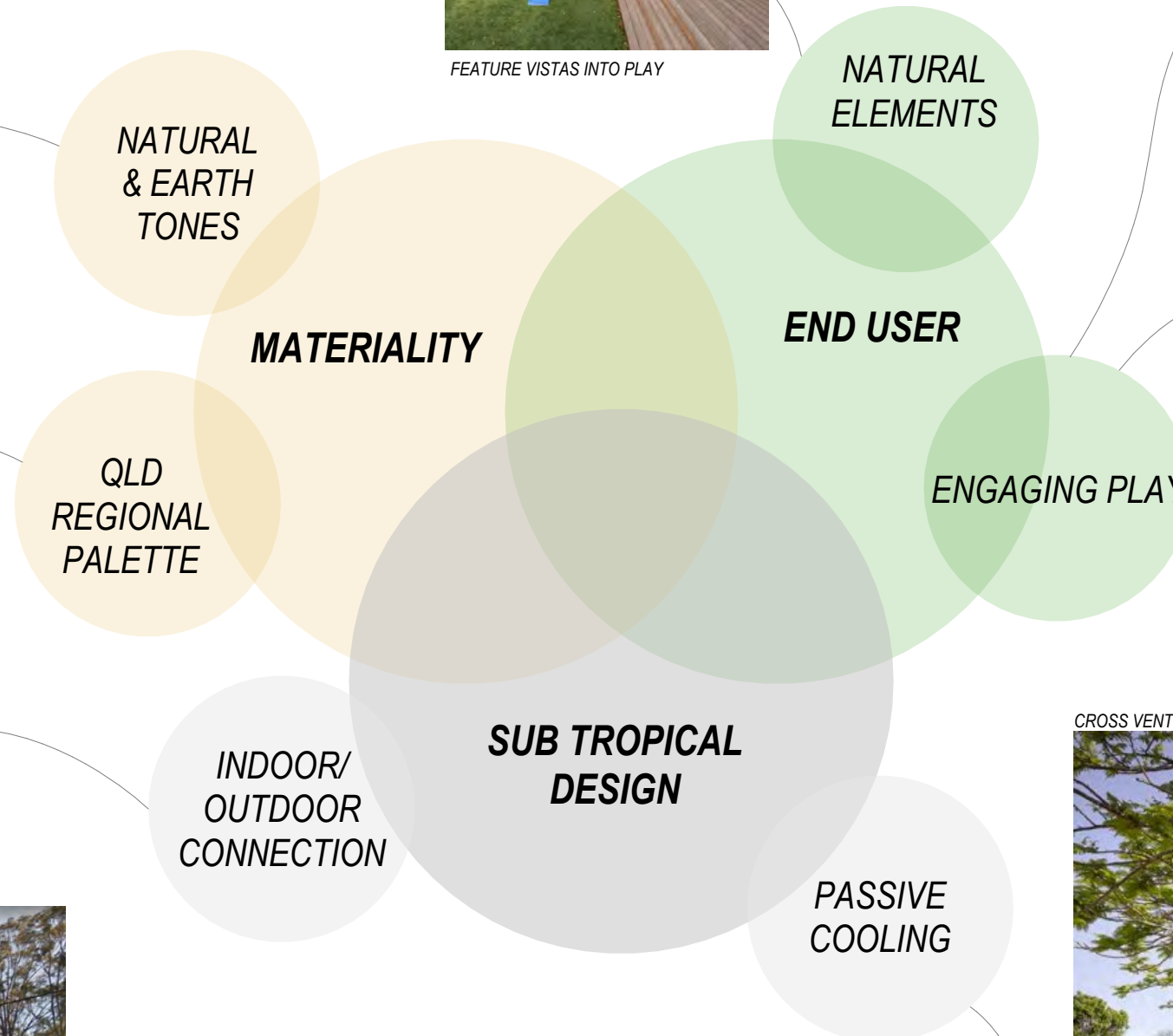
FEATURE VISTAS INTO PLAY



WEATHERBOARD FEATURES



CROSS VENTILATION



RPD

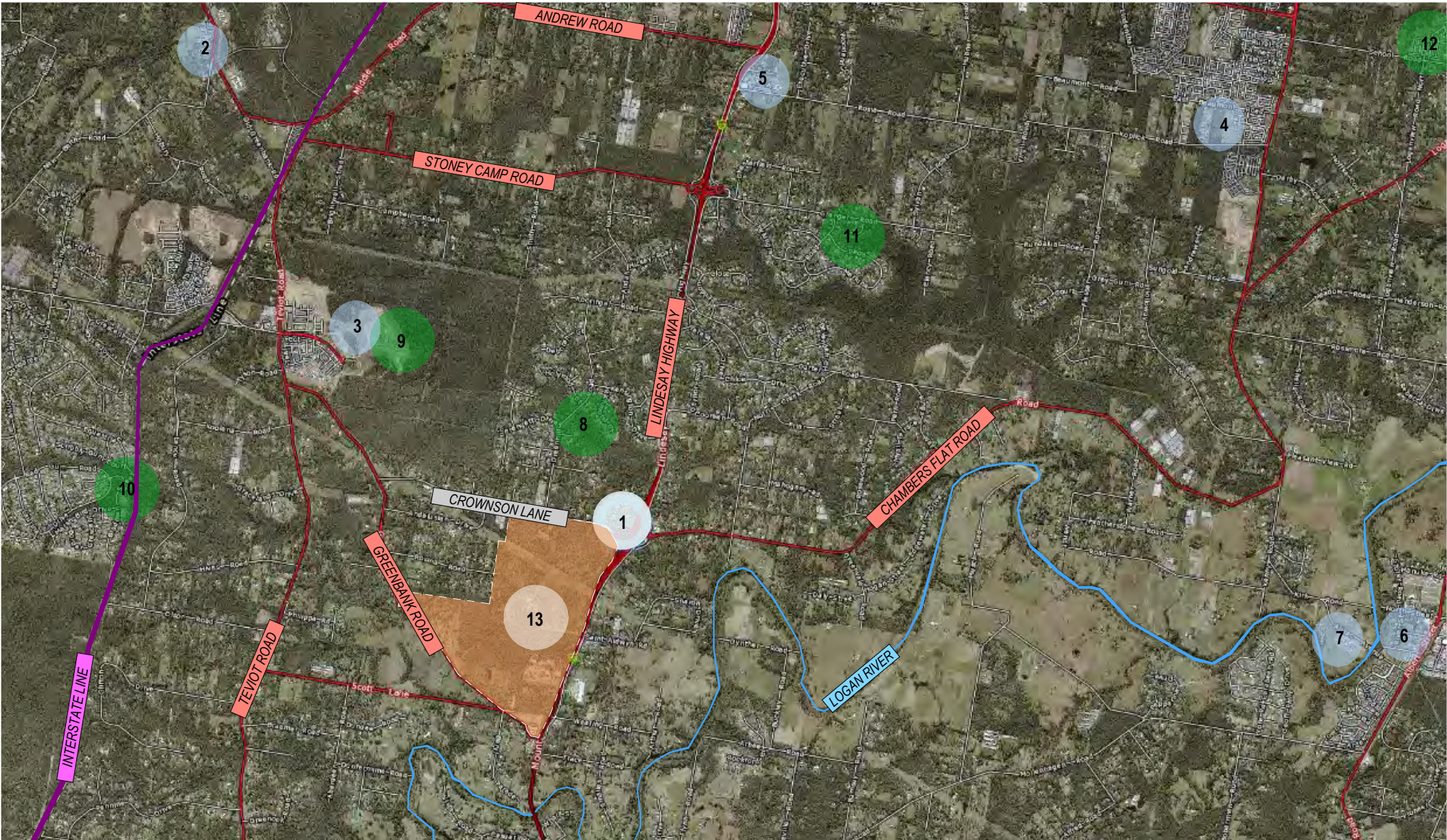
LOT PLAN:

