Bushfire Management Plan

Pickering Brook Townsite Bushfire Risk Assessment

Project No: EP19-138(01)

Prepared for Department of Planning, Lands and Heritage
April 2020

Document Control

Doc name:	Bushfire Management Plan Pickering Brook Townsite Bushfire Risk Assessment				
Doc no.:	EP19-138(01)--001				
Version	Date	Author		Reviewer	
1	February 2020	Anthony Rowe	AJR	Dana Elphinstone	DAE
	The report issued to the client for review.				
A	March 2020	Anthony Rowe	AJR	Dana Elphinstone	DAE
				Ashley Bird	ALB
	Subsystem Risk Assessment Colours labelled				
B	March 2020	Anthony Rowe	AJR	Dana Elphinstone	DAE
				Ashley Bird	ALB
	Clarifications requested by DPLH				
C	March 2020	Anthony Rowe	AJR	Dana Elphinstone	DAE
	Adjacent land use to roadway included in the road audit Appendix A				
D	April 2020	Anthony Rowe	AJR	Dana Elphinstone	DAE
	Clarification provided in response to comments received from DFES, DPLH and the City of Kalamunda				

Disclaimer:

This document has been prepared in good faith and is derived from information sources believed to be reliable and accurate at the time of publication. Nevertheless, it is distributed on the terms and understanding that the author is not liable for any error or omission in the information sources available or provided to us, or responsible for the outcomes of any actions taken based on the recommendations contained herein. It is also expected that our recommendations will be implemented in their entirety, and we cannot be held responsible for any consequences arising from partial or incorrect implementation of the recommendations provided.

This document has been prepared primarily to consider the layout of development and/or the appropriate building construction standards applicable to development, where relevant. The measures outlined are considered to be prudent minimum standards only based on the standards prescribed by the relevant authorities. The level of bushfire risk mitigation achieved will depend upon the actions of the landowner or occupiers of the land and is not the responsibility of the author. The relevant local government and fire authority (i.e. Department of Fire and Emergency Services or local bushfire brigade) should be approached for guidance on preparing for and responding to a bushfire.

Notwithstanding the precautions recommended in this document, it should always be remembered that bushfires burn under a wide range of conditions which can be unpredictable. An element of risk, no matter how small, will always remain. The objective of the Australian Standard AS 3959:2018 is to "prescribe particular construction details for buildings to reduce the risk of ignition from a bushfire while the front passes" (Standards Australia 2018). Building to the standards outlined in AS 3959 does not guarantee a building will survive a bushfire or that lives will not be lost.

EXECUTIVE SUMMARY

The State Government has formed a Project Taskforce and Project Working Group to prepare the Pickering Brook and Surrounds Sustainability and Tourism Strategy (the Strategy) for the Perth Hills between Paulls Valley in the north and Roleystone in the south. A subset of this strategy is an evaluation of the sustainable expansion of the Pickering Brook townsite.

The Project Working Group, on behalf of the Taskforce, is investigating six townsite expansion options (scenarios), within the context of the bushfire risk.

The Pickering Brook townsite is located within an 'extreme' bushfire hazard level area (determined by Appendix 2 Guidelines for Planning in Bushfire Prone Areas V1.3). The important consideration for the Taskforce is to compare the merit of an expansion of the Pickering Brook townsite and choose to recommend either:

1. Deny, avoid, further townsite expansion;
2. Support townsite expansion with no further mitigation (controls); or
3. Support townsite expansion with mitigation treatments to achieve an acceptable risk.

The purpose of this Bushfire Management Plan has been to demonstrate the capability, to achieve an acceptable risk through identifying a comprehensive range of practical and complementary measures. This is to assist the Taskforce in its deliberation on whether a townsite expansion can occur within an acceptable level of risk and the preferred scenario.

The six townsite expansion scenarios are located at the western section of the townsite and located on Pickering Brook Road, and for this BMP referred to as the Pickering Brook Planning Investigation Area (PIA). The PIA includes Town Lot 81 (scenario 1), which had been identified for townsite expansion many years ago but is now a conservation lot and therefore unlikely to be developed. The area comprising scenarios 2-6, and for this BMP referred to as the townsite expansion area, had been used for horticulture production (Landgate imagery 1974) and is mostly cleared of native vegetation.

The Pickering Brook locality has a population of 570 people (2016 Census) and is comprised of primary production lots and rural lifestyle lots. The townsite is conspicuous in the locality comprising a cluster of 53 residential lots (mostly 2000m^2 each ('R5')) in a double block located along Pickering Brook Road and opposite to the Pickering Brook Primary School (town). The townsite expansion area (scenarios 2-6) have a cumulative potential to add 770 persons to the Pickering Brook locality. The addition of Town Lot 81 (identified as scenario 1) would have the potential to add another 385 persons.

Given this is an expansion of an existing townsite, the expansion considerations must address the risk to the existing townsite and locality, be it positive or negative. This includes the capacity of existing bushfire mitigation infrastructure, road capacity and water supply. It is also an opportunity to highlight the effectiveness of existing mitigation measures and identify shortcomings that may benefit both the expansion (new settlement) and the existing townsite and its immediate locality.

Assessed Risk

This BMP has followed the comprehensive risk assessment method described in the *National Emergency Risk Assessment Guidelines* (2015 and updated 2020[1]) (NERAG), which is consistent with AS/NZ S ISO 310000:2018 *Risk management principles and guidelines*, to classify the inherent risk (do nothing) and scope the risks into components that evaluate current treatments (controls) and suggest further risk mitigations (treatments) to practically minimise the residual risk.

The townsite and PIA are set in a valley surrounded by National Parks with an extensive area greater than 5 km of contiguous vegetation (Forest – high fuel), slopes of 5-10°, and an FFDI of 80. The expected bushfire behaviour is an intense[2] fire, with high radiant heat, and potential for the townsite to be affected by spotting, and ember attack.

Based on a review of landscape-scale fires, since 2000[3], it is estimated that Pickering Brook will experience the effects of a landscape bushfire (ember attack or fireline radiant heat) within 5 km of the townsite occurring at least once every five years. This equates to a 20% chance of a landscape-scale bushfire every bushfire season. The fire history demonstrates that despite the rate of occurrence of landscape-scale fires in the area, there has yet to be a penetration of a bushfire within the townsite. This can be attributed to present bushfire mitigation measures and in particular, the fuel reduction activity taken in the adjacent National Parks, and Lot 81, and brigade suppression activity.

A study of the 2005 landscape-scale fire identified that it ignited east of Pickering Brook and was arrested in areas that had been treated (prescribed burns) within the last three years and significantly it had been effective in restricting the penetration of a bushfire into the townsite, and into urban Perth.

The BMP, following the NERAG risk assessment methodology, has determined the initial risk to the Pickering Brook townsite location is 'Extreme'. The determination is made on the assumption of an absence of mitigation measures, that bushfire is likely in the area and bushfires can cause fatalities (catastrophic). The NERAG however, provides an orderly and comprehensive approach to identify and weight the effectiveness of existing mitigations (controls) and propose and evaluate additional measures (treatments) to derive a potential residual risk (subjective), that may be used as a basis for determining an acceptable risk.

Acceptable risk

There is presently no reliable quantifiable measure that can identify an 'acceptable risk', nor is there a clear pathway to mitigate risks to a quantifiable 'acceptable' level. Determining authorities instead rely upon a mix of data, some empirical, some quantifiable, to make a judgement upon a range of measures that can reasonably mitigate the risk to a level that is as low as practical. Satisfaction in this regard may also be assisted by the identification of multiple options (redundancies) that act to reduce the risk and provide back up plans and multiple options for safety.

[1] NERAG 2015 has been updated , updated 2020 to account for AS31000:2018
2 Manual calculation is 43,400 kW/m
[3] DFES *All Fire Incidents Pickering Brook from 1/07/2000 to 30/06/2019*, 15 January 2020

The emphasis is therefore upon adopting a methodical and comprehensive approach, (NERAG) to identify the risk, its components and provide countermeasures, risk treatments, for each component.

"Emergency risk management helps to maximise limited resources, including time and energy. We take risks to make gains, hoping that the gain will be greater than the cost. Risk management helps make informed decisions and decisions about trading off costs and benefits of development."[4]

The role of buildings

This BMP has considered the fire history and compared the climatic and weather conditions affecting the Pickering Brook locality.

Bushfire behaviour is affected by weather conditions (measured as FFDI), the fuel type, and slope. This determines the bushfire intensity (radiant heat flux expressed as a Bushfire Attack Level (BAL)) and in turn determines the commensurate building performance required. The designed building performance is then a balancing of the separation from the classified vegetation and the construction standard. The relationship of FFDI (weather conditions) and the bushfire intensity is important because it is highly variable during the bushfire season and it cannot be controlled. Recent CSIRO[5] studies have found in a review of 260 bushfires between 1901 -2011, that 78% of all fatalities (773 civilian fatalities) occur within 30 m of a forest. 88% of fatalities 'within a structure' occur within 30 m of a forest when the buildings fail. Building failure increases significantly above an FFDI of 75[6] because as the intensity increases the separation that has routinely been provided becomes inadequate and the building performance (pre bushfire construction standard[7]) is overwhelmed.

Simplistically, people survive a bushfire if the building they shelter in survives but building survival has been found to reduce markedly over an FFDI of 100. House loss occurs when the intensity of the fire exceeds the performance of the building's construction.

"Using fire weather days (FFDI) as a point of correlation between life loss and house loss we find that house loss is a reasonably good predictor of potential or life loss……"[8]

Early evacuation is, therefore, the preferred emergency management response to avoid fatalities, particularly in areas predating construction standards, but also to allow for site preparations that are not commensurate with the performance level of the building. This, however, is predicated upon the route and destination being safer than the location being evacuated.

Contemporary bushfire construction standards aim to improve the passive survival of buildings and reduce the dependence upon active interventions and water resources, but they are not a guarantee that a building will survive.

---

[4] Australian Emergency Management Handbook Series, 2015) *National Emergency Risk Assessment Guidelines: practice guide10.1,* page 6

[5] Blanchi. R, Leonard. J, Haynes. K, Opie. K, James. M, Kilinc. M, Dimer de Oliveira. F, van den Honert.R, 2012, '*Life and House Loss Database Description and Analysis – Final Report*', CSIRO and Bushfire CRC

[6] An 'Extreme' Fire Danger Rating.

[7] There is conjecture that current construction standards underestimate the windspeed and its effect on the FFDI, but there was no change in AS3959:2018

[8] House loss is affected by human intervention, brigade intervention and self-defence. The early evacuation policy will increase the likelihood of house loss because people will not be present. The future ratio of house loss as a measure of potential fatality will require recalibration. The ratio may also be affected by improved bushfire construction and site planning intended to improve passive building survival.

The National Construction Code assumes a failure of 10% (a probability of fire ignition should not exceed 10%). This is not a measured rate of failure or a statistically representative level of failure. It is intended as a recognition that other factors are also important in contributing to building survival. It is intended to encourage the designer to strive to improve the resistance to ignition through the identification of complementary measures to reduce the risk

The probability of ignition is also reduced if the façade exposure is substantially below the performance limits of the construction methods used. The BMP has therefore used a higher FFDI based on a 1:200 (APE) occurrence and an FFDI of 100, to examine the proportionate risk across the area of each scenario, accounting for a projected increase in the FFDI for climate change and the expected building life.

This has been mapped across each scenario to illustrate the radiant heat categories in a BAL Contour Plan.

The mapping has illustrated that each scenario, given the minimum lot size of 2000m^2 enables all lots to comply with the maximum acceptable BAL level of BAL-29, and provides areas within each scenario determined as BAL Low.

The BMP has proposed that buildings within the scenarios should employ construction standards based upon an FFDI of 100 to exceed their façade exposure requirement under AS3959, and reduce the risk of building ignition from radiant heat.

In addition, the BMP has recommended a minimum BAL of 12.5 apply to all habitable buildings within the expansion area to address the potential for ember attack.

The BMP also recognised the importance of future land management to ensure the separation of structures, assisted by the large lot sizes, and controls on the vegetation to reduce ignition within the townsite expansion area.

These measures are expected to avoid house loss and reduce damage to a superficial level and a ‘minor’ consequence.

Minimising public exposure

It is now an important part of the planning and the justification of development in bushfire-prone areas to avoid public exposure to the effects of bushfire, to demonstrate that an effective multi-option evacuation road network is available.

The road network will need to support safe evacuation, suppression activity and support recovery. The effectiveness of the road network, aside from its physical capability, will also be affected by administrative parameters, including timely alerts, user certainty, and staging. It should also be supplemented as an alternative for refuge when the route and destination are less safe than the place of departure, and road closure is required to prioritise safe suppression activity.

The BMP has had regard to the traffic assessment reports prepared for the Metropolitan Regional Scheme (MRS) and this Study, and it has undertaken an audit of the roads leading from the Pickering Brook townsite in terms of their capacity and condition to support evacuation, with the urgency of an approaching bushfire.

In consideration of the fire history, it found legible routes available in alternate directions offering travel away from the bushfire front. This includes Canning Road both in a westerly direction or in a southerly direction and Patterson Road/ Walnut Road in a northerly direction. These roads comply with the specifications provided in the Guidelines, Table 6 – public roads.

The bushfire history has revealed bushfires predominantly arrive from west, south and east. They are rare from the northeast, and extremely rare from the north and northwest. The assessment also identified that Canning Road, as the primary service road for the townsite, should be prepared to act as a recovery road; immediately available after the passage of the fire across it. In this regard, the main threat to its function is from trees and powerlines falling into the roadway. The BMP recommends an audit of the trees and power poles within a 45^0 setback from the carriageway; to identify ground fuels and elevated vegetation required to be removed to separate the base of trees from a fire run, and to identify any tree structure weak points at the base. It is similarly recommended that the power poles and overhead wires be reviewed for clearance from falling trees and branches to minimise the disruption of power to the townsite. The audit is intended to act as a stimulus for communication between the stakeholders, to prioritise their works and establish Canning Road as a recovery road.

The BMP has investigated the capability for effective evacuation of a present population at Pickering Brook[9]. The present population recognises that the Pickering Brook townsite is not a through travel destination, i.e. a point between two destinations. It is instead an end destination; the present population is the maximum than may reasonably be expected to be present at any point in time. This includes the current population, the expansion population and the visiting population i.e. Core Cider and the Primary School.

The BMP has identified an evacuation process, the time available for early evacuation (described as Available Safe Egress Time (ASET)), and the time required for orderly evacuation accounting for road capacity and flow rate and human behaviour (described as the Required Safe Egress Time (RSET)). The ASET has been based upon the authorised rate of spread modelling (McArthur Mk 4) in AS 3959:2018. It is acknowledged this may underestimate the rate of spread in Extreme conditions (FFDI 75+) and that a firefront can also advance faster due to advanced spotting which increases with the scale of the fire and the extremity of the conditions.

The State Emergency Management Framework and the *Western Australia Community Evacuation in Emergencies Guideline* emphasise that the decision to evacuate is not taken lightly but is subject to a judgement of magnitude of the bushfire. Whilst the BMP has utilised an authorised model, to demonstrate capability, the Emergency Management Framework requires judgement needs to be made upon the magnitude of the fire, and the conditions, in determining whether evacuation is required and whether it is safe to evacuate.

[9] State Emergency Management Guidelines -*Western Australia Community Evacuation in Emergencies* Guideline 21 December 2018.

The BMP has considered the safety of firefighters and the State Emergency Management Framework. It is important to recognise that it is simply not safe for the public to be on the road in the presence of fire, therefore at the time when firefighting is being undertaken. Vehicles do not provide good protection if exposed to heat greater than 10 kW/m^2; excluding Black Saturday 2009, most public fatalities have occurred in transit. Suppression activities undertaken by emergency services occur when the route is too dangerous for public transit[10], when visibility is impaired due to smoke, therefore the public evacuation must be concluded before suppression activities commence, and an alternative to evacuation must be available when suppression activities have commenced.

The BMP has identified a safer place be established at the primary school oval if evacuation is not safe or the road has been closed (second redundancy). The school is central in Pickering Brook and only relatively minor works and landscaping (selective fuel removal) are required to achieve outdoor refuge of BAL-2 (calculated using FFDI 100 (instead of 80) and a flame temperature of 1200K (instead of 1090K))[11]. Studies of human behaviours[12] during the Black Saturday, 2009 bushfire found people wait and see, leave evacuation too late and go to spaces they know, not necessarily those nominated. The Primary School is prominent in the community, easily accessed and avoids the need to relocate children (during a school day) or cause parent anxiety, as parents will be at the same place.

In addition to the above, the package of measures associated with the new building construction will increase the survivability of the buildings. Should a house loss occur within the townsite expansion area, it is expected to be isolated, and not contribute significantly to the radiant heat within the expansion area, which has been determined as BAL low. Away from the interface with the nearest classified vegetation and direct radiant heat, tenable conditions are expected to be maintained within the estate supporting the ability to take refuge of last resort in the building.

Choosing between scenarios

All scenarios were assessed, using a higher standard FFDI of 100 instead of the routine FFDI 80 applicable to WA. Due to the large lot size, it was found that R5 development could be accommodated without any new building needing to exceed the acceptable construction level of BAL-29 (compliant with SPP 3.7 cl 6.7 and Element 2 Guidelines for planning in Bushfire Prone Areas v1.3.)

The BMP finds scenario 3, which also comprises the area of scenario 2, is the preferred option. These scenarios (2&3) are clear of native vegetation and straddle Pickering Brook Road, which is the town's main road. Pickering Brook Road provides low hazard access for evacuation, connecting to the main roads from town or the primary school as a safer place. Pickering Brook Road is a low hazard and is expected to be able to maintain serviceability throughout a bushfire event.

[10] State Emergency Management Guidelines *Traffic Management During Emergencies* Guideline 21 December 2018
[11] Australian Building Codes Board 2014, *Information Handbook: Design and Construction of Community Bushfire Refuges*,
[12] McLennan J. 2009, *Use of Informal Places of Shelter and Last Resort*, Bushfire Cooperative Research Centre, School of Psychological Science, La Trobe University.

Residual risk

The BMP has identified an 'as low as reasonably acceptable' outcome through the NERAG process, categorised within fire safety concepts[13] that address; ignition reduction; exposure minimisation; and bushfire management. These measures have been assessed to provide multiple redundancy and expediency (assessed on difficulty, cost, community acceptability, environmental impact); they also reflect a temporal Emergency Management considerations of prevention, preparedness, response and recovery.

The bushfire mitigation measures (following a Fire Safety Concepts methodology) are detailed in the *Bushfire Verification Method Handbook* (ABCB 2019).

With these measures in place, the risk whilst it will be reduced will not be zero. Only avoidance is a zero risk. A residual risk remains in spite of the reasoned 'minor' consequence achieved through the mitigation measures and risk treatments, because the risk of a fire affecting the town is 'likely' and because of this the risk level is determined by the National Emergency Risk Assessment Guidelines (2020) to be 'medium'.

Administration and Implementation

The purpose of this BMP is to identify the possibility for achieving an acceptable level of risk for the consideration of the Taskforce.

The controls and treatments identified in the BMP were identified for their expediency. Some measure is existing (controls) whilst the other measures (treatments) are largely coordination of existing responsibilities or a refocus on existing functions. This includes community awareness for bushfire preparation and response and communicating certain procedures and responsibilities.

These controls and treatments fit within the Local Emergency Management Arrangements within the State Emergency Management Committee Framework and the assignment of responsibility by the City of Kalamunda to incorporate the recommendations (**Table 1**) within the planning function of Local Emergency Management Arrangement for the City of Kalamunda. These aspects addressed in the BMP apply to the Pickering Brook townsite and locality and should be pursued regardless of the townsite expansion. In addition to the retention of current controls (mitigation measures)

This would include,

- The making of the Primary School oval as a safer place and alternative to evacuation
- Review of Canning Road and Pickering Brook Road between the townsite and the Kalamunda urban extent to minimise the likelihood of road blockage following the passing of a bushfire
- Community education – the establishment of a bushfire ready group?
    - for site preparation before the bushfire season and actions before the arrival of a bushfire front to separate materials and objects 6m from the building: and

[13] Australian Building Codes Board 2019, *Handbook: Bushfire Verification Method*, Commonwealth of Australia and States and Territories 2019, published by the Australian Building Codes Board.

- understanding of evacuation procedures, shelter procedures and fostering a preparedness

The facilitation of townsite expansion will require the implementation of specialised development controls. The Planning and Development (Local Planning Scheme) Regulations 2015, Deemed Provisions at cl. 78D (4)(a), enables a Local Planning Scheme to exceed the routine requirement within the Planning in Bushfire Prone Areas framework.

This may include establishing a Special Control Area and Local Development Plan to require the subdivision and the subsequent development incorporate the development control measures identified in this BMP. This includes:

- A determination of Bushfire Attack Levels based upon an FFDI of 100
- A separation between buildings of a minimum of 6 m, including positioning across boundaries, a minimum setback boundary setback of 3 m.
- A minimum construction Standard of no less than BAL 12.5
- A landscape requirement governing (restrictive covenant) each lot to ensure a vertical and horizontal separation of vegetation, and vegetation separated from the building in accordance with the Asset Protection Zone standard following Schedule 1 Element 3 in the Guidelines. This includes all fencing is to be non-combustible.
- The control of structures (restrictive covenant) exempt from development under the Planning and Development Act 2005 or Building Act 2011, to avoid potential ignition proximity to a habitable building.

Table 1: Recommended Bushfire Protection Measures

Recommended Bushfire Protection Measures	Stakeholder
Reduce Ignition	
Maintain the policing to reduce the rate of Arson.	The City of Kalamunda, Western Australian Police (WAPOL), and the Department of Fire and Emergency Services (DFES).
Undertake post-burn inspection to ensure smouldering objects are identified and extinguished.	The City of Kalamunda, and DFES.
Manage road verges, separate the carriage from classified vegetation by keeping space free of flammable material, to avoid ignition from a damaged vehicle and disposal of cigarettes.	The City of Kalamunda, and DFES.
Maintain community awareness on high fire risk days, avoid using open flame and undertaking activities that generate sparks that may contact cured grass and flammable vegetation, store combustible materials undercover.	The City of Kalamunda
Restrict public access to high-risk bushfire ignition areas.	The City of Kalamunda WAPOL, and DBCA.
Audit electrical equipment, Western Power assets on private land.	Western Power Pty Ltd.
Clear vegetation around power transmission lines.	The City of Kalamunda.
Minimise Exposure	
Identify and establish the evacuation road network	The City of Kalamunda.
In conjunction with the community prepare Pickering Brook Emergency Evacuations Plan that addresses:	The City of Kalamunda.
The means of reporting a fire.	
The means of alarm.	
Preparation to leave and what to take.	
The appropriate route (evacuation road network) for a given fire direction.	
The available period for evacuation – ASET/RSET thresholds.	
Assembly area a safer place and entry procedure.	
Recommended bushfire resistance improvement measures.	
Preparation of survival guidelines if it is too late to leave.	
Establish a local Bushfire Ready Group to promote procedures and refine the methods. *It is important that the local community understand the risk and have ownership for minimising their exposure.*	The City of Kalamunda.
Manage traffic to ensure the orderly movement of vehicles along evacuation routes and to the safer place within the townsite. Close exits when it is considered too late to leave, the route s unsafe, suppression activity has commenced.	The WAPOL, and the City of Kalamunda.

Table 1: Recommended Bushfire Protection Measures (continued)

Recommended Bushfire Protection Measures	Stakeholder
Minimise exposure (cont.)	
Establish permissions with the School and the Department of Education to utilise the school oval as a safer place shelter. Perimeter vegetation around the School oval and in adjacent road reserves will require modification to low threat (it is not a wholesale clearance but a horizontal and vertical separation of vegetation).	The Department of Education (DoE), and the City of Kalamunda.
Determine responsibilities and access to the oval outside of school hours.	The Department of Education, and the City of Kalamunda.
Ensure the telecommunications network is resistant to bushfire attack and can provide the community with guidance throughout the bushfire event.	DFES and communication carriers i.e. Telstra Pty. Ltd.
Manage the fire	
Through a descending hierarchy, Structure Plan, local development plans, and subdivision apply to the expansion area and should specify:	The City of Kalamunda, and the Western Australian Planning Commission (WAPC).
A minimum bushfire construction standard of BAL-12.5, or a higher level, as determined by AS3959:2018 and calculated with an FFDI 100; *Reason: Ember attack can occur at a distance greater than 100 m and cause a building to building fires and sequential loss.*	Development control policy
A restrictive covenant to maintain land in a low threat (from title creation through to building placement and the ongoing operation of the site), as described by AS 3959:2018 and by the Asset Protection Zone Standards described in Schedule 1 Appendix 4 of the *Guidelines for planning in bushfire prone areas* V1.3. *Reason: The resilience of the new development is dependent upon a collective resistance, including from vacant lots through to established operation.*	Development control policy
Reduce the threat of ignition and the spread of bushfire on private land by managing fuels by enforcing s33(1) of the *Bushfires Act 1954*.	The City of Kalamunda, and DFES.
Reduce the threat of ignition and the spread of bushfire on public land by reliably managing fuels, a maximum of a three-year cycle for land adjoining Pickering Brook townsite.	Parks and Wildlife Service, DBCA
Maintain community awareness of the importance of maintaining grounds around a building and being vigilant to flammable structures located close to the building, including the adjoining land.	The City of Kalamunda, and DFES community education programs.
Encourage owners to upgrade their existing buildings to improve bushfire resistance.	The City of Kalamunda, and DFES community education programs.
Reduce the threat of disruption to the function of Canning Road, and the townsite, by auditing vegetation and power infrastructure. Ensure vegetation is separated from power poles and powerlines separated from the potential of falling branches.	The City of Kalamunda and Western Power Pty. Ltd.
Maintain aerial spotting services and watchtower, for early identification of bushfire development.	The DBCA.

Table 1: Recommended Bushfire Protection Measures (continued)

Recommended Bushfire Protection Measures	Stakeholder
Provide for the safe undertaking of roadside fire suppression by managing community movement in a bushfire event – too late to leave, evacuate to the school, road closure to then enable fire brigade operations	The City of Kalamunda, WAPOL, and DFES.
Enable emergency service access and retreat from Pickering Brook Road through to Ashendon Road	The City of Kalamunda, DFES, and the Department of Biodiversity Conservation and Attractions (DBCA).
Ensure a water supply is available throughout a bushfire event for the replenishment of fire services and the conduct of fire suppression within the townsite.	The Water Corporation Pty. Ltd., and DFES.
Ensure that the townsite does not become isolated after the passing of the firefront. Pickering Brook Canning Road to be audited and measures identified to reduce the potential for road blockage from fallen trees or powerlines,	The City of Kalamunda, Mainroads WA, Western Power, and DFES.

Table of Contents

List of Tables

List of Plates

Appendices

Appendix A

Road Audit

Abbreviation Tables

Table A1: Abbreviations – General terms

General Terms	
AHD	Australian Height Datum
AS	Australian Standard
APZ	Asset Protection Zone
BAL	Bushfire Attack Level
BEEP	Bushfire Emergency Evacuation Plan
BMP	Bushfire Management Plan
BPAD	Bushfire Planning and Design
ESL	Emergency Services Levy
FDI	Fire Danger Index
FZ	Flame Zone

Table A2: Abbreviations – Organisations

Organisations	
DBCA	Department of Biodiversity Conservation and Attractions
DoW	Department of Water (now known as Department of Water and Environmental Regulation)
DFES	Department of Fire and Emergency Services
OBRM	Office of Bushfire Risk Management
SES	State Emergency Services
WAPC	Western Australian Planning Commission

Table A3: Abbreviations –Legislation and policies

Legislation	
Guidelines	*Guidelines for Planning in Bushfire Prone Areas version 1.3* (WAPC and DFES 2017)
SPP 3.7	*State Planning Policy 3.7 Planning in Bushfire Prone Areas* (WAPC 2015)

Table A4: Abbreviations – Planning and building terms

Planning and building terms	
AS 3959	*Australian Standard 3959-2018 Construction of buildings in bushfire-prone areas*
LSP	Local Structure Plan
MRS	Metropolitan Region Scheme
NERAG	*National Emergency Risk Assessment Guidelines*
POS	Public Open Space
TPS	Town Planning Scheme
PIA	Pickering Brook Planning Investigation Area

1 Introduction

1.1 Background

The State Government has formed a Project Taskforce and Project Working Group to prepare the Pickering Brook and Surrounds Sustainability and Tourism Strategy (the Strategy) for a significant portion of the Perth Hills between Paulls Valley in the north and Roleystone in the south (shown in **Plate 1**).

The Strategy includes two main streams of work:

- Stream 1: To investigate the potential sustainable expansion of the Pickering Brook townsite.
- Stream 2: To develop a strategy for economic development initiatives within the study area including the growth of tourism activities in the Hills rural areas.

The Project Taskforce and Project Working Group will oversee the preparation of the Strategy with members representing Parliament, Western Australian Planning Commission (WAPC), relevant State Government agencies (including the Department of Fire and Emergency Services), and the Cities of Kalamunda and Armadale.

The Project Working Group on behalf of the Taskforce is undertaking identification of suitable options for the Pickering Brook townsite expansion, to be used as a basis for a multi-criteria sustainability analysis (MCSA) of options.

Specific outputs requested include:

- A bushfire hazard level assessment and BAL Contour Map for the proposed townsite expansion area.
- An assessment of options for the proposed Pickering Brook townsite expansion including:
  - the provision of suitable separation of the proposed townsite from the adjoining hazard (reserve);
  - the potential access and egress solutions, including recommendations for upgrade or provision of new roads to ensure vehicle access, is available and safe during a bushfire event; and
  - the identification of any requirements relating to water for firefighting
- Based on the bushfire assessment and consideration of access, hazard separation and water provision, make recommendations on the suitability of the expansion area as a whole and consider whether different areas of the expansion area are preferable to others.

It is acknowledged that the townsite is in a bushfire prone area and avoidance is one option – no further expansion. The purpose of this assessment is to examine the potential suitability of the townsite expansion investigation area, by the identification and evaluation (effectiveness and acceptability) of all measures required, to achieve an acceptably low level of risk to life and property; for evaluation by the Project Taskforce.

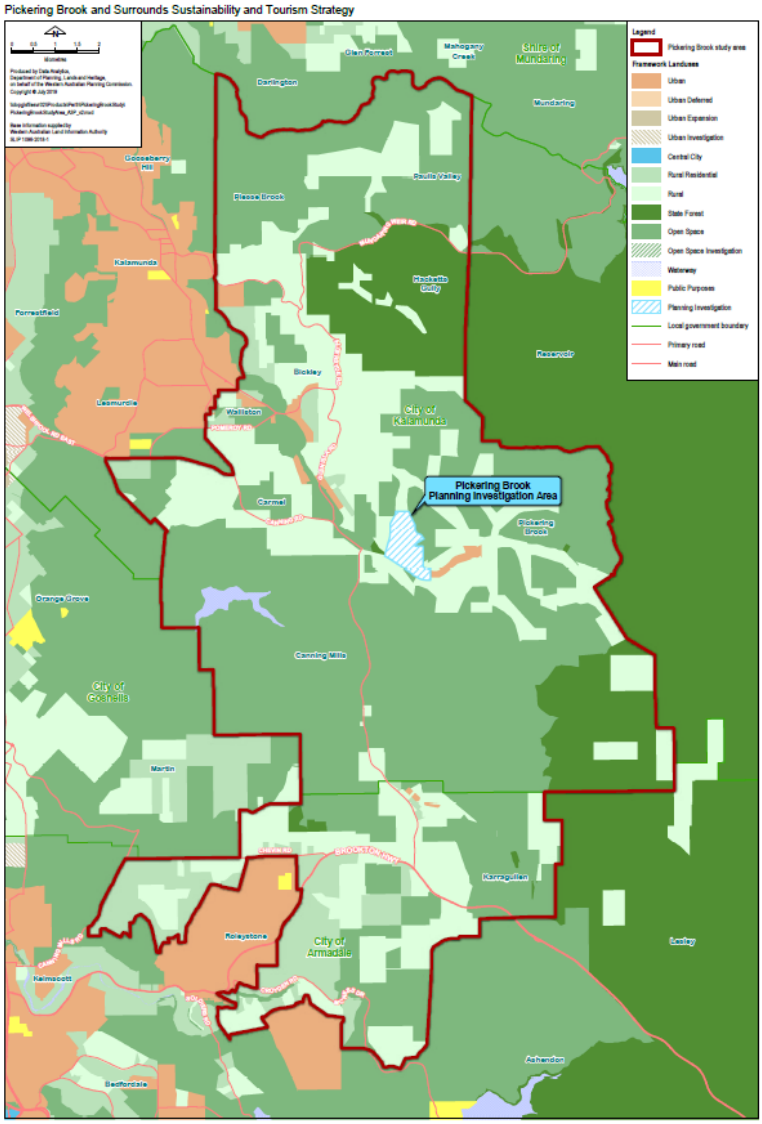


Plate 1: Pickering Brook and Surrounds Sustainability and Tourism Strategy Study Area

1.2 Pickering Brook Townsite and Surrounds

The Pickering Brook townsite is located on the Darling Plateau, 9 km east of the townsite of Kalamunda, 5.6 km from its urban extent and 32 km east of the Perth Central Business District. The location is shown in **Figure 1.**

The Australian Bureau of Statistics population for Pickering Brook locality, recorded from the 2016 Census, was 570 people. Pickering Brook is identified as orchards, and rural lifestyle blocks which occupy the valley floor, in addition to a cluster of residential lots ranging from 2000 m^2 – 4000 m^2 aligned along Pickering Brook Road.

The township for this BMP is the cluster of 53 lots ranging from 2000 m^2 – 4000 m^2 (R5) located in a double row block along the south side of Pickering Brook Road and opposite the Pickering Brook Primary School.

The townsite expansion investigation area for the report is the area bordered by Weston Road, Pickering Brook Road, Carrinyah Road, Isaacs Road, Repatriation Road and Patterson Road. This is referred to as the Pickering Brook Investigation Area (PIA). The PIA includes Town Lot 81, historically identified for township expansion but now recognised as a conservation lot and is unlikely to be suitable for development is considered separately but identified as scenario 1. The remainder of the PIA includes the five scenario areas (total 80.6 ha) which are over existing and former horticulture land (Landgate imagery 1974) and is mostly cleared of native vegetation. The area comprising scenarios 2-6 are referred to for this BMP as the townsite expansion area.

The townsite expansion is to accommodate residential subdivision into lots of a minimum size of 2000 m^2 (R5). The townsite expansion scenarios (2-6) are a progressive expansion extending west from the existing R5 residential lots. The progressive townsite expansion scenarios (2-6) range a population increase from 80 persons on 8.4 ha, through to 770 persons on 80.6 ha. Scenario 1 offers potentially a further 385 persons. The dimension and anticipated yield from cumulative scenarios are shown in **Table 2**. The location and spatial arrangement of each scenario are shown in **Figure 2.**

1.2.1 Scenarios

The six scenarios include the area affected by the previous MRS amendment (Proposed Metropolitan Region Scheme Amendment, Pickering Brook Townsite Expansion, tpg June 2016) plus the area identified as Lot 81 (scenario 1) (refer to **Figure 2**). Lot 81 whilst historically identified for townsite expansion is wholly populated by native vegetation and presently zoned as Rural Conservation under the City of Kalamunda Local Planning Scheme No 3. This vegetation is considered to be in good condition, whereas the townsite expansion area is largely cleared of native vegetation and used for agricultural production.

Table 2: The dimensions for each scenario with estimated cumulative dwelling and population yields

Scenario option	Area (ha)	Dwelling yield	Population yield
1	40.3	131	385.2
2	8.4	27.2	80.1
2A	8.4	26.5	77.9
3	13.7	44.5	130.8
4	24.3	79.0	232.3
5	30.4	98.7	290.2
6	80.6	262	770.4

The townsite and PIA are set within National Park and remnant vegetation (Forest) and identified to be within a bushfire prone area (OBRM 2019)(see **Plate 2**). The adjoining observable vegetation is assumed to be permanent. Future development is therefore expected to respond to its presence and make no further requirement upon the management of the National Park. The National Parks are shown in **Figure 3.**

The townsite expansion is, therefore, to be considered separately and the investigation has been asked to evaluate five cumulative expansion scenarios within the PIA, with Lot 81 identified as largely an academic consideration as clearing approval is unlikely to be supported.

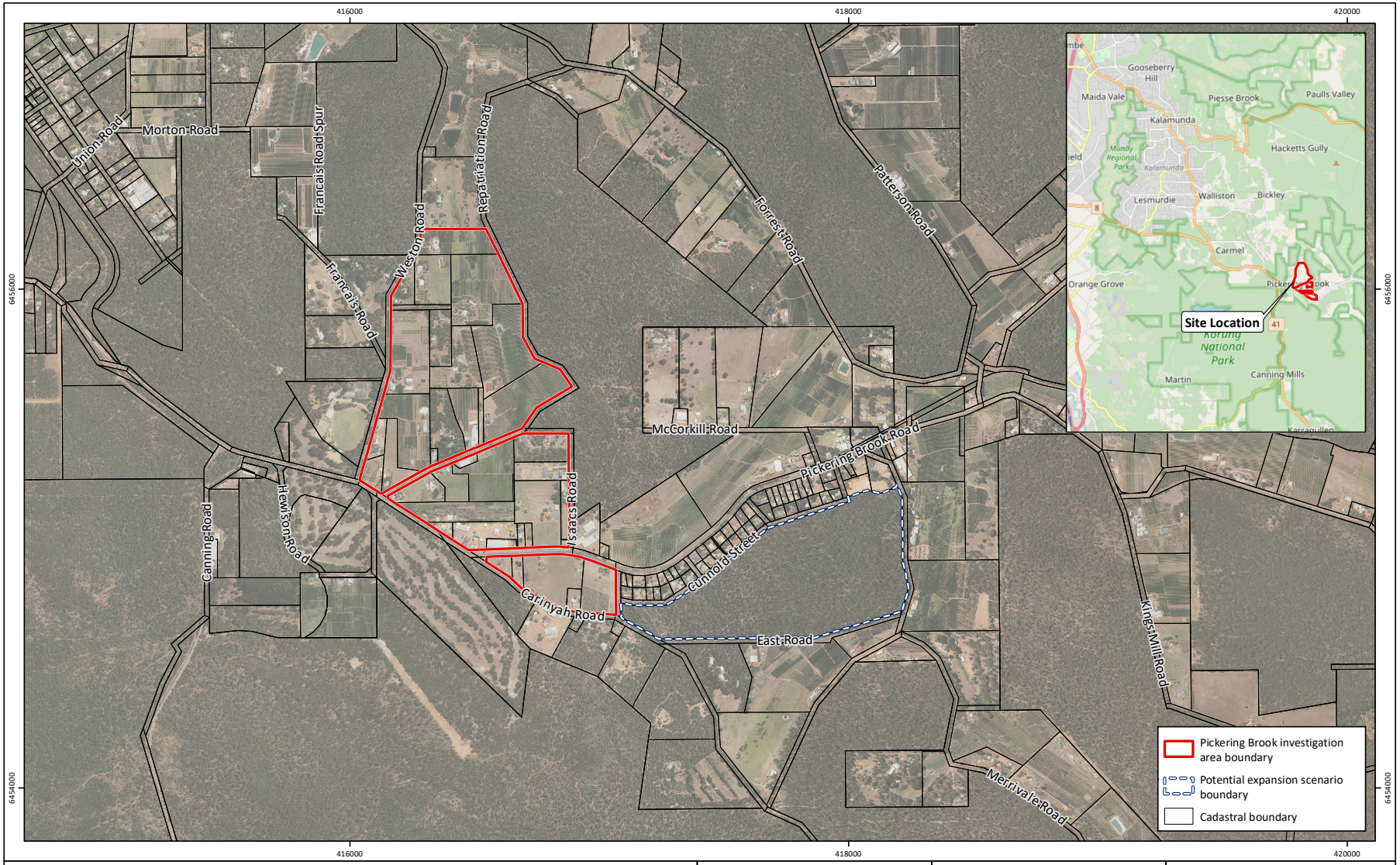


Figure 1: Site Location

Project: Bushfire Management Plan
Pickering Brook Bushfire Risk Assessment
Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(01)--F14
Drawn: SCM
Date: 30/01/2020
Checked: AJR
Approved: AJR
Date: 26/02/2020

N

0 200 400 600
Metres
Scale: 1:20,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

Figure 2: Scenario Extents

Project:	Bushfire Management Plan Pickering Brook Bushfire Risk Assessment
Client:	Department of Planning, Lands and Heritage

Pickering Brook scenario boundary

Cadastral boundary

Plan Number:
EP19-138(01)--F15
Drawn: GAR
Date: 07/02/2020
Checked: AJR
Approved: AJR
Date: 26/02/2020

N

0 200 400 600
Metres
Scale: 1:20,000@A3
GDA 1994 MGA Zone 50

emerge ASSOCIATES

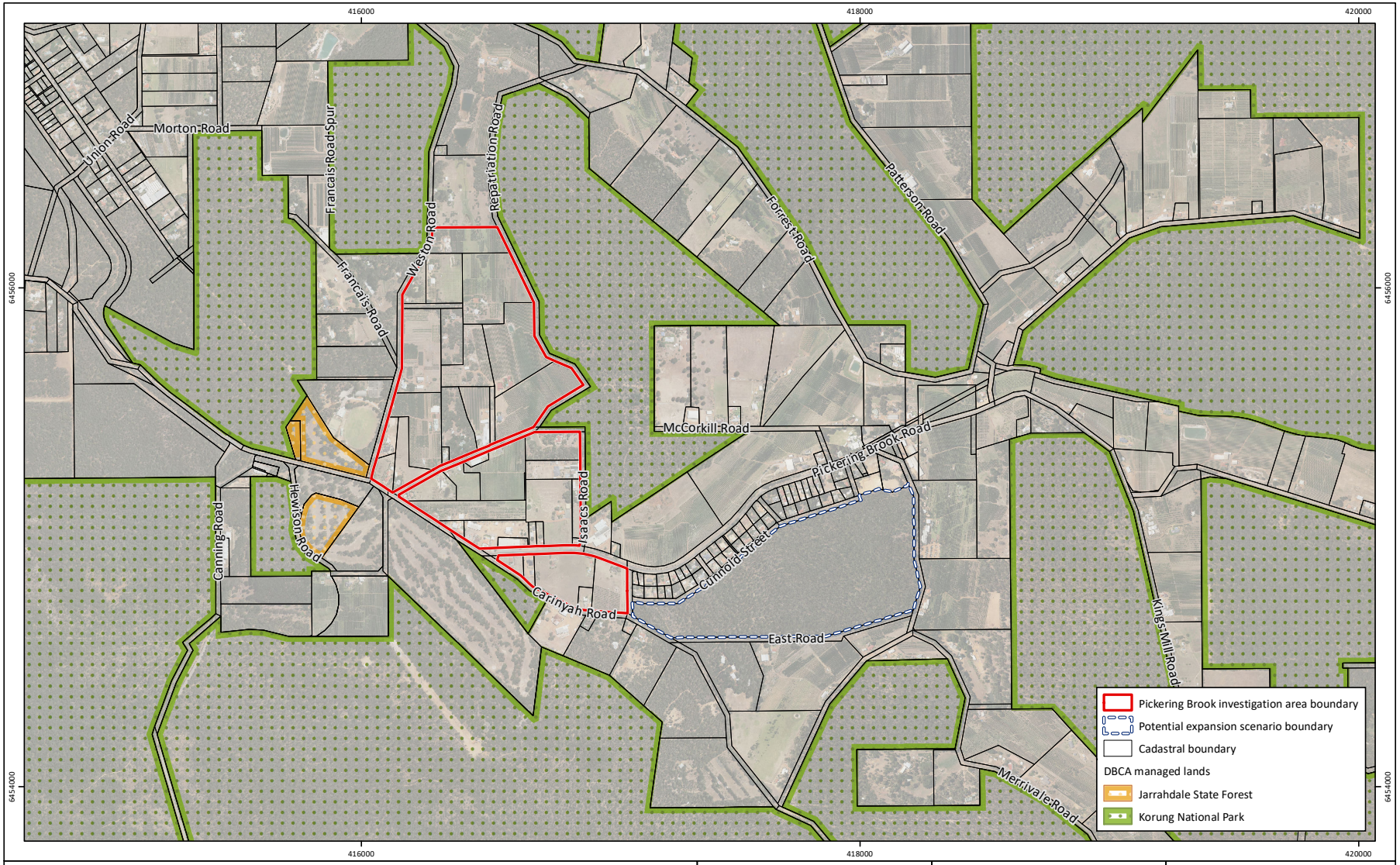


Figure 3: **Department of Biodiversity, Conservation and Attractions Managed Lands**

Project: Bushfire Management Plan
Pickering Brook Bushfire Risk Assessment
Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(01)--F16
Drawn: SCM
Date: 30/01/2020
Checked: AJR
Approved: AJR
Date: 26/02/2020

N

0 200 400 600
Metres
Scale: 1:20,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

1.3 Methodology

1.3.1 Assessment approach

This report addresses Stream 1; the potential sustainable expansion of the Pickering Brook townsite.