LOCAL AUTHORITY:
LOGAN CITY COUNCIL

SITE ADDRESS:
1-23 CROWSON LANE , MUNRUBEN QLD 4215

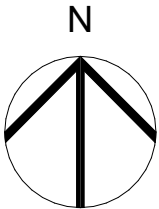


1 SITE ANALYSIS



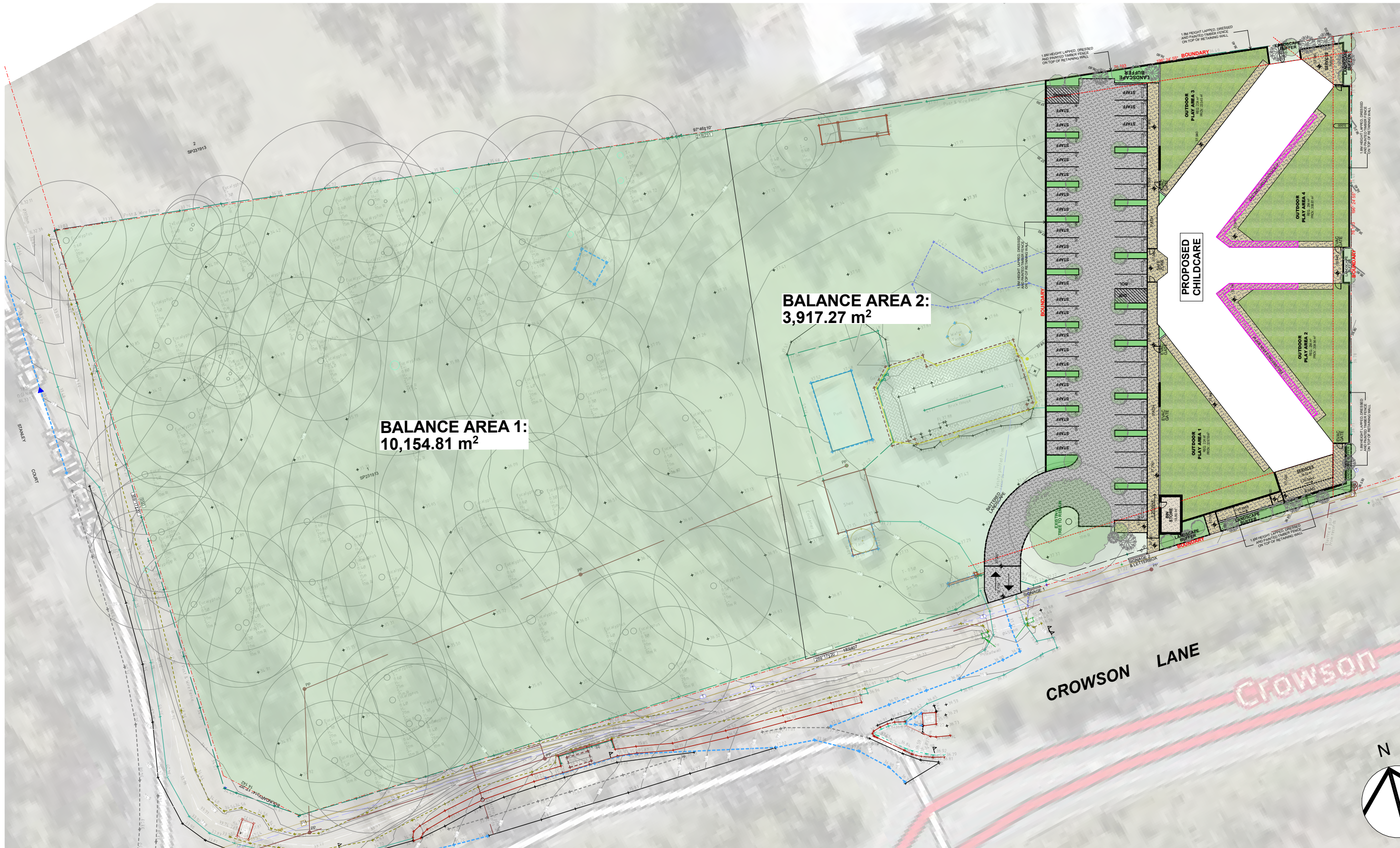
2 SITE CONTEXT

- 1. SITE
- 2. GRENK STATE SCHOOL
- 3. EVERLEIGH STATE SCHOOL
- 4. SAINT PHILOMENA SCHOOL
- 5. PARKLANDS CHRISTIAN COLLEGE
- 6. LOGAN VILLAGE STATE SCHOOL
- 7. KING'S CHRISTIAN COLLEGE LOGAN
- 8. WEARING PARK
- 9. EVERLEIGH PARK
- 10. TEVIOT DOWNS PARK
- 11. JINGERI PARK
- 12. STONELEIGH RESERVE PARK
- 13. NORTH MACLEAN PRIORITY DEVELOPMENT AREA