The potential expansion provided by Department of Planning, Lands and Heritage (DPLH) for investigation mostly follows the area previously proposed for townsite expansion by the City of Kalamunda in a Metropolitan Regional Scheme amendment (2016). This area is referred to as the townsite expansion area. DPLH has also requested an area previously identified for township expansion (Lot 81) be considered in these investigations as the Pickering Brook Investigation Area (PIA).

The townsite expansion investigation area is located within a 'bushfire prone area' under the state-wide Map of Bush Fire Prone Areas designated by the Fire and Emergency Services Commissioner under the *Fire and Emergency Services Act 1988*. (Prepared by the Office of Bushfire Risk Management (OBRM 2019). The bushfire prone area affecting the expansion of the Pickering Brook townsite is shown in **Plate 2**.

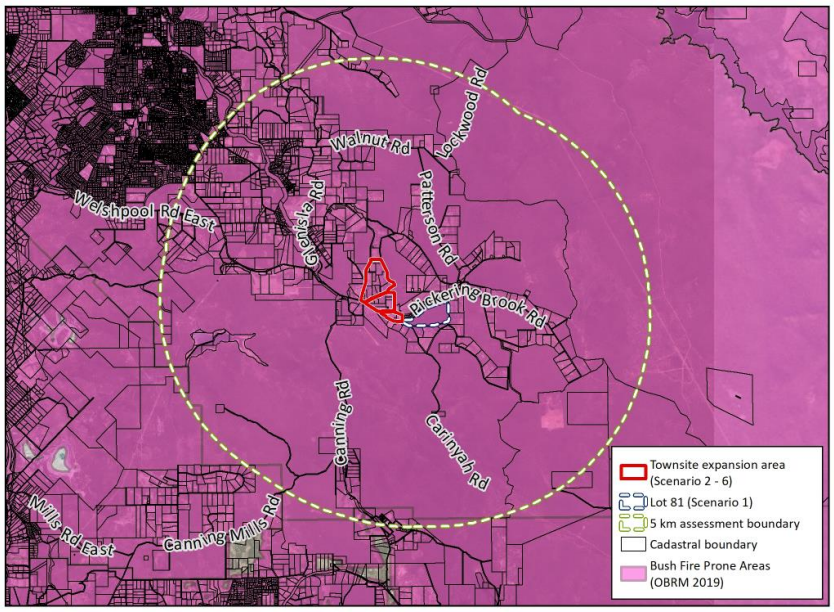


Plate 2: Areas within and surrounding the site (5 km yellow line) identified as 'bushfire prone areas' (as indicated in pink) under the state-wide Map of Bush Fire Prone Areas (OBRM 2019)

State Planning Policy 3.7 *Planning in Bushfire Prone Areas* (SPP 3.7) (WAPC 2015), (cl.4) applies to a designated bushfire prone area that has been identified by the fire and emergency services commissioner under the *Fire and Emergency Services Act* 1988. It also provides that it applies to all higher-order strategic planning documents. The policy is to be read in conjunction with the Deemed Provisions contained in the *Planning and Development (Local Planning Schemes) Amendment Regulations* 2015, the supporting *Guidelines for Planning in Bushfire Prone Areas* (V1.3) (WAPC and DFES 2015) and the Australian Standard AS 3959 *Construction of buildings in bushfire-prone areas (Standards Australia 2018)*.

Accordingly, SPP 3.7, which applies to "every stage of the planning process" applies to this assessment.

1.3.2 Key principles and objectives

SPP 3.7 is a risk-based land-use planning approach which necessitates a determination of the bushfire risk in response to a determined bushfire intensity and measures 'controls' required to achieve an acceptable level of risk, noting that a bushfire risk cannot be eliminated.

2 Policy intent

This policy intends to implement effective, risk-based land use planning and development to preserve life and reduce the impact of bushfire on property and infrastructure.

5 Policy objectives

The objectives of this policy are to:

5.1 Avoid any increase in the threat of bushfire to people, property and infrastructure. The preservation of life and the management of bushfire impact are paramount.

5.2 Reduce vulnerability to bushfire through the identification and consideration of bushfire risks in decision-making at all stages of the planning and development process.

5.3 Ensure that higher-order strategic planning documents, strategic planning proposals, subdivision and development applications take into account bushfire protection requirements and include specified bushfire protection measures.

5.4 Achieve an appropriate balance between bushfire risk management measures and, biodiversity conservation values, environmental protection and biodiversity management and landscape amenity, with consideration of the potential impacts of climate change.

The supporting *Guidelines for Planning in Bushfire Prone Areas* in section 4 identifies:

> "In SPP 3.7, 'bushfire risk' is defined as "the chance of a bushfire igniting, spreading and causing damage to people, property and infrastructure" and in this context, 'bushfire risk management' is "the application of the bushfire protection criteria contained in these Guidelines"

The supporting Guidelines for Planning in Bushfire Prone Areas in section 4.5 identifies the bushfire protection criteria (Appendix Four) and is a performance-based system of assessing bushfire risk management measures. An assessment against the criteria is to be undertaken for any strategic planning proposal, and bushfire protection criteria consisting of four elements: Element 1: Location, Element 2: Siting and design of development, Element 3: Vehicular access, and Element 4: Water.

Relevant policy measures include:

6.1 Higher-order strategic planning documents in bushfire-prone areas

Higher-order strategic planning documents such as frameworks, region schemes and sub-regional structure plans should include high-level consideration of relevant bushfire hazards when identifying or investigating land for future development.

6.2 Strategic planning proposals, subdivision and development applications

a) Strategic planning proposals, subdivision and development applications within designated bushfire prone areas relating to land that has or will have a Bushfire Hazard Level (BHL) above low and/or where a Bushfire Attack Level (BAL) rating above BAL-LOW applies, are to comply with these policy measures.

b) Any strategic planning proposal, subdivision or development application in an area to which policy measure 6.2 a) applies, that has or will, on completion, have a moderate BHL and/or where BAL-12.5 to BAL-29 applies, may be considered for approval where it can be undertaken in accordance with policy measures 6.3, 6.4 or 6.5."

6.3 Information to accompany strategic planning proposals

Any strategic planning proposal to which policy measure 6.2 applies is to be accompanied by the following information prepared in accordance with the Guidelines:

a) (i) the results of a BHL assessment determining the applicable hazard level(s) across the subject land, in accordance with the methodology set out in the Guidelines. BHL assessments should be prepared by an accredited Bushfire Planning Practitioner; or

(ii) where the lot layout of the proposal is known, a BAL Contour Map to determine the indicative acceptable BAL ratings across the subject site, in accordance with the Guidelines. The BAL Contour Map should be prepared by an accredited Bushfire Planning Practitioner, and

b) the identification of any bushfire hazard issues arising from the relevant assessment; and

c) clear demonstration that compliance with the bushfire protection criteria in the Guidelines can be achieved in subsequent planning stages.

6.7 Strategic planning proposals, subdivision or development applications in areas where an extreme BHL and/or BAL-40 or BAL-FZ applies

Strategic planning proposals, subdivision or development applications which will result in the introduction or intensification of development or land use in an area that has or will, on completion, have an extreme BHL and/or BAL-40 or BAL-FZ will not be supported.

6.11 Precautionary principle

Where a landowner/proponent has not satisfactorily demonstrated that the relevant policy measures have been addressed, responsible decision-makers should apply the precautionary principle to all strategic planning proposals, subdivision and development applications in designated bushfire prone areas. For example, if a landowner/proponent cannot satisfy the performance principles of the relevant policy measures through either the application of the acceptable solutions outlined in the Guidelines or through the alternative solutions endorsed by the WAPC and State authority/relevant authority responsible for emergency services, the application may not be approved.

In November 2019 the Western Australian Planning Commission released Position Statement: *Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design* to "provide clarity and guidance for planning proposals in an area with a bushfire hazard level (BHL) of extreme and/or where the lot(s) is impacted with a bushfire attack level (BAL) rating of BAL-40 or BAL-Flame Zone (BAL-FZ)."

> "If areas adjoining the subject site have an extreme BHL, consideration should be given to the level of bushfire exposure of the subject site from the type and extent of the vegetation that adjoins the subject site. If areas within the subject site have an extreme BHL, it should be demonstrated that development design strategies, including the removal or modification of hazardous vegetation in perpetuity and/ or that sufficient separation of these areas from development, can be incorporated into the design. This could be in the form of public roads, drainage reserves and managed public open space. Any areas that, on completion of the development, will retain an extreme BHL within the subject site should not create isolated pockets of developable land".

In order to address the strategic considerations of SPP 3.7 an orderly and methodical approach will be applied to this assessment

First, given this assessment is for an intensification of development within a bushfire prone area, it will identify the potential intensity of a bushfire at a landscape scale to assist in informing the suitability of the land.

A landscape context of 20 km has been chosen for broad consideration of integration to infrastructure and access routes; a 5 km context has been chosen to examine the elements of bushfire behaviour to determine the bushfire hazard level that may approach the townsite expansion investigation area. The 5 km distance was chosen because embers can travel up to 5 km, and fire within this area may affect the townsite expansion investigation area. 5 km is considered a potential alert distance to undertake community evacuation. A bushfire attack level assessment will then be undertaken to determine the radiant heat level and the nature of the bushfire attack likely to be experienced at the townsite.

This information will be combined with the fire history to determine the likelihood, together with the current arrangement, as a basis to determine the present risk. The likelihood and the potential consequence, of an event, excluding and including present controls will be analysed.

The subsystem risks to human safety and buildings and assets will be assessed and further controls identified to achieve compliance with the bushfire protection criteria.

1.3.2.1 Bushfire Protection Criteria

Element 1: Location

Intent: To ensure that strategic planning proposals, subdivision and development applications are located in areas with the least possible risk of bushfire to facilitate the protection of people, property and infrastructure

A strategic planning consideration in determining the suitability of land for development. It is used in a landscape context and an assessment of the bushfire hazard level (fireline intensity). The suitability of the land is contextualised by the fire history, likelihood and consequence and satisfies the 'planning' aspect within the traditional emergency management parameters of planning, preparation, response and recovery. Measures addressed may include actions to reduce ignition avoid community exposure, and manage the bushfire to conclude the event without human harm, or disruption to the normal function of the community by minimising damage to assets, infrastructure and property.

Element 2: Siting and design of development

Intent: To ensure that the siting and design of development minimises the level of bushfire impact.

A 'preparation' requirement satisfied by demonstrating bushfire protection measures are employed to ensure no habitable building is exposed to a BAL higher than BAL-29. Primarily utilises separation distance from classified vegetation to achieve the BAL, and a commensurate construction standard and immediate land management to minimise the bushfire impact. At subdivision design measures can include utilising the intervening space, utilising productive 'low threat' land uses as a buffering space and perimeter roads to support suppression activities.

Element 3: Vehicular access

Intent: To ensure that the vehicular access serving a subdivision/development is available and safe during a bushfire event.

Ostensibly a 'response' requirement. Alternate routes in the opposite direction of a fire facilitate safe evacuation to minimise community exposure. Alternate routes also support access and option for a retreat in providing suppression as part of the function of managing a fire.

The alternate access may also facilitate 'recovery' providing alternate access options, should one access be blocked by falling trees.

Element 4: Water:

Intent: To ensure that water is available to the subdivision, development or land use to enable people, property and infrastructure to be defended from bushfire

Whilst element 4 is narrowly interpreted as the availability of water as an essential component supporting suppression, it can be broadened to consider all aspects required for effective suppression, including a linkage to access for firefighting services.

2 Landscape Bushfire Hazard Assessment

In order to analyse the risk, the elements that contribute to the risk must first be identified. This includes the features that affect bushfire behaviour and its intensity. This has been examined at a landscape scale range of 5 km for the bushfire hazard level assessment and then 150 m for the assessment of the bushfire attack level upon buildings within the PIA.

This section addresses physical properties that contribute to bushfire behaviour, the history of bushfires in the area, and present bushfire protection measures.

2.1 Bushfire Behaviour

Bushfire behaviour is primarily affected by three factors;

- Topography (slope of the ground)
- Vegetation (fuel)
- Weather & Climate

2.1.1 Landscape topography

The townsite is located within a valley within the Darling Ranges which are described as a lateritic upland, ranging in elevation from 245 - 350 m Australian Height Datum (m AHD). The area is characterised by rolling hills and intersecting valleys with slopes predominantly ranging between 5° and 10°. The topographic contours are shown in **Figure 4**.

Deep steep-sided valleys run in a north-westerly direction either side of the 5 km assessment area, these valleys accommodate the Mundaring Weir-Reservoir, and the Canning Reservoir, the townsite is located on a broad plateau with gently undulating hills in between these long deep reservoir valleys. The Victoria Reservoir is located within a smaller isolated steep valley that is located 4 km south-east of the townsite.

The PIA has an elevation ranging from approximately 245 m Australian Height Datum (m AHD) in the south-east of the area up to 275 m AHD in the north-west of the PIA (Landgate 5 m contours).

The slope across the PIA is 0.0° to 5.0°.

The adjacent hillsides generally rise from the townsite at slopes of between 3° and 5° but with steeper slopes ranging from 5.0° -10.0° at the northeast of Scenario 6, and west of Weston Road.

2.1.2 Landscape vegetation

Native vegetation can be described and mapped at different scales or units in order to illustrate general patterns in its distribution. At a continental scale, the *Interim Biogeographic Regionalisation of Australia* (IBRA) (Department of the Environment 2012), the site is located within the Northern Jarrah Forest subregion, within the Jarrah Forest region (Environment Australia 2000). This area is characterised as *Eucalyptus marginata* (jarrah) forest on ironstone gravels, marri-wandoo (*E. calophylla – E. wandoo*) woodlands on loamy soils with sclerophyll understoreys (Beard 1990).

At a regional scale of 5 km the vegetation complex mapping by Heddle *et al.* (1980) indicates that two separate complexes occur within the site, which is shown in **Figure 5** and listed below:

- Yarragil complex (maximum development swamps) in medium to high rainfall. This complex is described as "Open forest of *Eucalyptus marginata* - *Corymbia calophylla* with admixtures of *Eucalyptus patens*.
- Dwellingup complex in medium to high rainfall. This complex is described as "Open forest of *Eucalyptus marginata* - *Corymbia calophylla* on the uplands.

The native vegetation within 5 km of the townsite is considered contiguous and uniform.

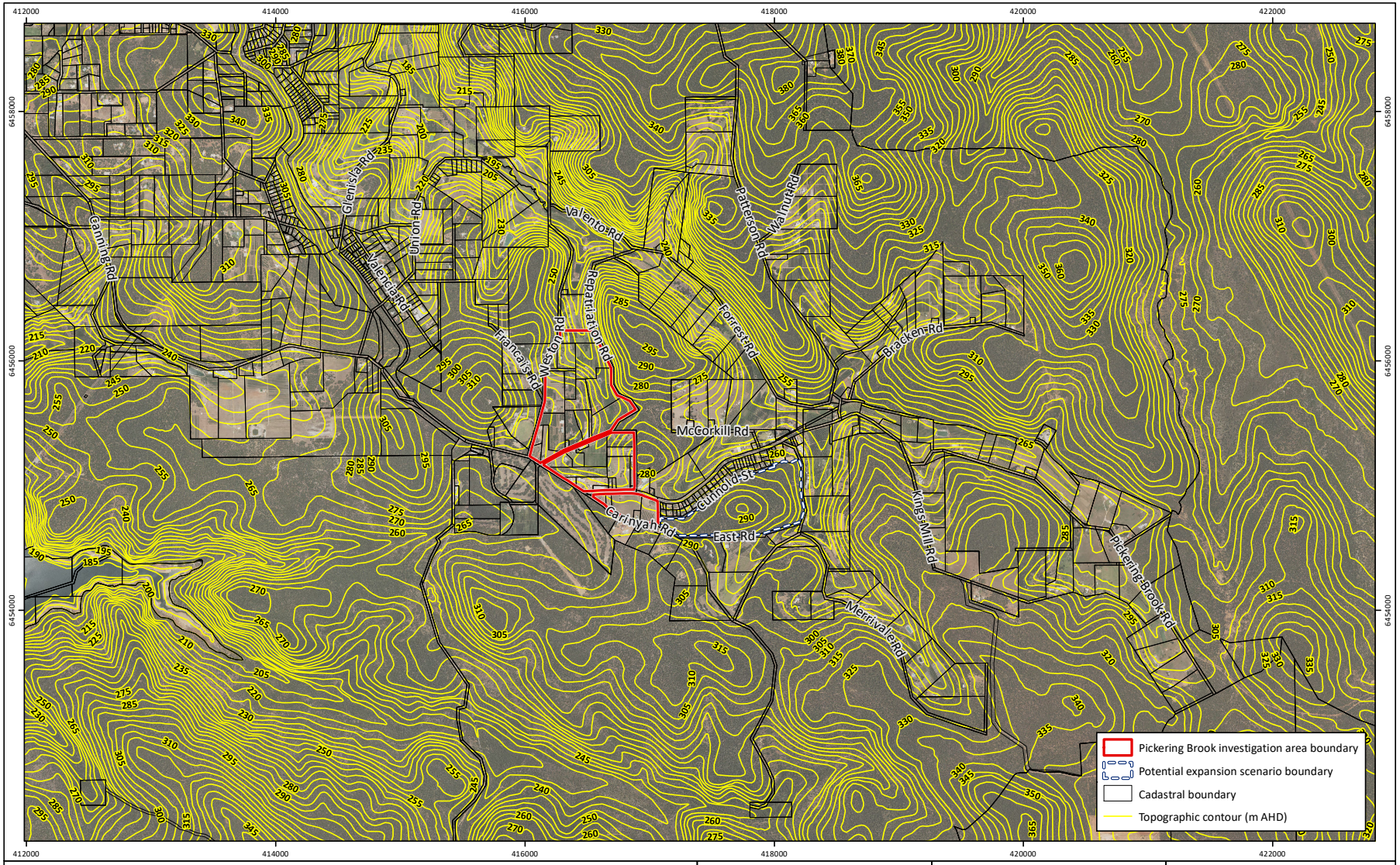


Figure 4: Topographic Contours

Project:	Bushfire Management Plan Pickering Brook Bushfire Risk Assessment
Client:	Department of Planning, Lands and Heritage

Plan Number:
EP19-138(01)--F17

Drawn:	SCM
Date:	30/01/2020
Checked:	AJR
Approved:	AJR
Date:	26/02/2020

N

0 500 1,000 1,500
Metres
Scale: 1:40,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

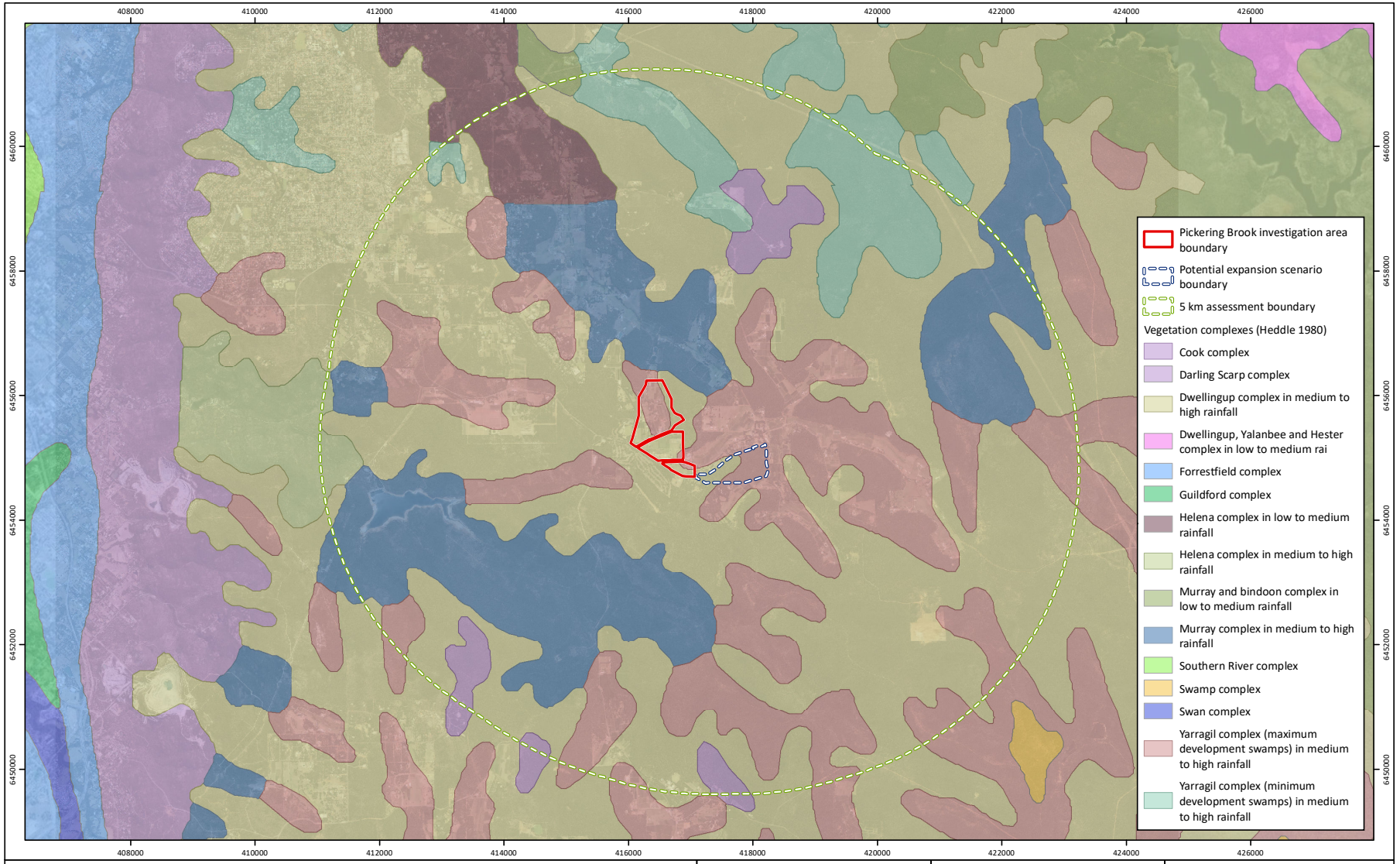


Figure 5: Vegetation Complexes

Project: Bushfire Management Plan
Pickering Brook Bushfire Risk Assessment
Client: Department of Planning, Lands and Heritage

Plan Number:
EP19-138(01)--F18
Drawn: SCM
Date: 30/01/2020
Checked: AJR
Approved: AJR
Date: 26/02/2020

N

0 1 2 3
Kilometers
Scale: 1:80,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

2.1.3 Landscape climate

Climate information has been obtained from the closest weather station at Bickley, 4.8 km from Pickering Brook. The bushfire season generally occurs over the summer months of December to February. During this period, the area experiences average temperatures of minimum 15°C to a maximum of 29.7°C and are slightly cooler in December. Mean rainfall is also lowest from December (14.6 mm) through to March (25.7 mm), with all other months experiencing at least double to over 14 times the average rainfall (216.2 mm in June). Annual rainfall is 1071.5 mm. Relative humidity at 9 am is 56% on average.

2.1.4 Landscape wind speed and direction

Records of wind information were obtained from the Bureau of Meteorology from the weather stations nearest the Assessment Area and include Bickley, Mount Dale and Perth Airport. Monthly climate statistics from 'Climate Data Online' (BoM, 2020[14]) were considered for the period 1994-2019 for Bickley (4 km from the Assessment Area), 1991-2019 Gosnells City (12.7 km away) and 1944-2019 for Perth Airport (18.3 km away). The mean wind speed and direction has been obtained for November, December, January and February at 9 am and 3 pm, as well as an overall average for 9 am and 3 pm.

In comparing the Bickley weather station to Perth Airport, Bickley is dominated 60% by easterly winds in the morning, with 5% exceeding 30-40km/h and 1% exceeding 40 km/h. Perth Airport is also dominated 40% by easterly winds and similarly, 5% exceeding 30-40km/h and 1% exceeding 40 km/h.

Both weather stations switch to a westerly biased wind direction in the afternoons although Bickley retains 25% from the east and 30% from the west and 15% from the south-west compared to Perth which is dominated from the west 20% and southwest 42%, with little 11% from the east. Wind strengths at Bickley in the afternoon are 2% at 30-40km/h, whereas Perth Airport has 7% at 30-40km/h from the south-west.

Notable from the wind rose comparisons (**Plate 3** to **Plate 5**) between the Bickley weather station and the Perth Airport is an absence of winds from the north and a rare occurrence and strength of wind from the south-west at Bickley compared to Perth, which has a high proportion of strong winds from the south-west during the summer months.

[14] Bureau of Meteorology (BoM) 2020, *Climate Data Online*, viewed 11 February 2020, http://www.bom.gov.au/climate/data/index.shtml

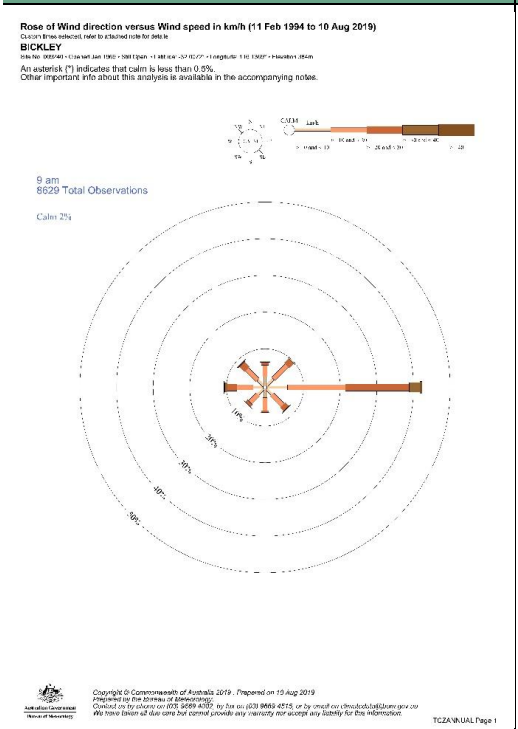
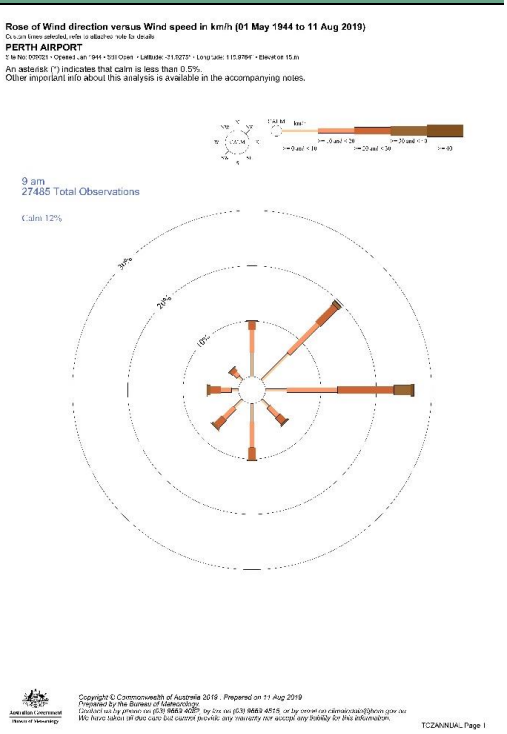
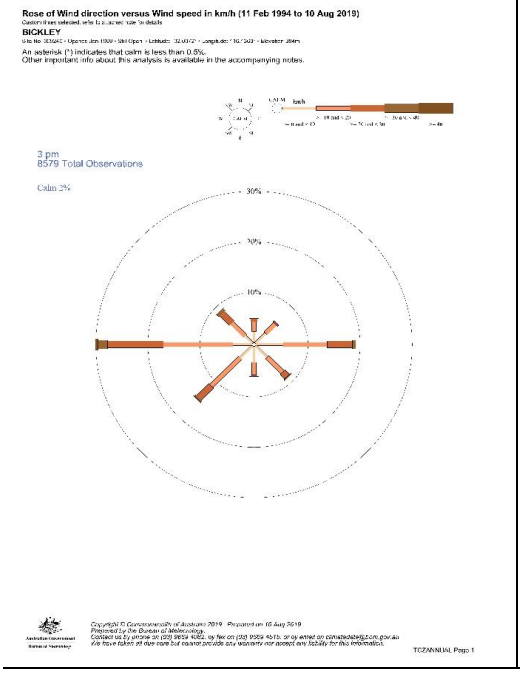
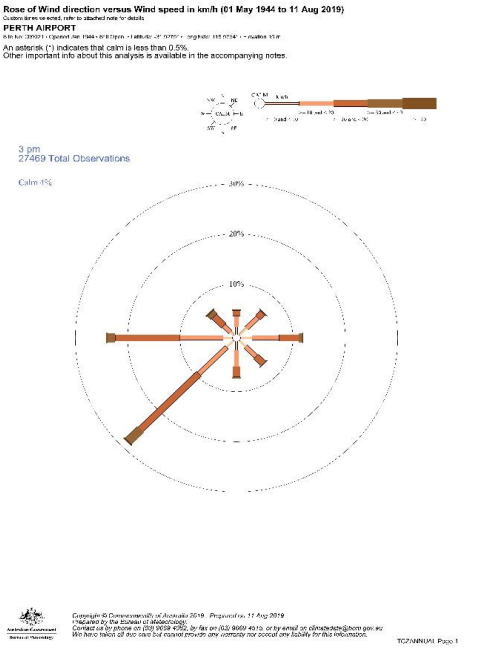
Bickley	Perth Airport
	
	

Plate 3: Windspeed and direction at Bickley and Perth Airport (BoM, 2020) Total Annual observations

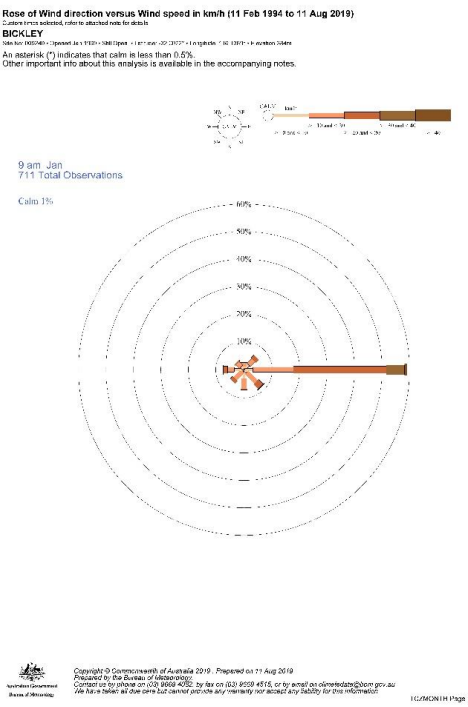
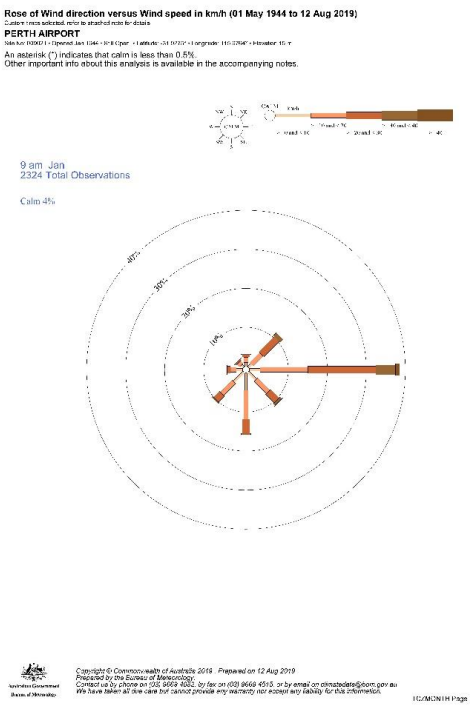
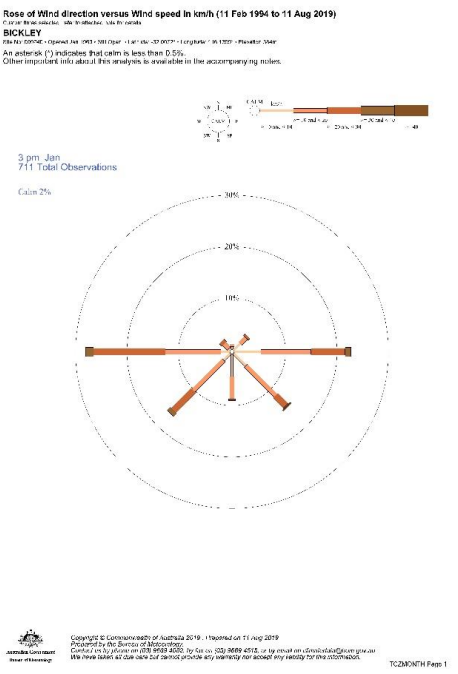
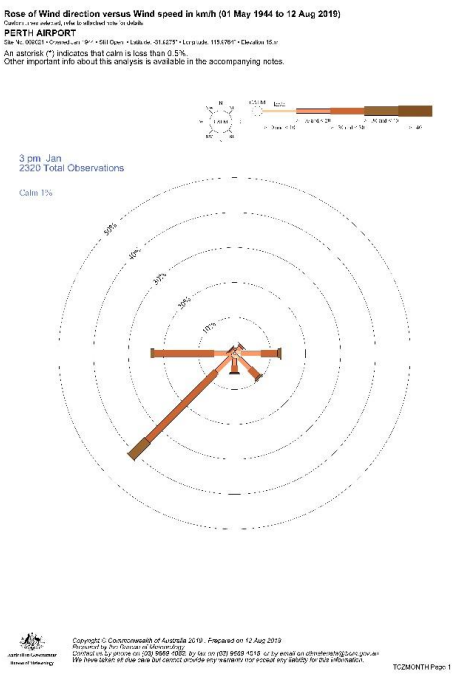
Bickley	Perth Airport
	
	

Plate 4: Windspeed and direction at Bickley and Perth Airport (BoM, 2020) January observations

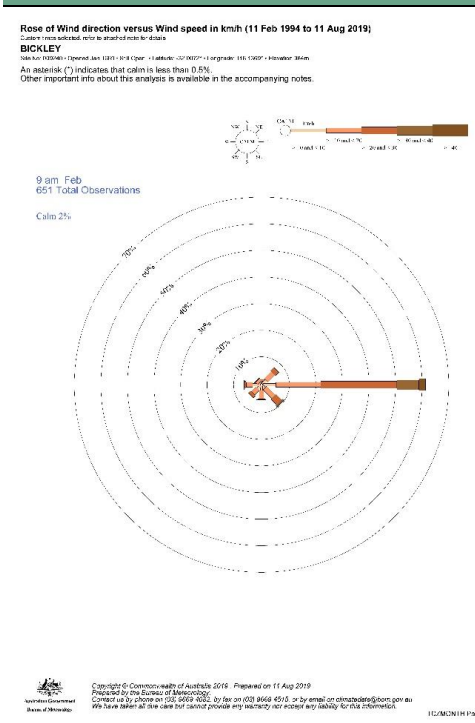
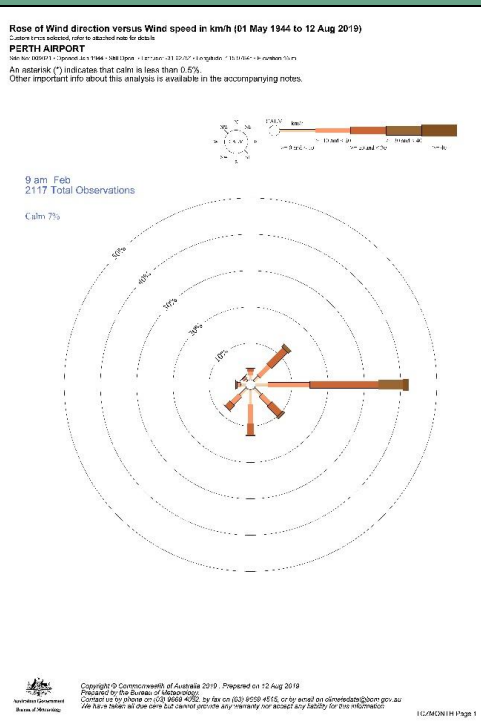
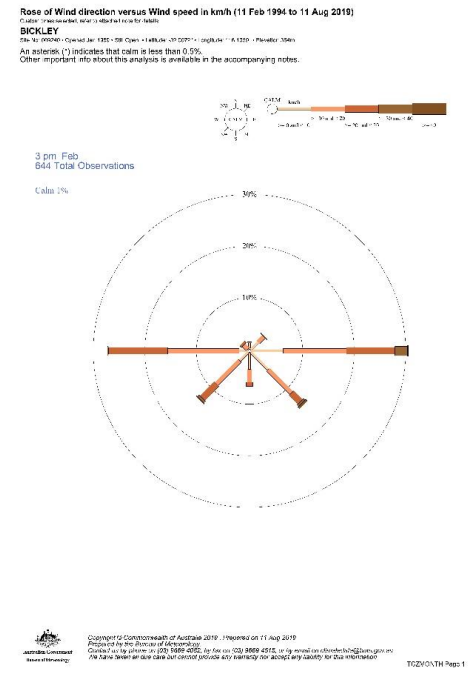
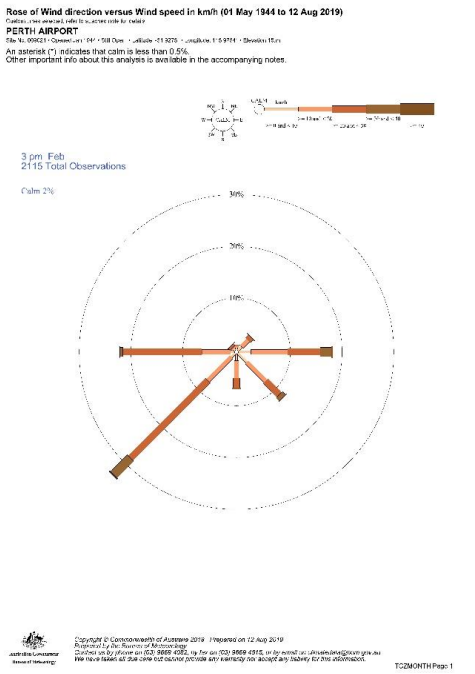
Bickley	Perth Airport
	
	

Plate 5: Windspeed and direction at Bickley and Perth Airport (BoM, 2020) February observations

2.1.5 Climate Change

The climate of Western Australia has changed over the past 100 years with the average temperature increased by about 1°C[15]. Rainfall has decreased along the coast and fire risk has increased across the state.

Rainfall has decreased between 450->700 mm in the region since 1999. The climate has become drier and hotter over the past 40 years.

Annual fire weather danger has increased in the Perth region between 1973-2010, with a greater seasonal increase observed in winter and spring.

2.1.6 Landscape FFDI

The Forest Fire Danger Index combines a record of dryness, based on rainfall and evaporation (drought factor), with meteorological variables for wind speed, temperature and humidity.

The significance of FFDI is a determinant of bushfire behaviour but also is a lead indicator for house loss. It is rare for houses to be destroyed or fatalities to occur when the FFDI is below 50, this rating reflects the intensity of the fire. A fire's controllability, the effectiveness of suppression measures, progressively deteriorates as the FFDI increases. As the FFDI increases above FFDI 75 (Extreme) and 100+ (Catastrophic), house losses and fatalities significantly increase.

The available locational data for the Forest Fire Danger Index (FFDI) in WA is limited. The Bureau of Meteorology (BoM) provides monthly spatial averages for the country based on the period 1950-2016 using the Keetch-Byram Drought Index at a limited scale[16]. The closest BoM historic record for FFDI and GFDI is Perth Airport. The closest automated weather station is at Bickley 4 km north of the Pickering Brook townsite. Full climate data is available from BoM at 77 sites across WA, but this does not include the Stirling Ranges. The Bickley station records limited data which did not allow a formulation of peak daily FFDI using FFDI equation. The Department of Primary Industries also collects climate data, has a station at Mount Dale commencing in 2016, but similarly, the data required to compute an FFDI is not available. From the data available, it illustrated quite different conditions to Perth Airport and Bickley, so the applicability to Pickering Brook is questionable.