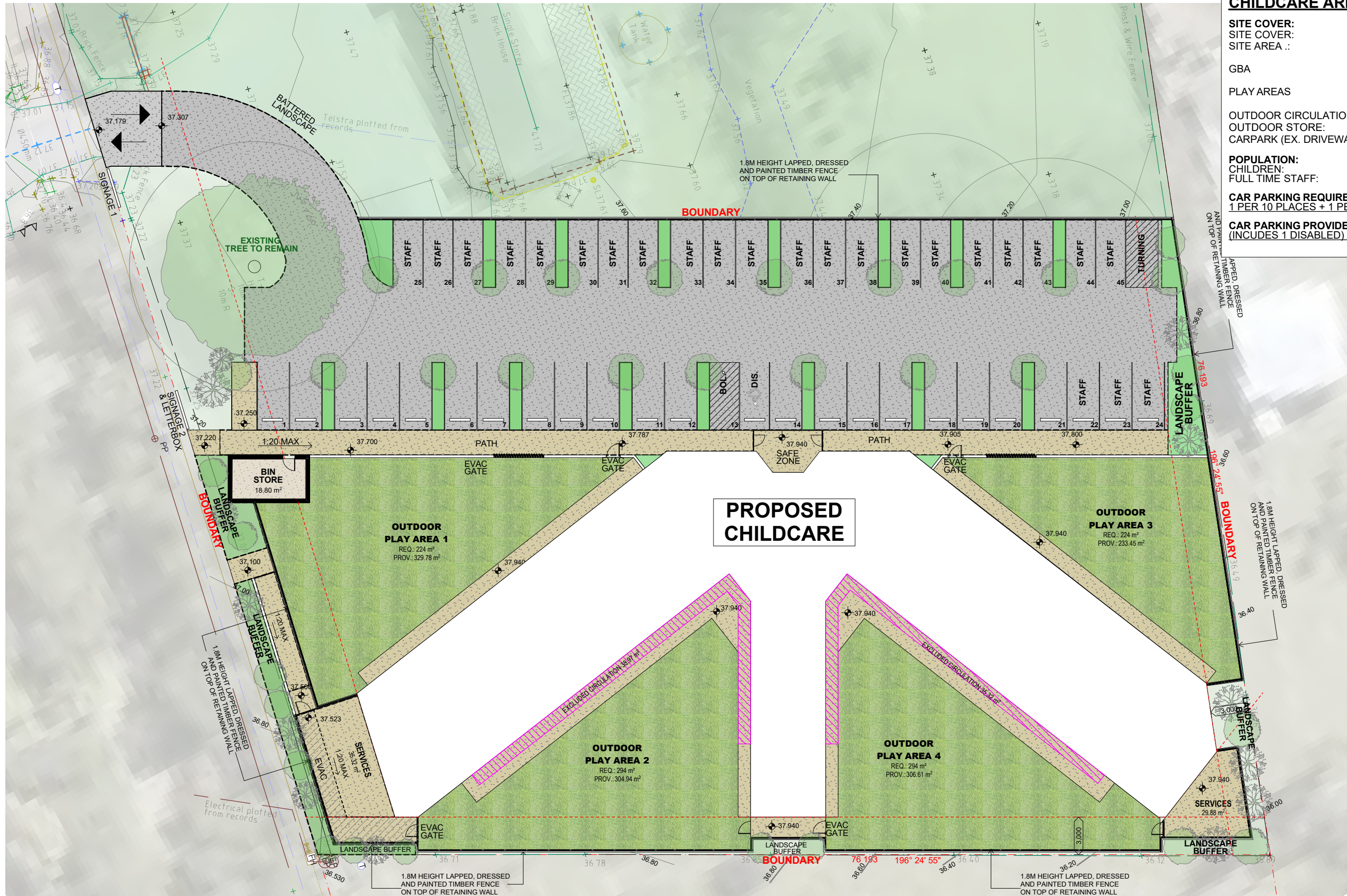
DA ISSUE
NOT FOR CONSTRUCTION

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11/09/2023



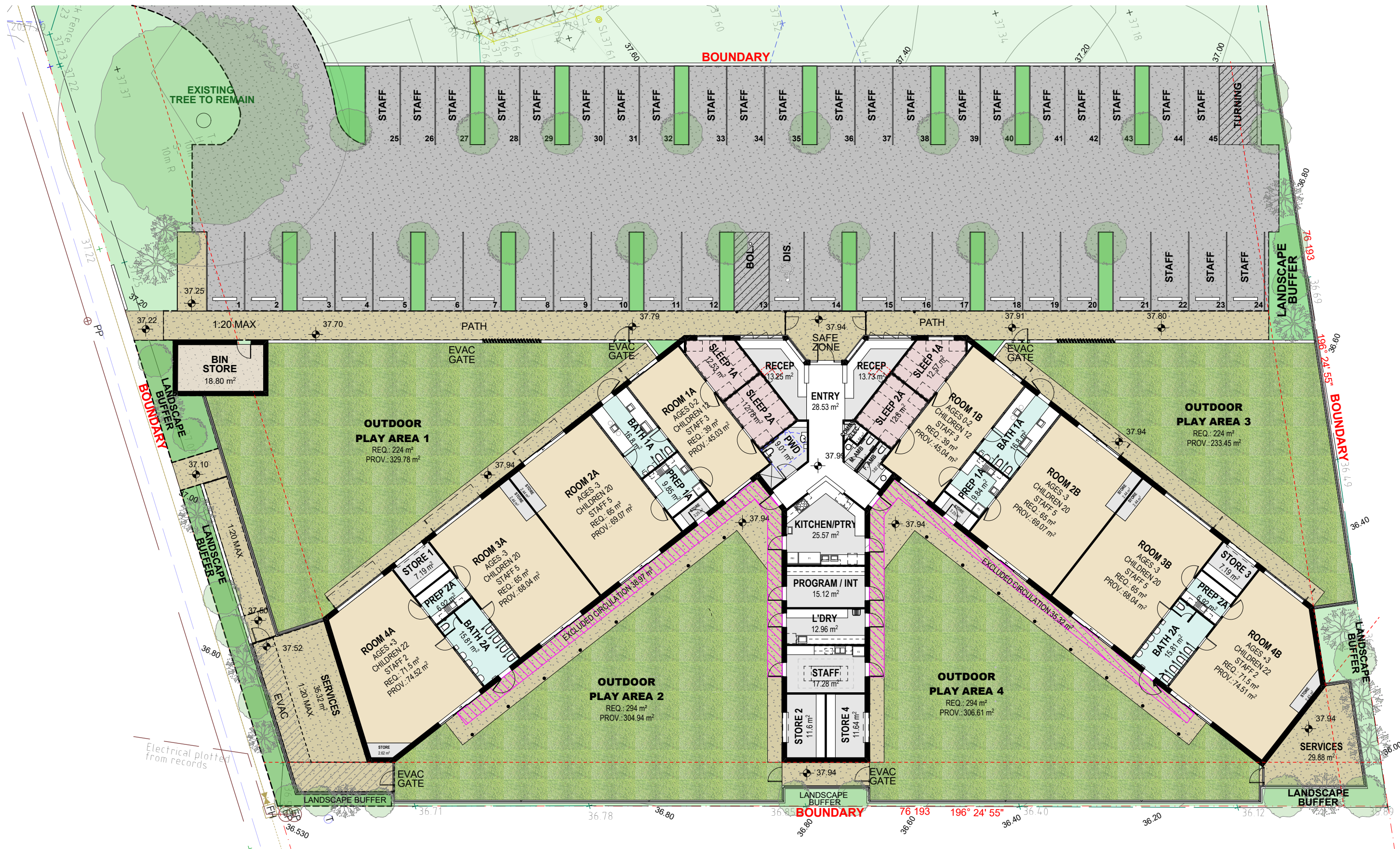
CHILDCARE AREA SCHEDULE

SITE COVER:	28.2%
SITE COVER:	1173m ²
SITE AREA :	4162m ²
GBA	915m ²
PLAY AREAS	1184m ²
OUTDOOR CIRCULATION:	78m ²
OUTDOOR STORE:	84m ²
CARPARK (EX. DRIVEWAY):	1170m ²
POPULATION:	
CHILDREN:	148
FULL TIME STAFF:	30
CAR PARKING REQUIRED:	
1 PER 10 PLACES + 1 PER FTE	44.8
CAR PARKING PROVIDED:	
(INCLUDES 1 DISABLED)	45