According to BoM records of FFDI, there have been 111 days with an FFDI of 50 or higher since June 1972 as recorded at Perth Airport. There have been 88 days over FFDI 50 in the last 30 years from 1989 to 2019. Over the past five years, there have been a total of 17 days where the FFDI was recorded as 50 or above at Perth Airport (BoM, 2020) **(Plate 11).** Of interest since 1990 the December FFDI is generally higher than that recorded for January, and since 2005 often over an FFDI of 50 **(Plate 12).**

It is expected that the Pickering Brook locality may have a different FFDI to that of the Perth Airport, because of the higher rainfall, generally lower wind speeds and a cooler climate. The closest weather station is at Bickley, 4 km north of the townsite. Unfortunately, the FFDI data is not available from this station but a number of parameters are, which have been considered in the applicability of the

[15] Department of Primary Industries and Regional Development (DPIRD) 2020, *Climate trends in Western Australia*, viewed 11 February 2020, https://www.agric.wa.gov.au/climate-change/climate-trends-western-australia

[16] Bureau of Meteorology (BoM) 2020, *Forest Fire Danger Index (FFDI)*, viewed 11 February 2020, http://www.bom.gov.au/jsp/ncc/climate_averages/ffdi/index.jsp

FFDI. They demonstrate little variation to that of the Perth Airport, with a tendency to be lower in key FDI values, temperature, wind speed, and humidity. This suggests that the FFDI at Pickering Brook may be marginally lower than Perth Airport, but nonetheless, the Perth data gives an indication of the FFDI for the purpose of the risk assessment and prudent bushfire protection measures

An Extreme Value Analysis (EVA) (Douglas, G. et al, 2014) was performed on recorded historical FFDI data from Perth Airport (Lucas, 2010). The result of the EVA is demonstrated in **Plate 6** below. As demonstrated the highest FFDI recorded in the last 25 years was FFDI 81 on 12 April 2009. The projected maximum FFDI to 2049 is approximately 89 at Perth Airport (97 at 1:200 APE). Similar data is not currently available for Bickley weather station, which is closer to Pickering Brook and therefore likely a better indicator of FFDI for the Pickering Brook area. Therefore, the key factors responsible for determining FFDI have been compared at Bickley and Perth Airport weather stations for the period 1 December 2019 to 26 February 2019. The historic data for Bickley weather station is limited online. Further comparison can be made in the future with a more comprehensive dataset.

The station at Bickley records consistently lower maximum daily temperature than Perth Airport as demonstrated in **Plate 7**. It is noted that this difference is slight and follows the same overall pattern as Perth Airport. Daily rainfall and relative humidity (3 pm) are consistently higher at Bickley than Perth Airport as seen in **Plate 9** and **Plate 8**. Daily wind speed (recorded at 3 pm) appears to be generally much lower at Bickley than at Perth Airport (refer to **Plate 10**). Overall, the brief window of weather patterns demonstrated in the plates below suggests that Pickering Brook would have a similar, if not slightly lower overall FFDI forecast to that of Perth Airport.

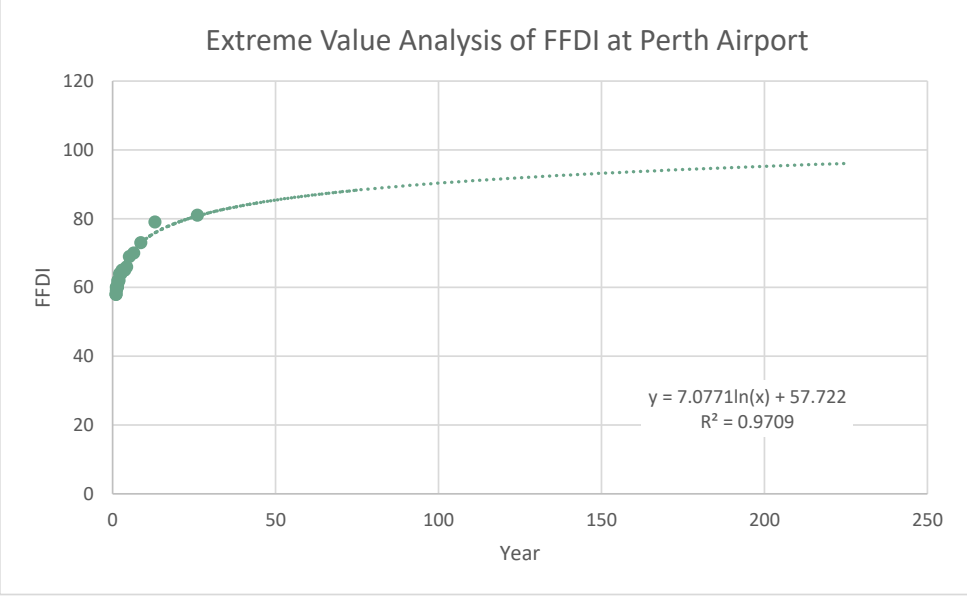


Plate 6: Extreme Value Analysis for FFDI for Perth Airport based on fire weather dataset using recorded FFDI values from 1994-2019 by Lucas (2010) received from BoM.

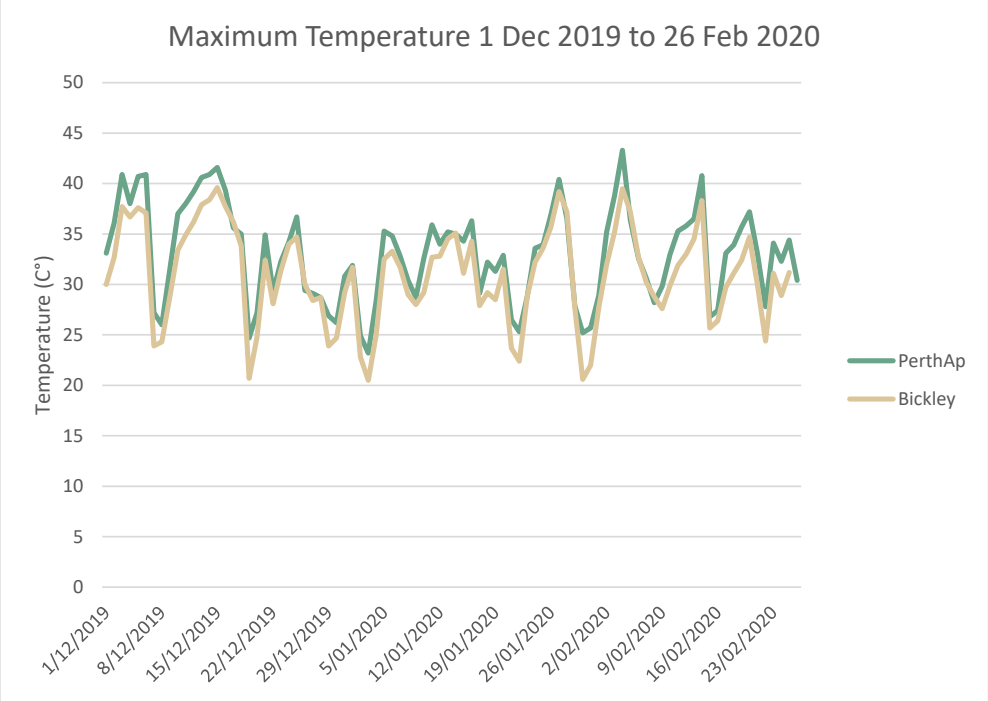


Plate 7: Maximum daily temperature at Perth Airport and Bickley Weather Stations over the period 1 December 2019 to 26 February 2020 (BoM, 2020).

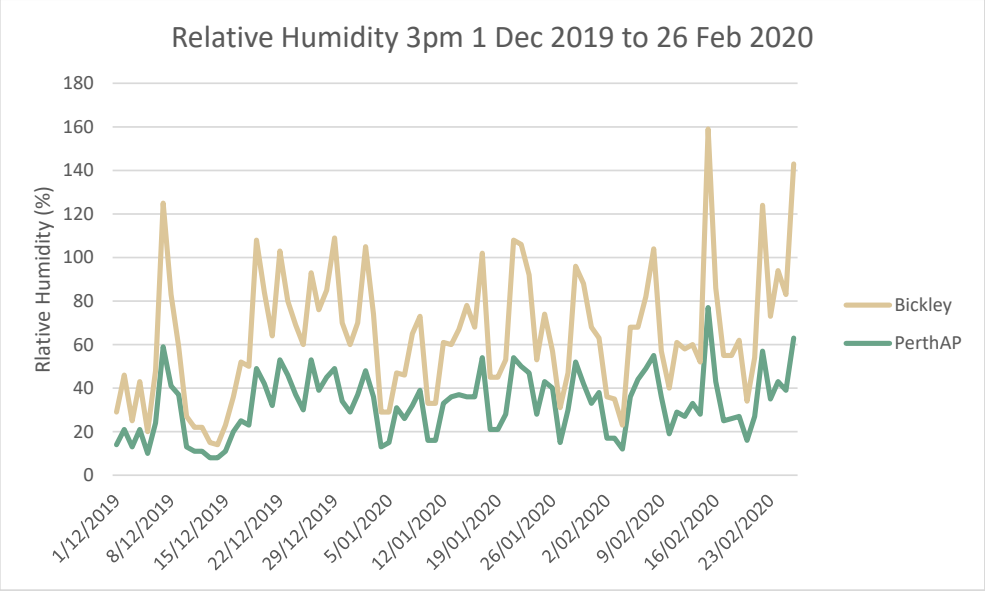


Plate 8:Daily Relative humidity at 3 pm at Perth Airport and Bickley Weather Stations over the period 1 December 2019 to 26 February 2020 (BoM, 2020).

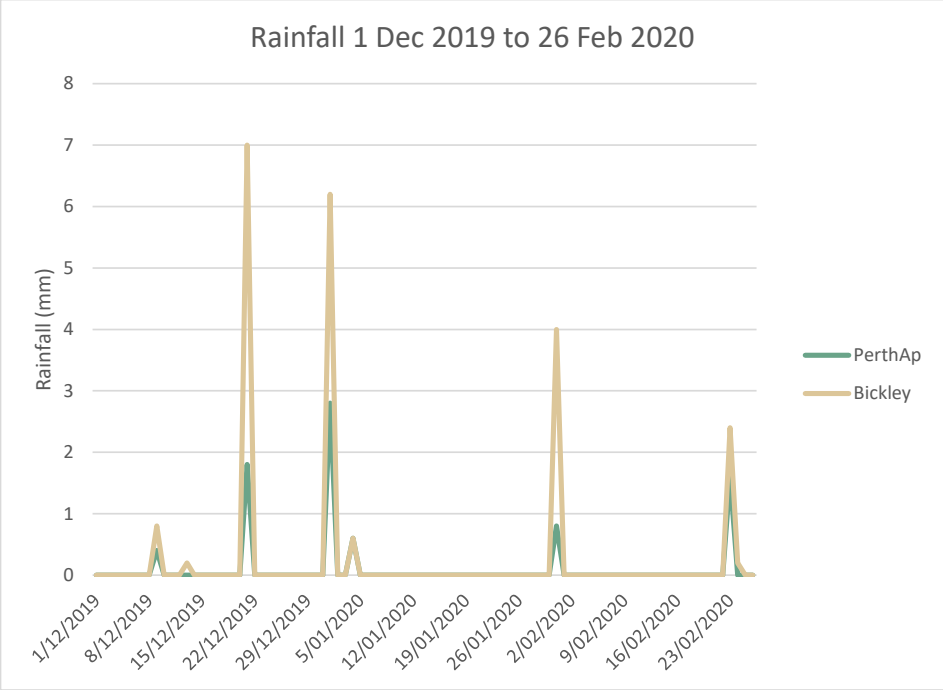


Plate 9: Daily Rainfall at Perth Airport and Bickley Weather Stations over the period 1 December 2019 to 26 February 2020 (BoM, 2020).

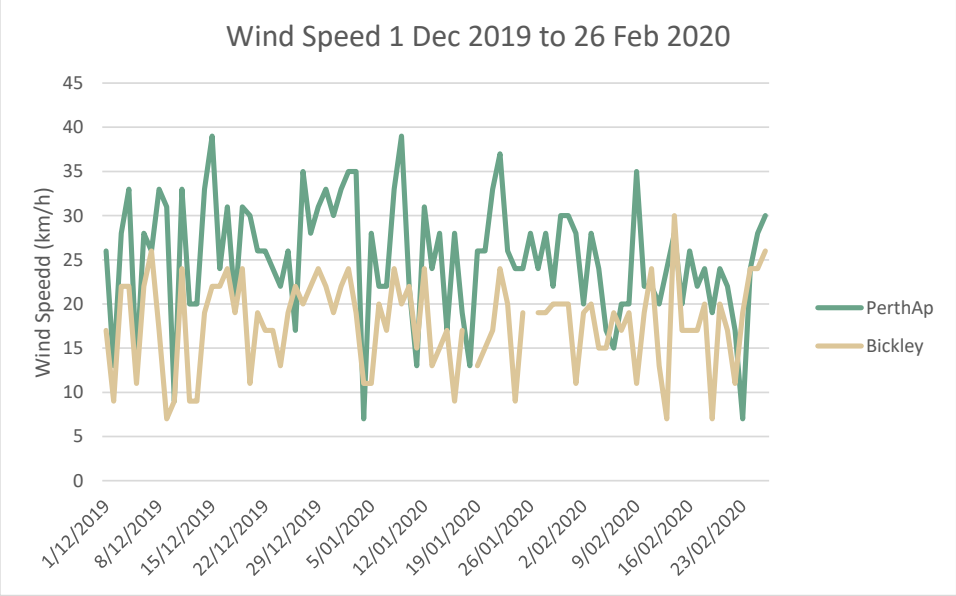


Plate 10: Daily Wind Speed at 3 pm at Perth Airport and Bickley Weather Stations over the period 1 December 2019 to 26 February 2020 (BoM, 2020).

The last 20 years provide an indication of the trend underlying climate change and has been projected forward. On the basis of this result, (FFDI 97 at 1:200 (APE)) the assessment of the Bushfire Attack Level at the townsite expansion investigation areas has assumed an FFDI of 100, to accommodate conditions expected over the life of buildings that may be accommodated in the expansion area.

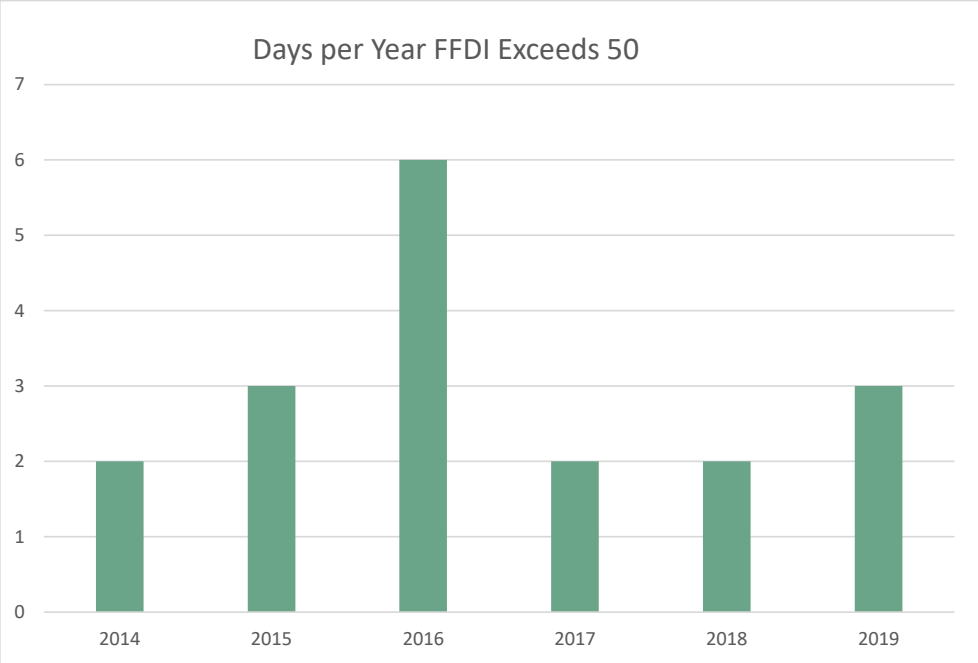


Plate 11: Number of days FFDI recorded as 50 or above at Perth Airport from 01/01/2014-31/08/2019 (BoM, 2020)

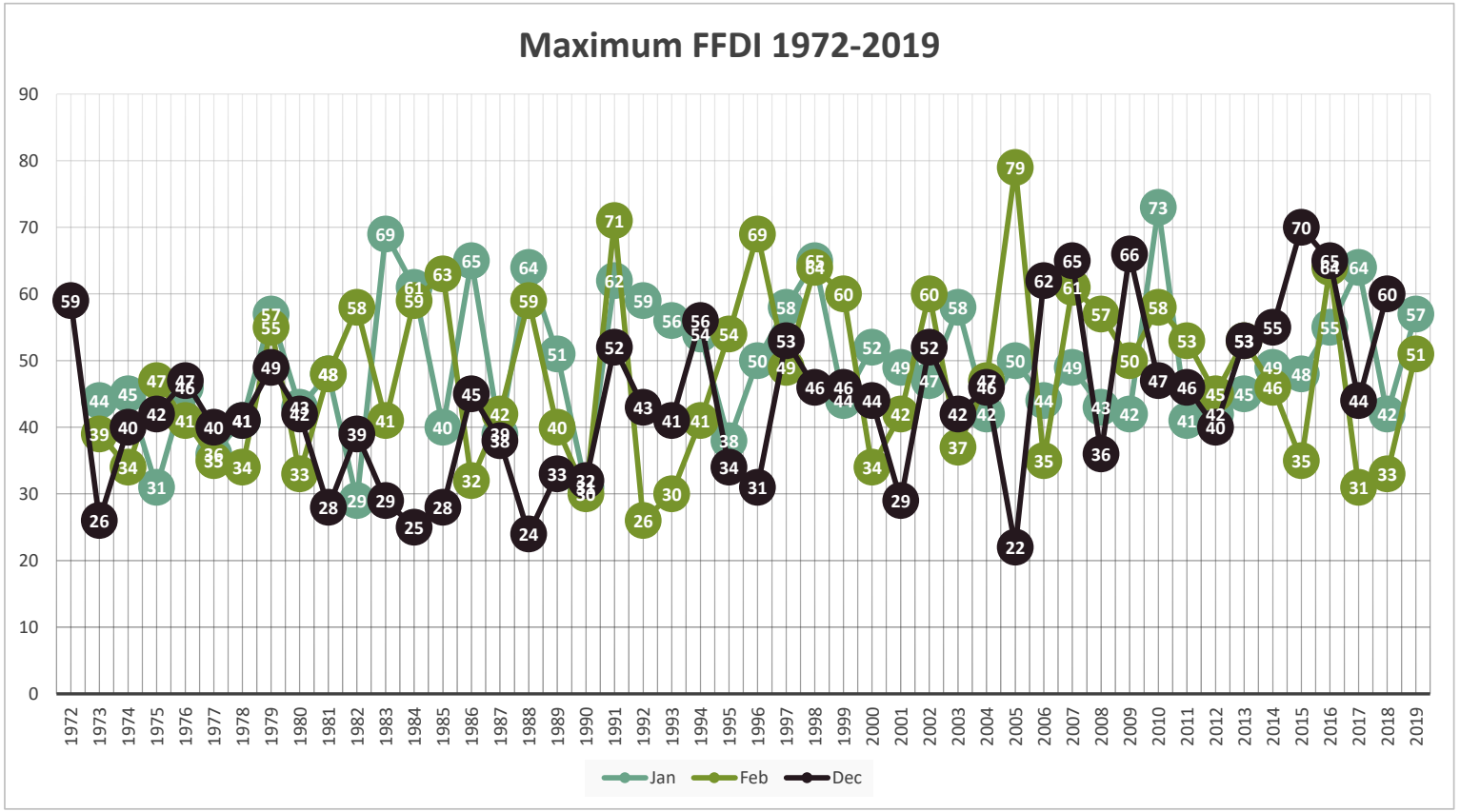


Plate 12: Maximum FFDI recorded at Perth Airport from 1972 to 2019 in January, February and December (BoM, 2020)

2.2 Landscape Bushfire History

There are multiple factors that contribute to the ignition, spread and termination of a bushfire. These factors have been considered in the context of known bushfire incidents within 5 km of the proposed expansion area.

The study area is located over two local government areas, within the area known as the 'Perth Hills'. Given the size of the study area, it was considered prudent to take into account the bushfire history within 5 km of the assessment area, as well as significant bushfire events in the region. Significant bushfires have been known to cross municipal lines and the entire impact of the fire is spread between more than one LGA. It is important to include this external data to obtain a thorough understanding of bushfire behaviour in the area.

This report has had regard to the following studies post 3 major bushfire events

- Day, J (Chair) (1994) Report of the Ministerial Working Group investigating the Darling Escarpment Fire Hazard
- M, Keelty (2011) A Shared Responsibility the Report of the Perth Hills Bushfire February 2011 Review
- N, Cheney (2010) Fire behaviour during the Pickering Brook wildfire, January 2005 (Perth Hills Fires 71 – 80)

In addition, DBCA and DFES record bushfire incidents and the likely means of ignition.

The draft City of Kalamunda Bushfire Risk Management Plan 2019-2024, identified from the period starting 1 July 2007 to 30 June 2018 a total of 1253 ignitions occurred at an average of 125 landscape fire ignitions per year[17]. A downward trend had been noted since 2010/11 by an average reduction of 19 per year attributed to weather and seasonal factors but also community awareness initiatives and targeted arson programs.

This is consistent with the *Bushfire Cooperative Research Centre Fire Development, Transitions and Suppression study 2014,* which studied urban and peri-urban areas around Perth comparing DFES incident data, and found ignitions were greatest with elevated fire conditions and human activity, with increased rates of ignition on weekends, public holidays and school days. These were assessed as deliberate causes 55.24%, accidental 29.81% (mostly cigarettes) 13.92% unknown, and 1.17%[18] from natural causes. It was noted that during the study period there was a decline in the annual number of ignitions due to reductions in deliberately lit fires, attributed to arson reduction programs and a range of public education and awareness programs.

DFES (2016) defines a significant landscape fire as a Level 2, 3 or 4 alarm, an area of five or more hectares, or where more than 25 fire appliances are in attendance. Based on this definition, there have been 8 significant landscape fire events within 5 km of the townsite area between January 2005

[17] City of Kalamunda Bushfire Risk Management Plan Draft 2019-2024 p. 22
[18] A L Sullivan et al *Bushfire Cooperative Research Centre Fire Development, Transition s and Suppression study CSIRO 2014 p 17*

and June 2016. Seven of these fires are believed to be suspicious/deliberate. All but one of the fires was less than 100 ha in total.

As noted in Keelty (2011), data on fuel loads are inconsistently available with land managed by multiple stakeholders. Similarly, information on historic bushfire events is not consistently available. The information has been obtained from the City of Kalamunda, DBCA and DFES to provide an overview of the bushfire history of the area. **Table 3** details the significant bushfire events considered in this report including, where available, the FDI on the day of ignition, the source of ignition, prevailing winds, fire path, the extent of damage caused by the bushfire and relevant factors in extinguishing the fire.

Table 3: Significant Bushfire Events in the Perth Hills Area from 2000-2020 (Cheney 2010; Keelty 2011; DFES 2016)

Date/Time of Ignition	Location	FDI	Ignition Source	Prevailing Wind	Area Burnt (ha)	Fire Path	Termination Factors
2001	Canning Mills		Unknown		601		
15/01/2005	Pickering Brook	35-37	Suspicious/ Deliberate	Easterly changing to north-easterly	27700	East to west	6-146 fire appliances Fuel <8 yrs. allowed for suppression Mosaic of low fuel loads restricted rate of spread and intensity North-east wind change reduced rate of spread Slope reduced rate of spread
29/1/2007	Brazier Road		Lightning		660		
6/02/2011	Roleystone Kelmscott Red Hills (Outside 5 km buffer)	60	Hot Works (Grinder)		400		154 fire appliances
1100 12/01/2014	Parkerville Stoneville Mt Helena (Outside 5 km buffer)	53	Power pole falling caused sparking	West-north-westerly Changing to south-west after1300			Drop-in fire intensity after 2000 hours. Intensity under 2000 KW/m allowed for a direct attack. Improved weather conditions. Ground crews, aerial suppression and earthmoving machinery. 100% fuel load curing
0031 16/05/2015	Merrivale Rd Pickering Brook		Suspicious/ Deliberate		100		18 fire appliances

2.2.1 Landscape bushfire ignition

Data collected by DBCA records 163 bushfires within 5 km of the assessment area between 1990 and 2019, 37 of which were believed to be deliberately lit. All but six of the 163 bushfires were under 30 hectares in area, with 138 (85%) under 5 hectares in area. Therefore, 25 bushfires exceeding 5 ha have occurred within 5 km of the townsite expansion investigation area in the last 30 years (DBCA, 2019). Of these, four were deliberately lit, 2 were escapes from burning off, one was accidental, one was caused by lightning, and the rest were of unknown origin. A visual representation of bushfire history within the townsite vicinity is provided in **Figure 6**, with a broader landscape map provided in **Figure 7**.

The most significant fire to occur in the study area was in January 2005 in Pickering Brook. This fire burnt 27,700 hectares south of the Pickering Brook townsite. The possible cause is recorded as 'Suspicious/Deliberate' and an investigation by Cheney (2010) found that there were a total of six ignitions that contributed to the overall fire.

Based on records from 2000-2020, bushfires occur every 3.5 years on average, within 5 km of the proposed expansion area.

2.2.2 Landscape bushfire spread and termination

Multiple factors are involved in the spread of bushfires, including weather conditions, new ignitions, ability to suppress fires or reduce fuel, and fuel load. The January 2005 fire in Pickering Brook spread to the southeast as a result of prevailing easterly/north-easterly winds. The spread was further influenced by spot fires; potentially deliberate ignition and lighting fires. The age and volume of the fuel load increased the fire spread up to 6 times faster in the 20-yr fuels than in the 3-yr fuels. Low fuel moisture in the afternoon increased fire spread. The confluence of individual fires into a single fire front made the fire harder to suppress.

The Study of the 2005 fire, by Cheney (2010), compared the rate of observed spread with predicted rates of spread (finding a close approximation with the Project Vesta 2007 results). The fires rate of spread was not uniform over the period of the event but peak rate of 1.6 km/h was observed and spotting occurred up to 2-3 km. Cheney also identified the ignitions had been estimated to have commenced 15 minutes before detection, and in this instance by a dedicated spotter plane.

The key factor involved in the termination of the fire was the presence of younger fuels (less than 8 yrs.) that allowed for the suppression of the fire once it entered these areas. In certain areas (fuel 1-2 yrs.) the low fuel load the fire front stopped without intervention. Areas where fuel reduction had occurred in the last 3 years, the reduce fuel load was significant in reducing the rate of spread and reducing the intensity of the fire front. This allowed for efficient suppression of the fire and reduced the overall area that was burnt. Fire in 3-year-old fuel spread six times slower and was 20 times less intense than a fire in 20-year-old fuel.

Significantly Cheney concluded that if not for the prescribed burning program and if the area had not been burnt for 20 years the fire would have burnt into the outer suburbs of Perth with the potential for extensive property damage.

The rates of spread observed from the 2005 fires were in relatively mild conditions windspeeds typically 17.5 km/h, suggesting the predicted models underestimated the Rate of Spread across some parameters, but the findings of Project Vesta 2007 were a closer fit particularly at lower wind speeds.

The fire history importantly reveals the significance of fuel reduction activity around Pickering Brook Townsite. It has to date restricted penetration of bushfire into the townsite, although it has stopped close by (east of the townsite) it has reduced the intensity for effective suppression.

The common wind direction from the east and fire history suggests the area to the east is a particular threat to the townsite and deliberately ignited fires have occurred from this area, in part warranting the closure of the Pickering Brook Road to the east of the townsite. Although at the same time this has restricted quick access for emergency services to a fire in this area, requiring a longer route to be taken.

The location, and direction of arrival, together with the rate of spread enables an ASET (available safe egress/evacuation time) and RSET (required safe egress/evacuation time) determined and route to be identified, and the availability of the route to be identified.

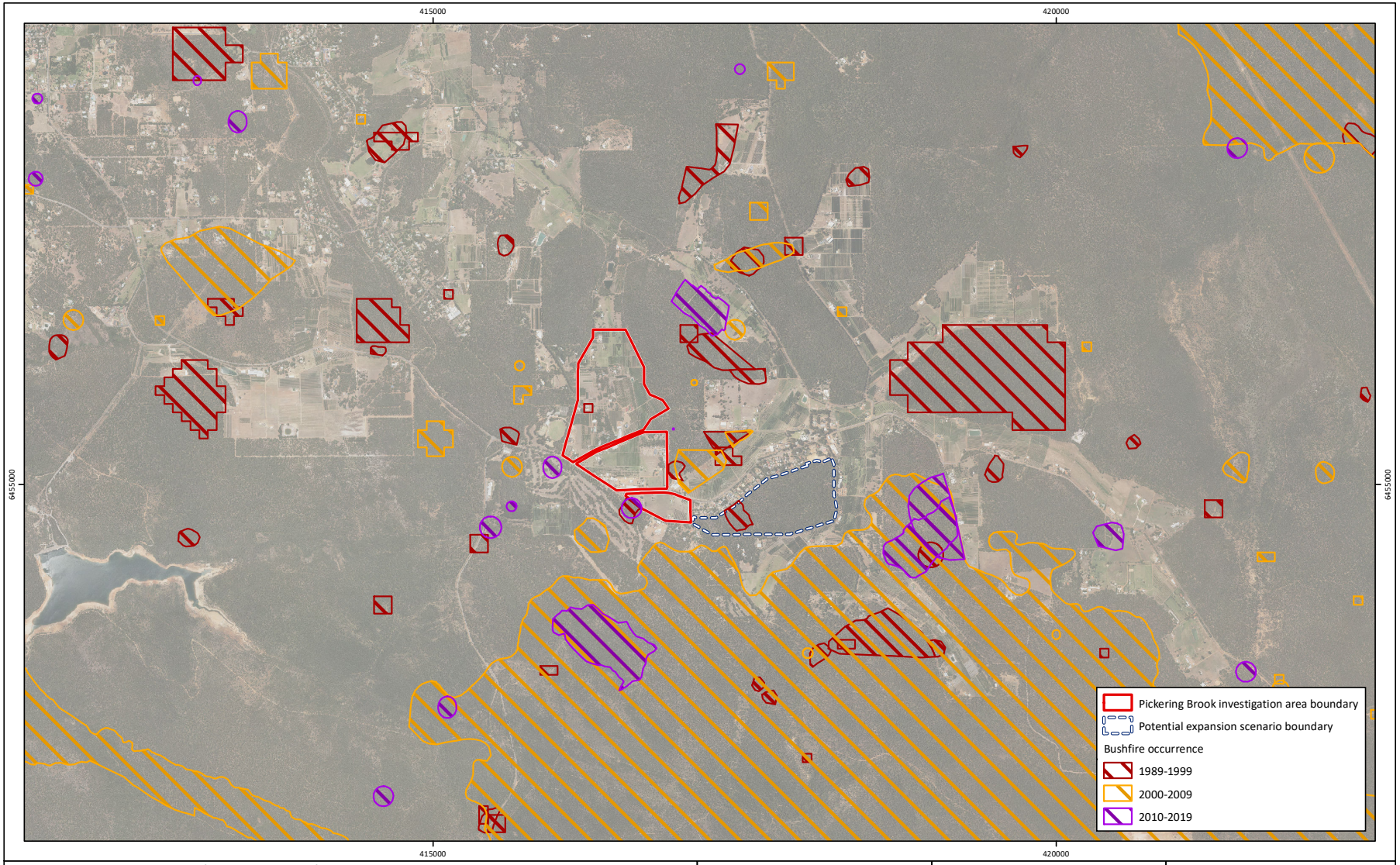


Figure 6: Bushfire History (Townsite Vicinity)

Project: Bushfire Management Plan
Pickering Brook Bushfire Risk Assessment
Client: Department of Planning, Lands and Heritage

Plan Number:
EP19-138(01)--F19
Drawn: GAR
Date: 13/02/2020
Checked: AJR
Approved: AJR
Date: 26/02/2020

N

0 500 1,000 1,500
Meters
Scale: 1:40,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

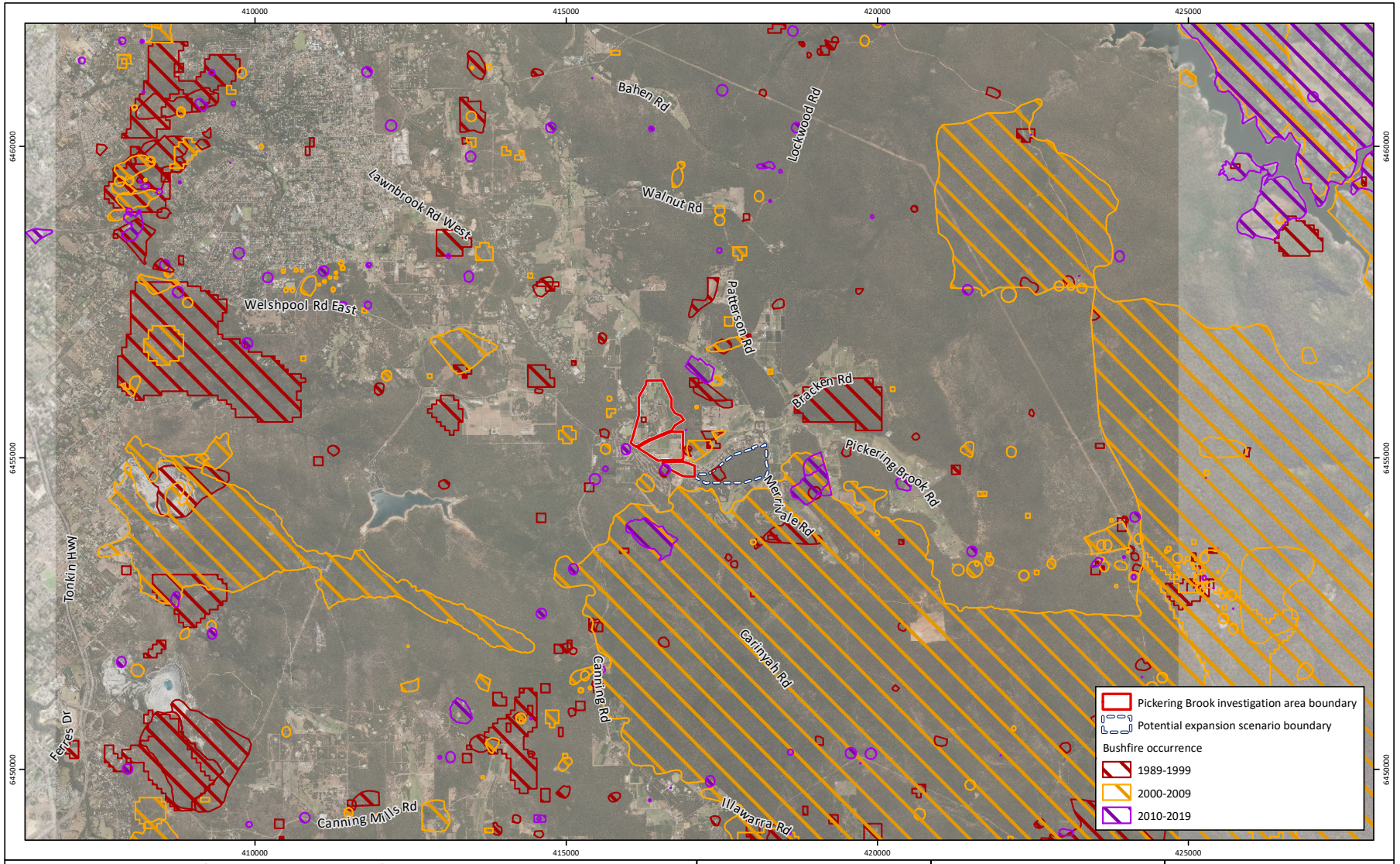


Figure 7: Bushfire History (Pickering Brook Surrounds)

Project: Bushfire Management Plan
Pickering Brook Bushfire Risk Assessment
Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(01)--F20
Drawn: GAR
Date: 13/02/2020
Checked: AJR
Approved: AJR
Date: 26/02/2020

N

0 1 2 3
Kilometers
Scale: 1:80,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

2.3 Landscape Bushfire Hazard Level assessment

A Bushfire Hazard Level (BHL) assessment is required for strategic planning proposals, in determining the potential intensity of a bushfire in a particular area.

For this assessment, the bushfire hazard level assessment was extended from 150 m to 5 km to determine the fuel continuity and factors affecting bushfire behaviour. It was also chosen to examine the prospects for evacuation routes and to determine the rate of spread and time to facilitate evacuation, which included the breaching of an intersection providing alternative directions for escape.

The BHL has followed the BHL Assessment Methodology as described in Guidelines Appendix 2 (WAPC and DFES 2017). It has been based on the slope and vegetation identified in this report. The predominant class of vegetation, as classified by AS3959 are Forest, Grassland >100 mm and low threat cl.2.2.3.2 (f) or excluded surfaces cl.2.2.3.2(e). For the purpose of the BHL assessment orchards have been classed as Grassland, similar to the current CSIRO mapping methodology for determining bushfire prone areas in WA.

In order to add value to the interpretation of 'extreme', this assessment has provided a fireline intensity graduation within the area mapped as extreme. The graduation has been applied based upon Fire Line Intensity using the calculator provided in AS 3959:2018.

$I = HW R_{slope} /36$
Where:
H = heat of combustion (18 6000-kJ/kg)
W = total fuel load 35 t/ha (no fuel reduction activities/areas have been counted)
R_{slope} = adjusted forward rate of spread (0°), (0°-5° @ 5°), (6°-10° @10°), and (11°+)

The mapped Fireline intensity within the Extreme BHL, (FFDI 80) are:

- 43,400 kW/m^2 @ 0°
- 61,280 kW/m^2 @ 1-5°
- 86,527 kW/m^2 @ 6-10°

An outcome from determining the fire line intensity is the calculation of the rate of spread.

Averaging the peak rate of spread from the townsite for forest over varying slopes flat and upslope, 0-5° and 5-10° gave a rate of 3.3 km/h, and a similar result from east, south and west. A fire will travel 5 km in 90 minutes (FFDI 100). *This is detailed in section 3.10 of this BMP to determine the ASET and RSET, for the purpose of evacuation*.

This rate of spread compares to the observed rate of spread by Cheney (2010) (see Fire history section) or if the same wind strength is applied. But as Cheney observed, the rate of spread in this landscape is not uniform and it assumed maximum fuel loads.

A more accurate BHL could be undertaken based upon fuel reduction programs and verification of fuels but was not available for this assessment. The BHL, therefore, reflects a "do nothing" assumption.

The BHL must also be read in consideration of the topography and aspect. The intensity of a fire experienced by a receiver is greater if it is located upslope from the fire. The calculations assume the measure is taken upslope from the fire. For a receiver located downslope of the fire line the intensity will reach approximate 43,400 kW/m^2, and whilst a fire on a steeper slope may be more intense, the flame angle increases the distance to a downslope receiver, offsetting the increased intensity.

In regard to this assessment the townsite, being on a valley floor, is downslope to the vegetation. Scenario 6 adjoins a steeper upslope that is classed as Forest and is indicated as up to 61,280 kW/m^2, but the townsite being downslope would experience approximately 43,400 kW/m^2.

Similarly, the access routes are generally set downslope of the vegetation, the exception being a section of Canning Road between Pickering Brook Road and the townsite of Kalamunda. A section straddles a slope greater than 5.0°, the road would be exposed to a fire line intensity of 61,280 kW/m$^{2.}$ Protections of infrastructure along this section should be adjusted accordingly. The bushfire hazard level assessment is provided in **Figure 8**.

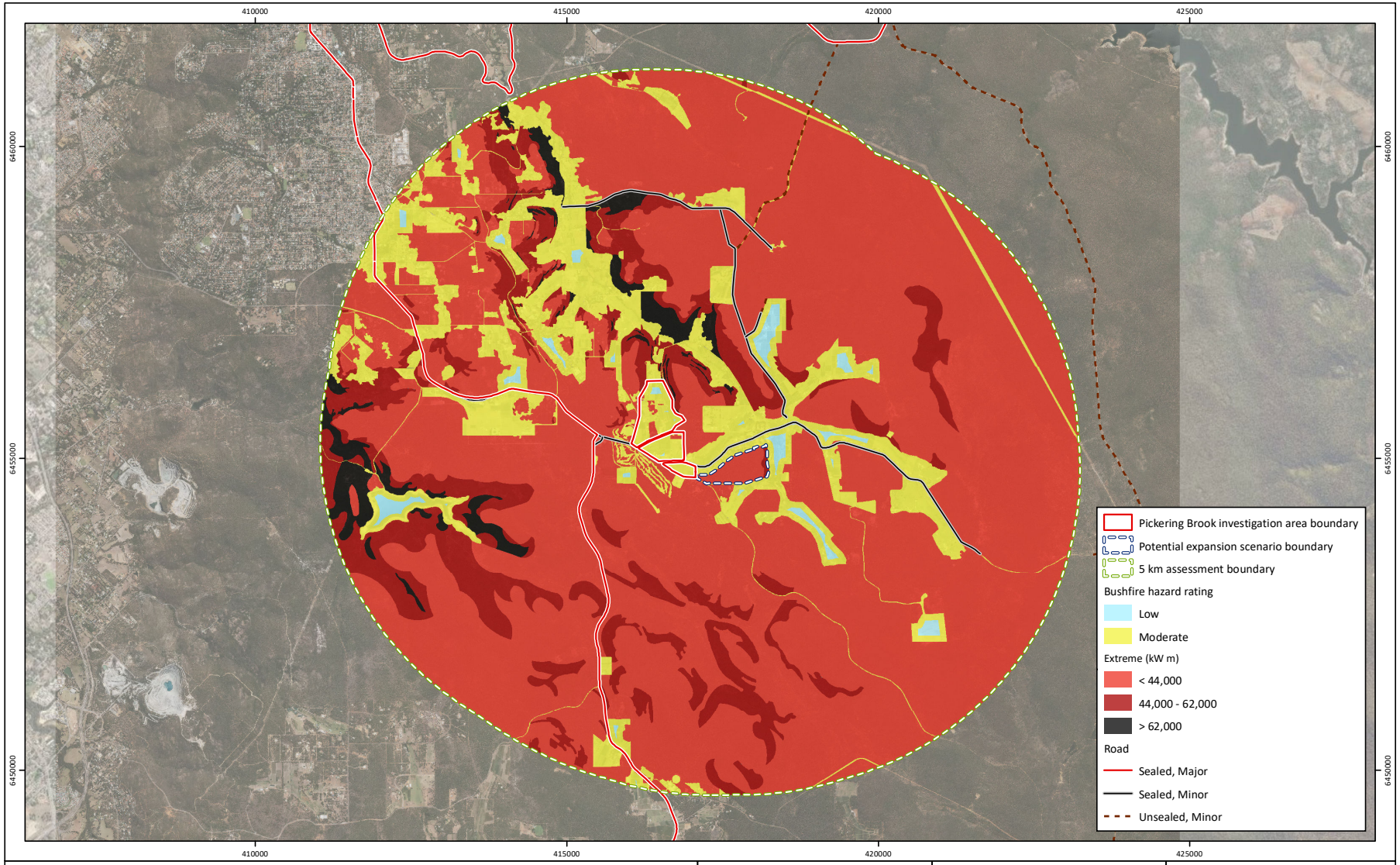


Figure 8: **Landscape Bushfire Hazard Level Rating**

Project:	Bushfire Management Plan Pickering Brook Bushfire Risk Assessment
Client:	Department of Planning, Lands and Heritage

Plan Number:
EP19-138(01)--F21

Drawn:	SCM
Date:	30/01/2020
Checked:	AJR
Approved:	AJR
Date:	26/02/2020

N

0 1 2 3
Kilometers

Scale: 1:80,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

2.4 Road Access

A key aspect of the assessment requested by the Project Taskforce is the potential access and egress solutions available and safe during a bushfire event, including recommendations for upgrade or provision of new roads to ensure vehicle access. The ability to safely evacuate a population is a key consideration in addressing the safety of the community where the route and destination are safer than the place of departure.

It is important to recognise that vehicles should not drive through fire. Vehicles do not offer effective protection from radiant heat above 10kWm^2 and smoke over roads can obscure vision increasing the risk of running off the road or colliding with operating fire services. Fallen trees can also block vehicle passage trapping vehicles and exposing vehicles to fire. The most effective method of reducing risk to the public is to avoid travelling on roads during a fire; to close the road before a fire arrives or when firefighting operations are taking place.

This, in turn, needs to be supported by an option for a safer place, in case the first preference of evacuation is not available. A firefront will pass a road quickly, peak (flame) residency and flaming time was identified by project Vesta to be 2 minutes up to 1100^{0}c before the temperature quickly decays to 500^{0}c before again tapering down to less than 200^{0}c and fading. Access along a road may be denied for up to 30 minutes, whilst individual heavy fuels continue to burn, or there may be further delays caused by fallen trees/branches and powerlines.

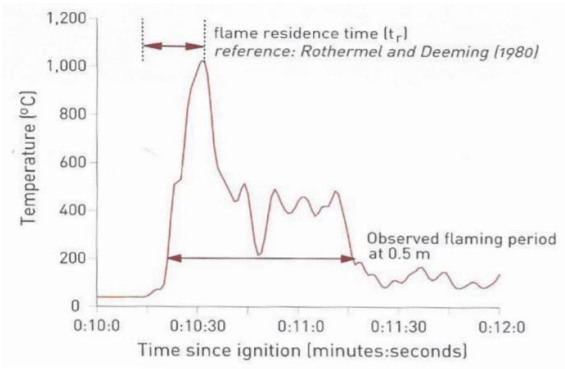


Plate 13: Project Vesta flame residency temperature profile for forest.[19]

It is now an important part of the planning and justification of development, to demonstrate an effective multi-option road network is available that will support safe evacuation[20], and also to include the administrative parameters that will make it effective including timely alert and certainty to use it when it is safe. Consideration has been given to the State Emergency Management Guidelines *Traffic Management During Emergencies Guideline* 21 December 2018.

Minimising the exposure of a community to bushfire is the opportunity to remove the community from the path of the bushfire which in turn requires analysis of the ability to move within the

[19] Australian Building Codes Board 2019, *Handbook: Bushfire Verification Method*, Commonwealth of Australia and States and Territories 2019, published by the Australian Building Codes Board.
[20] State Emergency Management Guidelines -Western Australia *Community Evacuation in Emergencies* Guideline, 21 December 2018.

townsite and the ability to safely evacuate to a safe destination with ample time before conditions deteriorate. For safe evacuation, an option to travel with minimal difficulty in the opposite direction to fire is important.

Access is also the key to supporting suppression activity and recovery. The fire's passing is relatively quick and damage to a road surface is rare, but blockages from fallen trees and debris can delay the reconnection. There is a priority to be able to establish a reconnection to the community after a fires passing and therefore a recovery road is recommended, with works identified to ensure it can achieve this function.

The capacity of other roads to support fire fighting is routinely limited throughout Western Australia and nationally. They usually do not have the width to permit the passage of the public whilst fire fighting operations are being conducted, which can include times of poor visibility. The operation may include the rapid movement of heavy vehicles used for fire fighting, stationary vehicles with personnel deployed around them, and slow-moving vehicles. It is not practical to expand roads to enable both public transit and fire fighting operations to occur at the same time, and it is not practical to only support development where this opportunity is provided.

The alternative is to administer a separation of activities that match a bushfire event. There is a time for evacuation and there is a time for undertaking suppression and preparation. Early evacuation for a number of reasons is the best and safest option for the community. Early evacuation means leaving before roads become compromised by smoke, at a time well in advance of the fire reaching the road.

There is a time that the exit roads should be closed for the purpose of evacuation (to townsite residents and residents along the road) and as a next-best redundancy, where it is too late to leave, to provide shelter in a safer place within the town.

It is a State Emergency Management Procedure [21] to close roads to prevent access to an incident area i.e. impingement by fire and when suppression operations are taking place. Pickering Brook Road and Patterson Road are local roads. Section 14B(2)(c) *Bushfires Act 1954* authorises the police or an authorised person i.e. bushfire liaison officer to close any road or access to an incident area to members of the public. This enables the freedom for firefighters to safely and effectively use the available road capacity to undertake their operations. The option of road closure can be assisted by a community expectation of procedures and decisive communication from the start, so the community evacuation can be completed before the road closure or if an alternative route or safer place is available, and communicated, for the community to evacuate by, or take shelter at.

On this basis, the assessment has considered the adequacy of the internal road network, as informed by reports prepared by KCTT (2016) and GTA (18 February 2020) to accommodate the expanded population, including visitors in the area i.e. Core Cider. The assessment has also included the undertaking of an audit of potential evacuation routes and a route for the purpose of recovery.

[21] State Emergency Management Guidelines – *Traffic Management During Emergencies Guideline 2015*, 21 December 2018.

2.4.1 Capacity

A traffic study was undertaken by KCTT *Transport Impact Assessment Pickering Brook Townsite* (June *2016)* as part of the investigations for the MRS amendment to analyse the road network **within** and surrounding the Pickering Brook Townsite to: -

- Determine the expected future traffic volumes accessing Pickering Brook Road via the Repatriation Road/Hewson Road intersection, Carinyah Road/Davey Road intersection, Cunnold Street and Merrivale Road, taking into consideration the planned residential densities;
- Assess Pickering Brook Road and Carinyah Road between Davey Road and Merrivale Road in terms of capacity, turning movements and safety

The existing road network was assessed in the KTCC report to be adequate to accommodate the optimised capacity represented by the townsite expansion.

In summary, the 2016 KTCC report forecast a maximum expansion of population would create an additional 3294 vehicle movements per day with a present peak hour rate of around 290 vehicles per hour. Traffic from the maximum expansion distributed into the adjacent road network was estimated as follows:

- 78% to/from the west via Pickering Brook Road - 2,569 Vehicles Per Day (VPD);
- 58% to / from the west via Canning Road - 1,911 VPD;
- 20% to/from the south via Canning Road - 659 VPD; and
- 14% to/from the east via Pickering Brook Road - 0461 VPD;

The GTA consultants *Technical Note Pickering Brook Urban Development*, examined the potential impact primarily upon the adjoining road network and intersections. This included access to and along Canning Road, and intersections from Pickering Brook including Welshpool Road East.

The GTA consultants considered the consequence of all scenarios combined (Scenario 6), to inform the townsite sustainability. That workshop resulted in identifying scenario 3 as the preferred option, concluding the internal Pickering Brook locality road network would not require any modifications. The GTA report concluded that the townsite expansion would have a negligible impact on the existing road network, with the majority of deficiencies at the external intersections due to forecast growth in the broader area up to the year 2031.

Given the townsite is not a through destination but effectively a spur from Canning Road, it is likely that in a bushfire event that large numbers from the broader area would travel into Pickering Brook or use its facilities. Evacuation, therefore, needs only to account for the peak number of people/cars expected to be present at any time.

The BMP in order to consider an emergency evacuation identified Pickering Brook is not a through destination, it is the population present at the time that must be provided for. Current vehicles likely to evacuate from within the townsite, based upon 1.5 vehicles per household, is 196, with scenario 3 it would be 297 vehicles. If scenario 6 was pursued it would be 460 vehicles. An additional 150

visiting vehicles at any one time has been allowed for visitation and school attendance (i.e. including Core Cider 80 vehicles). Total vehicles to evacuate scenario 3 is 447 vehicles.

The vehicle flow rate for a single road is 1800 vehicles per hour excluding heavy vehicles (GTA advice), but there is no specific flow rate attributed to an emergency evacuation. A conservative estimate for evacuation has been chosen to allow 10 seconds per vehicle, the capacity of the identified evacuation routes on mostly straight roads averaging 40 km per hour would enable 360 independent vehicles to pass within 60 minutes. This is consistent with the peak road movements (identified by KTCC 2016) for independent vehicles along roads in the broader area.

2.4.2 Access assessment

The road network, therefore, must address several bushfire objectives. This includes:

- An alternate route, in the opposite direction to the approaching fire, for safe community evacuation
- An alternate route for access and retreat of firefighting services
- Resilience – the ability to return to function after the fire's passing.

The passage of fire across a road is short, usually less than 30 minutes. The availability of the road to be used is affected by the time available before the fire arrives, the passing of the fire, and after the fire has passed whether objects have fallen to block the road way or are likely to fall on a traveller or block the roadway. A resilient road network one where the risk of blockage has been avoided, i.e. the setback of trees and powerlines would restrict a fall into the road carriageway. The availability of a resilient network is important because it will ensure townships and safer places, do not become isolated for extended periods.

It is acknowledged that there is a high dependency on access via Canning Road and Pickering Brook Road from the west. For recovery from a bushfire event, this access is identified as a recovery road, and preparation should ensure it is resilient to the effects of bushfire.

Whilst early evacuation, before a route is overtaken by fire, is the preferred approach to minimising exposure to the effects of a bushfire, the alternative is to shelter in a safe place ensuring safe access can be provided to it from within the Pickering Brook locality.

For the bushfire objectives, this assessment has identified potential road access in north, east, south, and west directions that provide the opportunity to reach multiple destinations, for evacuation, firefighting access, and recovery.

This assessment has adapted the methodology VicRoads, *Road Bushfire Risk Assessment Guideline and Risk Mapping Methodology Report* April 2013, as a basis for assessing the access for the townsite expansion investigation area.

The approach has been adapted with an emphasis upon a fire approaching the road and the potential for blockage by falling trees. A modified template was devised and the following roads were assessed.

- North - Patterson Road to Walnut Road and Kalamunda, or to continue along Patterson Road (dirt road section) through to Mundaring Weir Road and onto to the Great Western Highway
- East - Pickering Brook Road to Ashendon Road (then north to Mundaring Weir Road to Great Western Highway or south to Brookton Highway).
- West - Canning Road to the Perth Urban area via Welshpool Road East or Canning Road to the Perth Urban area via the townsite of Kalamunda (nearest Brigade location) and
- South - Canning Road to the Brookton Highway and the Perth urban area.

The preferred egress routes are shown in **Figure 9**.

The template used and the results recorded are provided in **Appendix A**.

The fire history suggests fires may come from the south, heading in a northerly direction, through to the east heading in a westerly direction. Our assessments found:

- Canning Road from Kalamunda is the primary service route for the townsite of Pickering Brook, and the first preference of access for emergency services as a direct route. The road is a sealed road in good condition and is identified as the best option as a 'recovery' road.
- Canning Road Welshpool Road East is the shortest evacuation route to the Perth Urban area.
- Patterson Road (heading north) Walnut Road (heading west), is the northern evacuation route for the Pickering Brook locality. Patterson Road and Walnut Road are sealed roads (compliant with Table 6 Guidelines V1.3) predominantly straight except for a corner approaching the Walnut Road intersection. The junction from Patterson Road onto Walnut Road is a left-hand turn. Walnut Road does not serve a large catchment to the east of the Patterson Road junction and therefore supports an orderly transition from Patterson Road on to Walnut Road.
- All roads are traversable by 2WD vehicles. The unsealed roads are wide, have few corners, and the existing corners are broad, not requiring a change of speed. They generally offer long visibility of the road ahead.
- All roads have trees within the verge that would have the potential to block access.
- No 'emergency' direction signage is presented along the roads.
- No safer locations were identified along the roads.
- Pickering Brook Road is blocked east of the townsite, rather than gated, and the blockages prevent access to Ashendon Road. Whilst the fire history would suggest it is unlikely travel in an easterly direction along Pickering Brook Road would be used for evacuation, it is conceivable that services attending a fire to the east would benefit from an opportunity to retreat directly to the Pickering Brook townsite via Pickering Brook Road. It is also the most direct route for fire services from the west (Kalamunda Brigade) or Parks and Wildlife Services to a fire in the east.

In most circumstances, emergency evacuation of the population can be facilitated via Patterson Road, to the north, although if sufficient warning is provided, or should a fire approach from the north, Pickering Brook to Canning Road is the most direct and familiar route for the Pickering Brook Residents.

Pickering Brook - Canning Road to the townsite of Kalamunda is also the best option to access the townsite immediately after the passing of the bushfire. It is also the route for the town power supply. Whilst the passage of fire is relatively short, the closure of a road includes a lead time for the fire's arrival, to permit safe passage, and the time for the fires passing. A resilient road can return to function immediately after the passing of the fire, enabling emergency access to the community for fire suppression to be applied to secondary fires within the townsite and for the provision of medical treatment.

Fallen trees and fallen powerlines can create dangerous conditions blocking a road after a fire's passing, and disrupting access. Road blockages have been a contributor to fatalities during a bushfire. In order to minimise potential disruption to the townsite, it is recommended that an audit be undertaken of trees and power poles within a 45° height to distance setback from the carriageway.

The audit would be to identify the individual items that may be at risk of falling into the carriageway. Trees in the locality which are Jarrah and Marri generally have deeper taproots and exhibit greater stability than observed interstate. Failure is likely if there is degradation at the base and it is vulnerable to the accumulation of embers. Where soils are shallow some trees will rely more on lateral roots and these can be destabilised by the use of suppression water. The symmetry of the tree and canopy can also be an indicator of stability.

Maintaining the base of the tree free of flammable material will assist to minimise the potential for failure and road blockage.

It was also noted that a number of the power poles are in poor condition and in contact with elevated/flammable vegetation. Replacing timber poles with steel poles, or clearing poles of vegetation will assist to minimise the potential for failure and road blockage.

Falling tree limbs weakened by a canopy fire can bring down powerlines and would disrupt the function of Pickering Brook, particularly if the power supply from Patterson Road was also brought down by falling trees. Where branches pose a risk of falling on to powerlines consideration should be given to pruning to reduce the potential risk of a branch fall.

There will be a point where it will be too late to evacuate and a safer place within the townsite will be required (addressed in the following section).

This assessment, having regard to the KTCC and GTA reports find the existing road capacity within the townsite will enable safe movement within the townsite in a bushfire event. In particular, Pickering Brook Road is a spine within the townsite that is wide and has expansive views. Whilst scenario 2 and 3 adjoin Pickering Brook Road, it is recommended the subdivision designs for scenarios 4, 5, and 6 should provide low threat access to also join it, to provide a continuous low threat connection linking the townsite.

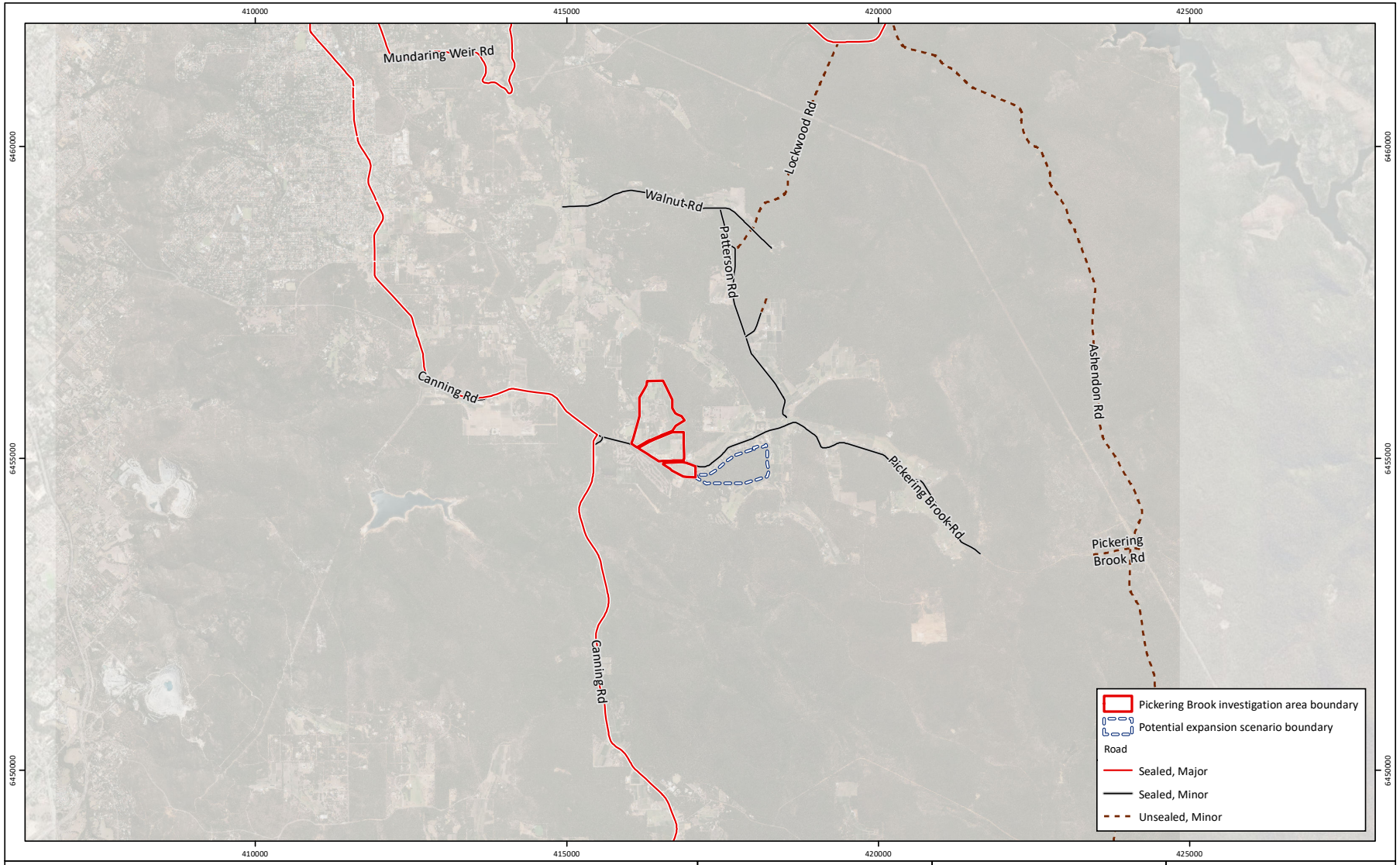


Figure 9: Potential Egress Routes

Project:	Bushfire Management Plan Pickering Brook Bushfire Risk Assessment
Client:	Department of Planning, Lands and Heritage

Plan Number:
EP19-138(01)--F22

Drawn:	SCM
Date:	30/01/2020
Checked:	AJR
Approved:	AJR
Date:	26/02/2020

N

0 1 2 3
Kilometers
Scale: 1:80,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

2.5 Water

2.5.1 Water supply

The Water Corporation in its advice provided June 2016 for the MRS, and reiterated on 16 December 2019 (DPLH), was that Pickering Brook is remote from any other sewerage networks and wastewater treatments plants and there are no plans to sewer the area, nor any viable plans to fund such infrastructure. This has been a major determinant of the minimum 2000 m^2 lot size (R5). The Water Corporation also has no drainage assets or licence obligations in this area.

The water supply infrastructure and distribution are located west of the townsite (408 m west of Weston Road at 310 m AHD). Two cement tanks 225 KL are located within an 1800 m^2 fenced compound set within forest vegetation (**Plate 14**).

The PIA will be provided with a reticulated water supply connected to the Water Corporation reticulated water supply system. The Water Corporation considered hydraulic modelling for the requirement of the proposed MRS amendment based on a yield of 350 dwellings and advised that minimal constraints are present but some minor upgrades to reticulation pipes may be required; this need will be monitored by Water Corporation.

The Water Corporation has advised in considering the full development of the PIA that up to 100 lots (services) could be served from within the capacity of the existing tank and infrastructure located west of Weston Road, but beyond these additional services, extra capacity providing an additional 225 KL, may be required to maintain adequate emergency storage for the scheme. The Corporation has also advised that the 150 mm outlet and distribution may need to be duplicated and an additional water tank, capacity, may be required on the eastern side of the project area at one of the high points, either south-east of Carrinyah Road at RL 309 m AHD or immediately adjacent to Isaacs Road (eastern side) at RL 285 m AHD.[22]

Plate 14: Water tank compound at Weston Road

The Corporation has advised that no development be located higher than its tanks west of Weston Road 319 m AHD. The highest point within the PIA is 290 m AHD.

[22] KTCC *Infrastructure Servicing Report June 2016*

Fire management will be an important consideration in the overall design of the water reticulation system. Hydrants will need to be provided at 200-metre spacings in accordance with Water Corporation requirements

As identified above, an outcome of contemporary bushfire building construction and land management is to achieve passive resistance to bushfire attack requiring less reliance on suppression activity and large volumes of water for fire suppression. New development, with commensurate BAL resistant construction, will not necessitate an increased capacity above the domestic supply considerations. It is, however, important to consider that the existing housing stock that predates construction is reliant on suppression and water for defence. Expansion of the townsite should not deplete the capacity required to defend the existing housing stock.

2.5.2 Wastewater management

The PIA area is within a proclaimed area under the *Country Areas Water Supply Act* 1947 as part of the Middle Helena Catchment (MHC) Public Drinking Water Source Area (PDWSA). It occupies approximately 1% of the catchment which ultimately supplies water to the Water Corporation Goldfields and Agricultural Water Supply Scheme and also supplies part of the Integrated Water Supply System, which serves the Perth Metropolitan Area (WAPC and DoP 2010)[23].

The provision of a reticulated wastewater system has not been considered economic and this has been a determinant upon the R5, 2000 m^2 minimum lot size for onsite disposal.

Wastewater from firefighting activities can include contaminants that may enter the environment and affect water supplies and it is a risk that is identified in the Guidelines for Planning in Bushfire Prone Area V1.3

An outcome of contemporary bushfire building construction and land management is to achieve a passive resistance to bushfire attack. Whereas previously the survival of a building was dependent upon the actions of a brigade and the application of water, passive resistance requires neither, thereby reducing the reliance upon brigade intervention and a reduced quantity of water required for suppression. The additional benefit of reduced interventions is the reduced release of toxins into the environment either from smoke or contaminated water from suppression, or eventual stormwater.

2.6 Electricity

The townsite is supplied by overhead power lines, 33 KV, that connect it from Canning Road through to Pickering Brook Road or by Patterson Road. Canning Road is prepared as a wider road than Patterson Road. The overhead powerlines in the Canning Road reserve are supported by timber poles. Some poles are located amongst shrubs and under the canopies of trees. The condition of the poles also varies and it is apparent that they are replaced individually on a need basis. The power poles along Patterson Road are timber and generally closer to consistent Jarrah Marri forest vegetation.

[23] Strategen - Pickering Brook District Water Management Strategy June 2016

2.7 Telecommunication

The telecommunication tower servicing Pickering Brook is located west of Weston Road, within a compound set amongst forest (**Plate 15**).

Telecommunications is increasingly essential for reporting and responding to a bushfire event and the increased expectations of self-reliance that is a practical response recognised by the National Strategy for Disaster Resilience. Telecommunication infrastructure can be affected by bushfire attack creating a level of community risk.

The Pickering Brook Townsite Expansion area is supplied with telecommunications assets suitable for general telephony and it has access to 4G coverage, although some indication was reported to the BMP that black spots are present within the locality.

The NBN Co is currently seeking to locate a tower in the area to provide improved internet services.

Plate 15: Tele-communications compound west of Weston Road

2.8 Gas utilities

No reticulated gas services are provided in the area.

2.9 Present Hazard Mitigation Measures

2.9.1 State Emergency Management Framework

The *Emergency Management Act 2005* has been established to detail roles and responsibilities at a State, district and local level in the implementation of the emergency management principles of Prevention, Preparation, Response, and Recovery (PPRR).

The *State Emergency Management Policy* (State EM Policy) provides a strategic framework for emergency management in Western Australia describing principles and objectives for the co-ordinated organisation of public authorities.

The policy is supported by a suite of documents that provide complete guidance on the strategic framework for EM in Western Australia.

Under s. 20(4) of the EM Act, a public authority that is given a role and responsibilities under a State EM Policy is to comply with the State EM Policy[24].

- State Emergency Coordinator (SEC)
- District Emergency Coordinators (DECs);
- Local Emergency Coordinators (LECs) (WAPOL officer for the City of Kalamunda); and
- Local Emergency Management Committee - oversees local emergency management activities PPRR, through articulation of stakeholder responsibilities in the Local Emergency Management Arrangements (LEMA).

A local government is to establish one or more Local Emergency Management Committees (LEMCs) for its area to ensure that effective Local Emergency Management Arrangements (LEMA) are prepared. The LEMA is to be consistent with the State Emergency Management policies the State Emergency Management plan. The LEMA addresses all emergencies but special considerations within the LEMA include the bushfire season. In the City of Kalamunda, it is the period between October – May, and the roles and responsibilities of public authorities and persons involved in emergency management (stakeholders) including the Hazard Management Agency (The City, WAPOL and DBCA).

The scope of the LEMA to address Prevention, Preparation, Response, and Recovery. The scope is broad.

The Hazard Management Agency (HMA), is tasked to provide the bushfire services comprises the City of Kalamunda, DFES, and Department Biodiversity Conservation and Attraction (DBCA).

The LEMA, following the State Emergency Management Policy, addresses community evacuation. The HMA is responsible for planning and implementing evacuation, ensuring the welfare of evacuees in consultation with the Department of Communities Child Protection and Family Support (State

[24] STATE EMERGENCY MANAGEMENT A Strategic Framework for Emergency Management in Western Australia October 2019

agency responsible for welfare) during the planning stage. The duration for evacuees to stay in nominated welfare centres are:

- Short term <24hrs.
- Long term up to a week.
- State Evacuation Centre > 1 week.

The City is responsible for the provision of local welfare centres in planning with the Department of Communities Child Protection and Family Support.

The Controlling Agency (HMA) is responsible for the decision to evacuate during an emergency and to assist community members in recognising a threat and being able to make an informed decision as to whether to evacuate[25].

Factors that may be taken into account when deciding whether to evacuate a community are:

- the magnitude of the fire;
- whether sufficient time is available to travel safely out of the area; and
- the availability of egress routes.

The Controlling Agency is responsible for the safety of people during the management of traffic during the emergency response requiring coordinated planning by both the Controlling Agency and the local government.[26]

2.9.2 City of Kalamunda Fire Management Planning

Activities in which City of Kalamunda is engaged, in addition to the LEMA that relate to development planning include:

- Administration of the *Bushfire Act 1954* and enforcement of the annual fire break notice to limit the ignition and spread of bushfire.
- Administration of the *Planning and Development Act* 2005, including the preparation of development policy and assessment supporting Development Approval, and compliance with the bushfire protection criteria.

  The Planning and Development (Local Planning Scheme) Regulations 2015, Deemed Provisions at cl. 78D (4)(a), enables a Local Planning Scheme to exceed the routine requirement within the Planning in Bushfire Prone Areas framework.

  Responsibility for the ongoing enforcement of the development authorisation is provided through s.214 *Planning and Development Act* 2005.
- Administration of the *Building Act 2011* and the requirements of the *National Construction Code*, construction standards in declared bushfire prone areas. Not all structures require development approval or building approval. The *Planning and Development (Local Planning Scheme) Regulations 2015*, Deemed Provisions at cl. 78E (1) bushfire construction standards

[25] State Emergency Management *Western Australia Community Evacuation in Emergencies Guideline,* December 2018
[26] State Emergency Management *Traffic Management During Emergencies Guideline 2015*, December 2018

provided in the *National Construction Code* can be applied by development approval if not in conflict with the *Building Act 2011*.

2.9.3 DBCA/PWS Fire Management Planning

The Parks and Wildlife Service (PWS) is responsible for managing fire in land managed by DBCA. This includes managing fuel loads through prescribed burning and other measures, responding to bushfire and undertaking research on fire behaviour.

The PWS aims to undertake to burn under prescribed conditions to assist in maintaining biodiversity and protecting life, property and community values from bushfire. PWS uses prescribed burning to mitigate the severity of bushfires, to maintain biodiversity, to rehabilitate vegetation after disturbance and to undertake research. Prescribed burning takes place in spring and autumn under cool conditions with higher moisture levels and stable weather conditions.

PWS prepares a plan for the burning program and schedules burns for the upcoming year as well as an indicative future burning program for the next three years. The burn plan aligns with the regional fire management plan. The program identifies burns required for biodiversity conservation, then vegetation management. This program is then assessed to ensure that it achieves strategic protection from bushfire. The plan is amended until the strategic requirements are fulfilled.

The PWS engagement in fuel reduction around the Townsite of Pickering Brook has been of long-standing and a reason why bushfires have not penetrated the urban area of Pickering Brook to date. Fuel reduction is not an assurance that the land will not carry a fire but the objective is to reduce its intensity, to have a low impact or manageability for effective suppression.

In July 2019 in accordance with its prescribed burning plan, the National Parklands adjacent the PIA were treated.

2.9.4 Local Fire Suppression Resources

The nearest brigade resources are located in the townsite of Kalamunda (**Table 4**), they are unmanned volunteer brigades meaning that assembly time is required before dispatch.

Table 4: Location of volunteer brigade resources

Location	Distance	Assembly	Travel time	Response time
Volunteer Bushfire Brigade 20 Raymond Road Kalamunda	10 km	20 minutes	11 minutes	31 minutes
Volunteer Fire and Rescue Service 38 Central Road Kalamunda	12 km	20 minutes	12 minutes	32 minutes

It is understood that members of the Pickering Brook community are seeking to establish a volunteer brigade at Pickering Brook to be located at the Pickering Brook playing fields George Spring Reserve at Weston Road.

2.9.5 Safer places

Safer places may be formal community refuges within buildings (not exceeding 10 kW/m^2 at their walls and with a demonstrated internal tenability) or open spaces where the BAL will not exceed 2 kW/m^2.

The Bushfire CRC study[27] of *Use of Informal Places of Shelter and Last Resort on 7 February 2009,* conducted interviews with survivors as a basis for planning for neighbourhood safer places. The study found that many people survived sheltering in their cars on large cleared areas such as ovals, and estimated exposure of up to BAL-10. Vehicles were shifted to avoid flames approaching across the playing field grass. It was noted that if people had sheltered outside of their vehicles, they may have sustained injuries due to embers and radiant heat.

The Study found people generally had poor knowledge of designated refuge areas but instead found the places they knew. Most ovals used were not compliant with Neighbourhood Safer Places standards. Many people went to the CFA fire station sheds, not intended as a safer place but it raised the question about the possible role of CFA fire sheds. The study found very few people had a plan to take refuge and none of those interviewed had supplied themselves with food and water.

Whilst early evacuation is the preferred response in minimising community exposure and harm at Pickering Brook, if warranted by the magnitude of the fire, in a situation where it is no longer safe to evacuate, the Pickering Brook Primary School is considered the next best option (second exposure minimising redundancy). *It may be the only option for residents along Cunnold Street that face lot 81. Their houses predate bushfire construction standards and their grounds are observed to not be prepared for bushfire, i.e. close proximity of flammable structures/objects and vegetation within 3m of a dwelling. Whilst mitigation measures have been effective to date, the dwellings are not reliable shelters if there is a coincidence of a bushfire occurring when conditions are Extreme or Catastrophic.*

The playing fields were another safer place location considered, subject to the management of the vegetation along Weston Road to a low threat. It is not preferred because it is closer to a hazard, the clubrooms are in BAL-FZ, denying access to amenities and it is at the extent of the town rather than central to the town.

The Pickering Brook Primary School is considered the best prospect as a safer place. Both in utilising the safest building on site but also the oval. Notwithstanding the presence of perimeter trees, the School is located within a BAL-Low context and is located on Pickering Brook Road which is the central road. The School also has amenities, water, toilets and shelter, and a school oval. The school is prominent in the awareness of the community and close to Core Cider for access by visitors.

The school has a stable administration during school terms, to be able to conduct an effective shelter. Arrangements would need to be assigned/delegated for times outside of school hours.

Whilst the school site has the capacity to accommodate an optimised population, utilising the buildings and oval, effective traffic management would be a priority to ensure an orderly arrival without disruption to movement along Pickering Road. Refuge of last resort on the oval would

[27] J McLennan Use *of Informal Places of Shelter and Last Resort on 7 February 2009. Bushfire CRC, LaTrobe University*

require orderly management and distribution of vehicles. The anticipated/attainable BAL at the oval is below BAL-2, and vehicles would provide shelter from falling particles and embers, and heated convective wind with a low risk of ignition.

A BAL Contour Plan has been prepared for the Pickering Brook Primary School. A determined level is shown based upon the current vegetation assessment, using an FFDI of 100 and a Flame temperature of 1200 K. An Attainable BAL Contour Plan has been provided, ostensibly management of adjacent trees in a parkland state to provide a vertical clearance of the tree canopy from the understory and horizontal clearance between canopy clusters, to break the canopy continuity.

Figure 10 illustrates the existing classified vegetation. **Figure 11** illustrates the current Bushfire Attack level, calculated with an FFDI of 100 and a Flame temperature 1200K. **Figure 12** illustrates the required works to reduce the bushfire fuels affecting the oval BAL-2. **Figure 13** illustrates the attainable BAL, after the completion of works.

It would be important for the community to be aware of the triggers for utilising the school and have a definite plan for whether they will be taking shelter on the oval as a safe place, or have an arrangement for sheltering in a school building.

The attainable BAL demonstrates the Pickering Brook Primary School oval will comply with the ABCB *Design and Construction of Community Bushfire Refuges* 2014, for external shelter 2 kW/m^2.

The calculated BAL (**Table 5**) from the nearest classified vegetation is less than 2kW/m^2. Note this assumes there are no secondary fires, radiant heat from nearby buildings, or vehicles or other objects on the oval igniting (unlikely due to the BAL level and if immediate action is taken to any ember/spot fires). Unlike the Black Saturday safer place experience[28], and survival, the BAL is lower and the oval does not adjoin a Forest.

Table 5: Calculated distance using the FPAA Flamesol calculator

Vegetation	FFDI	Flame Temperature	Radiant Heat Flux	Distance (m)
Forest	100	1200K	2.0	165
Woodland	100	1200K	2.0	130
Grassland	130	1200K	2.0	90

[28] J McLennan Use *of Informal Places of Shelter and Last Resort on 7 February 2009. Bushfire CRC, LaTrobe University*

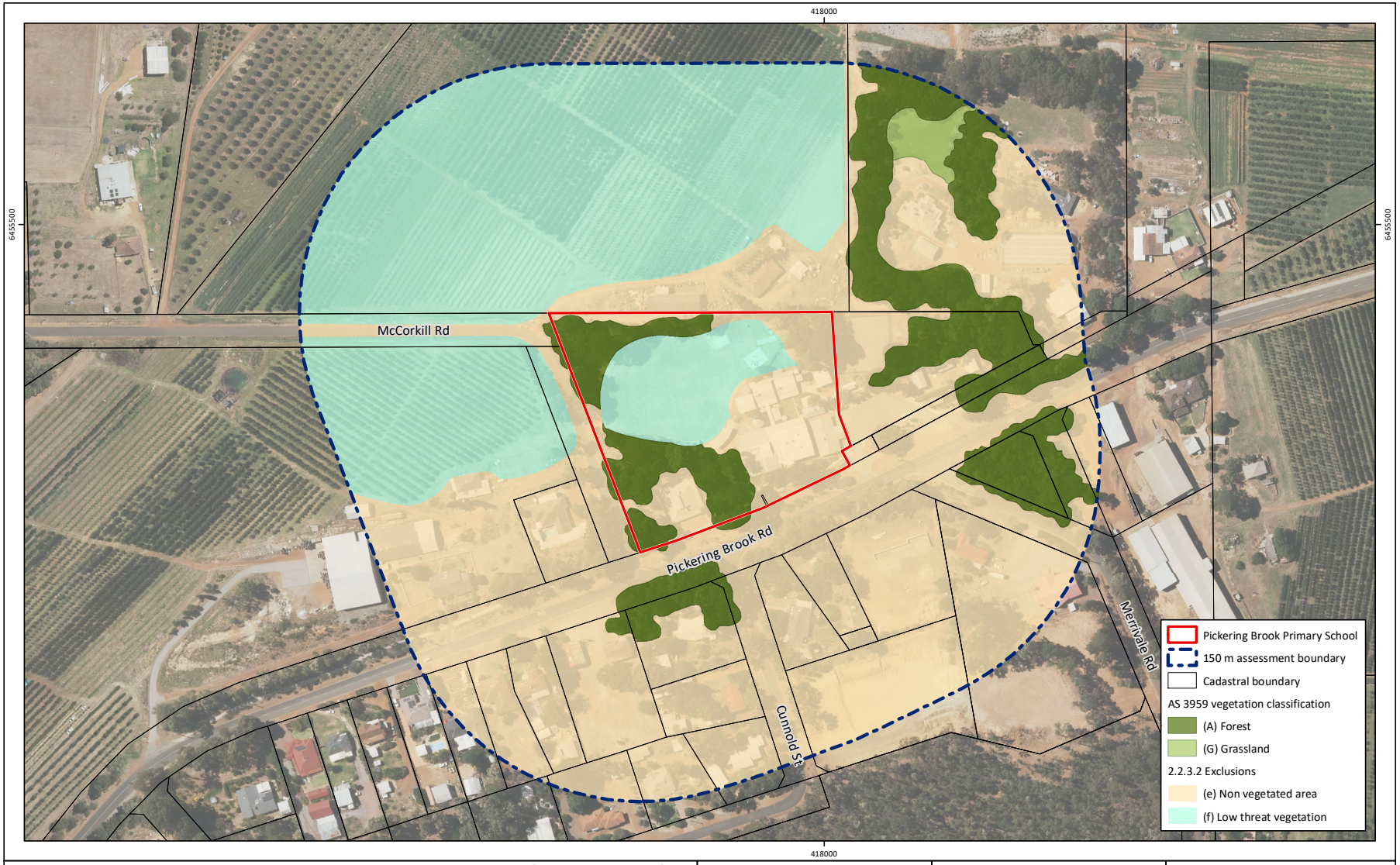


Figure 10: AS 3959 Vegetation Classification - Pickering Brook Primary School (Existing Conditions)

Project:	Bushfire Management Plan Pickering Brook Bushfire Risk Assessment
Client:	Department of Planning, Lands and Heritage

Plan Number: EP19-138(01)--F34

Drawn:	SCM
Date:	27/02/2020
Checked:	AJR
Approved:	AJR
Date:	27/02/2020

Scale: 1:3,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

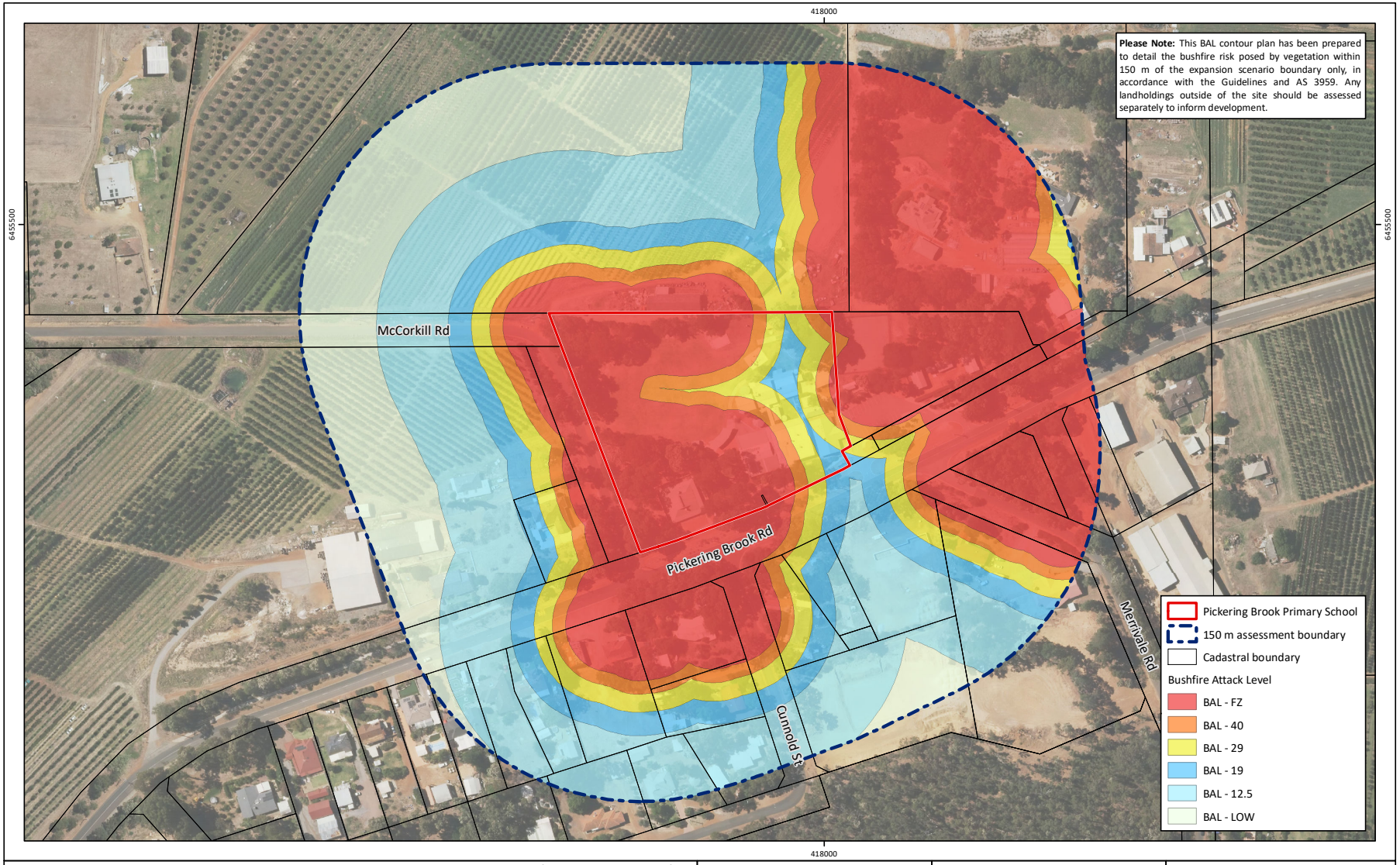


Figure 11: **Bushfire Attack Level Contour Plan - Pickering Brook Primary School (Existing Conditions) (FDI 100)**