SITE PLAN
1:300

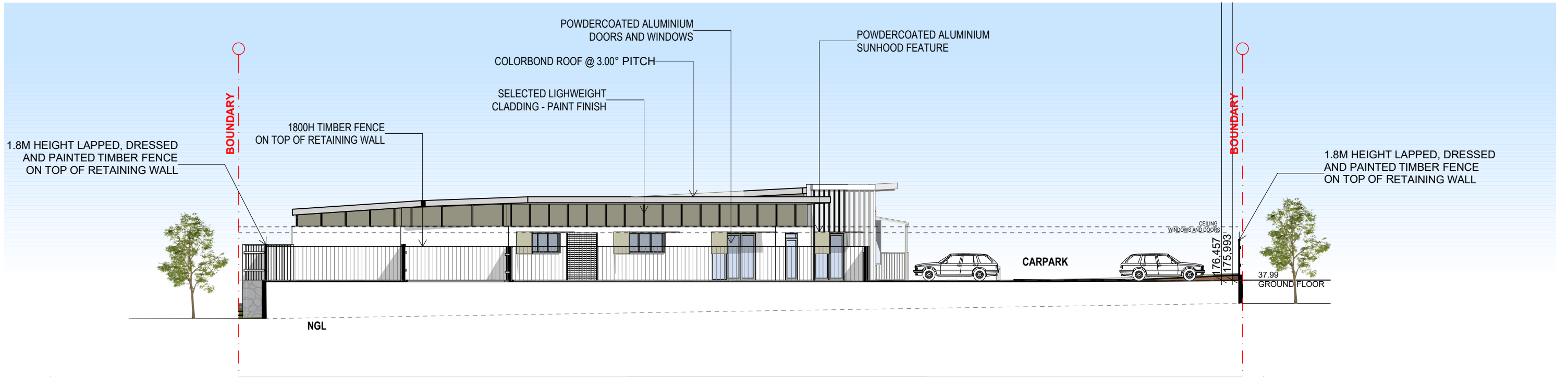
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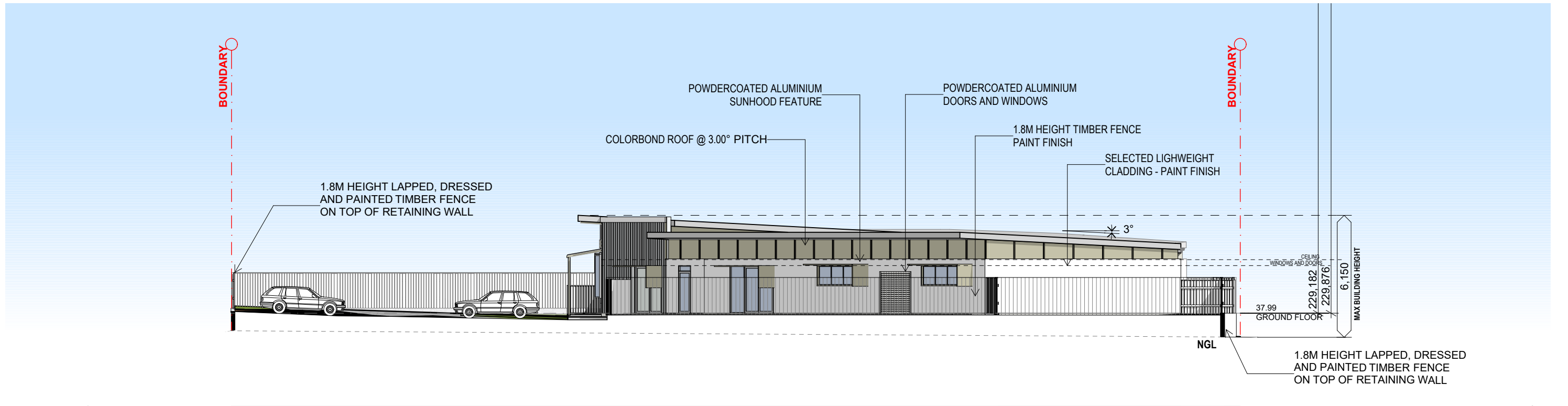