Project: Bushfire Management Plan
Pickering Brook Bushfire Risk Assessment
Client: Department of Planning, Lands and Heritage

Plan Number:
EP19-138(01)--F35
Drawn: SCM
Date: 27/02/2020
Checked: AJR
Approved: AJR
Date: 27/02/2020

N

0 50 100
Metres
Scale: 1:3,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

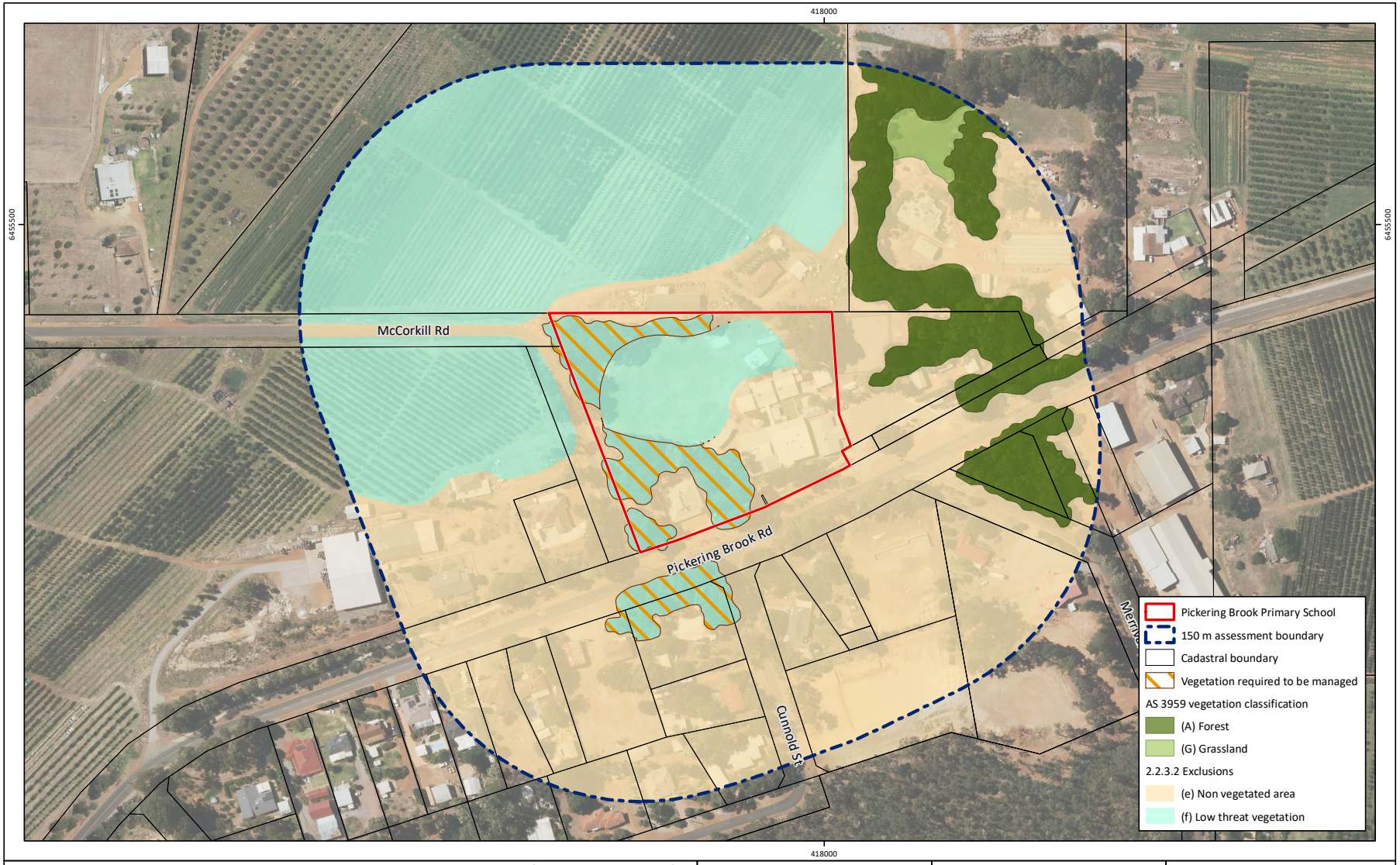


Figure 12: AS 3959 Vegetation Classification - Pickering Brook Primary School (Managed Conditions)

Project: Bushfire Management Plan
Pickering Brook Bushfire Risk Assessment
Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(01)--F36
Drawn: SCM
Date: 27/02/2020
Checked: AJR
Approved: AJR
Date: 27/02/2020

Scale: 1:3,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

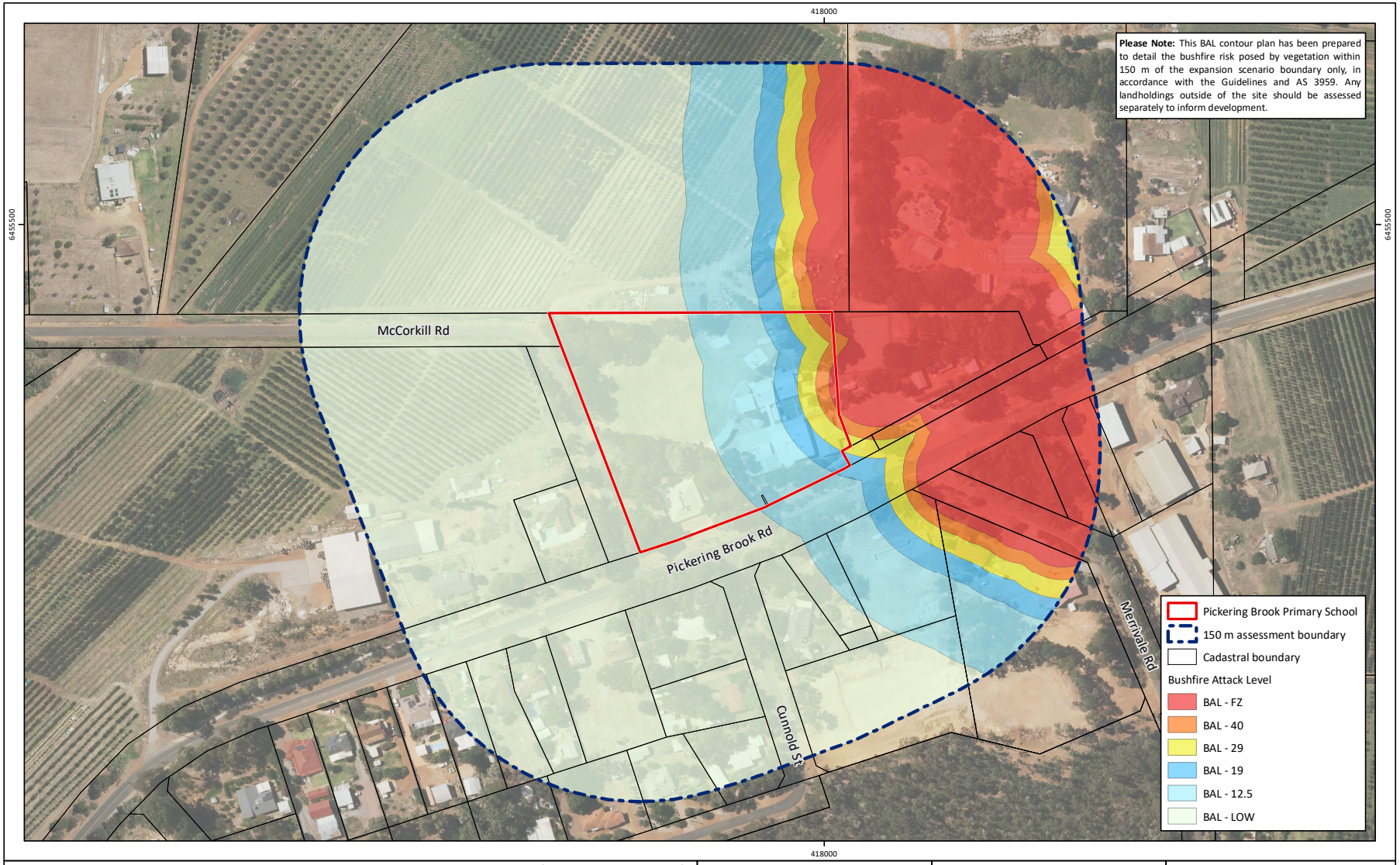


Figure 13: **Bushfire Attack Level Contour Plan - Pickering Brook Primary School (Managed Conditions) (FDI 100)**

Project: Bushfire Management Plan
Pickering Brook Bushfire Risk Assessment
Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(01)--F37
Drawn: SCM
Date: 27/02/2020
Checked: AJR
Approved: AJR
Date: 27/02/2020

N

0 50 100
Metres
Scale: 1:3,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

2.10 Bushfire Hazard Assessment

This assessment has identified the landscape context, within 5 km of the townsite, is characterised as rolling hills with slopes ranging from 5°-10°, with forest fuels that are largely contiguous and uniform. The surrounding vegetation is predominantly Marri and Jarrah and classified as Forest under AS3959:2018. This vegetation is associated with heavy fuels 35 t/ha, including bark, and can generate a high-intensity fire exceeding 43 400 kw, capable of ejecting heavy embers high and with a spread of up to 5 km.

The landscape has the potential for extreme bushfire behaviour. A fire in this landscape may have the potential to grow and develop over many hours developing a long wide fire run. Fire likely has high convective energy, strong winds, superheated air being driven ahead of the fire and channelled from the east by the topography, also bringing smoke, and advanced ember attack.

Due to the surrounding topography, the arrival of the fire front, as found in 2005, may not be uniform. The townsite is also in a long valley that runs from the east, and the prevailing wind condition in the afternoon through summer is east or west.

Outside the valley floor, the observable forest is National Park, excluding scenario 1 (Lot 81), this forest can be assumed to be permanent. It is noted that that Parks and Wildlife Services have been actively engaged (last in 2019) in fuel reduction in the area, including immediate to the town, and this was found in the study of the 2005 fire to have been critical to preventing the fire from penetrating the townsite.

An analysis of the fire history suggests that the townsite expansion investigation area may be affected by a significant landscape fire (within proximity of ember attack or direct fire line exposure) once in every 3.5 years. The prevailing wind is rarely from the north and fires approaching from the north are extremely rare. The propensity for fires to affect the townsite occurs in an arc extending from the southwest, through to northeast.

Access to the townsite is predominantly from the west from the townsite of Kalamunda, by Canning Road onto Pickering Brook Road (the intersection is 600 m west of the PIA). Pickering Brook Road runs through the town but is blocked at 3.8 km east of the townsite. The blockage was in part to protect the townsite from deliberately ignited fires from the east by restricting public access, but conversely, it delays access to attend fires to the east and retreat and service Pickering Brook.

The townsite consists largely of housing and a few service industries, the construction of which predate contemporary bushfire construction standards and therefore rely upon fire service suppression. A number of houses directly face and are accessed along roads adjoined by Forest vegetation. These houses and their residents are vulnerable and would be a priority for evacuation. The townsite is reliant upon suppression services travelling from Kalamunda by Canning Road. The protection of the existing housing stock and addressing secondary fires will compete for suppression resources.

Emergency egress is available to the west by Canning Road to the Kalamunda townsite, north-west by Patterson Road, Walnut Road, and south via Canning Road to Brookton Highway. All roads have good surfaces and are legible but are also tree-lined, lack emergency directional signage, and do not

provide safer places along their routes. A journey started must be completed without exposure to the bushfire, either smoke, ember attack or fire.

The Pickering Brook Primary School offers the prospect of a safer place (for less than 24 hours) within the townsite if early evacuation is not taken. It is assumed that each dwelling within the townsite (townsite plus 80 rural and lifestyle properties that Pickering Brook in a centroid for) will have a vehicle, parking capacity should include a space for each house, in addition to cars already parked as part of the business of the school, and provide an allowance for visitors to the townsite i.e. Core Cider. 90° parking along the Pickering Brook Road verge, is a low threat area providing safe pedestrian access from car to school.

Canning Road is the primary service road to Pickering Brook and is also the corridor for the town power supply. It is the most direct route for suppression services and medical resources to arrive. The route is vulnerable and infrastructure is vulnerable to falling trees.

A reticulated water supply is available to the townsite but not a reticulated effluence scheme. Present water supply tankage is located west of Weston Road 319 m AHD, within a clearing in the forest, and the operating plant may be vulnerable to damage during a bushfire.

An interview of resident intentions in the event of a fire has not been undertaken. It is however understood from the course of this assessment that most residents would intend to stay and defend their property largely because a bushfire has not penetrated the townsite to date, despite fires occurring nearby.

The lessons from the Black Saturday Fires 2009, and likely from the 2019/2020, is that many people had experienced bushfires, previously safely defended and were confident in their preparations. Many areas also had no history of a fire causing damage within the town. However, when faced with the ferocity of the Black Saturday Fire, many became overwhelmed, panicked and changed their intentions.

Further understanding of the preparedness of the community in this regard is required. History and the interviews of survivors, after a close call, highlights a lack of a certain plan, and changing intentions in the face of the fire, is a major contributor to fatalities.

Townsite evacuations are difficult as they require resources and are an inconvenience. They should not be undertaken lightly and unless conditions are such that life is reasonably threatened, they can be counter-productive and foster complacency. It is understood that a pre-incident plan for Pickering Brook, including evacuation has not been prepared (or at least known). A clear and communicated plan is required for Pickering Brook that articulates when and how to evacuate.

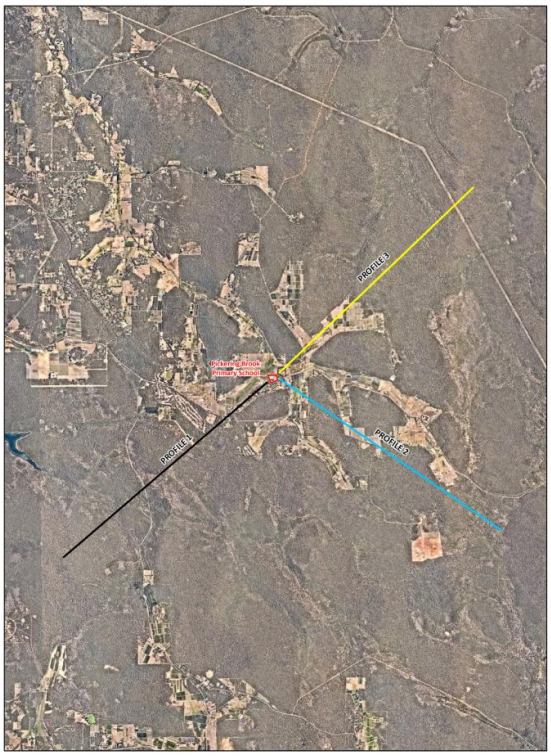
The Available Safe Egress Time (ASET) is the amount of time that elapses between fire ignition and arrival. The Required Safe Egress Time (RSET) is the amount of time (also measured from fire ignition) that required for occupants to evacuate a space and reach a safe destination. The RSET will include the time between ignition and alarm, the time to decide to leave, the time to prepare to leave, i.e. close doors and windows and collect essential items, and the travel time to reach a safe destination.

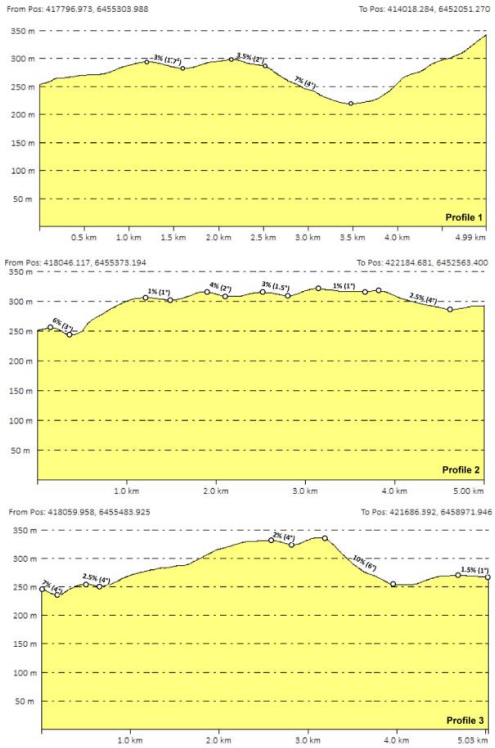
The ASET is calculated in **Table 6** below.

Table 6: ASET calculation

Vegetation	Slope	RoS (km/h) FFDI 80	RoS (km/h) FFDI 100	Profile 1 Percentage	Profile 2 Percentage	Profile 3 Percentage
Forest	0	2.4	3	70 (1:27) (1:10)	62 (1:17) (1:01)	67 (1:23) (1:07)
Forest	0-5	3.38	4.23	16 (:14) (:11)	38 (:34) (:27)	33 (:29) (:23)
Forest	5-10	4.78	5.98	14 (:8) (:7)		
Forest	10-15	6.75	8.44			
ASET 5 Km				1:49 1:28	1:51 1:28	1:52 1:30

Asset Slope profile radiating from the Primary School out to 5 km.





ASET, from consideration of Method 2 AS3959, and Rate of Spread (RoS) calculated on the slope under vegetation from prevailing wind directions radiated from the Pickering Brook Primary School, and the Rate of Spread out to 5km was calculated. At FFDI 100 the ASET is consistent whether the fire should arrive from the south-west, south-east or north-east (consistent with the fire history). In each direction, the ASET is 1:28 -1:30, the average rate of spread being 3.3kmh.

The ASET has been based upon the McArthur Mk 4 model reaffirmed with AS3959:2018, operational 1 May 2019. It is acknowledged this may underestimate the rate of spread in Extreme conditions (FFDI 75+) and that a firefront can also advance faster due to advanced spotting which increases with the scale of the fire and the extremity of the conditions.

The State Emergency Management Framework and the *Evacuation Community Evacuation in Emergencies Guideline* emphasise that the decision to evacuate is not taken lightly but is subject to a judgement of magnitude of the bushfire. Whilst the BMP has utilised an authorised model, to demonstrate capability, the Emergency Management Framework requires a judgement needs to be made upon the magnitude of the fire and the conditions in determining whether evacuation is required and whether it is safe to evacuate.

The calculated RSET (**Table 7**) includes 15 minutes for the ignition to be detected, 20 minutes to receive a notification, 30 minutes to prepare to leave (65 minutes) plus travel time to complete the journey, plus congestion 60 minutes for 360 vehicles allowing for evacuating traffic (average journey speed = 40km/h).

Table 7: Egress times to nearest urban areas via egress routes

Road	Journey distance	Journey time (average 40 km/h)	ASET	RSET – Alarm, pre-movement time, travel time	Too late to leave fires distance from Pickering Brook townsite
Canning Road (west)	8 km to the Kalamunda urban area	12 minutes	Rate of Spread 3.3 km/h	137 minutes	4 km
Patterson Road (north)	10 km to the Kalamunda urban area	13 minutes	Rate of Spread 3.3 km/h	138 minutes	4 km
Canning Road (south)	9 km to Brookton highway 21 km to Perth urban area	14 minutes	Rate of Spread 3.3 km/h	139 minutes	4 km

The sequence, for minimising community exposure in Pickering Brook is:

- Timely, and certain warning to evacuate townsite if the fire is of a magnitude likely to affect the townsite and is not yet within 5km. This is to enable the last vehicle to have left before the fire's arrival.
- Too late to leave the townsite, i.e. the RSET no longer achievable, the magnitude and speed of the fire is advancing too quick to complete safe evacuation. Emergency Services guidance required for the continuation of priority evacuation. Communication of road closure and movement/evacuation to the Pickering Brook Primary school.

Note time to settle at the school i.e. parking on the oval, minimum 45 minutes. If the fire is likely to affect the townsite and is not yet within 2.5 km.

- Survival plan, stay in place. If the fire is within 2.5 km, rapidly advancing, and the Bushfire Attack has commenced within the town (penetration), i.e. convective heat, thick smoke, falling embers. *Occupants of existing housing on Cunnold Street and along Isaacs Road, may have no option than to stay in the building, monitor the advance of the fire and leave the building after the fire's passing when survivable conditions have established outside.*

3 Locality – Bushfire Attack Level Assessment

3.1 Scenario Bushfire Attack Level Mapping

A Bushfire Attack Level Contour Map is used to spatially demonstrate the location of the flame contact and radiant heat ratings across a site. A Bushfire Attack Level Contour Map has been prepared for each townsite expansion scenario (the PIA and Lot 81).

A Bushfire Attack Level Contour Map informs the required construction standard and is used for the purpose of planning the siting of a habitable building, including any building within 6 m of the habitable building, at a BAL level of less than BAL-29. However, AS 3959:2018 does not address the potential impacts of wind or smoke or damage beyond 100 m. Buildings can be directly damaged by gale force winds or by collision from objects. Apart from the physical damage, this can also expose flammable materials to ignition from burning embers and flame penetration.

3.1.1 Assessment inputs

A BAL assessment has been undertaken, following the simplified procedure (Method 1, cl.,2.2.1) to determine the BAL ratings applicable to the future development of habitable buildings at the PIA, including the individual expansion scenarios.

Based upon a 1:200 (APE) GEV assessment, last 20 years to accommodate climate change effects, an FFDI of 100 has been used instead of the nominal FFDI 80.

The BAL outputs in this assessment are for determining the appropriateness of the scenarios and potential yield effects in applying routine bushfire protection measures. A separate BAL assessment has been prepared (section 2.1.6.4 of this assessment) for the Pickering Brook Primary School, and for the consideration of the Playing Field, to be nominated as a place of refuge. It used a Flame temperature of 1200K, instead of the nominal 1090K.

This has been based on:

- the Fire Danger Index of **100**,
- A flame temperature of **1090K**
- the vegetation classifications identified in **Figure 14**.
- the effective slope under the vegetation **Figure 15**.

Photographic verification of each scenario area and adjacent vegetation has been provided in **7**.

It has been assumed that vegetation adjoining the townsite expansion investigation area remains unchanged and that vegetation which is predominantly Forest upslope is at the maximum fuel weights as described in AS 3959:2018.

Not all vegetation is a classified bushfire risk. Vegetation and ground surfaces exempt from classification, a low threat under Section 2.2.3.2 of AS 3959, has included

1. Single areas of vegetation less than 1 ha in area and not within 100 m of other areas of vegetation being classified.
2. Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site, or each other or of other areas of vegetation being classified.
3. Strips of vegetation less than 20 m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 m of the site or each other, or other areas of vegetation being classified.
4. Non-vegetated areas, that is, areas permanently cleared of vegetation, including waterways, exposed beaches, roads, footpaths, buildings and rocky outcrops.
5. Vegetation regarded as a low threat due to factors such as flammability, moisture content or fuel load. This includes grassland managed in a minimal fuel condition, mangroves and other saline wetlands, maintained lawns, golf courses (such as playing areas and fairways), maintained public reserves and parklands, sporting fields, vineyards, **orchards**, banana plantations, **market gardens** (and other non-curing crops), cultivated gardens, commercial nurseries, nature strips and windbreaks.

The BAL Contour Plan has excluded 'orchards' and 'market garden' in accordance with AS 3959. The earlier Bushfire Hazard Level had included 'orchards' and 'market garden' as Grassland in accordance with the CSIRO methodology for mapping fireline intensity.

Grassland within the PIA has been excluded because it would obscure the effect of adjacent vegetation and potentially restricted vegetation within the PIA.

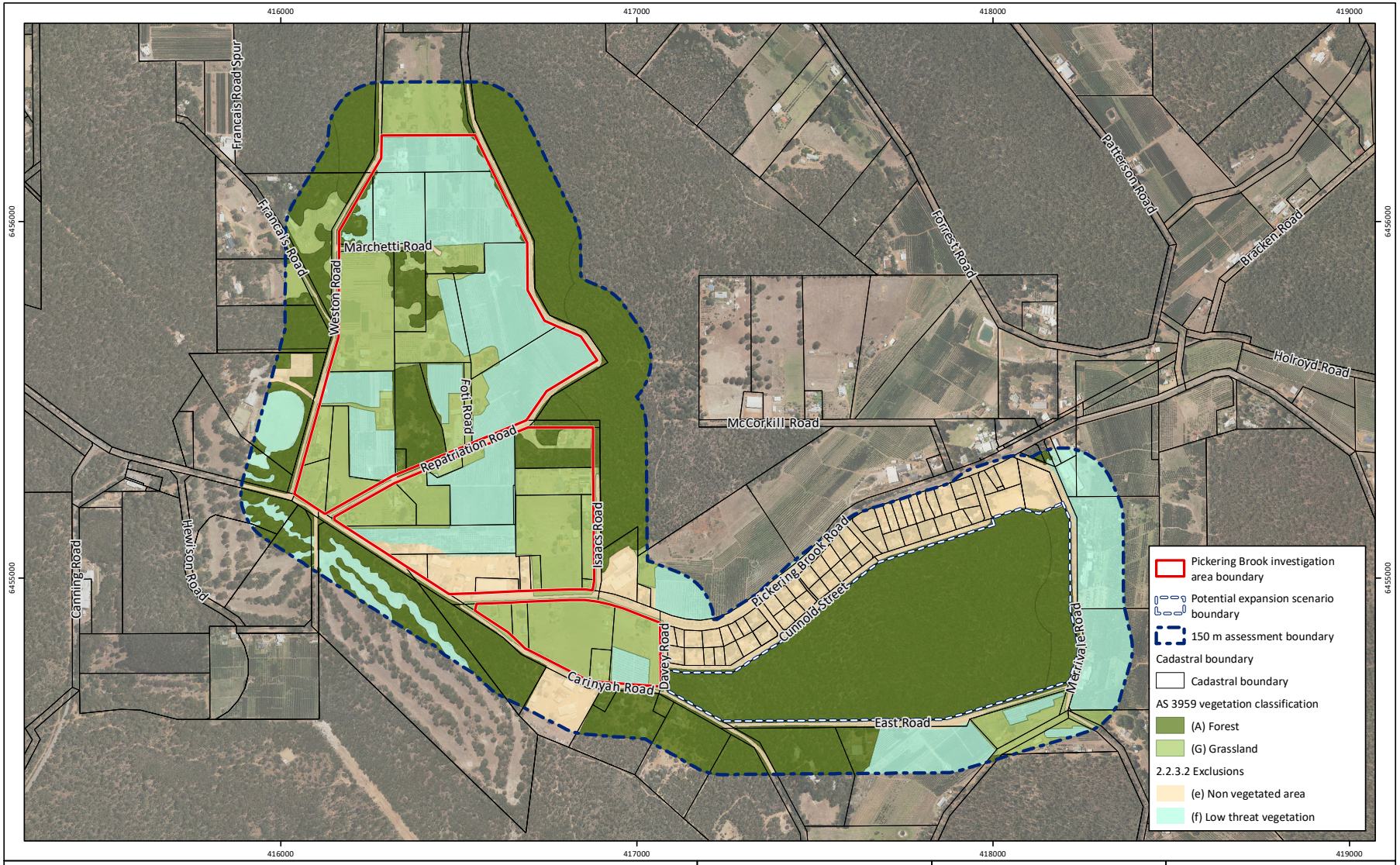


Figure 14: Existing Site Conditions - AS 3959 Vegetation Classification

Project:	Bushfire Management Plan Pickering Brook Bushfire Risk Assessment
Client:	Department of Planning, Lands and Heritage

Plan Number:
EP19-138(01)--F23

Drawn:	SCM
Date:	30/01/2020
Checked:	AJR
Approved:	AJR
Date:	27/02/2020

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

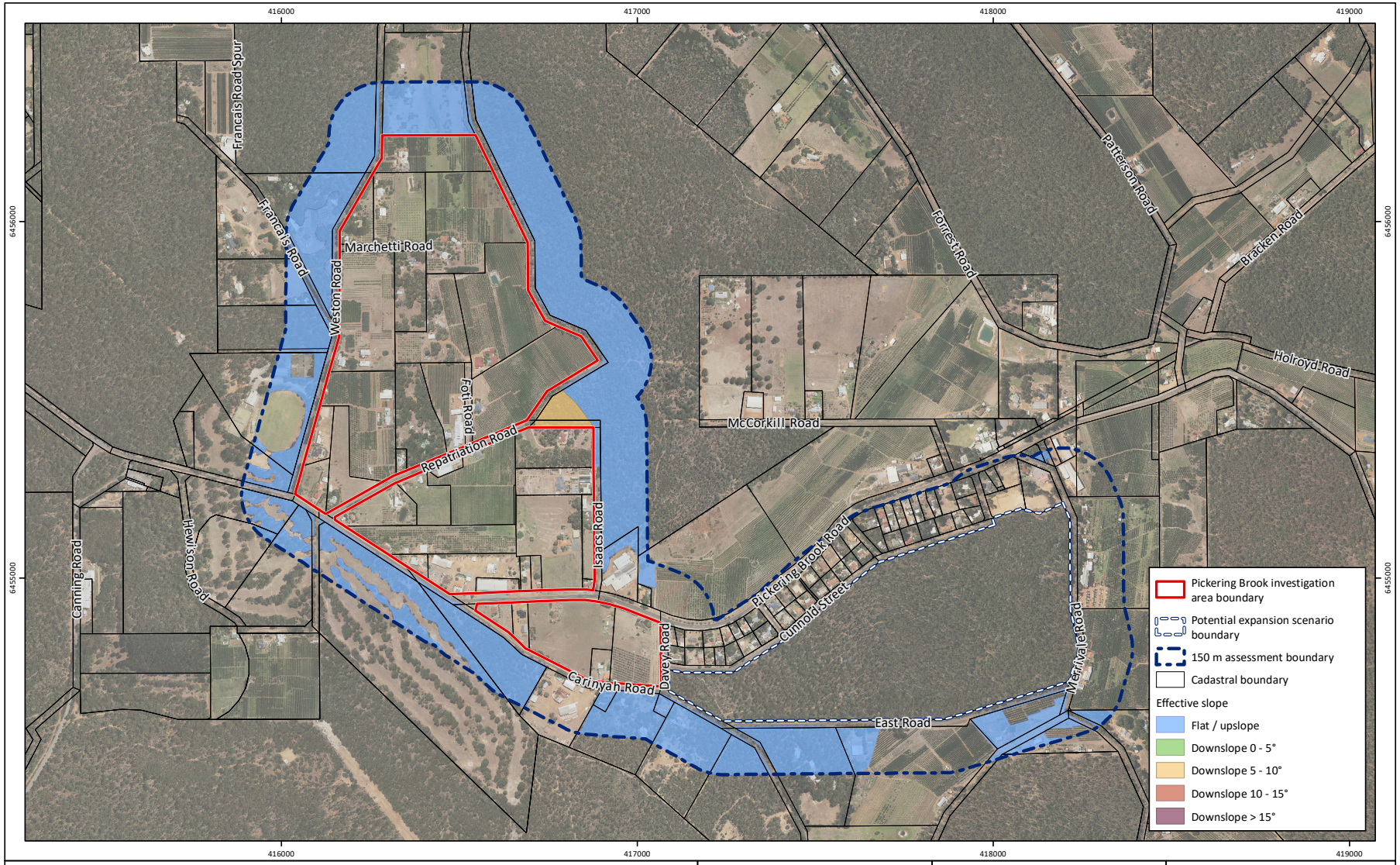


Figure 15: Existing Site Conditions - Effective Slope

Project: Bushfire Management Plan
Pickering Brook Bushfire Risk Assessment
Client: Department of Planning, Lands and Heritage

Plan Number:
EP19-138(01)--F24
Drawn: SCM
Date: 30/01/2020
Checked: AJR
Approved: AJR
Date: 27/02/2020

N

0 150 300 450
Metres
Scale: 1:14,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

Table 8: Vegetation classification, effective slope and future management

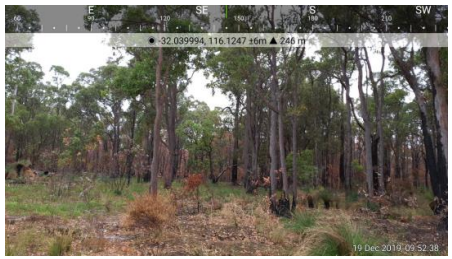
Pre-development			Post-development	
Scenario no	**AS 3959 classification and bushfire hazard rating**	**Site photo/s**	**Scenario no**	**AS 3959 classification, effective slope and assumptions**
1	**AS 3959 classification:** Forest (Class A) **Bushfire hazard rating:** Extreme **AS 3959 classification:** Grassland (Class G), including orchards **Bushfire hazard rating:** Moderate	 *Photo location 1: south of Cunnold Street – Forest*  *Photo location 2: south of Cunnold Street - Forest*  *Photo location 4: south of East Road - Forest*  *Photo location 3: south-east, East Road – Grassland and Orchards*	1	**AS 3959 classification:** Forest (Class A)

Table 8: Vegetation classification, effective slope and future management (continued)

Pre-development			Post-development	
Scenario no	**AS 3959 classification and bushfire hazard rating**	**Site photo/s**	**Scenario no**	**AS 3959 classification, effective slope and assumptions**
2	**AS 3959 classification:** Grassland (Class G), **Bushfire hazard rating:** Low **AS 3959 classification: Forest** (Class A) **Bushfire hazard rating:** Extreme	 *Photo location: south of Pickering Brook Road, Scenario 2 area - Grassland*  *Photo location: south Pickering Brook Road, Scenario 2 area - Grassland*  *Photo location: north of Carinyah Road, Scenario 2 area - Grassland*  *Photo location: within the Golf Course south of Carinyah Road, adjacent vegetation - Forest*	2	**AS 3959 classification** Excluded 2.2.3.2(e)

Table 8: Vegetation classification, effective slope and future management (continued)

Pre-development			Post-development	
Scenario no.	**AS 3959 classification and bushfire hazard rating**	**Site photo/s**	**Scenario no.**	**AS 3959 classification, effective slope and assumptions**
3	**AS 3959 classification:** Excluded 2.2.3.2(e) **Bushfire hazard rating:** Low **AS 3959 classification:** Grassland (Class G), **Bushfire hazard rating:** Low	 *Photo location: north of Pickering Brook Road, Scenario 3 area – Grassland*  *Photo Location: north of Pickering Brook Road, Scenario 3 area – Grassland*  *Photo location: east of Repatriation Road, Scenario 3 area – Orchard and Grassland*  *Photo location: north of Pickering Brook Road,* Scenario 3 *area – Orchard*		**AS 3959 classification:** Excluded 2.2.3.2(e)

Table 8: Vegetation classification, effective slope and future management (continued)

Pre-development			Post-development	
Scenario no.	AS 3959 classification and bushfire hazard rating	Site photo/s	Scenario no.	AS 3959 classification, effective slope and assumptions
4	**AS 3959 classification:** Grassland (Class G), including orchards **Bushfire hazard rating:** Low	 *Photo location: south of Redemption Road, Scenario 4 area - Orchards and Grassland*  *Photo location: south of Redemption Road, Scenario 4 area - Orchards and Grassland*	4	**AS 3959 classification:** Excluded 2.2.3.2(e)

Table 8: Vegetation classification, effective slope and future management (continued)

Pre-development			Post-development	
Scenario no.	AS 3959 classification and bushfire hazard rating	Site photo/s	Scenario no.	AS 3959 classification, effective slope and assumptions
5	**AS 3959 classification: Forest** (Class A) **Bushfire hazard rating:** Extreme **AS 3959 classification:** Excluded 2.2.3.2(e) **Bushfire hazard rating:** Low **AS 3959 classification: Forest** (Class A) **Bushfire hazard rating:** Extreme	 *Photo location: east of Isaacs Road, adjacent vegetation - Forest*  *Photo Location: west of Isaacs Road, option area - Grassland and Orchards beyond houses (Excluded 2.2.3.2(e))*  *Photo location: east of Isaacs Road, adjacent vegetation - Forest*  Photo location: north extent scenario 5 - Forest	5	**AS 3959 classification:** Excluded 2.2.3.2(e) **AS 3959 classification: Forest** (Class A)

Table 8: Vegetation classification, effective slope and future management (continued)

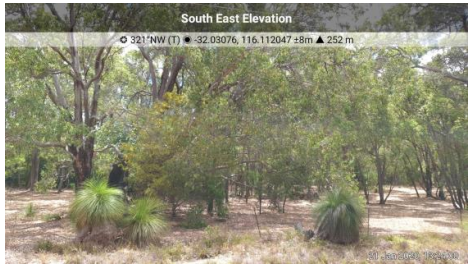
Pre-development			Post-development	
Scenario no.	AS 3959 classification and bushfire hazard rating	Site photo/s	Plot no.	AS 3959 classification, effective slope and assumptions
6	**AS 3959 classification: Forest** (Class A) **Bushfire hazard rating:** Extreme	 *Photo location: south of Repatriation Road, south-eastern extent, adjacent vegetation - Forest*  *Photo location: east of Repartition Road, adjacent vegetation - Forest*  *Photo location: west of Weston Road, adjacent vegetation - Forest*  *Photo location: west of Weston Road, adjacent vegetation - Forest*	6	**AS 3959 classification: Forest** (Class A)

Table 8: Vegetation classification, effective slope and future management (continued)

Pre-development			Post-development	
Scenario no.	AS 3959 classification and bushfire hazard rating	Site photo/s	Plot no.	AS 3959 classification, effective slope and assumptions
6	**AS 3959 classification: Forest** (Class A) **Bushfire hazard rating:** Extreme **AS 3959 classification:** Grassland/Orchard **Bushfire hazard rating:** Moderate	 *Photo location: west of Weston Road Sports oval southern extent – Forest, playing field beyond perimeter roadside vegetation*  *Photo location: north of Repatriation Road, options area, midway vegetation– modified – Forest, surrounded by grassland/orchards.*		**AS 3959 classification:** Excluded 2.2.3.2(e)

3.1.2 Assessment outputs

Table 9 provides a summary of the setback distances, taken from Table 2.4 of AS 3959:2018, to achieve the indicated BAL ratings.

A BAL Contour Plan for each scenario (Figures 18 -23) has been prepared and provides a visual representation of these distances determined from **Table 9**.