FLOOR PLAN
1:250

DA ISSUE
NOT FOR CONSTRUCTION
11/09/2023



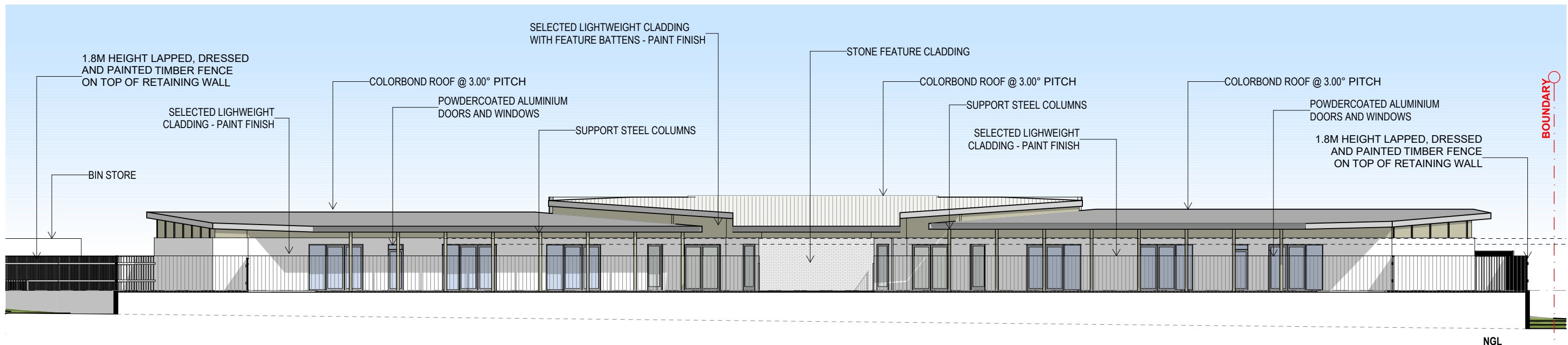
1 NORTH ELEVATION
1:200



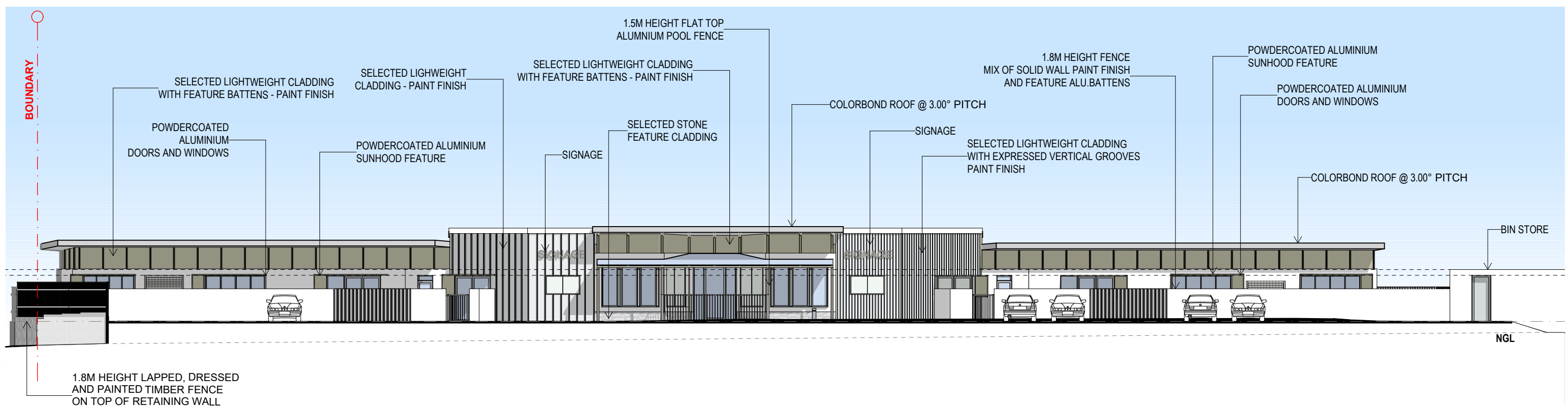
2 SOUTH ELEVATION
1:200

DA ISSUE
NOT FOR CONSTRUCTION

11/09/2023



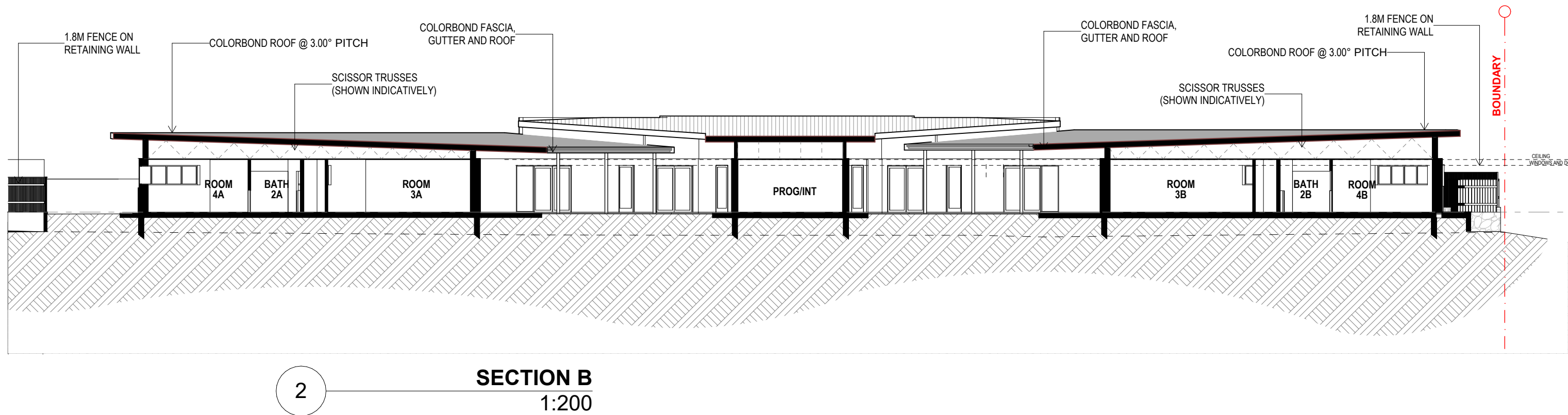
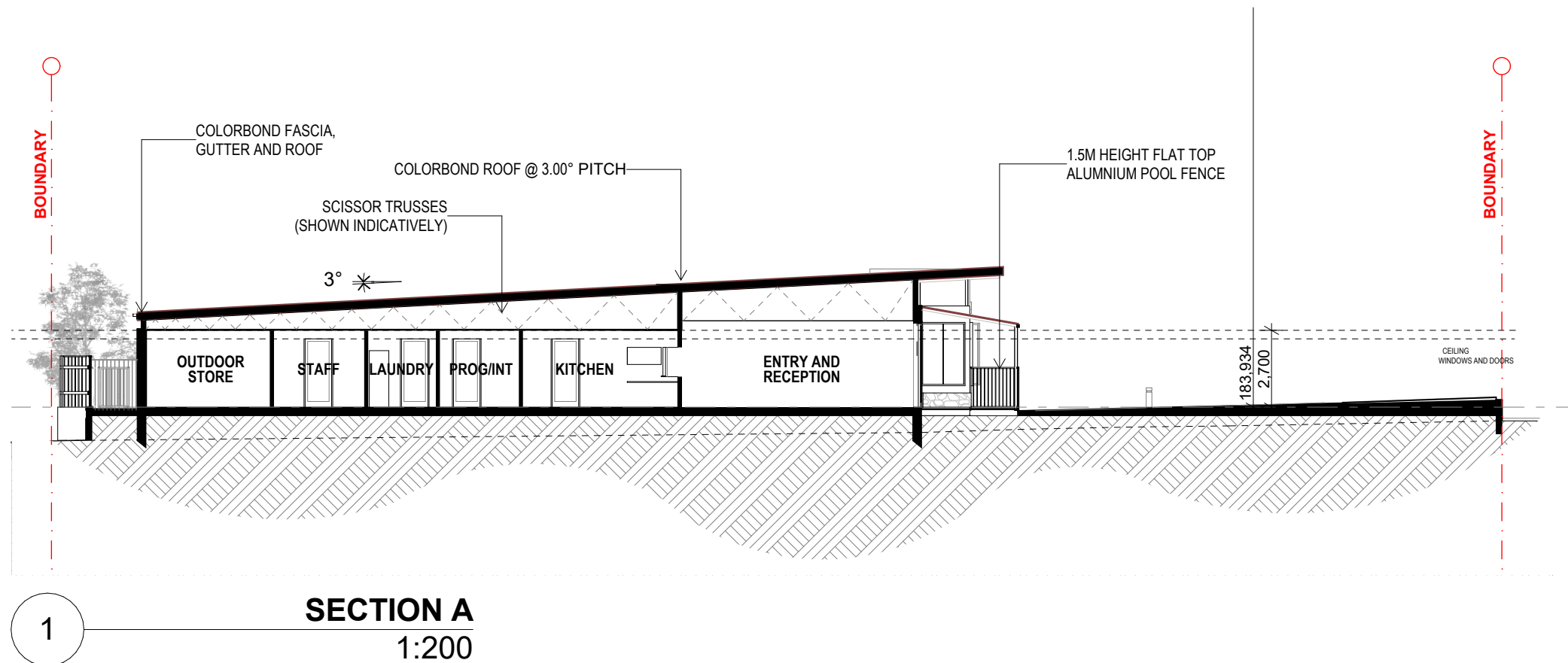
EAST ELEVATION
1:200