Table 9: Setback distances based on vegetation classification and effective slope and Table 2.5 of AS 3959

Post-development plot number	Vegetation classification	Effective slope	Distance to vegetation	BAL rating
Adjacent Scenario	Forest	Flat/upslope	< 19 m	BAL-FZ
			19 - < 25 m	BAL-40
			25 - < 35 m	BAL-29
			35 - < 48 m	BAL-19
			48 - < 100 m	BAL-12.5
			> 100 m	BAL-LOW
Adjacent Scenario	Forest	5°-10° downslope	< 24 m	BAL-FZ
			24 - < 32 m	BAL-40
			32 - < 43 m	BAL-29
			43 - < 57 m	BAL-19
			57 - < 100 m	BAL-12.5
			> 100 m	BAL-LOW
Adjacent Scenario	Grassland	Flat/upslope	< 6 m	BAL-FZ
			6 - < 9 m	BAL-40
			9 - < 13 m	BAL-29
			13 - < 19 m	BAL-19
			19 - < 50 m	BAL-12.5
			> 50 m	BAL-LOW
Adjacent Scenario	Grassland	1°-5° downslope	< 7 m	BAL-FZ
			7 - < 10 m	BAL-40
			10 - < 15 m	BAL-29
			15 - < 22 m	BAL-19
			22 - < 50 m	BAL-12.5
			> 50 m	BAL-LOW

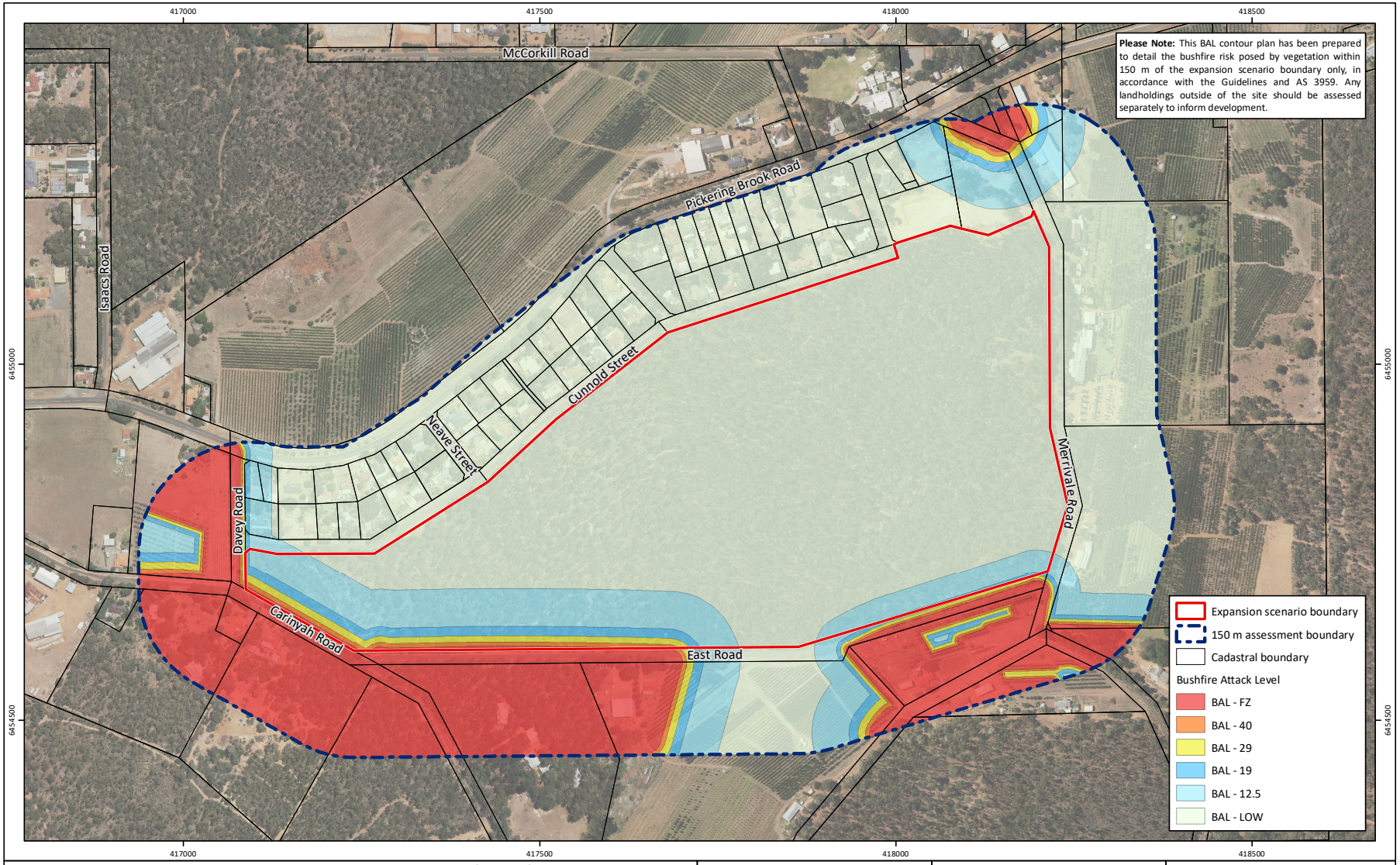


Figure 16: Bushfire Attack Level Contour Plan - Expansion Scenario 1 (FDI 100)

Project:	Bushfire Management Plan Pickering Brook Bushfire Risk Assessment
Client:	Department of Planning, Lands and Heritage

Plan Number:
EP19-138(01)--F25

Drawn:	SCM
Date:	30/01/2020
Checked:	AJR
Approved:	AJR
Date:	27/02/2020

N

0 100 200
Metres
Scale: 1:7,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

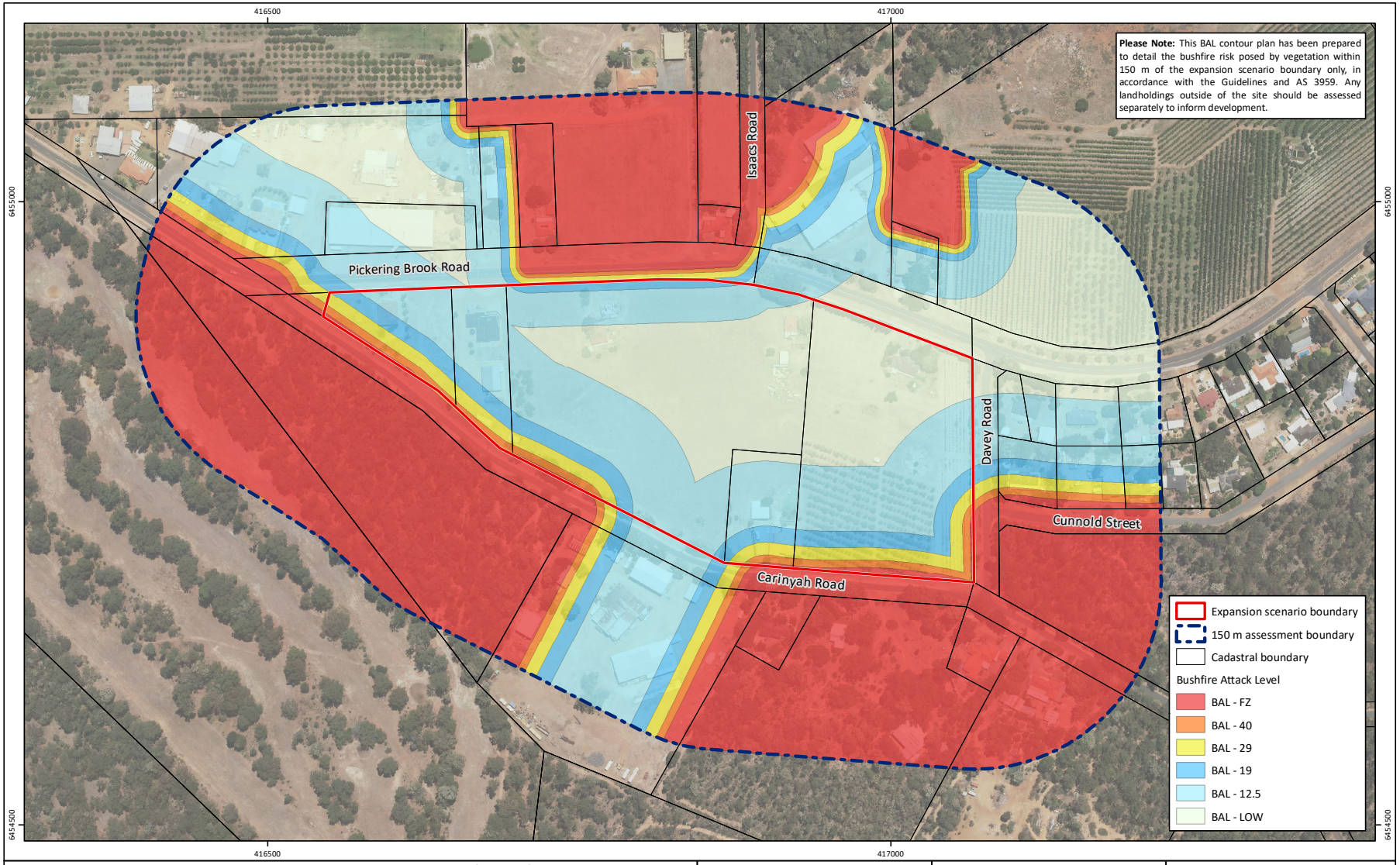


Figure 17: Bushfire Attack Level Contour Plan - Expansion Scenario 2 (FDI 100)

Project:	Bushfire Management Plan Pickering Brook Bushfire Risk Assessment
Client:	Department of Planning, Lands and Heritage

Plan Number:
EP19-138(01)--F26

Drawn:	SCM
Date:	30/01/2020
Checked:	AJR
Approved:	AJR
Date:	27/02/2020

N

0 50 100 150
Metres
Scale: 1:4,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

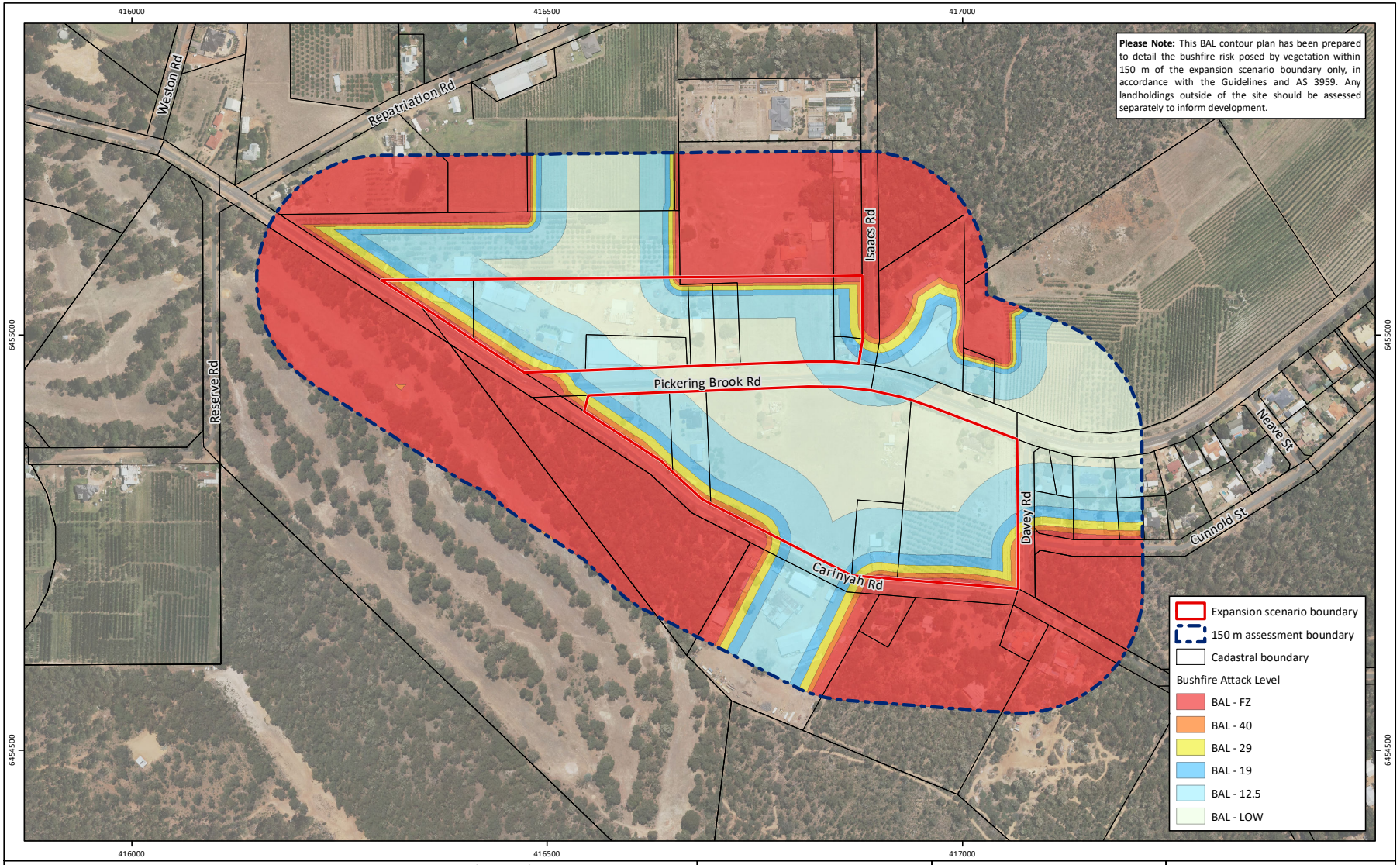


Figure 18: **Bushfire Attack Level Contour Plan - Expansion Scenario 3 (FDI 100)**

Project:	Bushfire Management Plan Pickering Brook Bushfire Risk Assessment
Client:	Department of Planning, Lands and Heritage

Plan Number:
EP19-138(01)--F27

Drawn:	SCM
Date:	30/01/2020
Checked:	AJR
Approved:	AJR
Date:	27/02/2020

N

0 100 200
Metres
Scale: 1:6,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

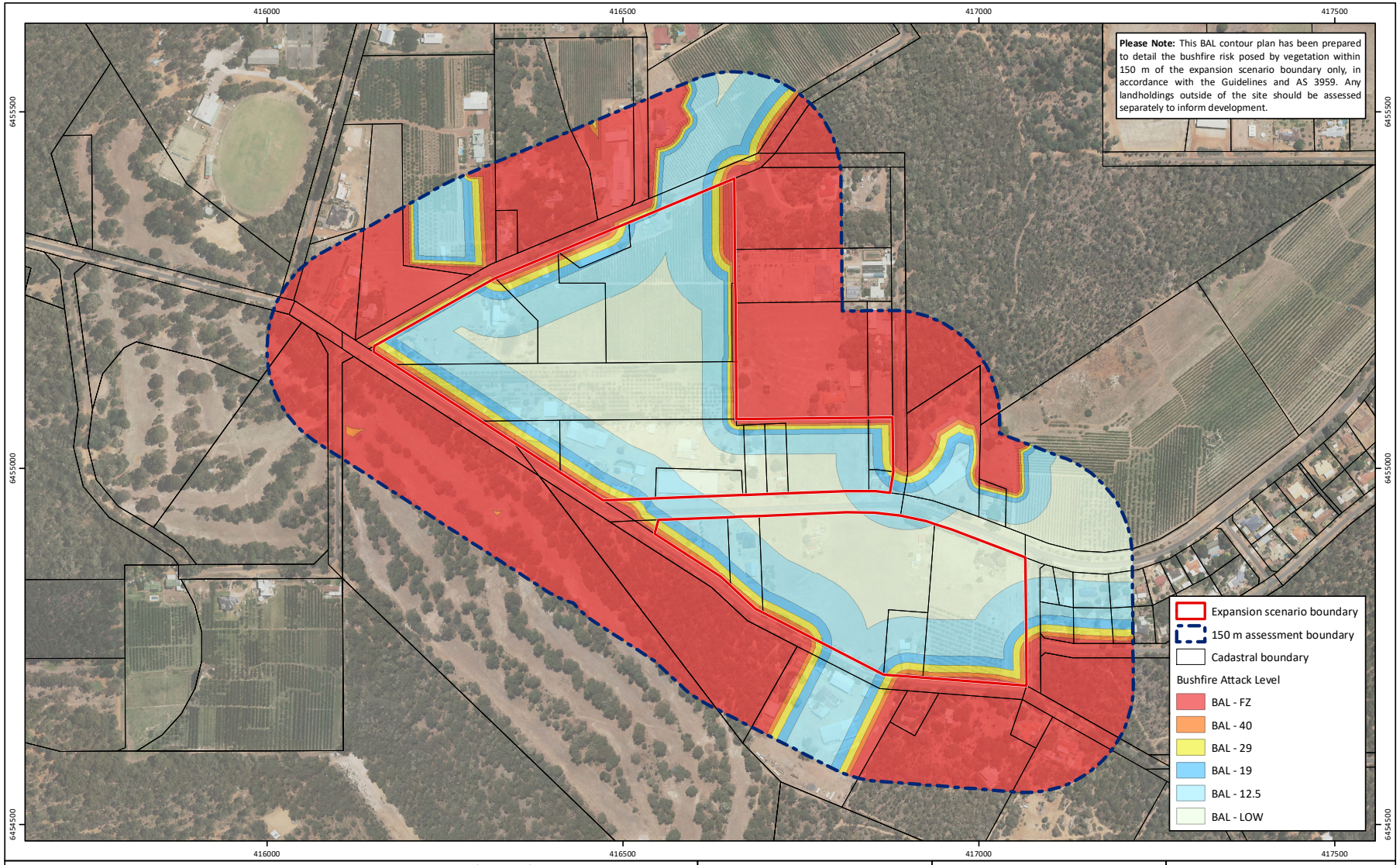


Figure 19: **Bushfire Attack Level Contour Plan - Expansion Scenario 4 (FDI 100)**

Project:	Bushfire Management Plan Pickering Brook Bushfire Risk Assessment
Client:	Department of Planning, Lands and Heritage

Plan Number:
EP19-138(01)--F28

Drawn:	SCM
Date:	30/01/2020
Checked:	AJR
Approved:	AJR
Date:	27/02/2020

N

0 100 200
Metres
Scale: 1:7,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

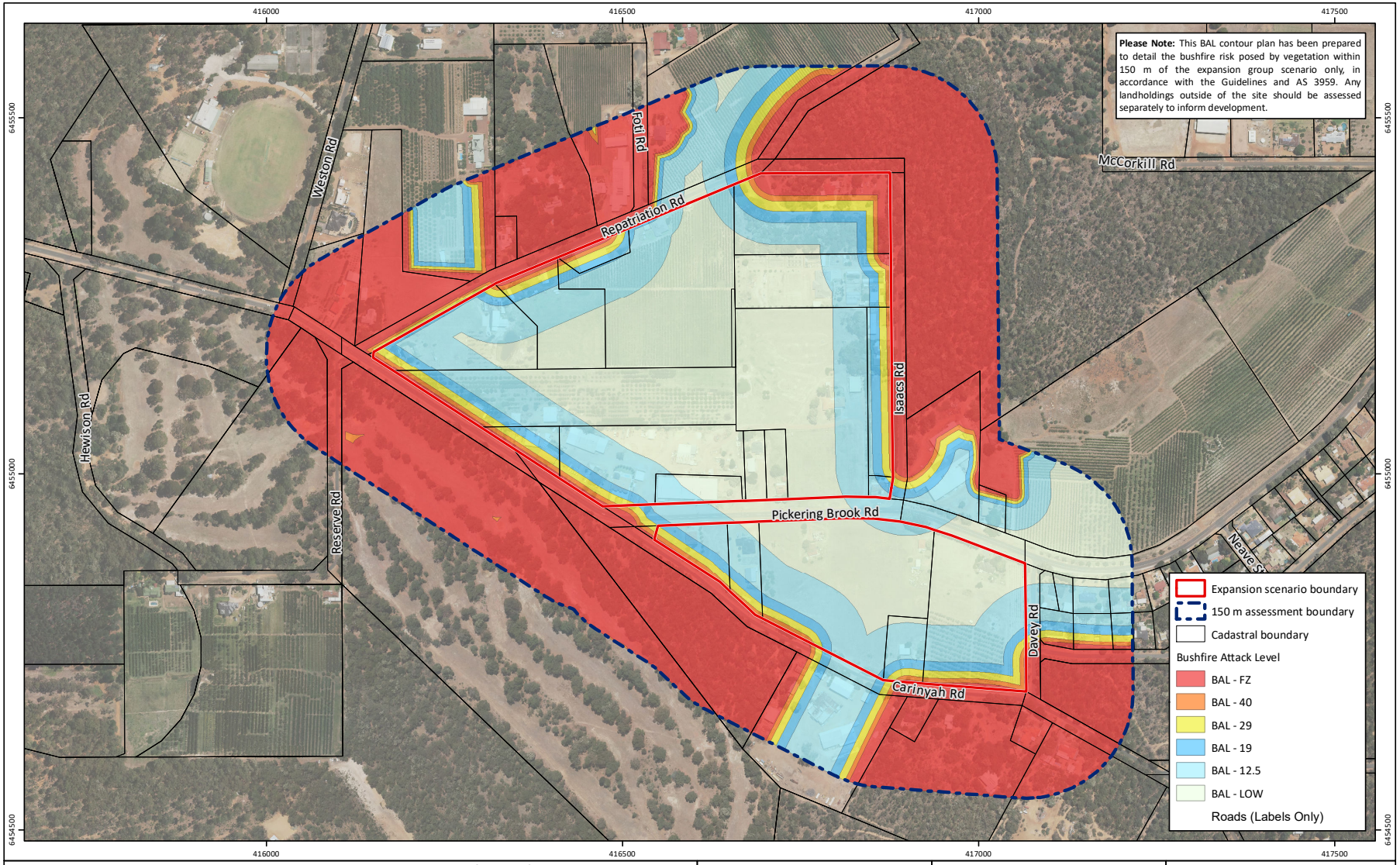


Figure 20: **Bushfire Attack Level Contour Plan - Expansion Scenario 5 (FDI 100)**

Project:	Bushfire Management Plan Pickering Brook Bushfire Risk Assessment
Client:	Department of Planning, Lands and Heritage

Plan Number:
EP19-138(01)--F29

Drawn:	SCM
Date:	30/01/2020
Checked:	AJR
Approved:	AJR
Date:	27/02/2020

N

0 100 200
Metres
Scale: 1:7,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

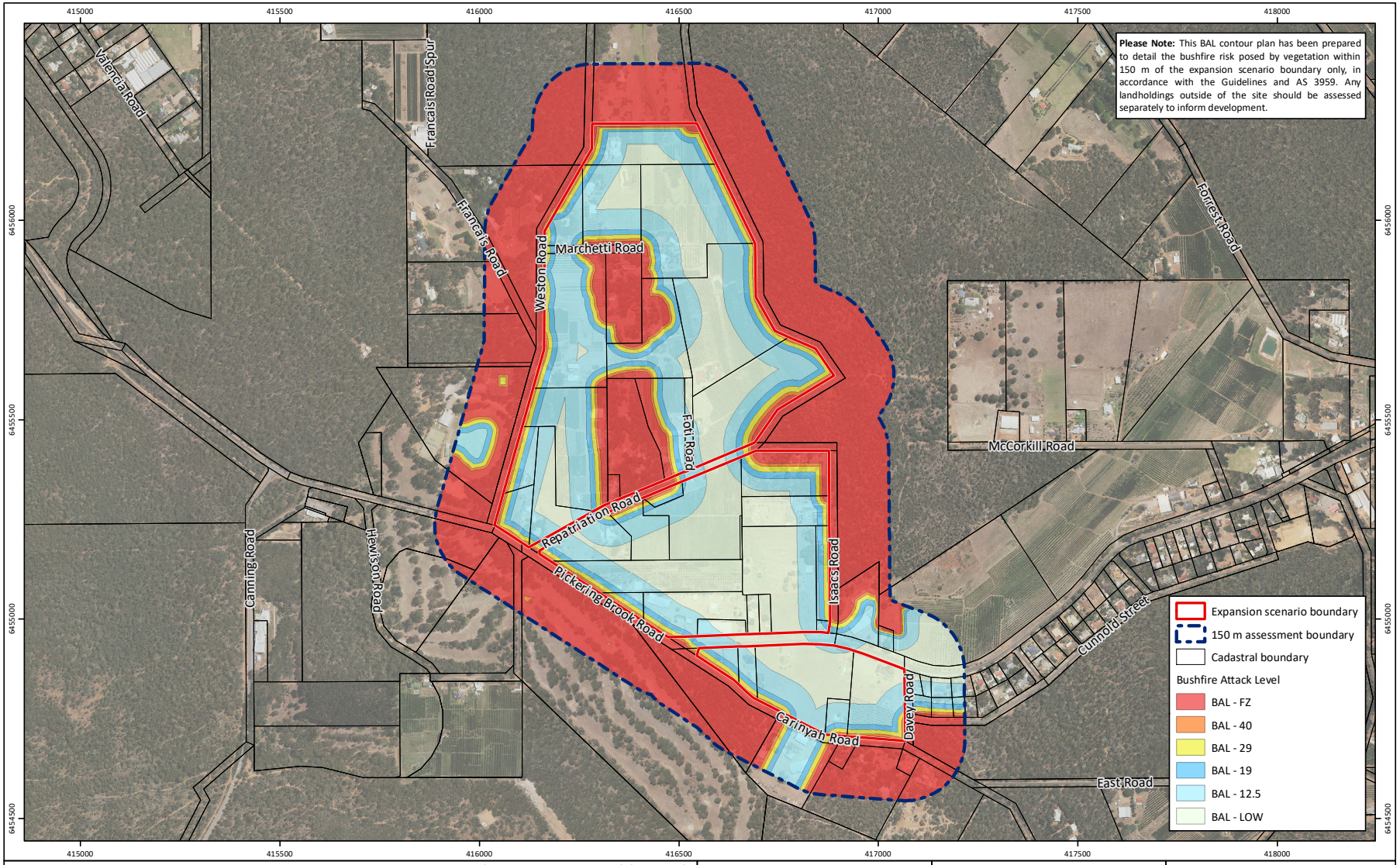


Figure 21: **Bushfire Attack Level Contour Plan - Expansion Scenario 6a (Retained Vegetation) (FDI 100)**

Project:	Bushfire Management Plan Pickering Brook Bushfire Risk Assessment
Client:	Department of Planning, Lands and Heritage

Plan Number:	**EP19-138(01)--F30**
Drawn:	SCM
Date:	30/01/2020
Checked:	AJR
Approved:	AJR
Date:	27/02/2020

N

0 150 300 450

Metres

Scale: 1:12,500@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

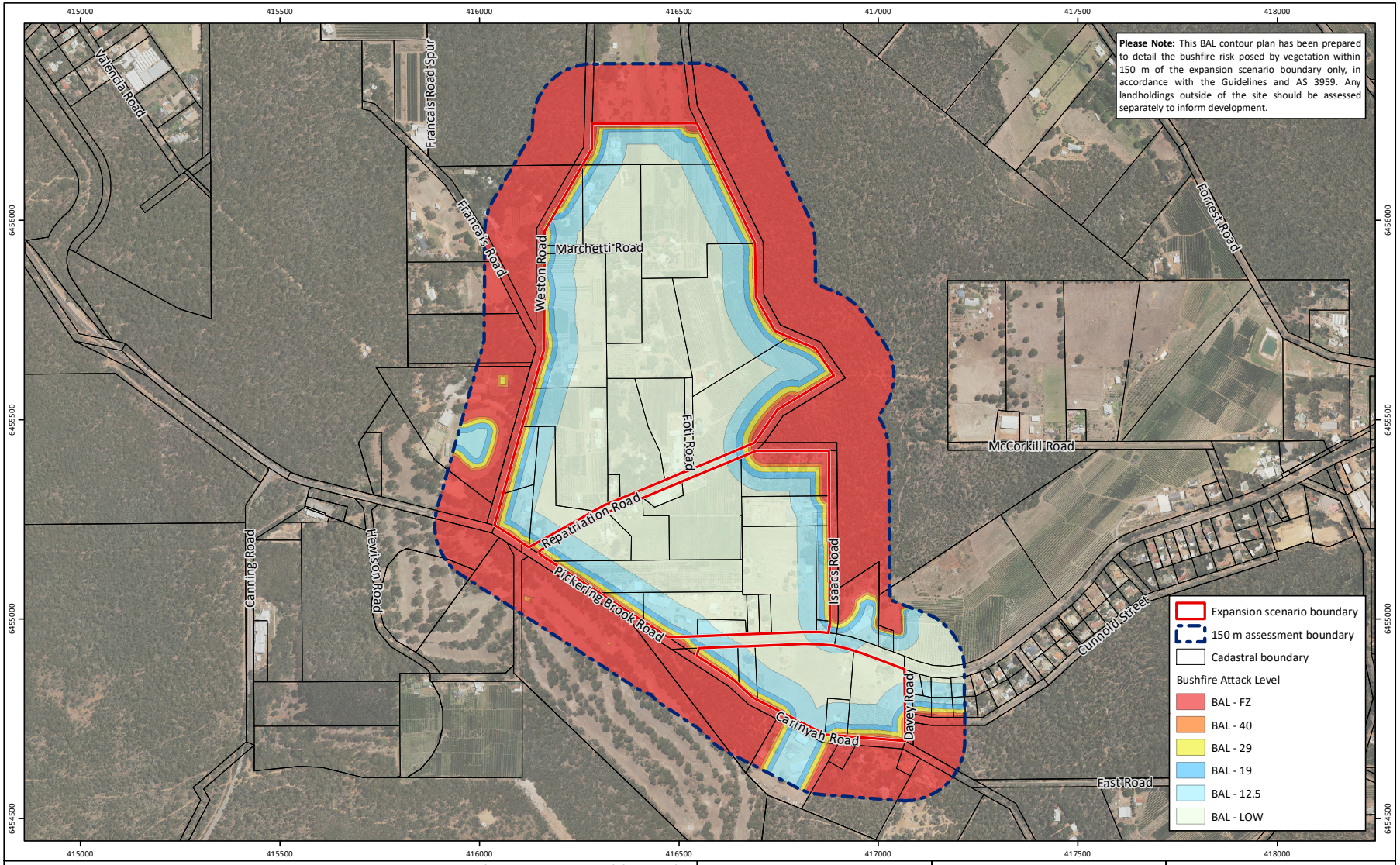


Figure 22: **Bushfire Attack Level Contour Plan - Expansion Scenario 6b (Vegetation Cleared) (FDI 100)**

Project:	Bushfire Management Plan Pickering Brook Bushfire Risk Assessment
Client:	Department of Planning, Lands and Heritage

Plan Number:
EP19-138(01)--F31

Drawn:	SCM
Date:	30/01/2020
Checked:	AJR
Approved:	AJR
Date:	27/02/2020

N

0 150 300 450
Metres
Scale: 1:12,500@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

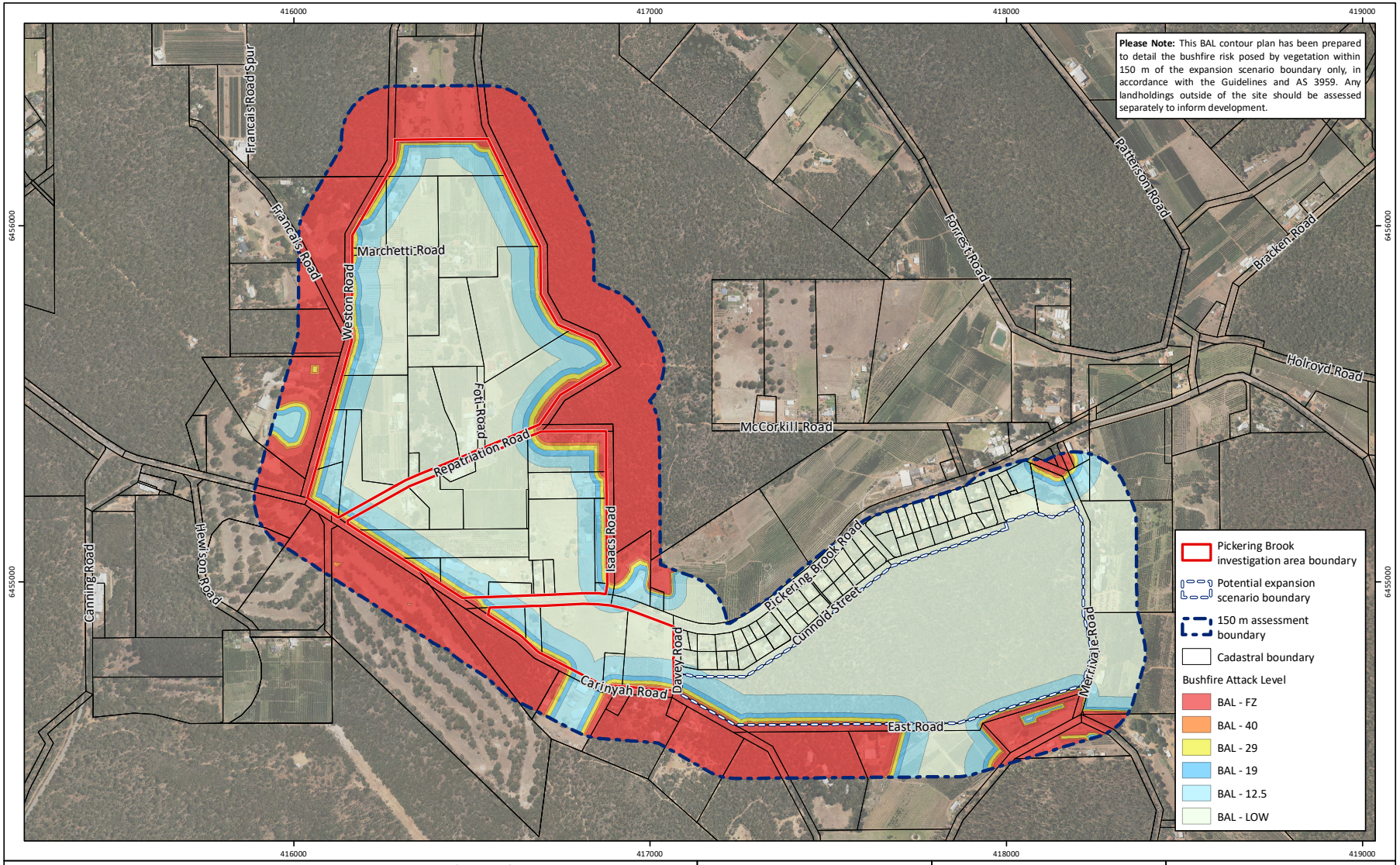


Figure 23: **Bushfire Attack Level Contour Plan - Investigation Area (FDI 100)**

Project: Bushfire Management Plan
Pickering Brook Bushfire Risk Assessment
Client: Department of Planning, Lands and Heritage

Plan Number: EP19-138(01)--F32
Drawn: SCM
Date: 30/01/2020
Checked: AJR
Approved: AJR
Date: 27/02/2020

Scale: 1:14,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

3.2 Analysis of Bushfire Protection Constraints

3.2.1 Environmental consideration

This assessment has considered whether any environmental values may require specific consideration through either protection, retention or revegetation. To support this, a review of publicly available databases and site-specific assessments has been undertaken, with particular reference to the Shared Location Information Platform (SLIP) databases. A summary of the search results has been provided in **Table 10**.

A review of historical aerial imagery indicates that the majority of the townsite expansion area was gradually cleared beginning before 1965 and continuing until 1974, with smaller localised areas of clearing occurring since. There are several areas of remnant vegetation that have not been cleared (Landgate 2019).

Table 10: Summary of potential environmental considerations that may be associated with the site (based on a search of the SLIP databases and site-specific information)

Key environmental feature:	Yes / no / potentially occurring within the site	If yes / potentially, describe the value that may be impacted
Conservation category wetlands and buffer (Geomorphic wetlands Swan Coastal Plain) (DBCA-019)	No	No wetlands have been identified within the site.
Waterways (DWER-031)	No	There are no natural watercourses identified within the site. Piesse Gully is located to the north-east of the site. There are several man-made dams located within the site, associated with existing agricultural land uses.
RAMSAR wetlands (DBCA-010)	No	No wetlands have been identified within the site.
Threatened and priority flora (DBCA-036)	Potentially	The majority of the PIA has been cleared to facilitate the historic agricultural activity that has occurred within the site, and therefore there has been minimal remnant vegetation retention. The areas of remnant vegetation within the site present the highest likelihood of containing any threatened or priority flora, particularly within Scenario 1 landholding.
Threatened and priority fauna (DBCA-037)	Potentially	The majority of the PIA has been cleared to facilitate the historic agricultural activity that has occurred within the site, and therefore there has been minimal remnant vegetation retention. The areas of remnant vegetation within the site present the highest likelihood of containing any threatened or priority fauna. It is noted that the retained vegetation within the site may represent potential foraging habitat for threatened fauna species, including Carnaby's and Forest Red-Tailed Black cockatoos, particularly within Scenario 1 landholding.
Threatened Ecological Communities (TECs) (DBCA-038)	No	There are no threatened ecological communities identified within or adjacent to the site.
Bush Forever areas (DPLH-019)	No	No Bush Forever sites are located within or adjacent to the site.

Table 10: Summary of potential environmental considerations that may be associated with the site (based on a search of the SLIP databases and site-specific information) (continued)

Key environmental feature:	Yes / no / potentially occurring within the site	If yes / potentially, describe the value that may be impacted
Clearing regulations – Environmentally Sensitive Areas (ESAs) (DWER-046)	No	There are no ESAs identified within the site. There are several ESA's located in adjacent landholdings.
DBCA controlled lands or waters (DBCA-011)	No	No DBCA managed lands occur within the site. It is noted that several blocks of remnant vegetation adjacent to the site form part of Korung National Park.
Swan Bioplan Regionally Significant Natural Areas 2010 (DWER-070)	No	No Swan Bioplan Regionally Significant Natural Areas have been identified within the site.
Aboriginal heritage (DAA-001)	No	Not applicable. No registered Aboriginal Heritage sites have been recorded within the site.
Non-indigenous heritage (DPLH-006)	Yes	One registered non-indigenous heritage site was identified within the site, the former Temby's home, located at 30 Foti Road.

Scenarios 2, 3 and 4 do not require the clearing of regulated vegetation and therefore are unimpeded in the implementation of bushfire protection measures within their areas.

The Cottera Environmental Assessment Report 1 June 2016 prepared to accompany an Amendment Report to the West Australian Planning Commission (WAPC) for the rezoning of the townsite expansion area found in reference to a biological survey undertaken November 2014 (Del Botanics, 2014, Appendix A) identified one vegetation type within the remnant vegetated areas consisting of Marri (*Corymbia calophylla)* and Jarrah (*Eucalyptus marginata*) woodland over shrubland of Grass trees (*Xanthorrhoea preissii*) and Zamia (*Macrozamia riedlei*).

The Del Botanics report identified that the only remnant vegetation within the townsite expansion at 30 Repatriation Road and 30 Foti Road as 'Degraded' (scenario 6) and remnant vegetation at 24 Marchetti Road (scenario 5) as in good condition. No flora species of conservation significance were recorded across the area of the townsite expansion area.

Should the areas identified in Del Botanics report be retained, they would be classed as Forest (AS3959:2018) and would require a setback for BAL purposes. The effect has been illustrated in **Figure 21**

3.2.2 Revegetation and landscape plans

No native re-vegetation/rehabilitation is proposed as part of the strategic consideration or assessed herein. The provision of a Public Open Space depending upon the proposed landscaping and the land management may affect the BAL ratings on adjoining land. The potential BAL impact should, therefore, be considered when designing any public open space.

The retention of adjacent horticultural production may require the inclusion of windrows (single row of trees) as a means of controlling (restricting) spray drift and as an alternative to a separation buffer. These may be placed within

40 m of a sensitive receiver. Whilst a windrow is normally not classified vegetation, excluded under 2.2.3.2(f), a density to be effective for the restriction spray drift needs should be considered as a BAL consequence.

The townsite expansion area has been largely cleared although Town Lot 81 retains remnant forest vegetation. Overall, the townsite expansion area is classed as a 'moderate' bushfire hazard level (Guidelines V1.3). However, care should be taken to ensure that future landscaping, particularly given the large lot sizes, does not create an extreme bushfire hazard level. Urban areas rely on overlapping Asset Protection Zones, through each landholder maintaining their land in a low threat condition following Section 2.2.3.2(e) and (f) AS 3959:2018.

This can be achieved by:

- Irrigation of grass and garden beds (where required).
- Regular removal of weeds and built up dead material (such as fallen branches, leaf litter etc.)
- Low pruning of trees (branches below 2 m in height removed where appropriate).
- Regular mowing/slashing of grass to less than 100 mm in height.
- Select non-curing vegetation, with high moisture content and low flammability
- Separation of other vegetation types in accordance with the Asset Protection Zone standards

3.2.3 Scenario evaluation

The BAL Contour Plans illustrate the potential development sites, i.e. those areas outside of BAL-40 and BAL-FZ.

Given the scenarios are an expansion within one area of the townsite, except for Town Lot 81, it is difficult to determine an advantage from one to another, as compared to a comparison of different locations. This is also because the large lot sizes enable the positioning of the building to meet an acceptable BAL of BAL-29. Generally, the larger and the more regular the shape of the lot is, the proportionately less of the area is affected by bushfire. This is because usually, it is only the first 100 m where the development is affected.

The previous assessments of the townsite expansion area excluded Lot 1. The review of present ecological datasets identifies the vegetation on Lot 81, Scenario 1, may provide foraging habitat for threatened fauna species, including Carnaby's and Forest Red-tailed Black cockatoos. The Vegetation within scenario 6 is generally degraded but some trees could be retained to support the habitat for Carnaby's and Forest Red-tailed Black cockatoos. The area of remnant vegetation in scenario 5 is in good condition.

Scenario 1, if not for its conservation value, would facilitate an orderly subdivision and reduce an existing bushfire risk within proximity to the townsite's houses. Its conservation value is understood to discount it from being pursued, and in accordance with SPP 3.7, other scenarios are alternatives that don't have the environmental consequence and should be pursued in preference.

Scenarios 2 and 3 are located either side of Pickering Brook road which provides a low threat access to the school and access for emergency services to attend secondary fires.

Scenarios 2 and 3 are considered relatively straight forward, they are unrestricted in terms of vegetation, the existing houses are widely spaced, providing for a flexible subdivision arrangement. Scenario 2 adjoins classified vegetation to its south which is part of the golf course. Whilst it is classified as a contiguous forest in accordance with the classification methodology, the golf course disrupts the continuity of the fuel. Multiple points of ignition, however, must be assumed. The actual bushfire may be different but it is prudent to consider the worst-case and accommodating that has little effect upon the development and yield of the area.

Scenario 3 has only a small exposure to classified vegetation effects at its eastern end but it can be accommodated in the large lot size. Scenario 3 may, however, be affected by the future use of the land at scenario 4, which is presently classed as an orchard and excluded in the BAL contour map. The placement of a windrow or a change of primary production on the land may affect the BAL rating across the site. However, as demonstrated in **Figure 24** a simple subdivision design can address the setback requirements that can accommodate flexibility of future options within scenario 4. The perimeter road and setbacks from the northern boundary should assume Forest occurs at scenario 4, to provide for the broadest contingency of possible uses that may impose a BAL into scenario 3. The ability to maintain safe access to perimeter road that will separate scenario 3 from scenario 4 will also be affected by the development at the boundary, Given that scenario 3 (setting aside scenario 2) is linear, it is recommended that an Emergency accessway be placed at the rear of the northern lots to permit low threat access to Pickering Brook Road and the school.

Scenario 4 is considered similarly to scenario three in terms of bushfire, and adjoining land considerations; although it is understood that other land use consideration may preclude its practical development for residential purposes. The addition of the area to scenario 3, to create scenario 4, should also include the provision of low threat access to Pickering Brook Road.

Scenario 5 and 6 as additions to the preceding scenarios have a higher length of the interface to the adjoining National Parks, they also retain remnant vegetation, which if retained will affect the siting of development and potentially reduce lot yields. These issues, whilst they affect the yields, are not a significant determinant in terms of bushfire. Should Scenarios 5 and 6 proceed it is recommended that the subdivision design restrict the direct access to the perimeter roads, that an internal route subject to BAL-Low is provided through to Pickering Brook Road and the Pickering Brook Primary school, to avoid exposure to bushfire and maintain safe access for emergency services to attend to secondary fires, and access for residents to the School through-out a bushfire event.

There is an aspect that as the scenarios are added there is more traffic demand particularly if there is convergence to a nominated safer place, i.e. the Pickering Brook Primary School, the travel evacuation time window widens (RSET), the capacity requirement for shelter at a safer place becomes greater and spaces such as the oval must be managed efficiently.

There are population steps where it becomes viable to provide dedicated resources to offset the consequence of growth. The scale offered between scenarios 2 and 6 is not of an economy that will justify dedicated resources, it instead will rely upon the social capacity of the community and volunteers, the administration of the Pickering Brook Primary School and arrangement to utilise the school outside of school hours.

From a bushfire emergency service perspective, the management of Pickering Brook Road as a low threat emergency management service spine favours the scenarios that line it. Arguably this, and their scale, favours scenarios 2 and 3, as the facing housing and the subsequent row have the shortest access to Pickering Brook Road.

3.2.4 Staging development and yield effects

Notwithstanding the permissibility of a land-use under the *Planning and Development Act 2005,* requirements of the *Building Act 2011* apply separately. In this regard when a proposal is a building permit, and in particular when the proposal affects land within a declared bushfire prone area, if it is a class 1-3 or 10a building, it is subject to the BAL assessment made by the building surveyor at the time of certifying the design compliance.

The determined bushfire attack level at building permit stage will depend upon the classification of nearby vegetation and the ability to achieve a separation distance conforming with the Asset Protection Zone standard, which can include an overlapping APZ or non-classified space outside of the development site.

With regard to the staging of development, the scenario areas are classified as Grassland, in accord with State bushfire mapping methodology. Scenario 6 retains some remnant tree canopy, which has been determined as Forest, and Scenario 5 also retains remnant vegetation at the northern section. If these remain then their potential for bushfire attack must be addressed within each adjoining lot. In terms of staging, if they are to be removed, they should be part of an integrated subdivision across the land ownerships, and no title issued until the works are done. In other states, the determination of future land use at planning will determine the building construction requirements that the Certificate of Design Compliance and Building Permit will be based. In WA the *Planning and Development Act 2005* and the *Building Act 2011* are separate. The Building Surveyor in WA, therefore, must be satisfied that the BAL as assessed at the time of the Certificate of Design Compliance matches the conditions on the ground and the construction standard to be approved at the Building Permit.

In terms of staging and building the required BAL, is determined at the building (development site), not at the site boundary. The distance required to achieve BAL-Low at a building is comparatively large, 100 m from Forest, but only 42 m to achieve BAL-12.5. (Forest is considered to be retained where it currently exists and where windrows for spray drift are placed). The distance required to achieve BAL-Low from Grassland is comparatively large, 50 m, but only 17 m to achieve BAL-12.5. A Barrier i.e. continuous metal fence can be used to reduce the BAL level between a building and grassland.

The intervening distance to achieve a maximum acceptable BAL of BAL-29 can be used purposefully through good planning; typically, by placing low threat surfaces or land uses in the separating space i.e. roadways and utilising routine building setbacks in the locality. Low hazard level vegetation, e.g. crops, can shorten the required distance that is required for a separation from a forest, and non-curing crops, can be considered, although the use of herbicides and pesticides can create siting conflict with sensitive receivers, depending upon the land management practice. That requires a densely planted windrow to retard spray drift, the density of the planting may constitute a forest, although depending upon the context a lesser intensity, required BAL may be determined.

Given the PIA is within an extreme bushfire hazard level area and could be subject to ember attack which can range over distances of 5km, a minimum BAL of 12.5 for protection against ember attack should apply across the townsite expansion area. Housing losses are recorded at 700 m from a fire front and embers can be carried to ignite flammable materials up to 3-5 km. Contemporary building constructions are largely BAL-12.5 compliant; the additional cost, if any, is small particularly in terms of the collective resistance to the occurrence of a sequential secondary fire.

A hypothetical division of the land has been illustrated in **Figure 24.** It is based upon the existing housing arrangement between Pickering Brook Road and Cunnold Street including the dwelling size and typically lots 40 m x 50 m, or 25 m x 80 m.

Utilising the rectangular lots at the perimeter, towards the nearest vegetation provides that BAL-12.5 can mostly be achieved by the dwelling being placed centrally within the lot. Buildings facing the perimeter can be placed up to the BAL-40 contour boundary to be within the Acceptable Solution specification of BAL-29, but in general, the lower the BAL, not only the lesser the impact but also the quicker tenable conditions will establish outside the building to facilitate evacuation and attendance.

The example illustrates that the highest BAL for the placement of a building on any lot is BAL-19. The ratings assume that within the subdivision all lots are maintained to a low threat standard.

If an adjoining windrow is located adjacent the northern boundary of scenario 3, and the windrow not excluded (AS 3959:2018) the set back to achieve BAL-12.5 would require the dwelling to occupy the rear third of the lot, in order to achieve a separation distance for an acceptable development site of BAL-29. The lots are large enough to accommodate the location of a windrow at the northern boundary, should this be desired.

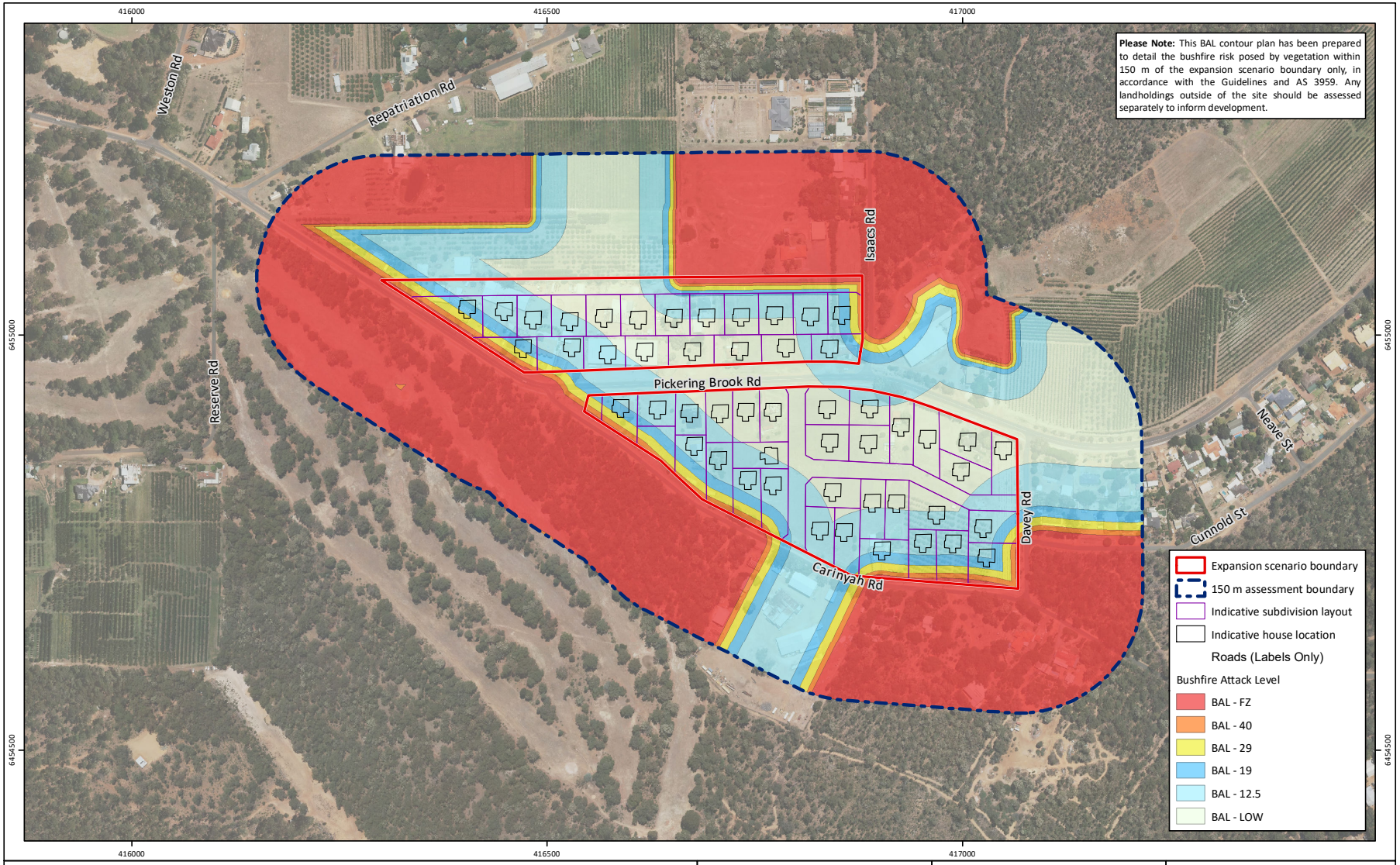


Figure 24: **Indicative Subdivison Layout**

Project:	Bushfire Management Plan Pickering Brook Bushfire Risk Assessment
Client:	Department of Planning, Lands and Heritage

Plan Number:
EP19-138(01)--F38

Drawn:	SCM
Date:	28/02/2020
Checked:	AJR
Approved:	AJR
Date:	28/02/2020

N

0 100 200
Metres
Scale: 1:6,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

4 Risk Assessment

As part of addressing the bushfire management measures that may apply to the expansion area, a qualitative risk assessment for bushfire has been undertaken, following the risk management processes, as described in NERAG (2015, 2020). The NERAG process is illustrated below (**Plate 16**). The previous section has been used to establish the background landscape and local context for the Risk Assessment.

The Risk Assessment process will be used to identify the risk treatments to be expressed as bushfire protection measures.

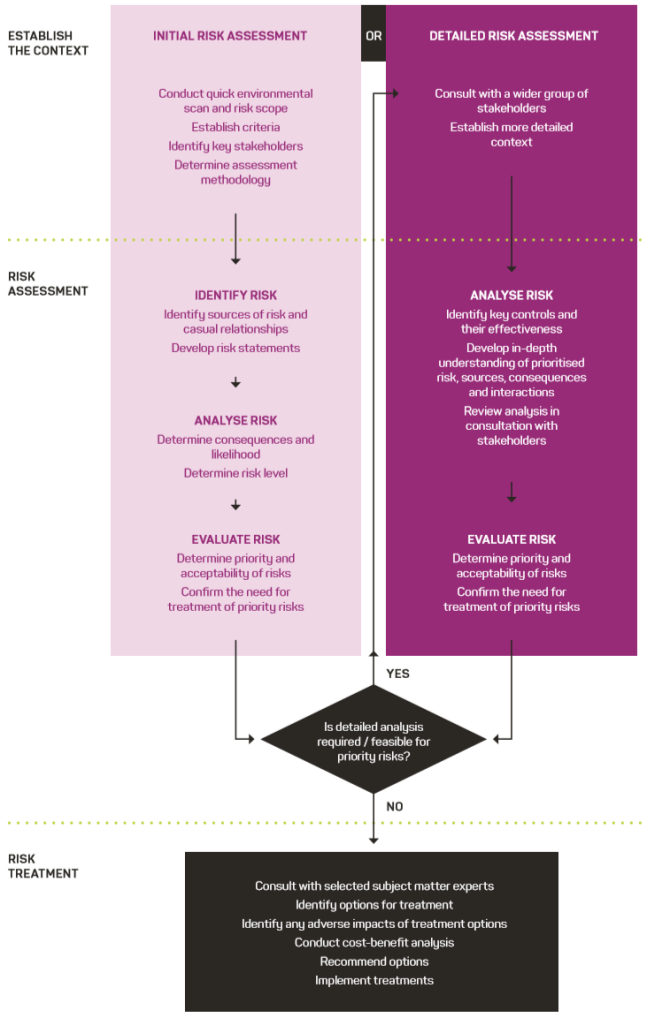


Plate 16: NERAG 2020 illustrative risk assessment process

4.1 The Primary Risk (Statement)

4.1.1 Scope

This risk assessment will assess the consequence of a landscape fire affecting the townsite expansion area and the immediate Pickering Brook locality. The purpose of the risk assessment process is to identify and evaluate the effectiveness and practicality of all measures (treatments) required to offset each risk; to achieve a level of risk acceptable in terms of the preservation of life and minimisation of impact upon buildings and infrastructure.

4.1.1.1 Responsibility

The context for this risk assessment is the objective of State Planning Policy 3.7 Planning in Bushfire Prone Areas

> ***Policy Intent***
>
> *The intent of this policy is to implement effective, risk-based land use planning and development to preserve life and reduce the impact of bushfire on property and infrastructure.*

4.1.1.2 Defining an acceptable risk

A different acceptance of risk applies to the preservation of life compared to buildings and infrastructure.

Within the SPP 3.7 policy intent, the preservation of life is paramount. The consideration of community safety includes the safety of firefighters and a measure of maintaining a 'wellbeing' that is broader than an immediate safety but psychological health and cumulative community function.

The secondary consideration is the impact of bushfire on property and infrastructure, considered in terms of resilience. The objective is to adapt to the fact that bushfire is part of the landscape, and resilience is minimal disruption to the ongoing daily function of the community immediately following a bushfire event.

4.1.1.3 Supporting evidence

The method to identify the source of risk and its potential consequence has been derived by an analysis of:

- The climate within 20 km of the PIA and FFDI
- The calculated fire line intensity within 5 km of the PIA
- The fire history within 20 km of the PIA
- Projected FFDI
- The road access network within 20 km of the PIA
- Infrastructure servicing the townsite of Pickering Brook, water, power, telecommunication
- The features of bushfire attack that affect human safety effect buildings and infrastructure.

4.1.2 Risk criteria

The evaluation process criteria are:

- Potential to cause harm to humans
- Potential to damage building and infrastructure
- Potential to disrupt community operation.

The aspects of bushfire attack that affect human safety include:

- Burns from radiant heat from the bushfire front or other ignited materials
- Burns from direct flame contact from the bushfire front, including embers, or other ignited materials
- Convective heat carried from the bushfire front – heat stress, lung damage
- Injuries from airborne particles – eye damage
- Smoke inhalation – asthma, excessive breathing heart attack. Toxic smoke can occur during a bushfire.
- Psychological trauma.

As an indication of harm, BAL-2 (2 kW/m^2) is recognised as the maximum acceptable for outdoor shelter, pain is experienced at 4 kW/m^{2}after 10-20 seconds (maximum for evacuation), 4.7 kW/m^2 is the maximum operating exposure for equipped firefighters, 10 kW/m^2 is the maximum short term 3-second exposure, and the maximum for safe shelter in a vehicle[29] is 10 kW/m^2. Standard float glass may fail at BAL-12.5, and at BAL-29 most timbers will ignite within 3 minutes without piloted ignition.

Smoke can be immediately hazardous to those with respiratory sensitivity, but the effects of sustained exposure to bushfire smoke effects are still to be determined and it is acknowledged that forest fire does contain toxic gases. These include formaldehyde, acrolein, formaldehyde, acrolein, xylenes, toluene, benzene, terpenes, and many other volatile compounds. These compounds are capable of causing respiratory illness, neurological symptoms, cancer and a range of other health effects.[30]

The psychological impact of a bushfire should be a significant consideration in an overall perspective of planning for the bushfire. A broader concept *Wellbeing* (NERAG 2020) rather than *resilience* is increasingly applied as a measure of recovery, whereas 'resilience' alone has generally focused on the physical properties of a bushfire. It is typically assessed by financial measures and the cost of replacement.[31]

Factors affecting 'wellbeing' are shock, even amongst those safely evacuated, and for those that stayed and defended, ongoing trauma, from fear experienced in the event. Most often people who stayed and defended after Black Saturday expressed confidence in their ability before the event, having previously been successful, but the intensity of the fire on Black Saturday was beyond expectation, causing fear for their lives and sense of a narrow escape.[32]

[29] J McLennan Use *of Informal Places of Shelter and Last Resort on 7 February 2009*. Bushfire CRC, LaTrobe University
30 Chemistry Centre of Western Australia
31 Florec V., and Pannell D J., (2016), *Economic assessment of bushfire risk management options in Western Australia*
32 J McLennan Use *of Informal Places of Shelter and Last Resort on 7 February 2009*. Bushfire CRC, LaTrobe University

An avoidance of fatalities and serious injury is important in determining the severity of consequence and intern an acceptable risk. Studies by the CSIRO[33] in a review of 260 bushfires between 1901 - 2011, has found that 78% of all fatalities (773 civilian fatalities) occur within 30 m of a forest, and 88% of fatalities 'within a structure' occur within 30 m of a forest. It has also found that if a building survives that people will survive.

"Using fire weather days as a point of correlation between life loss and house loss we find that house loss is a reasonably good predictor of potential or life loss…."[34]

Simplistically, people survive if the building they shelter in survives and building survival is reduced markedly over an FFDI of 100, evacuation is, therefore, the preferred response to avoid fatalities and psychological trauma if the route and destination are safer than the location being evacuated. Otherwise, a safer place is required.

The mechanisms for bushfire attack that affect buildings and infrastructure include:

- Direct flame contact from a bushfire front;
- Radiant heat from a bushfire front;
- A direct attack from airborne burning embers;
- Burning debris and accumulated embers adjacent to the building;
- Gale force winds generated by the convective forces of the bushfire front;
- Direct flame contact and radiant heat from ignited adjacent buildings, structures and stored materials; and
- Direct flame contact and radiant heat from ignited adjacent flammable vegetation.

As an indication of damage to buildings Annealed glass will fail at 13 kW/m^2, timber at 25 kW/m^2.[35] It is said that buildings do not burn from the outside but only when flammable materials within the building or under the building ignite.

The effect of wind on a building is an area of increasing focus because localised winds at the bushfire front can be gale force in strength, and tornadoes of varying sizes have been documented. Wind can cause the exterior protection to fail, lifting roof sheets or tiles to expose flammable materials inside and embers to accumulate and find gaps from all sides. The wind can also blow heavy objects against the house, either a potential fuel source against the building or damaging the exterior and opening it to embers. A recommended guidance for designing refuges is a 1:200 (APE) wind strength, but a guide for individual houses has not been provided.

CSIRO[36] research and others[37] have consistently identified that the location of buildings within 100 m of forest vegetation is a major determinant of building loss, with 92% of the total house losses having occurred within 100 m of the fire front.

CSIRO research on the Wye River Fires identified that despite the buildings being constructed to AS 3959:2009, they were vulnerable to exposed undersides and the proximity of heavy fuel, and timber

[33] Blanchi. R, Leonard. J, Haynes. K, Opie. K, James. M, Kilinc. M, Dimer de Oliveira. F, van den Honert.R, 2012, '*Life and House Loss Database Description and Analysis – Final Report*', CSIRO and Bushfire CRC

[34] Blanchi. R, Leonard. J, Haynes. K, Opie. K, James. M, Kilinc. M, Dimer de Oliveira. F, van den Honert.R, 2012, '*Life and House Loss Database Description and Analysis – Final Report*', CSIRO and Bushfire CRC

[35] ABCB (2019) *Bushfire Verification Method*

[36] Blanchi R et all 2010 *Meteorological conditions and wildfire related house loss in Australia*

[37] Douglas et all *bushfire building damage survey – a NSW perspective* – proceedings of the Royal Society of Queensland Bushfire 2006 Conference Special Edition Vol 115:161-169

retaining walls[38]. Changes were made in AS 3959:2018 to address the underside of building vulnerability.

The standards of building construction are based upon the assumption of external conditions immediate to the building. The Canberra fires in 2003[39] demonstrated that homes in urban areas are generally closely located which allows a radiant heat transfer from a nearby burning building to impact upon doors and windows eventually leading to their failure and the onset of sequential house loss. Failure to maintain external conditions consistent with those assumptions can cause the loss of a primary building, and the availability of flammable material is the basis for urban penetration of a bushfire. Flammable vegetation and flammable structures can present a direct flame contact with a building designed only to resist a low radiant heat. It is therefore important in addition to the bushfire construction of a building, to maintain the assumed conditions, including land management and the placement of structures and objects, that once ignited may present exposure to flame for a period longer than associated with the passing of the worst of a firefront.

A greenfields area provides the opportunity to incorporate bushfire protection measures into building construction and land management. The existing housing stock, which predates bushfire protection measures can undertake practical retrofit measures that can improve building resistance, but it is voluntary. Land management is potentially enforceable under s.33(1) of the *Bushfires Act 1954.* Litigation (causing damage to a neighbour by neglect), increasing insurance premiums, and resale value are potential motivators for voluntary improvements to be made by landowners and for owners to maintain approved construction standards for new housing.

4.1.3 Identified Stakeholders

- The community of Pickering Brook
- City of Kalamunda
  - Bushfire Advisory Committee
  - Bushfire Brigade Captains
- Water Corporation
- Western Power
- Telstra/ telecommunications sector
- State Agencies
  - Department of Planning Land and Heritage
  - Department of Fire and Emergency Services
  - Office of Bushfire Risk Management
  - Department of Biodiversity Conservation and Attractions
  - Parks and Wildlife Service
  - Main Roads Western Australia

4.1.4 Reporting (NERAG)

This assessment is to be used to inform the Project Taskforce in evaluating the expansion of the townsite of Pickering Brook. It can also provide a communication plan for engaging with the stakeholders identified above in the implementation of the risk treatment measures.

[38] Leonard. J, 2016, '*What Wye River Can Teach Us About Building for Bushfires'*, CSIRO,
[39] Leonard. J, 2016, '*What Wye River Can Teach Us About Building for Bushfires*', CSIRO,

4.2 Risk Analysis

4.2.1 Risk description

The surrounding landscape may lead to an uncontrollable landscape fire, from the direction of the prevailing wind, enveloping the townsite of Pickering Brook leading to fatalities, the loss of primary buildings and extended community disruption.

The 'Likelihood' is the chance of a bushfire igniting and reaching an asset (habitable building), but in terms of resilience, it is the effect upon anything that contributes to the day to day function of the community.

The frequency of ignition increases with human interaction, 90% of landscape fires are the result of unintentional ignitions, faulty equipment, and deliberate ignitions. Climate also plays an important part. Buildings and lives are rarely lost when the Fire Danger Index (fire climate and weather conditions) is less than 50. Above FDI 50 bushfire suppression techniques become ineffective. The FDI that applies to the PIA is FDI 80.

The 'Consequence' is the outcome or impact of a bushfire event as may be affected by the bushfire behaviour/intensity. Radiant heat is the cause of most fatalities and embers contribute to the greatest number of building losses. Smoke is a bushfire attack mechanism that can harm people susceptible to respiratory difficulties but is not yet subject to a development control consideration although contemporary building energy requirements also serve to limit the ingress of smoke from bushfire. Fatalities, attributed to bushfire attack i.e. heat, smoke, or a lack of oxygen, has not occurred within a dwelling/building that has survived a bushfire attack. This can be attributed to volume compared to private unauthorised small shelters, where fatalities have occurred (Black Saturday 2009)

Historically fatalities have been avoided when buildings have been saved, and where people had actively stayed and defended the property.

Most fatalities, excepting Black Saturday and up to an FFDI of 80, have occurred outside of a building and a large percentage have been volunteer firefighters. Black Saturday 2009 was an exception, where fatalities within a building exceeded fatalities occurring outside of a building. An important finding was that fatalities occurred when people remained in a burning building after the firefront had passed and survival outside was possible. It also identified that building failure greatly increased above an FDDI of 80[40]. This has, in turn, led to an emphasis upon early evacuation, and if sheltering in a building choosing a room with an immediate exit and view of the fire's passing.

It is acknowledged that the outcome of an early evacuation approach is an increase in the loss of buildings. The AS3959:2018 is not a guarantee of building survival but structural adequacy sufficient for a tenable condition to establish external to the building.

[40] Blanchi. R, Leonard. J, Haynes. K, Opie. K, James. M, Kilinc. M, Dimer de Oliveira. F, van den Honert.R, 2012, '*Life and House Loss Database Description and Analysis – Final Report*', CSIRO and Bushfire CRC

4.3 Risk Evaluation (Primary)

The National Emergency Risk Assessment Guidelines provides the criteria, definitions, to derive a likelihood illustrated in a Qualitative risk matrix. The definition range under 'likelihood' is from Almost Certain (extreme) to Extremely rare (very Low) and Consequence level is from Catastrophic (extreme) to Insignificant (very low).

The inherent risk analysis discounts the current interventions/controls. It assumes these are not in place – no confidence level is given to any present controls.

4.3.1 Likelihood

Two points of reference have been used to determine the likelihood of a bushfire event affecting the Pickering Brook townsite. This has included both a review of the bushfire history and 1 in 50-year fire weather event using a Generalised Extreme Value (GEV) analysis. Both methods have advantages and disadvantages. The history obscures interventions that may have occurred but not the inherent risk presented by weather conditions. Conversely, a focus on FDI, and weather conditions, does not address features that may mitigate the risk. The Fire History does not reflect necessarily peak fire intensity whereas the GEV provides a relationship to a required construction response.

From a review of the bushfire history, it is notable that ignitions occur frequently in the area but relatively few advance into a landscape-scale fire. Increased policing of arson significantly reduced ignitions[41], the rate of ignitions is sensitive to the policing efforts if efforts are reduced the probability of ignition will likely increase. This can be attributed to a quick response and the effectiveness of suppression, contributed to by the FFDI at the time and the fuel reductions initiatives that have occurred. A **landscape-scale** bushfire may affect the PIA, either by a direct attack or by ember attack from a fire located up to 5 km away. This may occur at least once in 5 years; which is an annual exceedance probability of 20%. Notwithstanding the occurrence in the locality, a fire has not penetrated the townsite to date.

A Generalised Extreme Value analysis was prepared for Perth Airport using data provided by the BoM. The use of the past 25 years and projected Generalised Extreme Value analysis includes the effect of climate change. Climate change is expected to increase the number of elevated FFDI days, which is a trend that has been observed Nationally since 2000.

The analysis of FFDI illustrates a trend for elevated FFDI has occurred within the Perth Airport weather station area. The projected FFDI within a 1:50 APE was FFDI 89.

Notwithstanding the GEV analysis, in this instance, the review of landscape bushfire occurrences, being every 3-5 years places the likelihood to be Likely. It is, however, a difficult likelihood to place because, there is no history of a bushfire penetrating the townsite of Pickering Brook, largely due to the preparation that includes the fuel reduction initiatives of the Parks and Wildlife Service, and reduced ignitions overall due to policing efforts to prevent deliberate ignitions. The history of fire within the townsite of Pickering Brook may suggest the likelihood is rare.

[41]Sullivan, A. L. et al. *Fire Development, Transitions and Suppression, Final Project Report*, 2014, Bushfire CRC, Australia

Table 11: Likelihood definitions NERAG

Likelihood Rating	Frequency	Average recurrence interval (ARI)	Annual probability exceedance (APE)
Almost Certain	Once or more per year	Less than 1 year	63% per year or more
Likely	Once per 10 years	1 to <10 years	10% to <63% per year
Unlikely	Once per 100 years	10 to <100 years	1% to <10% per year
Rare	Once per 1000 years	100 to <1000 years	0.1% to <1% per year
Very rare	Once per 10,000 years	1000 to <10,000 years	0.01% to <0.1% per year
Extremely rare	Once per 100,000 years	10,000 years or more	Less than 0.01% per year

NERAG 2015

4.3.2 Consequence

The location of the townsite within an extensive area greater than 5 km of contiguous vegetation (Forest – high fuel), slopes 5-10°, and an FDI of 80, means the expected bushfire behaviour is intense[42]

Efforts to find a probabilistic measure for bushfire including a review of the Fire DST[43] the project was not successful, or not effectively-identified, which may be due to the uncertainties involved and the relatively small samples and variation.

The NERAG (2015) uses a classification catastrophic of 1 in 10,000, for every population of interest. The affected population is up to 1000 persons, accounting for residents and visitors that may be present. Recorded fatalities from Bushfire in Western Australia, excluding firefighters is low and there is no proportionate population of interest to determine the ratio of total people affected by the events and the subsequent fatality.

Since 1925, 29 people have died in WA bushfires. The most recent fatalities occurred at the Waroona Yarloop fire in 2015 where two fatalities occurred in the township and at Esperance in 2015 when four fatalities occurred. The year 2015 is notable as the year having the peak recorded FFDI in WA.

A National study by the CSIRO[44] (Blanchi et al. 2012) of 260 bushfires since 1901 found most fatalities occur when the FFDI is at its peak, between 3 pm and 9 pm, where the conditions exceeded an FFDI 100. It also found that most fatalities were likely to have been aware of the fire nearby and had time to evacuate before the fire's arrival, but chose to stay. The study found 90 per cent of the fatalities occurred immediately after a wind change. The wind change meant the length of travel established by the fire in the course of the day suddenly became a wide fire front under the 90° wind change. For many who thought the fire would pass suddenly found it approaching with high intensity. The study

[42] Manual calculation is 48000, but as a function of the quantity of the fuel available, may be reduced at the interface with the townsite by fuel reduction measures.
[43] T Jones et al. *Quantitative bushfire risk assessment framework for severe and extreme fires*, Geoscience Australia 2012.
44 Blanchi. R, Leonard. J, Haynes. K, Opie. K, James. M, Kilinc. M, Dimer de Oliveira. F, van den Honert.R, 2012, '*Life and House Loss Database Description and Analysis – Final Report*', CSIRO and Bushfire CRC

found from interviews of survivors that many had the intention to stay and defend but became overwhelmed by the intensity of the bushfire and decided to leave.

The study found that late evacuation (30.3 per cent) was the most common cause of fatalities with most being trapped on roads by fallen trees or from having run off the road due to poor visibility as a result of smoke conditions (this has led to a preference for early evacuation and people not encouraged to wait and see). A further 22.4 per cent of fatalities occurred external to the building either attempting to flee or defending. Sheltering inside a structure had occurred in 24.8 per cent of fatalities, with many thought to have occurred from staying in a burning building after survivability outside had established (this has led to survival advice - to shelter in a room with an outside exit and with the observation of the fire's passing – not a bathroom).

The Australian fire history has also demonstrated people survive if the house survives. Simplistically the circumstances contributing to the highest level of house loss is a reflection of the potential for fatalities.

House loss, however, is affected by a number of factors and defended houses have a higher level of survival. The conundrum is a policy of leave early will reduce fatalities but house losses may be higher. This appears to be evident with the Black Summer fires 2019-2020.

Combining the history of house loss, with the FFDI gives a guide to the potential for loss of life. The history indicates that fatalities occur when the FFDI is above FFDI 75, or Extreme FDR.

Consequently, the frequency of days above FFDI 75 at Bickley/Pickering Brook, as a worst-case is potentially catastrophic.

Table 12: Consequence definitions

Consequence rating	Description	Injury or illness	Property
Catastrophic	Deaths directly from emergency greater than 1 in 10,000 people for a population of interest	Critical injuries with long-term or permanent incapacitation greater than 1 in 10,000 people for a population of interest	Multiple house loss, greater than 10% long term broad community disruption
Major	Deaths directly from emergency greater than 1 in 100,000 people for a population of interest	Critical injuries with long-term or permanent incapacitation greater than 1 in 100,000 people for a population of interest: or Serious injuries greater than 1 in 10,000 people for a population of interest	Multiple house loss less than 10%, isolated or limited community disruption.
Moderate	Deaths directly from emergency greater than 1 in 1,000,000 people for a population of interest	Critical injuries with long-term or permanent incapacitation greater than 1 in 1,000,000 people for a population of interest: or Serious injuries greater than 1 in 100,000 people for a population of interest	Damage requiring external resources, individual isolated house loss less than 1%
Minor	Deaths directly from emergency greater than 1 in 10,000,000 people for a population of interest	Critical injuries with long-term or permanent incapacitation greater than 1 in 10,000,000 people for a population of interest: or Serious injuries greater than 1 in 1,000,000 people for a population of interest	Superficial damage rectified by routine arrangement
Insignificant	Deaths directly from emergency greater than 1 in 10,000,000 people for a population of interest	Critical injuries less than 1 in 10,000,000 people for a population of interest: or Serious injuries less than 1 in 1,000,000 people for a population of interest: or Minor injuries to any number of people	

4.3.3 Risk Rating

The risk rating is the product of the likelihood of the occurrence and the anticipated consequence of the occurrence.

For the purpose of this risk assessment that anticipated consequence is made imagining the absence of current mitigation measures. It represents a 'do nothing' approach.

The NERAG provides a qualitative risk matrix for rating the risk. By utilising the Qualitative Risk Matrix, matching the likelihood (Likely) with the consequence level (Catastrophic) - the overall risk rating is classed as **Extreme**.

LIKELIHOOD	CONSEQUENCE LEVEL				
	INSIGNIFICANT	MINOR	MODERATE	MAJOR	CATASTROPHIC
ALMOST CERTAIN	Medium	Medium	High	Extreme	Extreme
LIKELY	Low	Medium	High	Extreme	Extreme
UNLIKELY	Low	Low	Medium	High	Extreme
RARE	Very low	Low	Medium	High	High
VERY RARE	Very low	Very low	Low	Medium	High
EXTREMELY RARE	Very low	Very low	Low	Medium	High

Plate 17: NERAG 2015- 2020 - Qualitative Risk Matrix

4.4 Subsystem Risk Assessment

A 'do nothing 'approach is a reflection of inherent risks. However, in regard to Pickering Brook, there are already in place a range of mitigation measures (hereon referred to as controls) and the purpose of the risk assessment is to evaluate their effectiveness and identify other treatments that may reduce the overall risk.

The basis of the Taskforce assessment is to determine the merit of the townsite expansion. Scenario 3 has been identified as the preferred townsite expansion extent. The Taskforce assessment is primarily about the townsite expansion and the risk to the future inhabitants and buildings. Whilst this risk assessment primarily has this focus it is also acknowledged that the merit of the expansion should not increase the risk for the existing townsite and locality. That there are vulnerabilities in the existing townsite that may affect the expansion area, the townsite expansion will benefit from a continuation of existing controls, but there are also opportunities that reduce the risk to the townsite expansion that would also benefit the existing townsite and locality.

It has been identified earlier that building survival is important in reducing fatalities but evacuation is preferred to reduce harm.

The National Construction Code Verification measure assumes a failure of 10% (a probability of fire ignition should not exceed 10%), which is no less than expected of a Deemed to Satisfy Solution (construction standard specified in AS3959). It is not statistically representative of failure. It is intended as a recognition that other factors are important to a building survival including immediate site conditions, the proximity of adjoining structures, and the attendance of emergency services, among others. Other matters that may affect the survival of a building in the long term include maintenance. In this regard, an oversight of compliance can also affect whether an individual building may fail and in turn as a heavy/persisting fuel increase the risk of ignition to the adjoining building.

The probability is also reduced if the façade exposure is substantially below the performance limits of the construction methods used.

The NCC encourages the designer to strive to improve the resistance to ignition through the identification of complementary measures, i.e. through NERAG, to reduce the risk

"Subjective judgements will be required in most instances and therefore close liaison with all relevant authorities will be necessary for determining these probabilities and inputs to the event trees used to derive probabilities"

The purpose of the Subsystem Risk Assessment is to identify a comprehensive level of risk treatments to reduce the overall risk rating. NERAG is not a quantitative risk assessment but an orderly methodology and an aid to decision making.

The following subsystem approach recognises there are similarities between building fires and bushfire, and fire safety concepts that enable the lessons learned from building fires to be applied to a bushfire consideration. Although rarely do the considerations of bushfire have an objective to slow the progress of a fire to provide sufficient time for escape, it could be argued that the fuel reduction undertaken by the P&WS around Pickering Brook does assist to slow the rate of spread increasing the time available for safe evacuation. To identify these relationships between fire safety concepts applicable to Pickering Brook, this assessment has adopted the National Fire Protection Association *NFPA 550: Guide to the fire safety concepts tree*, adapted for bushfire and illustrated in the ABCB bushfire verification method handbook July 2019[45]. *This has been used as the basis for categorising the Subsystem Risk Assessment, which includes subsystem risk identification, risk analysis, and risk treatment evaluation.*

The relationship between the safety concepts, that apply to a bushfire affecting the townsite, can be categorised into the following streams:

- **Minimising the ignition**
    - Manage human interaction, education and policing
    - Limit the consequence of faulty equipment
- **Minimising the exposure** of the community to the effects of bushfire
    - Early evacuation, detection, alarm
    - Evacuation facilitation
    - Safer places
- **Managing the fire** through planning, preparation, response and recovery measures including
    - Land management - fuel reduction (internal and external site control for prevention)
    - Fire Suppression – detect, respond, access and apply sufficient suppression
    - Limiting the vulnerability infrastructure, that may disrupt the function of the town
        - Immediate land management
        - Construction flammability and barrier protection

[45] Australian Building Construction Board Bushfire Verification Method Handbook July 2019

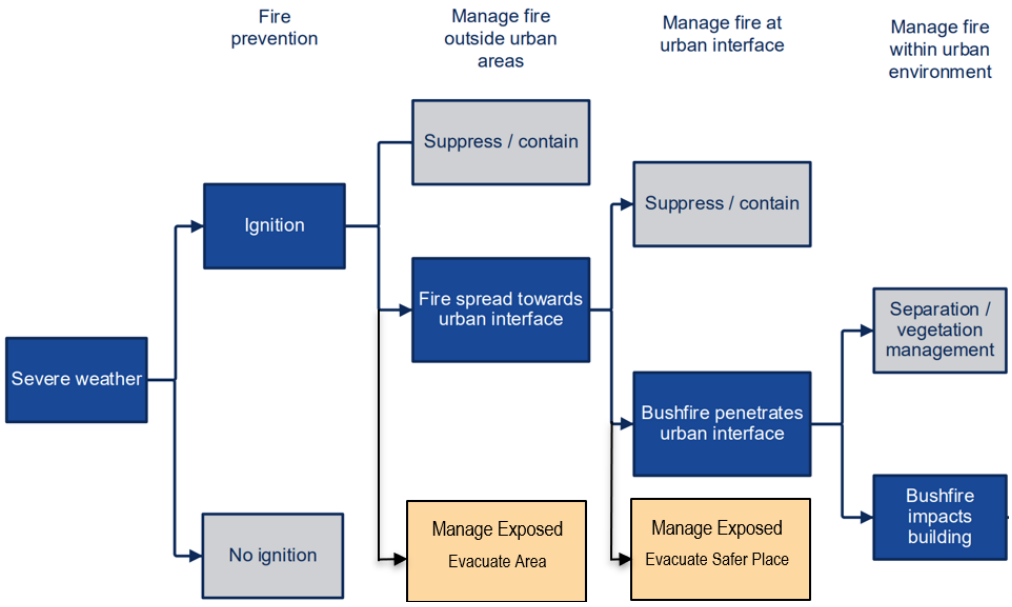


Plate 18: Adapted event tree from Bushfire Verification Method (ABCB, 2019) (pg. 35)

4.4.1 Subsystem Risk Assessment Table Interpretation

The Subsystem Risk Assessment Table (**Table 13**), overleaf, describes the subsystem risk identification, risk analysis, and risk treatment evaluation.

Table 13 follows the methodology described in the NERAG, including the construction of the risk statements.

Each risk statement is evaluated upon the current activity and commentary on the strength of the control. This determination has been derived from external observation. The control level is determined using the NERAG matrix, being a measure of strength ranging through: very low, low, medium and high.

Each risk statement has been evaluated upon its 'likelihood' and 'consequence'. Some items have a separate level of likelihood, otherwise, the overall likelihood of a bushfire 3-5 years has been applied 'likely'. The consequence has been rated upon the contribution to the response, what difference would it make if it was not provided, is a response assisted (moderate) or dependent (catastrophic)on its presence.

Each risk statement is accompanied by a risk treatment evaluated by considering its context to a time sequence of requirement using planning/mitigation, preparation, response and recovery. Residual risk is provided based upon the reductions that may be achieved to either the likelihood or consequence. The risk level ranges from very low, low, medium, high, and extreme, but often due to the likelihood or the consequence, the best that can be achieved is a medium or high risk. If the

consequence is a fatality (intolerable), the residual risk can be no lower than 'high', regardless of the likelihood, even when the likelihood is extremely rare.

Each risk statement treatment is accompanied by an evaluation of expediency which is a measure of low cost, high community acceptance, low difficulty, and low environmental impact. The rating range is low, medium and high (adapted from NERAG for this assessment). Each risk statement is in turn evaluated on its control strength, effectiveness and reliability. The rating is low, medium and high (adapted from NERAG for this assessment).

Generally, the NERAG methodology will prioritise treatments for those risk statements with a low control strength and high risk but this would otherwise preclude prioritising existing effective actions. NERAG asks for a judgement in this regard in addition to a mechanical application of the risk matrix.

The priority is based upon the combination of expediency and strength. The ratings are low, medium and high (adapted from NERAG for this assessment), rather than a rank. This is because there are multiple stakeholders and this is the basis for communication to be used to determine the delivery that may be applied through a LEMA.

Table 13: Subsystem Risk Assessment

Acknowledgement: The authors wish to express their gratitude to the people who had participated in the gathering of the following. It is to be acknowledged that the following is based on the authors understanding and observations and may not be an accurate account of the genuine endeavours and efforts of all those involved, and the language used may mean different things to different applications. The purpose of the following is an integrated review for the purpose of a Communication Plan to affirm actions, refine actions or discount actions.