WEST ELEVATION
1:200

DA ISSUE
NOT FOR CONSTRUCTION

11/09/2023



DA ISSUE
NOT FOR CONSTRUCTION

11/09/2023



ARTIST IMPRESSION ONLY- ENTRY



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Appendix 2

Flamesol Method 2 Minimum Distance Calculations



Calculated October 10, 2022, 9:03 pm (MDc v.4.9)

south

Minimum Distance Calculator - AS3959-2018 (Method 2)

Inputs

Outputs

Fire Danger Index	55	Rate of spread	1.39 km/h
Vegetation classification	Woodland	Flame length	11.22 m
Understorey fuel load	17 t/ha	Flame angle	66 °, 72 °, 77 °, 80 °, 81 ° & 85 °
Total fuel load	18 t/ha	Elevation of receiver	4.89 m, 5.02 m, 5.01 m, 4.89 m, 4.79 m & 3.83 m
Vegetation height	n/a	Fire intensity	12,967 kW/m
Effective slope	3.15 °	Transmissivity	0.866, 0.849, 0.825, 0.801, 0.789 & 0.733
Site slope	1 °	Viewfactor	0.4109, 0.3042, 0.2054, 0.1393, 0.1131 & 0.0305
Flame width	100 m	Minimum distance to < 40 kW/m ²	13.4 m
Windspeed	n/a	Minimum distance to < 29 kW/m ²	18 m
Heat of combustion	18,600 kJ/kg	Minimum distance to < 19 kW/m ²	26.1 m

Flame temperature	1,200 K	Minimum distance to < 12.5 kW/m ²	36.4 m
		Minimum distance to < 10 kW/m ²	42.9 m

Rate of Spread - Mcarthur, 1973 & Noble et al., 1980

Flame length - NSW Rural Fire Service, 2001 & Noble et al., 1980

Elevation of receiver - Douglas & Tan, 2005

Flame angle - Douglas & Tan, 2005

Radiant heat flux - Drysdale, 1999, Sullivan et al., 2003, Douglas & Tan, 2005