Risk Register		Risk Analysis				Risk Treatment	Treatment Evaluation			
Risk statement	Existing preventions	Control strength/expediency	Likelihood	Consequence	Risk level	Treatment	Residual	Expediency	Control strength	Priority
MINIMISING IGNITION										
Limiting faulty equipment										
A bushfire can be ignited by mechanical failure of transmission and electrical infrastructure, powerlines,	Main Roads and Local government Clear road reserves Clearance to utilities	Medium: Sparse grasses exceeding 100 mm evident adjoining carriageway (shoulder) to dense grass	34 in 11 years rare	Catastrophic	High	Maintain a mineral earth verge up to the tree line	Medium	Medium	Medium	Medium
	Western Power Grid management Vegetation management around audited risks	Medium: Grasses and elevated vegetation leading to 30 % of power poles.	rare	Catastrophic	High	Maintain a 2m mineral earth clearance from the grass around power poles, and 3m from shrubs	Medium	Medium	Medium	Medium
	Private land management and education	Medium: Utilities on private land are the landowner's liability, low awareness, i.e. failed white ant power pole failure	rare	Catastrophic	High	Maintain a 2m mineral earth clearance from the grass around power poles and 3m from shrubs. Monitor the condition of the supporting pole intermediately report any deterioration.	Medium	Medium	Medium	Medium
A bushfire can be ignited by the re-ignition of fires, fuel reduction burns/burn-offs, open flames	DBCA Fuel management procedures and suppression facilities.	Low: Opportunities for hazard reduction burns are narrowing	352 in 11 years Likely	Catastrophic	Extreme	Independently audit completion of prescribed burns Make resources available to extinguish and attend to any deep smouldering materials	Medium	High	High	High
	Local government Administration of the *Bushfires Act 1954,* fire bans, restricted burning times and management.	Low: Opportunities for hazard reduction burns are narrowing	Likely	Catastrophic	Extreme	Monitor the availability of burning times to reduce the risk of carryover ignitions.	Medium	High	High	High
Manage Human interaction										
A bushfire can be ignited by unintentional human actions cigarettes, metal grinding, fireworks	State and Local Government Community education Fire ban days announcements.	Low: Someone is usually in attendance, to report and take action. Private land management can limit the spread of a bushfire. Fires can occur outside the fire ban day. The education focus may diminish caution outside fire ban days. *The risk may understate the likelihood that many 'suspicious fires' are unintentional human interactions.*	12 in 11years Unlikely	Major	High	Community education Administration of the *Bushfires Act 1954,* to maintain private land fuels and firebreaks to help contain the fire.	Medium	Medium	Medium	Medium

Risk Register		Risk Analysis				Risk Treatment	Treatment Evaluation			
Risk statement	Existing preventions	Control strength/expediency	Likelihood	Consequence	Risk level	Treatment	Residual	Expediency	Control strength	Priority
Many Bushfires are deliberately ignited (including suspicious fires)	DFES WAPOL Arson prevention Eastern closure of Pickering Brook Road	Medium: Singularly the most effective bushfire reduction measure, a significant reduction in ignitions but still a major cause.	541 on 11 years 43% Certain	catastrophic	Extreme	Maintain existing program, expand if required Seek WAPOL improvement advice	Medium Likelihood remains high	High	High	High
Natural causes										
Bushfires can ignite by natural causes i.e. lightning and spread unless denied fuel	DBCA/ Parks and Wildlife Management of Government land (National Parks)	Medium: Detection may take time and multiple locations can occur stretching resource ability to respond. The ignition cannot be eliminated but the ability to control the bushfire can be assisted by strategic fuel reduction and firebreaks. Fires can jump strategic breaks but can work well with a reduction program. Fire break can stop a fire - deny fuel, whereas fuel reduction reduces intensity to a manageable level for suppression but does not stop a fire	46 in 11 years Likely	catastrophic	Extreme	Ensure a frequency consistent with the 3-5-year fuel cycle. Note reductions do not stop fires only provide for manageability and control. Investigate cultural efficacy with indigenous traditional bushfire practices at a higher frequency activity.	Medium	High	High	High
						Strategic firebreaks in coordination with fuel reduction. Strategic firebreaks are not always effective, but a high priority.	Medium Effectiveness is improved with fuel reduction.	Medium	Medium	High
MANAGING THE FIRE										
Land Management										
The presence of surface and elevated fuels on adjoining land increases the likelihood of intense and unmanageable bushfire affecting the urban area	Management of Government land (National Parks) Parks and Wildlife Service	High: Active fuel reduction 3-5 yrs.	Likely	Moderate	Medium	Ensure a frequency consistent with the 3-5-year fuel cycle. Note fuel reductions do not stop fires only provide for manageability and control. Investigate cultural efficacy with indigenous traditional bushfire practices and a higher frequency of reduction activity.	Medium			
	Local Government Administration of *Bushfires Act 1954* private land	Medium: Confusion over application in a residential area, unless growth is excessive and the property is untidy. Primary means of restricting the spread of bushfire over private land. Primary means to maintain 'mutual responsibility' between landowners	Likely	High	High	Broaden administrative focus. Increase community education. Integrate ignition management (Bushfires Act1954) with planning and building approvals.	Medium	High	Medium	Medium
	DBCA/DFES crown Land Management Lot 81	Medium: Limited opportunity to undertake reductions, climate and proximity of housing. Likely to become more difficult, Cunnold Street residents may need to improve their building resistance	Likely	Moderate	High	Ensure a frequency consistent with the 3-5 year fuel cycle. Investigate cultural efficacy with traditional practices higher frequency activity.	Medium	High	Medium	Medium

Risk Register		Risk Analysis				Risk Treatment	Treatment Evaluation			
Risk statement	Existing preventions	Control strength/expediency	Likelihood	Consequence	Risk level	Treatment	Residual	Expediency	Control strength	Priority
	Co-ordination of fuel reduction across public and private land	Low: Coordination of private and public lands remains elusive due to coordination practicality's funding works coordination and access to undertake operations. High administrative demand to coordinate. Will contribute to the spread of fire	Likely	Moderate	High	Surrounding land affects the townsite risk Communication between stakeholders, annual integration. Integration between fire break notices and strategic consideration. Coordinating many stakeholders is difficult, compared to individuals doing the best they can.	Medium	Low	Medium	Medium
	The establishment of Strategic Firebreaks to restrict fire runs and contain fire integrated across public and private land	Medium: Few visible within 5 Km	Likely	Moderate	High	Surrounding land affects the townsite risk Should be specifically addressed in OBRM Risk Management Planning, and outcome should be a strategic plan that individual development applications align to. Once the Strategic Plan is prepared, the administration can be a routine planning assessment, easy.	Medium	High	Medium	Medium
The presence of classified vegetation within an urban area can become involved in a landscape bushfire and ignite nearby buildings	Nil control.	Medium: Landscaping controls do not routinely apply within urban areas, existing or new. Residential lots incorrectly assumed as 'managed' vegetation and excluded as a consideration of risk.	Likely	Moderate	High	Encourage existing landowners to consider the ground to reduce the potential ignition and chose bushfire resistant vegetation.	Medium	High	High	High
	Local Government Administration of *Bushfires Act 1954* private land	Medium: The Bushfire Act 1954 whilst it can control the ignition and spread of bushfire on all land it is rarely used in an urban context	Likely	Moderate	High	Broaden administrative focus. Increase community education. Integrate ignition management (Bushfires Act1954) with planning and building approvals.	Medium	High	Medium	Medium
Limiting Vulnerability		Nil.								
The proximity of buildings to the bushfire front affects their vulnerability to damage from direct flame attack from and radiant heat.	Nil for existing development	Medium: Only applies to development since 8 December 2015, if within 100 m from classified vegetation. Building along Cunnold are BAL-19 but not constructed. May risk damage to a number of buildings =moderate	Unlikely	Moderate	Medium	Encourage retrofitting of existing buildings along Cunnold Street facing Lot 81, to BAL-19 Individual owner expense increases the difficulty, other incentives such as insurance costs may provide motivation if cost-effective means can be promoted. Significant gain to reduce sequential fire risk if joined with land management.	Medium	Medium	High	High

Risk Register		Risk Analysis				Risk Treatment	Treatment Evaluation			
Risk statement	Existing preventions	Control strength/expediency	Likelihood	Consequence	Risk level	Treatment	Residual	Expediency	Control strength	Priority
	For new development SPP 3.7 and AS3959:2018.	High Applies to development since 8 December 2015, if within 100 m from classified vegetation.	Rare	Minor	Low	Apply AS3959:2018 To Be applied to all housing BAL-12.5 min, and not just the first 100 m to reduce the sequential house to house fire greater than 100m from the fire front.	Low	High	High	High
Buildings facing classified vegetation are vulnerable to damage from wind-generated from a bushfire.	Not addressed	Medium: Recognised as a BAL mechanism but not addressed as a BAL design response provided with construction guidance.	likely	moderate	medium	Audit building roof attachments	Low	Low	Low	Low
						Educate Maintain grounds clear of loose objects in advance of a fire, treat as a gale force warning.	Low	Low	Low	Low
Buildings within a bushfire prone urban area are vulnerable to loss from airborne burning embers and burning debris accumulated adjacent the building	Current buildings are not constructed to resist ember attack.	Medium: Buildings outside of 100 m are not routinely required to be resistant to ember attack and are vulnerable to ignition from embers (urban penetration).	Unlikely	Moderate	Medium	Educate practical means to improve building resistance to ember attack	Medium	High	High	High
	For new development SPP 3.7 and AS3959:2018.	Medium: Buildings outside of 100 m are not routinely required to be resistant to ember attack and are vulnerable to ignition from embers (urban penetration).	Very Rare	Minor	Very Low	Apply a minimum BAL-12.5, FFDI 100, to all new buildings, or the determined BAL if greater than BAL-12.5	Very low	High	High	High
Buildings within a bushfire prone urban area are vulnerable to the ignition of a flammable structure close by.	Nil Existing houses	Medium: Bushfire development controls do not apply to a development site more than 100 m from a hazard and less than BAL-12.5	Likely	Minor	Medium	Broaden awareness of the risk Promote preparation prior to the bushfire season Issue reminders through the bushfire season Promote fire-resistant vegetation around buildings	Low	Medium	Medium	Medium
	For new development SPP 3.7 and AS3959:2018.	Medium: The lots are large enabling separation at authorisation, but relies on monitoring that exempt or unauthorised structures are placed that effects the buildings BAL rating	Unlikely	Minor	Low	Addressed at development approval	Low	High	High	High
Overhead powerlines and their supports can be damaged by bushfire, disrupting a return to function.	Pickering Brook Road, road verge maintenance by Local Government Low threat vegetation either side	High: Classified vegetation within Road verge and drainage reserve adjacent to the Pickering Brook Primary School	Very low	Minor	Very low	Remove grasses as part of the maintenance responsibility by Western Power. The frequency of audit and work can vary.	Very low	Medium	Low	Low
	Local Government Roadside verge, Pickering Brook townsite	Medium: Weston good mineral base - Low Issacs, McCorkill, Cunnold grasses at the base - Medium	Unlikely	Minor	Low	Subject to annual budgets	Low	Medium	Low	Low
	DBCA, management of land overhanging trees contact with overhead lines	Medium: Carinyah Road east Ave, adjacent lot 81	Likely	Minor	Low	It is not the main power line. Recent fuel reduction works will help reduce the fire intensity	Low	Medium		

Risk Register		Risk Analysis				Risk Treatment	Treatment Evaluation			
Risk statement	Existing preventions	Control strength/expediency	Likelihood	Consequence	Risk level	Treatment	Residual	Expediency	Control strength	Priority
	Western Power - audit and risk treatment program Canning Road	Medium: Canning Road Fire damage to the base of the pole can cause the failure of the pole to support the overhead wires. The poles are timber, of mixed condition, and a number are set within elevated vegetation Overhead wires are generally clear of rubbing vegetation but not clear of a falling tree or branch which could bring down power lines.	Likely	Major	Extreme	Investigate options to maintain power and access to the Pickering Brook Townsite: Underground power lines: or Protect power poles along Canning Road from damage from bushfire. Replace timber poles with steel poles as the opportunity arises, sheathing the base/barrier of timber poles to prevent ignition. Work with Main roads WA and DBCA, City of Kalamunda, to reduce fuel at the base of poles and around infrastructure to reduce ignition Investigate the protection of power lines from falling trees	Medium	High	High	High
	Western Power - audit and risk treatment program Patterson Road	High: Poles mostly cleared mineral at the base. Poles and wires clear of canopies	Rare	Minor	Low	Maintain current measures, to keep the base of the poles within a 3m perimeter of mineral earth.	Low	Medium	Medium	Medium
Water utilities, vital for suppression, can be damaged by bushfire and impede recovery	Water Corporation maintenance, no specific policy.	High: Pickering Brook water supply tanks (2 at 225 KL) are set within a compound amongst forest accessed is by a steep slope 400m west of Weston Road. The tanks are not accessible for fire appliance/suppression; their defence is to be self-reliant. The water tanks are cement not vulnerable The water tanks have steel covers may be vulnerable to wind damage Metal security fencing is not vulnerable Switchgear is located in a steel cabinet site in from the fence -vulnerable. Power supply no overhead power supply was observed. Loss of water supply in an event would be catastrophic.	Unlikely	Catastrophic	Extreme	The tanks and compound should be regularly inspected to ensure effective resistance to bushfire attack, heat and potentially falling objects. Maintain separation of vegetation, and ensure any equipment is shielded from radiant heat and bushfire attack and potential falling trees	Medium	High	High	High

Risk Register		Risk Analysis				Risk Treatment	Treatment Evaluation			
Risk statement	Existing preventions	Control strength/expediency	Likelihood	Consequence	Risk level	Treatment	Residual	Expediency	Control strength	Priority
Telecommunication infrastructure vital for coordinating suppression, community notification and safe evacuation can be damage by bushfire and impede recovery	Telstra – Asset management no specific policy.	High: Telecommunication tower set within a compound amongst the forest. Accessed is by a steep slope west of Weston Road. The facility is not accessible for fire appliance/suppression. Its defence is to be self-reliant. There are other cues for communication within the townsite bur dependence is likely to increase	Unlikely	Major	High	The Telstra tower is within a compound clear of vegetation and equipment is in a non-combustible structure. Maintain separation of vegetation, and ensure any equipment is shielded from radiant heat and bushfire attack and potential falling trees Dependency on telecommunications is increasing.	Medium	Medium	Medium	Medium
Suppress fire										
Detection										
A fire can grow to an unmanageable proportion if not quickly identified and attended early in its development.	Parks and Wildlife Service Bickley observation tower (manned) Parks and Wildlife Service, spotter planes.	High: Elevated views are important to the early identification of fires. Within 15 minutes	Unlikely	Catastrophic	Extreme	Maintain, the current arrangement appears the most effective with fires reported in 15 minutes of starting	Medium	High	High	High
	Dispersed occupied rural living lots provide an advanced warning (mobile coverage)	Low: Limited by Large areas of low populated areas. Elevated views of the landscape are not available within the townsite. Parks and Wildlife will see fire- moderate consequence	Likely	Moderate	High	Clarify the reporting of fire arrangements. Work to minimise telecommunication black-spots so that travelling residents can report the observation of smoke or fire.	Medium	Medium	Low	Low
	Forestry and DBCA officers travel through the area as a component of employment. (mobile radio coverage)	Medium: Limited Infrequent movement obscured views Parks and Wildlife will see fire- moderate consequence	Unlikely	Moderate	Medium	Little option to improve	Medium	Medium	Low	Low
Evacuation and preparation time are reduced by delay in the notification of a fire.	000 -SES - State Emergency Communication centre, dispatch	Low: Public notification of a fire can take an excess of 30 minutes to be communicated, it relies upon the assessment of the first response, which can take time. Preparation time is a significant portion of evacuation time expectations	Likely	Catastrophic	Extreme	Watch and Act alert issue upon a call out when the FDR is severe + An early alert is critical for implementing evacuation.	Medium	High	High	High
Respond										

Risk Register		Risk Analysis				Risk Treatment	Treatment Evaluation			
Risk statement	Existing preventions	Control strength/expediency	Likelihood	Consequence	Risk level	Treatment	Residual	Expediency	Control strength	Priority
Emergency services are unable to arrive before the fire front.	Kalamunda Volunteer Brigade	Low: The Kalamunda Volunteer Brigade is an unmanned station and is subject to personnel arrival attendance and dispatch. On Severe conditions volunteers to man the station. Travel time is 8 minutes from dispatch. Volunteer man the station on extreme days	Very rare	Catastrophic	High	New buildings are not reliant upon attendance Encourage practical works to improve the resilience of existing buildings Minimise community exposure	Medium	Medium	Medium	Medium
Emergency service responses are uncertain before the arrival of the fire front.	SEMC coordination between Emergency Services, Brigade Parks and Wildlife and the Police	Very Low: No pre-incident plan has been prepared for the townsite of Pickering Brook	Likely	Major	Extreme	Pre-incident planning is essential to undertaking operations with certainty, particularly to coordinate community actions	Medium	High	High	High
Emergency services are unable to access adjoining land to undertake suppression operation	Public Road Network Fire breaks tracks	Low: Planning subdivision design and enforcement of the firebreak notice. Enforcement constrained by city resourcing costs Condition of firebreaks often untraversable, apparent from aerial photography	Likely	Major	Extreme	Investigate owner self-certification with aerial varication undertaken by the City and random verification inspections	Medium	Medium	Medium	Low
Emergency Service volunteers are unable to safely access an individual property	Kalamunda Volunteer Fire Brigade	Low: Sequential urban fire - Emergency Services procedures include a triage, building attendance, is dependent upon safety of volunteers to conduct suppression and likely success of suppression. Poorly prepared buildings will be avoided.	**Likely**	Moderate	Medium	Encourage landowner to improve the resistance of their buildings and grounds to bushfire attack.	Medium	Medium	Low	Low
Emergency Service Personnel is unable to safely undertake operations due to road traffic.	Nil	Low: People leaving too late may come into contact with emergency service operations when visibility is impaired by smoke and the operation is precluding road passage. Early evacuation and alternatives to evacuation can avoid	Likely	Major	Extreme	Evacuate the community early Close roads during suppression operations, too late to leave Provide a townsite safer place Assist residents living along the roads to have an early evacuation or survival plan	Low	High	High	High
Sufficient suppression resources										

Risk Register		Risk Analysis				Risk Treatment	Treatment Evaluation			
Risk statement	Existing preventions	Control strength/expediency	Likelihood	Consequence	Risk level	Treatment	Residual	Expediency	Control strength	Priority
Insufficient water, availability and volume, prevents effective suppression by emergency services.	Pickering Brook water supply tanks (2 at 225 KL), are gravity fed. A hydrant network is provided along Pickering Brook Roads	Medium: Tankage is adequate for existing townsite demands and up to 100 additional dwellings. Too many demands upon the water draw can reduce the water pressure progressively from the water supply	Unlikely	Catastrophic	Extreme	Evaluate the capacity of the water supply for fire fighting. Review the need for strategic water tanks within the townsite. Future resilient housing low water defence need. Evaluate the dependency of the water supply on the reticulated power network	Medium	Medium	Medium	Low
MINIMISING EXPOSURE										
Early Evacuation										
A lack of certainty restricts the likelihood of early evacuation	Nil	Very Low: There is no plan in place for evacuation of the townsite, a judgment is made by the Incident controller on the event Community reticence to evacuation	Likely	Catastrophic	Extreme	Develop an integrated emergency evacuation plan	Medium	High	High	High
A lack of timely alarm restricts the likelihood of early evacuation	Emergency WA - DFES	Low: The community is reliant upon public declaration of bushfire warnings, timeliness is unreliable.	Likely	Catastrophic	Extreme	Notification of a watch and act upon the first brigade call out	Medium	Medium	Medium	Medium
An evacuation route will become unsafe if overtaken by the bushfire		Low: The best evacuation route is dependent upon the direction the fire is travelling. Sufficient time is required ASET/RSET to complete a journey before the rout is affected by the bushfire. Early evacuation should avoid the occurrence of smoke obscuring the visibility of the route	Likely	Catastrophic	Extreme	Establish a RESET time frame, independent evacuation up to a fire at 4 km from the townsite, guided evacuation up to 2km, too late to leave if the fire is at 2km, then shelter at the Pickering Brook Primary School	Medium	Medium	Medium	Medium
An inability to evacuate exposes the school children to bushfire attack	Department of Education, The *Principals Guide to Bushfire* and School and the *Bushfire Standalone Plan 2019-2020.* Not nominated as a community safer place	Medium: The school is located centrally within the townsite and in a low threat area. Access to the school by Pickering Brook Road is a predominantly low threat, Trees along McCorkill Road whilst not classified (2.2.3.2 (b)) could become involved in a bushfire, imposing heat onto the school oval, otherwise BAL-Low.	Unlikely	Catastrophic	Extreme	Undertake and maintain vegetation management on public land, road verges, drainage reserve to reduce the school exposure to BAL-Low	Medium	High	Medium	Medium

Risk Register		Risk Analysis				Risk Treatment	Treatment Evaluation			
Risk statement	Existing preventions	Control strength/expediency	Likelihood	Consequence	Risk level	Treatment	Residual	Expediency	Control strength	Priority
An inability to evacuate exposes the community to bushfire attack	No community safer place nominated.	Very Low: The School, car par, and oval has the capacity to accommodate 192 vehicles and a further 120 spaces are available immediately to the school in the Pickering Brook Road reserve without obstructing the carriageway. Steep swales along McCorkill Road prevent car parking and maintaining a clear carriageway.	Likely	Catastrophic	Extreme	In consultation with the City of Kalamunda and the Department of Education nominate the Primary School oval as a safer place. Prepare a pre-incident / emergency plan outlining responsibilities, traffic management, and operation outside school hours.	Medium	Medium	Medium	Medium
Houses not prepared as a place of last resort exposes the community to bushfire attack.	DFES /Local Government promotion of Bushfire Ready	Low: Existing houses demonstrate a moderate consideration of bushfire reduction measures. Typically, flammable buildings and structure are located close to the main house. Existing houses are not constructed to a BAL standard. Observation of existing houses, from the street, did not exhibit any properties with excessive grass although grasses above 100 mm occurred at a number of properties. Most existing buildings are set at BAL-19, practical measures would improve the building resistance although refuge would not be recommended in favour to taking refuge at the school and returning when safe to do so attend to extinguishing small fires at the property	Likely	Catastrophic	Extreme	Encourage landowners to undertake practical measures that will increase the resistance of their dwelling. Includes adjoining structures. Preference should be for evacuation or shelter at the school.	Medium	High	Medium	Medium

4.4.2 Residual Risk

The bushfire risk assessment contributes to one of several considerations informing the determinations of the Project Taskforce regarding the Pickering Brook Townsite.

From a bushfire perspective, the fundamental issue is the tolerance of risk, because, other than through avoidance, it cannot be made a zero risk. Avoidance will deny measures that may otherwise benefit the existing community.

Subsystem Risk Assessment has provided a comprehensive identification of component risks, current controls and improved treatments. The component risks all sit within a likelihood of 'likely', therefore the residual risk on each component even if effectively improved is 'medium'.

The proposed expansion is the development of a greenfield, enabling best practice bushfire protection measures to be applied. This includes a façade exposure that is substantially below the performance limits. The separation from classified vegetation is based upon an FFDI of 100 instead of the nominal FFDI 80, and the effect is to elevate the required construction above the compliant standard.

Additional treatments are proposed to ensure buildings are separated from other buildings and structures, in addition to the immediate land management, to ensure the whole expansion area is an Asset Protection Zone standard. The consequence upon the buildings due to the passive measures proposed is reasonably superficial damage or an isolated building loss which by NERAG is a minor consequence.

It is proposed that Evacuation is the measure to minimise harm. The BMP has demonstrated alternate evacuation routes offering evacuation in the opposite direction to an approaching fire. Evacuation is recommended if the route and destination are a safer place than the place to be departed from. The BMP provides redundancies to Evacuation, offering a safer place as an alternative, and for the new buildings, a high prospect of building survival; and fatalities do not occur in the act of shelter if the building survives.

There is also an established evacuation framework through the State Emergency Management Committee (SEMC) and in turn the operations coordinated by the Local Emergency Management Agreement (LEMA).

The BMP has proposed a comprehensive range of treatments, in addition to existing controls, to remove people from harm's way by minimising exposure through evacuation, shelter if evacuation is not safe, a refuge in place. This is to be supported by community preparation, decisive alarm, a prepared road network, facility preparation and individual housing construction standards respectively; to reasonably remove the likelihood of fatalities or serious injury and reduce the (NERAG) consequence to 'minor'.

	CONSEQUENCE LEVEL				
LIKELIHOOD	INSIGNIFICANT	MINOR	MODERATE	MAJOR	CATASTROPHIC
ALMOST CERTAIN	Medium	Medium	High	Extreme	Extreme
LIKELY	Low	Medium	High	Extreme	Extreme
UNLIKELY	Low	Low	Medium	High	Extreme
RARE	Very low	Low	Medium	High	High
VERY RARE	Very low	Very low	Low	Medium	High
EXTREMELY RARE	Very low	Very low	Low	Medium	High

An overall residual risk remains because, despite the detailed control measures that may be identified the likelihood of a fire affecting the town is 'likely' and this means that despite the effectiveness of the response measures, (the cumulative effect of the subsystem treatments) the risk level will remain 'medium' as defined by the National Emergency Risk Assessment Guidelines (2015), and AS 31000:2018.

In the case of Pickering Brook, the townsite expansion scenario 3, and the existing townsite population, the rating of 'Medium' serves as a continual alert that the controls and treatment identified in the BMP must be robust and continually applied because if they are not the consequence could be catastrophic.

If all treatments identified in the Subsystem Risk Assessment are applied effectively and maintained, then each risk has been methodically addressed and the consequence is minor. Bushfire can cause panic and poor choices can be made despite awareness and training. The main concern is ensuring the Subsystem Risk Assessment treatments are maintained. The 'Medium' residual risk serves as an alarm against complacency and whilst the LEMA provides an appropriate observance of its oversight it is important the treatments are regularly evaluated; to ensure their effectiveness continues.

The Subsystem Risk Assessment has been summarised in Table A, in the Executive Summary of this BMP.

4.5 Conclusion

The purpose of this assessment has been to examine the capability of townsite expansion investigation area, to comply with the bushfire protection criteria as described in the Guidelines for Planning in Bushfire Prone Areas. Demonstrating the capability, in turn, necessitates the identification and evaluation (effectiveness and practicality) of all measures required, to achieve an acceptable (low) level of risk to life and property; for evaluation by the Project Taskforce.

As required for this BMP, these investigations are to be concluded by a comparison of the Pickering Brook townsite expansion with the Bushfire Protection Criteria, to assist in the assessment of proposed bushfire risk management measures required for strategic planning proposals. These are found in Appendix Four in the Guidelines for Planning in Bushfire Prone Areas V1.3. They consist of four elements and the findings from this assessment are addressed under the intent of each element.

Element 1: Location

Intent: To ensure that strategic planning proposals, subdivision and development applications are located in areas with the least possible risk of bushfire to facilitate the protection of people, property and infrastructure

In November 2019 the Western Australian Planning Commission released Position Statement: *Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design*

> "If areas adjoining the subject site have an extreme BHL (Bushfire Hazard Level), consideration should be given to the level of bushfire exposure of the subject site from the type and extent of the vegetation that adjoins the subject site.

It is acknowledged that the townsite and the expansion area are within an extreme bushfire hazard area, being forest and National Park, although within the expansion area itself, due to the history of agricultural land use, it is either a low or moderate bushfire hazard level. An assessment of extreme weather conditions and a detailed analysis of the fire history has been undertaken for the area within 5 km of the townsite. It is notable that the existing measures to reduce ignition from deliberately ignited fires and the fuel reduction initiatives in the locality undertaken by the Parks and Wildlife Service and DFES have had success in reducing the occurrence and improving the manageability of recent bushfires. This has restricted entry of a bushfire into the townsite and into the broader Perth urban area.

Element 2: Siting and design of development

Intent: To ensure that the siting and design of development minimises the level of bushfire impact.

The assessment of the bushfire attack level, utilising an allowance for climate change (FFDI 100) has identified that within the scenario areas (scenarios 2-6) substantial areas are available to accommodate development sites with an acceptable BAL of 29 or lower. It is also recognised that whilst areas may be rated BAL-Low requiring no siting or construction response, burning embers can travel up to 5 km and house losses have been recorded 700 m from a fire front. The townsite's location within an area of forest warrants that precautions are applied broadly to reduce the risk of

sequential building ignitions by the application of management controls for landscaping and construction standards resistant to ember attack. This can be implemented through the subsequent Structure Plan, local development plan and in turn restrictive covenant on the title.

The BAL assessment has identified that Town Lot 81, is not viable due to the remnant vegetation present at the lot. Scenario 5 has remnant vegetation which any future build would be required to respond to. Scenario 6 contains degraded remnant vegetation. Scenarios 2 and 3 are un-encumbered by the presence of vegetation, although for scenario 3 the lot arrangement would be required to address the potential for a windrow at the northern boundary to arrest spray drift into the area.

Element 3: Vehicular access

Intent: To ensure that the vehicular access serving a subdivision/development is available and safe during a bushfire event.

Objective 5.1 (SPP 3.7) places the primacy upon the protection of human life above that of property. This supports evacuations as a means of addressing risk by avoidance, removing the population from exposure to the bushfire. A review of the fire history has identified fires generally occur in an east-west arc, and extremely rarely from the northeast, with major fires arriving mostly from the east, i.e. 2005. Pickering Brook is not a through destination and extends from Canning Road, which is the main link to the townsite of Kalamunda and the Perth Urban area. An audit of the road network extending from Pickering Brook identified that satisfactory standard roads are available to evacuate the population to alternate safe destinations away from an approaching fire. Canning Road in most instances would be used for both access to the townsite and evacuation. As the main service road, it is vital that any disturbance to its function is minimised, to avoid any prolonged isolation of the town. The assessment recommends that Canning Road be nominated as a recovery road. In turn, it is recommended that measures are taken to prevent fire damage to the base of trees and power poles and protect power lines from falling branches.

It is important to recognise the safety of firefighters, and given the limited road widths which exist throughout the State, measures should be taken to avoid a coincidence between public traffic and firefighting operations. This can be achieved by advanced alarm, early evacuation, and closure of roads to permit safer firefighting[46], supported by an alternative of a safer place within the townsite. The assessment has identified Pickering Brook Primary School oval as an appropriate safer place subject to adjacent landscape works. It is a known central and accessible place within the townsite, capable of accommodating residents and visitors.

The internal road network was subject to previous traffic study and recently reviewed. It identified the expansion options would make a negligible contribution to congestion within the townsite and the adjoining road network under normal traffic conditions, notwithstanding natural growth by 2031 in the broader area will require upgrades to key intersections along Canning Road. The potential for congestion in an emergency has been addressed by a generous time allowance ASET/RSET for independent evacuation, guided evacuation and evacuation to a nominated safer place within the townsite.

[46] State Emergency Management Guidelines Traffic Management During Emergencies Guideline 21 December 2018

Element 4: Water:

Intent: To ensure that water is available to the subdivision, development or land use to enable people, property and infrastructure to be defended from bushfire

Whilst Element 4 is narrow to the availability of water as an essential component supporting suppression it can be broadened to consider all aspects required for effective suppression, including a linkage to access for firefighting services and an increased role of telecommunication to raise alarm and coordinate community response.

It is significant that contemporary construction standards aim to minimise the burden upon emergency services through resistant construction. This combined with immediate landscape management can minimise the requirement for suppression resources (water) and in turn, reduces the volume of contaminated waters produced from firefighting. In addition, avoiding ignition avoids the release of toxic smoke that might otherwise occur from a burning building.

Reticulated water and a hydrant network are available to the townsite of Pickering Brook supplied by two 225 Kl tanks 400m west of the townsite at an elevation of 310 AHD, above the townsite and townsite expansion levels. Whilst the expansion areas are expected to impose a minimal demand upon firefighting resources, the existing capacity of the system to supply pressure for fire fighting when multiple draws on the resource are occurring should be evaluated. It may necessitate the consideration of strategic water tanks to be used for the replenishment of fire fighting services.

Telecommunication coverage is available to the townsite and within the expansion areas. The extent of coverage beyond the town, and blackspots, potentially limiting early reporting, has not been examined but should be explored further.

The Precautionary Principle

SPP 3.7 applies a precautionary approach to bushfire risk

> *"The presumption against approval……where there is a lack of certainty that the potential for significant adverse impacts can be adequately reduced or managed in the opinion of the decision-maker".*

This assessment has closely followed the methodology of the National Emergency Risk Assessment Guidelines (2005) (NERAG) and AS/NZS ISO 31000:2018 *Risk Management Principles and Guidelines*. A quantifiable method for bushfire is not available, other than a quantification through a projected fire behaviour (FFDI) that can be used to inform the likelihood of a damaging bushfire event. FFDI is used to determine the recurrence interval as a measure of 'likelihood' used in NERAG. It is also used to identify a construction standard commensurate to the radiant heat level. This informs the potential 'consequence' because fatalities are avoided if a building survives. However, this method is not a zero risk. The NERAG still requires identification of all measures to achieve a risk as low as reasonably acceptable. The approach is therefore not to rely on one solution but provide multiple redundancies. In this regard, the assessment has identified multiple redundancies to minimise the exposure of the population to harm from bushfire. This includes multiple access options that can provide a safe early evacuation option. If that is no longer available then evacuation to the safer place in the townsite. If that is not possible, improvement in bushfire building resistance (encouraged for existing buildings and mandated for new buildings) offers the prospect of survival in place.

The solutions identified in the assessment (Subsystem Risk Assessment) have been examined for 'control expediency'; strength of purpose deployed readily and accepted by the community. There are no immediate infrastructure works identified other than landscape treatment around the school, and the treatment of tree trunk management and power infrastructure maintenance along Canning Road. This may mean bringing forward existing programs.

Mostly the recommended actions recognise the importance of maintaining and refining the actions presently undertaken that have been successful. Fuel reduction, to assist suppression and policing to restrict deliberate ignitions are vital. They are important for the protection of Perth (Cheney 2009) as much as Pickering Brook.

Whilst the scope of the project did not enable interviews with the community, tangentially the assessment team is aware of a strong reticence within the community to evacuate, largely because of the success of the current interventions. Evacuation should not be taken lightly[47], it is difficult, but early evacuation is the safest option, both physically and psychologically, and Black Summer 2019-2020 has revealed there is no certainty, that back up options need to be known in advance and able to be quickly implemented as the circumstance requires. It is important therefore that the risk and the uncertainty are accurately conveyed to the community, that planning is made for evacuation, and the warnings and required actions, and alternatives are certain and understood.

[47] State Emergency Management Guidelines -Western Australia Community Evacuation in Emergencies Guideline 21 December 2018.

5 Applicant Declaration

5.1 Accreditation

This BMP has been prepared by Emerge Associates who have been providing bushfire risk management advice for more than six years, undertaking detailed bushfire assessments (and associated approvals) to support the land use development industry.

Anthony Rowe is a Fire Protection Association of Australia (FPAA) Level 3 Bushfire Planning and Design (BPAD) accredited practitioner (BPAD no. 36690) with over nine years' experience and is supported by a number of team members who have undertaken BPAD Level 1 and Level 2 training and are in the processing of gaining formal accreditation.

5.2 Declaration

I declare that the information provided is true and correct to the best of my knowledge.

Signature:

Name: Anthony Rowe

Company: Emerge Associates

Date: 21 April 2020

BPAD Accreditation: Level 3 BPAD no. 36690

6 References

6.1 General references

Australian Institute for Disaster Resilience 2015, *Australian Disaster Resilience Handbook 10: National Emergency Risk Assessment Guidelines*, CC BY-NC

Australian Building Codes Board 2019, *Handbook: Bushfire Verification Method*, Commonwealth of Australia and States and Territories 2019, published by the Australian Building Codes Board.

Australian Building Codes Board 2014, *Information Handbook: Design and Construction of Community Bushfire Refuges*, 2014

Blanchi R., Whittaker J., Haynes K., Leonard J., Opie K., Holland M., Dreyfuss S., 2015 *Sheltering practices during bushfire,* CSIRO Land and Water Report to the Emergency Management Victoria Natural Disaster Resilience Grants Scheme.

Cheney N.P. 2010, *Fire behaviour during the Pickering Brook wildfire, January 2005 (Perth Hills Fires 71-80)*, Conservation Science W. Aust. 7 (3): 451–46

Florec V., and Pannell D J. 2016, *Economic assessment of bushfire risk management options in Western Australia: case studies in the Perth Hills and in south-west of Western Australia*, The University of Western Australia, Report Prepared for The State Emergency Management Committee Secretariat, attachment 2

GTA Consultant 2020, *TECHNICAL NOTE Pickering Brook Urban Development* – 16 February 2020

McLennan J. 2009, *Use of Informal Places of Shelter and Last Resort*, Bushfire Cooperative Research Centre, School of Psychological Science, La Trobe University

Shire of Kalamunda *Local Emergency Management Arrangements* May 2013

State Emergency Management Committee (SEMC) 2019, *State Emergency Management - A Strategic Framework for Emergency Management in Western Australia*.

Sullivan A L., Cruz M G., Ellis F. M., Gould J S., Plucinski M P., Hurley R., and Koul V. 2014, *Fire Development, Transitions and Suppression, Final Project Report*, Bushfire Cooperative Research Centre, CSIRO Ecosystem Science and CSIRO Climate Adaptation Flagship.

Western Australian Planning Commission (WAPC) 2015, *State Planning Policy 3.7 Planning in Bushfire Prone Areas*, Perth.

Western Australian Planning Commission and Department of Fire and Emergency Services (WAPC and DFES) 2017, *Guidelines for Planning in Bushfire Prone Areas Version 1.3*, Western Australia. December 2017.

Western Australian Local Government Association, *Road Visual Condition Assessment Manual VERSION 1 – 2016*

Whittaker J., Blanchi R., Haynes K., Leonard J., Opie K., 2017 *Experiences of sheltering during Black Saturday bushfire: Implications for policy and research*

6.2 Online references

Blanchi R., Lucas C., Leonard J., and Finkele K. 2010, *Meteorological conditions and wildfire-related house loss in Australia.* International Journal of Wildland Fire, 19, 914-926

Douglas G., Midgley S., Tan Z., and Short L. 2009, *Bushfire Building Damage Survey – A NSW Perspective* – proceedings of the Royal Society of Queensland Bushfire 2006 Conference Special Edition Vol 115:161-169

International Journal of Public Health 2019, *Optimal Evacuation Strategy for Parking Lots Considering the Dynamic Background Traffic Flows*, viewed February 2020, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6617142/

Landgate 2019, *Map Viewer*, viewed November 2019, https://www0.landgate.wa.gov.au/maps-and-imagery/interactive-maps/map-viewer

Office of Bushfire Risk Management (OBRM) 2019, *Map of Bush Fire Prone Areas*, viewed January 2020, https://maps.slip.wa.gov.au/landgate/bushfireprone/

Mainroads *WA Road Hierarchy for Western Australia Road Types and Criteria*, viewed February 2020 https://www.mainroads.wa.gov.au/Documents/Road%20Hierarchy%20Criteria%20-%20April%202011.u_3158367r_1n_D11%5E2392185.PDF

State Emergency Management Committee (SEMC), 21 December 2018, *State Emergency Management Guidelines -Western Australia Community Evacuation in Emergencies Guideline*, viewed February 2020, https://semc.wa.gov.au/emergency-management/guidelines/Documents/WACommunityEvacuationinEmergenciesGuideline.pdf

State Emergency Management Committee (SEMC), 21 December 2018, *State Emergency Management Guidelines Traffic Management During Emergencies Guideline*, February 2020, https://semc.wa.gov.au/emergency-management/guidelines/Documents/TrafficManagementDuringEmergenciesGuideline.pdf

Appendix A

Road Audit

Table A1 - Audit of Major routes Entering and Leaving Pickering Brook Townsite

	Ashendon Road	Brookton Hwy	Canning Rd towards PB from west	Canning Rd towards PB from south	Canning Rd west from PB	Mundaring Weir Rd heading North-east from Lockwood	Patterson Rd, Walnut Ro.	Pickering Brook Rd towards PB	Pickering Brook Rd towards PB from East from Sala Rd	Welshpool Rd East heading West from Canning
Is the carriageway sealed	N	Y	Y	Y	Y	Y	Y	Y	N	Y
If sealed, what is the carriage width	N/A	>6 m	>6 m	>6 m	>6 m	>6 m	>6 m C	>6 m	N/A	>6 m
If sealed what is the shoulder width	N/A	<1 m	<1 m	<1 m	<1 m	<1 m	<1 m	<1 m	N/A	
If sealed is the carriageway surface unbroken	N/A	Y	Y	Y	Y	Y	N	Y	N/A	
If sealed is the surface clearly marked	N/A	Y	Y	Y	Y	Y	Y	Y	N/A	Y
If not sealed what is the overall width	>6 m	N/A	N/A	N/A	N/A	N/A	N/A	N/A	>6 m	N/A
If not sealed what is the estimated carriage width	>6 m A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	>6 m	N/A
If not sealed is the surface free of loose material	Y	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	N/A
Is the road surface smooth	Generally	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A
Is the road traversable by 2WD	Y	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A
Does the maximum grade exceed 1 in 10, for any length >50m	N	N	N	N	N	N	N	N	N	Y
Does the cross fall exceed 1 in 33 at any point	N	N	N	N	N	N	N	N	N	
Is the alignment of the roadway clearly defined	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
Is the presence of intersections clearly visible	N/A	Y	Y	Y	N	N	Y	N	N/A	Y
Are reflective delineators provided on guideposts, crash barriers and bridge railings	Y	Y	Y	Y	Y	Y	Y	Y	N	Y

	Ashendon Road	Brookton Hwy	Canning Rd towards PB from west	Canning Rd towards PB from south	Canning Rd west from PB	Mundaring Weir Rd heading North-east from Lockwood	Patterson Rd, Walnut Ro.	Pickering Brook Rd towards PB	Pickering Brook Rd towards PB from East from Sala Rd	Welshpool Rd East heading West from Canning
What is the percentage of the 'line of sight' < 200 m	<30%					0.3		0.9		
What is the frequency (distance between) a line of sight < 200 m										
What is the percentage of corners less than road speed	<10%			0				0		
Is the road illuminated	N	N	N	N	N	N	N	N	N	N
Are intersections illuminated	N	N	N	N	N	N	N	N	N	N
Are barriers provided to prevent access to dropping embankments	N	N	N	N	N	N	N	N	N	Y
Is the carriageway clear of vertical obstruction	N	N	N	N	N	N	Y	N	N	Y
Is the shoulder traversable, clear of obstruction, signs, drains, and trees	N	N	N	N	N	Y/N	N	N D	N/A	N
If the shoulder is not clear of obstructions what is the frequency	<20 m		<20 m	<20 m	<20 m	<20 m	<20 m	<20 m	N/A	<20 m
Is the shoulder level with the road	N	Y		Y/N	Y	Y	N	Generally	N/A	Y
If the shoulder is not level what is the frequency of occurrence		N/A			N/A	0.5			N/A	
Are overtaking opportunities provided	N	Y	Y	Irregular	N	N	N	Limited	N	Y
Are areas clear of vegetation, safer places, available along the road	Y	Y	Y	Y	Y	N	Y	Y	N	
Are bridges narrower than the shoulder and carriageway	Y	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

	Ashendon Road	Brookton Hwy	Canning Rd towards PB from west	Canning Rd towards PB from south	Canning Rd west from PB	Mundaring Weir Rd heading North-east from Lockwood	Patterson Rd, Walnut Ro.	Pickering Brook Rd towards PB	Pickering Brook Rd towards PB from East from Sala Rd	Welshpool Rd East heading West from Canning
What is the carriage width over the bridge	6 m	>6m	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
What is the frequency of bridges along the route	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Are all road signs conspicuous and clear	N/A	Y	Y B	Y	Y	Y	Y	Y	N/A	Y
Are road markings consistent along the route	N/A	N	Y	N	Y	Y	N	Y	N/A	Y
Are curve warnings and advisory speed signs installed	N/A	N	N	Y	Y	Y	Y	Y	N/A	Y
Is emergency advice provided along the road	N/A	N	N	N	N	N	N	N	N/A	N
Is signage vulnerable to bushfire attack	N/A	Metal	Metal	Metal	Metal	Metal	Metal	Metal	N/A	Metal
Do restrictions apply to any class of vehicle using the road	N	N	N	N	N	N	N	N	Probably	Y E
Does the route rely on electronic traffic signalling	N	N	N	N	N	N	N	N	N	N
Is the signage vulnerable to bushfire attack (power cut)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Is the electronic signage multi-functional	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
What are the adjoining land uses	State forest	State forest, parks & recreation, rural, urban	Parks & recreation, rural	Parks & recreation, rural	Parks & recreation, rural	State forest, parks & recreation, rural	Parks & recreation, rural	Parks & recreation, rural, urban	State forest, parks & recreation, rural, urban	Parks & recreation, rural, urban
What are the percentages along the route										

	Ashendon Road	Brookton Hwy	Canning Rd towards PB from west	Canning Rd towards PB from south	Canning Rd west from PB	Mundaring Weir Rd heading North-east from Lockwood	Patterson Rd, Walnut Ro.	Pickering Brook Rd towards PB	Pickering Brook Rd towards PB from East from Sala Rd	Welshpool Rd East heading West from Canning
Is the route likely to be free from large animals	Y	Y		N		Y	N		N	Y
What is the adjoining vegetation	Forest	Forest	Forest	Forest, Scrub	Forest	Forest	Forest	Forest, Grassland	Forest	Forest
What is the percentage along the route (the balance is 'excluded')										
Is the height greater than the setback from the carriageway	Y		Y	Y		Y		Y	Y	

NOTES
A Narrows to 6 m at culverts
B Some signs covered by vegetation
C 4.5 m carriageway width at Lockwood
D Traversable in some areas drains present a hazard
E Truck speed limited

A. B. C. Board (ABCB) 2019, *Handbook: Bushfire Verification Method*, Commonwealth of Australia and States and Territories.

Cheney, N. P. 2010, *Fire behaviour during the Pickering Brook wildfire, January 2005 (Perth Hills Fires 71-80)*, Conservation Science Western Australia, 7(3): 451-468.

Department of the Environment 2012, *Interim Biogeographic Regionalisation for Australia (Subregions) v. 7 (IBRA)*, Canberra.

Department of Fire and Emergency Services (DFES) 2016, *Significant Landscape Fire Incidents*.

Heddle, E. M., Loneragan, O. W. and Havel, J. J. 1980, *'Vegetation Complexes of the Darling System Western Australia'*, in Department of Conservation and Environment (ed.), *Atlas of Natural Resources Darling System Western Australia*, Perth.

Standards Australia 2018, *AS 3959:2018 Construction of buildings in bushfire-prone areas*, Sydney.

Western Australian Planning Commission (WAPC) 2015, *State Planning Policy 3.7 Planning in Bushfire Prone Areas*, Perth.

Western Australian Planning Commission and Department of Fire and Emergency Services (WAPC and DFES) 2015, *Guidelines for Planning in Bushfire Prone Areas*, Western Australian Planning Commission, Perth.

Western Australian Planning Commission and Department of Fire and Emergency Services (WAPC and DFES) 2017, *Guidelines for Planning in Bushfire Prone Areas Version 1.3*, Western Australia. December 2017.